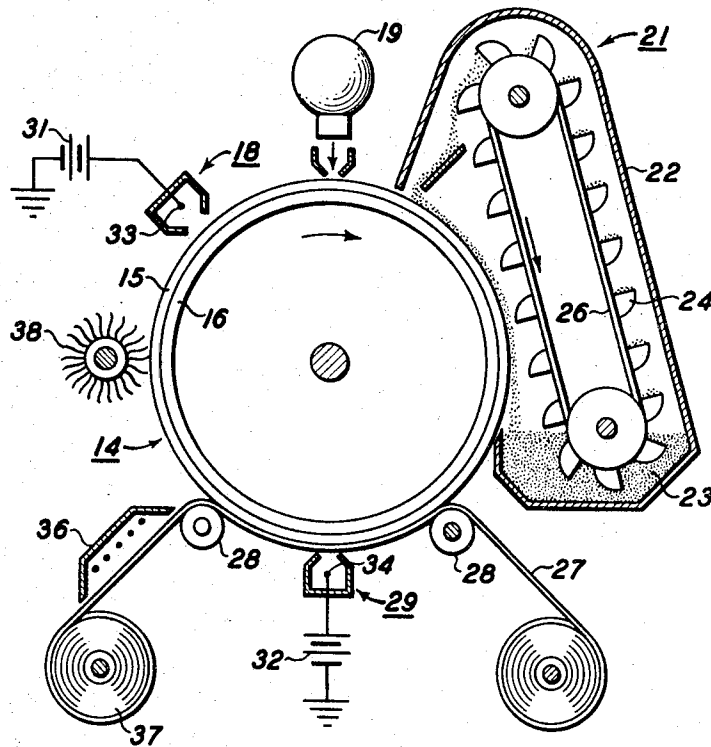


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ELECTROPHOTOGRAPHIC PROCESS USING A HIGH INTENSITY
ELECTROMAGNETIC RADIATION SOURCE
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ELECTROPHOTOGRAPHIC PROCESS USING A HIGH INTENSITY ELECTROMAGNETIC RADIATION SOURCE

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ABSTRACT OF THE DISCLOSURE

A method for forming an electrostatic latent image on the surface of a nonphotoconductive dielectric material is disclosed. It has been determined that the charge on the surface of an insulating material may be selectively dissipated, although the material itself is not photoconductive, upon exposure to a high intensity electromagnetic radiation source.

This invention relates to an imaging system and more specifically to a photoconductorless imaging system.

Many image and signal recording processes are known which involve the creation of an electrostatic record from or by means of which a visible record may subsequently be formed. One such technique, a form of electrostatic electrophotography, otherwise known as xerography, employs the use of a photoconductive insulating medium to form latent electrostatic images with the aid of electromagnetic radiation to produce a visible record. A second image forming process known as electrothermography relies upon a phenomena wherein certain dielectric layers, when charged electrostatically and heated exhibit breaks in their respective charge-temperature curves at a critical temperature, at which point the material experiences a sharp increase in conductivity. When exposed to heat in an imagewise configuration and the temperature exceeds the critical point for the particular plastic, the original charge is selectively dissipated in the heated, lower resistant areas. By dusting the remaining latent electrostatic image with a developer of the same charge reversal development will occur in the now uncharged areas and a positive copy obtained. A third imaging system useful for recording information termed chemography has been developed wherein irreversible chemical changes induced by light in specific materials can generate a persistent conductivity pattern which may be used for electrostatic imaging. Exposure to light in the absorption region for the particular material renders the material much more electrically conductive than before exposure. During or after exposure the film is sufficiently conducting so that, if an electrostatic charge is applied, it leaks off to ground in the exposed areas leaving an electrostatic latent image capable of visible development.

While these and other techniques have been found useful as image and signal recording processes there are inherent disadvantages to their use. For example, in the case of the xerographic process, it is necessary in order to develop and record specific information that a photoconductive material be utilized either alone or in combination with a particular binder material. A second disadvantage to this system is that it is required that the photoconductive material have the necessary resistivity properties so that it may support an electrostatic charge in the dark. The electrothermographic process is generally limited by the materials which will respond to and absorb the heat necessary to satisfy the requirements of the system in reproducing a copy of the original. A second disadvantage to this system is that specific dielectrics must be chosen which will exhibit the necessary charge-tem-

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perature response required. In the chemographic process it is again necessary to select a specific material which is both photosensitive and will have its electrical conductivity altered upon exposure to light.

It is, therefore, an object of this invention to provide an image forming system which will overcome the above noted disadvantages.

It is a further object of this invention to provide a novel method of preparing a photographic reproduction.

Another object of this invention is to provide a novel method of producing an electrostatic latent image.

Still a further object of this invention is to provide a novel imaging system which is generally not limited by the materials of the process, such as a requirement to use a photoconductive or photosensitive composition.

The foregoing objects and others are accomplished in accordance with this invention, generally speaking, by providing an imaging system whereby a support substrate such as aluminum, is coated with a dielectric material, such as polyethylene terephthalate, which will retain on the surface thereof an electrostatic charge when subjected to a charging mechanism. The charged surface of the resulting dielectric plate is selectively exposed to a high intensity electromagnetic radiation source, such as, for example, a xenon flash tube, for a preferred period of time of from about 60 to about 100 microseconds, thereby depleting the charge in the exposed areas and producing an electrostatic latent image on the surface of the dielectric material. The resulting latent image is developed thereby producing a copy of the original document.

It has been determined that the charge developed on the surface of a dielectric material may be selectively dissipated, when exposed to a high intensity electromagnetic radiation source, in a very short interval of time. Although it has further been determined that a low energy radiation source will produce a similar result when applied to the surface of a charged dielectric for an increased period of time so as to ultimately expose the charged surface to an equivalent amount of energy as produced by the high energy source, such an exposure becomes quite impractical and essentially non-useful as an image and signal recording process. Therefore, in order to effectively utilize the charge removal mechanism of the present invention as an image recording system it is generally considered desirable to employ a high intensity pulsating or flash radiation source which will selectively deplete the charge on an insulating layer in a corresponding limited time interval. In order to achieve the desired results, it has been determined that high energy pulsating sources such as flash lamps containing xenon, krypton, helium, neon, and/or argon gases and certain discharge devices containing gas combinations such as iodine-xenon and/or krypton generally provide the intense, concentrated electromagnetic radiation necessary. Although energy sources producing light in a continuous electromagnetic spectrum, such as xenon arc lamps or incandescent lamps which initially produce a lower energy quantum, may be used in order to obtain the required energy level, it is necessary to increase the exposure time to such a degree so as to make the process impractical. As a result of the exposure of the charged surface of the dielectric material to a high energy pulse, a charge differential is developed between the exposed and non-exposed areas, due to the decay of the charge in the exposed areas, in a very limited time interval thereby allowing for the development of a recognizable image.

In accordance with the present invention the surface of an insulating material, such as polyethylene terephthalate, is charged to an electrostatic potential by any suitable technique, such as by a corona charger. The

charged surface is selectively exposed to a high energy flash lamp, such as a xenon flash tube which may be commercially obtained from PEK Labs, Inc., Sunnyvale, Calif., thereby exposing the charge surface of the dielectric to a concentrated energy source ranging from about 200 to about 1000 joules input. Optimum results were obtained when the energy level was maintained between about 400 to about 1000 joules, thereby more consistently establishing the most desirable voltage differentials between the image and non-image areas. The imaging characteristics of the present invention may be obtained by establishing a voltage differential between the image and non-image areas of about 20 volts with optimum results being obtained at a voltage differential of about 40 volts or more. To produce a developable image it was determined that, as a result of the exposure to the above mentioned energy quantum, a voltage differential of 20 volts or more could readily be obtained.

The effective time interval for providing the desired energy input as provided by the pulsating radiation sources ranges from about 0 to about 140 microseconds with the major portion of the energy being supplied during a period of between about 20 to about 120 microseconds. However, the period of time at which the major portion of the discharge will occur will vary depending upon the specific energy source that is being employed. It is during this period that the maximum efficiency of the pulse generated by the radiation source is realized. In addition to the effect of the amount of energy incident upon the charged surface of the dielectric is the effect of distance which exists between the source of the radiant energy and the surface to be exposed. The amount of the charge that is dissipated will vary depending upon this distance, there being a greater differential produced as the distance between the energy source and the surface exposed is shortened. For purposes of the present invention this distance is generally restricted to from about 3 to about 12 inches with a preferred range being from about 5 to about 7 inches to obtain maximum efficiency of the imaging system.

Any suitable electromagnetic radiation source may be used in the course of the present invention. When used in a manner as specified in the above discussion, any similar energy source will produce the discharge effect necessary. Typical electromagnetic radiation sources are xenon flash lamps, helium, neon, argon, and krypton filled flash lamps, and combination iodine-xenon and/or krypton filled electric space discharge devices. Exploding wires are also a source of high energy electromagnetic radiation. Xenon arc lamps and incandescent lamps are examples of continuous radiation sources which ultimately will produce the effect desired by the present invention. In order to effectively utilize the charge removal mechanism of the present invention as an electrographic recording system it is preferred to use a high intensity pulsating or flash energy source to record the image in a limited period of time. As a result of the limited accessibility to the preferred energy sources, it is expedient to use the xenon and krypton filled flash lamps.

Any suitable insulating or dielectric material may be used in the course of the present invention such that it will retain an electrostatic charge when so exposed. Typical insulating materials are the Staybelite resins, a family of thermoplastic synthetic resins prepared from hydrogenated rosin and commercially available from the Hercules Powder Co.; polyethylene terephthalate (Mylar); styrene polymers such as Velsicol, a styrene terpolymer commercially available from the Velsicol Chemical Corp. and Piccolastic resins, styrene polymers available from the Pennsylvania Industrial Chemical Corp.; ethyl cellulose; cellulose acetate; polycarbonates such as Plestar commercially available from General Aniline and Film Co.; polyethylene; polypropylene; polymeric materials such as casein and Parlon-P, a chlorinated natural rubber, commercially available from the Hercules

Powder Co.; various thermosetting resins such as phenol formaldehyde, urea formaldehyde, and epoxy resins; silicone resins; VYNS, a vinyl chloride-acetate resin commercially available from Union Carbide Co.; polyvinyl chloride; Nevillac, an alkyl hydroxy resin commercially available from Neville Chemical Co.; Tedlar, a polyvinyl-fluoride resin, commercially available from E. I. du Pont de Nemours and Co.; glass; and numerous electrographic papers, such as C62-145, commercially available from Crown Zellerbach, and 9510-9, commercially available from Crocker Hamilton. Optimum results were obtained when using the electrographic paper commercially available from Crown Zellerbach and Mylar, a polyethylene terephthalate film commercially available from E. I. du Pont de Nemours and Co.

Any suitable toner or developer may be used in the course of this invention such as those disclosed in U.S. Patents 2,788,288; 3,079,342 and Re. Patent 25,136. The toner is generally a resinous material which when fixed has the necessary properties which will retain ordinary printing inks. Typical developer powders are styrene polymers, including substituted styrenes such as the Piccolastic resins commercially available from the Pennsylvania Chemical Corporation, phenol formaldehyde resins, as well as other resins having similar properties. The developer powder or electroscopic marking particles may be admixed with a carrier such as glass beads. The toner the insulating material or the developing particles may be admixed with a carrier such as glass beads. The toner may be applied in the form of a mixture with magnetic particles, such as magnetic iron, to impart a charge to the developer powder particles tribo-electrically. A developer particle is so chosen that it is attracted electrostatically to the charged image and/or repelled from the background area to the charged image and held thereon by electrostatic attraction.

Liquid developers may also be used in the course of this invention. Typical liquid developers are disclosed in U.S. Patents 2,890,174 and 2,899,335. Generally, the developer comprises a liquid combination of mutually compatible ingredients, which when brought into contact with an electrostatic latent image, will deposit upon the surface of the image in an image-wise configuration. In its simplest form, the composition comprises a finely divided opaque powder, a high resistance liquid and an ingredient to prevent agglomeration. Typical high resistant liquids are carbon tetrachloride, kerosene, benzene, trichloroethylene and other suitable hydrocarbons having a boiling point between about 70 and 200° C. Any of the finely divided opaque solid materials known in the art such as carbon black, talcum powder, and other pigments may be used in the liquid developer. Silica aerogel, commercially available from Monosano Chemical Co., is a deagglomeration ingredient generally used. However, any conventional and/or suitable ingredient known to be useful by the prior art in a liquid development system may be utilized. In addition, other commercially available oil based inks including alcohol base inks may be used in connection with this invention.

In addition to using the liquid developers containing a high resistance component suitable aqueous based or polar liquid developers may also be used when the system so warrants. Furthermore, any conventional and/or suitable aqueous based ink may be used in the process of the present invention either alone or in conjunction with the above developer, particularly when the developer is colorless. This includes both the inks containing a water soluble dye substance and the pigmented inks. It is also possible to use simple compounds or color water soluble complexes, such as those which are formed by certain number of transition elements. Typical such compounds are the known cuprous tetramine complex, chromium salts such as chromium sulfate, chrome and potassium alum, potassium chromate, the aquo-and aceto-complexes of trivalent chromium, certain ferric compounds such as ferric thio-

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cyanate, the prussic compounds of iron, iron-ammonium citrate, the thiocyanate and thiocyanocobaltates of bivalent cobalt, cobalt sulfate and chloride, the chlorides and sulfates of bivalent nickel, the ferric complexes with salicylic acid, and the compounds formed between titanium and iron salts.

The invention is illustrated in the accompanying drawing in which the exemplary electrostatic copying apparatus utilizing the process of the present invention is illustrated.

An exemplary electrostatic copying apparatus adapted to employ the process of the present invention in the form of a cylindrical drum is illustrated. The drum, generally designated 14 comprising a dielectric material 15 coated on support substrate 16, when in operation, is generally rotated at a uniform velocity in the direction indicated by the arrow so after portions of the drum periphery pass the charging unit 18 and have been uniformly charged they come beneath the energy source 19 for exposing the charged surface to the image to be reproduced. Subsequent to charging and exposure, sections of the drum surface move past the developing unit, generally designated 21. This unit is of the cascade type which includes an outer container or cover 22 with a trough at the bottom containing a supply of developing material 23. The developing material is picked up from the bottom of the container and cascaded over the drum surface by a number of buckets 24 on an endless driven conveyor belt 26. This development technique which is more fully described in U.S. Patents 2,618,551 and 2,618,552 utilizes a two element developing mixture including finely divided-pigmented marking particles or toner and larger carrier beads. The carrier beads serve both to deagglomerate the fine toner particles for easier feeding and charge them by virtue of the relative positions of the toner and carrier material in the triboelectric series. The carrier beads with toner particles clinging to them are cascaded over the drum surface. Electrostatic field from the charge pattern on the drum attracts toner particles from the carrier beads serving to develop the image. The carrier beads, along with any residual toner particles not utilized during the development step fall back into the bottom of the container 22. The developed image continues around until it comes into contact with the copy web 27 which is passed up against the drum surface by two idler rollers 28 so that the web moves at the same speed as the periphery of the drum. The toner in the developing mixture is periodically replenished from a toner dispenser not shown. A transfer unit 29 is placed behind the web and spaced slightly from it between the rollers 28. This unit is similar in nature to the surface charging mechanism 18 in that both operate on the corona discharge principal. Both the charging device 18 and the transfer unit 29 are connected to a source of high DC potential of the same polarity identified as 31 and 32, respectively, and including corotron discharge wires represented at 33 and 34, respectively, surrounded by a conductive metal shield.

In the case of the corona discharge transfer unit, a charge is deposited on the back of web 27 and this charge is of the same polarity as the charge initially deposited on the drum and also opposite in polarity to the toner particles utilized in developing the latent image. A discharge deposit on the back web 27 pulls the toner particles away from the drum by overcoming the force of attraction between the particles and the charge on the drum. It should be noted at this point that many other transfer techniques may be utilized in conjunction with the present invention. For example, a roller connected to a high potential source opposite in polarity to the toner particles may be placed immediately behind the copy web or the copy web itself may be adhesive to the toner particles. After transfer of the toner image to web 27, the web moves beneath a fixing unit 36 which serves to fuse or permanently fix the toner image to web 27. In this case, a resistance heating-type fixer is illustrated. However, here again, other techniques known in the art may also be

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utilized including the subjection of the toner image to a solvent vapor or spraying of the toner image with an adhesive film-forming overcoating. After fixing, the web is rewound on a coil 37 for later use.

After passing the transfer station, the drum continues around and moves beneath the cleaning brush 38 which prepares the surface for a new cycle of operation. It should be noted that this apparatus may also be operated at varying speeds by setting the corona discharge unit at a high enough voltage so that the surface of the dielectric will be charged fully at the highest speed. Overcharging will not occur because the drum configuration is of such a nature and has such electrical characteristics that any excessive current will be drained away by its voltage regulating characteristics.

Although the invention has been described in connection with corona charging, it is to be understood that this is exemplary only, and that the self-regulating drum may, in fact, be employed with any suitable charging technique. Other suitable charging methods include charging with a scorotron unit, friction charging and induction charging as described in U.S. Patent 2,934,649 and 2,833,930 and roller charging as described in U.S. Patent 2,934,650. Furthermore, any suitable development means may be used in the course of this invention such as cascade development as described in the illustration or powder cloud development more fully described in U.S. Patent 2,725,305 and 2,918,910 and magnetic brush development more fully described in U.S. Patent 2,791,949 and 3,015,305. Furthermore, as mentioned above, liquid developers may be used to develop the latent image formed on the surface of the dielectric material in which case the liquid may be applied to the surface of the drum in the form of a continuous film, as an ink mist generated with an ultrasonic unit as more fully described in U.S. patent application Ser. No. 418,642, or the electrostatic latent image may be developed utilizing a gravure dispensing unit according to the process described in U.S. Patent 3,048,043.

To further define the specifics of the present invention, the following examples are intended to illustrate and not limit the particulars of the present system. Parts and percentages are by weight unless otherwise indicated. The examples are also intended to illustrate various preferred embodiments of the present invention.

EXAMPLE I

Crown Zellerbach C-62-145 electrographic paper is charged on a Jossel designed scorotron charged at about +5000 volts DC at about 80 microamps charging current. Five passes by the scorotron charger are made. The charged surface of the electrographic paper is selectively exposed by way of an image stencil for approximately 80 microseconds to a PEK xenon flash lamp fired at about 3550 volts DC with about 136 microfarads of capacitance. The distance between the flash lamp and the exposed surface is maintained at about 6 inches. The number of joules incident on the surface of the exposed dielectric paper is measured at about 1000 joules, approximately 0.1 joule per square centimeter. The electrostatic latent image thereby produced is developed according to the magnetic brush technique as disclosed in U.S. Patent 2,618,551. The image thereby produced demonstrates the image capability of the process.

EXAMPLE II

The process of Example I is repeated excepting a Mylar sheet, polyethylene terephthalate commercially available from E.I. du Pont de Nemours and Company, is substituted for the electrographic paper. Results similar to those obtained in Example I are realized.

EXAMPLE III

A plate of anodized aluminum is dip coated with a Staybelite resin to a thickness of about 10 microns. The coated aluminum plate is corona charged to a potential of

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about +900 volts by means of a laboratory corotron unit powered by a high voltage power supply. Small opaque paper letters are placed on the surface of the charged plate to act as an image stencil and the stencil plate exposed to a flash of approximately 500 joules from a xenon flash lamp. The resulting electrostatic latent image is then developed by use of an ultrasonically generated ink mist thereby demonstrating the imaging capabilities of the described process.

EXAMPLE IV

The process of Example III is repeated excepting Mylar is substituted for the Staybelite resin. Similar results are obtained.

EXAMPLE V

The process of Example I is repeated excepting a krypton filled flash lamp commercially available from Edgerton, Germeshausen and Grier, Inc. is substituted for the xenon flash lamp. The remaining steps of the process being the same, the results, as obtained in Example I, are duplicated.

EXAMPLE VI

The process of Example I is repeated excepting a PEK 75 watt xenon arc lamp (X75) is substituted for the flash lamp. The remaining steps of the procedure are the same as those disclosed in Example I. The exposure time was increased so as to expose the plate to an equivalent amount of energy as provided by the flash lamp. An electrostatic latent image is produced and the image developed as described in Example I. However, an exposure time of about 30 minutes is necessary thereby illustrating the fact that a continuous system, as opposed to a pulse or flash exposure, becomes impractical.

Although the present examples were specific in terms of conditions and materials used, any of the above listed typical materials may be substituted when suitable in the above examples with similar results. In addition to the steps used in the imaging system of the present invention, other steps or modifications may be used, if desirable. For example, the latent image produced in the course of the process may be developed so as to be used as a projection system by heating the plate thereby producing a frosted image in the charge retention areas. In addition, other materials may be incorporated in the support, dielectric material, developer, or apparatus which will en-

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hance, synergize or otherwise desirably effect the properties of the imaging system of the present invention. For example, a photosensitive composition may be introduced into the insulating layer so as to enhance its responsiveness to a particular range in the electromagnetic radiation spectrum.

Anyone skilled in the art will have other modifications occur to him based on the teaching of the present invention. These modifications are intended to be encompassed within the scope of this invention.

What is claimed is:

1. A method of forming an electrostatic latent image which comprises coating on the surface of a non-photoconductive support substrate a dielectric material consisting essentially of polyethylene terephthalate, applying a uniform electrostatic charge to the surface of said dielectric and exposing said charged dielectric to a xenon flash lamp for a period of time ranging from about 20 to about 120 microseconds to produce said latent image.

2. The method as disclosed in claim 1 further including the step of developing said latent image.

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