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(54) Image forming method.

(57) A thermal development-type photosensitive member (11) is exposed imagewise and then heated to form an image thereon. In this instance, a density deviation liable to occur in the resultant image due to a difficulty in temperature control during the thermal development is suppressed by forming a test image, measuring an optical density of the test image, and correcting energy of the exposure based on the measured optical density to form an objective image.

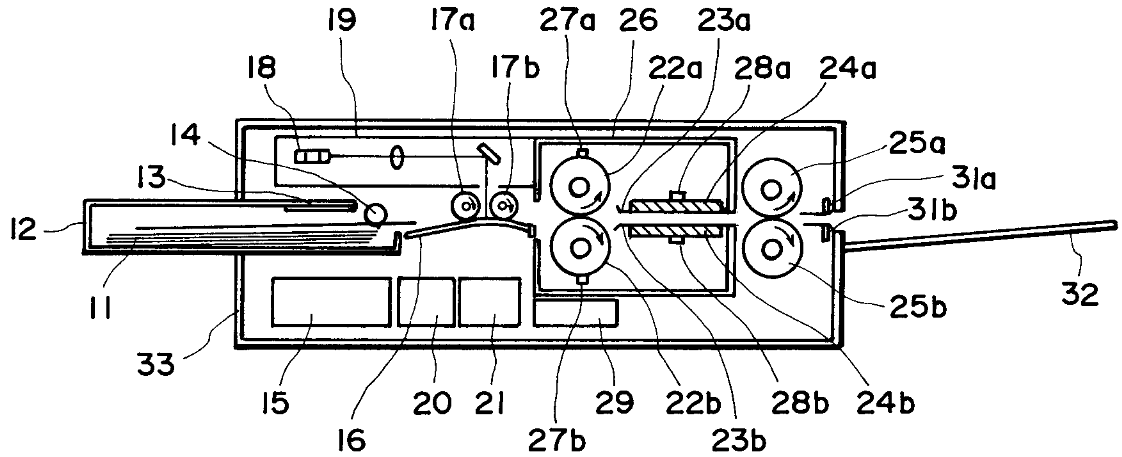

FIG. 1

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FIELD OF THE INVENTION AND RELATED ART

The present invention relates to an image forming method wherein a thermal development-type photosensitive member is exposed imagewise to light and subjected to thermal development to form an image, particularly such an image forming method wherein the imagewise exposure quantity is corrected so as to obviate a density deviation or irregularity in the resultant images.

The silver salt photography using a silver halide is excellent in resolution and gradation characteristic and has hitherto been widely adopted as a recording technology. However, the process includes wet processing steps of development, termination thereof and fixing after the imagewise exposure and is therefore inferior in processibility, simplicity and safety, which have been regarded as problematic. On the other hand, dry-process materials free from such wet treatments have also been studied and disclosed in, e.g., Japanese Patent Publication (JP-B) 43-4921 and JP-B 43-4924. These materials comprise a photosensitive silver halide in a catalytic amount and a non-photosensitive organic silver salt as an image forming material. The organic silver salt has been considered to function as an image forming material in the following mechanism. That is, (1) as a result of the imagewise exposure, silver nuclei are formed from the photosensitive silver halide in a catalystic amount to provide a latent image, and (2) when the photosensitive member is heated, the organic silver salt and a reducing agent cause an oxidation-reduction reaction with the silver nuclei as the catalyst to reduce the organic silver salt into silver which forms an image.

Such a thermal development-type photosensitive member has been adopted as a photosensitive material for various industries, such as image communication, medical field and outputting from computers.

Various proposals have been made regarding thermal development of an imagewise exposed thermal development-type photosensitive member. Among these, representative thermal development methods include: heating of a photosensitive member by a heat-generating heater, radiation heating using infrared rays or microwave, and heat generation by current conduction through a carbonations conductor layer disposed on the back side of a photosensitive member. The most popular among these is the heating by a heat-generating heater, inclusive of those disclosed in Japanese Laid-Open Patent Application (JP-A) 61-134761, JP-A 61-137152, JP-A 61-134761, JP-A 54-130025, JP-A 54-153426, JP-A 59-104648, JP-A 60-135947, JP-A 60-143338 and JP-A 61-173230.

A thermal development-type photosensitive member results in remarkably different image densities depending on thermal development temperatures and is therefore usually temperature-controlled so as not to change the thermal development temperature by placing a temperature sensor close to the heat source.

However, it has been very difficult to control the heat source temperature so as not to change the image density because a certain length of time is required from temperature detection by the sensor until the time when the heat source reaches a set temperature.

SUMMARY OF THE INVENTION

A principal object of the present invention is to provide an image forming method capable of providing images free from a density irregularity or deviation.

According to the present invention, there is provided an image forming method, comprising exposure and heating of a thermal development-type photosensitive member, wherein said method further including the steps of: forming a test image, measuring an optical density of the test image, and correcting energy of the exposure based on the measured optical density to form an objective image.

These and other objects, features and advantages of the present invention will become more apparent upon a consideration of the following description of the preferred embodiments of the present invention taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a sectional view of an image forming apparatus for practicing an embodiment of the image forming method according to the present invention.

Figure 2 is a plan view of a test image to be formed in an embodiment of the image forming method according to the present invention.

Figure 3 is a graph for determining a correction quantity of exposure energy in an embodiment of the image forming method according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

In the image forming method according to the present invention, a thermal development-type photosensitive member is exposed to light and then heated (thermally developed) to form an image corresponding to an exposure pattern.

In the image forming method according to the present invention, a thermal development-type photosensitive member is first exposed to a uniform intensity (i.e., a prescribed energy) of light and then heated to form a test image. The test image thus formed is ideally free from irregularity or deviation in optical density. However, because of a factor such as a heating temperature change during the thermal development, the test image is usually accompanied with a density deviation (i.e., a density distribution or irregularity).

Then, the optical density of the test image is measured by a densitometer to detect a density deviation in the test image.

Finally, based on the detected density deviation, the exposure energy of the light source is corrected to form an objective image free from density deviation. More specifically, a part expected to provide a lower optical density based on the detected density deviation is supplied with an increased exposure energy, whereas a part expected to provide a higher optical density is supplied with a decreased exposure energy.

The test image may be formed by exposing a whole image region (i.e., the entirety of a region where a image is formed) and heating the whole image region or may comprise an assembly of image portions (or spots or points) where optical densities are arranged as shown in Figure 2. The test image may preferably comprise a regularly arranged pattern so as to facilitate a density deviation (or distribution) in the image region. The test image shown in Figure 2 comprises a pattern of regularly arranged 25 (= 5x5) square spots or pixels (each measuring 7 mm x 7 mm). By measuring the density of the respective square spots in the test image, it is possible to know the density deviation occurring in the image region. The accuracy of density deviation detection may be increased by increasing the number of detection spots but too many spots provide no substantial meaning. The detection spots may preferably be arranged at 2 - 15 points, more preferably 3 - 10 points, in each of longitudinal and transverse directions.

Hereinbelow, an embodiment of the image forming method according to the present invention will be described with reference to Figure 1 showing an apparatus therefor.

Referring to Figure 1, the image forming apparatus includes a detachably mounted cassette 12 in which sheets of a thermal development-type photosensitive member 11 are stored.

Each sheet of thermal development-type photosensitive member comprises a photosensitive layer containing an organic silver salt, a reducing agent and a silver halide as will be described in further detail hereinafter. When such a thermal development-type photosensitive member is exposed imagewise, silver nuclei are formed from the silver halide at the exposed parts to form a latent image. During a subsequent heating, at portions where the latent image is formed, the organic silver salt and the reducing agent cause an oxidation-reduction reaction therebetween to reduce the organic silver salt into silver, which forms an image. The silver nuclei formed by the exposure function as a catalyst for the oxidation-reduction reaction.

The inside of the cassette 12 is optically masked by a shutter 13 before it is installed in the apparatus. When the cassette 12 is installed in the apparatus, the shutter 12 is opened and a supply roller 14 is caused to descend onto the sheets of photosensitive member 11 in the cassette. The apparatus is driven under the control of a controller 15.

The supply roller 14 is rotated to feed out the photosensitive member 11. A sheet of the photosensitive member 11 taken out from the cassette 12 is guided to an imagewise exposure section along a conveyance guide 16, and conveyer rollers 17a and 17b in the exposure section also start to rotate to convey the photosensitive member to a prescribed position (imagewise exposure start position). Thereafter, the supply roller 14 and the conveyor rollers 17a and 17b are stopped.

In the imagewise exposure section, the photosensitive member 11 is exposed imagewise to laser light supplied from a semiconductor laser scanner exposure apparatus 19 including a semiconductor laser (not shown) and a polygonal mirror 18.

The conveyor rollers 17a and 17b are caused to rotate in synchronism with the operation of the semiconductor laser scanner exposure apparatus 19 to convey the photosensitive member 11 while imagewise exposure is effected. The semiconductor laser is driven by a laser driver 20 and an image signal generating apparatus 21.

The exposure apparatus may comprise any type capable of effecting imagewise exposure depending on given image signals, inclusive of CRT, FOT, LED, LED array, LCD and PLZT shutter array, and fluorescent lamp, instead of the above-mentioned semiconductor scanner exposure apparatus 19.

The photosensitive member 11 thus subjected to imagewise exposure is conveyed by the conveyor rollers 17a and 17b to a thermal development section, where thermal development is effected.

The thermal development section includes heating rollers 22a and 22b, conveyance guides 23a and 23b, heat-generating members 24a and 24b, cooling rollers 25a and 25b, and an insulating member 26. The heating rollers 22a and 22b may comprise, e.g., silicone rubber. At the cores of the heating rollers 22a and 22b, halogen lamps are disposed as heaters. The heating rollers 22a and 22b are rotated at speeds identical to those of the conveyor roller 17a and 17b to effect thermal development while conveying the photosensitive member 11. The photosensitive member 11 is further guided by the conveyance guides 23a and 23b in the thermal development section to reach the cooling rollers 25a and 25b. The conveyance guides 23a and 23b are provided with heating members 24a and 24b, respectively, of a heat-generating silicone rubber sheet for effecting thermal development simultaneously conveying the photosensitive member 11. The thermal development of the photosensitive member 11 is terminated by cooling with the cooling rollers 25a and 25b. The cooling rollers 25a and 25b are rotated at identical speeds as the heating rollers 22a and 22b to discharge the photosensitive member 11 out of the apparatus.

In the above-described manner, a test image as shown in Figure 2 including square spots a_1 - a_{25} is formed on a thermal development-type photosensitive member 11. Then, each of the test spots a_1 - a_{25} is subjected to measurement of the optical density by using an optical densitometer (e.g., "NLM-STD-Tr", available from Narumi Shokai K.K.).

From the optical densities of the test spots a_1 - a_{25}, it is possible to predict a temperature deviation leading to a density deviation occurring in an objective image formed by the image forming apparatus.

In the image forming method according to the present invention, an objective image is formed in a similar manner as above for formation of a test image but the exposure energy quantity during the objective image formation is corrected based on the measured optical densities of the test spots a_1- a_{25}, e.g., through determination of temperature deviations at the test spots. More specifically, a part expected to provide a lowering in density based on the corresponding test spot is supplied with an increased exposure energy and a part expected to provide an elevation in density is supplied with a decreased exposure energy, e.g., based on deviated temperature at the parts.

The correction quantity of imagewise exposure energy is determined depending on the degree of deviation of the test image density from a reference optical density (objective optical density). The correction quantity of imagewise exposure energy may for example be determined by using a graph as shown in Figure 3.

Figure 3 is a graph showing a relationship between the light energy E during imagewise exposure and the resultant optical density (O.D.), e.g., at thermal development temperatures of 114.0 °C, 114.5 °C, 115.0 °C, 115.5 °C and 116.0 °C for a thermal development time of 15 sec. A relationship as shown by a graph of Figure 3 is determined according to the kind of a thermal development-type photosensitive member used. Accordingly, prior to practicing the image forming method according to the present invention, it is appropriate to prepare a graph as shown in Figure 3 corresponding to the kind of a photosensitive member used. A graph as shown in Figure 3 may easily be obtained by forming images at varying exposure energies and varying thermal development temperatures for a certain period corresponding to the thermal development means used and measuring the optical densities of the resultant images.

According to Figure 3, when an image formation is performed at an exposure energy E_0 and a thermal development temperature of 115.0 °C, it is expected to obtain an image having an O.D. = 0.7. In the thermal development step, however, the heating temperature is liable to be lowered because some heat is transferred to the photosensitive member as the photosensitive member is moved. As a result, the resultant image density is liable to be lowered. For example, a test spot a_{18} in a test image shown in Figure 2 may be formed at an O.D. = 0.6. Incidentally, an arrow A in Figure 2 represents the direction of progress of the photosensitive member.

In the case where the test spot a_{18} is formed at an O.D. = 0.6, it is understood that the test spot a_{18} is thermally developed at 114.5 °C from Figure 3. Further, it is also understood from Figure 3 that, even if the thermal development temperature is 114.5 °C, an objective O.D. = 0.7 can be obtained if the imagewise exposure energy is increased to E_1. Further, when an O.D. = 0.4 is desired at such a deviated temperature of 114.5 °C, the objective O.D. = 0.4 can be attained at a decreased imagewise exposure energy of E_2.

Accordingly, in a subsequent objective image formation cycle, a corrected exposure energy of E_1 or E_2 may be supplied to a part corresponding to a test spot a_{18} depending on whether an O.D. = 0.7 or 0.4 is desired.

The above-mentioned correction operation is effected at parts of all the test spots a_1 - a_{25}, whereby, an excellent objective image free from density deviation (sometimes density lowering) can be obtained. An increased number of curve as shown in the graph of Figure 3 may be obtained so as effect a more accurate correction by using an increased number of thermal development temperatures with a smaller pitch. However, there is a practical limit in lowering the temperature pitch, and it is practical to use a graph including ca. 5 curves at a temperature pitch of ca. 0.5 °C for obtaining an approximate correction quantity of exposure energy. Between the curve temperatures, it is appropriate to use the closest curve or more accurately use an exposure quantity obtained by interpolation between the curves.

In the apparatus shown in Figure 1, the heating rollers 22a and 22b, and heating members 24a and 24b are provided with temperature sensors 27a, 27b, 28a and 28b respectively, and the outputs from the temperature sensors 27a, 27b, 28a and 28b are fed back to a temperature controller 29 so as to control the temperatures of the heating rollers 22a and 22b and the heating members 24a and 24b at constant.

The constant temperature control of the thermal development temperature by feedback of the detection results of temperature sensors can result in a irregular temperature change around a central value of the temperatures of the heating rollers and the heating members when minutely examined. Such an irregular temperature change, while it is very delicate, can result in a density deviation in the objective image.

In such a case, it is appropriate not to effect a such a feedback constant temperature control of the thermal development temperature but effect such a control that the thermal development temperature will decrease or increase with time with a certain regularity, more preferably that the thermal development temperature will decrease with time with a certain regularity. More specifically, the thermal development means (inclusive of the heating rollers 22a and 22b and the heating members 24a and 24b) are kept at constant temperatures while they are not used in thermal development operation, and the energy supply to the thermal development means is terminated immediately before the commencement of the thermal development operation so that the thermal development temperature is allowed to naturally cool, i.e., decrease with a regularity, and the photosensitive member is heated by the remaining heat of the thermal development means.

Alternatively, it is also appropriate to apply a repetition of controlled pulsed energies according to a certain periodicity. In this instance, the pulses may preferably be applied at a frequency of 0.1 - 100 Hz, further preferably 0.5 - 50 Hz, and a pulse duty of 10 - 75 %, more preferably 20 - 75 %.

As the light source for the imagewise exposure, it is also possible to use a gas laser or an LED in addition to the semiconductor laser. The imagewise exposure energy on the photosensitive member may preferably be 0.5 - 20 $\mu J/cm^2$, more preferably 1.0 - 10 $\mu J/cm^2$.

The thermal development temperature may preferably be 60 - 200 °C, further preferably 70 - 150 °C. The heating time for the thermal development may preferably be 1 sec to 3 min, more preferably 3 sec to 60 sec.

The thermal development-type photosensitive member used in the present invention may comprise a photosensitive layer on a support. The photosensitive layer may comprise at least an organic silver salt, a reducing agent and a silver halide.

Preferred examples of the organic silver salt may include silver salts of organic acids, silver salts of acetylene derivatives and silver salts of organic compounds having an imino group or a mercapto group. A particularly preferred example of the organic acid silver salt is silver behenate.

The reducing agent may comprise a phenol compound, a hydrazine compound, a naphthol compound or a pyrazolidone compound.

Examples of the phenol compound may include: aminophenol, 2,6-dichloroaminophenol, 4,4'-dihydroxy-3,3'-di-t-butyl-5,5'-dimethylbiphenyl, 2,2'-dihydroxy-3,3',5,5'-tetrakis-t-butylbiphenyl, 2,2'-dihydroxy-3,3'-dichlorobiphenol, 2,2'-methylenebis(6-t-butyl-4-methylphenol), 2,2'-propylenebis(6-t-butyl-4-ethylphenol), 4,4'-butylindenebis(2-t-butyl-6-methylphenol), 4,4'-thiobis(2-t-butyl-6-ethylphenol), and 2,6-dichloro-4-benzenesulfoneamidephenol.

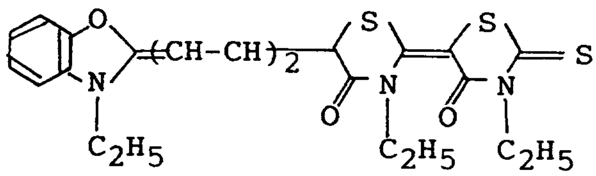
Examples of the hydrazine compound may include: β-acetylphenylhydrazine, and β-acetyltolylhydrazine.

Examples of the naphthol compound may include: 4-methoxynaphthol, 4-chloronaphthol, 4,4'-methylenebis(2-methylnaphthol), 4-(2,6-dimethyl-4-hydroxybenzyl)-2-methylnaphthol, and 4-(2-t-butyl-6-ethyl-4-hydroxybenzyl)-2-methylnaphthol.

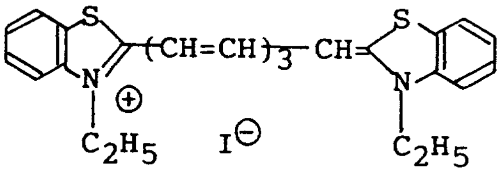
The pyrazolidone compound may for example be 1-phenyl-3-pyrazolidone.

Examples of the silver halide may include: silver chloride, silver bromide, silver iodide, silver iodobromide, silver chlorobromide, and silver iodochlorobromide. The silver salt can be doped with an Ir compound. The silver halide may effectively comprise a fine particulate form and particularly cubic crystal particles of 0.01 μm - 0.2 μm. Such a silver halide in a fine particulate form may for example be prepared by halogenating an organic silver salt with a silver halide-forming component, such as ammonium bromide, lithium bromide, sodium chloride, or N-bromosuccinic acid imide.

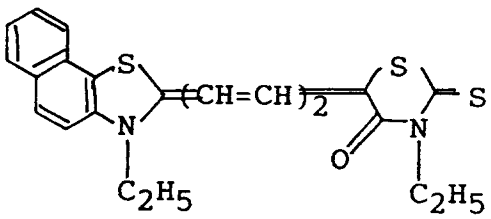
It is possible to use a silver halide subjected to sulfur sensitization, noble metal sensitization, reduction sensitization, etc. It is also possible to use various sensitizing dyes for spectral sensitization. The sensitizing dyes may for example include cyanine dyes and merocyanine dyes. Specific examples thereof may include those represented by the following formulae:



(I)



(II)



(III)

The photosensitive layer may be formed by mixing the above components together with a binder. The binder may preferably comprise a hydrophobic or hydrophilic polymer which may be transparent or semi-transparent. It is particularly preferred to use a hydrophobic binder. Preferred examples of the binder may include: polyviyl butyral, cellulose acetate butyrate, polymethyl methacrylate, polyester, polyvinyl chloride and copolymerization product of these polymers.

The support may for example comprise polyethylene, polypropylene, polyethylene terephthalate, polycarbonate, paper, synthetic paper, baryta paper for photography, or art paper.

In the photosensitive layer, the above-mentioned components may preferably be contained in the following ratios.

The reducing agent may preferably be contained in 0.05 - 3 mols, more preferably 0.2 - 1.3 mols, per 1 mol of the organic silver salt.

The organic silver salt may preferably be used in an amount of 0.3 - 30 g/m^2, particularly 0.7 - 15 g/m^2, further preferably 1.2 - 8 g/m^2.

The silver halide may preferably be used in 0.001 - 2 mols, more preferably 0.05 - 1 mol, per 1 mol of the organic silver salt. When a coloring agent is used, it may be used in 0.01 - 5 mols, preferably 0.05 - 2 mols, further preferably 0.08 - 1 mol, per 1 mol of the organic silver salt.

The binder may optionally be used in 0 - 10 wt. parts, preferably 0.5 - 5 wt. parts, per 1 wt. part of the organic silver salt.

The photosensitive layer may preferably be formed in a thickness of 0.5 - 30 μm, further preferably 2 - 17 μm.

Further, in order to improve the coloring characteristic and the stability of the resultant images, it is also possible to include in the photosensitive layer optional agents, such as an organic acid, a fog preventing agent, a coloring inhibitor, an antistatic agent, an ultraviolet absorber, an irradiation preventing dye, a fluorescent brightener, and a filtering dye.

It is also possible to dispose a protective layer, as desired, on the photosensitive layer. Such a protective layer may be composed principally of a various binder, which may preferably comprise a hydrophilic or water-soluble resin, such as polyvinyl alcohol, casein, gelatin, or an ethylene-maleic anhydride copolymer. The protective layer can further contain an optional additive, such as colloidal silica or an irradiation preventing dye. The protective layer may have a thickness of 0.1 - 7 μm, preferably 0.5 - 5 μm.

[Examples]

Hereinbelow, the present invention will be described more specifically based on Examples, wherein "part(s)" are used to mean "part(s) by weight.

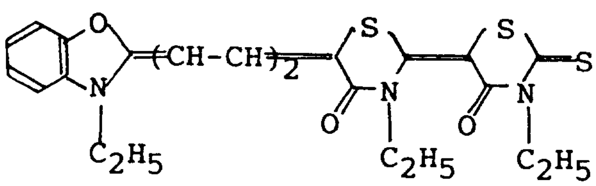
Example 1

A thermal development-type photosensitive member was prepared in the following manner.

A 100 µm-thick polyethylene terephthalate (PET) film was coated with a photosensitive liquid A having a composition shown below to form a photosensitive layer having a dry thickness of 13 µm, and then coated with a protective liquid B having a composition shown below to form a protective film having a dry thickness of 2 µm, thereby providing a photosensitive member suitable for the present invention.

[Photosensitive liquid A]

Silver behenate	25.0 part(s)
Silver bromide	2.5 part(s)
Polyvinyl butyral	30.0 part(s)
Behenic acid	11.0 part(s)
Homophthalic acid	0.1 part(s)
α,α,p-Tribromoacetophenone	0.1 part(s)
Phthalazinone	3.0 part(s)
2,2'-Methylenebis(4-t-butyl-6-methylphenol)	11.0 part(s)
2-Mercaptobenzooxazole	0.08 part(s)
Dye of the following formula (I)	0.01 part(s)
Xylene	200.0 part(s)
n-Butanole	180.0 part(s)
Dimethyl sulfoxide	5.0 part(s)



(I)

[Protective liquid B]

Polyvinyl alcohol	5 parts
Colloidal silica	5 parts
Water	70 parts

The thus-prepared photosensitive member was cut into a size of 210 mm x 290 mm and set in an image forming apparatus as shown in Figure 1 to be subjected to image formation. The photosensitive member showed a spectral sensitivity giving a spectral absorption maximum at around 680 nm.

The light source used in this Example was a semiconductor laser having an oscillation wavelength of 680 nm and a maximum output power of 30 mW. The photosensitive member was exposed at an exposure energy density at the surface of 3.3 µJ/cm². The exposed photosensitive member was subjected to thermal development for 15 sec. at a temperature of 115.0 °C set and controlled by using a PID temperature controller (Model "E4E5", available from Omron K.K.). The photosensitive member was conveyed at a rate of 15 mm/sec.

In the above-described manner, a test image as shown in Figure 2 including square spots a_1 - a_{25} (each measuring 7 mm x 7 mm) was first formed. As a result of measurement, the respective spots showed the following optical densities.

a_1 = 0.70, a_2 = 0.70, a_3 = 0.70, a_4 = 0.70,
a_5 = 0.68, a_6 = 0.68, a_7 = 0.69, a_8 = 0.70,
a_9 = 0.68, a_{10} = 0.66, a_{11} = 0.65, a_{12} = 0.66,
a_{13} = 0.67, a_{14} = 0.66, a_{15} = 0.64, a_{16} = 0.63,
a_{17} = 0.64, a_{18} = 0.65, a_{19} = 0.64, a_{20} = 0.62,
a_{21} = 0.60, a_{22} = 0.61, a_{23} = 0.63, a_{24} = 0.60,
a_{25} = 0.60.

As a result of a separate measurement, the photosensitive member showed an optical density (O.D.) - exposure energy (log E) relationship as shown in Figure 3 for a thermal development time of 15 sec.

Based on the above O.D. measurement data of the test image in comparison with the characteristic curves shown in Figure 3 while effecting a linear interpolation between the curves, the actual thermal development temperature (°C) for the test spots a_1 -a_{25} were estimated as follows:

a_1 = 115.0, a_2 = 115.0, a_3 = 115.0, a_4 = 115.0
a_5 = 114.90, a_6 = 114.90, a_7 = 114.95, a_8 = 115.0,
a_9 = 114.90, a_{10} = 114.80, a_{11} = 114.75, a_{12} = 114.80,
a_{13} = 114.85, a_{14} = 114.80, a_{15} = 114.70, a_{16} = 114.65,
a_{17} = 114.70, a_{18} = 114.75, a_{19} = 114.70, a_{20} = 114.60,
a_{21} = 114.50, a_{22} = 114.55, a_{23} = 114.65, a_{24} = 114.50,
a_{25} = 114.50.

By using the above-obtained temperature distribution data, an objective image formation was performed while correcting the exposure energy based on the O.D. - log E relationship shown in Figure 3 together with an appropriate linear interpolation between the curves.

Based on the corrected exposure energy distribution for an oblique image density distribution, the objective image formation was performed on 60 sheets of the photosensitive member at an interval of 1 min. each otherwise similarly as in the test image formation.

As a result, some density deviation occurred in the 50th and 54th images on the photosensitive members but the deviation was so slight that it was practically of no problem.

Example 2

Image formation was performed by using the photosensitive member and image forming apparatus used in Example 1. In this Example, however, the energy supply to the heating rollers 22a and 22b and the heating members 24a and 24b was stopped immediately before the photosensitive member was heated by the heating rollers 22a and 22b, and the energy supply was resumed immediately after the photosensitive member left the heating members 24a and 24b so as to maintain the heating rollers and the heating members at 115 °C. When the energy supply to the heating rollers and the heating members was stopped, the thermal development temperature was lowered at a rate of 4 °C/min.

In the above-described manner, a test image as shown in Figure 2 including square spots a_1 - a_{25} was first formed. As a result of measurement, the respective spots showed the following optical densities.

a_1 = 0.68, a_2 = 0.69, a_3 = 0.70, a_4 = 0.70,
a_5 = 0.68, a_6 = 0.67, a_7 = 0.67, a_8 = 0.67,
a_9 = 0.66, a_{10} = 0.66, a_{11} = 0.62, a_{12} = 0.63,
a_{13} = 0.63, a_{14} = 0.62, a_{15} = 0.61, a_{16} = 0.57,
a_{17} = 0.58, a_{18} = 0.60, a_{19} = 0.58, a_{20} = 0.56,
a_{21} = 0.51, a_{22} = 0.54, a_{23} = 0.55, a_{24} = 0.53,
a_{25} = 0.50.

Based on the above O.D. measurement data for the test image, the actual thermal development temperature (°C) at the respective spots a_1 - a_{25} were estimated as follows:

a_1 = 114.9, a_2 = 114.95, a_3 = 115.0, a_4 = 115.0
a_5 = 114.90, a_6 = 114.85, a_7 = 114.85, a_8 = 114.85,
a_9 = 114.80, a_{10} = 114.80, a_{11} = 114.60, a_{12} = 114.65,
a_{13} = 114.65, a_{14} = 114.60, a_{15} = 114.55, a_{16} = 114.35,
a_{17} = 114.40, a_{18} = 114.50, a_{19} = 114.40, a_{20} = 114.30,
a_{21} = 114.05, a_{22} = 114.20, a_{23} = 114.25, a_{24} = 114.15.
a_{25} = 114.0.

By using the above temperature distribution data, a corrected exposure energy distribution was obtained for an objective image density distribution based on the O.D. - exposure energy relationship shown in Figure 3 together with an appropriate linear interpolation between the curves.

Based on the corrected exposure energy distribution, the objective image formation was performed on 60 sheets of the photosensitive member at an interval of 1 min. each otherwise similarly as in the test image formation.

As a result, the resultant images were all clear and free from density deviation.

Example 3

Image formation was performed by using the photosensitive member and image forming apparatus used in Example 1. In this Example, however, the feedback control for maintaining the heating rollers 22a and 22b and the heating members 24a and 24b at 115 °C was stopped immediately before the photosensitive member was heated by the heating rollers 22a and 22b, and, instead, the energy supply to the heating rollers and the heating members was performed by applying repetitive heat pulse at 1 Hz and a duty of 25 %. As a result, the thermal development temperature decreased at a rate of 1 °C/min. After the photosensitive member left the heating members 24a and 24b, the feed back control of the heating rollers 22a and 22b and the heating members 24a and 24b at 115 °C was resumed.

In the above-described manner, a test image as shown in Figure 2 including square spots a_1 - a_{25} was first formed. As a result of measurement, the respective spots showed the following optical densities.

a_1 = 0.69, a_2 = 0.70, a_3 = 0.70, a_4 = 0.70,
a_5 = 0.67, a_6 = 0.68, a_7 = 0.69, a_8 = 0.70,
a_9 = 0.68, a_{10} = 0.66, a_{11} = 0.65, a_{12} = 0.66,
a_{13} = 0.67, a_{14} = 0.65, a_{15} = 0.64, a_{16} = 0.63,
a_{17} = 0.65, a_{18} = 0.65, a_{19} = 0.64, a_{20} = 0.62
a_{21} = 0.60, a_{22} = 0.61, a_{23} = 0.63, a_{24} = 0.60,
a_{25} = 0.60.

Based on the above O.D. measurement data for the test image, the actual thermal development temperature (°C) at the respective spots a_1 - a_{25} were estimated as follows:

a_1 = 114.95, a_2 = 115.0, a_3 = 115.0, a_4 = 115.0
a_5 = 114.90, a_6 = 114.90, a_7 = 114.95, a_8 = 115.0,
a_9 = 114.90, a_{10} = 114.80, a_{11} = 114.75, a_{12} = 114.80,
a_{13} = 114.85, a_{14} = 114.75, a_{15} = 114.70, a_{16} = 114.65,
a_{17} = 114.75, a_{18} = 114.75, a_{19} = 114.70, a_{20} = 114.60,
a_{21} = 114.50, a_{22} = 114.55, a_{23} = 114.65, a_{24} = 114.50,
a_{25} = 114.50.

By using the above temperature distribution data, a corrected exposure energy distribution was obtained for an objective image density distribution based on the O.D. - exposure energy relationship shown in Figure 3 together with an appropriate linear interpolation between the curves.

Based on the corrected exposure energy distribution, the objective image formation was performed on 60 sheets of the photosensitive member at an interval of 30 sec each otherwise in the same manner as in the test image formation.

As a result, the resultant images were all clear and free from density deviation. According to this Example, a higher image forming speed was possible than in Example 2.

Comparative Example 1

Image formation on 60 sheets of the photosensitive member was performed in the same manner as in Example 1 except that the correction of exposure energy was not performed.

As a result, all the resultant images were accompanied with a density deviation.

Claims

1. An image forming method, comprising exposure and heating of a thermal development-type photosensitive member, wherein said method further including the steps of: forming a test image, measuring an optical density of the test image, and correcting energy of the exposure based on the measured optical density to form an objective image.

2. A method according to Claim 1, wherein said test image comprises a regularly arranged pattern.

3. A method according to Claim 1, wherein the thermal development-type photosensitive member is heated at a temperature which is controlled by the feed back control scheme.

4. A method according to Claim 1, wherein the thermal development-type photosensitive member is heated at a temperature which is lowered or increased with a certain regularity.

5. A method according to Claim 4, wherein said temperature is lowered by stopping energy supply to thermal development means for heating the photosensitive member.

6. A method according to Claim 4, wherein thermal development means for heating the photosensitive member is supplied with energy pulses at a prescribed frequency.

7. A method according to Claim 6, wherein said prescribed frequency is 0.1 - 100 Hz.

8. A method according to Claim 6, wherein said prescribed frequency is 0.5 - 50 Hz.

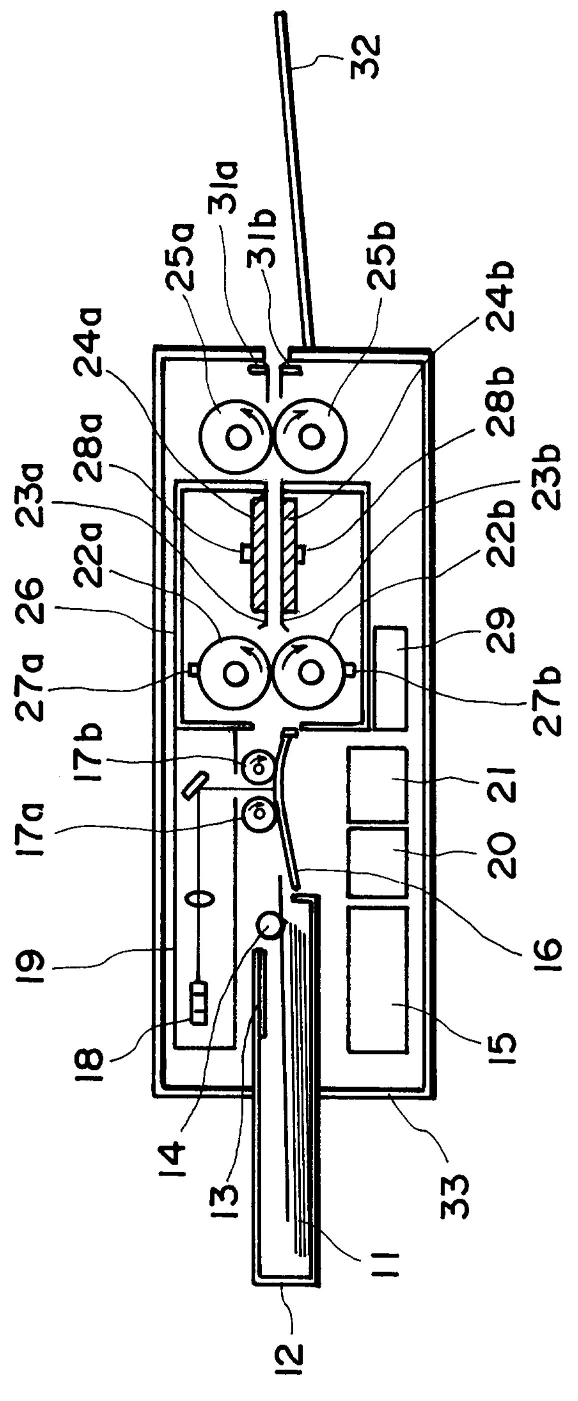

11
12
13
14
15
16
17a
17b
18
19
20
21
22a
22b
23a
23b
24a
24b
25a
25b
26
27a
27b
28a
28b
29
31a
31b
32
33

FIG. 1

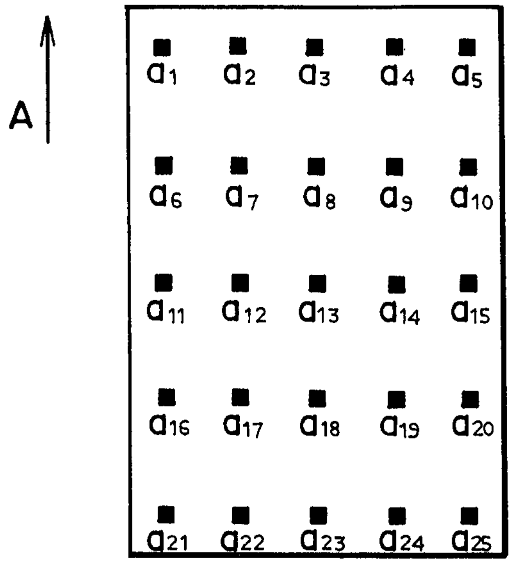

A
a1 a2 a3 a4 a5
a6 a7 a8 a9 a10
a11 a12 a13 a14 a15
a16 a17 a18 a19 a20
a21 a22 a23 a24 a25

FIG. 2

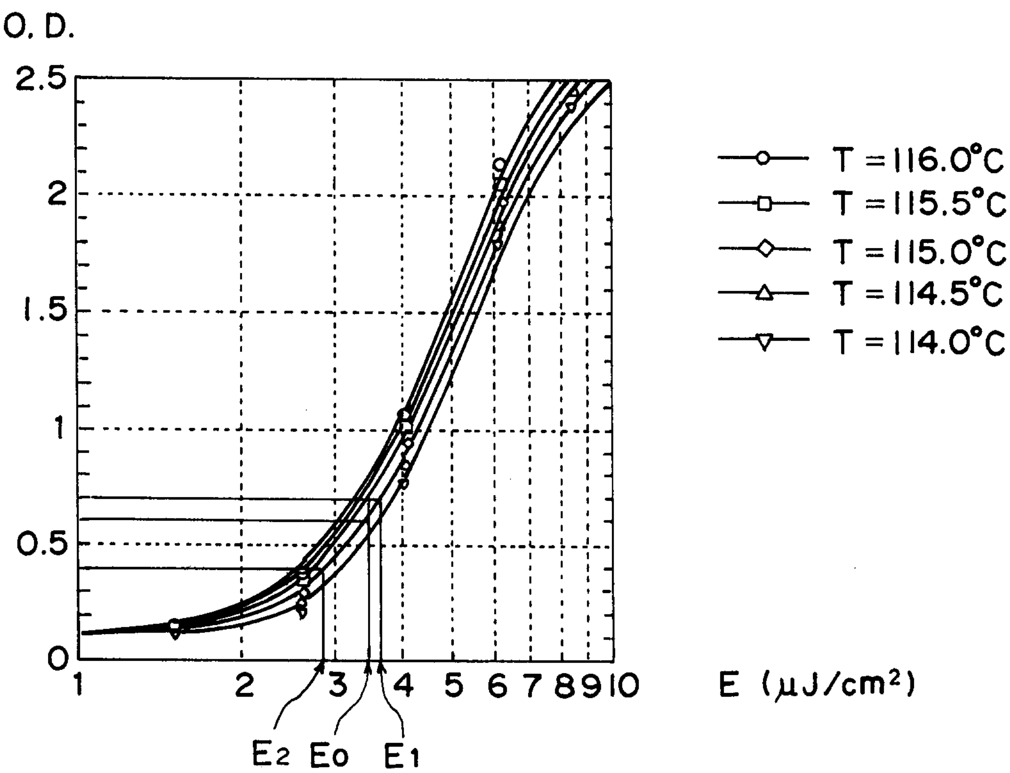

O. D.
2.5
2
1.5
1
0.5
0
1
2
3
4
5
6
7
8
9
10
E (μJ/cm²)
E2 Eo E1
T = 116.0°C
T = 115.5°C
T = 115.0°C
T = 114.5°C
T = 114.0°C

FIG. 3

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 95 10 5867

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	PATENT ABSTRACTS OF JAPAN vol. 012 no. 224 (P-721) ,25 June 1988 & JP-A-63 017440 (FUJI PHOTO FILM CO LTD) 25 January 1988, * abstract *	1,2	G03D13/00
X	US-A-4 371 246 (SIRYJ BOHDAN W) 1 February 1983 * column 1, line 56 - column 2, line 6 * * column 3, line 47 - column 5, line 57 * * figures *	1,3	
Y		4,6,7	
Y	US-A-3 938 164 (OHNISHI MASAHIRO ET AL) 10 February 1976 * column 2, line 17 - column 4, line 46 * * figures *	4,6,7	
X	US-A-4 322 158 (FRIAS RONALD J ET AL) 30 March 1982 * column 9, line 20 - line 46 *	1	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)
G03D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	21 August 1995	Heryet, C

CATEGORY OF CITED DOCUMENTS

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