

[54] **MULTICOLOR ELECTROPHOTOGRAPHIC REPRODUCTION DEVICE**

3,495,903 2/1970 Morley..... 355/4

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## Related U.S. Application Data

[63] Continuation of Ser. No. 40,942, May 25, 1970,  
abandoned.

[52] U.S. Cl. .... 355/4

[51] Int. Cl. .... G03g 15/00

[58] Field of Search..... 355/4, 5

## References Cited

### UNITED STATES PATENTS

2,986,466 5/1961 Kaprelian..... 355/4 X

## [57] ABSTRACT

An electrophotographic multicolor reproducing device comprises a table for supporting an object to be copied, sources of light for illuminating said object, color separation optical means for separating the image of said object into a number of colors and having exposure positions for said respective colors, electrically charging means and visualizing means both corresponding in number to said exposure positions, a photosensitive member, and means for carrying said photosensitive member along said electrically charging means, said exposure positions and said visualizing means. A detection marking means for registration may be additionally provided thereto.

**1 Claim, 9 Drawing Figures**

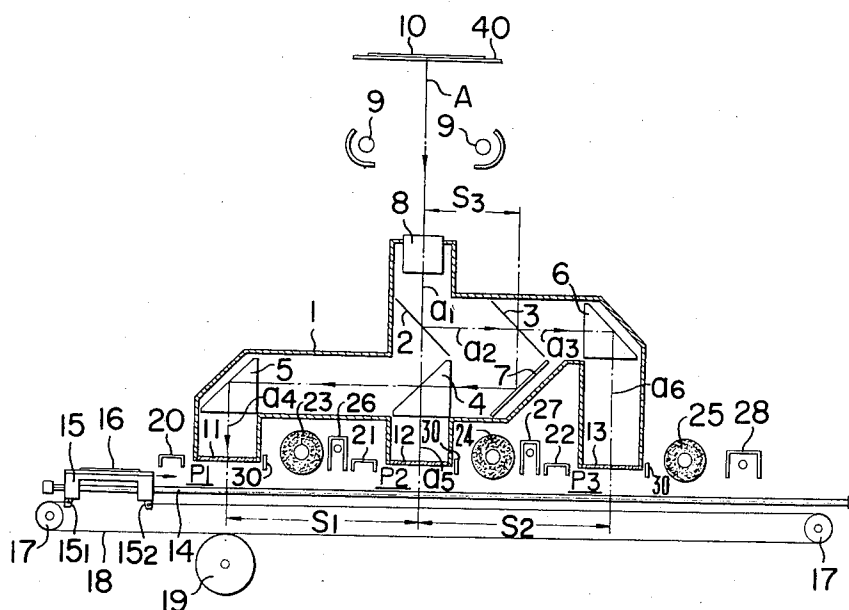


**FIG. 1**

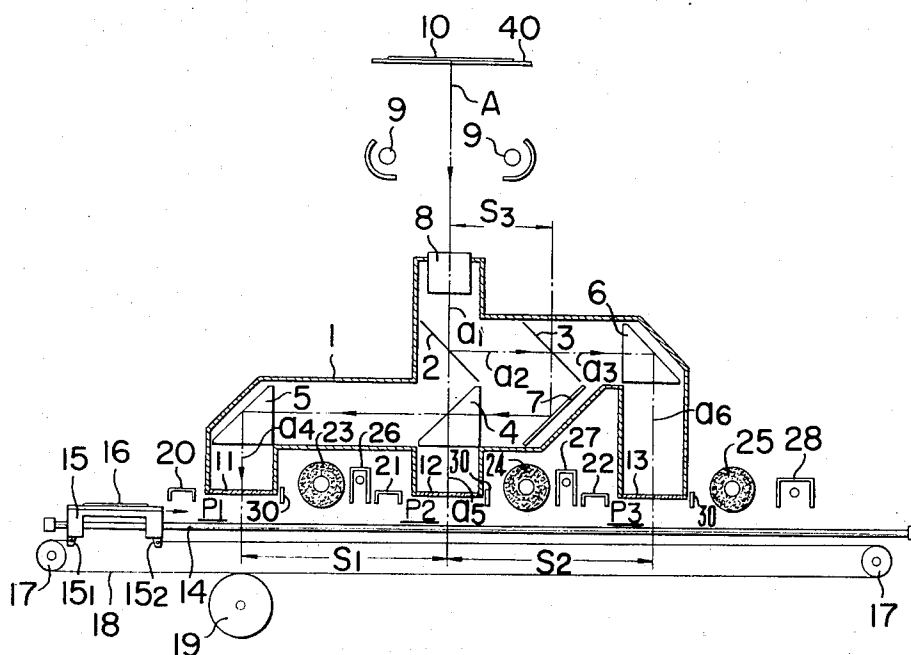


FIG. 2

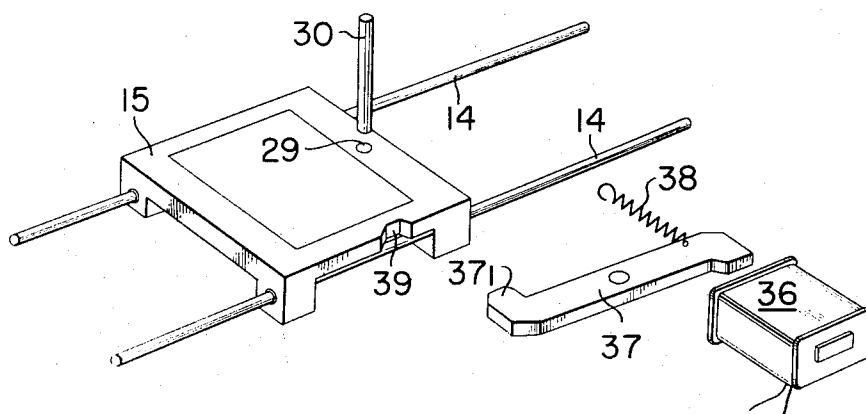


**FIG. 3**

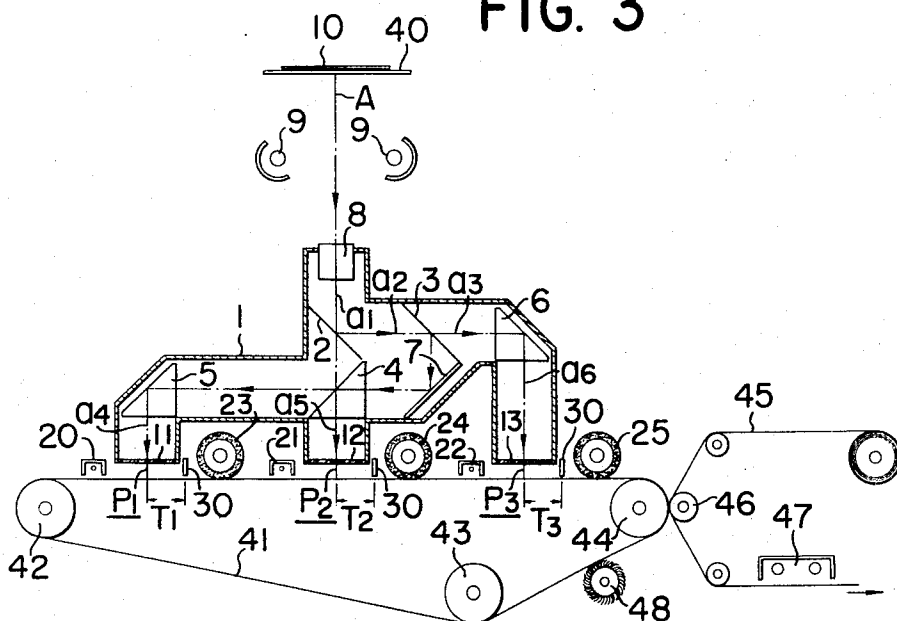


FIG. 4

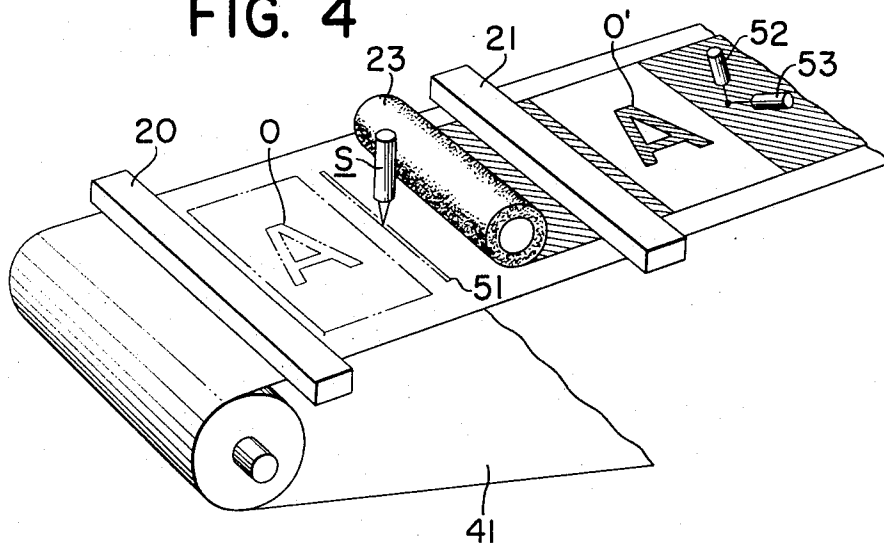


FIG. 5

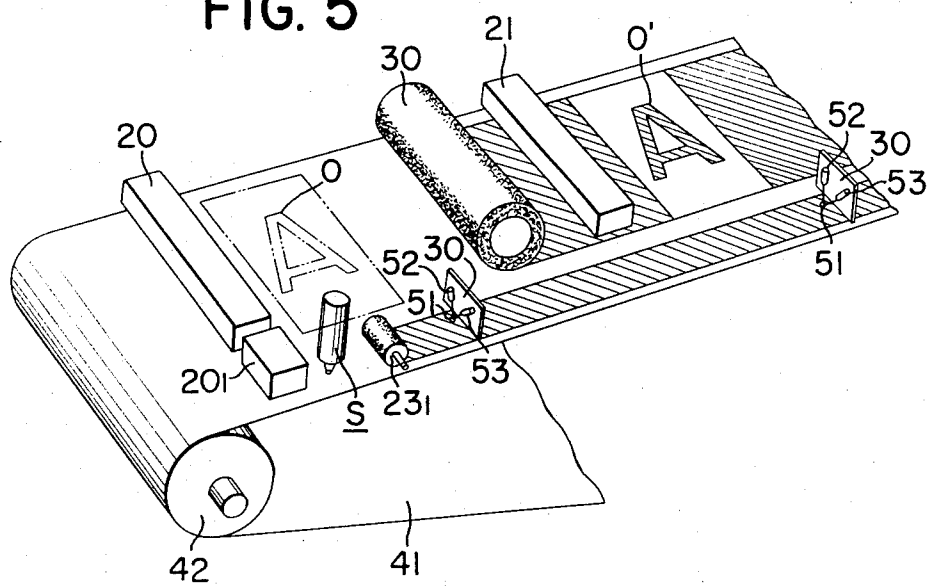


FIG. 6

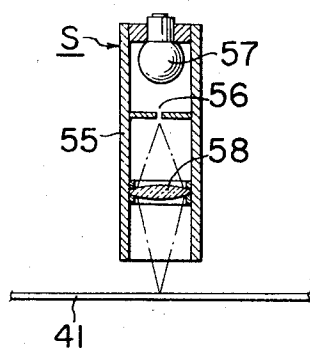


FIG. 7

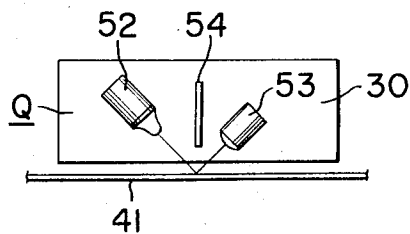


FIG. 8

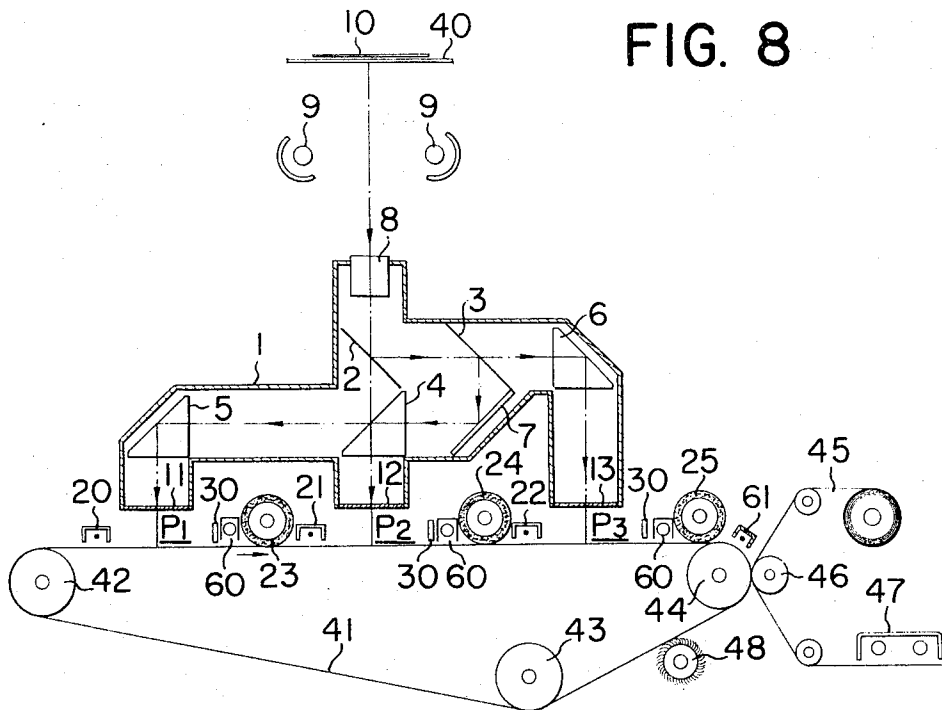
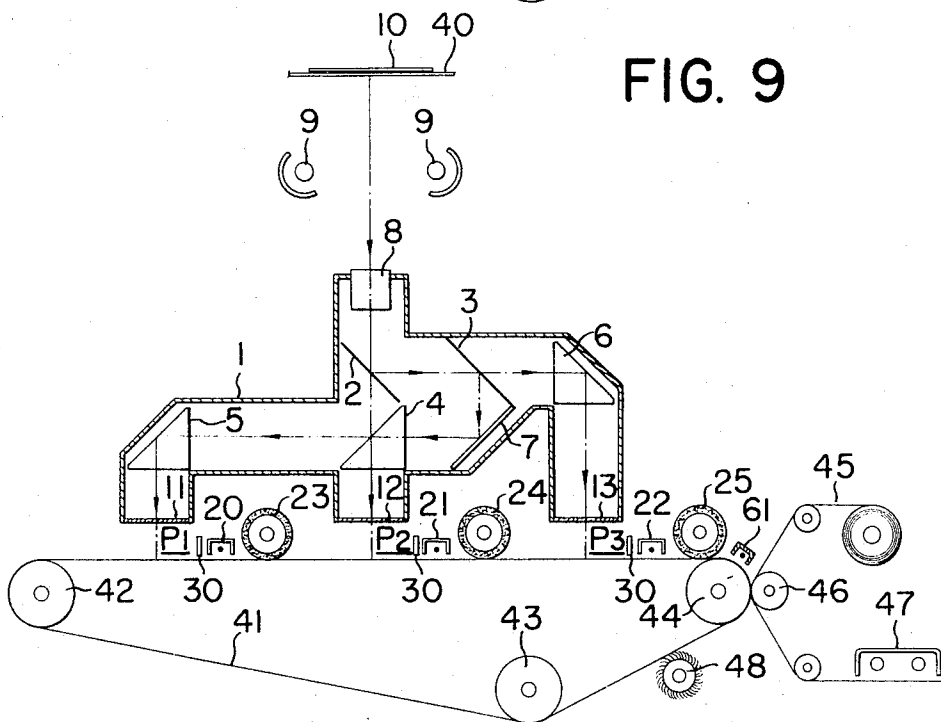


FIG. 9



## MULTICOLOR ELECTROPHOTOGRAPHIC REPRODUCTION DEVICE

This is a continuation of application Ser. No. 40,942, filed May 25, 1970.

This invention relates to an electrophotographic multicolor image reproducing device using a color separation optical system, and more particularly to process control for the multicolor image reproduction of high quality free from color misregistration.

The known electrophotographic multicolor image reproducing device can be generally classified into two groups. One of them uses stationary arrangement for the object to be copied, optical system and reproduction photosensitive member (hereinafter referred to as "photosensitive member") and movable arrangement for the electrically charging means, exposure means and developing means. The other type employs movable arrangement for the electrically charging means, exposure means and developing means but stationary arrangement for the photosensitive member.

The former type has a merit in that a high quality of the multicolor image reproduction can be obtained without the problem of color misregistration, while it has a demerit in that the device is large-sized and complicated in construction and that a high speed of reproducing operation is difficult to realize. The latter type is just opposite to the former type in merit and demerit and, if the problem of color misregistration can be overcome, this type would be more advantageous. This latter type is further divided into two groups, one of which uses a drum-like or belt-like photosensitive member on which a toner image is formed through electrically charging, exposing and developing processes and transferred onto a paper to effect a complete image reproduction, and the other type uses a cut photosensitive member which is carried by a suitable carriage means so that a complete copy can be obtained directly on the cut photosensitive member.

In the last-named type of the multicolor image reproducing device, the amount of movement of the photosensitive member is previously set and controlled by a cam or like means so as to be in accordance with the exposure position or exposure start timing. This requires the control means to be of high accuracy and of sufficient durability to withstand a long-term use, and thus the device becomes complicated and expensive. Also, the drum-like or belt-like shape photosensitive member allows only a predetermined portion thereof to be always used as the effective photosensitive part, leaving the other part unused at all, and this reduces the life of the photosensitive member.

The present invention contemplates to overcome all these drawbacks in the prior art.

It is therefore an object of the present invention to provide an electrophotographic multicolor image reproducing device in which an image to be reproduced is separated into a plurality of color images by an optical separation system and these separated color images are positioned in respective exposure positions lying in a common horizontal plane or in a common circular circumference.

It is another object of the present invention to provide an electrophotographic multicolor image reproducing device in which a photosensitive member is moved along said exposure positions and which comprises electrically charging means and visualizing

means disposed respectively upstream and downstream of the exposure positions in the path of the photosensitive member.

It is still another object of the present invention to form a detection marking in a photosensitive member and control the positioning of the photosensitive member in the exposure positions with the aid of the detection signal provided by the detection marking.

According to the present invention, a multicolor, for example, three-color, image reproduction is effected as follows. An object to be copied is illuminated by sources of light to provide image-carrier light, which is directed through pellicle mirrors and prisms to three exposure positions corresponding to three colors derived by three different color separation filters. A photosensitive member is moved to a first of the three exposure positions, where it is stopped so as to be exposed to a first color light and at the same time to light for the formation of a detection marking. Thereafter, the photosensitive member is further moved to a second exposure position. At this stage of its movement, the photosensitive member is electrically charged and visualized by electrically charging means and visualizing means disposed upstream and downstream of each exposure position. When the photosensitive member has reached the second exposure position, detector means detects the detection marking formed in the photosensitive member to stop and set the photosensitive member in the second exposure position. Such operation is repeated to move the photosensitive member to a third exposure position where it is exposed to a third color light to thereby provide a three-color image reproduction. If four or more colors are desired, the exposure positions and the optical means for directing the image-carrier light to the exposure positions may correspond in number to those four or more colors and the above-described operation may be repeated as frequently as the number of the colors to thereby provide a multicolor copy consisting of four or more colors. The quantity of light reaching each exposure position can be adjusted as by pellicle mirrors in accordance with the photosensitivity of the photosensitive member in use.

The present invention will be described further in detail referring to the accompanying drawing wherein:

FIG. 1 is a longitudinal cross-sectional view showing an example of the electrophotographic multicolor image reproducing device according to the present invention;

FIG. 2 is a perspective view of an embodiment of the carriage for carrying the photosensitive member according to the present invention;

FIG. 3 shows, in longitudinal cross section, another example of the device according to the present invention using an endless photosensitive member;

FIG. 4 is an enlarged perspective view showing an example of an essential part of FIG. 3;

FIG. 5 is an enlarged perspective view showing another example of the essential part of FIG. 3;

FIG. 6 is a cross-sectional elevation showing an example of an optical means forming the detection marking for positioning the photosensitive member in the exposure positions and used in FIG. 3;

FIG. 7 shows an example of the means for detecting the detection marking; and

FIGS. 8 and 9 illustrate modifications of the embodiment in FIG. 3 using an endless photosensitive member

formed of three layers, FIG. 8 including an arrangement for effecting the electrically charging process contemporaneously with the exposure process and FIG. 9 including an arrangement for effecting the electric charging after the exposure.

Referring to FIG. 1, there is shown an electrophotographic multicolor image reproducing device of the present invention using a photosensitive member such as cut paper or the like. The device includes three-color separation means 1 which contains first and second pellicle mirrors 2 and 3, prisms 4 to 6, a mirror 7 and a lens 8 which are disposed under a predetermined optical condition.

A pair of light sources 9 is provided to illuminate an object 10. Light beam A carrying the image of the object 10 passes through the lens 8, then a part of the light beam A passes through the first pellicle mirror 2 and is directed to a first focus exposure position P1 through prisms 4 and 5. The other part of the light which has passed through the lens 8 is reflected perpendicularly to an optic axis  $a_1$  by the first pellicle mirror 2 and reaches the second pellicle mirror 3, where a part of that light is directed downwardly perpendicularly to an optic axis  $a_2$  and finally reaches a second focus exposure position P2 through the mirror 7 and prism 4. The other part of the light which has reached the second pellicle mirror 3 passes therethrough to reach the prism 6, where it is reflected downwardly perpendicularly to an optic axis  $a_3$  and finally reaches a third focus or exposure position P3.

The first and second pellicle mirrors 2 and 3 may be formed of thin collodion film or any other suitable thin film having gold, silver, aluminium or other suitable metal attached thereto by vacuum evaporation.

As described above, the image-carrier light A which has passed through the lens 8 is directed along three paths  $a_1$  to  $a_3$  to reach three different exposure positions P1 to P3 which all lie in a common horizontal plane. Thus, three identical optical images are formed in the respective exposure positions P1 to P3. As illustrated in FIG. 1, it is now assumed that the prisms 4, 5 and 6 are positioned relative to one another in a relation that  $S_1 = S_2$ , and that the second pellicle mirror 3 and mirror 7 are positioned relative to each other in a relation that  $S_3 = S_1/2 = S_2/2$ . Then the distance between the first and second exposure positions P1 and P2 and the distance between the second and third exposure positions P2 and P3 are equal to each other. The exposure positions P1 to P3 have respective color separation filters 11 to 13 through which the objective image is color-separated and projected to each exposure positions. However, it should be noted that the optical means for effecting the color separation is not limited to the illustrated example.

A pair of rails 14 is disposed parallel to the exposure positions P1 to P3. On the rails 14 there is mounted a carriage 15 carrying thereon a photosensitive member 16 for reciprocal sliding movement along the rails. The carriage 15 has its opposite ends 15<sub>1</sub> and 15<sub>2</sub> connected to the ends of a tension belt 18 which is made taut by a pair of spaced apart pulleys 17. The belt 18 is driven by a drive source 19 so as to reciprocally move the photosensitive member carriage 15. Along the path of the photosensitive member 16 and upstream of the respective exposure positions P1 to P3 (or leftwardly thereof as viewed in FIG. 1), there are provided electrically charging means 20 to 22. Similarly along the path of

the photosensitive member 16 but downstream of the respective exposure positions P1 to P3 (or rightwardly thereof as viewed in FIG. 1), there are provided developing means 23 to 25 and fixing means 26 to 28.

In operation, a start button (not shown) is depressed to energize the drive source 19 which drives the belt 18 and accordingly the carriage 15 carrying thereon the photosensitive member 16 for movement in the direction indicated by an arrow (or in the rightward direction as viewed in FIG. 1). The moving photosensitive member 16 is first electrically charged uniformly by the electrically charging means 20, and then carried to the first exposure position P1. When the photosensitive member 16 reaches that position P1, a detection marking 29 formed in the carriage 15 forwardly thereof and a detector means 30 cooperate together to properly position the photosensitive member 16. The detection marking 29 and detector means 30 may take the form such as aperture 29 and pin 30 or magnetic mark and magnetic head. Thereafter, a detection signal is provided to energize an electromagnet 36 which attracts a lever 37 against the compression force of a spring 38 (see FIG. 2). Thus, one end 37<sub>1</sub> of the lever 37 is engaged with a recess 39 formed in the adjacent side of the carriage 15, which is thereby stopped in the first exposure position P1 and at the same time the drive source 19 also stops driving.

When the photosensitive member 16 has been set in the first exposure position P1, the light sources 9 are turned on (or alternatively, the lens 8 may be provided with a shutter to control the light sources), whereby the photosensitive member 16 is exposed to a first color light so as to form a first electrostatic latent image thereon.

Upon completion of the first color exposure, the electromagnet 36 is deenergized to allow the lever 37 to be pulled back by the spring 38, so that the engagement between the carriage 15 and the lever end 37<sub>1</sub> is released to move the carriage 15 with the photosensitive member 16 to the second exposure position P2. At this stage, the first electrostatic latent image formed on the photosensitive member 16 is developed or visualized by a developing means 23 disposed between the first and second exposure positions P1 and P2, and dried and again electrically charged by the drying means 26 and electrically charging means 21 while moving toward the second exposure position P2.

Upon arrival of the photosensitive member 16 at the second exposure position P2, the detection marking 29 of the photosensitive member 16 again cooperates with a second detector means 30 so as to properly position the photosensitive member 16, whereupon the electromagnet 36 is energized by the detection signal and the photosensitive member 16 is now set in the second exposure position P2 in the same way as in the first exposure position P1.

At this stage, there occurs the problem of color misregistration between the first color image and subsequent color images formed on the photosensitive member 16. Such problem may be fully solved by equalizing the distances T1, T2 and T3 between the detector means and the optic axes  $a_4$  to  $a_6$  for the first to third exposures, as shown in FIG. 3. When the photosensitive member 16 has been set in the second exposure position P2, the light sources 9 are again turned on (or the shutter provided for the lens 8 controls the light), whereby the photosensitive member 16 is exposed to a

second color light to form a second electrostatic latent image.

Upon completion of the second exposure, the photosensitive member 16 is moved through the developing means 24, drying means 27 and electrically charging means 22 to a third exposure position P3 in the same way as described previously. The arrival of the photosensitive member 16 at the third exposure position P3 is detected by the detector means 30 and the photosensitive member 16 is set in that position P3, where it is exposed to a third color light and thereafter carried through the developing means 25 and drying means 28 to provide a complete multicolor image reproduction on the photosensitive member 16.

When all the reproduction processes are finished, the electrophotographic device is released from its operative condition to reverse the rotation of the drive source 19 so as to return the carriage 15 to its initial position (the leftmost position as shown in FIG. 1). Thus, the photosensitive member 16 now having a complete color image formed thereon may be removed from the carriage 15 to thereby terminate the image reproducing operation.

In the embodiment of FIG. 1, the exposure and image formation have been accomplished with the object to be copied 10 and the photosensitive member 16 being both stationary, whereas it is also possible to arrange the document supporting table 40 and the photosensitive member carriage 15 for synchronous movement with each other during the exposure process.

FIG. 3 shows another embodiment of the present invention, which employs an endless photosensitive belt 41 formed of a photoconductive material such as ZnO, CdS or the like bound with a suitable binder and superposed on an electrically conductive belt member.

The endless photosensitive belt 41 is moved by pulleys 42 to 44 so that the upper horizontal portion thereof is parallel to the exposure positions P1 to P3. During the horizontal movement the photosensitive belt 41 is first electrically charged uniformly by the electrically charging means 20 and then exposed to a first color light in the first exposure position P1, where a first electrostatic latent image is formed on that part of the photosensitive belt 41 which has been exposed to light.

After the first exposure is completed, the first electrostatic latent image formed on the belt 41 is visualized by the developing means 23, and further subjected to subsequent process such as electrically charging, exposure and development, whereby an unfixed multicolor visible image is provided on the photosensitive belt 41. Up to this stage, the FIG. 3 embodiment is substantially the same as the FIG. 1 embodiment.

In the embodiment of FIG. 3, the unfixed visible image is transferred onto an image transfer member 45 such as paper or the like by the action of a transfer roll 46 and the transferred image is fixed by fixing means 47 to thereby provide a multicolor image reproduction.

On the other hand, the photosensitive belt 41, after the image thereon has been transferred, is cleaned by cleaning means 48 to remove any residual developer (which may be in powder or liquid form) so that the photosensitive belt may be used repeatedly.

The illustrated arrangement using such an endless photosensitive belt 41 enables the image pick-up and reproducing process to take place anywhere in the belt

as desired, and the entire area of the photosensitive belt surface can be effectively used so that a number of copies of an original image can be provided continuously.

The photosensitive member 16 of the cut type has been shown to be linearly moved with the carriage 15 in one direction in FIG. 1, whereas it is also possible either to use a rotary disc-like carriage for carrying the photosensitive member 16 and dispose the exposure positions of the optical separation means in a common horizontal plane with respect to the disc surface, or to use a rotary drumlike photosensitive member and dispose said exposure positions circumferentially of the drum. In either of these alternative cases, the electrically charging means may be disposed before or upstream of each exposure position, and the exposure position detector means and developing means may be disposed behind or downstream of each exposure position.

The shown electrically charging process may be eliminated if the present invention is used with an electrophotographic image reproducing system of the type whereby a photosensitive member having its photosensitive layer formed of titanium oxide is exposed to image-carrier light so as to form a latent image on the surface of the photosensitive layer due to the plane-light electromotive force and developed by water solution containing silver or other metal ions.

FIGS. 8 and 9 illustrate further embodiment of the present invention, which employ an endless photosensitive member comprising a transparent insulating layer, a photoconductive layer and an insulating layer. In FIG. 8, such photosensitive member is moved in the direction indicated by an arrow and charged with a predetermined polarity by electrically charging means 20, whereafter the photosensitive member is subjected to electric charges of the opposite polarity by unshown electrically charging means or to removal of electric charges by unshown AC discharging means, whereby an electrostatic latent image is formed on the photosensitive member. At this stage, the photosensitive member may be subjected to a whole surface exposure, if required, so as to increase the contrast of the resultant electrostatic image. Thereafter, the photosensitive member is further carried to developing means, where the latent image on the photosensitive member is developed. The abovedescribed processes are repeated for each color to thereby provide a multicolor print. The embodiment of FIG. 9 is similar in process to the FIG. 3 embodiment except that the exposure process precedes the electrically charging process to form an electrostatic latent image.

According to the present invention, the image to be reproduced is color-separated by color separation means and all the separated color images are focused to the exposure position on a common horizontal plane or on a common circular circumference, so that the photosensitive member is moved along these exposure positions and visualizing means disposed downstream of each exposure position. Therefore, a multicolor image reproduction can be provided simply by repeating the electrically charging, exposing and developing processes while moving the photosensitive member in one direction. Also, the control mechanism for moving and stopping the photosensitive member is much simplified to enhance the reproduction speed as well as to make the entire device compact in structure.

Description will now be made of further examples of the means S for forming the detection marking 29 and detector means Q with respect to the embodiments of FIG. 3 and the following Figures.

As shown in FIG. 6, marking 51 provided as by a spot or slit formed within an optical box 55 is optically projected onto the non-image-bearing area of the photosensitive member 41 by a source of light 57 through a lens 58. Such marking 51 may be detected by detector means Q, which may comprise, as shown in FIG. 7, a plate 30 having mounted thereon a spot or slit illuminator 52 and a photoelectric converter element 53 such as phototransistor or the like. The light from the illuminator 52 is reflected by the photosensitive member 41 and collected by the photoelectric converter element 53. There is also provided a shield plate 54 on the plate 30 between the illuminator 52 and photoelectric converter element 53.

FIGS. 4 and 5 show examples of the detection means according to the present invention. In FIG. 4, an image-carrier light is projected upon the first exposure position and contemporaneously therewith the detection marking 51 is formed at the boundary between a first formed image O and a second formed image O'. The detection marking 51 thus formed is detected by the detector means Q disposed in the second and further exposure positions, so that the photosensitive member 41 can be properly stopped in the second and further exposure positions with the aid of the detection marking 51. To stop the photosensitive member 41 in the first exposure position, the time required for the photosensitive member 41 to move from its start position to the first exposure position is detected as by an unshown time delay relay switch whose detection signal acts to stop the movement of the photosensitive member 41 in the first exposure position.

In FIG. 5, the photosensitive member 41 is electrically charged at one edge thereof by electrically charging means 20<sub>1</sub> (which may be integral with the electrically charging means 20) prior to the first exposure position, and momentarily exposed to light or stopped so that the detection marking 51 is exposed to the detection mark forming means S so as to develop the mark-

ing 51 by developing means 23<sub>1</sub>. Such marking 51 is then detected by the detector means Q provided in each exposure position, whereupon the photosensitive member 41 is stopped in each exposure position. The detection marking 51 is not limited to the form of spot or slit, but it may take any other form that can provide a visible reference mark. The term "visible" does not always mean the visibility to the human eyes but includes any detectability to the detector means Q.

Thus, in the multicolor electrophotography of the present invention, the photosensitive member is formed with the detection marking for the exposure positions and the detection signal produced thereby acts to properly set the photosensitive member in each exposure position. Such a system achieves much more accurate positioning of the photosensitive member for each exposure process than the prior art system using the control cam to position the photosensitive member, and ensures multicolor prints of high quality free from any color misregistration to be provided at a lower cost.

#### What is claimed is:

1. An electrophotographic reproduction apparatus capable of continuously producing a polychromatic reproduction of a color original comprising: light means for forming a light image of the color original, a single photoconductive surface movable linearly at its exposing position, optical means for separating the color image formed by said light means into at least two color separation images, means for conducting said color separation images along different optical paths of equal length to said photoconductive surface, means for separately forming on said photoconductive surface electrostatic latent images of each of said color separation images, means for separately developing each of said color separation images with different marking material, the color of which corresponds to the separation image being developed by said marking material, and means for transferring and affixing the developed images in superimposed relationship onto a copying material, and cleaning means for said photoconductive surface for repetitive use.

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UNITED STATES PATENT OFFICE  
CERTIFICATE OF CORRECTION

Patent No. 3,848,989 Dated November 19, 1974

Inventor(s) KEIZO YAMAJI ET AL

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

On the Title Page, Column 1, under "Foreign Application Priority Data" insert --Japanese Patent Application Nos. 42821/1969 and 42822/1969 filed May 31, 1969.--

Signed and sealed this 18th day of February 1975.

(SEAL)  
Attest:

RUTH C. MASON  
Attesting Officer

C. MARSHALL DANN  
Commissioner of Patents  
and Trademarks

**UNITED STATES PATENT OFFICE**  
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