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Kurakawa et al.

[11] **3,820,891**

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[54] **ELECTROPHOTOGRAPHIC COPYING METHOD USING A LIQUID DEVELOPING AGENT CAPABLE OF EFFECTING BOTH REGULAR COPYING AND INVERSE COPYING**

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[52] **U.S. Cl.** ..... **355/10,** 96/1 LY, 117/37 LE, 118/637, 355/17

[51] **Int. Cl.** **G03g 13/10,** G03g 15/10

[58] **Field of Search** ..... 355/10, 3 R, 17; 117/37 LE; 96/1 LY, 1 C; 118/637

[56] **References Cited**

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Primary Examiner—Richard L. Moses
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[57] **ABSTRACT**

A method of electrophotography using a liquid developing agent permitting regular copying (positive-to-positive and negative-to-negative) or inverse copying (positive-to-negative and negative-to-positive) to be effected by selectively charging a photoreceptor either positively or negatively without the need to bother to use a developing agent of a suitable polarity. The method comprises the steps of charging the photoreceptor so that it may carry a charge of a selected polarity, exposing the charged photoreceptor to an optical image of an original to be copied, developing an electrostatic latent image formed by exposure on the photoreceptor or an electrostatic latent image transferred from the photoreceptor to a copy sheet with a liquid developing agent, and squeezing out excess liquid developing agent from the photoreceptor or copy sheet after developing by means of a squeeze roller. When toner particles in the liquid developing agent are of the same polarity as the electrostatic latent image on the photoreceptor or copy sheet, a bias voltage of the same polarity as the electrostatic latent image is impressed on the squeeze roller when brought into contact with the image-bearing surface of the photoreceptor or copy sheet, or such squeeze roller is electrically insulated from other members in the squeezing step. When the charge carried by the toner particles is of opposite polarity to the charge carried by the electrostatic latent image, the squeeze roller when brought into contact with the image-bearing surface of the photoreceptor or copy sheet is grounded. By this arrangement, duplicates of optimum density and good contrast can be produced without the squeeze roller developing an offset phenomenon both in regular copying and inverse copying.

7 Claims, 3 Drawing Figures

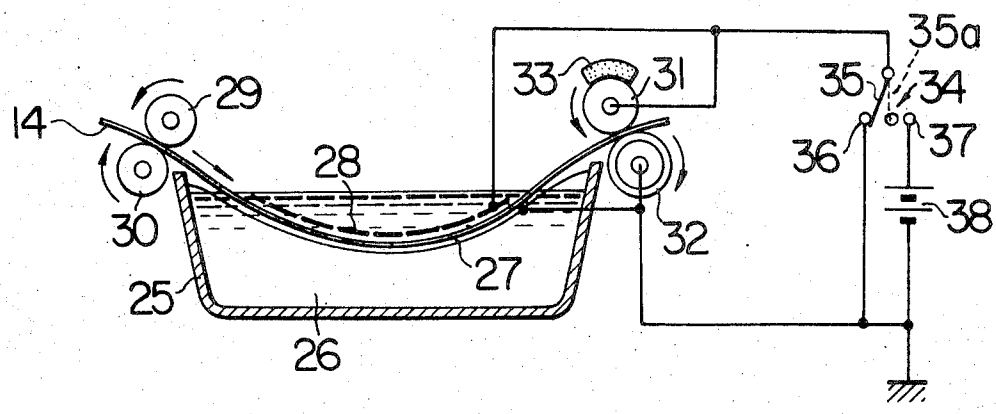


FIG. 1

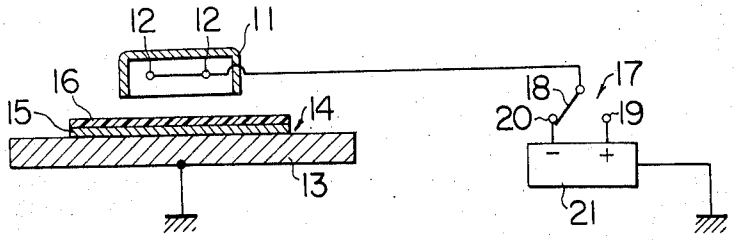


FIG. 2

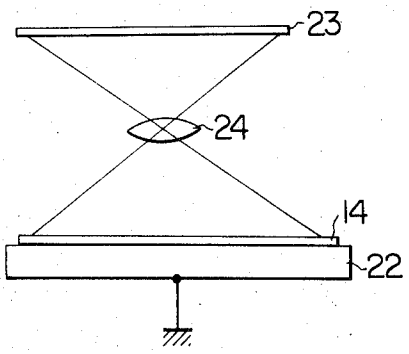
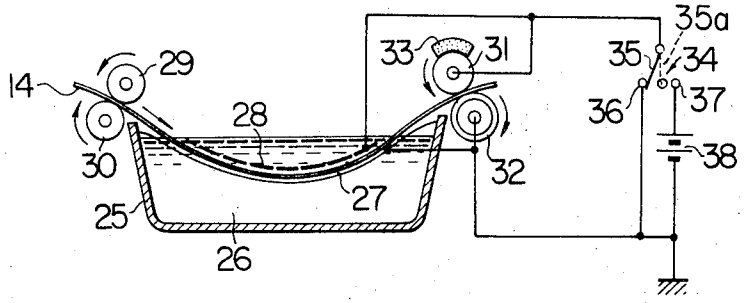


FIG. 3



ELECTROPHOTOGRAPHIC COPYING METHOD USING A LIQUID DEVELOPING AGENT CAPABLE OF EFFECTING BOTH REGULAR COPYING AND INVERSE COPYING

BACKGROUND OF THE INVENTION

This invention relates to an electrophotographic copying method using a liquid developing agent capable of effecting both regular copying and inverse copying

In electrophotographic copying, production of a positive duplicate from a positive original or a negative duplicate from a negative original is referred to as regular copying, and production of a positive duplicate from a negative original or a negative duplicate from a positive original is referred to as inverse copying. Heretofore, when it was desired to effect both regular copying and inverse copying, it has been customary to use a photoreceptor carrying a charge of one polarity while selectively using a developing agent containing toner particles of opposite polarity to the photoreceptor, or a developing agent containing toners of the same polarity as the photoreceptor, respectively, as desired.

This requires having readily on hand both a liquid developing agent containing positively charged toner particles and a liquid developing agent containing negatively charged toner particles, so that either one of the two types of developing agents could be used depending on whether regular copying or inverse copying was effected. It is troublesome and time consuming selectively to use one or the other of the two types of developing agents and the operator may sometimes use an agent of the wrong type.

In recent years, proposals have been made to use a photoreceptor for electrophotography which is coated with a layer of specially treated zinc oxide and which can be selectively charged either positively or negatively (such as variously disclosed in Japanese Pat. Publication No. Sho 45-9591; Japanese Pat. Publication No. Sho 45-12711; and U.S. Pat. No. 3,634,080) or a photoreceptor which comprises poly-N-vinyl carbazole or other organic semi-conductor and which can also be selectively charged either positively or negatively, so that a positive or negative duplicate can be readily produced as desired by switching the photoreceptor between positive and negative charges in charging it without the need to bother to use a developing agent of a suitable polarity. This is referred to as a bi-charge system and the practice of using this system has been popularized in the field of production of film for reader-printers.

Some disadvantages are associated with the bi-charge system. When a copying apparatus adapted to produce a positive duplicate from a positive original is used for producing a positive duplicate from a negative original, toner particles adhering to the image regions of the photoreceptor tend to be transferred to the squeeze roller when the excess liquid developing agent on the photoreceptor is removed by the squeeze roller and a so-called offset phenomenon tends to occur. An opposite electrode is used and arranged in spaced juxtaposed relation to the photoreceptor on the liquid developing agent so as to produce a true-to-life duplicate when the original consists of surfaces and lines, although it is not necessary to use the opposite electrode when the original only consists of lines. The opposite

electrode tends to attract toner particles and this interferes with the developing operation, with a result that the duplicate produced is low in darkness.

SUMMARY OF THE INVENTION

This invention has as its object the provision of an electrophotographic copying method, using a liquid developing agent of the type capable of effecting both regular copying and inverse copying, which permits a duplicate of high quality to be produced in positive-to-positive and negative-to-negative copying or positive-to-negative and negative-to-positive copying by switching the squeeze roller between a positive potential and a ground potential or placing the squeeze roller in a position in which it is electrically insulated from other members when the photoreceptor is switched between a positive charge and a negative charge when it is charged according to the type of copying to be performed.

According to the invention, there is provided a method of electrophotographic copying which is free from the fear of toner particles being transferred from the photoreceptor to the squeeze roller and causing an offset phenomenon to occur, and which permits a duplicate of high quality to be produced at all times, because a duplicate made from an original consisting of surfaces and lines has a suitable degree of darkness, tone and contrast.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a view of the charging device of an electrophotographic copying apparatus adapted to carry out the electrophotographic copying method according to the invention.

FIG. 2 is a view of the exposing device of an electrophotographic copying apparatus adapted to carry out the electrophotographic copying method according to the invention;

FIG. 3 is a view of the developing device of an electrophotographic copying apparatus adapted to carry out the electrophotographic copying method according to the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 1. shows a charging device comprising a corona discharge electrode 12 disposed in a shield frame 11 and an opposite electrode plate 13 disposed in spaced juxtaposed relationship. Disposed on the opposite electrode plate 13 is a photoreceptor 14 for electrophotography comprising a conducting supporter 15 and a photoconductive material layer 16.

The opposite electrode plate 13 is grounded while the corona discharge electrode 12 is connected to a movable contact 18 of a switch 17 which also has fixed contacts 19 and 20 connected to a positive output terminal and a negative output terminal of a DC power source 21 respectively. The DC power source 21 also has a ground terminal which is grounded.

When it is desired to perform regular copying, that is, to produce a positive duplicate from a positive original or a negative duplicate from a negative original with the toner particles in the liquid developing agent being positively charged, the movable contact 18 of the switch 17 is brought into engagement with the fixed terminal 20. Thus a negative voltage of a predetermined value is impressed on the corona discharge electrode

12, and a corona discharge takes place between the corona discharge electrode 12 and the opposite electrode plate 13 through the photoreceptor 14, so that the surface of the photoreceptor 14 is negatively charged throughout the entire extent.

When it is desired to perform inverse copying, that is, to produce a positive duplicate from a negative original or a negative duplicate from a positive original with the toner particles in the liquid developing agent being positively charged, the movable contact 18 of the switch 17 is brought into engagement with the fixed terminal 19. Thus a positive voltage of a predetermined value is impressed on the corona discharge electrode 12, and a corona discharge takes place between the corona discharge electrode 12 and the opposite electrode plate 13 through the photoreceptor 14, so that the surface of the photoreceptor 14 is positively charged throughout the entire extent.

FIG. 2 shows an exposing device comprising an opposite electrode plate 22 which is grounded and on which the photoreceptor 14 charged by the charging device shown in FIG. 1 is placed. The photoreceptor 14 on the opposite electrode plate 22 is exposed to an optical image of an original 23 through an optical system 24, so that an electrostatic latent image of the original is formed on the charged surface of the photoreceptor 14.

FIG. 3 shows a developing device comprising a liquid developing agent 26 contained in a developing tank 25. The liquid developing agent 26 contains therein toner particles which are positively charged as aforementioned. A guide 27 made of metal is disposed in the developing tank 25 and an opposite electrode 28 made of metal in screen or plate form is also disposed in the developing tank 25 to form a photoreceptor passageway between the guide 27 and the opposite electrode 28. The photoreceptor 14 on which an electrostatic latent image of the original 23 is formed by the exposing device shown in FIG. 2 is introduced into the developing tank 25 by a pair of guide rollers 29 and 30, moves through the photoreceptor passageway between the guide 27 and the opposite electrode 28 and is discharged from the developing device by a squeeze roller 31 and a roller 32.

The squeeze roller 31 which is adapted to come into engagement with the image-bearing surface of the photoreceptor 14 is made of metal and has a smooth surface which is adapted to be cleaned by a cleaner 33. The periphery of the squeeze roller 31 may have a thin and smooth coat of a synthetic resinous material in order to increase the cleaning effect. The roller 32 which is disposed against the squeeze roller 31 is made of metal and has a layer of rubber or sponge on its periphery.

The guide 27 and roller 32 are grounded, and the opposite electrode 28 and squeeze roller 31 are connected to a movable contact 35 of a switch 34 having one fixed terminal 36 which is grounded and the other fixed terminal 37 which is connected to a positive terminal of a DC power source 38 whose negative terminal is grounded.

When it is desired to perform regular copying, the movable contact 35 of the switch 34 is brought into engagement with the fixed terminal 36; and when it is desired to perform inverse copying, the movable contact 35 is brought into engagement with the fixed terminal 37 or brought to a neutral position as indicated by dotted line 35*a*. The switch 34 may be coupled to the switch 17 so as to close contacts 20 and 36, and 19 and 37, respectively, in unison.

Assuming that the movable contact 35 of the switch 34 is brought into contact with the fixed terminal 36 to produce a positive duplicate from a positive original, the photoreceptor 14 formed thereon with a negatively charged positive electrostatic latent image by the charging device and exposing device is introduced into the developing tank 25 by the guide rollers 29 and 30 and moves through the photoreceptor passageway between the guide 27 and the opposite electrode 28 in the liquid developing agent 26. In this process, the positively charged toner particles in the liquid developing agent 26 adhere to the image regions of the photoreceptor 14 and the electrostatic latent image is developed into a visible image. Since the opposite electrode 28 is grounded through the switch 34 and short-circuited to the non-image-bearing surface of the photoreceptor 14 to be disposed in close proximity to the photoconductive material of the photoreceptor 14, it is possible to produce a good developed image having no edge effect, even if the original 23 consists of surfaces and lines.

Excess developing agent is removed from the developed photoreceptor 14 when the latter passes between the squeeze roller 31 and roller 32. Since the squeeze roller 31 is grounded through the switch 34 and the positively charged toner particles in the developing agent adhere to negatively charged regions of the photoreceptor 14, no offset phenomenon occurs and no fog is produced in the background of the original on the photoreceptor 14.

Assuming that the movable contact 35 of the switch 34 is brought into contact with the fixed terminal 37 or brought to the neutral position 35*a* to produce a positive duplicate from a negative original, the photoreceptor 14 formed thereon with a positively charged negative electrostatic latent image by the charging device and exposing device is introduced into the developing tank by the guide rollers 29 and 30 to move through the developing agent 26 as aforementioned. A positive DC voltage is impressed on the opposite electrode 28 from the DC power source 38 through the switch 34, or the opposite electrode 28 is electrically insulated from other parts. As a result, electric lines of force directed from the opposite electrode 28 to the photoreceptor 14 are produced in non-charged regions or slightly positively charged regions of the photoreceptor 14, while electric lines of force are not produced between the opposite electrode plate 28 and positively charged non-image regions of the photoreceptor 14. The positively charged toner particles in the developing agent 26 move along the electric lines force and reach the surface of the photoreceptor 14 to positively develop the electrostatic latent image.

The developed photoreceptor 14 is passed between the squeeze roller 31 and roller 32 to have excess developing agent thereon removed therefrom. In this case, a positive DC voltage is impressed on the squeeze roller 31 from the DC power source 38 through the switch 34 or the squeeze roller 31 is electrically insulated from other members and switch 34 placed in the neutral position 35*a*, so that the positively charged toner particles in the developing agent adhere to non-charged or slightly positively charged image regions of the photoreceptor 14 and do not adhere to positively

charged non-image regions of the photoreceptor **14.** Thus no offset phenomenon occurs.

If the squeeze roller **31** is grounded at this time, the positively charged toner particles adhering to the non-charged or slightly positively charged image regions of the photoreceptor **14** would be attracted in part to the grounded squeeze roller **31** and adhere thereto when excess developing agent is removed from the surface of the photoreceptor by the squeeze roller **31.** This would result in reduced darkness of the image, and an offset phenomenon would tend to occur. The method according to the invention is devoid of these disadvantages of the prior art.

The photoreceptor **14** having the electrostatic latent image thereon developed as aforementioned is delivered to a fixing device (not shown) where the developed image is fixed and a desired duplicate is produced.

It is to be understood that the method according to this invention can also be carried into practice by an electrophotographic copying apparatus in which the electrostatic latent image formed on the photoreceptor **14** by the charging device and exposing device shown in FIG. **1** and FIG. **2** respectively is transferred to a copy sheet and then developed into a toner image by the developing device shown in FIG. **3.**

The aforementioned description refers to an embodiment in which the toner particles in the developing agent are positively charged. When the liquid developing agent contains negatively charged toner particles, the photoreceptor is positively charged in the charging step, and the squeezing roller is grounded in the squeezing step when regular copying is performed. When inverse copying is performed, the photoreceptor is negatively charged in the charging step, and a negative bias voltage is impressed on the squeeze roller or the squeeze roller is electrically insulated from other members in the squeezing step.

What is claimed is:

1. An electrophotographic copying method using a liquid developing agent with toner of a given charge and capable of affecting both regular copying and inverse copying by selectively charging an electrophotographic photoreceptor either positively or negatively, comprising the steps of:

a. charging the photoreceptor with electric charge of a selected polarity;

b. exposing the charged photoreceptor to an optical image of an original so as to form an electrostatic latent image of the original on the photoreceptor;

c. developing the electrostatic image on the exposed photoreceptor with the liquid developing agent into a visible image;

d. removing excess liquid developing agent from the developed photoreceptor by passing and squeezing it between a squeeze member and a pressing member with the squeeze member in contact with the image-bearing surface of the photoreceptor;

e. electrically grounding said pressing member; and

f. alternatively impressing a bias voltage of the same polarity as the electrostatic latent image on the photoreceptor onto said squeeze member in the squeeze step when the toner particles in the liquid developing agent are of the same polarity as the electrostatic latent image on the photoreceptor, and grounding the squeeze member in the squeeze step when the toner particles in the liquid developing agent are of the opposite polarity to the electrostatic latent image on the photoreceptor.

2. An electrophotographic copying machine of the liquid development type having:

a. a developing tank for holding a liquid developing agent;

b. guide means in said developing tank for guiding therethrough a member containing an electrostatic latent image to be developed thereon;

c. a squeeze roller at the exit of said developing tank for engaging the developed image bearing side of said member;

d. a pressing roller disposed opposite said squeeze roller and cooperating therewith to squeeze excess liquid from said member while passing therebetween;

wherein the improvement comprises:

e. means connecting said guide means and said pressing roller to ground;

f. a source of bias voltage; and

g. switching means for alternatively connecting said squeeze roller means between said bias voltage source and ground.

3. A machine as in claim **2** further comprising an opposite electrode means disposed in said developing tank opposite said guide means and electrically connected to said squeeze roller.

4. A machine as in claim **3** wherein said opposite electrode is a metallic screen.

5. A machine as in claim **2** further comprising:

h. discharge means for producing electrostatic charge for forming said electrostatic latent image; and

i. polarity means for connecting said discharge means alternatively to produce positive charge and negative charge, which polarity means is switched in unison with said switching means.

6. A machine as in claim **2** wherein said source of bias voltage is a DC power source.

7. An electrophotographic copying method using a liquid developing agent with toner of a given charge and capable of affecting both regular copying and inverse copying by selectively charging an electrophotographic photoreceptor either positively or negatively, comprising the steps of:

a. charging the photoreceptor with electric charge of a selected polarity;

b. exposing the charged photoreceptor to an optical image of an original so as to form an electrostatic latent image of the original on the photoreceptor;

c. developing the electrostatic image on the exposed photoreceptor with the liquid developing agent into a visible image;

d. removing excess liquid developing agent from the developed photoreceptor by passing and squeezing it between a squeeze member and a pressing member with the squeeze member in contact with the image-bearing surface of the photoreceptor;

e. electrically grounding said pressing member; and

f. alternatively electrically insulating said squeeze member in the squeeze step when the toner particles in the liquid developing agent are of the same polarity as the electrostatic latent image on the photoreceptor, and grounding the squeeze member in the squeeze step when the toner particles in the liquid developing agent are of the opposite polarity to the electrostatic latent image on the photoreceptor.

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