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(71) Applicant: **Hewlett-Packard Company**
3000 Hanover Street
Palo Alto, California 94304(US)

(72) Inventor: **Storlie, Chris A.**
11965 Alfred Street Boise,
Idaho 83704(US)

(74) Representative: **Baillie, Iain Cameron et al**
c/o Ladas & Parry, Altheimer Eck 2
W-8000 München 2 (DE)

(54) **Electrophotographic color printer and method.**

(57) A color development system (10), method, and apparatus for an electrophotographic color printer (80) which utilizes a plurality of developer rollers (22, 24, 26, 28) positioned at stationary locations between individual sources of color toner (29, 31, 33, 35) and the surface of an adjacent photoconductive drum (50). Each of these developer rollers (22, 24, 26, 28) are rotated about a fixed axis of rotation (38, 40, 42, 44) to attract charged color toners to the surface thereof while simultaneously being selectively driven by sources (45, 47, 49, 51) of AC and DC signal voltage to thereby electrostatically project colored toners of cyan, yellow, magenta, and black onto the surface of the photoconductive drum (50). Individual colored toner layers are then developed on the surface of the photoconductive drum (50) and then serially transferred to an adjacent print media (62) which passes between the surface (48) of the photoconductive drum (50) and an adjacent transfer roller (58). The print media (62) traverses a 360^0 path for the transfer thereon of each of the cyan, yellow, magenta, and black color images, and each color plane is successively fused into the paper on each 360^0 pass. The composite developed color image is then passed by a fuser roller (90, 92) and into a paper collection tray or bin (84).

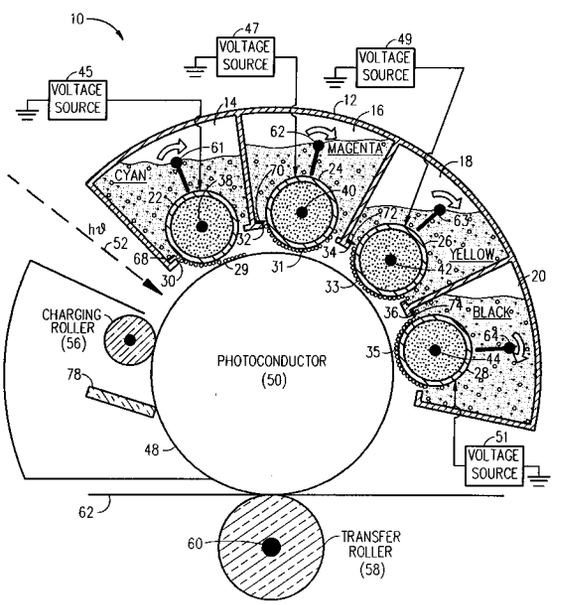

FIG. 1.

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Technical Field

This invention related generally to electrophotographic color printers, also known as laser printers, and more particularly to a projection type of electrophotographic color printer using stationary positioned developer rollers.

Background Art

In the field of electrophotographic color printing, it is known to move cyan, yellow, magenta, and black developer rollers into and out of contact with an adjacent photoconductive drum in order to provide the surface of the photoconductive drum with cyan, yellow, magenta, and black color toners. These color toners are selectively applied to the surface of the photoconductive drum and there developed to thus produce color images on the surface of the photoconductive drum which are subsequently transferred in series to an adjacent print medium.

One disadvantage of these prior color development systems which move the developer rollers into and out of contact with the surface of the photoconductive drum is that either motor driven cams or the like are required to control the physical motion of the developer rollers or a rotating carousel is required to successively bring the cyan, magenta, yellow, and black rollers into contact with the photoconductive drum. In either case, there are attendant mechanical disadvantages associated with the mechanical precision and high cost required for imparting highly controlled motion to these developer rollers. Accordingly, it is the solution to the above problems to which the present invention is directed.

Disclosure of Invention

The general purpose and principal object of the present invention is to provide a new and improved projection type of electrophotographic color printer which has been constructed in a novel manner to utilize stationary positioned development rollers adjacent to the surface of a photoconductive drum. In this manner, no mechanical motion other than rotational motion need be imparted to these rollers, and this approach overcomes the above described disadvantages associated with prior art carousel and cam driven developer rollers in a color printing system.

Another object of this invention is to provide a new and improved electrophotographic color printer of the type described which is relatively straightforward and economical in construction, reliable in operation and requires a minimum of moving parts and maintenance.

Another object of this invention is to provide a new and improved printer and method of the type described where the position and shape of the photoconductive drum is not critical, since each color plane will be deposited accurately relative to one another.

To accomplish this purpose and objects, there is disclosed and claimed herein an improved electrophotographic color printer and method of operation which comprises, among other things, providing color toners of cyan, yellow magenta, and black adjacent to the surface of a photoconductive drum; providing cyan, yellow, magenta, and black development rollers at fixed locations between these color toners and the photoconductive surface of the drum and at a predetermined distance from the surface of the photoconductive drum; and selectively driving the development rollers with both AC and DC signals while simultaneously rotating these development rollers within adjacent color toner compartments to thereby selectively and electrostatically project the toners from the surfaces of the development rollers onto the adjacent surface of the photoconductive drum. Using this approach, the selectively projected color toners of cyan, yellow, magenta, and black are then developed in series on the surface of the photoconductive drum, which has been selectively discharged by the use of a laser light beam or an equivalent image development source. The developed images in each color plane are then transferred in series to the surface of a print medium which is passed between the surface of the photoconductive drum and an adjacent transfer roller.

The above brief summary of the invention, together with its novel features and attendant advantages, will become better understood from the following description of a preferred embodiment of the invention shown schematically in the accompanying drawing.

Brief Description of the Drawing

Figure 1 is a schematic cross section view of a color development system constructed in accordance with a preferred embodiment of the invention.

Figure 2 is an abbreviated isometric view which shows how the development system of Figure 1 will be positioned and operated within the housing of a color laser printer.

Description of the Preferred Embodiment

Referring now to Figure 1, the color printer development system shown therein is designated generally as 10 and includes a fixed position or non-rotating carousel 12 having a plurality of color

toner compartments 14, 16, 18, and 20 of the tapered configuration shown. Each of these color toner compartments 14, 16, 18, and 20 carries, respectively, colored toners of cyan, magenta, yellow, and black and includes therein a single developer roller 22, 24, 26, and 28 rotatably mounted at a fixed location adjacent to openings 30, 32, 34, and 36 in the bottom walls of each of the tapered compartments 14, 16, 18, and 20.

Each of the developer rollers 22, 24, 26, and 28 are rotatably driven about their central axes 28, 40, 42, and 44, respectively, and each of these rollers is connected, respectively, to a separate voltage source 45, 47, 49, and 51. The voltage produced by the voltage sources 45, 47, 49, and 51 on the selected developer of either roller 22, 24, 26, or 28 consists of an AC component and a DC component. The DC component should be set to about -400 volts and between the voltage in the latent image areas of -100 volts and the non-image areas of -600 volts on the surface 48 of the photoconductive drum 50. These voltage settings will therefore drive the negatively charged toner 29, 31, 33, and 35 through the electric fields to develop in the image areas on the photoconductive drum 50. Additionally, the AC voltage of about 200 Hertz and 1000 Vpp is also added to enhance image development as explained in more detail by Takahaski et al in an article entitled "Mechanism of Canon Toner Projection Development", Photographic Science and Engineering, Volume 26, No. 5, September/October 1982, incorporated herein by reference.

Each of the developer rollers 22, 24, 26, and 28 have been carefully positioned at a fixed location above the surface 48 of the photoconductive drum 50 by a distance slightly greater than twice the thickness of the toner layers to be projected onto the outer surface 48 of the photoconductive drum 50. The height of the toner on the developer rollers 22, 24, 26, and 28 is adjusted by the doctor blades 68, 70, 72, and 74, respectively, within the toner compartments 14, 16, 18, and 20. By making the toner height on the developer rollers 22, 24, 26, and 28 less than twice the gap between the developer roller 22 and the photoconductive drum 50, the color toner which has been developed on the photoconductor surface is not disturbed as it passes beneath the next developer station. Thus, this approach is applicable to the projection development systems used in Hewlett Packard's Laser Jet printers where the toner is projected across a gap by the use of externally applied electric fields.

Using this approach, the colored toners are magnetically and eletrostatically attracted to the surfaces of the developer rollers 22, 24, 26, and 28 as these rollers move through the adjacent cyan, magenta, yellow, and black toners within the compartments 14, 16, 18, and 20 and are then electrostatically projected onto the surface 48 of the photoconductive drum 50 only upon the selective application of an AC and DC signal to a desired one of these developer rollers. In this manner, the individual colored toners may be selectively projected onto the surface of the photoconductive drum 50 where latent images produced by a beam 52 of light from a laser source (not shown) are developed into color images. An example of such a projection type of development system is disclosed in the above-identified Takahaski et al article and developed by Canon of Japan.

The color development system shown in Figure 1 will also include rotatable toner stirring blades 61, 62, 63, and 64 located as shown in each of the C, Y, M, and K compartments 14, 16, 18, and 20, respectively, and these stirring blades are operative to provide a desired amount of agitation in the toner compartments to maintain toner uniformity at the surfaces of the developer rollers 22, 24, 26, and 28. The color development system in Figure 1 will also typically include a charging roller 56 for providing a desired level of electrostatic charge on the surface of the photoconductive drum 50 and for providing the desired level of electrostatic attraction for the individually projected color toners. The projection system 10 in Figure 1 will further include a transfer roller 58 rotatably mounted about a central axis 60 and positioned as shown immediately adjacent to the surface 48 of the photoconductive drum 50 at a location through which the print medium 62 or other suitable intermediate transfer member (ITM-not shown) will pass.

Therefore, in operation, the print medium 62 will traverse a 360° path for the transfer of each of the cyan, magenta, yellow, and black developed images in series from the surface of the photoconductive drum 50 to the medium 62. The print medium 62 will be guided on each successive pass between the fuser rollers 90 and 92 shown in Figure 2 described below where the composite color image is fixed on the surface of the print medium 62 before being finally passed into an output paper collection tray or bin using well known paper motion and control techniques. Suitable media control techniques for controlling paper motion during the above color printing process are disclosed in my above identified co-pending applications which are incorporated herein by reference.

Referring now to Figure 2, there is shown a color electrophotographic printer housing 80 which includes an input paper tray 82 and an output paper collection bin 84 of the type currently used, for example, in Hewlett Packard's LaserJet Printers. The near side wall 86 of the printer housing is shown with a section 88 thereof cut-away so that the general location of the color development sys-

tem of Figure 1 therein can be seen in relation to the paper guide mechanisms used for controlling the paper motion. These paper guide mechanisms include, of course, the previously described photoconductive drum 50 which is mounted adjacent to the transfer roller 58 and between which the paper 62 passes four successive times as it receives color toner from the AC and DC operated color projection rollers 22, 24, 26, and 28 previously described above with reference to Figure 1.

The paper guide system shown in Figure 2 will further include a pair of output fuser rollers 90 and 92 which are operative in a well known manner to serially fuse the cyan, yellow, magenta, and black color images into the paper 62 on each of four successive passes of the paper 62 along a 360° path, first around the interior surface of a first contoured paper guide member 94, then through a first pair of lower paper guide rollers 96 and 98 and then through a second pair of paper guide rollers 100 and 102 around which is positioned a second contoured paper guide member 104. When the paper 62 has made three successive 360° passes around this 360^0 path, the media is caused to traverse over the surface of the upwardly facing paper deflection member 106 in the direction of arrow 108 and then out of the paper exit port 110 at the far end of the paper receiving bin 84.

Various modifications may be made in/to the above described embodiment without departing from the spirit and scope of this invention. The color development system shown in an abbreviated form and schematically in Figures 1 and 2 is intended to illustrate broad principles of color image development operation without being specifically limited to any particular hardware, design or to the use with only the subtractive colors of cyan, yellow, magenta, and black. Thus, for this reason, the preferred embodiment described herein has been illustrated in abbreviated schematic diagram form and is not limited to any particular constructional hardware, the selection and variations of which may be made by designers and engineers skilled in the art. Accordingly, many mechanical design variations in Figures 1 and 2 may be made by those skilled in the art without departing from the scope of the following appended claims.

Claims

1. A process for electrophotographic color printing which includes the steps of:
   a. providing color toners (29, 31, 33, 35) of cyan, yellow, magenta, and black,
   b. providing cyan, yellow, magenta, and black developer rollers (22, 24, 26, 28) at a fixed location between said toners (29, 31, 33, 35) and said surface (48) of said photoconductive drum (50) and at a predetermined distance from the surface of said photoconductive drum, and
   c. selectively driving said developer rollers (22, 24, 26, 28) with separate AC and DC signals (45, 47, 49, 51) while simultaneously rotating said developer rollers (22, 24, 26, 28) to attract charged color toners to the surface thereof to thereby selectively project said color toners (29, 31, 33, 35) onto the surface of said photoconductive drum (50) in preparation of color image development thereon.

2. The process defined in claim 1 which also includes serially transferring developed color images from the surface of said photoconductive drum (50) to the surface of an adjacent print media (62) which passes between said drum (50) and a transfer roller (58).

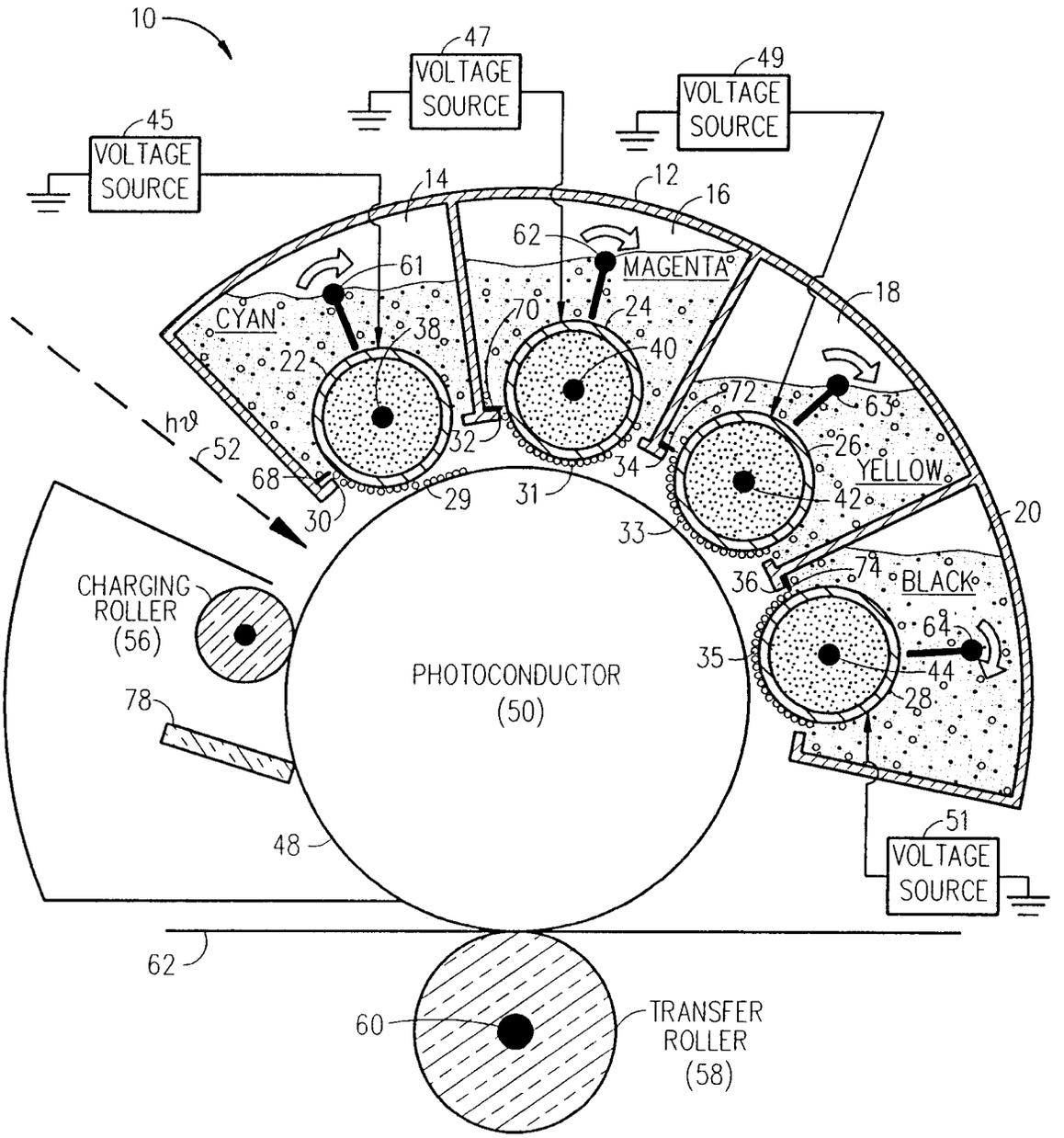
3. An electrophotographic color printer which includes:
   a. means for providing color toners (29, 31, 33, 35) of cyan, yellow, magenta, and black, and
   b. cyan, yellow, magenta, and black developer rollers (22, 24, 26, 28) disposed at a fixed location between said toners and the surface of a photoconductive drum (50) and at a predetermined distance from said surface of said photoconductive drum (50),
   c. said developer rollers being selectively driven with AC and DC signals (45, 47, 49, 51) while being simultaneously rotated to deliver charged color toners to the surface thereof to thereby selectively and electrostatically project said color toners onto the surface of said photoconductive drum (50).

4. The printer defined in claim 3 further including means for serially transferring developed color images from said surface of said drum (50) to an adjacent print media (62) which passes between said drum surface (48) and an adjacent transfer roller (58).

5. The printer defined in claims 3 or 4 further including a height adjustment doctor blade (68, 70, 72, 74) positioned adjacent to each of said developer rollers (22, 24, 26, 28) for controlling the amounts of color toner (29, 31, 33, 35) transferred to said photoconductive drum (50).

6. The printer defined in claims 3, 4, or 5 further including a print media-feed path (50, 58, 90, 92, 96, 98, 100, 102) for passing said print media (62) over a 360^0 path for the serial

transfer of each color image thereon and for guiding a developed composite color image on said print media past a fuser roller (90, 92) to an output paper collection tray or bin (84).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CHARGING ROLLER (56)
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VOLTAGE SOURCE
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TRANSFER ROLLER (58)

FIG. 1.

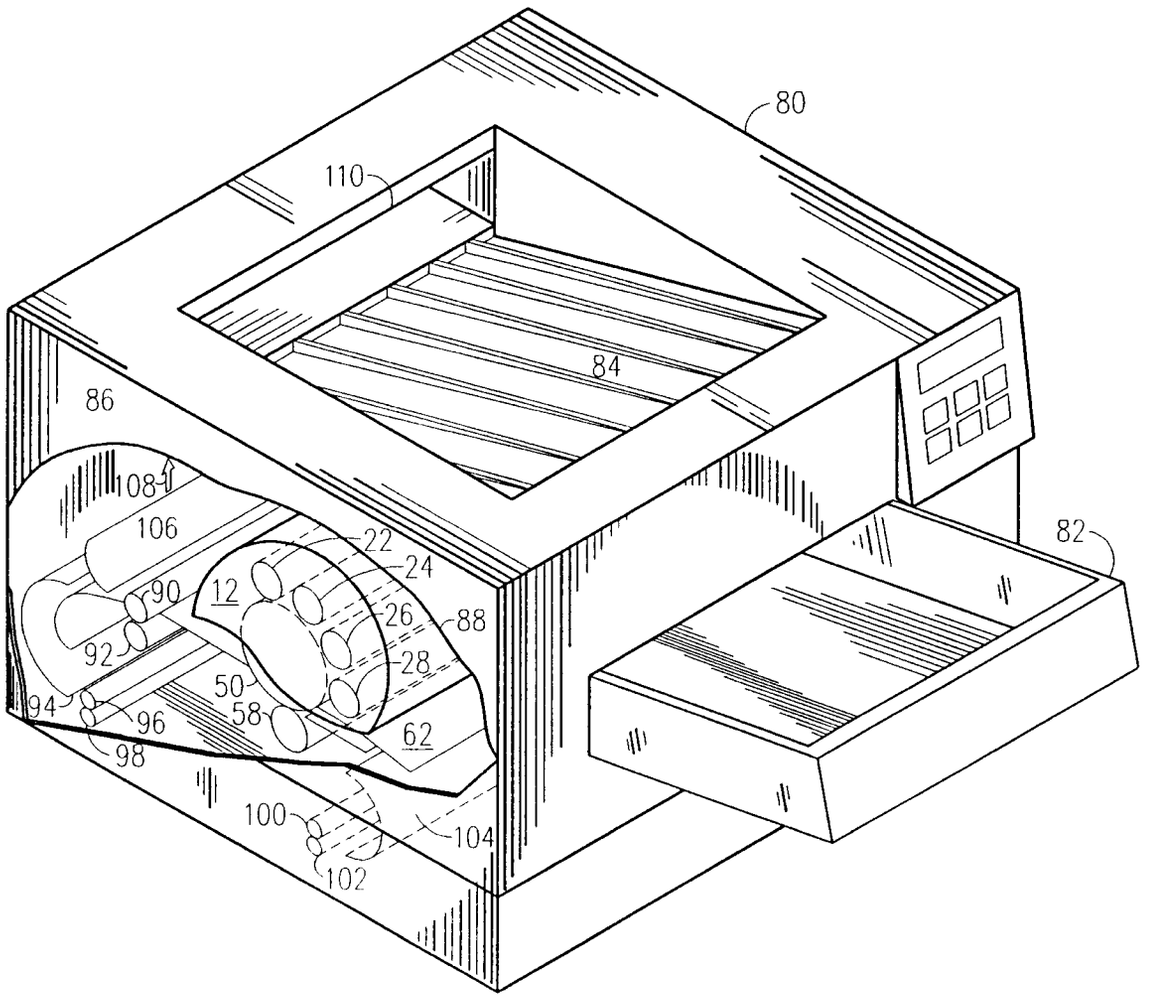
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FIG. 2.