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

(11) EP 4 303 001 A1

(12) # EUROPEAN PATENT APPLICATION
published in accordance with Art. 153(4) EPC

(43) Date of publication:
10.01.2024 Bulletin 2024/02

(21) Application number: **21929052.5**

(22) Date of filing: **04.03.2021**

(51) International Patent Classification (IPC):
B41J 2/01 *(2006.01)*

(52) Cooperative Patent Classification (CPC):
B41J 2/01

(86) International application number:
PCT/JP2021/008445

(87) International publication number:
WO 2022/185479 (09.09.2022 Gazette 2022/36)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

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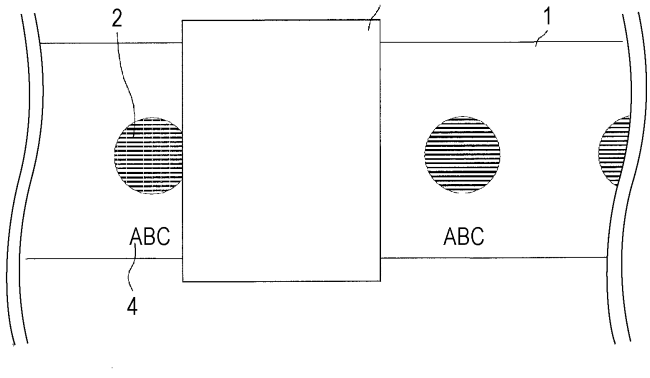
(54) **DRYING DEVICE, IMAGE FORMING DEVICE, AND IMAGE FORMING METHOD**

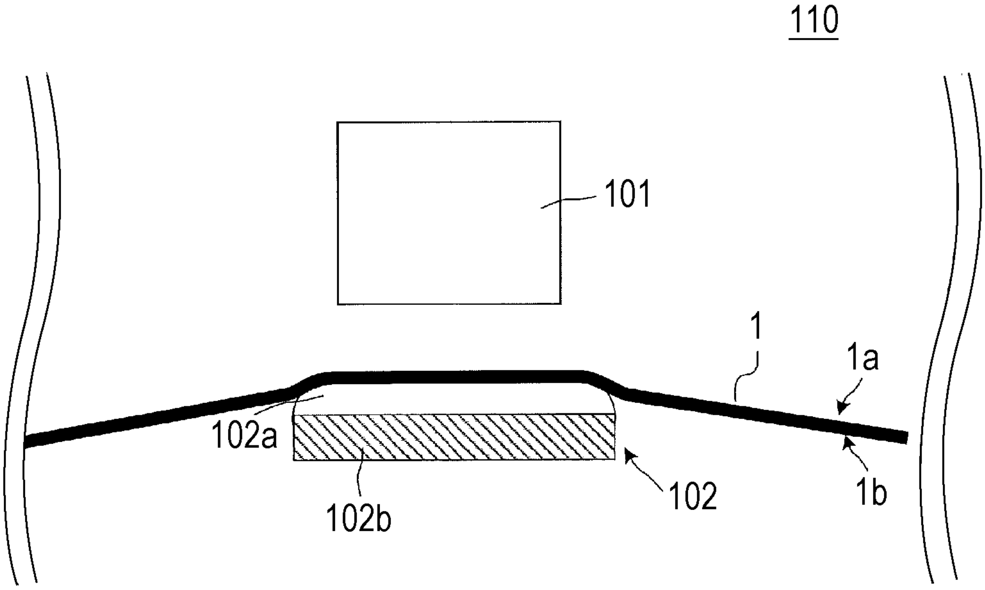
(57) A problem is to provide a drying device which can dry an ink image formed on a recording medium in a short time and in which the recording medium and the formed image are less likely to be deteriorated. A drying device that solves the problem dries an ink image including an undried ink formed on one surface of a recording medium. The drying device includes: an energy irradiation unit for irradiating the one surface of the recording medium with energy to heat and dry the ink image; and a temperature control unit that is disposed so as to face the energy irradiation unit with the recording medium interposed therebetween and so as to be in contact with the other surface of the recording medium. The energy irradiation unit is an infrared light irradiation unit that emits infrared light having a wavelength of 0.8 μm or more and 3.0 μm or less at an output of 30 kW/m^2 or more, or an ultraviolet light irradiation unit that irradiates the one surface of the recording medium with ultraviolet light having a wavelength of 200 nm to 410 nm at an illuminance of 1 W/cm^2 or more.

FIG. 1A



(Cont. next page)

FIG. 1B



Description

Technical Field

[0001] The present invention relates to a drying device, an image forming device, and an image forming method.

Background Art

[0002] In recent years, a method for applying a liquid ink onto a low-absorbent or non-absorbent recording medium to form an image has been widely used. According to this method, a desired image can be formed even on a recording medium having low ink absorbability, and a product having high designability can be manufactured.

[0003] In an image forming device that performs such printing, an ink is applied onto a recording medium to form an ink image, and then a solvent or the like in the ink image is removed to fix a coloring agent to the recording medium. As a method for removing the solvent in the ink image, a method for blowing hot air is known. However, hot air drying requires a drying furnace, and has a problem that a device tends to be large.

[0004] Therefore, an ink image is heated by infrared light to remove a solvent in the ink image (for example, Patent Literature 1).

Citation List

Patent Literature

[0005] Patent Literature 1: JP 2019-162870 A

Summary of Invention

Technical Problem

[0006] In recent years, there has been a demand for speeding up various types of printing, and there has been a demand for drying an ink image in a shorter time. However, long-wavelength infrared light irradiation as described in Patent Literature 1 has a problem that it is difficult to raise the temperature of an ink image, and it takes time to remove a solvent (dry the ink image).

[0007] In order to solve such a problem, a method for irradiating the ink image with energy at a high output to raise the temperature of the ink image in a short time is conceivable. However, when the ink image includes a plurality of color inks, an energy absorption ratio is different among the inks. As a result of intensive studies by the present inventors, when energy is emitted at a high output, it has been clarified that the degree of temperature rise is largely different between a region having a high energy absorption ratio and a region having a low energy absorption ratio, and it has been found that unevenness is likely to occur in the temperature of the ink when the ink is heated. For example, when energy is emitted according to drying of an ink having a high energy absorption ratio, the temperature of an ink having a low energy absorption ratio is not sufficiently raised, and drying is insufficient. Meanwhile, when energy is emitted according to a drying condition of the ink having a low energy absorption ratio, it has been clarified that the temperature of a region to which the ink having a high energy absorption ratio is applied is excessively raised, and a formed image and a recording medium are deteriorated by heat.

[0008] In addition, in a case where a mark, a pattern, or the like is printed on a recording medium in advance, when energy is emitted at a high output, the temperature of only a region of the recording medium having a high energy absorption ratio is likely to rise, and the recording medium is likely to be damaged.

[0009] The present invention has been achieved in view of such a problem. Specifically, an object is to provide a drying device which can dry an ink image formed on a recording medium in a short time and in which the recording medium and the formed image are less likely to be deteriorated. Another object is to provide an image forming device and an image forming method using the drying device.

Solution to Problem

[0010] The present invention provides the following drying device.

[0011] A drying device for drying an ink image including an undried ink, formed on one surface of a recording medium, the drying device including: an energy irradiation unit for irradiating the one surface of the recording medium with energy to heat and dry the ink image; and a temperature control unit that is disposed so as to face the energy irradiation unit with the recording medium interposed therebetween and so as to be in contact with the other surface of the recording medium, in which the energy irradiation unit includes either an infrared light irradiation unit that emits infrared light having a wavelength of 0.8 μm or more and 3.0 μm or less at an output of 30 kW/m^2 or more or an ultraviolet light irradiation unit that irradiates the one surface of the recording medium with ultraviolet light having a wavelength of 200 nm to 410 nm at an illuminance of 1 W/cm^2 or more.

[0012] The present invention provides the following image forming device.

[0013] An image forming device including: a conveyance unit that conveys a recording medium; a primer ink discharge unit for discharging a primer ink containing an aggregating agent; a color ink discharge unit for discharging a color ink containing a coloring agent; and the above-described drying device.

[0014] The present invention provides the following image forming method.

[0015] An image forming method including: a step of applying ink to one surface of a recording medium to form an ink image; and a step of drying the ink image by irradiating the one surface of the recording medium with energy while a temperature control unit for controlling a temperature is in contact with the other surface of the recording medium, in which in the step of drying the ink image, infrared light having a wavelength of 0.8 μm or more and 3.0 μm or less is emitted at an output of 30 kW/m^2 or more, or ultraviolet light having a wavelength of 200 nm or more and 410 nm or less is emitted at an illuminance of 1 W/m^2 or more.

Advantageous Effects of Invention

[0016] According to the drying device of the present invention, an ink image formed on a recording medium can be sufficiently dried in a short time, and the recording medium and the formed image are less likely to be damaged.

Brief Description of Drawings

[0017]

Fig. 1A is a plan view illustrating a configuration of a drying device according to an embodiment of the present invention, and Fig. 1B is a side view illustrating the configuration of the drying device.

Fig. 2 is a side view illustrating a modification of the drying device according to the embodiment of the present invention.

Fig. 3A is a plan view illustrating a configuration of an image forming device according to an embodiment of the present invention, and Fig. 3B is a side view of the printing.

Fig. 4 is a side view illustrating a modification of the image forming device according to the embodiment of the present invention.

Description of Embodiments

[0018] Hereinafter, an embodiment of the present invention will be described in detail. Note that the present invention is not limited to the embodiment.

1. Drying device

[0019] A drying device of the present invention is a device for drying an ink image including an undried ink, formed on a recording medium. In the drying device, the temperature of an ink image is raised by energy irradiation, and a solvent or the like is volatilized to dry the ink image. The drying device of the present invention is very useful when an ink image including a plurality of color inks, formed on a recording medium is dried or when an ink image formed on a recording medium partially having a region with a different color.

[0020] As described above, in a case where a printed matter is formed by forming an ink image with a plurality of color inks or by using a recording medium partially having a region with a different color, when the ink image or the recording medium is irradiated with energy at a high output, temperature unevenness is likely to occur due to a difference in an energy absorption ratio of the ink or the recording medium. Specifically, the temperature rises in a short time in a region where a color ink having a high energy absorption ratio is applied or in a region of the recording medium having a high energy absorption ratio. Meanwhile, the temperature is less likely to rise in a region where a color ink having a low energy absorption ratio is applied or in a region of the recording medium having a low energy absorption ratio. Therefore, when an energy irradiation condition is determined according to an ink having a high energy absorption ratio, drying of the ink image tends to be insufficient. Meanwhile, when drying is performed according to an ink having a low energy absorption ratio, a region where an ink having a high energy absorption ratio is applied and a region of the recording medium having a high energy absorption ratio are likely to be deteriorated. Note that when long-wavelength infrared light is emitted for a long time, such temperature unevenness is less likely to occur.

[0021] Fig. 1A illustrates a plan view of a drying device 110 according to an embodiment of the present invention, and Fig. 1B illustrates a side view of the drying device 110. Fig. 2 illustrates a side view of a modification of the drying device 110. As illustrated in Figs. 1A, 1B, and 2, the drying device 110 of the embodiment includes: an energy irradiation unit 101 for irradiating an ink image 2 formed on one surface (hereinafter, also referred to as "printing surface") 1a of a recording medium 1 with energy; and a temperature control unit 102 disposed so as to face the energy irradiation unit 101 with the recording medium 1 interposed therebetween and so as to be in contact with the other surface (hereinafter, also referred to as "non-printing surface") 1b of the recording medium 1. The drying device 110 in Fig. 2 is the same as the drying device 110 illustrated in Figs. 1A and 1B except for the shape of the temperature control unit 102.

[0022] In the drying device 110 of the present embodiment, even if the energy irradiation unit 101 irradiates the ink image 2 and the recording medium 1 with energy at a high output, the temperatures of the recording medium 1 and the ink image 2 are made uniform by the temperature control unit 102 disposed on the non-printing surface 1b side of the recording medium 1. More specifically, heat is transferred from the recording medium 1 to the temperature control unit 102, and the temperatures of the recording medium 1 and the ink image 2 are thereby less likely to rise excessively. Meanwhile, low temperature regions in the recording medium 1 and the ink image 2 are warmed by the temperature control unit 102. Therefore, according to the device 110, the entire ink image 2 can be uniformly dried in a short time. In addition, since the temperatures of the recording medium 1 and the ink image 2 do not excessively rise during drying of the ink image 2, the recording medium 1 and the obtained image are less likely to be deteriorated.

[0023] Note that the drying device 110 only needs to include the energy irradiation unit 101 and the temperature control unit 102, but may include, in addition to the energy irradiation unit 101 and the temperature control unit 102, a pressing means (not illustrated) for bringing the recording medium 1 and the temperature control unit 102 into close contact with each other, a conveyance means (not illustrated) for conveying the recording medium 1 or the like, and the like. In addition, the drying device 110 may further include a housing (not illustrated) that covers the energy irradiation unit 101, the temperature control unit 102, and the like. In the following description and Figs. 1A, 1B, and 2, an example using an elongated recording medium 1 is illustrated, but the drying device 110 may be used when the ink image 2 formed on a sheet-shaped recording medium 1 is dried. Hereinafter, each component of the drying device 110 will be described.

(1) Energy irradiation unit

[0024] The energy irradiation unit 101 is a component for irradiating the ink image 2 formed on the printing surface 1a of the recording medium 1 with energy. By energy irradiation by the energy irradiation unit 101, the temperature of the ink image 2 formed on the recording medium 1 is raised, and a solvent and the like in the ink image 2 are volatilized, and the ink image 2 is dried.

[0025] The energy irradiation unit 101 of the present embodiment only needs to include at least one of an infrared light irradiation unit that emits infrared light having a wavelength of 0.8 μm or more and 3.0 μm or less at an output of 30 kW/m^2 or more and an ultraviolet light irradiation unit that emits ultraviolet light having a wavelength of 200 nm to 410 nm at an illuminance of 1 W/cm^2 or more, and may include both of these. When infrared light is emitted by the infrared light irradiation unit, a coloring agent and a solvent in the ink image absorb the infrared light. Then, the temperature of the ink image rises, and the solvent is volatilized. Meanwhile, when ultraviolet light is emitted by the ultraviolet light irradiation unit, the coloring agent in the ink image mainly absorbs the ultraviolet light, and the temperature of the coloring agent rises. Then, heat is transferred to the solvent by heat conduction, and the solvent is volatilized. Hereinafter, each of the units will be described.

(Infrared light irradiation unit)

[0026] A configuration of the infrared light irradiation unit is not particularly limited as long as the infrared light irradiation unit can emit light having a wavelength of 0.8 μm or more and 3.0 μm or less at an output of 30 kW/cm^2 or more. The infrared light irradiation unit usually includes one or more heat sources, a control unit for controlling an output of infrared light from the heat sources, a cooling unit for controlling temperature, and the like. The infrared light irradiation unit may include another component as necessary.

[0027] In the infrared light irradiation unit, one or more heat sources are usually disposed so as to be able to emit infrared light in the entire width direction of the recording medium 1. Note that the "width direction" in the present specification is a direction perpendicular to a conveyance direction of the recording medium 1 when the drying device 110 is viewed in plan. Note that the heat source may be disposed so as to irradiate only a part of the recording medium 1 in the width direction with infrared light depending on a position where the ink image 2 is formed, the shape of the recording medium 1, the type of the recording medium 1, and the like.

[0028] In addition, the length of a region irradiated with infrared light by the infrared light irradiation unit is appropriately selected according to a desired infrared light irradiation amount, irradiation time, and the like. In the infrared light irradiation unit, a plurality of heat sources may be disposed in the conveyance direction of the recording medium 1.

[0029] The heat source of the infrared light irradiation unit is disposed with a gap from the recording medium 1. A distance between the heat source of the infrared light irradiation unit and the recording medium 1 may be constant or may change continuously or intermittently. Note that the distance between the heat source of the infrared light irradiation unit and the recording medium 1 is preferably 3 cm or more and 20 cm or less, and more preferably 5 cm or more and 15 cm or less. When the distance between the heat source of the infrared light irradiation unit and the recording medium is 5 cm or more, the recording medium and the heat sources are less likely to come into contact with each other even if the recording medium 1 warps. Meanwhile, when the distance is 20 cm or less, the recording medium can be efficiently irradiated with infrared light by the heat source of the infrared light irradiation unit.

[0030] Here, the wavelength of the infrared light emitted by the heat source of the infrared light irradiation unit only needs to be 0.8 μm or more and 3.0 μm or less, and is preferably 0.8 to 2.5 μm, and more preferably 1.7 to 2.5 μm. When the wavelength of the light emitted from the infrared light irradiation unit (heat source) is within the range, the temperature of the ink image 2 can be raised in a short time. For example, when the wavelength of the infrared light is 1.7 to 2.5 μm, not only the ink temperature can be raised in a short time, but also a difference in infrared light absorbability among a plurality of types of inks can be suppressed to be small.

[0031] The output of the infrared light from the infrared light irradiation unit (heat source) only needs to be 30 kW/m^2 or more, and is preferably 40 kW/m^2 or more and 350 kW/m^2 or less, and more preferably 60 kW/cm^2 or more and 150 kW/m^2 or less. When the output from the infrared light irradiation unit is within this range, the ink image can be dried in about 10 seconds, for example. Note that the output of the infrared light can be specified from specifications of the heat source or the like.

[0032] The temperature of the heat source is preferably 900°C or higher, more preferably 900°C or higher and 2000°C or lower, and still more preferably 1400°C or higher and 2000°C or lower. When the temperature of the heat source is 900°C or higher, the temperature of the ink image rises in a short time. Note that when the temperature of the heat source is excessively high, deformation, deterioration, and the like of the recording medium may occur, and thus the temperature is preferably 2000°C or lower. The temperature of the heat source can be specified by a non-contact infrared sensor or the like.

[0033] The heat source of the infrared light irradiation unit is not particularly limited as long as the heat source can emit infrared light at the above-described wavelength and output, and a known heat source can be used. In addition, the heat source may be a point-shaped heat source or a linear heat source. Examples of such a heat source include a halogen lamp heater, a quartz tube heater, and a carbon heater. The number of heat sources included in the infrared light irradiation unit is not particularly limited, and is appropriately selected according to the width and length of a region irradiated with infrared light.

[0034] Meanwhile, the control unit of the infrared light irradiation unit only needs to be able to monitor the temperature of the heat source and to adjust the amount of power to be supplied to the heat source according to the temperature of the heat source, for example, and is similar to a control unit of a known infrared light irradiation device. Furthermore, the cooling unit only needs to be able to cool the heat source, surroundings thereof, and the like in order to suppress excessive rise of the temperature of the infrared light irradiation unit, and can be, for example, a blower, a water-cooled chiller, or the like.

(Ultraviolet light irradiation unit)

[0035] A configuration of the ultraviolet light irradiation unit is not particularly limited as long as the ultraviolet light irradiation unit can emit light having a wavelength of 200 nm or more and 410 nm or less at an illuminance of 1 W/cm^2 or more. The ultraviolet light irradiation unit includes, for example, one or more light sources, a control unit for controlling an output of ultraviolet light from the light sources, a cooling unit for adjusting temperature, and the like.

[0036] In the ultraviolet light irradiation unit, a light source is usually disposed so as to be able to emit ultraviolet light in the entire width direction of the recording medium 1. Note that the light source may be disposed so as to irradiate only a part of the recording medium 1 in the width direction with ultraviolet light depending on a position where the ink image 2 is formed, the shape of the recording medium 1, the type of the recording medium 1, and the like.

[0037] In addition, the length of a region irradiated with ultraviolet light by the ultraviolet light irradiation unit is appropriately selected according to a desired ultraviolet light irradiation amount, irradiation time, and the like. In the ultraviolet light irradiation unit, a plurality of light sources may be disposed in the conveyance direction of the recording medium 1.

[0038] Furthermore, the light source of the ultraviolet light irradiation unit is disposed with a gap from the recording medium. A distance between the light source of the ultraviolet light irradiation unit and the recording medium 1 may be constant or may change continuously or intermittently. The distance between the light source of the ultraviolet light irradiation unit and the recording medium 1 is usually more preferably 5 mm or less. When the distance between the light source and the recording medium is 5 mm or less, the recording medium can be efficiently irradiated with ultraviolet light by the light source.

[0039] Here, the wavelength of the ultraviolet light emitted from the light source of the ultraviolet light irradiation unit only needs to be 200 nm or more and 410 nm or less, and is preferably 350 nm or more and 410 nm or less when an LED is used. When the wavelength of the ultraviolet light is 200 nm or more and 410 nm or less, the ultraviolet light is easily absorbed by the coloring agent contained in the ink image 2, and the temperature of the ink image 2 can be raised in a short time.

[0040] The illuminance of the ultraviolet light from the ultraviolet light irradiation unit (light source) only needs to be 1 W/cm^2 or more, but is preferably 2 W/cm^2 or more and 4 W/cm^2 or less. When the output from the ultraviolet light irradiation unit is 1 W/cm^2 or more, the ink image is easily dried in a short time, and for example, time for irradiating each ink image with the light source can be 10 seconds or less. The illuminance of the ultraviolet light is measured with an illuminance meter (for example, illuminance system UIT-201 manufactured by USHIO INC.).

[0041] The light source of the ultraviolet light irradiation unit is not particularly limited as long as the light source can emit ultraviolet light at the above-described wavelength and illuminance, and a known light source can be used. The light source may be a point-shaped light source or a linear light source. Examples of such a light source include a halogen lamp and a UV-LED lamp. Specific examples of the UV-LED lamp include a 300 nm LED, a 375 nm LED, a 395 nm LED, and a 410 nm LED, which are appropriately selected according to the type of the coloring agent contained in the ink image (color ink). When the ink image 2 including a plurality of color inks is dried, a plurality of types of LED lamps may be combined. The number of light sources included in the ultraviolet light irradiation unit is not particularly limited, and is appropriately selected according to the width and length of a region irradiated with ultraviolet light.

[0042] Meanwhile, the control unit of the ultraviolet light irradiation unit only needs to be able to monitor the amount of light from the light source and to adjust the amount of power to be supplied to the light source according to the amount of light of the light source, for example, and is similar to a control unit of a known ultraviolet light irradiation unit. Furthermore, the cooling unit only needs to be able to cool the light source, surroundings thereof, and the like in order to suppress excessive rise of the temperature of the ultraviolet light irradiation unit, and can be, for example, a blower, a water-cooled chiller, or the like.

(2) Temperature control unit

[0043] The temperature control unit 102 is a member for making the temperature of the recording medium 1 uniform, and includes: for example, a heat conduction unit 102a having high heat conductivity, in contact with the non-printing surface 1b of the recording medium 1; and a temperature adjusting mechanism 102b for adjusting the temperature of the heat conduction unit 102a.

[0044] The heat conduction unit 102a is constituted by a member having high heat conductivity or the like, and is a member for making the temperature of the recording medium 1 and the temperature of the ink image 2 uniform by releasing heat in a high temperature region of the recording medium 1 or the ink image 2 or heating a low temperature region when the energy irradiation unit 101 emits energy. Usually, the heat conduction unit 102a is appropriately heated or cooled by the temperature adjusting mechanism 102b described later such that the surface temperature of the heat conduction unit 102a is a set temperature.

[0045] The heat conduction unit 102a preferably has a heat conductivity of 150 kcal/m•h•°C or more. When the heat conductivity of the heat conduction unit is 150 kcal/m•h•°C or more, the temperature of the recording medium 1 is easily made uniform in a short time. Note that the heat conductivity is a value specific to a material, and the conductivity of the heat conduction unit 102a can be specified from the type of a constituent material. Note that when the heat conduction unit 102a includes a plurality of materials, the heat conductivity can be calculated by multiplying a content ratio of each material by the heat conductivity of the material and adding the obtained values.

[0046] A material constituting the heat conduction unit 102a is preferably metal, and copper, aluminum, a composite thereof, or the like is preferable. Among these materials, copper is particularly preferable from a viewpoint of high heat conductivity, low cost, good processability, and the like.

[0047] Here, the shape of the heat conduction unit 102a is not particularly limited as long as the heat conduction unit 102a can be in contact with the non-printing surface 1b of the recording medium 1 while the energy irradiation unit 101 irradiates the recording medium 1 and the ink image 2 with energy. The heat conduction unit 102a may have, for example, a flat plate shape as illustrated in Fig. 1B, or may have a roll shape as illustrated in Fig. 2.

[0048] As illustrated in Fig. 2, when the heat conduction unit 102a has a roll shape and the heat conduction unit 102a is pivotally supported so as to be rotatable, the heat conduction unit 102a rotates according to movement of the recording medium 1. Therefore, excessive friction is less likely to occur between the recording medium 1 and the heat conduction unit 102a, and the non-printing surface of the recording medium 1 is less likely to wear. Furthermore, when the heat conduction unit 102a rotates, a specific region of the heat conduction unit 102a is less likely to be irradiated with energy for a long time, and the temperature of the heat conduction unit 102a is less likely to rise excessively. Therefore, there is also an advantage that temperature adjustment by the temperature adjusting mechanism 102b is easy.

[0049] The width of a region where the heat conduction unit 102a and the recording medium 1 are in contact with each other is not particularly limited, and only needs to be at least equal to or larger than the width of a region irradiated with energy by the energy irradiation unit 101. Note that the width of the region where the heat conduction unit 102a and the recording medium 1 are in contact with each other is more preferably equal to or larger than the width of the recording medium 1. When the width of the region where the heat conduction unit 102a and the recording medium 1 are in contact with each other is equal to or larger than the width of the recording medium 1, the temperature of the entire recording medium 1 is adjusted to be constant.

[0050] In addition, the length of the region where the heat conduction unit 102a and the recording medium 1 are in contact with each other (a distance in a direction parallel to the conveyance direction of the recording medium) is preferably at least equal to or longer than the length of the region irradiated with energy by the energy irradiation unit 101.

[0051] In addition, the non-printing surface 1b of the recording medium 1 and the heat conduction unit 102a are preferably in contact with each other in substantially the entire region irradiated with energy by the energy irradiation unit 101.

[0052] Meanwhile, the temperature adjusting mechanism 102b of the temperature control unit 102 only needs to be able to control the surface temperature of the heat conduction unit 102a. For example, the temperature adjusting mechanism 102b can include a heating means for raising the temperature of the heat conduction unit 102a, a cooling means for lowering the temperature of the heat conduction unit 102a, a temperature measuring means for directly or indirectly measuring the temperature of the surface of the heat conduction unit 102a, a control means for controlling the heating means and the cooling means on the basis of a set temperature and a temperature measured by the temperature measuring means, and the like.

[0053] Examples of the heating means include a known heater, and examples of the cooling means include a blower and a water-cooled chiller. The heating means and the cooling means may be disposed inside or outside the heat conduction unit 102a.

(3) Other components

[0054] The drying device 110 may further include a pressing means (not illustrated) for bringing the recording medium 1 and the temperature control unit 102 into closer contact with each other, or the like. The pressing means may have a structure in which the recording medium 1 is pressed against the temperature control unit 102, a structure in which the temperature control unit 102 is pressed against the recording medium 1, or a structure in which the recording medium 1 and the temperature control unit 102 are pressed against each other. While the energy irradiation unit 101 emits energy, a tension may be adjusted while being measured with a pressure gauge or the like such that a constant tension is applied to the recording medium 1.

[0055] The drying device 110 may further include a conveyance means (not illustrated) for conveying the recording medium 1. The conveyance means only needs to be able to relatively move the recording medium 1 and the energy irradiation unit 101, and may be, for example, a means that moves the recording medium 1, a means that moves the energy irradiation unit 101, or a means that moves both of these. In addition, the conveyance means may move the temperature control unit 102 according to the position of the energy irradiation unit 101. The conveyance means may continuously or intermittently move the recording medium 1, the energy irradiation unit 101, and the like.

[0056] Furthermore, the drying device 110 may include a housing for protecting the energy irradiation unit 101, the temperature control unit 102, the recording medium 1, and the like from dust and the like, and preventing energy from the energy irradiation unit from leaking to the outside.

(4) Drying method using drying device

[0057] A method of drying the ink image 2 using the drying device 110 will be described below. As described above, the drying device 110 heats and dries the ink image 2 including an undried ink, formed on the recording medium 1. Here, the ink image 2 may be dried while the recording medium 1 is relatively moved with respect to the energy irradiation unit 101, or may be dried in a state where the recording medium 1 and the energy irradiation unit 101 are fixed. Note that when drying is performed while the recording medium 1 is relatively moved with respect to the energy irradiation unit 101, a moving speed may be constant, or may change continuously or intermittently according to the position and pattern of the ink image 2, the type of recording medium, and the like.

[0058] Drying time of the ink image by the drying device 110 is not particularly limited. In general, the shorter the drying time is, the better. Note that in the drying device 110, a selection range of the drying time during which both suppression of damage to the recording medium and sufficient drying of the ink image can be achieved is preferably wide because design or the like of an image forming device using the drying device is easy and a printed matter can be stably formed. For example, the selection range of the drying time during which a color ink can be sufficiently dried without causing damage to the recording medium is preferably three seconds or more, and more preferably five seconds or more.

[0059] In the present specification, the drying time of the ink image refers to a time from start of energy irradiation to end of energy irradiation. More specifically, when the energy irradiation unit 101 is an infrared light irradiation unit and drying is performed while the recording medium 1 is conveyed, a time point when a predetermined position of the recording medium 1 is located immediately below a most upstream end of the heat source of the infrared light irradiation unit is defined as irradiation start, and a time point when the predetermined position of the recording medium 1 is located immediately below a most downstream end of the heat source is defined as irradiation end. Meanwhile, when the energy irradiation unit 101 is an ultraviolet light irradiation unit and drying is performed while the recording medium 1 is conveyed, a time point when a predetermined position of the recording medium 1 is located immediately below a most upstream end of the light source of the ultraviolet light irradiation unit is defined as irradiation start, and a time point when the predetermined position of the recording medium 1 is located immediately below a most downstream end of the light source is defined as irradiation end.

[0060] While the energy irradiation unit 101 irradiates the recording medium 1 and the ink image 2 with energy, the surface temperature of the heat conduction unit 102a of the temperature control unit 102 is preferably constant. For example, when energy is continuously or intermittently emitted by the energy irradiation unit 101, the temperature of the heat conduction unit 102a itself may rise. In such a case, the temperature adjusting mechanism 102b in the temperature control unit 102 cools the heat conduction unit 102a. Meanwhile, when it is desired to raise the recording medium 1 also from the non-printing surface 1b side, the heat conduction unit 102a is heated by the temperature adjusting mechanism 102b.

[0061] The surface temperature of the heat conduction unit 102a when the energy irradiation unit 101 emits energy is preferably a temperature that does not affect the recording medium 1. For example, when the recording medium 1 is made of resin, the surface temperature of the heat conduction unit 102a is preferably set to a temperature lower than the glass transition temperature (Tg) of the recording medium 1 (resin) by 5°C or more. In addition, in any type of the recording medium 1, the surface temperature of the heat conduction unit 102a is preferably lower than 80°C, and more preferably lower than 70°C. Meanwhile, a lower limit thereof is preferably 50°C, and more preferably 60°C. When the surface temperature of the heat conduction unit 102a is lower than 80°C, deterioration less likely to occur in the recording medium 1 and an obtained image.

(Recording medium)

[0062] Here, the recording medium 1 that can be used for the drying device 110 is preferably made of a material that is less likely to be deteriorated due to heating by irradiation with infrared light or irradiation with ultraviolet light. The recording medium 1 may be formed of one layer, or may be formed by a plurality of layers stacked. Furthermore, a surface of the recording medium 1 may be printed, embossed, drilled, or the like. The entire printing surface 1a of the recording medium 1 may have the same color, or the printing surface 1a may partially have a region with a color (an energy absorption ratio) different from that of the other region. For example, as illustrated in Fig. 1A, the recording medium 1 may have a mark for aligning positions when an ink image is formed, a mark indicating a cutting position for cutting a printed matter, and a pattern for enhancing designability of a printed matter, the marks and the pattern being printed in advance on the recording medium 1 (hereinafter, the marks and the pattern are also referred to as "printed portion 4"). In a case where the printed portion 4 is formed on the recording medium 1 and the color of the printed portion 4 is dark, or the like, the temperature of the printed portion 4 rises when the ink image 2 is dried, and the recording medium 1 is easily deformed. However, according to the above-described drying device 110, since the heat conduction unit 102a of the temperature control unit 102 makes the temperature of the recording medium 1 uniform, such deformation and the like are less likely to occur

[0063] A method for forming the printed portion 4 is not particularly limited. The printed portion 4 may be printed by a known printing method, for example, an inkjet method, gravure printing, or screen printing.

[0064] As described above, the recording medium 1 may have an elongated shape or a sheet shape. Here, the recording medium 1 may partially have a region with a different thickness, but the recording medium 1 preferably has a constant thickness because the temperature can be easily adjusted by the temperature control unit 102 of the above-described drying device 110.

[0065] Examples of the recording medium 1 include a known plastic film, and examples of the plastic film include: a polyester film such as polyethylene terephthalate; a polyolefin film such as a polyethylene film or a polypropylene film; a polyamide-based film such as nylon; a polystyrene film; a polyvinyl chloride film; a polycarbonate film; a polyacrylonitrile film; and a biodegradable film such as a polylactic acid film. The recording medium 1 may be a metal plate, a metal film, an inorganic film such as glass, leather, or the like. Furthermore, the recording medium 1 may be a stacked body of these.

[0066] The thickness of the recording medium 1 is appropriately selected according to use of ae printed matter, the type of the recording medium 1, and the like. Note that the excessively large thickness of the recording medium 1 may make it difficult to adjust the temperature by the above-described temperature control unit 102 when the ink image 2 is dried. Therefore, when the recording medium 1 is a plastic film, the thickness thereof is preferably 5 to 150 μm, more preferably 10 to 120 μm, and still more preferably 12 to 60 μm. When the recording medium 1 is a metal plate, the thickness thereof is preferably 0.05 to 0.5 mm, and more preferably 0.1 to 0.3 mm. When the recording medium 1 is leather, the thickness thereof is preferably 1 to 5 mm, and more preferably 1 to 3 mm. The thinner the recording medium 1, the more easily the recording medium 1 itself is affected when the ink image 2 is dried.

(Ink image)

[0067] The pattern, area, and the like of the ink image 2 that can be dried by the above-described drying device 110 are not particularly limited. For example, the ink image 2 may be formed on the entire printing surface 1a of the recording medium 1, or the ink image 2 may be formed only in a partial region of the printing surface 1a. In addition, the ink image 2 may include only one type of ink, or may include a plurality of types of inks.

[0068] In particular, when an energy absorption ratio of the recording medium 1 at a wavelength of 1.2 μm is 1, the ink image 2 preferably includes a region where the energy absorption ratio is 1.3 or more at a wavelength of 1.2 μm. As described above, when the energy absorption ratio of the recording medium 1 and the energy absorption ratio of the ink region 2 are largely different from each other, heating unevenness occurs in a general drying device. On the other hand, according to the drying device 110, even if the energy absorption ratio of the recording medium 1 and the energy absorption ratio of the ink image 2 are largely different from each other, the temperatures of the recording medium 1 and the ink image 2 tend to be uniform. Note that the energy absorption ratio of the recording medium 1 at a wavelength of 1.2 μm and the energy absorption ratio of the ink image 2 at a wavelength of 1.2 μm are measured with a Fourier transform infrared spectrophotometer.

[0069] Here, the composition of an ink constituting the ink image 2 is not particularly limited as long as the ink can be dried by heating, and may include only a color ink containing a coloring agent and a solvent. Note that the ink image 2 particularly preferably includes a primer ink and a color ink. When the ink image 2 includes the primer ink and the color ink, the ink image 2 is less likely to bleed even if time from formation of the ink image 2 to drying thereof is long, and a desired high-quality image can be obtained. In addition, when the ink image 2 includes the primer ink and the color ink, as described in the section of the image forming device, an ink image forming unit and a drying unit can be disposed apart from each other. Therefore, it is possible to suppress clogging of a nozzle for ink application and deterioration of an ink due to heat generated in the drying unit.

[0070] The ink image 2 preferably contains 5 to 35% by mass of a water-soluble solvent in an undried state. The amount of the water-soluble solvent in the ink image 2 is more preferably 5 to 20% by mass.

[0071] Hereinafter, the color ink and the primer ink constituting the ink image 2 will be described.

•Color ink

[0072] The color ink only needs to contain at least a coloring agent, and may be, for example, an ink containing a coloring agent, a dispersant for dispersing the coloring agent, resin fine particles, and a solvent.

[0073] Examples of the coloring agent include known pigments. The coloring agent may be either an organic pigment or an inorganic pigment. When a primer ink described later is used together with the color ink, the coloring agent is preferably an anionic pigment. When the coloring agent is an anionic pigment, the coloring agent is easily fixed by the primer ink described later. The pigment in the color ink preferably has an average particle size of 50 nm or more and less than 200 nm. The average particle size of the pigment is a value measured by a dynamic light scattering method.

[0074] The amount of the coloring agent in the color ink is not particularly limited, but is preferably 7 to 18% by mass when the coloring agent is an inorganic pigment, and is preferably 0.5 to 7% by mass when the coloring agent is an organic pigment.

[0075] Examples of the dispersant for dispersing the coloring agent include a polymer dispersant having an anionic group. The polymer dispersant preferably has a molecular weight of 5000 to 200000.

[0076] Examples of the polymer dispersant include: a block copolymer and a random copolymer of two or more monomers selected from styrene, a styrene derivative, a vinylnaphthalene derivative, acrylic acid, an acrylic acid derivative, maleic acid, a maleic acid derivative, itaconic acid, an itaconic acid derivative, fumaric acid, and a fumaric acid derivative, and salts thereof; a polyoxyalkylene; and a polyoxyalkylene alkyl ether. As the polymer dispersant, a commercially available product may be used, and examples of the commercially available product of the polymer dispersant include 819 manufactured by BASF.

[0077] The amount of the dispersant is preferably 10 to 100% by mass, and more preferably 10 to 40% by mass with respect to the amount of the coloring agent.

[0078] The coloring agent and the dispersant are preferably contained in the color ink in a state where the coloring agent is coated with the dispersant, that is, in a state of a so-called capsule pigment. A method for coating the coloring agent with the dispersant is not particularly limited, and for example, a phase inversion emulsification method or an acid deposition method may be used. In addition, the coloring agent may be coated with a polymer dispersant by dispersing the coloring agent in a dispersion medium with a polymerizable surfactant, supplying a monomer serving as a raw material of the polymer dispersant to the dispersion medium, and polymerizing the monomer.

[0079] The resin fine particles contained in the color ink are preferably resin fine particles insoluble in water (hereinafter, also referred to as "water-insoluble resin fine particles"). Examples of the water-insoluble resin fine particles include a polyester-based resin, a polyurethane-based resin, a polyacrylic resin, and a composite resin of a polyurethane-based resin and a polyacrylic resin. These water-insoluble resin fine particles are preferably anionic.

[0080] The water-insoluble resin fine particles preferably have an acid structure from a viewpoint that emulsification can be performed in a solvent described later without using a surfactant or the like. Examples of the acid structure include a carboxy group (-COOH) and a sulfonic acid group (-SO_3H). The acid structure may be present in a side chain of the resin or may be present at a terminal.

[0081] When the water-insoluble resin fine particles have an acid structure, a part or the whole of the acid structure may be neutralized. When the acid structure is neutralized, water dispersibility of the water-insoluble resin fine particles is improved. Examples of a neutralizing agent include an organic amine, and specific examples thereof include trimethylamine, triethylamine, tripropylamine, tributylamine, N-methyldiethanolamine, and triethanolamine.

[0082] The resin fine particles may be a commercially available product, and examples thereof include: PESRESIN A-110F, PESRESIN A-520, PESRESIN A-613D, PESRESIN A-615GE, PESRESIN A-640, PESRESIN A-645GH, and PESRESINA-647GEX manufactured by TAKAMATSU OIL & FAT Co., Ltd.; Elitel KA-5034, Elitel KA-5071S, Elitel KA-1449, Elitel KA-0134, Elitel KA-3556, Elitel KA-6137, Elitel KZA-6034, Elitel KT-8803, Elitel KT-8701, Elitel KT-9204, Elitel KT-8904, Elitel KT-0507, and Elitel KT-9511 manufactured by UNITIKA LTD.

[0083] Examples of a commercially available product of the urethane-based resin fine particles include: NeoRez R-967, NeoRez R-600, and NeoRez R-9671 manufactured by Kusumoto Chemicals, Ltd.; and W-6061, W-5661, and WS-4000 manufactured by Mitsui Chemicals, Inc.

[0084] Examples of a commercially available product of the acrylic resin fine particles include: NeoCryl A-1127 manufactured by Kusumoto Chemicals, Ltd.; Mowinyl 6899D, Mowinyl 6969D, Mowinyl 6800D, and Mowinyl 6810 manufactured by Japan Coating Resin Corporation; and TOCRYL W-7146, TOCRYL W-7150, and TOCRYL W-7152 manufactured by Toyochem Co., Ltd.

[0085] The amount of the resin fine particles in the color ink is not particularly limited, and is preferably 2 to 10% by mass, and more preferably 2 to 5% by mass.

[0086] The solvent contained in the color ink is preferably water and/or a water-soluble solvent. The water-soluble solvent refers to a solvent that maintains a uniform appearance even after 100 parts by mass of the solvent is mixed with 100 parts by mass of water at 20°C, the mixture is stirred, and flow is stopped. Examples of the water-soluble solvent include an alcohol, a polyhydric alcohol, an amine, an amide, a glycol ether, and a 1,2-alkanediol having 4 or more carbon atoms. The ink may contain only one solvent or two or more solvents.

[0087] Specific examples of the alcohol include methanol, ethanol, 1 -propanol, 2-propanol, 1-butanol, 2-butanol, 2-methyl-1-propanol, t-butanol, 3-methoxy-1-butanol, 3-methoxy-3-methyl butanol, 1-octanol, 2-octanol, n-nonyl alcohol, tridecyl alcohol, n-undecyl alcohol, stearyl alcohol, oleyl alcohol, and benzyl alcohol.

[0088] Examples of the polyhydric alcohol include ethylene glycol, diethylene glycol, triethylene glycol, tetraethylene glycol, a polyethylene glycol having 5 or more ethylene oxide groups, propylene glycol, dipropylene glycol, tripropylene glycol, a polypropylene glycol having 4 or more propylene oxide groups, butylene glycol, hexanediol, pentanediol, glycerin, hexanetriol, and thiodiglycol.

[0089] Examples of the amine include ethanolamine, diethanolamine, triethanolamine, N-methyldiethanolamine, N-ethyldiethanolamine, morpholine, N-ethylmorpholine, ethylenediamine, diethylenediamine, triethylenetetramine, tetraethylenepentamine, polyethyleneimine, pentamethyldiethylenetriamine, and tetramethylpropylenediamine.

[0090] Examples of the amide include formamide, N,N-dimethylformamide, and N,N-dimethylacetamide.

[0091] Examples of the glycol ether include ethylene glycol monoethyl ether, ethylene glycol monobutyl ether, diethylene glycol monoethyl ether, diethylene glycol monobutyl ether, triethylene glycol monobutyl ether, propylene glycol monopropyl ether, dipropylene glycol monomethyl ether, and tripropylene glycol monomethyl ether.

[0092] Examples of the 1,2-alkanediol having 4 or more carbon atoms include 1,2-butanediol, 1,2-pentanediol, 1,2-hexanediol, and 1,2-heptanediol.

[0093] Among the above solvents, a polyhydric alcohol is preferable, and 1,2-pentanediol, 1,2-hexanediol, 1,2-heptanediol, ethylene glycol, diethylene glycol, triethylene glycol, tetraethylene glycol, propylene glycol, dipropylene glycol, and tripropylene glycol are preferable from a viewpoint that bleeding of an ink image can be suppressed, and 1,2-pentanediol, 1,2-hexanediol, and 1,2-heptanediol are particularly preferable from a viewpoint that wettability to a non-absorbent recording medium tends to be good.

[0094] The color ink preferably contains both water and a water-soluble solvent as a solvent. The amount of water in the color ink is not particularly limited, but is preferably 45 to 80% by mass. Meanwhile, the amount of the water-soluble solvent in the color ink is preferably 5 to 35% by mass, more preferably 5 to 25% by mass, and still more preferably 5 to 20 parts by mass.

[0095] Note that the color ink may further contain a known surfactant, a storage stabilizer, and the like as necessary.

[0096] Here, a viscosity of the color ink before application to the recording medium as measured with a viscometer

(MCR-102) manufactured by Anton Paar GmbH at a temperature of 25°C and a shear rate of 1000 (1/second) is preferably 1 to 40 mPa•s, and more preferably 2 to 10 mPa•s at 25°C. When the viscosity of the color ink is within the above range, the color ink is less likely to flow after the color ink is applied to the recording medium, and a high-quality image can be easily obtained.

[0097] In addition, a static surface tension of the ink before the ink is applied to the recording medium is preferably larger than a static surface tension of the primer ink described later. The static surface tension of the color ink is preferably 22 to 33 mN/m, and more preferably 22 to 26 mN/m at 25°C from a viewpoint that an image with high image quality can be formed on a non-absorbent recording medium. The static surface tension of the color ink can be measured with a surface tensiometer.

•Primer ink

[0098] The primer ink only needs to contain at least an aggregating agent, and may be, for example, an ink containing an aggregating agent and a solvent. According to such a primer ink, even if the color ink is applied without drying the primer ink after the primer ink is applied, bleeding or the like is less likely to occur. Therefore, an ink image can be formed through a simple process without requiring a drying or curing step before the color ink is applied. In addition, when the primer ink having such a composition is used, an ink image is less likely to bleed even if time until the ink image is dried after the ink image is formed is long. Therefore, a high-quality image can be obtained. Note that the primer ink may further contain a surfactant, a crosslinking agent, an antifungal agent, a disinfectant, and the like as necessary, but the primer ink preferably does not contain the above-described resin fine particles. By no inclusion of the resin fine particles in the primer ink, the primer ink is less likely to be thickened.

[0099] The aggregating agent only needs to be able to generate an aggregate when the aggregating agent is combined with the color ink. The aggregating agent functions to fix an ink image onto the recording medium. The aggregating agent is appropriately selected according to the type of coloring agent in the color ink.

[0100] Examples of the aggregating agent include a thermally decomposable dissolvable cationic polymer, a polyvalent metal salt, and an organic acid, and a dissolvable cationic polymer or a polyvalent metal salt is more preferable because the pH thereof is neutral or weakly alkaline.

[0101] The dissolvable cationic polymer and the polyvalent metal salt aggregate an anionic component (a coloring agent and the like) in the color ink by salting out. Meanwhile, the organic acid aggregates an anionic component in the color ink by pH fluctuation.

[0102] Examples of the dissolvable cationic polymer include polyallylamine, polyvinylamine, polyethyleneimine, and polydiallyldimethylammonium chloride. Examples of a commercially available product thereof include: KHE100L and FPA100L manufactured by SENKA CORPORATION; and PAS-92A, PAS-M-1A, and PAS-21CL manufactured by Nittobo Medical Co., Ltd.

[0103] Examples of the polyvalent metal salt include a water-soluble salt such as a calcium salt, a magnesium salt, an aluminum salt, or a zinc salt. Examples of a compound that forms a salt with a polyvalent metal include hydrochloric acid, hydrobromic acid, hydroiodic acid, sulfuric acid, nitric acid, phosphoric acid, thiocyanic acid, an organic carboxylic acid such as acetic acid, oxalic acid, lactic acid, fumaric acid, citric acid, salicylic acid, or benzoic acid, and an organic sulfonic acid.

[0104] Examples of the organic acid include: a compound having a carboxy group, such as formic acid, acetic acid, propionic acid, isobutyric acid, oxalic acid, fumaric acid, malic acid, citric acid, malonic acid, succinic acid, maleic acid, benzoic acid, 2-pyrrolidone-5-carboxylic acid, lactic acid, acrylic acid and a derivative thereof, methacrylic acid and a derivative thereof, or acrylamide and a derivative thereof; a sulfonic acid derivative; and a phosphoric acid and a derivative thereof.

[0105] Note that the organic acid is preferably an acid having a first dissociation constant of 3.5 or less, and more preferably an acid having a first dissociation constant of 1.5 to 3.5. When the first dissociation constant is within the range, the color ink is easily fixed to the recording medium.

[0106] The primer ink preferably contains 5% by mass or less of the aggregating agent, and more preferably contains 1 to 4% by mass of the aggregating agent. When the primer ink contains the aggregating agent within the above range, the anionic component in the color ink is effectively aggregated, and image quality is improved. Note that the amount of the aggregating agent in the primer ink can be measured by a known method. For example, when the aggregating agent is a polyvalent metal salt, the amount of the aggregating agent can be measured by ICP emission spectrometry, and when the aggregating agent is an organic acid, the amount of the aggregating agent can be measured by high performance liquid chromatography (HPLC).

[0107] The solvent in the primer ink is preferably water and/or a water-soluble solvent, and preferably contains both of these. The type of water-soluble solvent is similar to the type of water-soluble solvent contained in the color ink. The amount of water in the primer ink is preferably 45 to 80% by mass. Meanwhile, the amount of the water-soluble solvent in the primer ink is preferably 5 to 35% by mass, and more preferably 5 to 20% by mass.

[0108] A viscosity of the primer ink as measured with a viscometer (MCR-102) manufactured by Anton Paar GmbH at a temperature of 25°C and a shear rate of 1000 (1/second) is preferably 1 to 40 mPa•s, more preferably 1 to 10 mPa•s, and still more preferably 4 to 7 mPa•s. When the viscosity of the primer ink is within the above range, the primer ink is less likely to flow after the primer ink is applied to the recording medium, and a high-quality image can be easily obtained.
[0109] In addition, as described above, a static surface tension of the primer ink is preferably smaller than a static surface tension of the color ink at 25°C. The static surface tension of the primer ink is preferably 22 to 30 mN/m, and more preferably 22 to 26 mN/m at 25°C.
[0110] A dynamic surface tension of the primer ink at 25°C and 50 ms is preferably 40 mN/m or less, more preferably 36 mN/m or less, and still more preferably 35 mN/m or less. A lower limit value of the dynamic surface tension is preferably 25 mN/m. The dynamic surface tension of the primer ink can be measured with a surface tensiometer. Unless otherwise specified, the dynamic surface tension in the present specification is a dynamic surface tension at 25°C and 50 ms.

2. Image forming device

[0111] The above-described drying device may be used alone, or may be used in an image forming device in combination with an ink image forming unit or the like. Fig. 3A illustrates a plan view of an image forming device 100 according to an embodiment of the present invention, and Fig. 3B illustrates a side view of the image forming device 100. The image forming device 100 includes a conveyance unit (not illustrated) for conveying the recording medium 1, an ink image forming unit 120 (a primer ink discharge unit 12P and a color ink discharge unit 12Q) for forming an ink image, and a drying unit (the above-described drying device) 110 for forming the ink image.
[0112] Note that the image forming device may include a fixing unit (not illustrated) for further fixing the image dried by the drying unit 110 to the recording medium 1, an unwinding unit (not illustrated) for unwinding the recording medium 1, a winding unit (not illustrated) for winding the recording medium 1, and the like as necessary. Note that since the drying unit 110 is similar to the above-described drying device 110, description thereof will be omitted, and the ink image forming unit 120 will be described below.

(Ink image forming unit)

[0113] The ink image forming unit 120 may include only the color ink discharge unit 12Q for discharging the color ink, but in the image system device illustrated in Figs. 3A and 3B, the ink image forming unit 120 includes the primer ink discharge unit 12P and the color ink discharge unit 12Q.
[0114] Note that when the ink image forming unit includes only the color ink discharge unit 12Q, the ink image may bleed, for example, if time until the color ink is dried after the color ink is applied is long Therefore, the ink image forming unit 120 (color ink discharge unit Q) is preferably disposed at a position close to the drying unit 110. Note that when a distance between the ink image forming unit 120 and the drying unit 110 is short, heat from the drying unit 110 is easily transferred to the ink image forming unit 120, and there is a possibility that the ink is thickened in the ink image forming unit 120 or a nozzle is clogged.
[0115] Therefore, the ink image forming unit 120 preferably includes the primer ink discharge unit 12P and the color ink discharge unit 12Q. When the color ink is discharged onto the undried primer ink after the primer ink is applied onto the recording medium 1, the ink image 2 is easily held on the recording medium 1. Therefore, for example, as illustrated in Figs. 3A and 3B, the ink image forming unit 120 and the drying unit 110 can be disposed sufficiently apart from each other.
[0116] Here, the primer ink discharge unit 12P only needs to be able to discharge a desired primer ink, and examples of the primer ink include those described above. When the above-described primer ink is used, the color ink can be applied without drying the primer ink after the primer ink is applied. Note that the color ink may be applied after the primer ink is dried.
[0117] Meanwhile, the color ink discharge unit 12Q only needs to be able to discharge a desired color ink, and examples of the color ink include those described above. Note that the type of the color ink discharged by the color ink discharge unit Q is not particularly limited, and in Figs. 3A and 3B, the color ink discharge unit Q includes a black ink discharge unit 12K, a cyan ink discharge unit 12C, a magenta ink discharge unit 12M, and a yellow ink discharge unit 12Y, but is not limited thereto. An arrangement order of the color ink discharge units is appropriately selected according to a desired printed matter, and is not limited to the mode illustrated in Figs. 3A and 3B.
[0118] Here, in a case where the energy irradiation unit 101 of the drying unit 110 includes an infrared light irradiation unit, when two or more color inks containing coloring agents having different absorption ratios of infrared light having a specific wavelength selected from wavelengths of 0.8 μm or more and 3.0 μm or less are applied as the color ink, the degrees of temperature rise of the color inks are different from each other. Therefore, a drying speed tends to be different between the color inks. Therefore, the compositions of these two or more color inks may be adjusted as necessary such that the drying speeds of the color inks, for example, drying ratios thereof when the color inks are dried in an oven at 100°C for 30 seconds are different from each other. An infrared light absorption ratio of the coloring agent contained in

each of the color inks can be specified by an ultraviolet-visible near-infrared spectrophotometer (for example, UH4150 manufactured by Hitachi High-Technologies Corporation). Note that when the infrared light absorption ratios of the plurality of coloring agents are measured, measurement wavelengths are the same.

[0119] Meanwhile, regarding the drying ratio, the same amount (for example, 10 g) of each of the inks is dropped onto a petri dish, and a mass A thereof is measured. Then, a hot air oven is set at 100°C, and the petri dish is left to stand therein for 30 seconds. Thereafter, a mass B is measured. Then, a value ((A - B)/10) × 100) obtained by dividing a weight loss amount (A - B) in the hot air oven by the amount of the ink is defined as a drying ratio.

[0120] Here, as a method for adjusting the drying ratios of the plurality of color inks, a solvent having a high boiling point is used or the amount thereof is adjusted for a color ink whose drying ratio is to be lowered. Meanwhile, a solvent having a low boiling point is used or the amount thereof is reduced for a color ink whose drying ratio is to be increased.

[0121] Note that a drying ratio of a color ink in which the temperature is less likely to rise, that is, a drying ratio of a color ink containing a coloring agent having a high infrared light absorption ratio is preferably adjusted to be lower than a drying ratio of a color ink containing a coloring agent having a low infrared light absorption ratio.

[0122] In addition, in a case where the energy irradiation unit 101 of the drying unit 110 includes an ultraviolet light irradiation unit, when two or more color inks containing coloring agents having different absorption ratios of ultraviolet light having a specific wavelength selected from wavelengths of 200 nm or to 410 nm are applied as the color ink, the degrees of temperature rise of the color inks are different from each other. Therefore, a drying speed tends to be different between the color inks. Therefore, also in this case, the compositions of these two or more color inks be adjusted as necessary such that the drying speeds of the color inks, for example, drying ratios thereof when the color inks are dried in an oven at 100°C for 30 seconds are different from each other. An ultraviolet light absorption ratio of the coloring agent contained in each of the color inks can be specified by an ultraviolet-visible near-infrared spectrophotometer (for example, UH4150 manufactured by Hitachi High-Technologies Corporation). In addition, when the ultraviolet light absorption ratios of the plurality of coloring agents are measured, measurement wavelengths are the same. In addition, a method for measuring the drying ratio and a method for adjusting the drying ratio are the same as those described above.

[0123] In addition, at this time, a drying ratio of a color ink in which the temperature is less likely to rise, that is, a drying ratio of a color ink containing a coloring agent having a high ultraviolet light absorption ratio is preferably adjusted to be lower than a drying ratio of a color ink containing a coloring agent having a low ultraviolet light absorption ratio.

[0124] Here, as illustrated in Figs. 3A and 3B, the primer ink discharge unit 12P and the color ink discharge unit 12Q (hereinafter, also collectively referred to as "ink discharge unit 12") may be line type discharge units or serial head type discharge units. Note that a line type discharge unit is more preferable from a viewpoint that an ink image can be formed in a short time. When the ink discharge unit 12 is a line type discharge unit, usually, the primer ink discharge unit 12P is disposed on an upstream side, and the color ink discharge unit 12Q is disposed on a downstream side. Note that the primer ink discharge unit 12P may be disposed on a downstream side of the color ink discharge unit 12Q. In addition, a component for temporarily curing the primer ink discharged by the primer ink discharge unit 12P or the color ink discharged by the color ink discharge unit 12Q, and the like may be included as necessary.

[0125] Each ink discharge unit 12 includes a head for discharging the primer ink or the color ink and an ink tank for storing the primer ink or the color ink. The type of the head of each ink discharge unit 12 is not particularly limited, and may be either an on-demand type or a continuous type. Examples of the on-demand type head include: an electromechanical conversion type such as a single cavity type, a double cavity type, a bender type, a piston type, a share mode type, or a shared wall type; and an electrothermal conversion type such as a thermal inkjet type or a bubble jet (bubble jet is a registered trademark of Canon Inc.) type. Among these heads, an electromechanical conversion type head is preferable, and in particular, a head using a piezoelectric element (also referred to as "piezoelectric inkjet head") is preferable.

(Conveyance unit)

[0126] The type of the conveyance unit is not particularly limited as long as the conveyance unit can convey the recording medium 1 from the ink image forming unit 120 side to the drying unit 110 side, and the conveyance unit can have a structure similar to a conveyance unit of a known image forming device. Note that the conveyance unit may have a structure that supports the recording medium 1 from a non-printing surface side, and in the above-described drying unit 110, the recording medium 1 is preferably supported such that the non-printing surface of the recording medium 1 and the heat conduction unit 102a of the temperature control unit 102 are in close contact with each other.

(Image forming method using the image forming device)

[0127] In an image forming method using the above-described image forming device 100, the ink image forming unit 120 applies ink to the printing surface 1a of the recording medium 1 to form the ink image 2. At this time, in the ink image forming unit 120, the primer ink discharge unit 12P applies a primer ink onto the recording medium 1, and the color ink discharge unit 12Q applies a color ink onto the undried primer ink.

[0128] After the desired ink image 2 is formed, the recording medium 1 is moved toward the drying unit 110 by the conveyance unit. Then, the energy irradiation unit 101 irradiates the printing surface 1a of the recording medium 1 with energy while the heat conduction unit 102a of the temperature control unit 102 is in contact with the non-printing surface 1b of the recording medium 1. At this time, the energy irradiation unit 101 emits infrared light having a wavelength of 0.8 μm or more and 3.0 μm or less at an output of 30 kW/m^2 or more, or emits ultraviolet light having a wavelength of 200 nm or more and 410 nm or less at an illuminance of 1 W/m^2 or more. Meanwhile, in the temperature control unit 102, the temperature adjusting mechanism 102b adjusts the temperature of the heat conduction unit 102a such that the temperatures of the recording medium 1 and the ink image 2 are constant.

[0129] Note that energy irradiation time by the energy irradiation unit 101, the temperature of a surface of the heat conduction unit 102a controlled by the temperature control unit 102, and the like are similar to those in the above-described drying method.

(Others)

[0130] As described above, the image forming device 100 may include a component other than the ink image forming unit 120 and the drying unit 110. Fig. 4 illustrates a side view illustrating a modification of the image forming device 100. Note that the same components as those of the image forming device illustrated in Figs. 3A and 3B are denoted by the same reference numerals, and description thereof will be omitted.

[0131] An image forming device 200 according to the modification is an image forming device in a case of performing printing by a roll-to-roll method, and further includes, in addition to the ink image forming unit 120 and the drying unit 110 described above, an unwinding unit 131 for unwinding the recording medium 1, a fixing unit 132 for further fixing an image dried by the drying unit 110 to the recording medium 1, and a winding unit 133 for winding a printed matter. In addition, the image forming device 200 includes a first ink image forming unit 120A including the primer ink discharge unit 12P and the color ink discharge unit 12Q (white ink discharge unit 12W), and a second ink image forming unit 120B including the primer ink discharge unit 12P and the color ink discharge unit 12Q (yellow ink discharge unit 12Y, magenta ink discharge unit 12M, cyan ink discharge unit 12C, and black ink discharge unit 12K). A first drying unit 110A and a second drying unit 110B are disposed downstream of the first ink image forming unit 120A and the second ink image forming unit 120B, respectively.

[0132] In the image forming device 200, a primer ink and a white ink are applied to the recording medium 1 unwound from the unwinding unit 131 by the first ink image forming unit 120A. Then, the ink image is dried by the first drying unit 110A.

[0133] Subsequently, the primer ink and each color ink are further applied onto the recording medium 1 by the second ink image forming unit 120B. Then, the ink image formed by the second ink image forming unit 120B is dried by the second drying unit 110B.

[0134] Thereafter, the fixing unit 132 blows hot air onto the recording medium 1 to further fix the image to the recording medium 1. Then, the printed matter is wound in a roll shape by the winding unit 133. Note that configurations of the unwinding unit 131, the winding unit 133, and the fixing unit 132 are similar to those of a conventional image forming device.

Examples

[0135] Hereinafter, specific Example of the present invention will be described together with Comparative Example, but the present invention is not limited thereto. Note that in Examples, "parts" and "%" mean "parts by mass" and "% by mass", respectively, unless otherwise specified.

(1) Preparation of primer ink

[0136] 3 parts by mass of calcium acetate, 20 parts by mass of propylene glycol, 0.5 parts by mass of a surfactant (KF-351A manufactured by Shin-Etsu Chemical Co., Ltd.), and 66.5 parts by mass of water were mixed to obtain a primer ink. A viscosity of the primer ink as measured with a viscometer (MCR-102) manufactured by Anton Paar GmbH at a temperature of 25°C and a shear rate of 1000 (1/second) was 4.89 mPa•s, a static surface tension of the primer ink as measured with a surface tensiometer at 25°C was 28.8 mN/m, and a dynamic surface tension of the primer ink at 25°C and 50 ms was 38.3 mN/m.

(2) Preparation of color ink

[0137] Each of a yellow ink (Y), a magenta ink (M), a cyan ink (C), a black ink (K), and a white ink (W) was prepared by mixing the components presented in Table 1 with the compositions presented in Tables 1 and 2, and each color ink set was prepared.

(3) Measurement of ultraviolet light absorption ratio and infrared light absorption ratio of coloring agent (pigment) contained in color ink

[0138] An ultraviolet light absorption ratio and an infrared light absorption ratio of a coloring agent contained in the color ink were specified by an ultraviolet-visible near-infrared spectrophotometer (UH4150 manufactured by Hitachi High-Technologies Corporation). In the ultraviolet light absorption ratio measurement, an absorption ratio of light having a wavelength of 365 nm was measured. In the infrared light absorption ratio measurement, an absorption ratio of light having a wavelength of 1.2 μm was measured.

(4) Drying ratio after heating at 100°C for 30 seconds

[0139] The same amount (for example, 10 g) of each of inks of ink sets 5 to 7 was dropped onto a petri dish, and a mass A thereof was measured. Then, a hot air oven was set at 100°C, and the petri dish was left to stand for 30 seconds in the oven. Then, a mass B after heating was measured.

[0140] From the obtained values, a drying ratio (= ((A - B)/10) × 100) was specified.

[Table 1]

			Color ink set 1					Color ink set 2		Color ink set 3		Color ink set 4		Color ink set 5		Color ink set 6		Color ink set 7	
			Y	M	C	K	W	Y	K	Y	K	Y	K	Y	K	Y	K	Y	M
Composition (% by mass)	Pigment	Yellow pigment	4.0					4.0		4.0		4.0		4.0		4.0		4.0	
		Magenta pigment		4.0															4.0
		Cyan pigment			4.0														
		Black pigment				4.0			4.0		4.0		4.0		4.0		4.0		
		White pigment					10.0												
	Pigment dispersant	Joncryl 819*1	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
	Fixing resin	Polyacrylic resin*2	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
	Viscosity modifier	OPTO*3										0.2	0.2						
	Surfactant	KF-351A*4	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
		Olfine E1010*5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Water-soluble solvent	Propylene glycol	25.0	25.0	25.0	25.0	25.0	5.0	5.0								20.0		
		2-Methyl-1.3-propanediol								5.0	5.0								
		Glycerin	5.0	5.0	5.0	5.0	5.0								3.0			1.0	
		1,2-Pentanediol	5.0	5.0	5.0	5.0	5.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
		Water	53.2	53.2	53.2	53.2	47.2	68.2	68.2	68.2	68.2	73.0	73.0	73.2	70.2	73.2	53.2	72.2	73.2
Ultraviolet light absorption ratio of coloring agent (pigment) (%)		Measurement wavelength: 365 nm	30	22	28	32	-	30	32	30	32	30	32	30	32	30	32	30	22
Infrared light absorption ratio of coloring agent (pigment) (%)		Measurement wavelength: 1.2 μm	25	25	28	83	-	25	83	25	83	25	83	25	83	25	83	25	25

(continued)

		Color ink set 1					Color ink set 2		Color ink set 3		Color ink set 4		Color ink set 5		Color ink set 6		Color ink set 7	
		Y	M	C	K	W	Y	K	Y	K	Y	K	Y	K	Y	K	Y	M
Drying ratio after heating at 100°C for 30 seconds	(%)	-	-	-	-	-	-	-	-	-	-	-	97	94	97	93	93	97

*1 Joncryl 819 (manufactured by BASF), *2 Mowinyl 6800D, *3 OPTOFlow T1010 (manufactured by BYK), *4 KF-351A (manufactured by Shin-Etsu Chemical Co., Ltd.), *5 Olfine E1010 (manufactured by Nissin Chemical Co., Ltd.)

(3) Examples and Comparative Examples

•Example 1

[0141] A primer ink and color inks of color ink set 1 were filled into an ink image forming unit including a primer ink discharge unit and a color ink discharge unit. As the primer ink discharge unit and the color ink discharge unit, those including an independently driven inkjet head (360 dpi, discharge amount: small droplet 7 pL, medium droplet 15 pL, large droplet 23 pL) manufactured by KONICA MINOLTA, INC., were used. The inkjet head was disposed on a roll-to-roll device, and the inkjet head was connected to a head control device IJCS-1 manufactured by KONICA MINOLTA, INC. Then, to an elongated polyethylene terephthalate film (recording medium) having a recording medium thickness of 20 μm, the primer ink was applied in a solid 20% pattern, and each of the color inks was applied in a solid 100% pattern to form an ink image.

[0142] Subsequently, the recording medium on which the ink image was formed was moved to a drying unit including a temperature control unit. A medium wavelength carbon IR heater (wavelength 1.2 μm, temperature of heat source: 1200°C) manufactured by Heraeus Co., Ltd. was used for an infrared light irradiation unit. The temperature control unit of the drying unit included a metal roll (heat conduction unit) and a temperature adjusting mechanism disposed in the metal roll. Then, the temperature of a surface of the metal roll was adjusted by the temperature adjusting mechanism such that the surface temperature of the metal roll was 60°C all the time, and drying was performed while the metal roll and the recording medium were in contact with each other.

[0143] Then, an output value of the infrared light irradiation unit was set to 30 kW/m^2, 60 kW/m^2, 100 kW/m^2, or 150 kW/m^2, and a drying property of the color ink when irradiation time of infrared light was changed was confirmed. Evaluation was performed as follows. Table 2 illustrates results thereof.

[0144] OK: An ink is completely dried and there is no change even if wiping or tape peeling is performed.

[0145] Undried: An ink is undried and removed by wiping or tape peeling.

[0146] Substrate deformation: A substrate (recording medium) is deformed or burned.

•Example 2

[0147] An ink image was dried in a similar manner to Example 1 except that the surface temperature of the metal roll of the temperature control unit was adjusted so as to be 50°C all the time. Table 2 illustrates results thereof.

•Comparative Example 1

[0148] An ink image was dried in a similar manner to Example 1 except that the metal roll of the temperature control unit was not used. Table 2 illustrates results thereof.

[Table 2]

Configuration of drying device		Example 1 (Temperature of temperature control unit: 60°C)					Example 2 (Temperature of temperature control unit: 50°C)					Comparative Example 1 (No temperature control)				
Ink color		Y ink	Mink	C ink	K ink	Wink	Y ink	Mink	C ink	K ink	Wink	Y ink	Mink	C ink	K ink	Wink
Drying condition	30 kW/m^2 Drying time 10 s	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	Substrate deformation	OK
	30 kW/m^2 Drying time 5 s	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	Undried	Undried	Undried	OK	Undried
	60 kW/m^2 Drying time 5 s	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	Substrate deformation	OK
	60 kW/m^2 Drying time 2.5 s	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	Undried	Undried	Undried	OK	Undried
	100 kW/m^2 Drying time 2 s	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	Substrate deformation	OK
	100 kW/m^2 Drying time 1 s	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	Undried	Undried	Undried	OK	Undried
	150 kW/m^2 Drying time 1 s	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	Substrate deformation	OK
	150 kW/m^2 Drying time 0.5 s	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	Undried	Undried	Undried	OK	Undried

•Example 3

[0149] An ink image to which the primer ink and the color inks of ink set 1 were applied was dried in a similar manner to Example 1 except that the infrared light irradiation unit of the drying device was changed to an ultraviolet light irradiation unit (light source: LED lamp, wavelength: 385 nm). Note that an illuminance from the ultraviolet light irradiation unit was set to 4 kW/cm^2, 2 kW/cm^2, or 1 kW/cm^2, and a drying property of the color ink when irradiation time of ultraviolet light was changed was confirmed. Table 3 illustrates results thereof.

•Example 4

[0150] An ink image was dried in a similar manner to Example 3 except that the surface temperature of the metal roll of the temperature control unit was adjusted so as to be 50°C all the time. Table 3 illustrates results thereof.

•Comparative Example 2

[0151] An ink image was dried in a similar manner to Example 3 except that the metal roll of the temperature control unit was not used. Table 3 illustrates results thereof.

[Table 3]

Configuration of drying		Example 3 (Temperature of temperature control unit: 60°C)					Example 4 (Temperature of temperature control unit: 50°C)					Comparative Example 2 (No temperature control)				
Ink color		Y ink	Mink	C ink	K ink	Wink	Y ink	Mink	C ink	K ink	Wink	Y ink	Mink	C ink	Kink	Wink
Drying condition	4 kW/cm^2 Drying time 2 s	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	Substrate deformation	Substrate deformation	Substrate deformation	Substrate deformation	Substrate deformation
	4 kW/cm^2 Drying time 1 s	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	Undried	Undried	Undried	Undried	Undried
	2 kW/cm^2 Drying time 4 s	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	Substrate deformation	OK	OK	Substrate deformation	Substrate deformation
	2 kW/cm^2 Drying time 2 s	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	Undried	Undried	OK	OK
	1 kW/cm^2 Drying time 10 s	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	Substrate deformation	OK	OK	Substrate deformation	OK
	1 kW/cm^2 Drying time 5 s	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	Undried	Undried	OK	OK

[0152] As presented in Tables 2 and 3 above, when an ink image was dried while the temperature was controlled by the temperature control unit, the color inks had little variation in a drying property, and even if the recording medium was irradiated with infrared light or ultraviolet light at a higher output, the recording medium was less likely to be deformed (Examples 1 to 4). Meanwhile, when the temperature control was not performed by the temperature control unit, the recording medium was easily deteriorated or curing tended to be insufficient (Comparative Examples 1 and 2).

•Example 5

[0153] An ink image was formed and dried in a similar manner to Example 1 using the above-described primer ink and a Y ink and a K ink of each of ink sets 1 to 6. At this time, an output of the infrared light irradiation unit was set to 100 kW/m^2, and a temperature of the temperature control unit was set to 60°C. In addition, a drying time was changed, and a range of an irradiation time during which the recording medium was not deformed and both the Y ink and the K ink could be dried was specified. This range is presented in Table 4.

[Table 4]

Type of ink set	Range of irradiation time
Ink set 1	1 to 2 seconds
Ink set 2	0.5 to 2 seconds
Ink set 3	0.5 to 2 seconds
Ink set 4	0.5 to 2 seconds
Ink set 5	0.5 to 6 seconds
Ink set 6	0.5 to 6 seconds

[0154] As presented in Table 4 above, it has been clarified that when two color inks (Y ink and K ink) containing coloring agents having different infrared light absorption ratios are applied and dried, by using ink sets 5 and 6 having a different drying ratio depending on a color, time during which each color ink can be sufficiently dried without deforming the recording medium is extended.

•Example 6

[0155] An ink image was formed and dried in a similar manner to Example 3 using the above-described primer ink and a Y ink and an M ink of each of ink sets 1 and 7. At this time, an illuminance from the ultraviolet light irradiation unit was set to 4 kW/cm^2, and a temperature of the temperature control unit was set to 60°C. In addition, a drying time was changed, and a range of an irradiation time during which the recording medium was not deformed and both the Y ink and the M ink could be dried was specified. This range is presented in Table 5.

[Table 5]

Type of ink set	Range of irradiation time
Ink set 1	1 to 2 seconds
Ink set 7	1 to 6 seconds

[0156] As presented in Table 5 above, it has been clarified that when two color inks (Y ink and M ink) containing coloring agents having different ultraviolet light absorption ratios are applied and dried, by using ink set 7 having a different drying ratio depending on a color, time during which each color ink can be sufficiently dried without deforming the recording medium is further extended.

Industrial Applicability

[0157] According to the drying device of the present invention, an ink image formed on a recording medium can be sufficiently dried in a short time, and the recording medium and the formed image are less likely to be damaged. Therefore, the drying device is useful in various printing fields.

Reference Signs List

[0158]

1	Recording medium
1a	One surface (printing surface) of recording medium
1b	Other surface (non-printing surface) of recording medium
2	Ink image
4	Printed portion
12C	Cyan ink discharge unit
12K	Black ink discharge unit
12M	Magenta ink discharge unit
12P	Primer ink discharge unit
12Q	Color ink discharge unit
12Y	Yellow ink discharge unit
100, 200	Image forming device
101	Energy irradiation unit
102	Temperature control unit
102a	Heat conduction unit
102b	Temperature adjusting mechanism
110	Drying device (drying unit)
120	Ink image forming unit
131	Unwinding unit
132	Fixing unit
133	Winding unit

Claims

1. A drying device for drying an ink image including an undried ink, formed on one surface of a recording medium, the drying device comprising:

an energy irradiation unit for irradiating the one surface of the recording medium with energy to heat and dry the ink image; and

a temperature control unit that is disposed so as to face the energy irradiation unit with the recording medium interposed between the temperature control unit and the energy irradiation unit, and so as to be in contact with the other surface of the recording medium, wherein

the energy irradiation unit includes either an infrared light irradiation unit that emits infrared light having a wavelength of 0.8 μm or more and 3.0 μm or less at an output of 30 kW/m^2 or more or an ultraviolet light irradiation unit that irradiates the one surface of the recording medium with ultraviolet light having a wavelength of 200 nm to 410 nm at an illuminance of 1 W/cm^2 or more.

2. The drying device according to claim 1, wherein when the energy irradiation unit emits energy, the temperature control unit adjusts a surface temperature of the temperature control unit to lower than 80°C.

3. The drying device according to claim 1 or 2, wherein the temperature control unit includes a metal roll in contact with the other surface of the recording medium.

4. The drying device according to claim 3, wherein the metal roll has a heat conductivity of 150 kcal/m•h•°C or more.

5. The drying device according to any one of claims 1 to 4, wherein

the energy irradiation unit includes the infrared light irradiation unit, and

a temperature of a heat source of the infrared light irradiation unit is 900°C or higher

6. An image forming device comprising:

a conveyance unit that conveys a recording medium;
a primer ink discharge unit for discharging a primer ink containing an aggregating agent;
a color ink discharge unit for discharging a color ink containing a coloring agent; and
the drying device according to any one of claims 1 to 5.

7. An image forming method comprising:

a step of applying ink to one surface of a recording medium to form an ink image; and
a step of drying the ink image by irradiating the one surface of the recording medium with energy while a temperature control unit for controlling a temperature is in contact with the other surface of the recording medium, wherein
in the step of drying the ink image, infrared light having a wavelength of 0.8 μm or more and 3.0 μm or less is emitted at an output of 30 kW/m^2 or more, or ultraviolet light having a wavelength of 200 nm or more and 410 nm or less is emitted at an illuminance of 1 W/m^2 or more.

8. The image forming method according to claim 7, wherein
when an energy absorption ratio of the recording medium at a wavelength of 1.2 μm is 1, the ink image includes a region where the energy absorption ratio is 1.3 or more at a wavelength of 1.2 μm.

9. The image forming method according to claim 7 or 8, wherein
the one surface of the recording medium partially has a region with a different energy absorption ratio.

10. The image forming method according to any one of claims 7 to 9, wherein
the ink contains 5 to 20% by mass of a water-soluble solvent.

11. The image forming method according to any one of claims 7 to 10, wherein

in the step of forming the ink image,
a primer ink containing at least an aggregating agent is applied, and
a color ink containing at least a coloring agent is applied.

12. The image forming method according to any one of claims 7 to 11, wherein

in the step of forming the ink image,
two or more color inks containing coloring agents having different absorption ratios of infrared light having a specific wavelength selected from wavelengths of 0.8 μm or more and 3.0 μm or less, or containing coloring agents having different absorption ratios of ultraviolet light having a specific wavelength selected from wavelengths of 200 nm or to 410 nm are applied.

13. The image forming method according to claim 12, wherein
the two or more color inks have different drying ratios when the two or more color inks are dried in an oven at 100°C for 30 seconds.

14. The image forming method according to claim 13, wherein
out of the two or more color inks, an ink containing a coloring agent having a higher infrared light absorption ratio or a higher ultraviolet light absorption ratio has a lower drying ratio when the two or more color inks are dried in an oven at 100°C for 30 seconds.

FIG. 1A

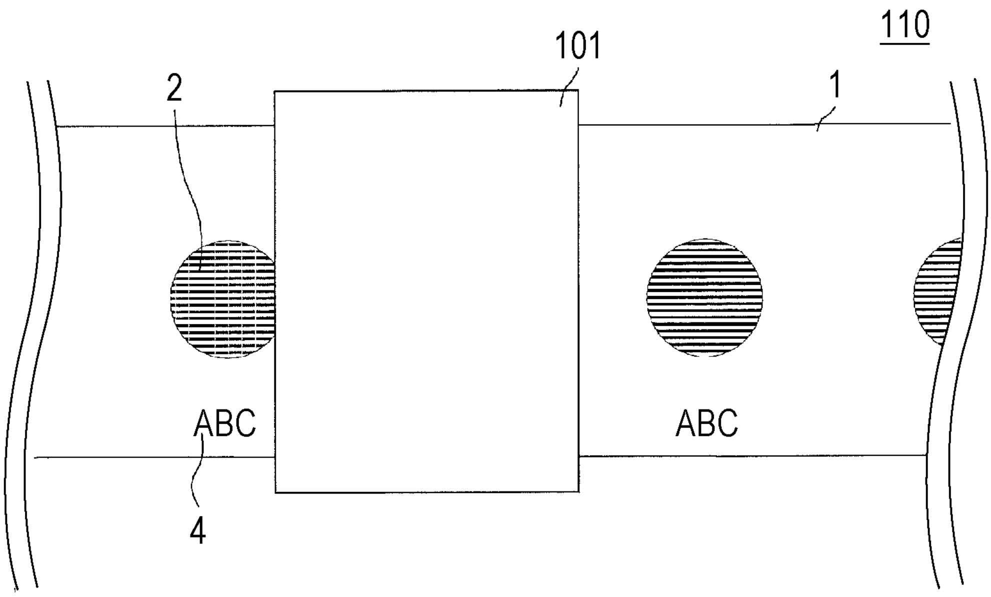


FIG. 1B

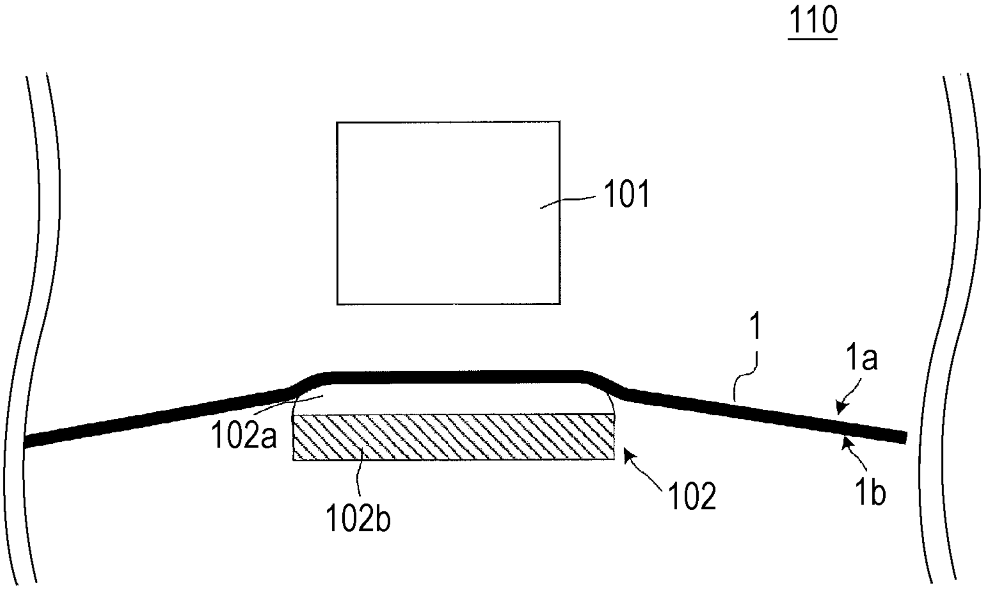
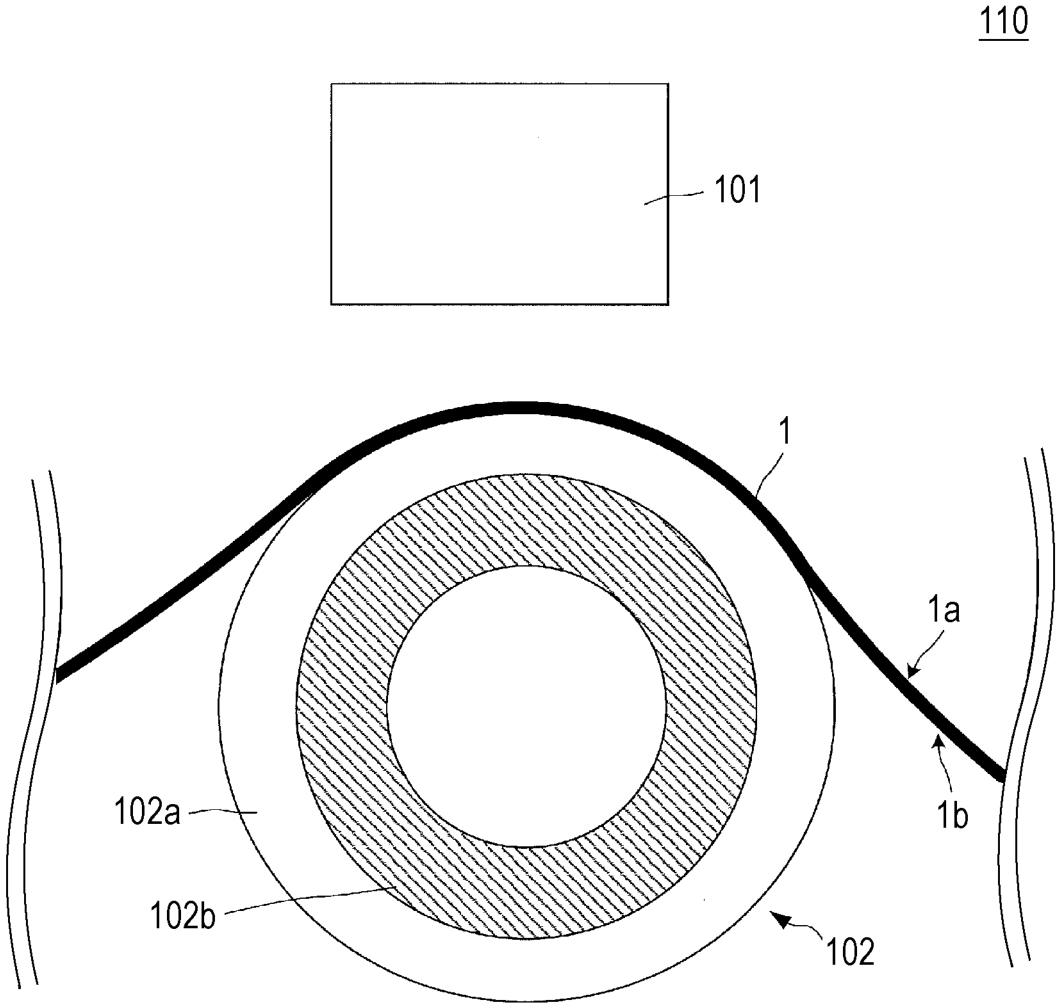


FIG. 2



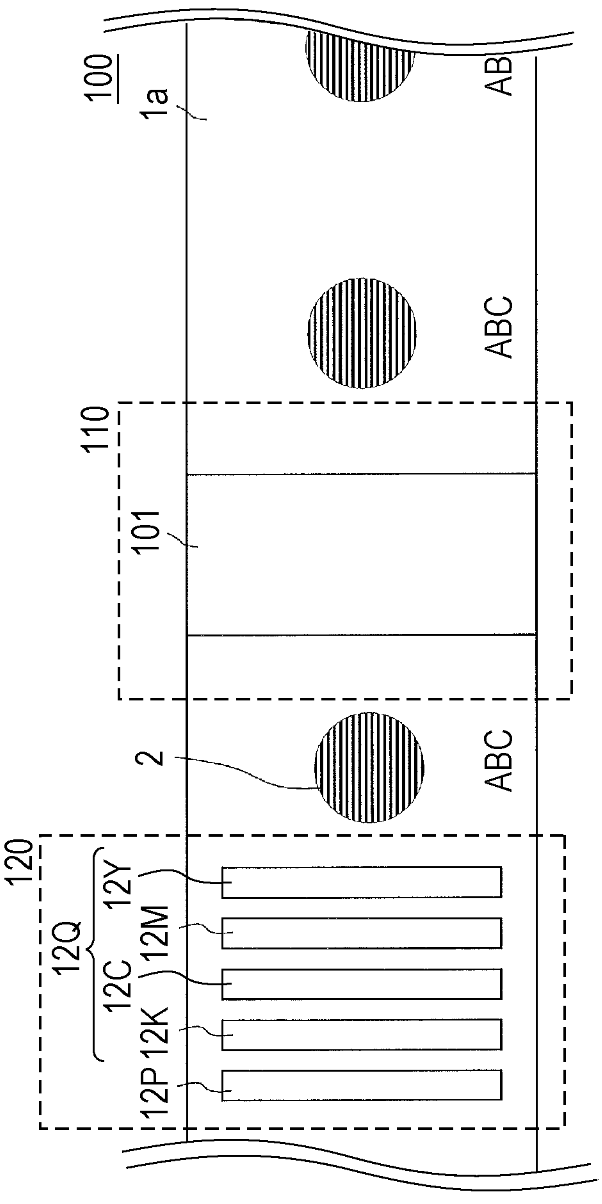

100
1a
AB
ABC
110
101
2
ABC
120
12Q
12Y
12M
12C
12K
12P

FIG. 3A

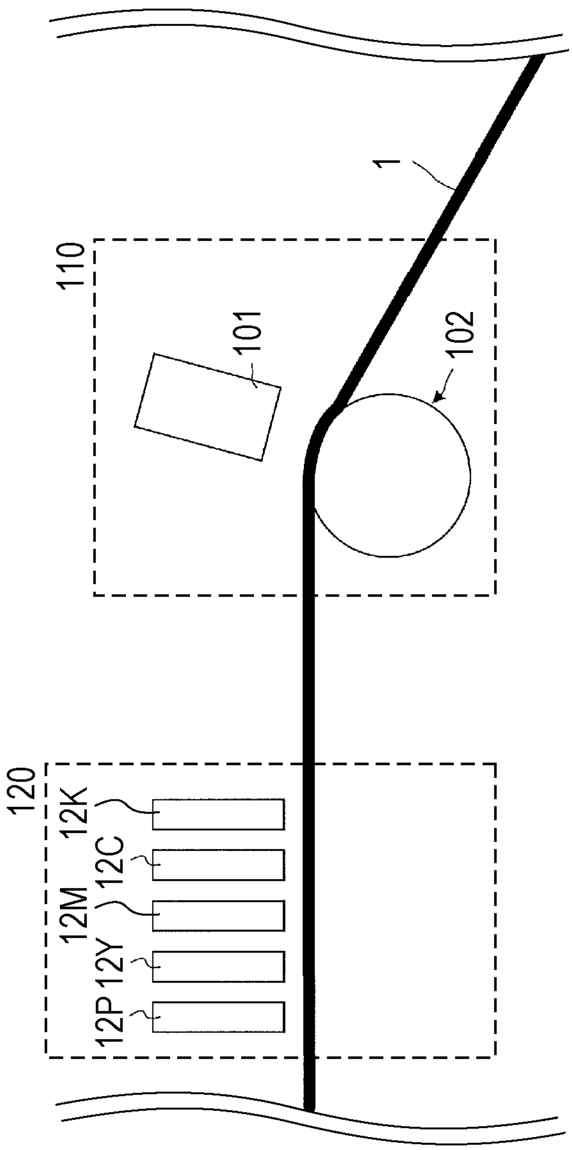
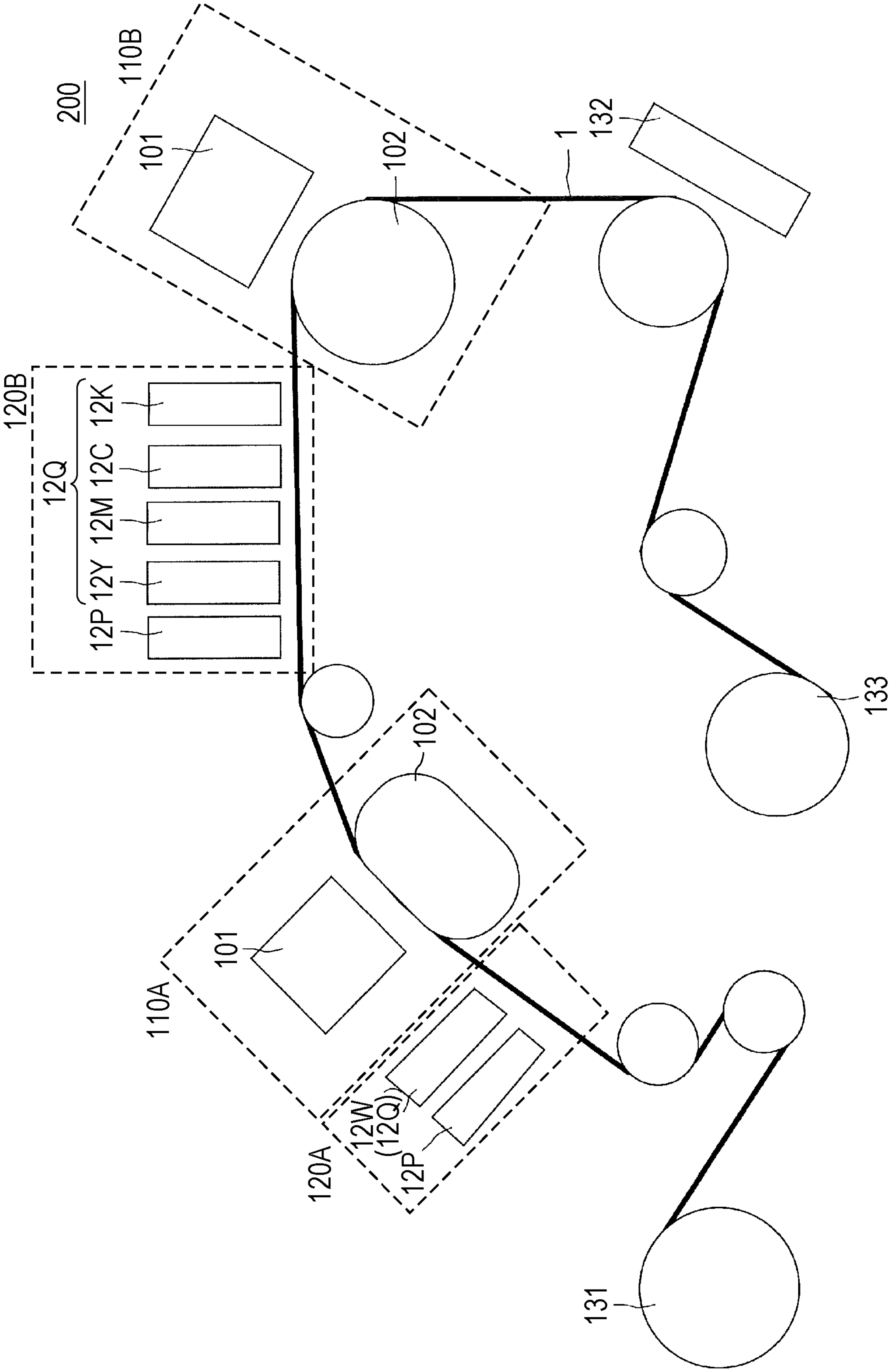

1
110
101
102
120
12K
12C
12M
12Y
12P

FIG. 3B

FIG. 4


200
110B
101
102
1
132
120B
12Q
12P
12Y
12M
12C
12K
102
133
110A
101
120A
12W
(12Q)
12P
131

INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2021/008445

A. CLASSIFICATION OF SUBJECT MATTER
B41J 2/01(2006.01)i
FI: B41J2/01 125; B41J2/01 129
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)
B41J2/01

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan	1922-1996
Published unexamined utility model applications of Japan	1971-2021
Registered utility model specifications of Japan	1996-2021
Published registered utility model applications of Japan	1994-2021

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2020/129568 A1 (MIMAKI ENG CO LTD) 25 June 2020 (2020-06-25) paragraphs [0037]-[0038], [0112]-[0115], fig. 1	1-2, 7-8
Y	paragraphs [0037]-[0038], [0112]-[0115], fig. 1	6, 11
Y	JP 2015-205510 A (HITACHI MAXELL) 19 November 2015 (2015-11-19) paragraphs [0012]-[0014], [0077]-[0078], [0110]	6, 11
A	WO 2013/161270 A1 (KONICA MINOLTA INC) 31 October 2013 (2013-10-31) entire text, all drawings	1-14
A	JP 2018-155478 A (RICOH CO LTD) 04 October 2018 (2018-10-04) entire text, all drawings	1-14
A	JP 2018-202843 A (KONICA MINOLTA INC) 27 December 2018 (2018-12-27) entire text, all drawings	1-14

☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
10 May 2021 (10.05.2021)	25 May 2021 (25.05.2021)

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2021/008445

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2016-074207 A (XEROX CORPORATION) 12 May 2016 (2016-05-12) entire text, all drawings	1-14

Form PCT/ISA/210 (continuation of second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2021/008445

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
WO 2020/129568 A1	25 Jun. 2020	(Family: none)	
JP 2015-205510 A	19 Nov. 2015	JP 2012-140615 A paragraphs [0012]-[0014], [0077]-[0078], [0110] JP 2017-140845 A	
WO 2013/161270 A1	31 Oct. 2013	US 2015/0138289 A1 whole document	
JP 2018-155478 A	04 Oct. 2018	US 2018/0264803 A1 whole document	
JP 2018-202843 A	27 Dec. 2018	(Family: none)	
JP 2016-074207 A	12 May 2016	US 9193142 B1 whole document DE 102015218036 A1 CA 2904934 A1	

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP 2019162870 A **[0005]**