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METHOD AND APPARATUS FOR CONTROLLING DUPLICATING PROCESS ACCORDING TO OPTICAL DENSITY OF DEVELOPED DUPLICATING MATERIAL

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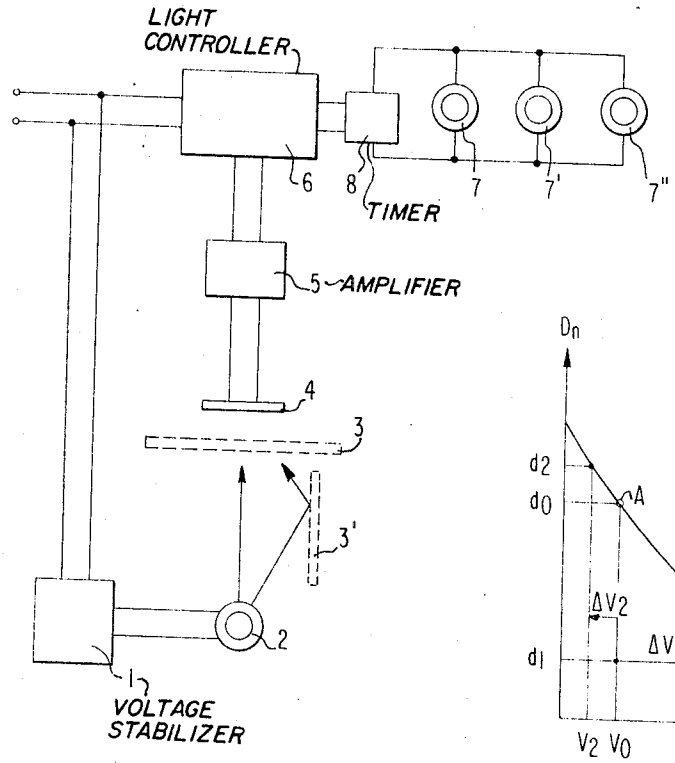


FIG. 1

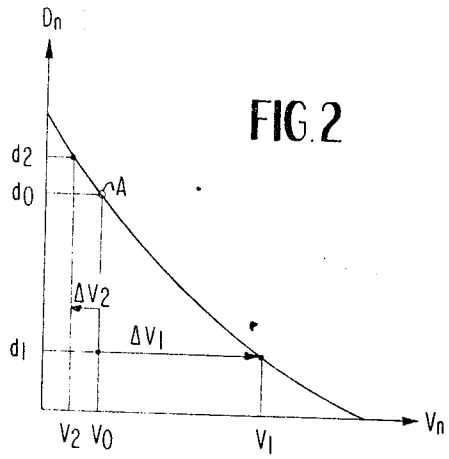


FIG. 2

FIG. 3

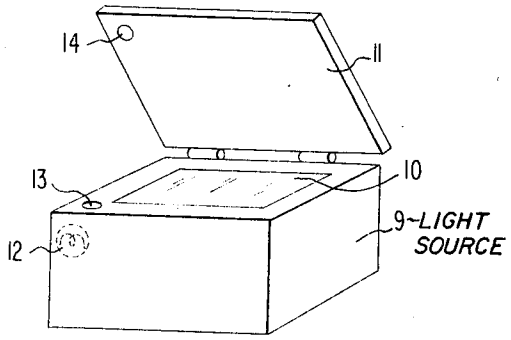
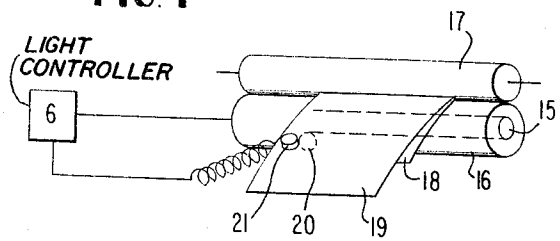


FIG. 4



INVENTORS
MATAICHI TAJIMA
TUTOMU KIMURA

BY Sughrue, Rothwell, Mion, Zinn & Macpeak
ATTORNEYS

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METHOD AND APPARATUS FOR CONTROLLING DUPLICATING PROCESS ACCORDING TO OPTICAL DENSITY OF DEVELOPED DUPLICATING MATERIAL

Mataich Tajima, and Tutomu Kimura, Ashigara-Kamigun, Kanagawa, Japan, assignors to Fuji Shashin Film Kabushiki Kaisha, Aishigara-Kamigun, Kanagawa, Japan

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ABSTRACT OF THE DISCLOSURE

A method of controlling a duplicating process is disclosed. The method consists of forming a visible image on a duplicating material by electromagnetic radiation exposure, submitting the image to radiation from a collimated constant intensity light source, generating an electrical signal indicative of the amount of radiation received by detecting the intensity of radiation either transmitted or reflected by the image on a radiation sensitive means that generates an electrical signal, and controlling the radiation exposure of subsequent materials by means of the generated electrical signal.

The present invention relates to a method of controlling the degree of printing in duplication, by which the number of printing failures during the course of a duplication operation is lessened.

A number of methods utilizing a thermosensitive material or a photosensitive material, such as diazo compounds and silver salts, have previously been put into practical use for the duplication of literature and documentary records. In the case of duplication of such a sort, however, many failures have been encountered during the course of printing operations for duplication, because a great number of factors must be taken into consideration concerning the quality of paper on which an image to be copied is printed, characteristic of a photosensitive or thermosensitive material, and image-forming conditions. The problem of printing failure in duplication is linked directly with lack of economy owing to losses of material and time, and is a dominant cause by which the value of the products of duplication is lowered. Thereby, the demand for such a product may diminish when coupled with the economics, this being one of the principal laws in the industrial world.

It is a primary object of this invention to provide a method of controlling the degree of printing in duplicating so that the number of printing failures is minimized or made substantially naught in accordance with circumstances. More particularly, the method of this invention comprises the steps of forming a visible image on the surface of a duplicating material by exposing the same to electromagnetic radiation (light or heat), applying light from a collimated constant intensity light source onto the duplicating material, detecting the intensity of light transmitted through or reflected from the duplicating material by means of a light detector of the semi-conductor type, and controlling the intensity of electromagnetic radiation (light or heat) which is generated from a light source

or a heat source and intended to be used for printing subsequent duplicating materials, based on an electrical signal issued from the light detector. Thereby, the intensity of electromagnetic radiation to be applied onto the duplicating material for developing an image is properly adjusted.

This invention will now be more closely described by several examples with reference to the accompanying drawing, in which:

FIG. 1 is a block diagram illustrating a general system for carrying out the method of this invention;

FIG. 2 is a graph showing how a set-value, by which the degree of printing is controlled, is determined; and

FIGS. 3 and 4 are perspective views showing an important part of an apparatus by which embodiments in accordance with this invention are achieved.

Referring now FIG. 1, there is shown a collimated light source **2** which is operated through voltage stabilizing means **1**. Collimated light from the light source **2** advances through a test piece **3** or **3'** of a duplicating material on the surface of which an image is developed, and reaches a photosensitive semiconductor **4** made, for example, out of cadmium sulfide. Electrical signals generated from the irradiated semiconductor are fed to a radiation source controller **6** which serves to vary the extent of supply voltage to electromagnetic radiation sources **7**, **7'** and **7''** of a printer. Thereby the radiation intensity of each source is properly adjusted, while taking into due consideration the optical density of the test piece **3** or **3'**. A voltage Vn to be applied for operating the electromagnetic radiation controller **6** is established after a preliminary examination, while comparing, on the other hand, the extent of the optical density D_n, which results in the same radiation intensity In as that of the electromagnetic radiation sources **7**, **7'** and **7''**. In the embodiment shown in FIG. 1, a timer **8** is utilized for establishing the voltage Vn or the radiation intensity In.

Further, referring to FIG. 2, showing by way of example the relation between said optical density Dn on a test piece and said voltage Vn, it should be understood that the fixed point A represents both the optimum voltage Vo and the optimum optical density d_0. In addition, an optical density Dn higher than d_0, viz., on the upper side on which a d_2 locates, and an optical density Dn lower than d_0, viz., on the lower side on which a d_1 locates, means an excess of optical density or over-exposure, and insufficiency thereof, respectively. In a case where the optical density of a test piece is d_1, an electrical voltage of v_2 must be employed for operating the electromagnetic radiation source because the extent of the insufficiency of optical density, namely the voltage of the light source, is equal to v_0-v_2, in the curve shown in FIG. 2. With respect to the optical density, the condition under which an image is formed is greatly influenced by the quality of the paper carrying the image to be copied, because one duplicating material, such as a photosensitive or thermosensitive material, very different from another in such a characteristic is generally not used. From the standpoint of examining (detecting) the quality of paper, it is preferred to employ as a test piece, for example, a negative resulting from a trial print, that gives information about the uppermost optical density thereof that can be obtained, if the negative is of the type using a silver salt as a photosensitive material to be subjected to a stabilizing system.

Exposure of copying (transfer) paper to light or heat transmitted through an original paper carrying an image to be copied, to prepare the test piece **3** or **3'** in FIG. 1, may be attained by an instant printer for duplication (a duplication printer to be used), if both the sensitivity of the copying (transfer) paper and the image-forming conditions therefor are substantially constant without departing from a practically acceptable range. In a case where both factors above mentioned vary out of the practically acceptable range, moreover, it is necessary to stabilize the intensity of electromagnetic radiation (light or heat) to be applied to the test piece. For this purpose, it is desirable to use a stabilized light source **2** for measuring the optical density of an image, shown in FIG. 1, in combination therewith.

The principle on which the method of this invention is based and the manner in which the method is achieved may more clearly be illustrated by the following examples.

EXAMPLE 1

As can be seen from FIG. 3, a duplication printer of the conventional type and comprising a light source box **9**, an image-printing station **10** and a weighting cover **11** is provided with a series of devices comprising a stabilized light source **12** for both test exposure and detection, a light opening **13**, and a light detector **14** of the semiconductor type, in accordance with this invention. Said duplication printer may be operated as follows:

(1) Either a small piece cut from a duplication material is positioned on the opening **13** for exposure, or duplication material of practically handled dimensions is so placed on the image-printing station as to allow one portion of the material to cover the opening.

(2) After pressing the small piece or portion of duplicating material down by the weighting cover **11**, it is then exposed to light. Unless an image is formed instantly upon exposure, it is required to subsequently carry out an image-forming treatment, such as a development, while leaving suspended the function of the light detector **14**.

(3) The image formed in this manner, through opening **13**, is intended to be employed as the standard for indicating the degree of printing during the course of subsequent printing operations. Namely, subsequent printing runs for practical purposes are carried on with the electric current including the light detector **14** in operation, while leaving the small piece or portion of duplicating material thus printed in position on the opening **13**. Said printing runs are suitably carried out by virtue of both an automatic voltage-controlling system, established in accordance with the relative curve shown in FIG. 2 and an equivalent circuit which is illustrated by the block diagram in FIG. 1, without failure, unless there is a great variation in the quality (especially, a variation in color of the surface and in the shade of the color) of the paper. When a photographic paper comprising silver halides, to be subjected to a stabilizing system in which two or three sheets of photographic paper have been spoiled to obtain one sheet of copy, is processed in accordance with the instant example, there are obtained many pieces sufficient to carry out nearly ten runs of trial printing from one sheet of duplicating material.

EXAMPLE 2

A rotary printer of the conventional type, for use with photosensitive material made out of silver salts to be subjected to a stablizing system, and comprising a glass cylinder **16** having a radiation source **15** therein, and a rubber roller **17**, is equipped with a constant intensity light source **20** and a light detector **21**, in accordance with this invention. Both a duplicating material **18**, previously processed, and a duplicating material **19**, still not processed are passed in overlapping relationship between the glass cylinder and the rubber roller. The latter is exposed to electromagnetic radiation transmitted from source **15** within the glass cylinder through the former. The duplicating material **18** is irradiated with light from the constant intensity light source and, radiation transmitted from source **15** through the duplicating material **18** is received by the light detector, so that the source **15** is controlled by radiation controller **6** which is operated by the light detector **21**.

EXAMPLE 3

Although Examples 1 and 2, and the principle of this invention, are suitably achieved or clearly understood when referred to FIGS. 3, 4 and 1 showing a conventional duplication printer coupled with the device or spirit of this invention, in the order described respectively, this device of this invention may also be operated automatically in other forms. In the instant example, the system comprising elements **1** through **5**, shown in FIG. 1, is separated from the other elements and the amplifier **5** is electrically connected with an ammeter for detecting the power thereof. We have found that the logarithm of electric current changes approximately in inverse proportion to Dn in FIG. 2, so that Vn is easily calculated. In this operation, the voltage of the radiation sources **7**, **7'** and **7''** is manually controlled while using an auto-trance in place of the radiation controller **6**. This arrangement of devices is characterized by low cost and is especially fit for use in a case where a number of factors affecting the duplication must be taken into consideration, because only the use of an exchange table is needed.

As will be understood from the previous description, printing failure during the course of duplication operations can suitably be avoided, in accordance with the method of this invention, even if there are variations in the quality of paper to be copied, characteristics of the photosensitive or thermosensitive material, and the image-forming condition, so that the value of the duplication products is elevated without losses of material and time.

What is claimed is:

1. A method of controlling a duplicating process comprising forming a developed, visible image on the surface of a duplicating material by exposing the same to electromagnetic radiation and developing the resultant image,

measuring the optical density of the duplicating material carrying said image by

applying light originating from a collimated constant intensity light source onto the duplicating material carrying said image,

detecting the intensity of said light transmitted from said duplicating material carrying said image by means of light sensitive means capable of generating an electrical signal indicative of the intensity of light detected and

controlling the intensity of said electromagnetic radiation used to expose subsequent duplicating materials in response to the electric signal generated by said light sensitive means.

2. The method of claim **1** wherein said image is formed by exposure to light radiations.

3. The method of claim **1** wherein said image is formed by exposure to heat radiations.

4. The method of claim **1** wherein said transmitted light is impinged on the surface of a photosensitive semiconductor element.

5. Duplicating apparatus for producing copies of controlled and uniform quality by image formation in response to electromagnetic radiation comprising

a source of constant intensity light,

light sensitive means capable of generating an electrical signal in response to the intensity of light radiation received,

duplicating material having a developed, visible image thereon and arranged so that radiation from said constant intensity light source first impinges upon said material and then is transmitted to and impinges

upon said light sensitive means, so that the amount of radiation transmitted to said light sensitive means is determined by the optical density of said material, and

an exposure means, controlled by the electrical signal generated in said light sensitive means by said transmitted radiation, for exposing subsequent duplicating elements to produce copies of uniform quality.

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WILLIAM F. LINDQUIST, Primary Examiner

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