

[54] DARK DECAY RETARDATION

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96/1 C; 250/324, 325, 326

[56] **References Cited**

UNITED STATES PATENTS

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Primary Examiner—Robert P. Greiner

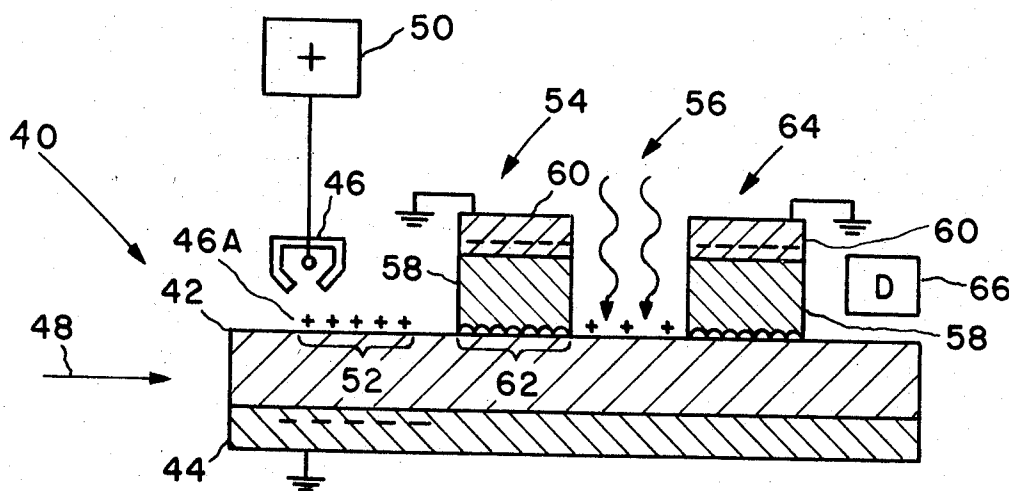
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[57]

ABSTRACT

The device described herein relates to a method and apparatus for reducing the dark decay rate of a photoreceptor surface. Disclosed is a method of reducing the dark decay rate of a photoreceptor surface by a set of steps reducing the internal field intensity causing reduction in a recombination of trapped diffused hole-electron pairs, including the steps of placing a charge of a first polarity on a surface of the photoreceptor thereby creating an internal field in the photoreceptor, and applying to the photoreceptor an opposite polarity field for maintaining the surface charge but reducing the internal field intensity and thereby reducing the dark decay. Apparatus for effecting reduction of dark decay as disclosed includes a means for inductively creating an oppositely charged field in conjunction with a critical segment of the photoreceptor surface or, alternatively, for placing a negatively charged electrode adjacent the critical segment of the photoreceptor surface.

6 Claims, 3 Drawing Figures



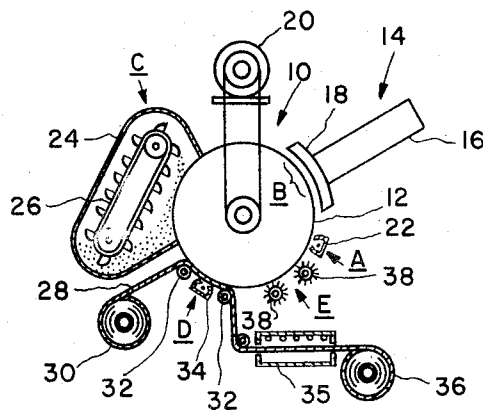


Fig. 1

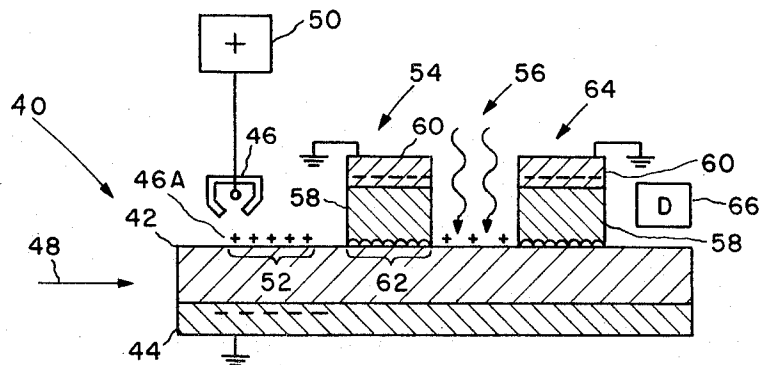


Fig. 2

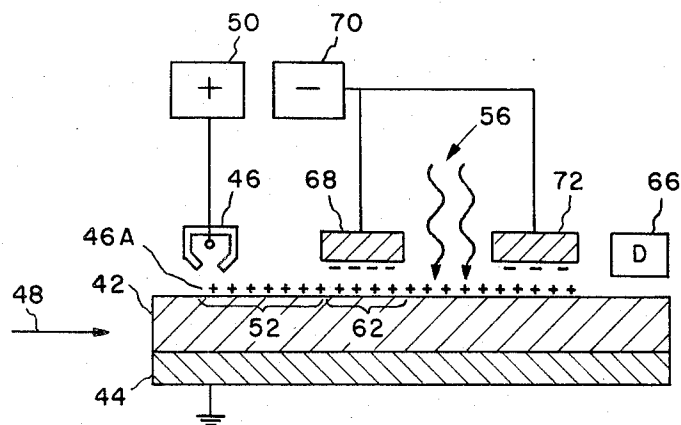


Fig. 3

DARK DECAY RETARDATION

The present invention relates to a reproduction apparatus and more particularly to a method or apparatus for substantially reducing the dark decay rate of a photoreceptor surface employed in reproduction processes.

In electrostatography, a photoreceptor comprising a layer of a photoconductive insulating material placed upon a conductive backing can be employed as an imaging surface. The photoreceptor may be formed in any shape. An electrostatic latent image is formed thereon, by uniformly electrostatically charging the photoreceptive surface and then exposing it to a radiation pattern in the form of the image to be reproduced. This radiation selectively discharges areas of the photoreceptor forming an electrostatic charge pattern conforming to the radiation image. This radiation image is formed generally from an original document or other object which is illuminated and optically imaged on the photoreceptor.

The latent image on the photoconductive layer is then developed by contacting it with a finely divided electrostatically attractable material such as a resinous powder hereinafter called a toner. The toner is held to the image areas by electrostatic charge fields on the layer. The toner is held proportionately to the charge field so that the greatest amount of material is deposited where the greatest charge field is located. Where there is a minimum charge, there is little or no material deposited. Therefore, a toner image is produced to conform with the latent image previously placed on the photoreceptor. The toner may then be transferred to a sheet of paper or other surface and suitably fixed thereto to form a permanent print. This fixing may take place by heat or vapor which may fuse the toner to the support material to which it has been transferred.

The toner used to develop the image is generally employed as a developer material comprising the toner and a carrier of larger granular beads formed with glass, sand or steel cores coated with a material which is removed in the triboelectric series from the toner so that there is a triboelectric charge attraction between the toner and the carrier. The charge causes the toner to adhere to the carrier making it easily handled in a developer system which brings the developer into contact with the previously exposed imaging surface. Because the charge pattern on the imaging surface has a greater attraction for the toner than the triboelectric charge attraction the toner has for the carrier, the toner is attracted electrostatically to the image on the surface forming a visible toner image thereon.

One of the difficulties often encountered in the use of photoreceptor surfaces is loss of charge due to dark decay. This has the effect of reducing the contrast of the developed images as a result of the loss of charge in the nondischarged or non-imaged portions of the photoreceptor layer. The most common form of photoreceptors in use today includes selenium, and which photoreceptor in its simplest form comprises a base electrode, usually metallic, which has been coated with a vacuum evaporated layer of vitreous selenium. In the first step of the electrostatographic process, the photoreceptor is charged as by a corona generator current. During this step, the selenium photoreceptor or plate may be considered to be a simple capacitor in which the air/selenium interface is one electrode. In the

charging operation, the base electrode is grounded so that an induced charge of appropriate sign, opposite to the surface charge is conducted to it. The corona charge deposited at the air/selenium interface is trapped in surface sites with sufficient binding energy to limit to low values the direct injection of charge into the bulk selenium material, and charge migration along the surface, but some loss of charge does occur in the dark as a consequence of charge injection at the selenium surfaces and internal charge generation within the bulk selenium.

It should be noted that the dark discharge rate observed for a given photoreceptor may depend on its previous history. Most photoreceptors exhibit an increase in dark discharge rate when charging has been immediately preceded by intense exposure to light or other actinic radiation. This increase in discharge rate is referred to as light fatigue and is the result of carrier trapping and impurity sites within the selenium. In addition, if the photoreceptor has been charged while under illumination, it may exhibit further increases in its dark discharge rate immediately following this process. This latter effect is referred to as charge fatigue and is most often traced to effects at the interfacial region between the selenium bulk and the substrate. Prior art devices, directed to reducing dark decay, are related to controlling the processing of the substrate materials as well as the purity of the photoreceptor material, in order to reduce the sources of increased discharge. In addition, more uniform evaporation techniques for applying the photoreceptor to the substrate also serve to reduce the dark discharge rate. These techniques however, are expensive and difficult to control over large areas of photoreceptor surfaces, such as drums or endless loop photoreceptors.

In conventional electrostatography, the dark discharge can be of the order of a half-life involving several hours. This rate is normally satisfactory for most electrostatographic processing; however, in applications wherein unusually long time delay may be required between application of the initial charge and ultimate developing, dark discharge becomes a crucial factor in allowing a developed image of sufficiently observable contrast to be provided. In such event, the cost of providing a photoreceptive material of such purity as to limit the dark discharge rate to acceptable values for such durations becomes prohibitive.

It is, therefore, a primary object of the present invention to provide a method and apparatus for improving the dark discharge rate of a photoconductive plate.

It is a further object of the present invention to provide a novel method and apparatus improving the dark discharge rate without affecting the manufacturing process of the photoreceptor material.

It is still a further object of the present invention to provide an inexpensive, convenient and effective method and apparatus for eliminating or substantially reducing dark decay rate in a photoreceptor to enable substantially long periods of time to transpire between the initial charge period and the ultimate development.

The foregoing objects are accomplished within the concept of the present invention by providing a first charge to a critical photoreceptor and thus an internal field in the photoreceptor, and applying to the photoreceptor a subsequent charge resulting in an opposite polarity field sufficient to maintain the surface charge while reducing the internal field and thereby reducing

the dark decay rate. The foregoing method is accomplished within the scope of the present invention by providing an induction electrode positioned at a critical segment of the photoreceptor between the charging and developing stations, or between the charging and imaging stations, or between the imaging and developing stations, wherein a charge is induced of opposite polarity to the charge applied initially to the photoreceptor, the opposite charge having the effect of maintaining the surface charge on the photoreceptor as desired, but reducing the internal field in the photoreceptor, and thereby reducing the dark decay rate. Alternatively, a fixed potential biased electrode can be positioned, as above, between the charge application device and the imaging station, between the imaging station and the developing station, or both, this electrode being charged with a polarity such that the surface charge level of the photoreceptor is maintained wherein the internal charge intensity of the photoreceptor is reduced, thereby decreasing the dark decay rate.

The foregoing objects and brief description of the present invention, as well as further objects and other aspects of the present invention, will become more apparent in the following more detailed description and appended drawings wherein:

FIG. 1 illustrates a conventional electrostatic processing operation incorporating a representation of the present invention;

FIG. 2 illustrates a first embodiment of the present invention employing an induction electrode;

FIG. 3 illustrates an alternative embodiment of the present invention employing a fixed potential bias electrode.

Referring now to FIG. 1, a conventional electrostatic processing device is illustrated in conjunction with the present invention. Thus, as shown in FIG. 1 the reproduction apparatus includes drum 10 having a photoconductive imaging surface thereon. An imaging device 14 which includes a conventional optical imaging system 16 provides a projection of desired form or format onto the imaging surface. This general region is shown with a dark decay prevention or retardation device 18 which will be explained in further detail below. The apparatus shown herein for translating optical images to printed images on a sheet of paper is an electrostatic apparatus well known in the art. Although a drum configuration is shown, it is well known that the same results can be obtained by means of an endless loop photoreceptor such as is shown in the U.S. Pat. No. 3,540,806, to Starkweather. The drum 10 containing the photoconductive surface which is normally an insulating surface in the dark is driven through a series of process stations by a motor 20. As the drum 10 is driven by the motor 20 past the charging station A, a corotron 22 places the uniform electrostatic charge on the surface of the drum. The drum then rotates to the exposure station B wherein the drum surface is exposed to a light image projection of the matter to be printed. The light of the image renders the photoconductor surface conductive rather than insulating and discharges the electrostatic charge in the image areas so that the drum surface contains essentially uncharged areas in image configuration. The drum then rotates to the developing station C wherein a developer material containing a triboelectric charge of the same polarity as the charge on the drum surface is cascaded over the sur-

face of the drum. The developer material consists of a finely divided pigmented resinous powder hereinafter referred to as toner carried on the surface of relatively larger spheroidal particles hereinafter referred to as carrier particles. The developer material is supplied from a reservoir in the bottom of the developer housing 24 to the surface of the drum 10 by means of a conveyor 26 and is cascaded over the drum surface back to the reservoir at the bottom of the developer housing. The carrier particles carry the toner from the reservoir to the drum surface 10 as is well known. Upon contact with the edges of the non-charged image areas the toner adheres thereon to the drum surface. In the non-image or charged areas the toner is repelled by the charge on the drum surface and returns with the carrier material to the reservoir. Thus, a toner or powder image of the light image to which the drum is exposed at the station B is developed on the drum surface. It is apparent that the foregoing process, termed reversal development when employed with a negative image projection, can be varied to provide a positive development from a positive image by imparting a polarity charge to the development material opposite to that described hereinabove.

The drum then rotates past a transfer station D wherein a web of paper or other suitable material 28 is supplied from a supply roll 30 over a pair of guide rollers 32 and into contact with the imaging surface. A transfer corotron 34 places an electrostatic charge on the surface of the web of paper while the paper is in contact with the drum surface. The electrostatic charge is of opposite polarity to the charge on the toner material and thus attracts the toner material from the surface of the drum onto the web of paper. The paper then passes through heat fuser 35 wherein heat supplied to the paper and toner material causes the toner to coalesce and bond to the surface of the web. The web then contains the permanent image of the powder image transferred from the drum surface to the paper and is accumulated on a pick-up roll 36. After the transfer operation the drum is rotated past the cleaning station E wherein a pair of rotating brushes remove any residual particles of toner powder from the drum surface prior to recharging and reexposure to the drum. Obviously, a web of paper may be replaced by sheets of paper fed by a suitable feeding mechanism in serial relationship to the surface of the drum wherein the same operations can be performed. The operation of such electrostatic apparatus is well known in the art.

As was noted in the foregoing description, the electrostatic contrast which is defined as the relative charge levels between the residual charge placed on the drum by means of the corotron 22 and the discharged areas resulting from the light exposure at the imaging station B must remain at a high level in order that the toner developing material will adhere in sufficient quantity to provide a sufficient development image for visibility. The dark decay rate of the photoconductive surface during the time the surface requires to move after charging application A to the developing station C will be a function of the length between these two areas. As will be apparent, if sufficient time transpires, the dark decay of the photoreceptor may be sufficient to reduce the background charge level placed on the drum surface by the corotron 22 to the point where the electro-

static contrast is insufficient to provide a developable image.

Referring now to FIG. 2, a first embodiment of the invention is illustrated in conjunction with a photoreceptor for inhibiting the dark decay characteristic. It is understood that although prior discussion describes a photoreceptor drum, a photoreceptive flat plate configuration can be employed, as for example an endless loop photoreceptor. The following description should therefore be considered as merely illustrative as to how the invention is employed in conjunction with a photoreceptive surface. Thus, as shown, a photoreceptor 40 which consists of a photosensitive material 42 such as a selenium photoconductor or the like and a grounded conductive backing 44 such as aluminum, brass, or the like, rotates past the fixed corotron device 46, corresponding to a charge corotron such as 22 in FIG. 1, is assumed to be connected to a source of d.c. potential 50 having a relatively positive polarity with reference to the backing member 44 and places a positive charge 46A on the surface of the photoconductor material 42. As a result of the placement of the positive charge 46A on the surface of the photoconductor material 42, a corresponding negative charge is induced at the surface of the conductive backing 44. The resultant field between the positive and negative charge areas, illustrated generally in the region 52 provides a dark decay rate in accordance with the intensity of the field in region 52. To compensate for the intensity of the field in region 52 without dissipating charge on the surface of the photoconductor 42, a dark decay retardation electrode indicated generally as 54 is provided between the corotron 46 and the imaging area indicated generally as 56. The electrode 54 includes an insulating portion 58 which may be composed of an extremely high purity photoconductive material such as a high quality selenium or the like, having a much lower dark decay rate than the photoconductor material 42, and a grounded conductive backing 60 which may be aluminum, brass, or the like. As the photoreceptor region 42 passes beneath the dark decay retardation electrode 54, a negative charge is induced at the surface of the conductive material 60 in the same manner as the negative charges are induced in the surface of the conductive material 44 in the region 52. Therefore, as the photoconductor material 42 enters the region generally indicated as 62, the field strength between the upper surface of the photoconductor 42 and the upper surface of the backing 44 is reduced. The difference is taken up by the field strength provided in the dark decay electrode across the insulating region 58 from the photoconductor material 42 to the conductive backing 60. Since the two fields together maintain the same charge relationship at the various surfaces, this charge on the surface of the photoconductor 42 upon emergence is ideally unchanged. After emergence from the dark decay electrode 54 into the optical imaging station 56 the optical energy or photons provided by the imaging source act to create hole electron pairs at the surface of the photoconductor which provides selective dissipation as by diminution of the charge at the surface of the photoconductor for creating the light and dark image required for reproduction. After emergence from the optical imaging station area 56, an additional dark decay electrode 64 may be provided to maintain the surface charge with a minimum of dark decay in the same manner as indicated with the dark decay electrode 54. Al-

ternatively, a single electrode for dark decay retardation 54 may be provided where the dark decay rate is expected to be excessive because of long time periods between charging at station 46 and imaging at station 56. In addition, the dark decay electrode 64 may be employed where a long period of time is dissipated between the imaging station 56 and the developing area 66. As a further alternative, a single dark decay electrode with a slit or like optical imaging position area may be provided to cover the entire image pattern between the charging area 46 and the developing area 66. Thus, by the time the imaged area passes beneath the developing area 66, the integrity of the image is maintained.

To prevent abrasion to the photoreceptor surface, the insulator material forming the insulating portion 58 of the dark decay electrode should have a relatively low coefficient of friction. Examples of such materials may include TEFLON, and the like. Further, the interfacing surfaces of material 58 may be shaped, as shown, to further reduce friction. The dark decay electrode insulator may also include air, with the conductive backing being mounted in fixed position above the photoreceptor 42 by a distance corresponding to the desired air gap forming the insulating layer. The spacing of the conductive backing from the photoreceptor will be a function of the time durations involved, decay rate of materials used, magnitude of charging potentials and like factors, and may be varied within the scope of this invention to its point of desired effectiveness.

Referring now to FIG. 3, an alternative method for maintaining maximum charge on the surface of the photoconductor material 42 is indicated. As shown in FIG. 3, wherein like reference numerals indicate like components, a dark decay electrode is provided in the form of a metallic potential plate 68 and 72, each of which is connected to a source of potential 70. In this embodiment, again assuming a positive charge is placed by the potential source 50 onto the corotron 46, it is desired to provide an opposite or negative charge above the surface of the photoconductor between the corotron 46 and the imaging area 56, or between the imaging area 56 and the developing area 66, or between the corotron 46 and the developing area 66. In this embodiment, the source of potential 70 applies negative potential to the electrodes 68 and 72, creating a field between the upper surface of the photoconductor 42 and the electrodes 68 and 72 respectively. The creation of this additional field reduces the total field intensity within the photoconductor 42 and thereby inhibits the dark decay rate.

As noted above, the electrodes 68 and 72 can be in the form of a continuous electrode with a slit therein for passing optical energy provided from a scanning source to the charged photoreceptor surface 42. The electrode shown in FIG. 3 is thus positioned anywhere between the corotron 46 and developing station 66 in accordance with the location of the photoreceptor area having a dark decay rate for which compensation is desired.

The dark decay compensation electrode can be employed in either dynamic or static configurations. That is to say, when used over a continually moving photoreceptor, the electrode serves to increase the electrostatic contrast over a level otherwise achieved without the electrode. Thus, a less expensive, less refined, photoreceptor may be employed. Alternatively, when a

static system is to be used, wherein a long time period may transpire between charging and developing, the electrode can be employed to hold a charge to a level for such time which will remain sufficient to provide the necessary electrostatic contrast. In the latter case, the electrode can be made to occupy a lateral area along the photoreceptor surface corresponding to the size of the ultimately developed image so as to prevent variations in contrast which may otherwise be caused by applying the dark decay retardation field over a discontinuous time displacement.

Other variations and changes will obviously be apparent to those skilled in the art. It will be understood that the examples given in this embodiment are given for purposes of illustration and that the invention may be modified and embodied in other forms without departing from the scope and spirit of the invention as disclosed herein.

What is claimed is:

1. A device for reducing the dark decay of a photoreceptor material employed in an electrostatographic reproduction process wherein first means are provided for charging the photoreceptor and forming a first electrostatic field in said photoreceptor, second means for selectively discharging the charged photoreceptor to form a light and dark image area, and third means for developing the light and dark image area, the combination comprising a dark decay retardation electrode po-

sitioned between said first means and said third means, said dark decay electrode responsive to the charged condition of said photoreceptor for forming a second electrostatic field, said second electrostatic field thereby reducing the intensity of said first electrostatic field and inhibiting said dark decay rate.

2. The combination of claim 1 wherein said dark decay electrode comprises an insulating layer and a conductive backing, said insulating layer contacting said photoreceptor surface.

3. The combination of claim 1 wherein said dark decay electrode includes a metallic electrode, and further including a source of potential, said source of potential applying a potential to said dark decay electrode of an opposite polarity to the charge on the surface of said photoreceptor, said opposite charge thereby forming said second electrostatic field.

4. The combination of claim 1 wherein said dark decay electrode is positioned between said first and second means.

5. The combination of claim 1 wherein said dark decay electrode is positioned between said second and third means.

6. The combination of claim 2 wherein said insulating material is the same composition as said photoreceptor, with a higher degree of purity.

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