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Tamai

[11] **3,779,639**

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[54] **COLOR ELECTROPHOTOGRAPHIC APPARATUS**

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

[51] **Int. Cl.** **G03g 15/04**

[58] **Field of Search** 355/4

[56] **References Cited**

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3,495,903	2/1970	Morley	355/17
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Primary Examiner—John M. Horan

Attorney—Gerald J. Ferguson, Jr. et al.

[57] **ABSTRACT**

Color electrophotographic apparatus comprises a plurality of operation stations each of which has a charging section, an optical image exposure section and a developing section. Two sets of endless belts travel between the plurality of operation stations and convey a flexible electrophotographic material. The endless belts contact only the end or edge portions of the electrophotographic material. An optical system is provided wherein the optical axis for exposing the electrophotographic material is maintained in the same position in all the optical image exposure sections, the surface of the photoconductive insulating layer is perpendicular to the optical axis, and the optical images formed on the insulating layer are equal to each other in size during all exposures.

10 Claims, 3 Drawing Figures

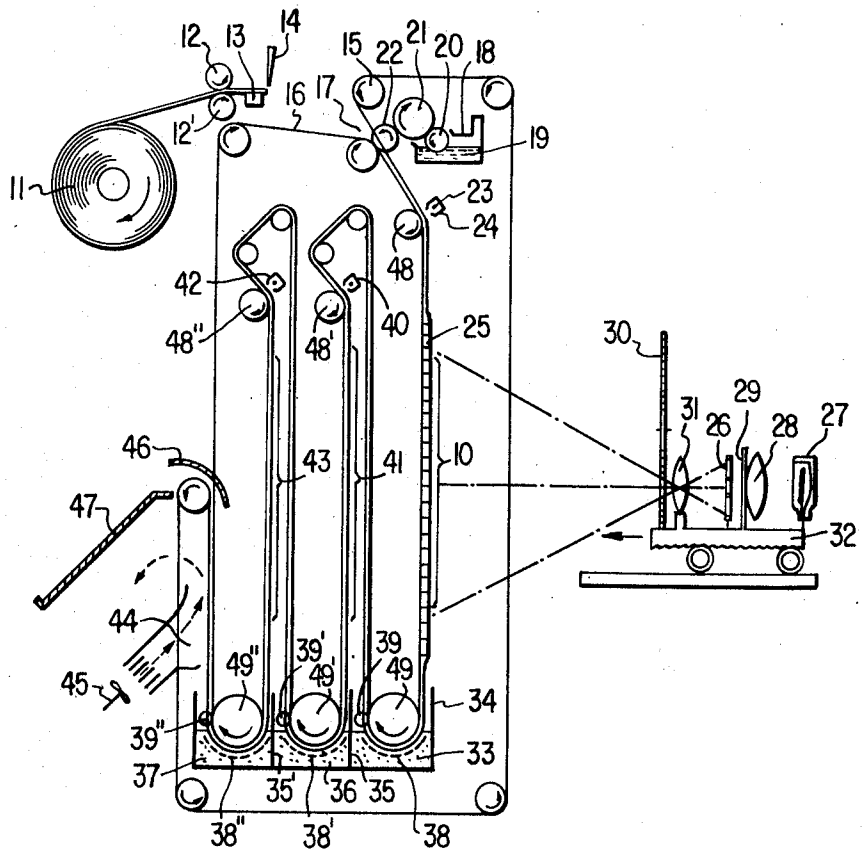

FIG. 1

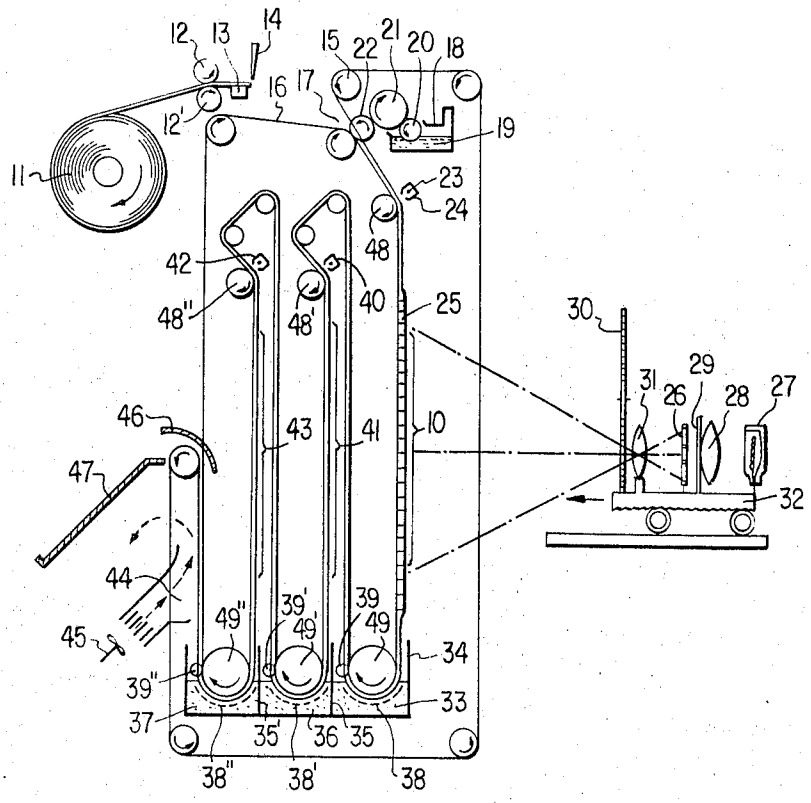
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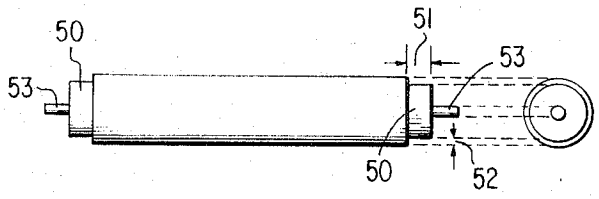
FIG. 2



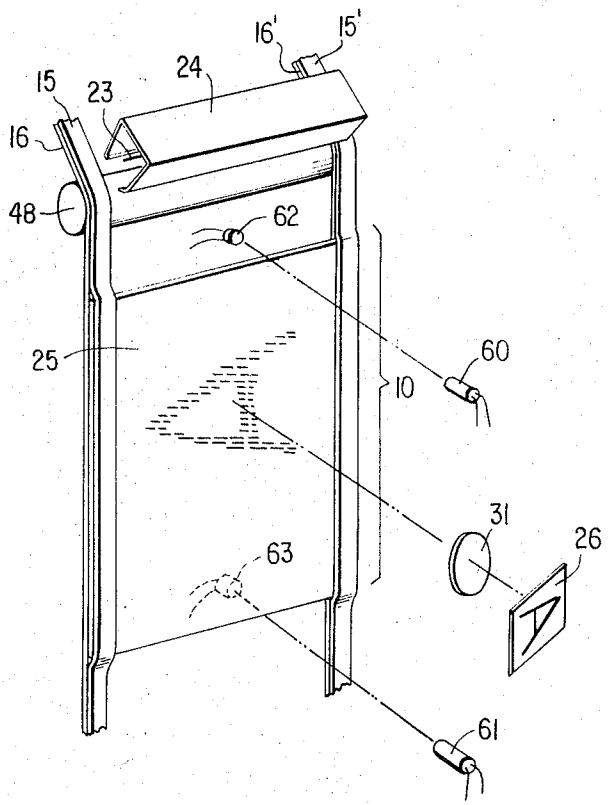


FIG. 3

COLOR ELECTROPHOTOGRAPHIC APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to color electrophotographic apparatus.

2. Description of the Prior Art

In one method known in the art of electrophotography, a color image is obtained by repeating an electrophotographic process wherein an electrostatic latent image on a photoconductive insulating layer is developed using coloring particles (hereinafter referred to as toner).

In order to obtain a color image by the xerox system, it is necessary to obtain a toner image by repeating exposure to an optical image maintained in registration with the photoconductive insulating layer and developing the toner images.

This invention is directed to an improved electrophotographic apparatus for obtaining a color image by the electrofax system. In obtaining a color image by the electrofax system, it is necessary to carry out at least the following operations:

The photoconductive insulating layer is subjected to first charging, first exposure (to an optical image of the original passed through a green color filter, for example), first developing (using a magentatoner), second charging, second exposure (using, e.g., a red color filter), second developing (using a cyan toner), third charging, third exposure (using, e.g., a blue color filter), and third developing (using a yellow toner) in the indicated order. These operations are performed on the same photoconductive insulating layer (photosensitive layer). Exposure must, of course, be carried out in strict registration.

Because of these troublesome operations, apparatus for electrophotographically obtaining a color image has hitherto had the disadvantages of being complex in construction and large in size. Particularly, it has hitherto been necessary to carry out exposure in such a manner that the photosensitive layer is returned to a predetermined position on the exposure table for registration purposes each time developing of the latent image in one color is finished. When the photosensitive layer is maintained immovable during the processing operations, the copying machine used must be such that the charging device and developing device are capable of moving successively across the surface of the photosensitive layer (such as described in U.S. Pat. No. 3,371,651 for example). This problem can be solved by using an original which is separated into its component colors (such as described in U.S. Pat. No. 3,307,457). It is, however, time consuming and requires a lot of manual attention to prepare an original which is separated into its component colors. Thus, this is not desirable as means for obtaining a duplicate of a color picture for general use.

SUMMARY OF THE INVENTION

One object of this invention is to provide a novel color electrophotographic apparatus which obviates the aforementioned disadvantages of convention apparatus.

Another object is to provide a color copier which is simple and involves no maintenance trouble.

According to the present invention, there is provided an electrophotographic apparatus in which an electrophotographic photoreceptor comprising a photoconductive insulating layer provided on a support which is electrically charged and passed at least twice through different charging sections and developing sections, and in which color separation filters used for different operations of exposure to an optical image have different absorption wavelength ranges, and the colors of the toners in the developing agents used in different operation are complementary to the colors of such filters, characterized in that the photosensitive surface of the photoreceptor is disposed on and perpendicular to the same optical axis of an optical system for exposing the photosensitive surface to the optical image in different exposure operations, optical images formed on the photoreceptor in different exposure operations are of a substantially identical size, and the photoreceptor is supported in different positions in the electrophotographic apparatus during different exposure operations.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a vertical side sectional view of electrophotographic apparatus according to this invention.

FIG. 2 shows, in a front view and a side view, a roller used in the apparatus according to this invention.

FIG. 3 is a perspective view of essential portions of the apparatus according to this invention.

DETAILED DESCRIPTION OF THE INVENTION

This invention will now be explained with reference to the drawings. In FIG. 1, 11 is a photoreceptor wound in roll form. The photoreceptor may be wound such that the photosensitive layer thereof faces disposed inwardly. In the embodiment shown, however, the photoreceptor is wound such that the photosensitive layer faces outwardly. The photoreceptor need not be wound in roll form but can be cut into predetermined lengths in sheet form. In the embodiment shown, the photoreceptor **11** is held between a pair of rollers **12, 12'** and drawn out thereby to be delivered to a cutting section comprising a support table **13** and a cutter **14.** A length of the photoreceptor is cut and conveyed by endless belts **15** and **16** while being held therebetween. The endless belts **15** and **16** form a pair and support an end portion of the photosensitive layer. The other end portion of the photosensitive layer is held by another pair of endless belts **15'** and **16'** (shown in FIG. 3 but not shown in FIG. 1). The end portion of a sheet of the photoreceptor cut in a predetermined length by the cutter **14** is held by the endless belt **15** and **16** at the upper surface and underside of a portion designated **17.** It is known that in developing an electrophotographic picture without using a liquid developer undesirable background stain (so-called fog) can be obviated by wetting the photoreceptor beforehand with an insulating liquid containing no toner therein. A highly insulating liquid **19** for obviting background density is contained in a vessel **18.** Kerosene, mineral spirits, cyclohexane, decaline, isoparaffinic base solvents and silicone oil are known as liquids which serve this purpose.

The insulating liquid **19** is scooped up by a roller **20** from vessel **18** and transferred to roller **22** via roller **21.** Rollers **20, 21** and **22** are made of material which may be either hard or soft and either solid or porous. Roller **22** is maintained in contact with the photosensitive layer of the photoreceptor a length smaller than the distance between the two sets of endless belts, and applies

the insulating liquid to the photosensitive layer surface to form a coating of the liquid thereon. In this embodiment, the coating of the liquid is formed prior to charging. However, the coating of the liquid may be formed between charging and exposure to an optical image or between exposure to an optical image and developing.

In this embodiment, the photoreceptor having the coating of the liquid formed thereon is conveyed to a first charging section which comprises a corona electrode **23** and a shield case **24** which is open on one side. The corona electrode **23** may consist of either fine metal wires or metal needless. A high voltage is impressed on the corona electrode **23** from an external power source (not shown). When the electrophotographic photoreceptor contains zinc oxide, a negative the high voltage of −6 KV, for example, is impressed. The surface of the photoreceptor is negatively charged by the corona discharge from corona electrode **23.**

It has been found that it is the surface of the photosensitive layer that is charged even when the coating of the insulating liquid is formed beforehand. Charging may be effected by the so-called double corona system whereby opposite surfaces of the photoreceptor are charged.

After passing through the charging section, the photoreceptor is passed on to an optical image exposure section. In the drawings, a sheet of photoreceptor being exposed to an optical image in the optical image exposure section is designated **25.** Exposure of the photreceptor **25** to an optical image is not interfered with by the endless belts **15** and **16** and the set of endless belts (the endless belts **15'** and **16'** shown in FIG. **3**) which only hold the photoreceptor at opposite ends thereof. The original shown is a transparent positive color picture (color slide) **26.**

The original is illuminated by a light source **27.** Light rays from the light source **27** are rendered uniform by a condenser lens **28** and a diffuser **29. 30** designates a set of color separation filters comprising red, blue and green color filters which are placed in front of or at the back of an image forming lens **31,** depending on the steps of the operation. In the embodiment shown, an optical system comprising the transparent positive picture **26,** light source **27,** condenser lens **28,** diffuser **29,** filters and lens **31** is firmly secured on a table **32.** The table **32** is movable for causing an image to be formed on the surface of the photoreceptor in each step of exposure of the photoreceptor to an optical image for each color component.

When the photoreceptor is disposed in the optical image exposure section designated **10,** the table **32** is disposed in the rightmost position in FIG. **1.** When the green filter is selected from among the set of filters **30** and the photoreceptor is exposed to an optical image through the green filter, it is necessary to place the photoreceptor perpendicular to the optical axis in order to prevent distortion of the image formed. Deviation from the perpendicular may be allowed, of course, if the deviation is negligible. After being exposed to the optical image, the photoreceptor **25** is conveyed to a developing section. A toner **33** used for developing a latent image formed through the green filter as aforementioned is a pigment of magneta color which is dispersed in a carrier liquid.

The developing section comprises a vessel **34** which is divided by partition plates **35** and **35'** into portions for receiving three types of liquid developer. The partition plates prevent the developer from mixing with each other. The toner **33** used in the first developing section is of magenta color, toner **36** used in the second developing section is of cyan color and toner **37** used in the third developing section is yellow. Preferably, the colors of the color separation filters and the colors of the toners are complementary to each other. However, the filters and toners available in an actual operation may deviate from this theoretical ideal. Therefore, the materials used may be as near the theoretical ideal as possible. A black toner may be used in combination with the magenta, cyan and yellow toners. In each developing section, **38, 38'** and **38''** are electrically conducting plates or wire-nettings which serve as developing electrodes. The photosensitive layer faces outwardly in the developing sections and is juxtaposed to development electrodes **38, 38'** and **38''.** The toners adhere to the surface of the photosensitive layer by being attracted to or replulsed therefrom by the latent images formed by exposure to the optical images.

After the latent image is developed in the first developing section, excess liquid developer wetting the photoreceptor is removed by a squeeze roller **39.** The photoreceptor having gone through the primary developing step is conveyed to a second charging portion **40** while being held at opposite end portions thereof by the endless belts. The second charging station is constructed in the same manner as the first charging section. The photoreceptor is conveyed to a second exposure section **41** after being charged again. At this time, the table **32** on which the original rests moves leftwardly in the figure, so that an optical image is formed on the surface of the photosensitive layer in the second optical image exposure section **41.** In the secondary exposure operation, the red color filter is selected from the filters **30** and moved to a position in which it is disposed in front of the image forming lens in this embodiment. A latent image formed by exposing the photosensitive layer to the optical image is developed using cyan color toner **36.** Following developing, the photoreceptor is squeezed by a squeeze roller **39'.**

After going through the second developing step, the photoreceptor then passes through a third charging section **42** to be conveyed to a third optical image exposure section **43** where a blue color filter is selected from among the set of filters **30.**

The moving distance of the table **32** leftwardly in the figure is equal to the distance between the first optical image exposure section **10** and the second optical image exposure section **41.**

After going through a third developing step, the photoreceptor which has been squeezed by a squeeze roller **39''** is conveyed to a drying section **44** where it is exposed to an air current from a fan **45.** The air current is indicated by the arrow. In the drying section **44,** the carrier liquid wetting the photoreceptor is removed.

The photoreceptor formed thereon with a color toner image after developing of the latent images in three colors is finished is stripped from the endless belt **16** by a guide plate **46** and placed on a plate **47.**

In the apparatus shown in FIG. **1,** rollers **48, 48'** and **48''** disposed in the respective charging sections are preferably electrically conducting and electrically grounded so as to provide an uniform charge. Preferably, the rollers **48, 48'** and **48''** and rollers **49, 49'** and **49''** of the respective developing sections have end portions **50** which are narrowed an amount corre-

sponding to the width **51** of the endless belts as shown in FIG. **2.** Its depth **52** is equal to the thickness of the endless belt **15. 53** and **53'** are shafts. It is required that the three squeeze rollers **39, 39'** and **39''** be narrowed similarly at their end portions or slightly shorter than the distance between the two sets of endless belts.

FIG. **3** shows the first charging section and first optical image exposure section **32** and a portion of the optical system. All reference numerals are corresponding to those of FIG. **1.** The photoreceptor **25** has passed through the first charging section where it has been negatively charged by being subjected to a corona discharge from the corona electrode assembly **23, 24** on which a high voltage is impressed, before being disposed in the position shown in the figure. The photoreceptor is held at opposite end portions thereof by the two sets of endless belts **15, 16** and **15', 16'**. An image of the transparent positive original **26** disposed on the right in the figure is formed on the photosensitive layer **25** by the image forming less **31,** so that an electrostatic latent image corresponding to the original is formed on the surface of the photosensitive layer **25.**

Although lacking in the apparatus described above, a device may be provided for carrying out the operation of washing the surface of the photoreceptor with a highly insulating liquid containing no toner after the photoreceptor has passed through various developing sections. The provision of this device is conductive to increasing the quality of the color image obtained in which background density is minimized. The same type of carrier may be used within the different colors developer; the use of a carrier liquid of particularly high volatility facilitates drying. The colors of the toners of the developer should be complementary with the colors of the color separation filters. Therefore, developing of the image in different colors may be carried out in any colors desired, so long as the colors of the toners are in a predetermined relation with the colors of the filters.

In the embodiment described above, the table **32** on which the original and optical system rest moves along the same optical axis whenever the optical image exposure operation is carried out in different colors. Alternatively, the lens along may have its position and focal length varied without moving the light source, condenser lens, diffuser and original as indicated in FIG. **3** at **65.** Even in this case, the optical axis must remain in the same position and the images formed must be substantially equal in size. A zoom lens of any type as desired which is commercially available can be used to attain the end.

In the apparatus according to this invention, duplicates of color printed matter or a color print may be made by using a reflection exposure system. The use of an image forming lens and a reflector is essential when the reflection exposure system is employed. Even in this case, liquid images formed on the photoreceptor must register with one another and be substantially equal in size in the optical image exposure operation in different colors. Exposure to an optical image may be in the form of either stationary exposure or scanning exposure. In transmission exposure and reflection exposure, different lenses may be used for the optical image exposure and operations in different colors. This process and the use of zoom lens best facilitate registration of images. In effecting registration, a microswitch or photocell is preferably used for detecting the movement of the photoreceptor supported by the endless belts. The position in which the photoreceptor is held must be kept constant with respect to the optical axis at all times.

A method for enforcing an exact registration is described in FIG. **3.** In short, **60** and **61** are units of light-source, whose inward provide a light-source, a lens and a pin-hole like slit, and therein emit a minute light beam toward the direction of the arrow as shown in the drawing. On the other hand, **62** and **63** are photo-cells which receive light from the units of light source. The apparatus is provided with means to stop the endless belts when electrical resistance becomes identical in the two photo cells or a light electromotive force.

This stopping function occurs after leading edge of the photosensitive paper **25** passes said unit **60** and photo cell **62.** The distance between said unit **60** and unit **61** (or photo cell **62** and photo cell **63**) is decided to be as long as the photosensitive cut paper **25** or less longer.

When the photosensitive paper **25** is sent by the endless belt of this apparatus, and the leading edge and trailing edge of the paper passes just, both elements **62** and **63** are equivalent in electric resistance or light electromotive force and the proceeding of a paper **25** is stopped.

Then the registration is performed as a photosensitive paper is in aveyance on a settled position.

In FIG. **1,** if said units of light source and said photocells are provided respectively on the right of the first optical image exposure section **10** and on the left of the third optical image exposure section **43,** the registrations at the optical image exposure sections of the first, the second and the third can be completely performed.

Of course, said two light beams should be made to transit a portion near the endless belt, i.e., a portion near the side end of the photosensitive paper, since it is undesirable that the light beams project to the surface of the photosensitive paper charged electrically.

One of the features of the apparatus according to the present invention is that no malfunction occurs in moving the photoreceptor because the photoreceptor is coveyed while held by two sets (four in number) of endless belts at all times.

Developing is not confined to liquid developing in the apparatus according to this invention. That is, a cascade developing process, powder cloud developing process, magnetic brush developing process and similar processes may also be used.

The liquid developing process is particulary superior to other processes in faithfully reproducing tonal gradients. In the apparatus according to this invention, when the charge of the electrostatic latent image and the charge of the toner have different signs, negative to positive work is carried out, e.g., to obtain a color print from a negative color picture. In this case, a bias voltage is impressed on developing electrodes **38, 38'** and **38''**. These electrodes are grounded when positive to positive work is being carried out. By using the apparatus according to this invention, it is possible to obtain a color picture image of high quality quite readily. Maintenance of the apparatus can be performed readily, and no jamming of the photoreceptor occurs in the apparatus.

What is claimed is:

1. A color electrophotographic apparatus comprising conveying means for sequentially conveying a sheet of electrophotographic material to at least two ex-

posure sections disposed a predetermined distance apart;

means for charging said electrophotographic sheet prior to it being conveyed to each said exposure section;

means for sequentially image exposing said electrophotographic material at each of said exposure sections, said image exposing means having an optical axis along which said two exposure sections are disposed and including means for making the optical images on the surface of the electrophotographic sheet equal to one another in size at each of the exposure sections to accommodate said predetermined distance therebetween; and

means for developing the latent images on said electrophotographic sheet resulting from the image exposures at said exposure, said developing occuring after each said exposure section,

said sheet being conveyed by said conveying means across said optical axis in a first direction at the first of said two exposure sections and in a second direction across said optical axis at the second of said two exposure sections.

2. Apparatus as in claim **1** where said means for making the optical images equal to one another includes means for moving said exposure means said predetermined distance between each of said sequential exposures.

3. Apparatus as in claim **1** where said conveying means comprises two pairs of endless belts where one pair grips one side of said sheet and the other pair grips the other side, at least a portion of said endless belts traversing a path which respectively perpendicularly crosses the optical axis of said exposure means at said exposure sections.

4. Apparatus as in claim **3** including means for moving said two pairs of endless belts at the same speed.

5. Apparatus as in claim **3** where each said pair of endless belts are separated at a point subsequent to the last developing means to permit the removal of the developed electrophotographic sheet therefrom.

6. Apparatus as in claim **1** where said exposing means includes a plurality of filters of differing colors, a different filter being introduced for each exposure for color separation.

7. Apparatus as in claim **6** where said developing means includes means for developing said latent images with colored toners, the colors of which are respectively complementary to said color separation filters.

8. Apparatus as in claim **7** where said toners are magenta, cyan, and yellow respectively.

9. Apparatus as in claim **1** where said first direction is opposite to said second direction.

10. Apparatus as in claim **1** where said conveying means includes means for gripping said sheet at each side thereof.

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