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

(11) EP 3 243 666 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
15.11.2017 Bulletin 2017/46

(51) Int Cl.:
B41J 11/00 *(2006.01)* ***B41M 7/00*** *(2006.01)*

(21) Application number: **17170398.6**

(22) Date of filing: **10.05.2017**

(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:
MA MD

(30) Priority: **11.05.2016 JP 2016095496**
04.04.2017 JP 2017074153

(71) Applicant: **Ricoh Company, Ltd.**
Tokyo 143-8555 (JP)

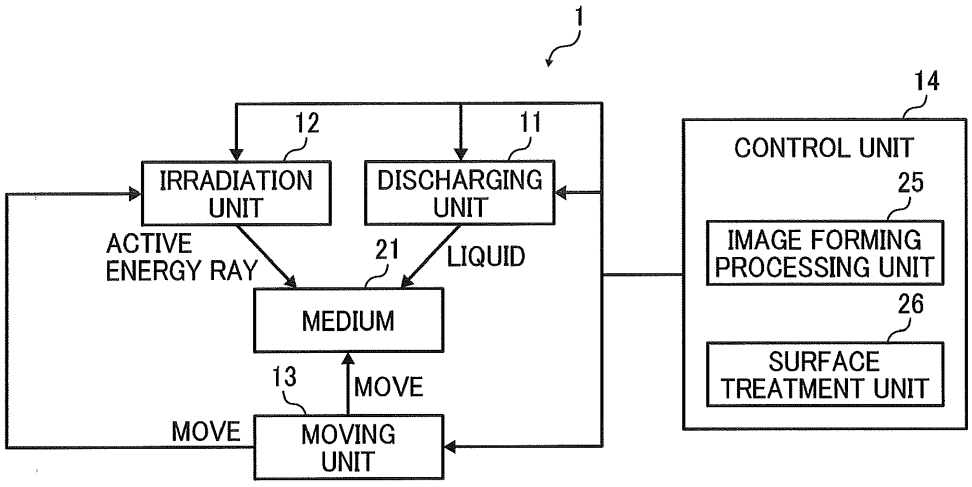
(72) Inventors:
- **MEZAKI, Daisuke**
  Tokyo, 143-8555 (JP)
- **IIO, Masato**
  Tokyo, 143-8555 (JP)

(74) Representative: **Schwabe - Sandmair - Marx**
Patentanwälte Rechtsanwalt Partnerschaft mbB
Joseph-Wild-Straße 20
81829 München (DE)

(54) LIQUID DISCHARGING DEVICE, PROCESSING METHOD, AND CARRIER MEANS

(57) A liquid discharging device (1) includes a liquid discharging unit (11) to discharge a liquid including an active energy ray curable composition to an object (21), an irradiator (12) to irradiate the liquid with active energy rays to allow the liquid to cure, and a moving unit (13) to move at least one of the irradiator (12) and the object (21) onto which the liquid is discharged. When the object (21) is divided into multiple sections including a first section (51) and a second section (52) adjacent to the first section (51) disposed in a direction perpendicular to the moving direction of the moving unit (13), the irradiator (12) conducts temporary irradiation on the first section (51) with the active energy rays in an integral of light less than a predetermined integral of light, irradiation on the second section (52) with the active energy rays, and proper irradiation on the first section (51) with the active energy rays in an integral of light to be not less than the predetermined integral of light.

FIG. 1



EP 3 243 666 A1

Description

BACKGROUND

Technical Field

[0001] The present invention relates to a liquid discharging device, a processing method, and a carrier means.

Background Art

[0002] There is a device to discharge a liquid including an active energy ray curable composition such as an ultraviolet ray curing resin and irradiate the discharged liquid with an active energy ray for image forming, surface treatment, etc. For example, an inkjet printer is known which discharges an ultraviolet ray curable ink on a medium and irradiates the ink on the medium with ultraviolet rays to conduct image forming, surface treatment, etc.

[0003] An inkjet depicting device including an active energy ray irradiator scanning an active energy ray in the main scanning direction has been proposed in Japanese Unexamined Patent Application Publication No. 2008-087221 which is characterized by satisfying $1.0 \leq (D/dx) \leq 3.0$, where dx represents the travel distance of a medium in the sub-scanning direction and D represents the length of the irradiation outlet of the active energy ray in the sub-scanning direction, to improve image quality.

[0004] An optical irrradiator which irradiates a medium to be conveyed in a first direction with light has been proposed in Japanese Unexamined Patent Application Publication No. 2012-106367. In order to prevent uneven irradiation intensity, the irradiator includes multiple point light sources disposed along a second direction perpendicular to the first direction and each point light source includes a unification mechanism to unify the irradiation intensity of the emitted light in the second direction.

[0005] An active energy ray curable composition for use in inkjet printers has been proposed in Japanese Unexamined Patent Application Publication No. 2015-071718 which includes diethylene glycol dimethacrylate to reduce odor, improve reactivity, and ameliorate safeness.

SUMMARY

[0006] According to the present invention, provided is an improved liquid discharging device (1) including a liquid discharging unit (11) to discharge a liquid including an active energy ray curable composition to an object (21), an irradiator (12) to irradiate the liquid with active energy rays to allow the liquid to cure, and a moving unit (13) to move at least one of the irradiator (12) and the object (21) onto which the liquid is discharged. When the object (21) is divided into multiple sections including a first section (51) and a second section (52) adjacent to the first section (51) disposed in a direction perpendicular to the moving direction of the moving unit (13), the irradiator (12) conducts temporary irradiation on the first section (51) with the active energy rays in an integral of light less than a predetermined integral of light, irradiation on the second section (52) with the active energy rays, and proper irradiation on the first section (51) with the active energy rays in an integral of light to be not less than the predetermined integral of light.

[0007] According to the present invention, surface smoothness of an object obtained by an active energy ray curable composition is improved.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0008] Various other objects, features and attendant advantages of the present invention will be more fully appreciated as the same becomes better understood from the detailed description when considered in connection with the accompanying drawings in which like reference characters designate like corresponding parts throughout and wherein:

FIG. 1 is a diagram illustrating a function configuration of the liquid discharging device according to an embodiment of the present invention;
FIG. 2 is a block diagram illustrating a hardware configuration of the liquid discharging device according to an embodiment of the present invention;
FIG. 3 is a diagram illustrating a side view of a hardware configuration of the liquid discharging device according to an embodiment of the present invention;
FIG. 4 is a diagram illustrating a top view of a hardware configuration of the liquid discharging device according to an embodiment of the present invention;
FIG. 5 is a diagram illustrating a relation between the drive current and the discharging amount of a liquid in a head unit according to an embodiment of the present disclosure;

FIG. 6 is a diagram illustrating a procedure of the surface treatment according to Comparative Example;
FIG. 7 is a diagram illustrating a procedure of the surface treatment according to the first embodiment of the present disclosure;
FIG. 8 is a diagram illustrating a procedure of the surface treatment according to the second embodiment of the present invention;
FIG. 9 is a diagram illustrating a procedure of the surface treatment according to the third embodiment of the present invention;
FIG. 10 is a flow chart illustrating the flow of the surface treatment in the liquid discharging device according to an embodiment of the present invention;
FIG. 11 is a diagram illustrating a discharging area including four sections and the execution sequence of temporary irradiation or proper irradiation to each section according to an embodiment of the present disclosure,
FIG. 12 is a diagram illustrating a discharging area including six sections and the execution sequence of temporary irradiation or proper irradiation to each section according to an embodiment of the present disclosure,
FIG. 13 is a diagram illustrating a discharging area including seven sections and the execution sequence of temporary irradiation or proper irradiation to each section according to an embodiment of the present disclosure,
FIG. 14 is a diagram illustrating the comparison of the surface of the surface-treated discharging area treated by a liquid discharging device of Comparative Example and the surface of the surface-treated discharging area treated by a liquid discharging device according to an embodiment of the present invention;
FIG. 15 is a diagram illustrating an example of ink accommodation embodiment; and
FIG. 16 is a diagram illustrating an example of the ink cartridge including an ink bag.

[0009] The accompanying drawings are intended to depict exemplary embodiments of the present invention and should not be interpreted to limit the scope thereof. The accompanying drawings are not to be considered as drawn to scale unless explicitly noted. Also, identical or similar reference numerals designate identical or similar components throughout the several views.

DESCRIPTION OF THE EMBODIMENTS

[0010] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the present invention. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "includes" and/or "including", when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

[0011] In describing preferred embodiments illustrated in the drawings, specific terminology may be employed for the sake of clarity. However, the disclosure of this patent specification is not intended to be limited to the specific terminology so selected, and it is to be understood that each specific element includes all technical equivalents that have the same function, operate in a similar manner, and achieve a similar result.

[0012] FIG. 1 is a diagram illustrating a function configuration of a liquid discharging device (1) according to an embodiment of the present invention. The liquid discharging device (1) forms images and conducts surface treatment using a liquid including an active energy ray curable composition and can be an inkjet printer, a facsimile machine, a multifunction peripheral, etc. The active energy ray curable composition is a material which cures upon irradiation of an active energy ray and its examples are ultraviolet ray curable resins and electron beam curable resins.

[0013] For example, ink, coating agents for surface treatment, discharging liquid for 3D object modeling, and adhesives can be the liquid.

[0014] The liquid discharging device includes a discharging unit (11), an irradiator (12), a moving unit (13), and a controller (14).

[0015] The discharging unit (11) discharges a medium (21). Articles onto which the discharged liquid can be attached, cure, and be fixed can be the medium (21). Taking into account the property of the active energy ray curable composition, it is preferable that the composition be made of a material which has a low liquid permeability such as plastic and metal and is treated with non-permeable coating. The discharging unit (11) may further optionally discharge a liquid including no active energy ray curable composition. The discharging unit (11) is constituted of, for example, an inkjet mechanism. "The object" subjected to image forming and surface treatment by the liquid discharging device (1) according to an embodiment of the present invention includes "the surface of the medium (21)" and "the surface of an image formed on the medium (21)".

[0016] The irradiator (12) irradiates the liquid discharged to the medium (21) with an active energy ray. The irradiator (12) has a configuration utilizing ultraviolet light sources, electron beam sources, optical elements, etc.

[0017] The moving unit (13) relatively moves the irradiation range of an active energy ray emitted from the irradiator

(12) against the discharging area of the liquid on the medium (21). The irradiation range is irradiated with active energy rays at the same time. The irradiation range is determined by the configuration (arrangement of luminous elements, etc.) of the irradiator (12) and the form of the irradiation range is not particularly limited. The irradiation range is, for example, a single dimension form (linear form) when the luminous elements of the irradiator (12) are disposed in the single dimension and in two dimension form (plane form) when the luminous elements of the irradiator (12) are disposed in the two dimension. In addition, the irradiation range can be transformed. The relative position of the irradiation range changes in the discharging area since the moving unit (13) moves, for example, the irradiator (12) and/or the medium (21). The moving unit (13) includes, for example, an electric motor, a link mechanism, and a conveyor belt.

[0018] The moving unit (13) moves the irradiation range in such a manner that the discharging range (the area of the medium (21)) of a liquid is divided into multiple sections. For example, when the length of the irradiation range of the irradiator (12) in the Y direction (sub-scanning direction) is shorter than the length of the discharging range in the Y direction, the moving unit (13) sequentially moves the irradiator (12) in a direction parallel to the X direction (main scanning direction), shifts to the Y direction, and thereafter repeats the sequential move in the direction parallel to the X direction and the shift to the Y direction. In such an operation, it is possible to regard as a single section the portion sequentially irradiated with an active energy ray in the X direction (i.e., the portion irradiated with the active energy ray while the irradiator (12) moves in the main scanning direction once). At this point, the liquid does not cure at the same time because the active energy ray is emitted on different timing among multiple sections.

[0019] The controller (14) controls the discharging unit (11), the irradiator (12), and the moving unit (13). The controller (14) includes an image forming processor (25) and a surface treating unit (26). The controller (14) is constituted of, for example, a central processing unit (CPU), programs to control the CPU, memories to store the programs, etc.

[0020] The image forming processor (25) conducts processing to form an image on the medium (21). The image forming processor (25) executes control computation processing to control the position and the amount of ink discharged so as to form a predetermined image on the medium (21) based on image data.

[0021] The surface treating unit (26) executes processing to conduct surface treatment at an arbitrary position on the medium (21). For example, the surface treating unit (26) executes control computation processing to control the position and the amount of a coating agent discharged to form a coating layer having a predetermined feature on the surface of an image formed by the image forming processor (25) or the surface of the medium (21) on which no image is formed. The feature of the coating layer includes gloss, non-gloss, abrasion resistance, hardness, non-permeation, etc.

[0022] As described above, the moving unit (13) moves the irradiation range in such a manner that the discharging range of the liquid is divided into multiple sections. Since the multiple sections are sequentially irradiated with the active energy rays on different timing, the processes of curing of the liquid are different among the section irradiated with the active energy rays first and the sections with the active energy rays thereafter. Such a difference of the processes of curing among the sections causes defects such as wrinkles.

[0023] To solve this problem, the controller (14) executes temporary irradiation and proper irradiation on the irradiator (12). By the temporary irradiation, a section is irradiated with an active energy ray in an integral of light less than a predetermined integral of light. The liquid on a section can sufficiently cure in terms of practical use with the predetermined integral of light, which can be calculated by, for example, UV intensity x irradiation time. Sufficient curing in terms of practical use means, for example, causing no feel of tacking when the liquid is touched. The liquid on the section subject to temporary irradiation does not cure completely but in some extent. By the proper irradiation, a section is irradiated with an active energy ray in an integral of light not less than the predetermined integral of light. The liquid on the section treated with the proper irradiation completely cure in terms of practical use. For example, when the predetermined integral of light is 2 and the temporary irradiation has an integral of light of 1, the liquid can completely cure upon further the proper irradiation of the active energy ray having an integral light of 1. With no temporary irradiation, the integral light of the proper irradiation is 2 to allow the liquid to sufficiently cure.

[0024] The irradiator (12) conducts temporary irradiation first on the first section (51), thereafter temporary irradiation or proper irradiation on the second section (52) adjacent to the first section, and finally proper irradiation on the first section (51). By such a temporary irradiation on one of the two sections (51) and (52) adjacent to each other, the difference of the process of curing of the liquid between both of the sections can be reduced. Therefore, multiple adjacent sections can be prevented from defects such as wrinkles, etc. The first section and the second section adjacent thereto may have an overlapped area. The irradiation amount of an active energy ray on the border of both the sections may be short if there is an error to the movement of the irradiator (12). However, it is possible to secure a sufficient integral of light on the border by overlapping the irradiation of the active energy rays.

[0025] The temporary irradiation and the proper irradiation can be executed for both the image forming by the image forming processor (25) and the surface treatment by the surface treating unit (26).

[0026] Although the device in this description is assumed to form two dimensional images on the medium (21), a 3D printer, etc., which discharges liquid including an ultraviolet ray curable resin composition into a space to manufacture predetermined three dimensional objects can be the liquid discharging device (1).

[0027] FIG. 2 is a block diagram illustrating a hardware configuration of the liquid discharging device (1) according to

an embodiment of the present invention. FIG. 3 is a diagram illustrating a side view of a hardware configuration of the liquid discharging device (1) according to an embodiment of the present invention. FIG. 4 is a diagram illustrating a top view of a hardware configuration of the liquid discharging device (1) according to an embodiment of the present invention.

[0028] The liquid discharging device (1) illustrated in FIGS. 2 to 4 includes a conveyor unit (101), a carriage unit (102), a head unit (103), an irradiation unit (irradiator) (104), a maintenance unit (105), a group of sensors (106), and a control unit (controller) (107). In FIGS. 3, 4, and 6 to 9, the X direction is the main scanning direction of the irradiation unit (104), which is the direction of sequential irradiation of the active energy ray (ultraviolet ray) on the surface of the medium (21). The Y direction is the sub-scanning direction of the irradiation unit (104), which is a direction perpendicular to the X direction on a plane parallel to the surface of the medium (21). The Z direction is perpendicular to the surface of the medium (21).

[0029] The conveyor unit (101) moves the medium (21). The conveyor unit (101) includes, for example, a conveyor belt mechanism to convey the medium (21) from a predetermined storing site, a placement board 111 on which the medium (21) conveyed is placed, and an adsorption mechanism to fix the medium (21) on the placement board 111.

[0030] The carriage unit (102) moves the head unit (103) and the irradiation unit (104). The carriage unit (102) includes, for example, a chassis onto which the head unit (103) and the irradiation unit (104) are fixed, a link mechanism to link with the chassis, and a motor to drive the link mechanism.

[0031] The head unit (103) discharges a color ink for use in image forming and a clear ink (coating agent) for use in the surface treatment. The head unit (103) includes a head (103K) to discharge a black ink, a head (103C) to discharge a cyan ink, a head (103M) to discharge a magenta ink, a head (103Y) to discharge a yellow ink, a head (103CL) to discharge a clear ink, and a head (103W) to discharge a white ink. In this embodiment, ultraviolet ray curable inks are used for the color inks (black, cyan, magenta, yellow, and white) and the clear ink. Inks including acrylate-based monomers or methacrylate-based monomers are suitable as the ultraviolet ray curable ink. The acrylate-based monomer easily cure and has an advantage of lowering the curing energy. In addition, anionic monomers negative to skin sensitivity are preferable as the methacrylate-based monomer. In general, methacrylate-based monomers take longer time to cure than acrylate-based monomers so that the impact of the present embodiment is greater when methacrylate-based monomers are used. The coating agent for use in the surface treatment is not limited to being clear (transparent) but can be colored. In addition, color ink prepared for image forming can be used as the coating agent for surface treatment. The head unit (103) is fixed onto the chassis of the carriage unit (102) and displaced together with the carriage unit (102).

Monomer

[0032] (Meth)acrylates, (meth)acrylamide, or vinylether can be used in combination as the active energy ray curable composition.

[0033] Specific examples include, but are not limited to, ethylene glycol di(meth)acrylate, hydroxy pivalic acid neopentyl glycol di(meth)acrylate, γ-butylolactone acrylate, isobornyl (meth)acrylate, formalized trimethylol propane mono(meth)acrylate, polytetramethylene glycol di(meth)acrylate, trimethylol propane (meth)acrylic acid salicylic acid ester, diethylene glycol di(meth)acrylate, triethylene glycol diacrylate, tetraethylene glycol diacrylate, polyethylene glycol diacrylate [(CH_2=CH-CO-(OC_2H_4)n-OCOCH=CH_2(n = 4)], polyethylene glycol di(meth)acrylate [(CH_2=CH-CO-(OC_2H_4)n-OCOCH=CH_2 (n is equal to or approximately 9)], polyethylene glycol di(meth)acrylate [(CH_2=CH-CO-(OC_2H_4)n-OCOCH=CH_2 (n is equal to or approximately 14)], polyethylene glycol di(meth)acrylate [(CH_2=CH-CO-(OC_2H_4)n-OCOCH=CH_2 (n is equal to or approximately 23)], dipropylene glycol di(meth)acrylate, tripropylene glycol di(meth)acrylate, polypropylene glycol dimethacrylate [(CH_2=C(CH_3)-CO-(OC_3H_6)n-OCOC(CH_3)=CH_2 (n is equal to or approximately 7)], 1,3-butane diol di(meth)acrylate, 1,4-butane diol di(meth)acrylate, 1,6-hexane diol di(meth)acrylate, 1,9-nonene diol di(meth)acrylate, neopentyl glycol di(meth)acrylate, tricyclodecane dimethanol diacrylate, propylene oxide-modified bisphenol A di(meth)acrylate, 1,6-hexane dioldi(meth)acrylate, polyethylene glycol di(meth)acrylate, dipenta erythritol hexa(meth)acrylate, methacryloyl morphorine, 2-hydroxypropyl (meth)acryl amide, propylene oxide-modified tetramethylol methane tetramethacrylate, dipentaerythritol hydroxypenta(meth)acrylate, caprolactone-modified dipentaerythritol hydroxy penta(meth)acrylate, ditrimethylol propane tetra(meth)acrylate, pentaerythritol tetra(meth)acrylate, trimethylol propane triacrylate, ethylene oxide-modified trimethylol propane tri(meth)acrylate, propylene oxide-modified trimethylol propane tri(meth)acrylate, caprolactone-modified trimethylol propane tri(meth)acrylate, pentaetythritol tri(meth)acrylate, tris(2-hydroxyethyl)isocyanulate tri(meth)acrylate, ethoxylated neopentyl glycol di(meth)acrylate, propylene oxide-modified neopentyl glycol di(meth)acrylate, propylene oxide-modified glyceryl tri(meth)acrylate, polyester di(meth)acrylate, polyester tri(meth)acrylate, polyester tetra(meth)acrylate, polyeter penta(meth)acrylate, polyester poly(meth)acrylate, N-vinylcaprolactam, N-vinyl pyrrolidone, N-vinyl formamide, polyurethane di(meth)acrylate, polyurethanetri(meth)acrylate, polyurethane tetra(meth)acrylate, polyurethane penta(meth)acrylate, polyurethane poly(meth)acrylate,triethylene glycol divinylether, cyclohexane dimethanol divinylether, cyclohexane dimethanol monovinylether, hydroxyethyl vinylether, diethylene glycol monovinylether, diethylene glycol divinylether, dicyclopenta dienevinylether, tricyclodecane vinylether, benzylvinylether, ethyloxethane methylvinylether, triethylene glycol divinylether, hy-

droxybutylvinylether, and ethylvinylether. These can be used alone or in combination.

[0034] Most of the monomers for use in typical active energy ray curable composition are toxic. In particular, most of (meth)acrylic acid esters, which are inexpensive and easily available and have sufficiently low viscosity, usually have high toxicity about skin sensitization indicating the degree of allergy at the contact with the skin. Currently, such inks are used with protective equipment in some cases. However, it is desirable to use an active energy ray curable composition free of skin sensitization problem and having a sufficiently low viscosity to a degree that it can be discharged at room temperature even when polymer components are added.

[0035] An active energy line curing type composition negative about skin sensitization satisfies at least one of the following 1 to 3.

1. Compounds having a stimulation index (SI) value of less than 3, which indicates the degree of skin sensitization in the skin sensitization test as measured in Local Lymph Note Assay (LLNA) method.
2. Compound evaluated as "negative about skin sensitization" or "no skin sensitization" in Material Safety Data Sheet (MSDS).
3. Compound evaluated as "negative for skin sensitization" or "no skin sensitization" in documents (for example, Contact Dermatitis 8 223-235, published in 1982).

[0036] Regarding 1 mentioned above, compounds having an SI value of less than 3 are determined as negative about skin sensitization as described in literatures, for example, "Functional Material" (Kino Zairyou) 2005, September, Vol. 25, No. 9, p. 55. Lower SI values means lower levels of skin sensitization. It is preferable to use monomers having lower SI values. The SI value is preferably less than 3, more preferably 2 or less, and furthermore preferably 1.6 or less.

[0037] Specific examples of the monomers negative about skin sensitization include, but are not limited to, t-butyl methacrylate, n-pentyl methacrylate, n-hexyl methacrylate, glycerol dimethacrylate, ethyleneoxide-modified trimethylol propane trimethacrylate, caprolactone-modified dipentaerythritol hexaacrylate, trichlodecane dimethanol dimethacrylate. In addition, it is possible to mix at least one kind of the monomers selected from the group consisting of the above.

Active Energy Ray

[0038] The liquid discharged onto the medium (21) cures with an active energy ray emitted from the irradiator (12). The irradiator (12) has a configuration utilizing ultraviolet light sources, electron beam sources, optical elements, etc.

Polymerization Initiator

[0039] The active energy ray curable composition may include a polymerization initiator. The polymerization initiator produces active species such as a radical or a cation upon application of the energy of an active energy ray and initiates polymerization of a polymerizable compound (monomer or oligomer). As the polymerization initiator, it is suitable to use a known radical polymerization initiator, cation polymerization initiator, base producing agent, or a combination thereof. Of these, radical polymerization initiators are preferable. Moreover, the polymerization initiator preferably accounts for 5 percent by mass to 20 percent by mass of the total content (100 percent by mass) of the composition to obtain sufficient curing speed.

[0040] Specific examples of the radical polymerization initiators include, but are not limited to, aromatic ketones, acylphosphineoxide compounds, aromatic oniumchlorides, organic peroxides, thio compounds (thioxanthone compounds, thiophenyl group containing compounds, etc.), hexaarylbiimidazole compounds, ketoxime-esterified compounds, borate compounds, azinium compounds, metallocene compounds, active ester compounds, compounds having a carbon halogen bond, and alkylamine compounds.

[0041] In addition, a polymerization accelerator (sensitizer) can be optionally used together with the polymerization initiator. The polymerization accelerator is not particularly limited. Preferred examples include, but are not limited to, amines such as trimethylamine, methyldimethanolamine, triethanolamine, p-diethylaminoacetophenone, p-dimethylaminoethylbenzoate, p-dimethyl aminobenzoate-2-ethylhexyl, N,N-dimthylbenzylamine, and 4,4'-bis(diethylamino)benzophenone. The content of the polymerization accelerator is suitably determined to suit to a particular application depending on the identification and the amount of the polymerization initiator.

Coloring Material

[0042] The active energy ray curable composition may include a coloring material. As the coloring material, although depending on the objectives and requisites of the composition of embodiments of the present disclosure, various pigments and dyes can be used, which impart black, white, magenta, cyan, yellow, green, orange, and gloss colors such as gold and silver. The content of the coloring material is not particularly limited and determined considering the desired color

density and dispersibility of the coloring material in a composition, etc. It is preferred that the content of the coloring material account for 0.1 percent by mass to 20 percent by mass of the total content (100 percent by mass) of the composition. The active energy ray curable composition does not necessarily include a coloring material but can be clear and colorless.

[0043] If no coloring material is included, the composition is suitable as an overcoat layer to protect images.

[0044] As the pigment, an inorganic or organic pigment can be used alone or in combination.

[0045] Specific examples of the inorganic pigment include, but are not limited to, carbon blacks (C.I. Pigment Black 7) such as furnace black, lamp black, and acetylene black, and channel black, iron oxides, and titanium oxides.

[0046] Specific examples of the organic pigment include, but are not limited to, azo pigments such as insoluble azo pigments condensed azo pigments, azo lakes, chelate azo pigments, polycyclic pigments such as phthalocyanine pigments, perylene pigments, perinone pigments, anthraquinone pigments, quinacridone pigments, dioxane pigments, thioindigo pigments, isoindolinone pigments, and quinofuranone pigments, dye chelates such as basic dye type chelates, acid dye type chelates, dye lakes such as basic dye type lake and acid dye type lake, nitro pigments, nitroso pigments, aniline black, and daylight fluorescent pigments.

[0047] In addition, a dispersant is optionally added to the active energy ray curable composition to enhance dispersibility of a pigment. The dispersant has no particular limit and can be, for example, polymer dispersants conventionally used to prepare a pigment dispersion material.

[0048] The dye includes, for example, an acidic dye, a direct dye, a reactive dye, a basic dye, and a combination thereof.

[0049] Inclusion of a coloring material prevents passing through of ultraviolet ray upon application of irradiation and prolongs the time to be taken for curing, which increases the level of smoothing in the present disclosure.

Organic Solvent

[0050] The active energy ray curable composition may include an organic solvent, but if possible, it is preferred that the composition be free of an organic solvent. The curable composition free of an organic solvent, in particular volatile organic compound (VOC) is preferable because it enhances safeness at the place where the composition is handled and makes it possible to prevent pollution of the environment. The organic solvent represents a conventional non-reactive organic solvent, for example, ether, ketone, xylene, ethylacetate, cyclohexanone, and toluene, which is clearly distinguished from reactive monomers. Furthermore, "free of" an organic solvent means that no organic solvent is substantially included. The proportion thereof is preferably less than 0.1 percent by mass.

Other Components

[0051] The active energy ray curable composition may include other known components. The other known components are not particularly limited.

[0052] Specific examples include, but are not limited to, known articles such as surfactants, polymerization inhibitors, leveling agents, defoaming agents, fluorescent brighteners, permeation-enhancing agents, wetting agents (humectants), fixing agents, viscosity stabilizers, fungicide, preservatives, antioxidants, ultraviolet absorbents, chelate agents, pH adjusters, and thickeners.

Preparation of Active Energy Ray Curable Composition

[0053] The active energy ray curable composition can be prepared by using the components mentioned above.

[0054] The preparation devices and conditions of the active energy ray are not particularly limited.

[0055] For example, the curable composition can be prepared by charging a polymerizable monomer, a pigment, a dispersant, etc., into a dispersing machine such as a ball mill, kitty mill, a disk mill, a pin mill, and a DYNO-MILL to prepare a pigment liquid dispersion followed by mixing with a polymerizable monomer, an initiator, a polymerization inhibitor, and a surfactant.

Viscosity

[0056] Viscosity of the active energy ray curable composition has no particular limit and can be adjusted to suit to a particular application. For example, if a discharging device to discharge a composition from a nozzle is used, viscosity thereof is preferably in the range of from 3 mPa·s to 40 mPa·s, more preferably from 5 mPa·s to 15 mPa·s, and particularly preferably from 6 mPa·s to 12 mPa·s in the temperature range of from 20 degrees C to 65 degrees C, preferably at 25 degrees C. In addition, it is particularly preferable to satisfy this viscosity range without including the organic solvent mentioned above. The viscosity mentioned above can be measured by a cone-and-plate type rotary viscometer (VISCOMETER TVE-22L, manufactured by TOKI SANGYO CO., LTD.) using a cone rotor (1°34' × R24) at a number of

rotation of 50 rpm with a setting of the temperature of hemathermal circulating water in the range of from 20 degrees C to 65 degrees C. VISCOMATE VM-150III can be used for the temperature adjustment of the circulating water.

[0057] The discharging mechanism of the head unit (103) can be constituted utilizing known or new suitable method such as a piezoinkjet method, a thermal inkjet method, etc. FIG. 5 is a diagram illustrating the relation between the drive current and the discharging amount of a liquid in the head unit (103). In this embodiment, the piezoelectric method is used. Each of the heads (103K), (103C), (103M), (103Y), (103CL), and (103W) discharges ink due to the change of pressure caused by shrinking movement of piezo elements when drive signals (voltage) are applied thereto. The discharging power of ink is changed by the mask signals of on and off. The mask signal is suitably selected depending on the gradation of pixels and the thickness of a coating layer.

[0058] The irradiation unit (104) irradiates the medium (21) with ultraviolet rays to allow color ink and clear ink to cure. The irradiation unit (104) is constituted utilizing, for example, a semiconductor luminous element to output ultraviolet rays and optical elements such as lens. The irradiation unit (104) is fixed onto the chassis of the carriage unit (102) as with the had unit 103 and displaced together with the carriage unit (102) and the head unit (103). In this embodiment, two of the irradiation unit (104) are used and each is separately fixed onto the chassis of the carriage unit (102) at both ends in the X direction.

[0059] The maintenance unit (105) do maintenance (prevention of clogging, etc.) of each head of the head (103K), the head (103C), the head (103M), the head (103Y), the head (103CL), and the head (103W). The maintenance unit (105) is placed on a maintenance area separated from the area in which the medium (21) is placed during image forming or surface treatment and the carriage unit (102) moves to the position above the maintenance unit (105) during maintenance. The maintenance unit (105) is constituted of, for example, caps to prevent drying of nozzles of each of the head (103K), the head (103C), the head (103M), the head (103Y), the head (103CL), and the head (103W) and wiping blades to clean the nozzles.

[0060] The group of the sensors (106) acquires various data required for image forming processing, surface treatment, maintenance, etc. The group of sensors (106) acquires detected values indicating statuses of each of the conveyor unit (101), the carriage unit (102), the head unit (103), the irradiation unit (104), and the maintenance unit (105). The group of sensors (106) includes a height sensor 112 fixed to the carriage unit (102).

[0061] The control unit (107) controls the conveyor unit (101), the carriage unit (102), the head unit (103), the irradiation unit (104), and the maintenance unit (105). The control unit (107) includes a unit control circuit (121), a memory (122), a central processing unit (CPU) (123), and an interface (I/F) (124). The unit control circuit (121) converts the computing results by the CPU (123) into control signals corresponding to each unit of (101) to (105). The CPU (123) executes computation processing based on the firmware stored in the memory (122), the detected values acquired by the group of sensors (106), and the data sent from a personal computer (PC) (131) connected with the I/F (124). A driver is installed in the PC (131) to control and operate the liquid discharging device (1).

[0062] The control unit (107) controls the operation (moving direction, amount of travel, travel speed, etc.) of the carriage unit (102), the operation (selection of liquid, amount of discharging, timing of discharging, etc.) of the head unit (103), and the operation (amount of light, irradiation timing, etc.) of the irradiation unit (104). While moving the carriage unit (102), the head unit (103) discharges ink (color ink or clear ink) onto the medium (21). Thereafter, while moving the carriage unit (102), the irradiation unit (104) irradiates the ink with ultraviolet rays to form an image or a coating layer on the medium (21).

[0063] The control unit (107) controls the position of the carriage unit (102) in the Z direction based on the detected value by the height sensor (112) in order that the distance between the tip of each of the nozzles of the head unit (103) and the surface of the medium (21) matches the predetermined value. Thereafter, the control unit (107) moves the carriage unit (102), discharges the ink from the head unit (103), and emits ultraviolet rays by the irradiation unit (104). Specifically, based on the image data acquired from the PC (131), the control unit (107) executes image forming processing to form an image on the medium (21) with color ink and surface treatment to form a coating layer on the formed image with clear ink or on the medium (21) on which no image is formed with clear ink or color ink.

[0064] The time interval between the discharging of the ink onto the medium (21) and the irradiation of ultraviolet rays is suitably set to suit to a particular application. For example, it is possible to irradiate the ink with the ultraviolet ray immediately or a predetermined time after the ink is discharged. The predetermined time can be the leveling time required to the ink is smoothed to a degree due to gravity. The leveling time changes depending on viscosity, surface tension, film thickness, etc. of ink.

[0065] FIG. 6 is a diagram illustrating a procedure of the surface treatment according to Comparative Example. The state illustrated in FIG. 6 is that after ink (clear ink but color ink is also allowable) is discharged onto the discharging area (41) having a length of D in the Y direction, the discharging area (41) is divided into two sections 50A and 50B which are irradiated with ultraviolet rays by the irradiation unit (104) having an irradiation range having a length of L in the Y direction. In this Comparative Example, D = 2L. The carriage unit (102) continuously moves in a direction parallel to the X direction in the first irradiation to irradiate the section (50A), shifts in the Y direction, and thereafter moves in the direction parallel to the X direction in the second irradiation to irradiate the section (50B) in the second irradiation.

[0066] In the Comparative Example, the first irradiation and second irradiation are not temporary irradiation but proper irradiation. As a result, the ink on the sections (50A) and (50B) separately and completely cure. "Completely cure" means that the ink sufficiently cures in terms of practical use. For example, monomers and/or oligomers of the ultraviolet ray curable resins contained in the ink are significantly completely polymerized. The control unit (107) adjusts the integral of light in the proper irradiation to amount to a predetermined integral of light with which the ink is completely polymerized.

[0067] The ink on the section (50A) completely cures by the proper irradiation on the section (50A) in the first irradiation. At this point, there is a large difference of the properties between the ink on the section (50A) and the ink on the section (50B) because the ink on the section (50B), which is not irradiated, is liquid. Therefore, a border wrinkle (wrinkle on border) (55) may appear between the section (50A) and the section (50B). It is highly probable that such a border wrinkle (55) remains even after the ink on the section (50B) cures by the proper irradiation on the section (50B).

[0068] FIG. 7 is a diagram illustrating a procedure of the surface treatment according to the first embodiment of the present disclosure. In this embodiment, temporary irradiation is conducted on the section (50A) in the first irradiation, proper irradiation is conducted on the section (50B) in the second irradiation, and thereafter the proper irradiation is conducted on the section (50A) in the third irradiation.

[0069] In the first irradiation, the ink on the section (50A) incompletely cures by the temporary irradiation on the section (50A). "Incompletely cure" means that the ink does not sufficiently cure in terms of practical use. Although polymerization of the ultraviolet ray curable resin contained in an ink proceeds to some extent, monomers and/or oligomers remain in some amount. The ink in the incomplete curing state has liquidity to some extent. The temporary irradiation is conducted by irradiation of the ink with an integral of light less than a predetermined integral of light. For example, temporary irradiation can be conducted by controlling the irradiation unit (104) to lower the UV strength per unit of time or setting the moving speed of the carriage unit (102) faster than the moving speed at the time of the proper irradiation while keeping the UV strength constant.

[0070] Thereafter, in the second irradiation, the ink on the section (50B) completely cures by the proper irradiation on the section (50B). At this point, the ink on the section (50A) cures to some extent. Therefore, the difference of properties between the ink on the section (50A) and the ink on the section (50B) is relatively small. Accordingly, probability of the occurrence of the border wrinkle (55) between the section (50A) and the section (50B) becomes low.

[0071] Thereafter, in the third irradiation, the incompletely curing ink on the section (50A) completely cures by the proper irradiation on the section (50A). Probability of the occurrence of the border wrinkle (55) between the section (50A) and the section (50B) becomes low as well because the difference of properties between the ink on the section (50A) and the ink on the section (50B) is small as with the second irradiation.

[0072] Hereinafter, of multiple sections (50A) and (50B) disposed adjacent to each other as described above, the section (50A) irradiated with temporary irradiation first is referred to as a reference section (first section) (51) and the section (50B) disposed adjacent to the reference section (51) and irradiated with ultraviolet rays after the temporary irradiation onto the reference section (1) is referred to as an adjacent section (second section) (52).

[0073] FIG. 8 is a diagram illustrating the procedure of the surface treatment of the second embodiment of the present disclosure. In this embodiment, a temporary irradiation is conducted on the section (50A) in the first irradiation, a temporary irradiation is conducted on the section (50B) in the second irradiation, a proper irradiation is conducted on the section (50A) in the third irradiation, and a proper irradiation is conducted on the section (50B) in the fourth irradiation. What is different from the first embodiment illustrated in FIG. 7 is that the temporary irradiation is conducted on the section (50B) in the second irradiation and the proper irradiation is conducted on the section (50B) in the fourth irradiation.

[0074] As in the case of the embodiment, by conducting temporary irradiation on the adjacent section (52) after the temporary irradiation on the reference section (51), the difference of properties between the ink on the section (50A) and the ink on the section (50B) can be furthermore smaller. This makes is possible to securely prevent occurrence of the border wrinkle (55).

[0075] FIG. 9 is a diagram illustrating the procedure of the surface treatment of the third embodiment of the present disclosure. The length (D) of the discharging area (41) in the third embodiment is three times as long as the length (L) of the irradiation range, which is divided into three sections (50A), (50B), and (50C).

[0076] The section (50B) of the center has two adjacent sections (50A) and (50C). Each of the distal sections 50A and 50C has a single adjacent section of the section (50B). Namely, the section (50B) has the largest number of adjacent sections among the three sections (50A), (50B), and (50C). In this embodiment, the section (50B), which relatively has the largest number of adjacent sections, is defined as the reference section (51).

[0077] In this embodiment, temporary irradiation is conducted on the section (50B) in the first irradiation, proper irradiation is conducted on the section (50A) in the second irradiation, proper irradiation is conducted on the section (50C) in the third irradiation, and proper irradiation is conducted on the section (50B) in the fourth irradiation.

[0078] If the section (50B), which relatively has the largest number of adjacent sections, is defined as the reference section 51, it is possible to reduce the number of irradiations required until the entire cures. For example, if the section (50B) is defined as the adjacent section (52), the two sections (50A) and (50B) are defined as the reference sections (51). In such a case, the number of irradiations required until the entire cures is five times.

[0079] For example, temporary irradiation is conducted on the section (50A) in the first irradiation, temporary irradiation is conducted on the section (50C) in the second irradiation, proper irradiation is conducted on the section (50B) in the third irradiation, proper irradiation is conducted on the section (50A) in the fourth irradiation, and proper irradiation is conducted on the section (50C) in the fifth irradiation. The procedure in this embodiment makes it possible to conduct the surface treatment free of the border wrinkle (55) with the minimum number of irradiations when three or more sections are present.

[0080] FIG. 10 is a flow chart illustrating the flow of the surface treatment in the liquid discharging device (1) according to an embodiment of the present disclosure. When forming a coating layer with clear ink, etc. starts (S101), whether or not the width (D) of the discharging area (41) (to be coated) is equal to or shorter than the width (L) of the irradiation range of the irradiation unit (104) is determined (S102). When the width (D) of the discharging area (41) is equal to or shorter than the width (L) (Yes to S102), the position of the carriage unit (102) in the Y direction is adjusted in such a manner that the center of the width (L) of the irradiation range matches the center of the width (D) (S103) and thereafter proper irradiation is conducted on the discharging area (41) (S104).

[0081] Conversely, when the width (D) of the discharging area (41) is greater than the width (L) of the irradiation range (No to S102), whether or not the number n of the sections (D/L) of the discharging area (41) is an end number is determined (S105).

[0082] FIG. 11 is a diagram illustrating the discharging area (41) including four sections of (50A) to (50D) of the embodiment of the present disclosure and an irradiation sequence (45) of temporary irradiation or proper irradiation to each section of (50A) to (50D). FIG. 12 is a diagram illustrating the discharging area (41) including six sections of (50A) to (50F) and the execution sequence (45) of temporary irradiation or proper irradiation to each section of (50A) to (50F). FIG. 13 is a diagram illustrating the discharging area (41) including seven sections of (50A) to (50G) and the execution sequence (45) of temporary irradiation or proper irradiation to each section of (50A) to (50G). In FIGS. 11 to 13, to the sections of (50A) to (50D), the sections of (50A) to (50F), and the sections of (50A) to (50G), the section numbers 1 to 4, 1 to 6, and 1 to 7 are respectively assigned from the bottom end to the upper end of the discharging area (41) in the ascending order.

[0083] When the number n of sections is an end number (Yes to S105), the temporary irradiations onto the reference sections (51) are conducted in the sequence of the section number 2, 4, 6, ..., n (S106). When the number n of the sections is 4 illustrated in FIG. 11, the temporary irradiation is conducted in the sequence of the section (50B) (section number 2) and the section (50D) (section number 4). When the number n of the sections is 6 as illustrated in FIG. 12, the temporary irradiation is conducted in the sequence of from the section (50B) (section number 2), the section 50D (section number 4), to the section (50F) (section number 6). That is, the temporary irradiation onto the reference sections (51) is conducted from the bottom end toward the top end of the discharging area (41).

[0084] Thereafter, the proper irradiation onto the adjacent sections (52) is conducted in the sequence of from the section numbers n-1, n-3, n-5, ..., to 1 (S107). When the number n of the sections is 4 as illustrated in FIG. 11, the proper irradiation is conducted in the sequence of from the section (50C) (section number 3) to the section (50A) (section number 1). When the number n of the sections is 6 as illustrated in FIG. 12, the proper irradiation is conducted in the sequence of from the section 50E (section number 5), the section 50C (section number 3), to the section (50A) (section number 1). That is, the proper irradiation onto the reference sections (52) is conducted from the top end toward the bottom end of the discharging area (41).

[0085] Thereafter, the proper irradiation onto the reference sections (51) is conducted in the sequence of from the section number 2, 4, 6, ..., to n (S108). When the number n of the sections is 4 as illustrated in FIG. 11, the proper irradiation is conducted in the sequence of from the section (50B) (section number 2) to the section (50D) (section number 4). When the number n of the sections is 6 as illustrated in FIG. 12, the proper irradiation is conducted in the sequence of from the section (50B) (section number 2), the section (50D) (section number 4), to the section (50F) (section number 6). That is, the proper irradiation onto the reference sections (51) is conducted from the bottom end toward the top end of the discharging area (41).

[0086] When the number n of sections is not an end number (No to S105), the temporary irradiations onto the reference sections (51) are conducted in the sequence of from the section number 2, 4, 6, ..., to n-1 (S109). When the number n of the sections is 7 as illustrated in FIG. 13, the temporary irradiation is conducted in the sequence of from the section (50B) (section number 2), the section 50D (section number 4), to the section (50F) (section number 6). That is, the temporary irradiation onto the reference sections (51) is conducted from the bottom end toward the top end of the discharging area (41).

[0087] Thereafter, the proper irradiation onto the adjacent sections (52) is conducted in the sequence of the section number n, n-2, n-4, ..., to 1 (S110). When the number n of the sections is 7 as illustrated in FIG. 13, the proper irradiation is conducted in the sequence of from the section (50G) (section number 7), the section (50E) (section number 5), the section (50C) (section number 3), to the section (50A) (section number 1). That is, the proper irradiation onto the reference sections (52) is conducted from the top end toward the bottom end of the discharging area (41).

[0088] Thereafter, the proper irradiation onto the reference sections (51) is conducted in the sequence of the section

number 2, 4, 6, ..., to n-1 (S111). When the number n of the sections is 7 as illustrated in FIG. 13, the proper irradiation is conducted in the sequence of from the section (50B) (section number 2), the section 50D (section number 4), to the section 50F (section number 6). That is, the proper irradiation onto the reference sections 51 is conducted from the bottom end toward the top end of the discharging area (41).

[0089] As described above, in the embodiment illustrated in FIG. 10, the temporary irradiation to the reference sections (51), the proper irradiations onto the adjacent sections (52), and the proper irradiation onto the reference sections (51) are conducted in a reciprocating manner on the discharging area (41). This makes it possible to minimize the behaviors of the irradiation unit (104) (carriage unit (102). In this description, the starting point of the temporary irradiation and the proper irradiation is set at the bottom end of the discharging area (41) but it can be also at the top end.

[0090] FIG. 14 is a diagram illustrating the comparison of the surface of a surface-treated discharging area (201) by a liquid discharging device of Comparative Example and the surface of the discharging area (41) surface-treated by the liquid discharging device (1) of the present disclosure. The border wrinkle (55) between the two sections (50A) and (50B) adjacent to each other is visually confirmed on the surface of the discharging area (201) relating to Comparative Example. Conversely, the border wrinkle (55) between the two sections (50A) and (50B) is not visually confirmed on the surface of the discharging area (41) relating to the present disclosure, demonstrating excellent smoothness. In FIG. 14, the vision referred to as (60) is a ghost image reflecting part of the luminous device during the photoshooting but not the state of the surfaces of the discharging areas (41) and (201).

[0091] The program to execute the function of the liquid discharging device (1) can be recorded and provided in a file installable or executable in a computer-readable recording medium such as CD-ROM, flexible disk, CD-R, digital versatile disc (DVD), etc.

[0092] It is possible to have a configuration such that the program can be stored in a computer (server) connected with a network such as the Internet and downloaded to the liquid discharging device (1) or the PC (131) via the network. It is also to have a configuration in which the program can be provided or distributed via a network. Moreover, the program can be installed into a storage such as the memory (122) and the PC (131) of the liquid discharging device (1) in advance. The program may have a module configuration including each function unit.

[0093] Below are descriptions about specific examples of the surface treatment conducted in the sequence illustrated in FIG. 7.

Acrylate-based Monomer

Examples 1 to 6

[0094] The materials of the following A to D were mixed in the mixing ratio shown in corresponding columns of each Example in Table 1 (the value is represented in parts by mass) and the ink of each Example was prepared according to a typical preparation method of inkjet ink.

A. Mono-functional Acrylate

A1: Acryloyl morpholine
A2: Benzyl acrylate
A3: Phenoxyethyl acrylate
A4: Isobonyl acrylate
A5: N-vinyl caprolactam

B. Multi-functional Acrylate

B1: 1.9-nonane diol acrylate
B2: bifunctional urethane acrylate (weight average molecular weight: 3,000)
B3: bifunctional urethane acrylate (weight average molecular weight: 4,000)

C. Inert Resin

C: Acrylic resin (weight average molecular weight: 5,000 to 10,000)

D: Photoradical Polymerization Initiator

D: 2-dimethylamino-2-(4-methylbenzyl)-1-(4-morpholine-4-yl-phenyl)butane-1-on (Carbon Black #10, manufactured by Mitsubishi Chemical Corporation) and a polymer dispersant (Solsperse 39000, manufactured by Lubrizol

Japan Ltd.) were mixed in a mass ratio of 3:1.

[0095] Ink used is as follows. FIG. 15 is a diagram illustrating an example of ink accommodation embodiment. FIG. 16 is a diagram illustrating an example of the ink cartridge (200) including an ink bag (241). The ink bag (pouch bag) (241) was sealed in to include ink not to let air bubbles into the bag. The ink bag (241) was filled with ink through an ink inlet (242). Subsequent to evacuation of air remaining in the ink bag (241), the ink inlet (242) was closed by fusion. When in use, an ink outlet (243) made of rubber was pierced by a needle. The ink bag (241) was formed of a packaging material such as aluminum laminate film having no air permeability. An ink cartridge accommodates the ink bag (241) in a plastic cartridge housing (244). The ink cartridge (200) was accommodated in a chassis and the ink was discharged onto the medium (21) from the ink cartridge (200) via ink flow passages communicating with an inkjet head (GEN4, manufactured by Ricoh Industry Company, Ltd.). The ink can be accommodated in a tank, which can be connected with the liquid discharging device (1) (image forming apparatus) from outside.

[0096] As illustrated in FIG. 6, when the irradiation width of one pass by the irradiation unit (104) was set as L, the ink was discharged onto the discharging area (41) having a width of 2L (the length D in the sub-scanning direction) to form a solid batch on the medium (21). Thereafter, as illustrated in FIG. 7, a temporary irradiation (1) was conducted on the section (50A) and thereafter a proper irradiation (2) was conducted onto the section (50B) followed by a proper irradiation (3) on the section (50A).

[0097] After the irradiations described above, whether or not there was the border wrinkle (55) was evaluated and the result is shown in Table 1. The border wrinkle (55) was evaluated according to the following criteria.

G (Good): No wrinkle visually observed
M (Marginal): Wrinkle slightly visually confirmed but causing no problem in terms of practical use.
P (Poor): Clear wrinkle visually observed

Table 1

	Example 1	Example 2	Example 3	Example 4	Example 5	Example 6
A1	40	10	20	10	20	40
A2	30				10	30
A3		25	20			
A4		25	40	30	20	
A5		25		30	20	
B1	20				10	15
B2			10		5	
B3				20	5	
C		5				
D	10	10	10	10	10	10
Carbon black						5
Temporary irradiation (mJ/cm^2)	300	200	400	250	300	500
Proper irradiation 2 (mJ/cm^2)	600	500	600	500	600	1000
Proper irradiation 3 (mJ/cm^2)	300	500	500	250	600	500
Border wrinkle	G	M	G	M	G	G

Methacrylate-based Monomer

Examples 7 to 10

[0098] Compounds having an SI value (indicating the degree of skin sensitization) of 1.6 in the skin sensitization test according to Local Lymph Note Assay (LLNA) method or compounds evaluated as "negative about skin sensitization" or "no skin sensitization" in Material Safety Data Sheet (MSDS) or a document were used.

E. Mono-functional Methacrylate

E1: t-butyl methacrylate (Acrylester TB, manufactured by Mitsubishi Rayon Co., Ltd.) "negative" on the evaluation according to a document (testing method: maximization method)
E2. n-pentylmethacrylate (n-Amylmethacrylate, manufactured by Zhangjiagang Render Chemical) "negative" on the evaluation according to a document (testing method: maximization method)

F. Multi-functional Methacrylate

F1. Glycerol dimethacrylate (701, manufactured by SHIN-NAKAMURA CHEMICAL CO., LTD.) SI value: 1.2
F2: Tricyclodecane dimethanol dimethacrylate (DCP, manufactured by Shin-Nakamura Chemical Co., Ltd.) SI value: 1.3

G. Photoradical Polymerization Initiator Negative About Skin Sensitization

G: 2-dimmethylamino-2-(4-methylbenzyl)-1-(4-morpholine-4-yl-phenyl)butane-1-one)(Irgacure 379, manufactured by BASF) SI value: None Evaluation on MSDS (testing method: OECD test guideline 406) Carbon Black #10, manufactured by Mitsubishi Chemical Corporation and a polymer dispersant (Solsperse 39000, manufactured by Lubrizol Japan Ltd.) were mixed in a mass ratio of 3:1.

[0099] The methacrylate-based monomers were evaluated in the same manner as the acrylate-based monomers and the evaluation result regarding the border wrinkle is shown in Table 2.

Table 2

	Example 7	Example 8	Example 9	Example 10
E1	40		20	40
E2		40	20	
F1	50		25	
F2		50	25	50
G	10	10	10	10
Carbon black				5
Temporary irradiation (mJ/cm^2)	800	1000	900	1000
Proper irradiation 2 (mJ/cm^2)	1500	2000	2000	2000
Proper irradiation 3 (mJ/cm^2)	800	1000	900	1000
Border wrinkle	G	G	G	G

Consideration

[0100] The results of Examples 1 to 6 and Examples 7 to 10 are discussed below. In general, the curing speed of acrylate-based monomers is faster than that of methacrylate-based monomers. Namely, the integral of light required for the proper irradiation on acrylate-based monomers is lower than the integral of light required for the proper irradiation on methacrylate-based monomers. The border wrinkle (55) is ascribable to the difference of the curing speed therebetween so that the probability of occurrence of the border wrinkle (55) rises as the curing speed increases. As seen in the results, the border wrinkle (55) was slightly visually observed in the case of the acrylate-based monomer having a particularly high curing speed (low level of integral of light in the proper irradiation) but did not cause a practical problem. Therefore, according to the sequence of the surface treatment illustrated in FIG. 7, no practical border wrinkle (55) causing a practical problem occurs.

Mixture of Acrylate-based Monomer and Methacrylate-based Monomer

Examples 11 to 15

[0101] Examples of mixtures of acrylate-based monomers and methacrylate-based monomers are shown in Table 3. When the proportion of the acrylate-based monomer in the mixture composition was about 80 percent, the curing speed increased and the border wrinkle (55) was slightly confirmed but causing no practical problem. The degree of the border wrinkle (55) was confirmed to be improved when the proportion of the acrylate-based monomer is reduced. Therefore, when utilizing a mixture (liquid mixture) of an acrylate-based monomer and a methacrylate-based monomer, it is preferable to set the proportion of the acrylate-based monomer not greater than 80 percent.

Table 3

	Example 11	Example 12	Example 13	Example 14	Example 15
A1	70	60	50	40	
B1	10	10	10	10	
C	5	5	5	5	5
E1	5	15	20	35	75
F1					10
D				10	
G	10	10	10		10
Carbon black			5		
Temporary irradiation (mJ/cm^2)	300	400	500	600	1000
Proper irradiation 2 (mJ/cm^2)	600	800	1000	1200	2000
Proper irradiation 3 (mJ/cm^2)	300	400	500	600	1000
Border wrinkle	M	G	G	G	G

[0102] According to the present disclosure, it is possible to improve surface smoothness of an object obtained by an active energy ray curable composition.

[0103] According to the present disclosure, it is possible to improve surface smoothness of an object obtained by an active energy ray curable composition.

[0104] The above-described embodiments are illustrative and do not limit the present invention. Thus, numerous additional modifications and variations are possible in light of the above teachings. For example, elements at least one of features of different illustrative and exemplary embodiments herein may be combined with each other at least one of substituted for each other within the scope of this disclosure and appended claims. Further, features of components of the embodiments, such as the number, the position, and the shape are not limited the embodiments and thus may be preferably set. It is therefore to be understood that within the scope of the appended claims, the disclosure of the present invention may be practiced otherwise than as specifically described herein.

[0105] The present invention can be implemented in any convenient form, for example using dedicated hardware, or a mixture of dedicated hardware and software. The present invention may be implemented as computer software implemented by one or more networked processing apparatuses. The processing apparatuses can compromise any suitably programmed apparatuses such as a general purpose computer, personal digital assistant, mobile telephone (such as a WAP or 3G-compliant phone) and so on. Since the present invention can be implemented as software, each and every aspect of the present invention thus encompasses computer software implementable on a programmable device. The computer software can be provided to the programmable device using any conventional carrier medium (carrier means). The carrier medium can compromise a transient carrier medium such as an electrical, optical, microwave, acoustic or radio frequency signal carrying the computer code. An example of such a transient medium is a TCP/IP signal carrying computer code over an IP network, such as the Internet. The carrier medium can also comprise a storage medium for storing processor readable code such as a floppy disk, hard disk, CD ROM, magnetic tape device or solid state memory device.

Claims

1. A liquid discharging device (1) comprising:

   a liquid discharging unit (11) to discharge a liquid including an active energy ray curable composition to an object (21) divided into multiple sections including a first section (51) and a second section (52) adjacent to the first section (51);
   an irradiator (12) to irradiate the liquid with active energy rays to allow the liquid to cure; and
   a moving unit (13) to move at least one of the irradiator (12) and the object (21) onto which the liquid is discharged,
   characterized in that the irradiator (12) conducts temporary irradiation on the first section (51) with the active energy rays in an integral of light less than a predetermined integral of light, irradiation on the second section (52) disposed in a direction perpendicular to a moving direction of the moving unit (13) with the active energy rays, and proper irradiation on the first section (51) with the active energy rays in an integral of light to be not less than the predetermined integral of light.

2. The liquid discharging device (1) according to claim 1, **characterized in that** the irradiation on the second section (51) is conducted with the active energy rays in an integral of light to be not less than the predetermined integral of light.

3. The liquid discharging device (1) according to claim 1, **characterized in that** the irradiation on the second section (51) is the temporary irradiation.

4. The liquid discharging device (1) according to claim 2, **characterized in that** when the number of the multiple sections is three or more, the first section (51) subjected to the temporary irradiation for the first time is selected from the multiple sections disposed not at both ends of the multiple sections.

5. The liquid discharging device (1) according to any one of claims 1 to 4, **characterized in that** the irradiator (12) starts irradiation with the active energy rays after a leveling time of the liquid discharged elapses.

6. The liquid discharging device (1) according to any one of claims 1 to 5, **characterized in that** a relative moving speed of the object (21) onto which the liquid is discharged against the irradiator (12) is faster at the temporary irradiation than the proper irradiation.

7. The liquid discharging device (1) according to any one of claims 1 to 6, **characterized in that** the liquid includes a coating agent for a predetermined surface treatment to a surface of the object (21).

8. The liquid discharging device (1) according to claim 7, **characterized in that** the object (21) includes an image formed on a medium (21).

9. The liquid discharging device (1) according to claim 7, **characterized in that** the object (21) includes a medium (21) on which an image is to be formed.

10. The liquid discharging device (1) according to any one of claims 1 to 6, **characterized in that** the liquid includes an ink with which an image is formed on a medium (21).

11. The liquid discharging device (1) according to any one of claims 1 to 10, **characterized in that** the active energy ray curable composition includes an acrylate-based monomer.

12. The liquid discharging device (1) according to any one of claims 1 to 10, **characterized in that** the active energy ray curable composition includes a methacrylate-based monomer.

13. The liquid discharging device (1) according to any one of claims 1 to 10, **characterized in that** the active energy ray curable composition is a liquid mixture of an acrylate-based monomer and a methacrylate-based monomer with the acrylate-based monomer accounting for 80 percent or less of a total amount of the liquid mixture.

14. A processing method comprising:

   discharging a liquid including an active energy ray curable composition to an object (21) including multiple sections including a first section (51) and a second section (52) adjacent to the first section (51) in a direction

perpendicular to a moving direction of a moving unit (13);
irradiating the liquid with active energy rays by an irradiator (12) to allow the liquid to cure;
moving at least one of the irradiator (12) and the object (21) onto which the liquid is discharged;
conducting temporary irradiation on the first section (51) with the active energy rays in an integral of light less than a predetermined integral of light,
conducting irradiation with the active energy rays on the second section (52), and
conducting proper irradiation on the first section (51) with the active energy rays in an integral of light to be not less than the predetermined integral of light.

15. A carrier means carrying computer readable code for controlling a computer to carry out the method of claim 14.

FIG. 1

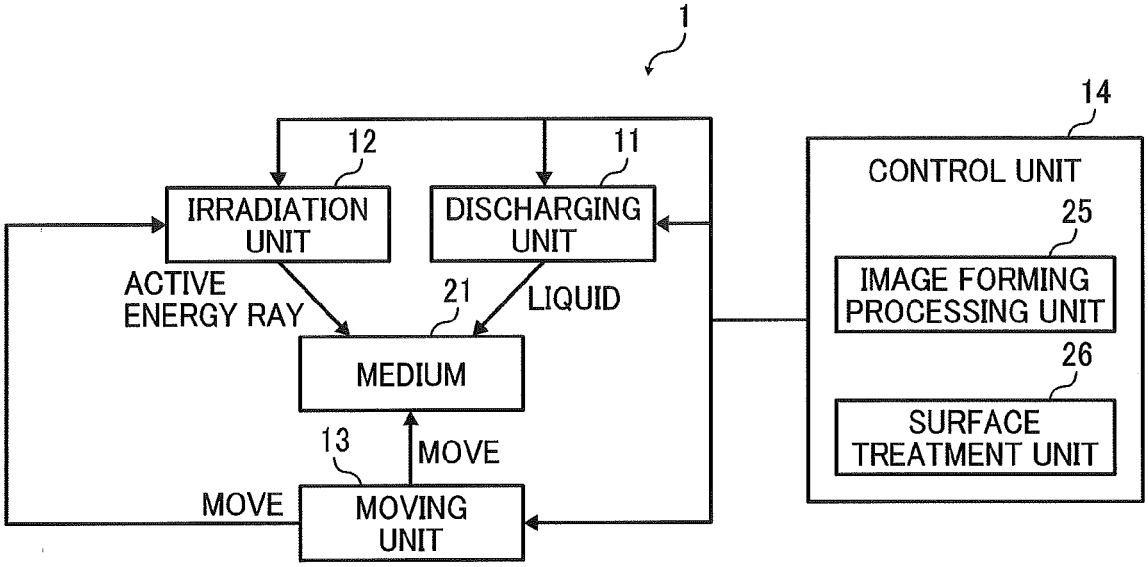

1
14
12
11
CONTROL UNIT
IRRADIATION UNIT
DISCHARGING UNIT
25
ACTIVE ENERGY RAY
21
LIQUID
IMAGE FORMING PROCESSING UNIT
MEDIUM
26
SURFACE TREATMENT UNIT
13
MOVE
MOVE
MOVING UNIT

FIG. 2

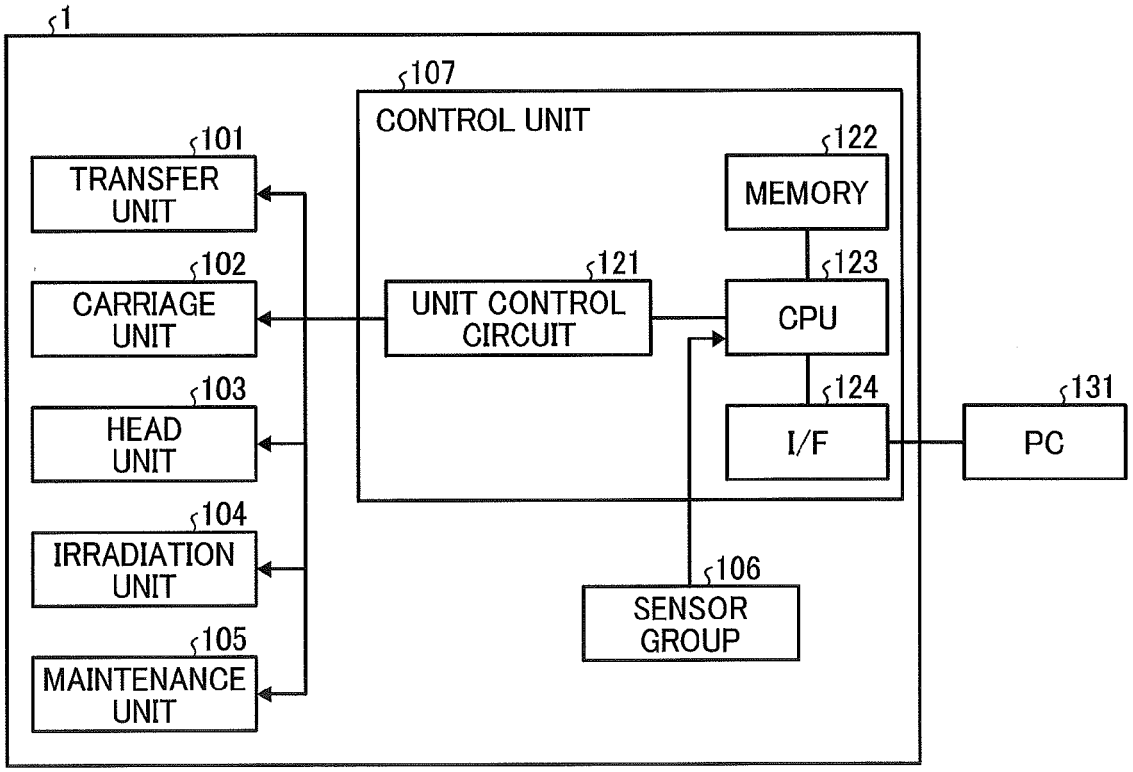

1
107
CONTROL UNIT
101
TRANSFER UNIT
122
MEMORY
102
121
123
CARRIAGE UNIT
UNIT CONTROL CIRCUIT
CPU
103
124
131
HEAD UNIT
I/F
PC
104
IRRADIATION UNIT
106
SENSOR GROUP
105
MAINTENANCE UNIT

FIG. 3

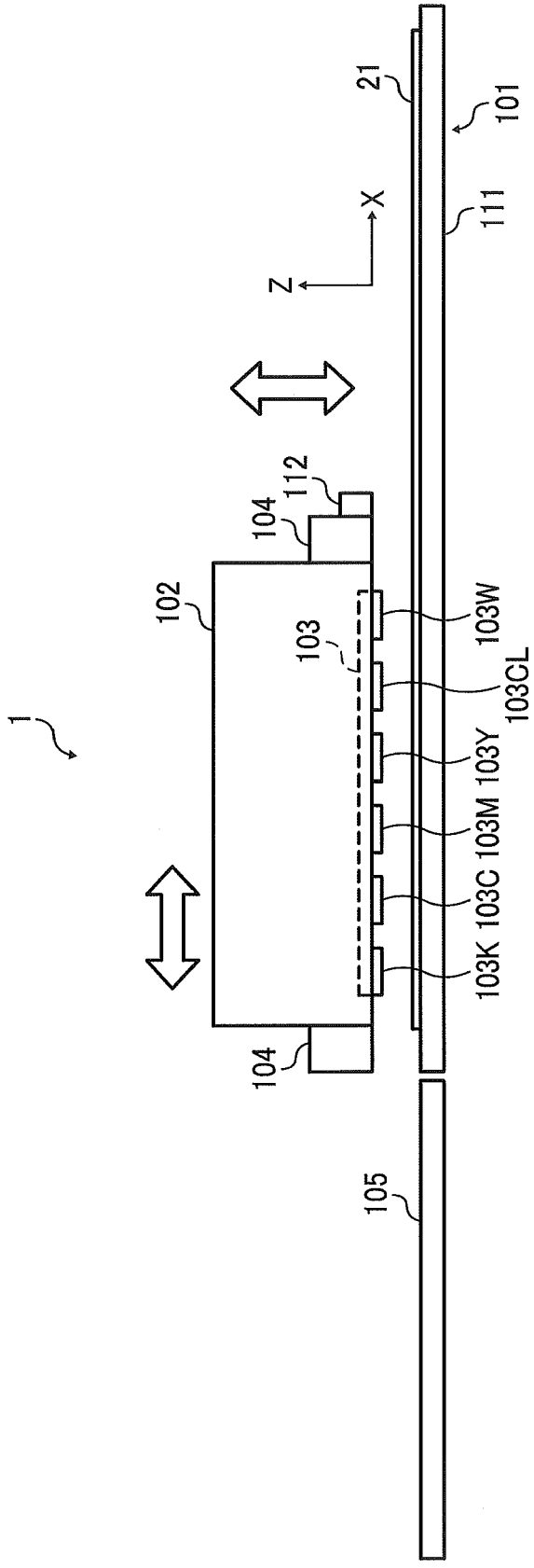

1
21
101
111
X
Z
112
104
102
103
103W
103CL
103Y
103M
103C
103K
104
105

FIG. 4

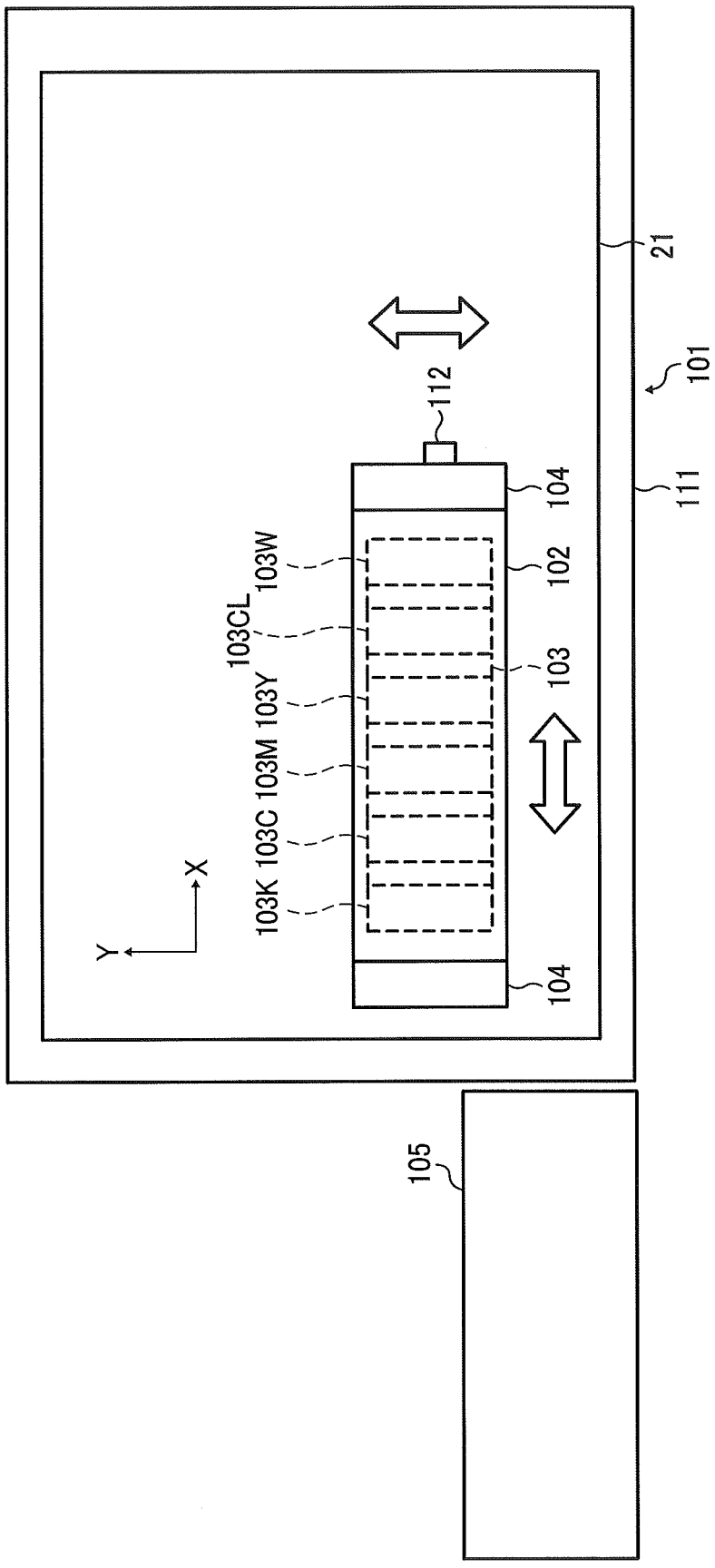

21
101
112
111
104
102
103W
103CL
103
103Y
103M
103C
103K
X
Y
104
105

FIG. 5

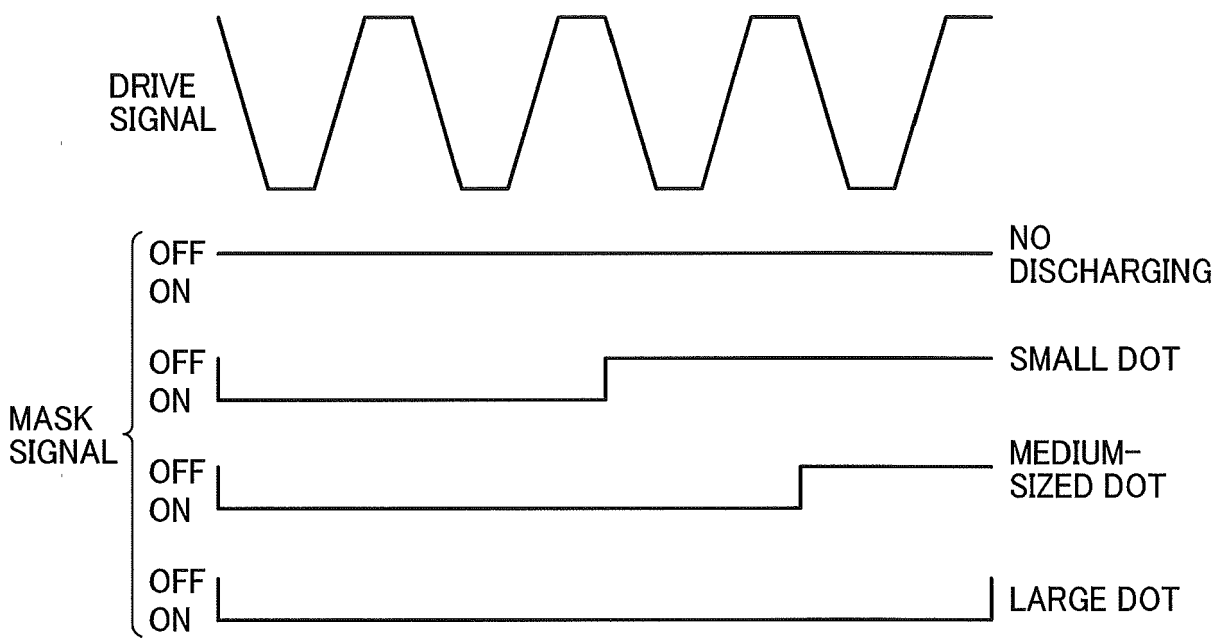
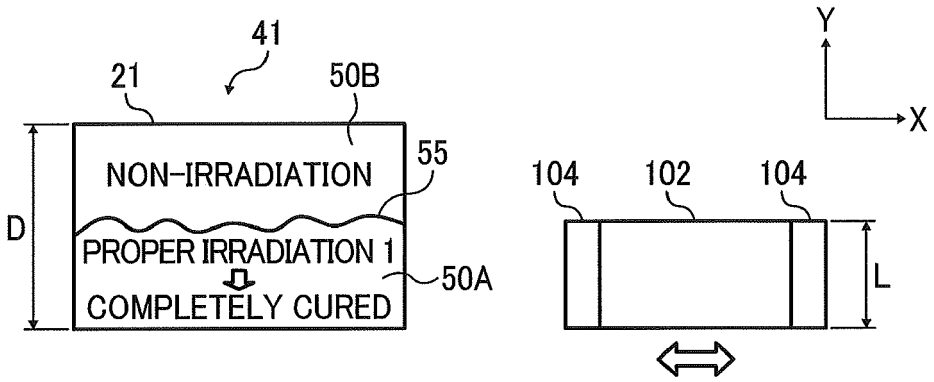
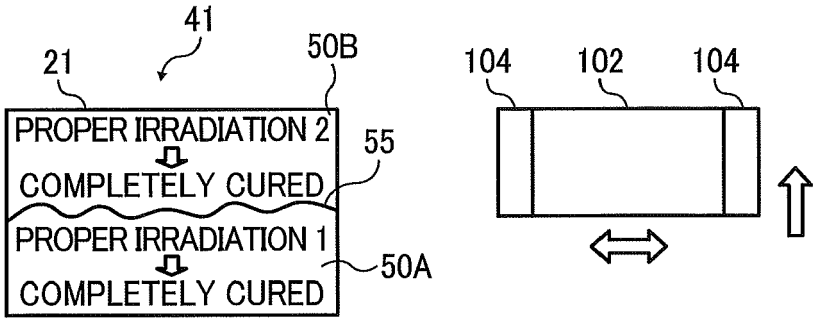

DRIVE SIGNAL
MASK SIGNAL
OFF
ON
NO DISCHARGING
SMALL DOT
MEDIUM-SIZED DOT
LARGE DOT

FIG. 6



FIRST IRRADIATION



SECOND IRRADIATION

FIG. 7

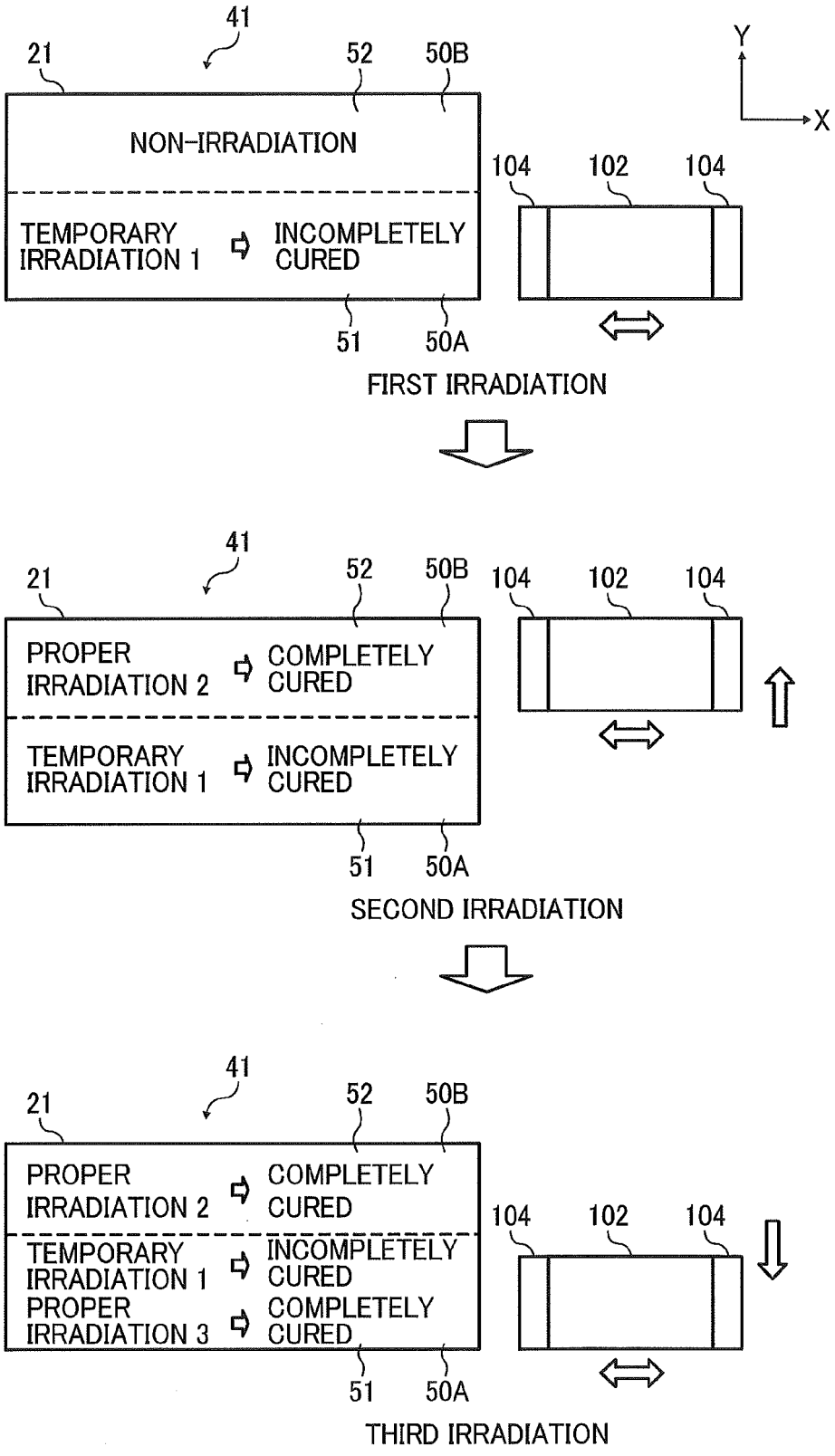

41
21
52
50B
Y
X
NON-IRRADIATION
TEMPORARY IRRADIATION 1
INCOMPLETELY CURED
104
102
104
51
50A
FIRST IRRADIATION
PROPER IRRADIATION 2
COMPLETELY CURED
SECOND IRRADIATION
PROPER IRRADIATION 3
THIRD IRRADIATION

FIG. 8

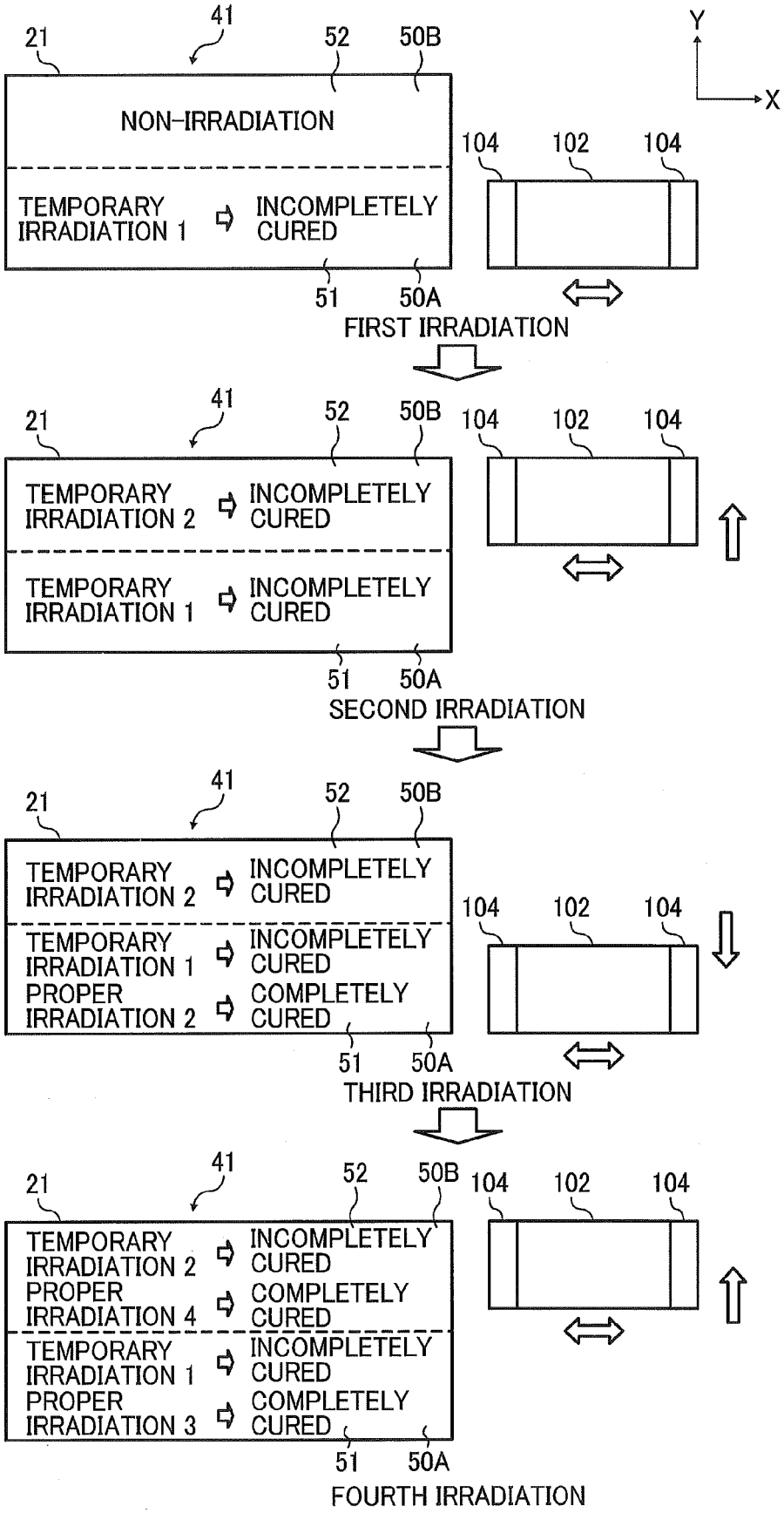

21
41
52
50B
Y
X
NON-IRRADIATION
TEMPORARY IRRADIATION 1 ⇨ INCOMPLETELY CURED
104
102
104
51
50A
FIRST IRRADIATION
TEMPORARY IRRADIATION 2 ⇨ INCOMPLETELY CURED
TEMPORARY IRRADIATION 1 ⇨ INCOMPLETELY CURED
SECOND IRRADIATION
PROPER IRRADIATION 2 ⇨ COMPLETELY CURED
THIRD IRRADIATION
PROPER IRRADIATION 4 ⇨ COMPLETELY CURED
PROPER IRRADIATION 3 ⇨ COMPLETELY CURED
FOURTH IRRADIATION

FIG. 9

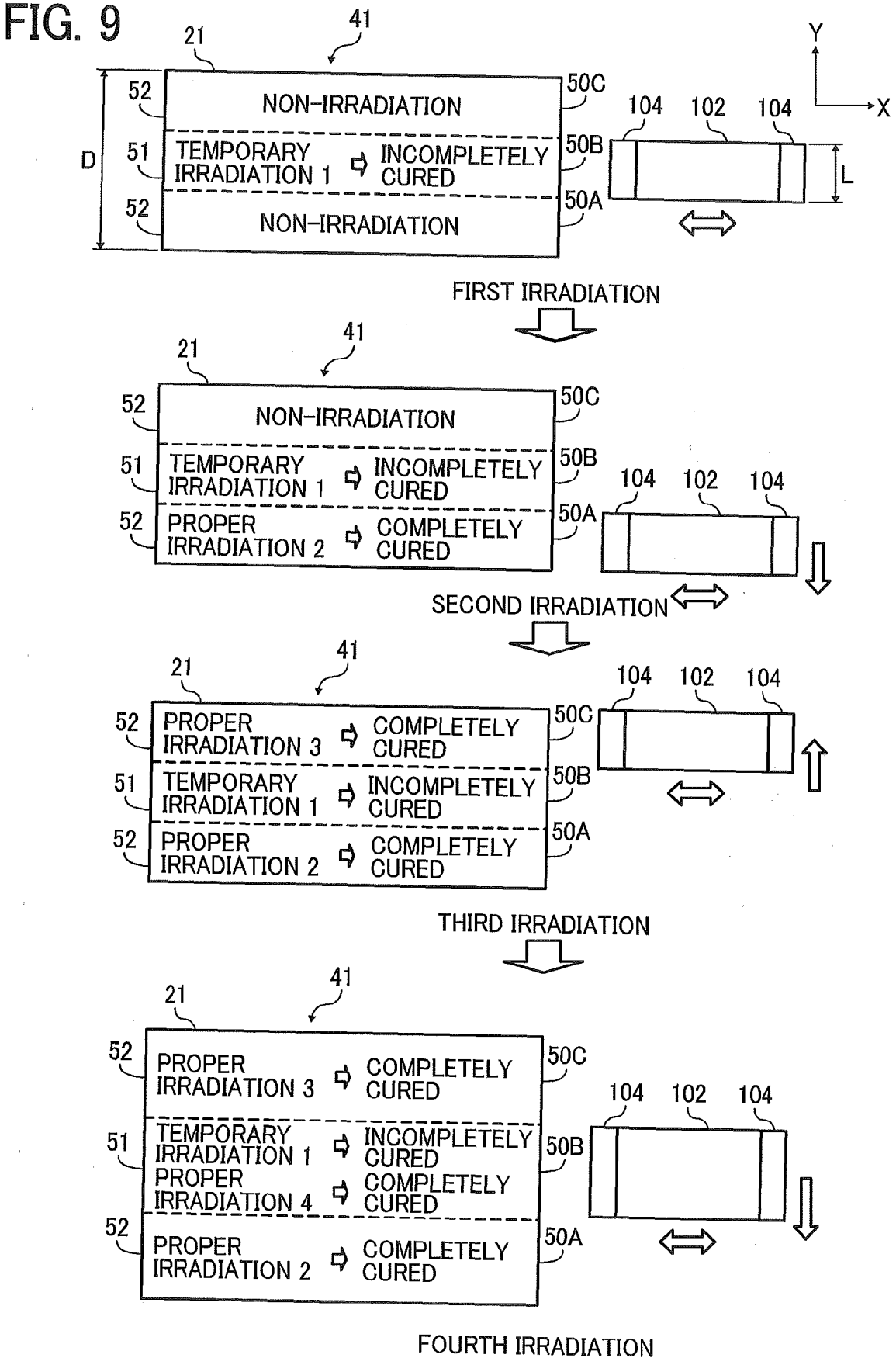

21
41
52
NON-IRRADIATION
50C
D
51
TEMPORARY IRRADIATION 1
INCOMPLETELY CURED
50B
52
NON-IRRADIATION
50A
104
102
104
Y
X
L
FIRST IRRADIATION
PROPER IRRADIATION 2
COMPLETELY CURED
SECOND IRRADIATION
PROPER IRRADIATION 3
COMPLETELY CURED
THIRD IRRADIATION
PROPER IRRADIATION 4
COMPLETELY CURED
FOURTH IRRADIATION

FIG. 10

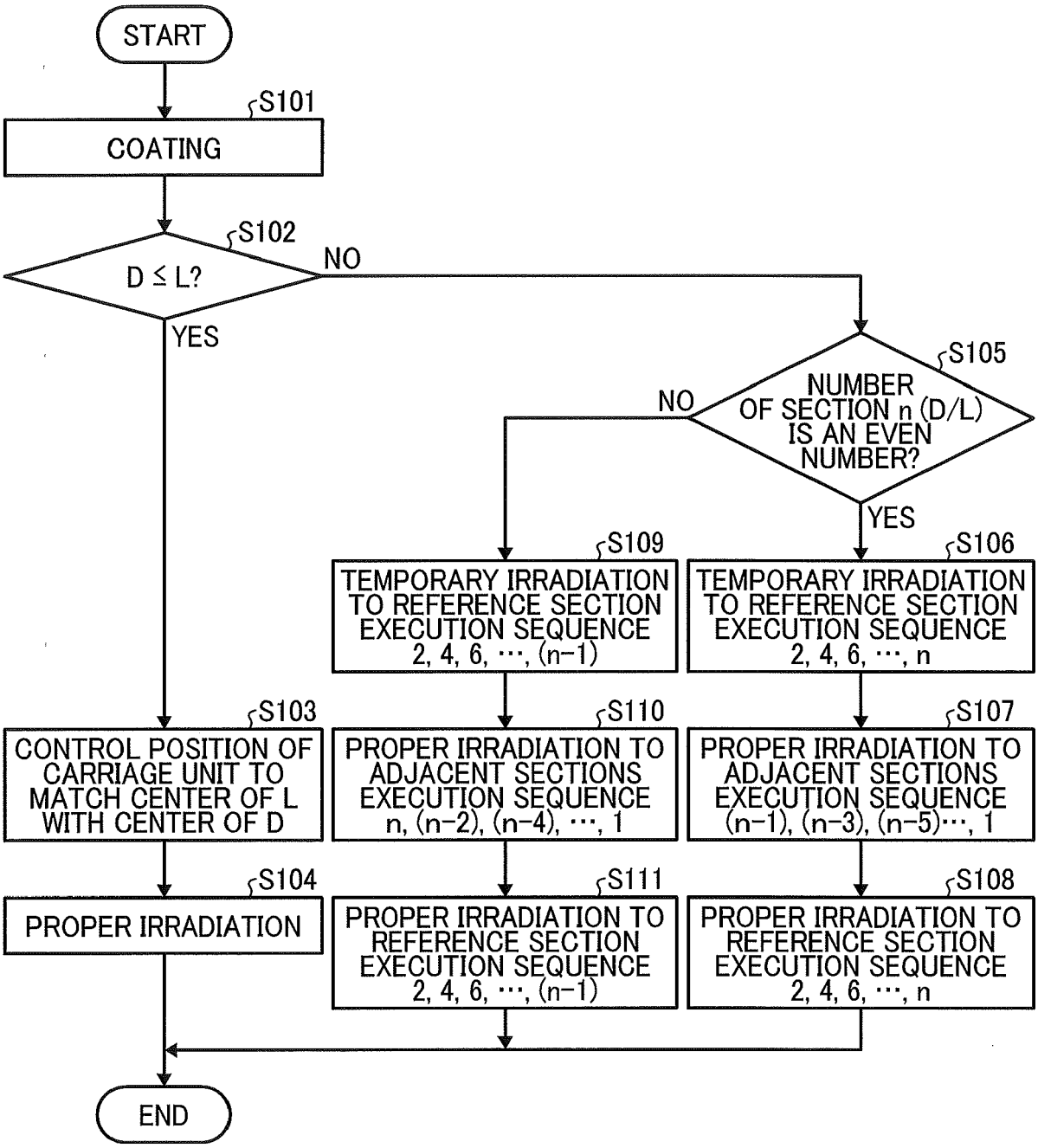
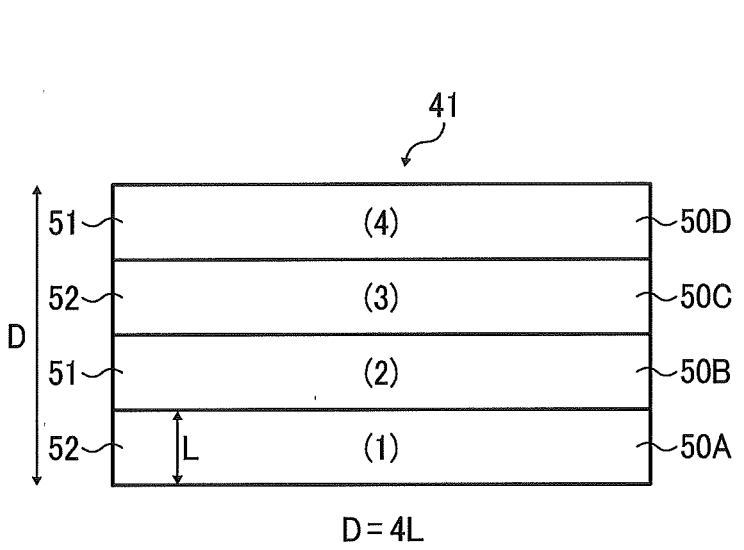

START
S101
COATING
S102
D ≤ L?
NO
YES
S105
NUMBER OF SECTION n (D/L) IS AN EVEN NUMBER?
NO
YES
S109
TEMPORARY IRRADIATION TO REFERENCE SECTION EXECUTION SEQUENCE 2, 4, 6, ···, (n-1)
S106
TEMPORARY IRRADIATION TO REFERENCE SECTION EXECUTION SEQUENCE 2, 4, 6, ···, n
S103
CONTROL POSITION OF CARRIAGE UNIT TO MATCH CENTER OF L WITH CENTER OF D
S110
PROPER IRRADIATION TO ADJACENT SECTIONS EXECUTION SEQUENCE n, (n-2), (n-4), ···, 1
S107
PROPER IRRADIATION TO ADJACENT SECTIONS EXECUTION SEQUENCE (n-1), (n-3), (n-5)···, 1
S104
PROPER IRRADIATION
S111
PROPER IRRADIATION TO REFERENCE SECTION EXECUTION SEQUENCE 2, 4, 6, ···, (n-1)
S108
PROPER IRRADIATION TO REFERENCE SECTION EXECUTION SEQUENCE 2, 4, 6, ···, n
END

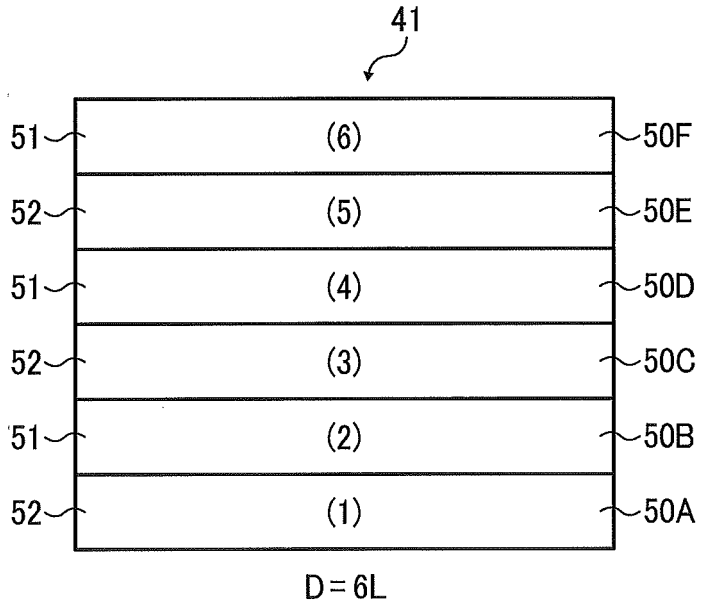
FIG. 11



45

TEMPORARY IRRADIATION	PROPER IRRADIATION
2	6
	3
1	5
	4

FIG. 12



45

TEMPORARY IRRADIATION	PROPER IRRADIATION
3	9
	4
2	8
	5
1	7
	6

FIG. 13

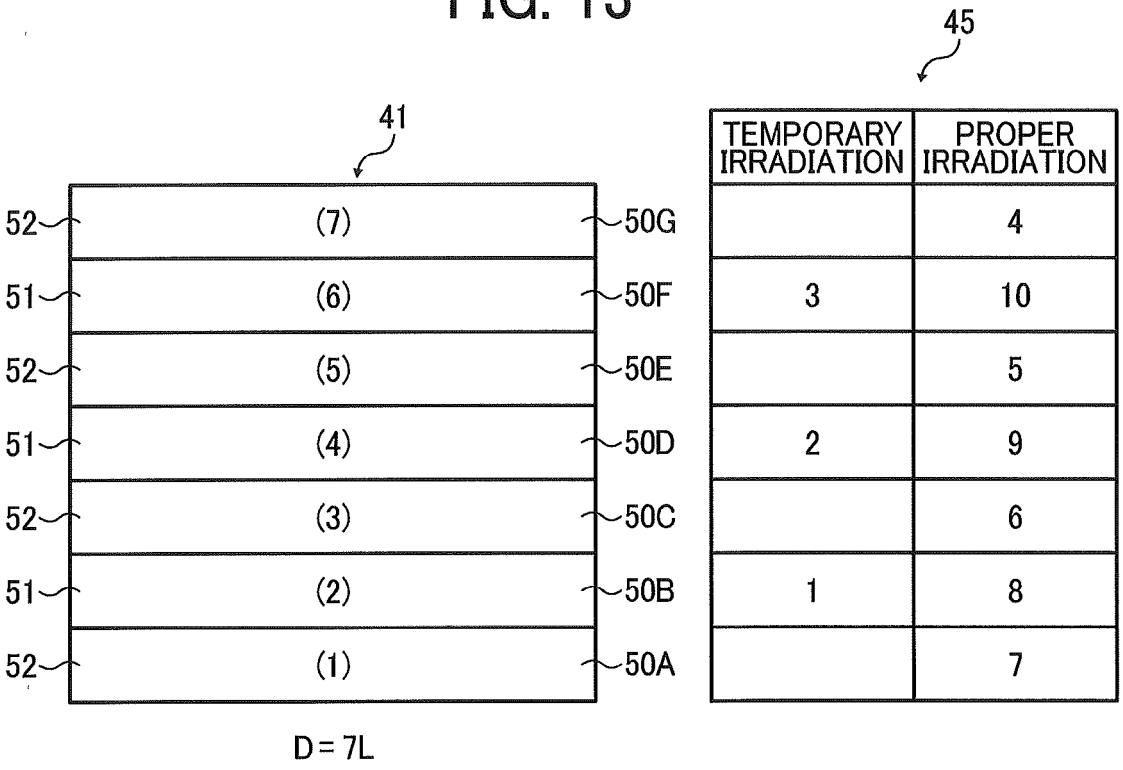

41
45
52
51
52
51
52
51
52
(7)
(6)
(5)
(4)
(3)
(2)
(1)
50G
50F
50E
50D
50C
50B
50A
D = 7L
TEMPORARY IRRADIATION
PROPER IRRADIATION
4
3
10
5
2
9
6
1
8
7

FIG. 14

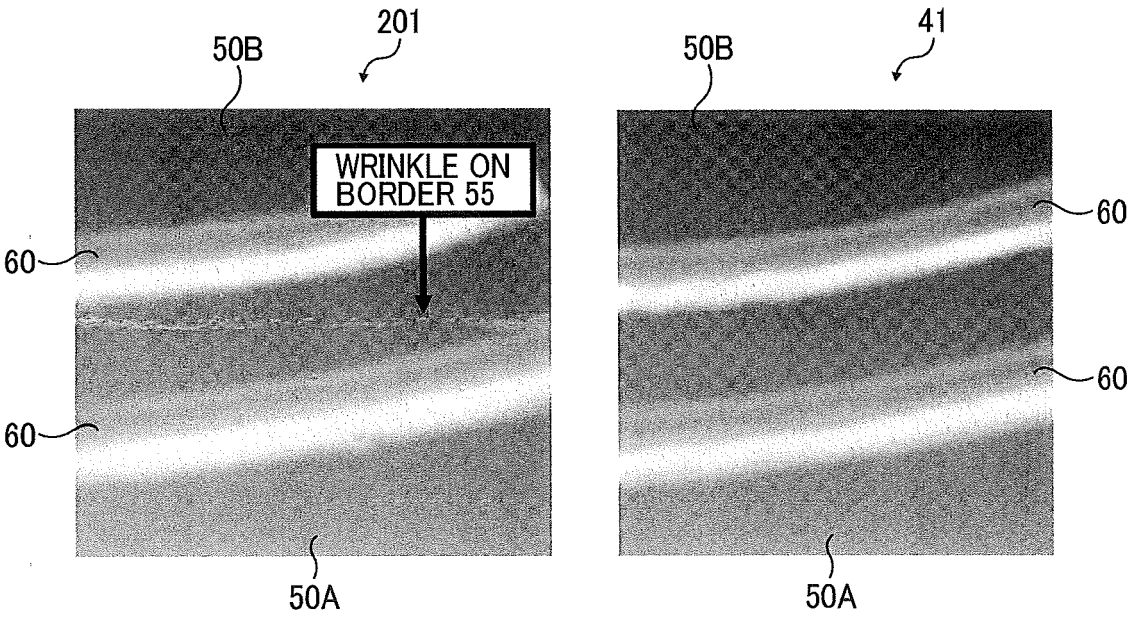

50B
201
WRINKLE ON BORDER 55
60
60
50A
50B
41
60
60
50A

FIG. 15

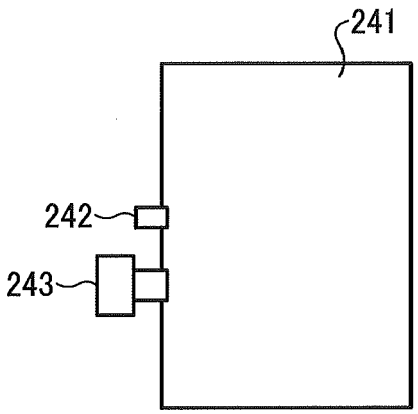
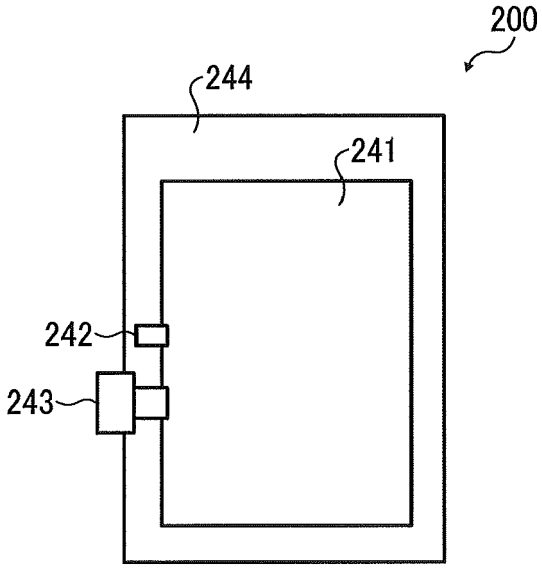


FIG. 16



Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 17 17 0398

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	US 2011/069128 A1 (ONISHI HIROYUKI [JP]) 24 March 2011 (2011-03-24) * paragraph [0078] - paragraph [0083]; figures 6A,6B,6C,6D * -----	1-10,14, 15 11-13	INV. B41J11/00 B41M7/00
Y	US 2014/240414 A1 (HIRAOKA TAKAO [JP]) 28 August 2014 (2014-08-28) * paragraph [0019] - paragraph [0021] * -----	11-13	

TECHNICAL FIELDS SEARCHED (IPC)

B41J
B41M

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	4 October 2017	Wehr, Wolfhard

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 17 17 0398

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

04-10-2017

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2011069128 A1	24-03-2011	JP 2011062995 A	31-03-2011
		US 2011069128 A1	24-03-2011
US 2014240414 A1	28-08-2014	BR 112014011047 A2	02-05-2017
		CA 2854278 A1	16-05-2013
		CN 103917612 A	09-07-2014
		EP 2776520 A1	17-09-2014
		JP 5803583 B2	04-11-2015
		JP 2013095910 A	20-05-2013
		KR 20140083003 A	03-07-2014
		KR 20160150655 A	30-12-2016
		RU 2014123371 A	20-12-2015
		SG 11201400752Q A	28-04-2014
		US 2014240414 A1	28-08-2014
		WO 2013069580 A1	16-05-2013

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2008087221 A **[0003]**
- JP 2012106367 A **[0004]**
- JP 2015071718 A **[0005]**

Non-patent literature cited in the description

- *Contact Dermatitis,* 1982, vol. 8, 223-235 **[0035]**
- *Functional Material,* September 2005, vol. 25 (9), 55 **[0036]**