PATENT SPECIFICATION (11) 1 586 101

1 586 101

(21) Application No. 24778/77 (22) Filed 14 Jun. 1977

(19) THE PATENT OFFICE LONDON

(31) Convention Application No. 695351 (32) Filed 14 Jun. 1976 in

(33) United States of America (US)

(44) Complete Specification Published 18 Mar. 1981

(51) INT. CL.^{3} G03G 13/01

(52) Index at Acceptance
G2C 1011 1015 1016 1023 1032 1033
1041 1043 1044 1045 1062 C17F

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(54) MULTICOLOUR ELECTROPHOTOGRAPHIC REPRODUCTION PROCESS

(71) We, EASTMAN KODAK COMPANY, a Company organized under the Laws of the State of New Jersey, United States of America of 343 State Street, Rochester, New York 14650, United States of America do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed to be particularly described in and by the following statement:-

The invention relates to colour electrophotography and, more particularly, to an electrophotographic process, material and apparatus for producing on a single support a self-registered, multicoloured image from a single exposure of a colour original.

The well known and basic dry electrophotographic process can be adapted to produce multicolour reproductions by first colour separating the original document to be reproduced into its primary colour components red, green and blue. Each colour component is then used to record a separate latent electrostatic image on the surface of a photoconductive material. The recorded red, green and blue images are developed using toners containing subtractive colorants that are complements of the primary colour recorded, i.e., cyan, magenta and yellow, respectively. Finally, each developed image is individually transferred from the photoconductive material to a final support material to produce a multicolour reproduction of the original. One disadvantage of this process is that the formation of colour separations is an expensive and tedious operation. Another disadvantage is that multiple exposure and transfer operations are required, which operations must be in precise registration in order to produce high quality prints.

A subtractive colour electrophotographic process which eliminates the need to form colour separations is disclosed in U.S. Patent No. 2,962,375. In accordance with the teachings of this reference, a plurality of photoconductive layers, each conductively sensitive to light of a different primary colour are superimposed one on top of the other. A light image of a colour original is projected on the array of photoconductors from one side thereof so that the wavelengths of the exposing light selectively pass through the first of the photoconductors in reaching the last of the photoconductors. An electric field is applied through the photoconductive layers while they are exposed in this manner so as to produce a plurality of developable electrostatic latent images which are developed with a toner of the colour complementary to the primary light of the exposure. While this process requires only a single exposure of the original, registration is still a problem since each of the developed images must still be individually transferred in register to a final receiving support.

U.S. Patent No. 3,702,483 discloses an electrophotographic method for producing a colour reproduction of an original employing a single exposure and a single transfer operation. In this method, a colour original is exposed to a uniformly charged photoconductive layer. The original contains colours having reflective characteristics that are capable of selectively discharging the photoconductive surface to discrete charge density levels so that each colour is recorded thereon at a discrete charge potential. The photoconductive layer is then transported through a developing station containing a plurality of developing units equal in number to the number of discernible colours in the original. Each developing unit has an electrical control means associated therewith so that only colour components recorded at or above a predetermined potential are developed within the unit. The recorded images are developed in a descending order of magnitude and the final colour rendition is then transferred in a single operation to a sheet support material. One disadvantage of this method is that it cannot faithfully reproduce originals comprised of colours which reflect or transmit similar quantities of light to the photoconductor. Another disadvantage is that some residual voltage remains in the developed regions which, in some cases, may be sufficient to attract additional toner in subsequent developing units, thereby altering the colour balance of the reproduction.

Another electrophotographic method for producing a colour reproduction of an original which requires only a single exposure and a single transfer operation is disclosed in U.S. Patent No. 3,836,363. This method uses a recording material comprising a multicolour additive filter mosaic sandwiched between two pan-sensitive photoconductive layers. To carry out the process, one photoconductive layer of the recording material is uniformly charged and imagewise exposed to a colour original through the mosaic. The resulting electrostatic latent image is developed with an opaque toner. The other photoconductive layer is then uniformly charged, exposed through the opaque toner bearing surface of the first photoconductive layer and the mosaic, and developed three successive times using red, green and blue exposing lights and cyan, magenta and yellow toners, respectively. The resulting colour image is then transferred to a final receiver sheet. One disadvantage of this process is that a high quality filter mosaic is required which increases the manufacturing costs of the recording material. Furthermore, use of a mosaic requires controlled smearing of either the exposure or transfer operation of the process in order to produce a faithful colour reproduction.

According to the present invention there is provided a multicolour electrophotographic reproduction process comprising providing a recording material having an electrically conducting layer, an electrically insulating layer and at least first and second photoconductive layers sandwiched between the conducting and insulating layers, each of the photoconductive layers being sensitive to a different wavelength of the optical spectrum and the conducting and insulating layers being at least partially transparent to radiation in the optical spectrum; uniformly electrostatically charging the insulating layer; and imagewise exposiing the recording material, through the transparent insulating or conducting layer, to an image that comprises wavelengths to which the first and second photoconductive layers are sensitive thereby forming an inter-layer charge distribution pattern; uniformly exposing the recording material through the transparent insulating or conducting layer to radiation of wavelength and intensity that will substantially discharge one of the photoconductive layers thereby providing a first surface charge pattern on the recording material; treating the first surface charge pattern with toner particles having a first subtractive colour characteristic, as herein defined, while establishing across the recording material and the first toner particles an electrical field of a first bias potential; uniformly exposing the recording material through the transparent insulating or conducting layer to radiation of wavelength and intensity that will substantially discharge at least the other of the photoconductive layers thereby providing a second surface charge pattern on the recording material; treating the second surface charge pattern with toner particles having a second subtractive colour characteristic while establishing across the recording material and the second toner particles an electrical field of a second bias potential whereby a multicoloured self-registered particle image is formed on the insulating layer.

There is further provided a recording material comprising an electrically conducting layer and an electrically insulating layer, at least one of the electrically conducting and insulating layers being at least partially transparent to radiation in the optical spectrum, a first photoconductive layer sensitive to radiation in a first portion of the optical spectrum and substantially transparent to radiation of at least a second portion of the optical spectrum and a second photoconductive layer sensitive to at least radiation in the second portion of the optical spectrum.

To carry out the process of the invention, the recording material is uniformly charged and exposed to a colour original. The photoconductive layers are then successively discharged by successive overall uniform exposures of the recording material to the radiation to which the photoconductive layers are selectively sensitive; so scalled 'flooding' exposures. Simultaneously with or subsequent to each flooding exposure step, a toner having a particular subtractive colour characteristic is applied to the surface of the recording material in combination with an appropriate electrical bias. The term "subtractive colour characteristic" as used herein with respect to a marking particle, e.g. a toner, is intended to include both particles having a subtractive colour colorant and particles having the ability to form a subtractive colour in a subsequent step.

The above-described multistep development procedure forms a multicolour image on the insulator layer comprised of a plurality of superimposed subtractive colour images which is then transferred in a single operation to a final receiver.

The invention provides an electrophotographic process utilizing a recording material which can be readily manufactured by techniques known in the art to produce full colour images with a single exposure of the original and a single transfer operation. The process may be utilized to form a camera original or a reproduction of a colour document. The process may also be used in a reversal mode to form an internegative or colour mask.

The invention also provides a unique electrophotographic apparatus for effecting the aforedescribed colour recording procedure.

A recording material useful in the present invention can be fabricated in a number of alternative configurations. The optimum recording materials and configuration of a material will depend upon such factors as the source of activating radiation used and the desired image. A typical recording material configuration useful in the process of the invention comprises an electrically conductive support or, alternatively a support coated with a conducting layer, the support or conducting layer having thereon an electrically insulating layer and at least two photoconductive layers conductively sensitive to different portions of the optical spectrum i.e., the ultraviolet, visible and infrared portions of the electromagnetic spectrum. The photoconductive layers and the insulating layer can be arranged on the conducting layer in any desired order provided that the insulating layer is outermost, for example, to optimize the recording process in view of unwanted absorption in one or more of the photoconductive layers. Preferalby, the recording material is a unitary structure formed of a plurality of adhered layers although the layers can be formed separately if desired and then sandwiched together during the recording process.

A variety of photoconductive layers which absorb light of primarily only one wavelength or group of wavelengths and are substantially transparent to light of other wavelengths can be used in the described recording material. The photoconductive layers can be formed from both organic and inorganic materials. Organic materials have been found especially useful including homogeneous organic photoconductive compositions containing, for example, an organic photoconductive polymer or a solid solution of an organic photoconductor in a polymeric binder. Other especially useful organic photoconductive materials are the "heterogeneous" or "aggregate" photoconductive compositions such as described in U.S. Patent No. 3,615,414 and Belgian Patent 836,892. Still another especially useful type of organic photoconductive material includes mixtures of one or more organic photoconductive pigments dispersed in a polymeric binder. A photoconductive layer useful in the described recording material can be formed as a single layer member or as a multilayer member as described in the aforementioned Belgian Patent 836, 892. Preferably, the photoconductive layers contained in the recording element are regenerative and of matched speed, i.e., the layers have an approximately equal photosensitive response when illuminated with light of a colour to which they are selectively sensitive. In a particularly preferred embodiment of the invention, the recording material contains three regenerative, matched speed photoconductive layers which are respectively blue-light sensitive, green-light sensitive and red-light sensitive. In alternative embodiments the layers can be selectively sensitive to light in other portions of the visible spectrum as well as to the ultraviolet and infrared portions of the optical spectrum.

A multilayered unitary recording material can be manufactured by a variety of well known techniques, including lamination, solvent coating and a combination of solvent coating and lamination. When the process for manufacturing the recording material includes the steps of solvent coating two adjacent selectively-conductive photoconductor layers, the recording material preferably further includes a transparent barrier layer such as a cellulose nitrate layer between the adjacent photoconductive layers. For such solvent coated recording materials, the cellulose nitrate layer has been found to provide useful chemical barrier properties between each of the separate photoconductive components of the recording materials, for example, solvent hold-out. The cellulose nitrate layer may also reduce the electrical charge migration and enhance the storage properties of the recording material.

If one or more of the selectively sensitive photoconductive layers do not have the desired absorption spectrum, the recording element may also include one or more filters to compensate for this unwanted absorption. The filter or filters may be formed as a separate layer or incorporated into the appropriate photoconductive layer or into the cellulose nitrate barrier layer. In the latter instance, a single interlayer can serve all three of the above-noted functions, i.e. as the filter layer, the chemical barrier layer and the electrical barrier layer.

The invention will now be described with reference to the accompanying drawings, in which:-

Fig. 1 is a cross section of an illustrative multilayer recording material useful in carrying out the process of the invention;

Figs. 2a - 2d schematically illustrate the sequential steps of the process according to the invention;

Fig. 3 schematically illustrates a top plan view of an automatic apparatus for carrying out the process of the invention;

Fig. 3a is a cross sectional view taken along line 3-3 of Fig. 3 showing the corona charging mechanism in greater detail;

Fig. 4 is a side elevational view of the apparatus; and

Fig. 4a is a cross sectional view taken along line 4-4 of Fig. 4 showing the development and rinse voltage biasing mechanism in greater detail.

A particularly useful recording material is illustrated in Fig. 1. As shown, the recording material includes a transparent support 12 of polyethylene terephthalate coated with a transparent electrically conducting layer 13. Adjacent the conducting layer 13 is a first photoconductor 14 which absorbs light primarily in the blue region of the visible spectrum and is substantially transparent to wavelengths of the other two primary colours. The photoconductor 14 is of composite structure and comprises a blue-sensitive emitter layer 15 and a charge transport layer 16 having a yellow filter material incorporated therein. Since the recording material is manufactured using solvent coating techniques, a transparent barrier layer 18, such as cellulose nitrate, is coated on top of the charge transport layer 16. Adjacent to the transparent barrier layer 18 is a second composite photoconductor 20 which absorbs light primarily in the green region of the visible spectrum and is substantially transparent to light in the red region of the spectrum. The photoconductor 20 comprises a green sensitive emitter layer 21 and a charge transport layer 22 having a magenta or red filter material incorporated therein. Another barrier layer 24 is coated between the charge transport layer 22 and a third composite photoconductor 26 comprising a red-sensitive emitter layer 27 and a charge transport layer 28 and having a peak sensitivity in the red region of the visible spectrum. An electrically insulating layer 30 heat laminated onto the layer 28, completes the recording material. If the insulating layer 30 is solvent coated on the charge transport layer 28 another barrier layer would be coated between the layers 28 and 30.

It is to be noted that the above-listed order of the three selectively-conductive composite photoconductors 14, 20 and 26, respectively, is illustrative only and other combinations could be used if desired or required for optimization of the process. If a two-colour system is desired, one of the selectively conductive photoconductors can be omitted from the recording material. Furthermore, the yellow filter material is included in the charge transport layer 16 to compensate for the unwanted sensitivity of the green-sensitive photoconductor 20 and, to a lesser degree, of the red-sensitive photoconductor 26 to blue light. Similarly the magenta or red filter material is included in the charge transport layer 22 to compensate for the unwanted sensitivity of the red-sensitive photoconductor 26 to green light. If the photoconductive elements used in the recording material are conductively sensitive to light of only one primary colour to the substantial exclusion of sensitivity to light of the other two primary colours, then the filter materials can be eliminated from the recording material structure.

To use the recording material described above to produce a multicolour image, the recording material is uniformly charged while being exposed to a colour original and then successively developed three times by flood exposing the recording material to blue, cyan and white light and applying three toners having different subtractive colour characteristics in combination with appropriate electrical biases. With the illustrative recording material shown in Fig. 1, both the flooding and exposing steps are made through the transparent support 12. In alternative recording materials the exposure and/or flooding steps can be made through a transparent insulating layer.

In the preferred embodiment of the invention the toners contain cyan, magenta and yellow colorants that are predominantly spectrally absorptive of the red, green and blue light to which the photoconductive layers of the recording element are selectively sensitive. Alternatively, the toners may be colourless and contain a dye coupler and a catalyst which react with a photographic developing solution to form a multicoloured image. In still other embodiments the toners may be nucleated or sensitized in a manner which allows them to form colour images in a subsequent development or amplification procedure. It is important to note that the process of the invention does not require the above-described or any predetermined sequence of flooding or toner applying steps to be followed. The flooding and/or toner applying steps can be arranged in any desired sequence, for example, in order to optimize the recording process in view of the particular absorption characteristics of the recording material. Furthermore, the process does not require the above-described combination of blue, cyan and white flooding lights. Other combinations of flooding lights can be used which selectively discharge one or more photoconductive layers, for example, blue, green and red flooding lights. The blue, cyan and white combination is preferred because it first discharges the blue-sensitive photoconductor, then discharges the blue and green-sensitive photoconductors and finally discharges all three photoconductors. This discharging sequence provides the greatest flexibility in selecting the other process parameters.

The aforementioned steps of the process of the invention are schematically illustrated in Figs. 2a - 2d. To aid the reader's understanding of how a multicoloured image is formed, the process will be explained in the succeeding paragraphs in conjunction with an idealized three-colour recording material. The assumptions of the idealized recording material are as follows:

1) the photoconductive layers and the insulating layer of the recording material all have the same capacitance;

2) the voltage across each of the photoconductive layers is reduced to or maintained at zero when exposed in its maximum absorption region without affecting the other photoconductive layers;

3) when the recording material is developed, all the potential difference available for development is used to attract toner until the electric field in the development zone is neutralized;

4) during each development step, the dielectric layers of the recording material (i.e., the insulating layer and photoconductive layer or layers in a nonconducting state) recharge to voltage which in sum are equal in magnitude to the developing bias voltage applied to the recording material, the potential difference between the bias voltage and the total dielectric layer voltage across the recording material after exposure being divided equally among such dielectric layers since they are of equal capacitance; and

5) electrical charges migrate across the layer interfaces when an external voltage is applied to the recording material, but store across such layers when the voltage is removed.

As will be noted, the conductive layer 13 of the recording material is connected to a reference potential during the three development steps of the process and the three development heads are grounded. Alternatively the conductive layer 13 can be maintained at earth potential during development with an appropriate electrical bias applied to each of the three development heads. Also the flooding light exposures are made prior to and simultaneously with the developing steps to prevent recharging in the photoconductive layer or layers being flooded. Alternatively the photoconductive layers can be flooded only prior to development in which case the flooded photoconductive layer or layers as well as the other dielectric layers of the recording element in a nonconducting state recharge during the development steps.

The first step of the process is to charge uniformly and expose the recording material to a colour original 11 shown having clear, opaque, yellow and red areas.

Preferably such charging and exposure occurs simultaneously since it results in the creation of a uniform surface potential on the insulating layer 30, which potential comprises a unique series of interlayer charge patterns distributed across the photoconductive and insulating layers that are representative of each colour component in the colour original 11, the patterns in total forming a stored, multicolour latent charge image within the recording material. Alternatively, the charging and exposure can be performed as separate steps of the process. This procedure will produce the required unique series of interlayer charge patterns distributed across the photoconductive and insulating layers of the recording material, however, the surface potential on the insulating layer will be non-uniform. One potential disadvantage of this procedure is that the range of useful biasing voltages applied in the toner applying steps may be limited.

The charge distribution pattern formed by charging and simultaneously exposing the idealized recording material to the colour original 11 comprising clear (white), opaque (black), yellow and red areas is shown in Fig. 2a. For the purpose of illustration, the uniform charge is shown to be of a positive polarity, of a magnitude of 1,000 volts and to be produced by a conventional corona charger unit 32. In the idealized three-colour recording material the surface potential on the insulating layer is a uniform 1,000 volts; however, the distribution of that charge across each of the three photoconductive layers and the insulating layer will vary uniquely in accordance with each colour component in the colour original 11. As illustrated, light from the red portion of the original 11 dissipates the charge only in the red-sensitive complex photoconductor 26. The 1,000 volts potential applied by the corona charger 32 is, therefore, divided equally between the blue-sensitive complex photoconductor 14, the green-sensitive complex photoconductor 20 and the insulating layer 30 so that the potential across each of these components is approximately 333 volts. Light from the yellow portion of the original dissipates charge in both the green and red-sensitive photoconductors, 20 and 26, respectively. As a result, the 1,000 volt applied potential is divided equally between the blue-sensitive photoconductor 14 and the insulating layer 30. Where white light from the clear area of the original 11 strikes the recording material, the charge is dissipated from all three photoconductors so that the full 1,000 volt potential appears across the insulating layer 30. In the opaque black areas of the original 11, no light strikes the recording material and the potential across each of the four layers 14, 20, 26 and 30, respectively, is approximately 250 volts.

After being uniformly charged and exposed to the colour original 11, the recording material is uniformly flooded with blue light to dissipate the charge on the blue-sensitive photoconductor 14. A developing bias of 1,000 volts positive with respect to the conducting layer 13 is then applied to the developing head 72, see Figure 3, while maintaining the blue flood exposure and the recording material is developed with positively charged yellow coloured toner particles forming a blue separation toner image of the original 11. A section of the insulating layer 30 will receive the yellow coloured toner particles during development if the surface potential of that section (which is equal to the sum of the potentials across the photoconductors 20 and 26 and the insulating layer 30) is less than that of the bias potential. However, if the surface potential is equal to or greater than the bias potential then no yellow colored toner particles will be deposited. As shown in Fig. 2b, the areas of the insulating layer 30 corresponding to the black, yellow and red areas of the original 11 initially all have a surface potential of less than 1,000 volts as a result of the blue light flooding and receive yellow coloured toner particles whereas the area of the insulating layer 30 corresponding to the white area of the original 11 has a surface potential equal to 1,000 volts and therefore receives no toner.

During the yellow development procedure, the portions of the recording material in which the sum of the interlayer potentials is reduced below the 1,000 volt charging level as a result of the blue light flooding, recharge to the 1,000 volt bias level dividing the difference in potential between the initially blue exposed and recharged states equally between the green-sensitive photoconductor 20, the red-sensitive photoconductor 26 and the insulating layer 30. Thus the area of the recording material corresponding to the black area of the original 11 recharges from 750 to 1,000 volts, dividing the 250 volt potential difference available for yellow development equally among the red-sensitive photoconductor 26, the green-sensitive photoconductor 20 and the insulating layer 30 (i.e., the voltage across these layers increases from 250 to 333 volts). Similarly the areas of the recording material corresponding to the yellow and red areas of the original 11 recharge from 500 to 667 volts, respectively, to 1,000 volts and divide the 500 volt potential difference and the 334 volt potential difference available for yellow development equally among the green-sensitive photoconductor 20, the red-sensitive photoconductor 26 and the insulating layer 30 (i.e., in the area of the recording material corresponding to the yellow area of the original 11, the voltage across the green-sensitive photoconductor 20 and the red-sensitive photoconductor 26 increases from 0 to 167 volts while the voltage across the insulating layer 30 increases from 500 to 667 volts. In the area of the recording material corresponding to the red area of the original 11, the voltage across the green-sensitive photoconductor 20 and the insulating layer 30 increases from 333 volts to 444 volts while the voltage across the red-sensitive photoconductor 26 increases from 0 to 111 volts.)

Next, as shown in Fig. 2c, the recording material is uniformly flooded with cyan light which insures that the blue-sensitive photoconductor layer 14 is maintained at zero voltage and dissipates the voltage across the green-sensitive photoconductor 20. A developing bias of 834 volts positive with respect to the conducting layer 13 is then applied to the development head 76, see Figure 3, while maintaining the cyan flood exposure. The recording material is developed with positively charged magenta coloured toner particles, forming a green separation toner image of the original 11 superposed exactly in register with the previously formed blue separation. The 834 volt bias potential is equal to the surface potential in the area of the insulating layer 30 corresponding to the yellow area of the original 11 and is less than the initial surface potential in the area of the insulating layer corresponding to the white area of the original 11 and, therefore, no magenta coloured toner particles are deposited in these areas. Magenta coloured toner particles are deposited, however, in the areas of the insulating layer 30 corresponding to the black and red areas of the original 11 since these areas initially have a surface potential of less than 834 volts. Again, during development, the areas of the recording material, wherein the sum of the interlayer potentials is reduced below the 834 volt bias level as a result of the cyan flooding, i.e., those areas corresponding to the black and red areas of the original, charge up to the bias potential level dividing equally the potential difference available for magenta development between the red-sensitive photoconductor 26 and the insulating layer 30. However, the area of the recording material corresponding to the white area of the original 11 is initially at 1,000 volts and must discharge to reach the 834 volt bias level. This discharge is also equally divided between the two layers 26 and 30 with the insulating layer 30 dropping to 917 volts and the red-sensitive photoconductor 26 acquiring a negative charge of 83 volts.

Finally, as shown in Fig. 2d, a red separation toner image of the original 11 is formed on the insulating layer 30 by uniformly flooding the recording material with white light which discharges all three photoconductors while simultaneously applying positively charged cyan coloured toner particles in combination with a bias voltage of 583 volts positive with respect to the conducting layer 13. This red separation toner image is again in exact registration to the previous two colour separations. Cyan coloured toner particles are deposited in the area of the insulating layer 30 corresponding to the black area of the original 11 since the surface potential is initially less than 583 volts. No cyan coloured toner particles, however, are deposited in the other area of the insulating layer since the surface potential in these areas is equal to or above the bias potential. As a result of the three development steps, the area of the insulating layer 30 corresponding to the black area of the original 11 contains superimposed yellow, magenta and cyan toner deposits, the area corresponding to the red area of the original 11 contains yellow and magenta toner deposits, the area corresponding to the yellow area of the original 11 contains only yellow toner and the area corresponding to the white area has not deposited toner. This three-colour positive-to-positive image can be transferred from the insulating layer 30 to any suitable receiver by techniques known in the art and fixed thereon. The recording material can then be prepared to be recycled through the process steps illustrated in Figs. 2a-2d to produce another colour print by cleaning residual toner particles remaining on the insulating layer 30 and then reverse charging the recording material the corona charger set at 0 volts while flooding the recording material with white light.

It should be noted that in the development of the idealized recording material, different potentials are available for different toners and this difference may affect the colour balance of the resulting image. For example, in forming the red image on the insulating layer 30, a potential of 333 volts is available for yellow development (the 1,000 volt bias potential less the total interlayer potential of 666 volts) and 279 volts is available for magenta development (the 834 volt bias potential less the total interlayer potential of 555 volts). To provide better colour balance in the image, the capacitance of each of the photoconductors could be individually selected and/or a different combination of biasing potential utilized.

The practical operability of the process described above is illustrated by the following examples.

EXAMPLE 1

A multilayer recording material comprising two photoconductive layers selectively conductive to light of different wavelengths was fabricated in the following manner. A blue-sensitive photoconductive layer was prepared by adding 2.25 grams of dibenzothiophene formaldehyde resin, 2.25 grams 'Vitel' 101 (the trade mark of a polyester manufactured by the Goodyear Rubber Company in the U.S.A.), 1.5 grams of 2,4,7-trinitro-9-fluorenone and 0.75 ml of a 10% solution of poly(bisphenol A-block copolydimethylsiloxane sebacate) in dichloromethane to 35.1 grams of dichloromethane.

After the components has been dissolved, the composition was coated on a transparent, electrically conducting film support subbed with a thin layer of a polymeric adhesive using a 100 micrometre coating knife. The resulting coating was dried in an oven at 90°C for 15 minutes. A barrier layer was then prepared by dissolving 0.26 grams of cellulose nitrate in 0.8 grams n-butanol and 9.2 grams methanol. This composition was coated on the blue-sensitive layer described above.

A red-sensitive photoconductive layer was formed by adding 0.494 grams of 4-(4-dimethylaminophenyl)-2,6-diphenyl thiapyrylium fluoroborate, 29.7 grams Lexan'145 (the trade mark of a polycarbonate manufactured by the General Electric Co. in U.S.A.) and 19.7 grams 4,4'-bis(diethylamino)-2,2'-dimethyl triphenylmethane to 200 grams of dichloromethane. After shearing in a blender for 75 minutes, the composition was coated on the above-described barrier layer and dried at 60°C for 16 hours. Finally, a subbed 12.5 micrometre 'Mylar' film (the trade mark of a biaxially oriented polyethylene terephthalate film manufactured by E.I. du Pont de Nemours & Co. in U.S.A.) was heat laminated to the red-sensitive photoconductive layer to serve as the insulator layer.

Two positive-to-positive, two-colour prints were made with this two photoconductive layer recording material using the apparatus shown in Figs. 3, 3a, 4 and 4a. To produce the prints, a sheet of recording material 10 was placed on a transparent platen 38 and uniformly charged to a positive potential of approximately 1250 volts with respect to its conducting layer 13 by a grid controlled corona charger unit 40 comprising a plurality of corona wires 42 surrounded on one side by an electrically conducting shield 44 and on the other side by a wire grid 48. Both the shield and grid were connected to a bias voltage source 50. The corona wires 42 were connected to a high voltage source 46. Simultaneously with charging, the recording material 10 was exposed by projecting a colour original with light provided by a xenon source 54 (a 'Xenographic' 500 projector manufactured by the Optical Radiation Corporation in the U.S.A.) The colour original consisted of adjacent bands of blue and red KODAK 'Wratten' filters along with clear and dark regions. KODAK and 'Wratten' are registered trade marks. A spring biased mirror 58 positioned by a pin 59 mounted on the platen 38 intercepts the light image of the original and reflects such image through the platen 38 to the recording material 10. As shown in Fig. 4, the corona charger unit 40 was then pivoted in a downwardly direction to the retracted position shown in phantom and the platen 38 carrying the recording material 10 thereon was pivoted in an upwardly direction to a position overlaying the path of movement of a movable carriage 63. Concurrent with the movement of the platen 38, the mirror 58, no longer supported by the pin 59, pivoted to an inoperative position spaced from the path of movement of the carriage 63. The recording material 10 was then flooded with red light provided by projecting white light from a second xenon source 60 (a 'Xenomega' Pro-Lab enlarger manufactured by the Berkey Photo Corporation in the U.S.A.) positioned above the platen 38 through a red filter contained in a filter wheel 62 and the platen 38 to the recording material 10. While maintaining the red flooding light, the carriage 63 having three development stations 64, 70 and 76, respectively, mounted thereon was moved along rods 65 such that the development station 64 was passed in close proximity to the insulating layer 30 of the recording material 10. The development station 64 comprised a liquid development head 66 containing positively charged cyan coloured toner particles in 'Isopar' G solvent (the trade mark of Exxon in U.S.A. and used to designate an isoparaffinic hydrocarbon liquid of very high purity having a boiling range from 145°C to 185°C) and a rinse head 68 containing 'Isopar' G solvent. Each of the heads 66 and 68 is constructed with small alternating channels in a flat metal surface to allow the liquid to flow in, across the flat surfaces and drain away. With a negative electrical bias of 1100 volts applied to the conducting layer 13 of the recording material 10 from a source 69, see Figure 4a, the development head 66 earthed and a positive electrical bias of 1080 volts applied to the rinse head 68, cyan coloured toner particles were deposited on the insulating layer in the areas corresponding to the blue and dark regions of the original. The filter wheel 62 was then rotated to position a blue filter in the light beam provided by the xenon source 60. While maintaining the blue flooding light, the carriage 63 was rotated in a counterclockwise direction so that the development station 70 was positioned to pass adjacent the insulating layer 30. The development station 70 is identical to the development station 64 except that its development head 72 contained positively charged yellow coloured toner particles in 'Isopar' G solvent. With negative electrical bias of 1,000 volts applied to the recording material 10, the development head 72 earthed and a positive electrical bias of 980 volts applied to the rinse head 74, yellow coloured toner particles were deposited on the insulating layer in the areas corresponding to the red region and the dark region of the original. The resulting images were thus composed of cyan, yellow and green toner deposits corresponding to the blue, red and dark regions of the original and no toner deposits in the area corresponding to the clear region of the original. The only difference in the two prints was the method of transferring the images to a final receiving support; one transfer was electrostatic and the other transfer was adhesive. Pertinent data for the processing of the recording material 10 is listed below:-

Exposure:

a) Intensity of the 'Xenographic' projector - power of density at the exposure plane was 5,200 microwatts/cm^2

b) Permanent filters - a KODAK 'Wratten' No. 2B filter and a 725 nanometre (nm) interference cutoff filter were permanently positioned in the light beam of the 'Xenographic' projector,

c) The colour original

1) The blue portion of the original comprised two thicknesses of a KODAK 'Wratten' No. 47B filter,

2) The red portion of the original comprised a KODAK 'Wratten' No. 70 filter,

3) The clear portion of the original comprised a KODAK 'Wratten' No. 96 filter (Neutral Density of 1.0),

4) The dark portion of the original comprised an opaque black mask, and

d) Time of exposure was 4 seconds.

Charging:

a) Magnitude - positive 7 kilovolts on the corona wires and grid bias set at 1250 volts positive all with respect to the conducting layer 13,

b) Time of charging -4 seconds simultaneous with exposure and then continued for an additional 1 second in the dark, and

c) Construction of corona charger - corona wires were 25 micrometres in diameter. Grid has 8 lines per 25.4 millimetres and was oscillated while charging. Active charging area was about 120 mm by 170 mm).

Flooding and Developing:

a) Intensity of the 'Xenomega' enlarger - with lens at f/4.5 and KODAK 'Wratten' No. 2B and a 725 nanometre cutoff interference filter permanently in the beam, the power density at the exposure plane was 330 microwatts/cm^2,

b) Spacing - the rinse and development heads were spaced about 0.5 millimetre from the insulating surface of the recording material 10,

c) Development time -about 4 seconds.

d) First flood and development:

1) Filter pack -

KODAK 'Wratten' No. 29 (red) filter,

2) Developer -positively charged cyan colored toner particles in 'Isopar' G solvent,

3) Time - 10 seconds flood prior to development plus 10 seconds flood while developing.
e) Second flood and development.
1) Filter pack - two thicknesses of a KODAK 'Wratten' No. 47B (Blue) filter,
2) Developer - positively charged yellow coloured toner particles in 'Isopar' G solvent,
3) Time - 1 second flood prior to developing plus 10 seconds flood while developing.

Transfer:

a) Electrostatic - 2 kilovolts positive applied to the recording material 10 with respect to a grounded gel roller. A piece of insulator-coated paper was used as the receiver sheet. The colour print was fused at 100°C for 30 seconds.

b) Adhesive - 4 inch wide 'Scotch' Magic tape (the trade mark of a tape manufactured by Minnesota Mining and Manufacturing Company in U.S.A.) was used to transfer the colour print from the recording material 10 to the above receiver sheet.

EXAMPLE 2

A recording material containing three selectively-conductive, composite photoconductive layers was fabricated in the following manner. A blue-sensitive photoconductor was prepared by dissolving 120.0 grams of 'Lexan' 145 resin in 1560 ml of tetrahydrofuran (hereinafter referred to as THF) containing 6.0 grams of surfactant solution (10% weight%weight in THF) with rapid stirring. The surfactant is the same block copolymer as in Example 1, hereinafter referred to as surfactant solution. After the solution was obtained, 49.60 grams (0.22 mole) of 2-nitrodibenzothiophene and 62.16 grams (0.22 mole) of tri-*p*-tolylamine were added. This solution was filtered and set aside. 68.24 grams (0.22 mole) of 2,4,7-trinitro-9-fluorenone (hereinafter referred to as TNF) was dissolved in 700 ml of THF and filtered as above. The TNF solution was added to the 'Lexan' resin solution and mixed thoroughly. This solution was then coated at 0.056g/m^2 dry coverage on a transparent, electrically conducting film support subbed with a thin layer of an adhesive polymeric material to form a blue-sensitive emitter layer.

Next, a solution containing 110.0 grams 'Lexan' 145, resin 10.0 grams ethylene terephthalate-neopentylglycol polymer, (hereinafter referred to as ETN) 80.0 grams of tri-*p*-tolylamine and 9.6 grams surfactant solution (10% weight/weight in chloroform in 960 ml chloroform was prepared and filtered. This solution was coated directly on the above element at 1.0g/ft^2 (.093g/m^2) dry coverage.

Finally, a solution containing 110.0 grams 'Lexan' 145 resin, 10.0 grams ETN, 60.0 grams tri-*p*-tolylamine, 20.0 grams 4-(di-*p*-tolylamino)-4'-[4-(di-*p*-tolylamino)-β-styryl]stilbene and 9.6 grams surfactant solution (10% weight/weight in chloroform) in 1220 ml chloroform was prepared and filtered. This solution was coated directly on the above element at 0.023 g/m^2 dry coverage.

This two-step procedure produces a charge-transport and yellow filter layer for the blue-sensitive photoconductor.

A barrier layer was prepared by dissolving 66.4 grams of cellulose nitrate in 1356 ml methanol diluted with 232 ml *n*-butanol after all the cellulose nitrate had dissolved. After filtration, this solution was directly coated on the blue-sensitive photoconductive element described above at 0.0070g/m^2 dry coverage.

A green-sensitive photoconductor was prepared by dissolving 36.35 grams of 9-anthronitrile (0.18 mole) in 500 ml of refluxing methylene chloride and filtering by gravity to remove insoluble material. Concurrently, a solution of TNF (57.4 grams, 0.18 mole) in 725 ml of refluxing methylene chloride was prepared and filtered. The latter solution was stirred rapidly while the hot 9-anthronitrile solution was added slowly thereto at a constant rate. Bright orange-red crystals separated from the reaction mixture. The mixture was stirred and cooled to room temperature to complete crystallization. Filtration, washing with liberal amounts of methylene chloride, and drying yielded 63.6 grams (68%) of 9-anthronitrile:TNF complex. To a solution of 24.0 grams 'Geon' 222 resin (the trade mark of a vinyl chloride/vinylidene chloride 40/60 from B.F. Goodrich Rubber Co. in U.S.A.) and 12.9 grams tri-*p*-tolylamine in 105 ml toluene containing 2.25 grams surfactant solution (10% weight/weight in toluene) was added 23.1 grams of the 9-anthronitrile:TNF complex and 400 grams Zirconia beads (a ball milling material manufactured by the Zircoa Corporation of Solon, Ohio) of -6 to +10 mesh, 3.175 mm diameter. This mixture was prepared in duplicate and each batch was placed in a polypropylene container and milled on a paint shaker for 3.5 hours. The resulting milled dispersions were combined, diluted with 580 ml toluene, filtered to remove the Zirconia beads, and coated on the cellulose nitrate barrier layer at 0.023g/m^2 dry coverage. The dispersion was stirred throughout the coating operation to insure uniformity.

A solution of 20.0 grams 'Lexan' 145 in 135 ml chloroform containing 6.0 grams surfactant solution (10% weight/weight in chloroform was prepared as above. To this solution was added 20.0 grams 'Electra' Red (Harmon Colors; Color Index No. 21200, Pigment Red 41) and 400 grams Zirconia beads (-6 to +10 mesh, 3.175 mm diameter). The resulting mixture was milled on a paint shaker for three hours in a polypropylene container. To the dispersion so obtained was added a solution of 90.0 grams 'Lexan' 145 resin, 10.0 grams ETN and 60.0 grams tri-*p*-tolylamine in 630 ml. chloroform. The dispersion was filtered to remove the Zirconia beads and coated on the above element at 0.125g/m^2 dry coverage. The dispersion was stirred throughout the coating operation to insure uniformity. This two step coating procedure produces a green-sensitive photoconductor having a green-sensitive emitter layer and a charge-transport layer containing a red filter.

The above-described cellulose nitrate solution was then coated at 0.0070 g/m^2 dry coverage on the green-sensitive photoconductive element described above to provide a second barrier layer.

A red-sensitive photoconductive layer was prepared by adding 2.4 grams of 'Geon' 222 resin to 138 ml. toluene. To this solution was added 10.0 grams of isolated aggregate crystals consisting of a co-crystalline complex of a thiapyrylium dye and 'Lexan' 145 resin as described in U.S. Patent No. 3,732,180, and 300 grams Zirconia beads (-6 to +10 mesh, 3.175 mm diameter). This mixture was prepared in duplicate, and both batches were placed in polypropylene containers and milled on a paint shaker for 3.5 hours. The resulting dispersions were combined, diluted with 268 ml toluene, and filtered as above to remove the Zirconia beads. The mixture was stirred to maintain uniformity and coated on the above element at 0.009g/m^2 dry coverage.

A solution of 110.0 grams 'Lexan' 145 resin, 10.0 grams ETN, 80.0 grams tri-*p*-tolylamine and 9.6 grams surfactant solution (10% weight/weight in chloroform in 960 ml chloroform was prepared, filtered, and coated at 0.139 g/m^2 on the above element. This two step coating procedure produces a red-sensitive photoconductor having a red-sensitive emitter layer and a charge-transport layer.

To complete the recording element for development purposes, a length of 12.7 micrometre 'Mylar' film subbed with a polymeric adhesive was heat laminated to the red-sensitive photoconductor.

A postive-to-positive three-colour print was made with the above-described recording material using the apparatus of Figs. 3, 3a, 4 and 4a. To produce the print, the recording element was uniformly charged to a negative potential of approximately 1450 volts by the grid controlled corona charger unit 40 and simultaneously exposed by projecting a colour original from the source 54 consisting of adjacent bands of blue, red and green KODAK 'Wratten' filters along with clear and dark regions. The recording material was then flooded with red light provided by projecting light from the xenon source 60 through a red filter contained in the filter wheel 62. Upon termination of the red flood exposure, the recording material was developed using negatively charged cyan coloured toner particles in the development head 66, a positive bias potential of 1450 volts applied to the conducting layer 13 of the recording material by the source 69 and the development head 66 and rinse head 68 earthed. The filter wheel 62 was then rotated to position a green filter in the light beam provided by the xenon source 60. Upon termination of the green flooding light, the development station 76, identical to the development station 64 except that the development head 78 contained negatively charged magenta colored toner particles in 'Isopar' G solvent, was positioned adjacent the insulating layer of the recording material while a bias potential of 1300 volts positive was applied to the conducting layer 13 of the recording material and the development head 78 and rinse head 80 were earthed. Finally, the recording material was flooded with blue light and then developed by the development station 70 using negatively charged yellow coloured toner particles in the development head 72, a positive bias potential of 1100 volts on the conducting layer 13 of the recording material and the development head 72 and the rinse head 74 earthed. The resulting image was allowed to dry and then transferred from the recording material to a receiver sheet using 'Scotch' Magic tape. Pertinent data for the processing of this recording material is listed below:-

a) Intensity of the xenographic projector - power density at the exposure plane was 4,300 microwatts/cm^2,

b) Permanent filters - two thicknesses of a CC30M colour compensating filter and a 725 nanometre (nm) interference cutoff filter were permanently positioned in the light beam, of the 'Xenographic' projector,

c) The colour original

1) The blue portion or original comprised a KODAK 'Wratten' No. 36 filter and a KODAK 'Wratten' No. 98 filter,

2) The red portion of original comprised a KODAK 'Wratten' No. 70 filter,

3) The green portion of original comprised a KODAK 'Wratten' No. 74 filter,

4) The clear portion of original comprised a KODAK 'Wratten' No. 96 filter (1.0 ND),

5) The dark portion of original comprised a black mask, and

d) Time of exposure was 3 seconds.

Charging:

a) Magnitude - negative 10 kilovolts on the corona wires with the grid bias set at negative 1450 volts all with respect to the conducting layer 13,
b) Time of charging -2 seconds simultaneous with exposure, and
c) Construction of corona charger- identical to that of Example 1.

Flooding and Development

a) Spacing and rate of development - identical with that of Example 1,
b) First flood and development:
  1) Filter pack - a KODAK 'Wratten' No. 70 filter with a resultant power density of 850 microwatts/cm^{2} at the exposure plane,
  2) Developer - negatively charged cyan coloured toner particles in 'Isopar' G solvent,
  3) Time - 3 seconds flood prior to developing.
c) Second flood and development:
  1) Filter pack - a KODAK 'Wratten' No. 74 filter with a resultant power density of 540 microwatts/cm^{2},
  2) Developer - negatively charged magenta coloured toner particles in 'Isopar' G solvent,
  3) Time - 5 seconds flood prior to developing.
d) Third flood and development:
  1) Filter pack - two thicknesses of a KODAK 'Wratten' No. 47B filter with a resultant power density of 690 microwatts/cm^{2},
  2) Developer - negatively charged yellow coloured toner particles in 'Isopar' G solvent,
  3) Time - 8 seconds flood prior to developing.

EXAMPLE 3

A red-sensitive photoconductor was prepared by adding 2.26 grams of 4-4(dimethylaminophenyl)-2,6-diphenyl thiapyrylium fluoroborate to 1200 grams of methylene chloride. The solution was allowed to stir overnight. 'Lexan' 145 resin (135.9 grams) was added slowly, with rapid stirring to the above solution and allowed to stir one hour after the final portion had been added.

Bis(4-diethylamino-2-methylphenyl) phenylmethane (90.6 grams) was added and the solution was stirred for one hour. The solution was then sheared 80 minutes in a blender. Finally, 12.8 grams of a 10% weight/weight SF-1066 (a copolymer of dimethylpolysiloxane and a polyoxyalkylene ether from General Electric Co. in USA) in methylene chloride was added and the resulting solution filtered and coated on an unsubbed electrically conductive polyester film support at 0.121 g/m^{2} dry coverage.

In a separate procedure, a blue-green multilayer coating was prepared in a manner similar to that described in Example 2 above.

A length of the red-sensitive photoconductor was laminated at 121°C to a length of the blue-green multilayer; and the support on the red-sensitive coating was then stripped off. This procedure was repeated so that two thicknesses of the red-sensitive layer were applied to the blue-green multilayer. To complete this element for the development process, a length of a 13 micrometre 'Mylar' film support subbed with a thin layer of a polymer adhesive was laminated to the above multilayer structure using the conditions described above. This recording material was then processed using the apparatus on Figs. 3, 3a, 3b, 4 and 4a in a manner similar to that described in Example 2 to produce a positive-to-positive three-colour print. The data for processing of this recording material is listed below:

Exposure:

a(Intensity of the xenographic projector - power density at the exposure plane was 4300 microwatts/cm^{2},
b) Permanent filters - two thicknesses of a CC30M colour compensating filter and a 725 nanometre (nm) interference cutoff filter were permanently in the light beam of the 'Xenographic' projector,
c) The colour original
  1) The blue portion of the original comprised a KODAK 'Wratten' No. 36 filter and a KODAK 'Wratten' No. filter,
  2) The red portion of the original comprised of a KODAK 'Wratten' No. 70 filter,
  3) The green portion of the original comprised a KODAK 'Wratten' No. 12 filter and a KODAK 'Wratten' No. 61 filter,
  4) The clear portion of the original comprised a KODAK 'Wratten' No. 96 filter (1.0 ND),
  5) The dark portion of the original comprised a black mask, and
d) Time of exposure was 3 seconds.

Charging:

a) Magnitude - negative 10 kilovolts on the corona wires with the grid bias set at 1900 volts negative all with respect to the conducting layer 13,
b) Time - 3 seconds simultaneous with exposure,
c) Construction of corona charger - identical with that of Example 1.

Flooding and Development:

a) Spacing and development rate - identical with that of Fig. 1,
b) First flood and development:
    1) Filter pack - a KODAK 'Wratten' No. 70 filter with a resultant intensity of 850 microwatts/cm^2 at the exposure plane,
    2) Developer - negatively charged cyan coloured toner particles in 'Isopar' G solvent,
    3) Time - 10 seconds flood prior to developing,
    4) Developer bias potentials - 1760 volts positive on the recording element, development and rinse heads grounded.
c) Second flood and development:
    1) Filter pack - a KODAK 'Wratten' No. 12 filter and a KODAK 'Wratten' No. 61 filter with the resultant power density of 600 microwatts/cm^2 at the exposure plane,
    2) Developer - negatively charged magenta coloured toner particles in 'Isopar' G solvent,
    3) Time - 4 seconds prior to developing,
    4) Developer biases plus 1570 volts on the recording element, development and rinse heads grounded.
d) Third flood and development:
    1) Filter pack - two thicknesses of a KODAK 'Wratten' No. 47B filter with the resultant power density of 530 microwatts/cm^2 at the exposure plane,
    2) Developer - negatively charged yellow coloured toner particles in 'Isopar' G solvent,
    3) Time - 10 seconds flood prior to developing,
    4) Developer bias potentials - 1280 volts positive on a recording material, developer and rinse heads grounded.

Transfer:

a) Adhesive - 4 inch wide 'Scotch' Magic tape was used to transfer the print from the recording element to a receiver sheet.

A number of insulator overcoats known in the art can be substituted for the described 'Mylar' film layer. If desired, such insulator overcoat can be transparent and the exposure to the color original can be made therethrough.

Persistent photoconductive layers may be used in the invention. With the use of persistent photoconductive layers, the recording material can be exposed first without charging prior to, or simultaneously with, the image exposure. The multilayer recording material would then be charged with a grid-controlled charger, charging only the unexposed areas. Flooding and development steps would then follow as outlined in the above examples. Materials of this type could probably not be reused until the persistent conductivity decayed. However, it might be possible to find a set of persistent photoconductive layers which would exhibit persistent conductivity at high intensities but could be discharged at a lower intensity flood light and thus rapidly destroy the persistent conductivity areas. This would allow the production of multiple copies of a colour document with only single exposure.

The inventive process may be used with a recording material containing a separable insulating layer. After preparing the photosensitive portion of the material as in the above examples, a piece of 13 micrometre 'Mylar' sheet can be held in intimate contact with the material while the material is exposed and developed in the manner described above. The 'Mylar' sheet would then be removed and taped face down to a piece of white paper or viewed as a transparency. This affords a three-colour image as in the previous examples. Use of a separable insulating layer avoid the difficulty inherent in electrical charges being stored in a permanently affixed overcoat layer, since a fresh piece of insulating sheet can be used for each cycle. Furthermore, the need for transfer of the image from the insulator to a receiver is obviated because the entire insulator is transferred although a separate transfer step could be included. A piece of insulating paper might also be used in place of the 'Mylar' film, this would allow toning to occur directly on the final receiver. Alternatively, a temporary image could be transferred to the insulator web followed by a subsequent transfer to a paper receiver.

A negative-to-positive colour print can be produced by first charging only the insulating layer of the recording material to one polarity and then by reversing the corona polarity and grounding the grid, charging the recording material while exposing it to a colour original. The charging of only the insulating layer could be accomplished by white light flooding the photoconductor layers while charging. The light flooding and development steps would be similar to the positive-to-positive process.

WHAT WE CLAIM IS:

1. A multicolour electrophotographic reproduction process comprising providing a recording material having an electrically conducting layer, an electrically insulating layer and at least first and second photoconductive layers sandwiched between the conducting and insulating layers, each of the photoconductive layers being sensitive to a different wavelength of the optical spectrum and the conducting and insulating layers being at least partially transparent to radiation in the optical spectrum; uniformly electro-statically charging the insulating layer; and imagewise exposing the recording material through the transparent insulating or conducting layer, to an image that comprises wavelengths to which the first and second photoconductive layers are sensitive thereby forming an inter-layer charge distribution pattern; uniformly exposing the recording material through the transparent insulating or conducting layer to radiation of wavelength and intensity that will substantially discharge one of the photoconductive layers thereby providing a first surface charge pattern on the recording material; treating the first surface charge pattern with toner particles having a first subtractive colour characteristic, as herein defined, while establishing across the recording material and the first toner particles an electrical field of a first bias potential; uniformly exposing the recording material through the transparent insulating or conducting layer to radiation of wavelength and intensity that will substantially discharge at least the other of the photoconductive layers thereby providing a second surface charge pattern on the recording material; treating the second surface charge pattern with toner particles having a second subtractive colour characteristic while establishing across the recording material and the second toner particles an electrical field of a second bias potential whereby a multicoloured self-registered particle image is formed in the insulating layer.

2. The process as claimed in claim 1 wherein the charging and imagewise exposure steps occur simultaneously.

3. The process as claimed in claims 1 and 2 wherein the electrical fields are of magnitude and polarity that urge toner toward the recording material in accordance with said surface charge patterns.

4. The process as claimed in claims 1, 2 or 3 wherein the uniform exposure steps continue during the toner particle treatment steps.

5. The process according to claims 1, 2 or 3 wherein the uniform exposure steps occur prior to the toner particle treatment steps.

6. The process according to claim 1 wherein portions of the recording material are recharged by the bias potentials during the toner particle treatment steps.

7. The process as claimed in claim 6 wherein the recording material is recharged during each development step to a potential equal to the biasing potential.

8. The process as claimed in any of the preceding claims wherein the recording material comprises three photoconductive layers sensitive to the blue, green and red regions of the optical spectrum.

9. The process as claimed in claim 8 wherein the uniform exposure of the blue sensitive layer is to blue light, the uniform exposure of the green sensitive layer is to green light and the uniform exposure of the red sensitive layer is to red light.

10. The process as claimed in claim 8 wherein the uniform exposure of the blue sensitive layer is to blue light, the uniform exposure of the green sensitive layer is to cyan light, and the uniform exposure of the red sensitive layer is to white light.

11. The process as claimed in claims 8, 9 or 10 wherein after or during the uniform exposure of the blue sensitive layer a yellow toner is applied to the insulating layer, after or during the uniform exposure of the green sensitive layer a magenta toner is applied to the insulating layer and after or during the uniform exposure of the red sensitive layer a cyan toner is applied to the insulating layer.

12. Colour reproduction processes as claimed in claim 1 and as herein described.

13. A recording material comprising an electrically conducting layer, an electrically insulating layer, and at least first and second photoconductive layers sandwiched between the conducting and insulating layers, each of the photoconductive layers being sensitive to a different wavelength of the optical spectrum and the conducting and insulating layers being at least partially transparent to radiation in regions of the optical spectrum to which the photoconductive layers are sensitive.

14. A recording material as claimed in claim 13 in which the first photoconductive layer is transparent to light to which it is not sensitive, the second photoconductive layer is transparent to light to which neither the first or second photoconductive layer is transparent and which has a third photoconductive layer sensitive to light passed by the first and second photoconductive layers.

15. A recording material as claimed in claim 14 in which the first, second and third photoconductive layers are sensitive to blue, green and red light respectively.

16. A recording material as claimed in claims 13, 14 or 15 in which at least one

photoconductive layer consists of a photoconductive layer in contact with a charge transport layer.

17. A recording material as claimed in claim 16 in which at least one charge transport layer contains a filter material which absorbs light to which the associated photoconductive layer is sensitive.

18. A recording material as claimed in any of the claims 13 to 17 in which at least one chemical barrier layer is located between the conducting and insulating layers.

19. Recording materials as claimed in claim 13 and as herein described.

20. The method of making a recording material as claimed in claims 13 to 19 wherein at least one of the layers is heat laminated to an adjacent layer.

21. The method of making a recording material as claimed in claims 13 to 19 wherein at least one of the layers is coated from a liquid media containing an organic solvent on the adjacent layer.

22. Methods of making recording materials as claimed in claims 13 to 19 as herein described.

23. Colour reproductions whenever made by the method of any of the claims 1 to 12.

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Agent for the Applicants

Printed for Her Majesty's Stationery Office, by Croydon Printing Company Limited, Croydon, Surrey, 1981.
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from
which copies may be obtained.

FIG. 1

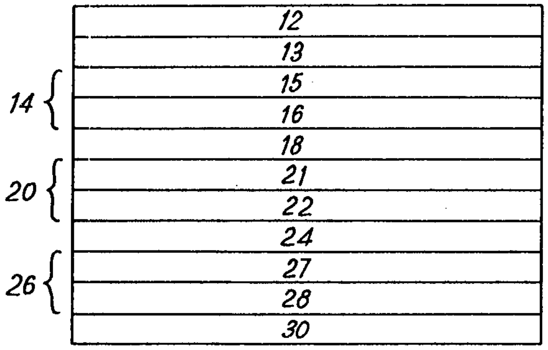
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FIG. 2a

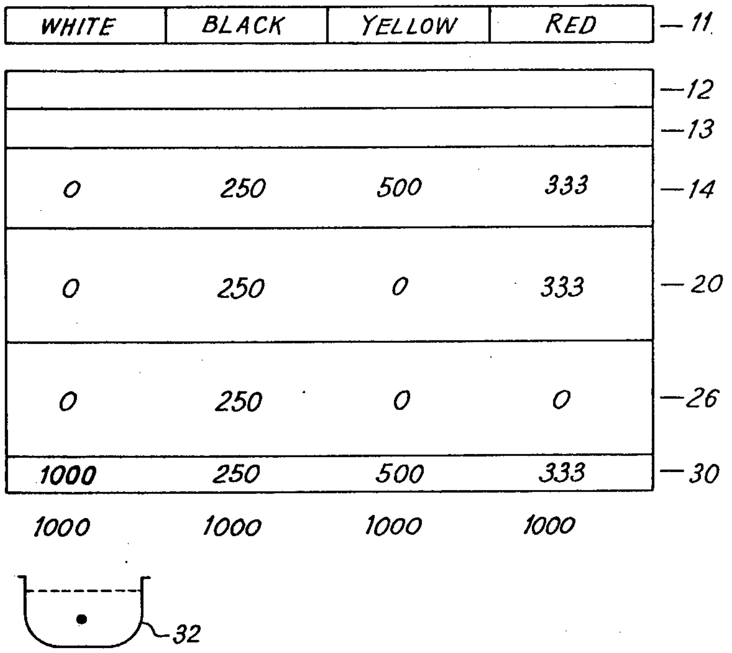
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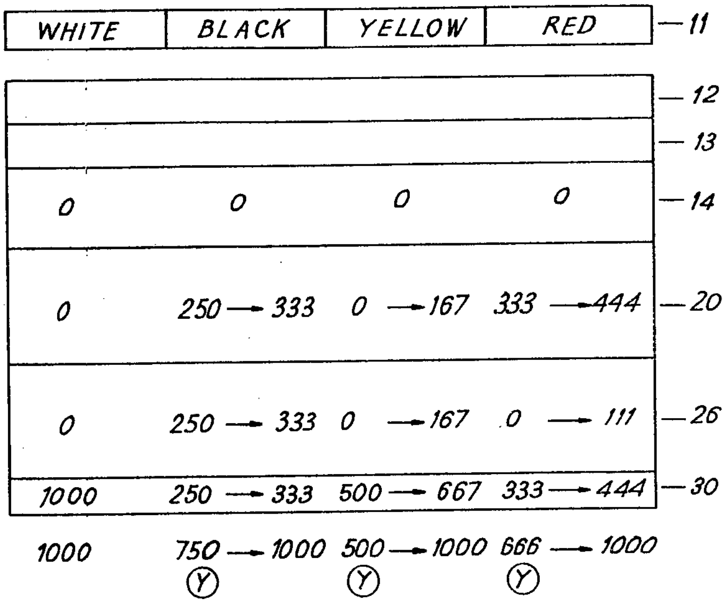
FIG.2b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26
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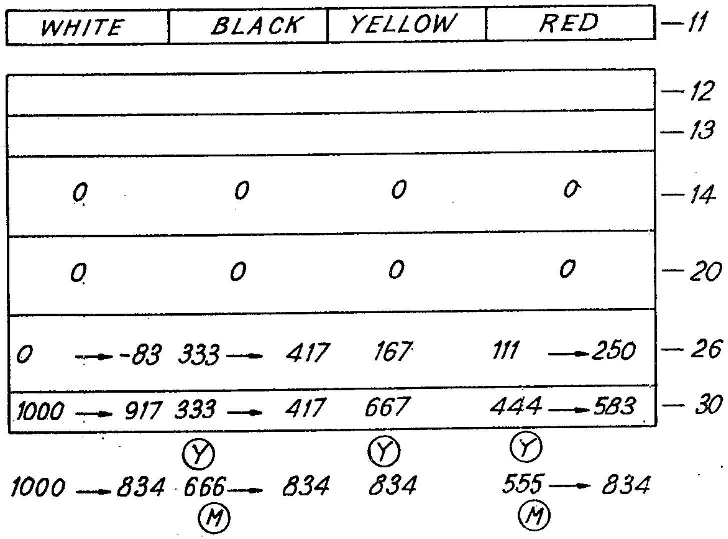
30
1000 750 → 1000 500 → 1000 666 → 1000
Y
Y
Y

FIG.2c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13
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14
0 0 0 0
20
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26
1000 → 917 333 → 417 667 444 → 583
30
Y
Y
Y
1000 → 834 666 → 834 834 555 → 834
M
M

FIG. 2d

WHITE	BLACK	YELLOW	RED
0	0	0	0
0	0	0	0
0	0	0	0
917 → 583	417 → 583	667 → 583	583
	Ⓨ Ⓜ	Ⓨ	Ⓨ Ⓜ
917 → 583	417 → 583 Ⓒ	667 → 583	583

FIG.3

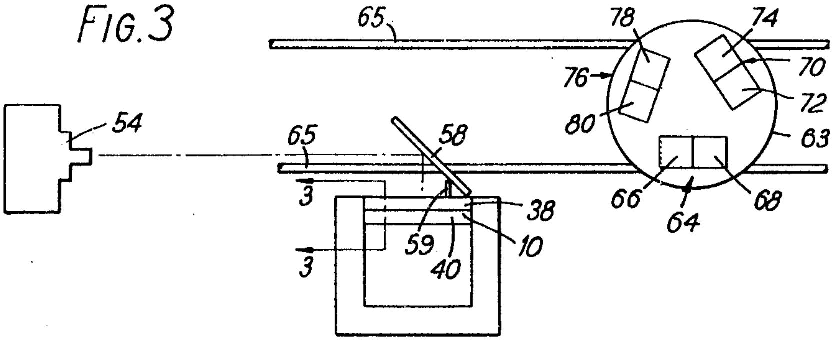

FIG.3a

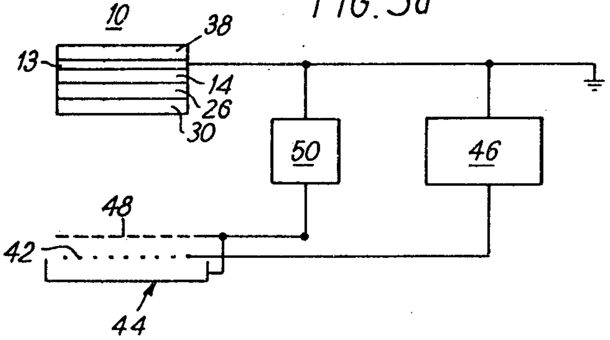

FIG.4

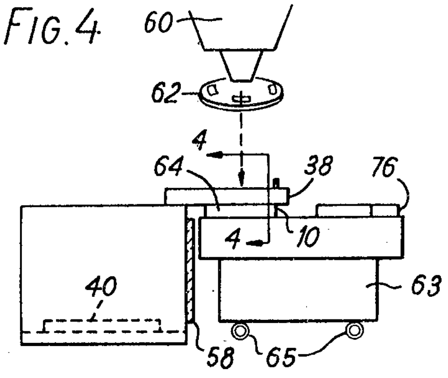

FIG.4a