

- [54] **MIGRATION IMAGING PROCESS WITH UNIFORM EXPOSURE BEFORE OR DURING THE SOFTENING STEP**
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- [22] Filed: **June 1, 1967**
- [21] Appl. No.: **642,828**
- [52] U.S. Cl..... **96/1 PS, 117/37 R**
- [51] Int. Cl..... **G03g 13/22**
- [58] Field of Search 96/1, 1 R, 1.1, 1.3, 1.5, 96/1.8; 117/37 LK; 204/181

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[57] **ABSTRACT**
A positive to positive (negative to negative) imaging system the imaging member generally comprising, in its simplest form, photosensitive fracturable material contained in a softenable electrically insulating layer on a substrate, the process steps generally comprising in a preferred embodiment, uniform charging, uniform exposure and imagewise exposing while the softenable layer is soft. For some photosensitive materials, the uniform exposure step may be eliminated.

24 Claims, 7 Drawing Figures

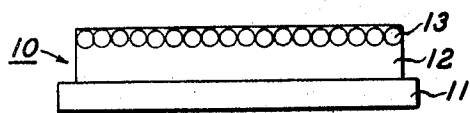


FIG. 1

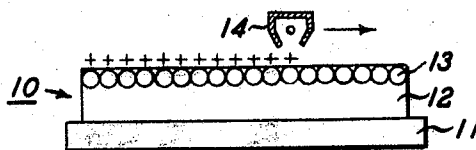


FIG. 2

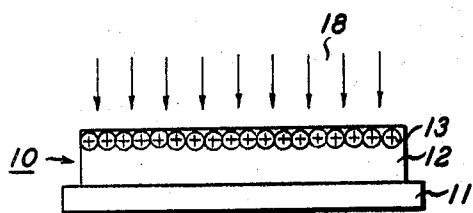


FIG. 3

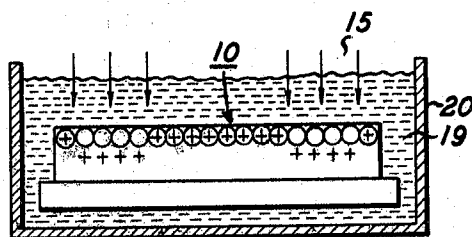


FIG. 4

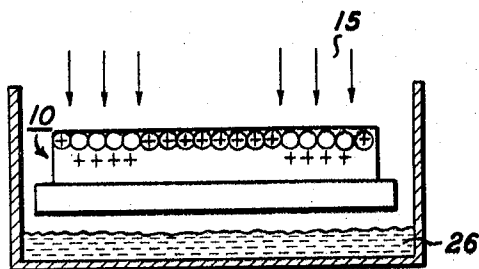


FIG. 5A

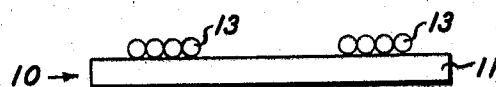


FIG. 6

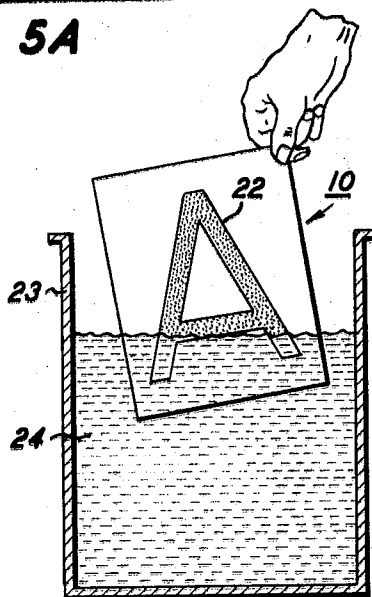


FIG. 5B

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MIGRATION IMAGING PROCESS WITH UNIFORM EXPOSURE BEFORE OR DURING THE SOFTENING STEP

BACKGROUND OF THE INVENTION

This invention relates in general to imaging, and more specifically to a new positive to positive imaging system.

There has recently been developed a migration imaging system capable of producing high quality images of high density, continuous tone, and high resolution, an embodiment of which is described in U.S. Pat. No. 3,520,681. Generally, according to an embodiment thereof, an imaging member comprising a conducting substrate with a layer of softenable (herein also intended to include soluble) material, containing photosensitive particles overlaying the conductive substrate is imaged in the following manner: a latent image is formed on the photosensitive surface, for example, by uniformly electrostatically charging and exposing it to a pattern of activating electromagnetic radiation. The imaging member is then developed by exposing it to a solvent which dissolves only the softenable layer. The photosensitive particles which have been exposed to radiation migrate through the softenable layer as it is softened and dissolved, leaving an image of migrated particles corresponding to the radiation pattern of an original, on the conductive substrate. The image may then be fixed to the substrate. For many preferred photosensitive particles the image produced by the above process is a negative of a positive original. Those portions of the photosensitive material which do not migrate to the conductive substrate may be washed away by the solvent with the softenable layer. As disclosed therein, by other developing techniques, the softenable layer may at least partially remain behind on the supporting substrate.

In general, three basic imaging members may be used: a layered configuration which comprises a conductive substrate coated with a layer of softenable material, and a fractureable and preferably particulate layer of photosensitive material at or embedded near the upper surface of the softenable layer, this layer being referred to as contiguous the surface of the softenable layer upon which it may be coated or slightly, partially, or substantially embedded; a binder structure in which the photosensitive particles are dispersed in the softenable layer which overcoats a conducting substrate; and an overcoated structure in which a conductive substrate is overcoated with a layer of softenable material followed by an overlaying of photosensitive particles and a second overcoating of softenable material which sandwiches the photosensitive particles. Fracturable layer or material as used herein, is intended to mean any layer or material which is capable of breaking up during development and permitting portions to migrate towards the substrate in image configuration.

This imaging system generally comprises a combination of process steps which includes forming a latent image and developing with solvent liquid or vapor, or heat or combinations thereof to render the latent image visible. In certain methods of forming the latent image non-photosensitive or inert, fractureable layers and particulate material may be used to form images, as described in application Ser. No. 483,675, filed Aug. 30, 1965 now U.S. Pat. No. 3,656,990, wherein a latent

image is formed by a wide variety of methods including charging in image configuration through the use of a mask or stencil; first forming such a charge pattern on a separate photoconductive insulating layer according to conventional xerographic reproduction techniques and then transferring this charge pattern to the members hereof by bringing the two layers into very close proximity and utilizing breakdown techniques as described, for example, in Carlson U.S. Pat. No. 2,982,647 and Walkup U.S. Pat. Nos. 2,825,814 and 2,937,943. In addition, charge patterns conforming to selected, shaped, electrodes or combinations of electrodes may be formed by the "TESI" discharge technique as more fully described in Schwertz U.S. Pat. Nos. 3,023,731 and 2,919,967 or by techniques described in Walkup U.S. Pat. Nos. 3,001,848 and 3,001,849 as well as by electron beam recording techniques, for example, as described in Glenn U.S. Pat. No. 3,113,179.

In another variation of this imaging system an image is formed by the selective disruption of a particulate material overlaying or in an electrostatically deformable, or wrinkleable film or layer. This variation differs from the system described above in that the softenable layer is deformed in conjunction with a disruption of the particulate material as described more fully in application Ser. No. 520,423, filed Jan. 13, 1966 now abandoned.

The characteristics of the images produced by this new system are dependent on such process steps as charging, exposure and development, as well as the particular combination of process steps. High density, continuous tone and high resolution are some of the image characteristics possible. The image is generally characterized as a fixed or unfixed particulate image with or without a portion of the softenable layer and unmigrated portions of the layer left on the imaged member, which can be used in a number of applications such as microfilm, hard copy, optical masks, and strip out applications using adhesive materials.

For some preferred photosensitive particles a positive to negative imaging system results when an imaging member is uniformly charged, imagewise exposed and developed. In many imaging applications it is desirable to produce positive images from a positive original and negatives from a negative original.

A system has now been devised to produce positive images from a positive original (and negative images from a negative original) utilizing the above imaging system and member.

SUMMARY OF THE INVENTION

It is, therefore, an object of this invention to provide an imaging system with a member comprising photosensitive fractureable material in a softenable layer on a substrate to produce positive images from a positive original.

It is a further object of this invention to provide an imaging system with a member comprising photosensitive fractureable material in a softenable layer on a substrate to consistently produce improved quality positive to positive images.

It is a further object of this invention to provide an imaging system which eliminates the need for a mechanical shutter during exposure.

It is a still further object of this invention to provide a positive to positive imaging system requiring only the

surface charge potentials taught by the prior art for the imaging members described herein.

The foregoing objects and others are accomplished in accordance with this invention by providing an imaging member comprising in its simplest form, photosensitive fracturable material in or on a softenable electrically insulating layer on a substrate, processed by uniformly electrostatically charging said member, uniformly exposing said member and imagewise exposing while the softenable layer is soft. Softening of the softenable layer may be accomplished by treatment with a liquid solvent or vapor, heat or combinations thereof. Image-wise exposure while this layer is in a softened condition according to this invention produces images of improved quality and also, surprisingly provides for positive images from positive optical images in imaging members which heretofore were known to produce a negative image from a positive optical image. For some photosensitive fracturable materials, the uniform exposure step may be eliminated.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the invention as well as other objects and further features thereof, reference is made to the following detailed disclosure of this invention taken in conjunction with the accompanying drawings wherein:

FIG. 1 is a partially schematic illustration of an embodiment of an imaging member according to the invention.

FIG. 2 is a partially schematic illustration of the electrostatic charging step according to the invention.

FIG. 3 is a partially schematic representation of the uniform exposure step of this invention.

FIG. 4 is a partially schematic illustrative representation of a preferred mode of imagewise exposure according to the invention.

FIG. 5 is a partially schematic and perspective view of an alternative preferred mode of imagewise exposure and development according to the invention.

FIG. 6 is a cross section of the imaging member of FIG. 1 after processing according to a preferred embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIG. 1 there is shown a schematic drawing of an example of one embodiment of an imaging member 10 according to this invention comprising substrate 11, electrically insulating softenable layer 12 which contains contiguous its upper surface a fracturable layer of particulate photosensitive material 13.

Substrate 11 may be electrically conductive or insulating. Conductive substrates generally facilitate the charging or sensitization of the member according to the invention and typically may be of copper, brass, nickel, zinc, chromium, stainless steel, conductive plastics and rubbers, aluminum, steel, cadmium, silver and gold. The substrate may be in any suitable form such as a metallic strip, sheet, plate, coil, cylinder, drum, endless belt, moebius strip or the like. If desired, the conductive substrate may be coated on an insulator such as paper, glass or plastic. Examples of this type of substrate are a substantially transparent tin oxide coated glass available under the trademark NESA from the Pittsburgh Plate Glass Co.; aluminized polyester film, the polyester film available under the trademark Mylar

from the E. I. DuPont de Nemours and Co.; or Mylar coated with copper iodide.

Electrically insulating substrates may also be used which opens up a wide variety of film formable materials such as plastics for use as substrate 11.

Softenable layer 12 may be any suitable material which is soluble or softenable in a solvent liquid or vapor or heat or combinations thereof, and in addition, is substantially electrically insulating during the latent image forming and developing steps hereof. Typical materials include Staybelite Ester 10, a partially hydrogenated rosin ester, Foral Ester, a hydrogenated rosin triester, and Neolyne 23, an alkyd resin, all from Hercules Powder Co.; SR type silicone resins available from General Electric Corporation; Sucrose Benzoate, Eastman Chemical; Velsicol X-37, a polystyrene-olefin copolymer from Velsicol Chemical Corp.; Hydrogenated Piccopale 100, a highly branched polyolefin, Piccotex 100, a styrene-vinyl toluene copolymer, Piccolastic A-75, 100 and 125, all polystyrenes, Piccodiene 2215, a polystyrene-olefin copolymer, all from Pennsylvania Industrial Chemical Corp.; Araldite 6060 and 6071, epoxy resins from Ciba; R5061A, a phenylmethyl silicone resin, from Dow Corning; Epon 1001, a bisphenol A-epichlorohydrin epoxy resin, from Shell Chemical Corp.; and PS-2, PS-3, both polystyrenes, and ET-693, a phenol-formaldehyde resin, from Dow Chemical; a custom synthesized copolymer of styrene and hexylmethacrylate, a custom synthesized polydiphenylsiloxane; a custom synthesized polyadipate; acrylic resins available under the trademark Acryloid from Rohm and Haas Co., and available under the trademark Lucite from the E. I. DuPont de Nemours and Co.; thermoplastic resins available under the trademark Pliolite from the Goodyear Tire and Rubber Co.; a chlorinated hydrocarbon available under the trademark Aroclor from Monsanto Chemical Co.; thermoplastic polyvinyl resins available under the trademark Vinylite from Union Carbide Co. and blends thereof.

The above group of materials is not intended to be limiting, but merely illustrative of materials suitable for softenable layer 12. The softenable layer may be of any suitable thickness, with thicker layers generally requiring a greater potential for charging. In general, a thickness from about 1 to 4 microns is found to be preferred.

The material comprising layer 13, portions of which migrate to the substrate during image formation, may comprise any suitable photosensitive fracturable material. While it is preferred for images of highest resolution and density that the fracturable material be particulate, it may comprise any continuous or semi-continuous, such as a swiss cheese pattern, fracturable layer which is capable of breaking up during the development step and permitting portions to migrate to the substrate in image configuration.

Any suitable photosensitive fracturable material may be used herein. Typical such materials include inorganic or organic photoconductive insulating materials.

Typical inorganic photoconductors include amorphous selenium; amorphous selenium alloyed with arsenic, tellurium, antimony or bismuth, etc.; cadmium sulfide, zinc oxide, cadmium sulfoselenide, cadmium yellows such as Lemon Cadmium Yellow X-2273 from Imperial Color and Chemical Dept. of Hercules Powder Co., and many others. Middleton et al. Patent No.

3,121,006 lists typical inorganic photoconductive pigments. Typical organic photoconductors include azo dyes such as Watchung Red B, a barium salt of 1-(4'-methyl-5'-chloro-azobenzene-2'-sulfonic acid)-2-hydroxy-3-naphthoic acid, C. I. No. 15865, and Monastral Red B, both available from DuPont; Indofast double scarlet toner, a Pyranthrone-type pigment available from Harmon Colors; quindo magenta RV-6803, a quinacridone-type pigment available from Harmon Colors; Cyan Blue, GTNF, the beta form of copper phthalocyanine, C. I. No. 74,160, available from Collway Colors; Monolite Fast Blue GS, the alpha form of metal-free phthalocyanine, C. I. No. 74,100, available from Arnold Hoffman Co.; commercial indigo available from National Aniline Division of Allied Chemical Corp.; yellow pigments prepared as disclosed in copending applications Ser. No. 421,281, filed Dec. 28, 1964, or as disclosed in Ser. No. 445,235, filed Apr. 2, 1965, X-form metal-free phthalocyanine prepared as disclosed in copending application Ser. No. 505,723, filed Oct. 29, 1965, quinacridonequinone from DuPont, sensitized polyvinyl carbazole, Diane Blue, 3,3'-methoxy-4,4'-diphenyl-bis (1'' azo-2'' hydroxy-3''-naphthanilide), C. I. No. 21180, available from Harmon Colors; and Algol G. C., 1,2,5,6-di (D,D'-diphenyl)-thiazole-anthraquinone, C. I. No. 67300, available from General Dyestuffs and mixtures thereof. The above list of organic and inorganic photoconductive photosensitive materials is illustrative of typical materials, and should not be taken as a complete listing of photosensitive materials.

It is found that some photosensitive materials which produce migration images of outstanding quality, such as the optimum materials comprising amorphous selenium and the preferred materials including Watchung Red B, Diane Blue, commercial indigo and Monastral Red B, will generally produce negative images from positive originals when uniformly charged, exposed and developed as described more fully in U.S. Pat. No. 3,520,681. With such photosensitive materials, the system of this invention provides for a positive to positive imaging system.

It is also found that other preferred photosensitive materials such as Monolite Fast Blue GS and zinc oxide will sometimes provide for a positive to positive or positive to negative imaging system depending on variations in imaging member makeup and in the three basic process steps of charge, imagewise exposure and development as disclosed in U.S. Pat. No. 3,520,681. For these photosensitive materials, the inventive system hereof may be used to establish with certainty a positive to positive imaging system with images of increased quality over those processed according to the three basic steps of the prior art. Also with such materials, it is found that the same effect may be accomplished in many instances even without the uniform exposure step hereof. Although it is not completely understood when the uniform exposure step may be eliminated for such materials, it is thought to be due to the higher dark electrical conductivity of these materials as opposed to the materials such as those comprising amorphous selenium which must be uniformly exposed to achieve sufficient conductivity to cause the charges to become more firmly bound to the fracturable materials which, as will be explained, is thought to be part of the theory of operation of this invention.

In addition to the configuration shown in FIG. 1, additional modifications in the basic structure such as the use of the binder form in which the structure consists of the photosensitive fracturable material dispersed in and in one embodiment throughout the softenable layer, may also be used. In addition, an overcoated structure in which the photosensitive material is sandwiched between two layers of the softenable material which overlays the substrate is also included within the scope of this invention.

The fracturable layer for the layered configurations of FIG. 1 may be formed by any suitable method. Typical methods include vacuum evaporation such as disclosed in application Ser. No. 423,167, filed Jan. 4, 1965 now abandoned, wherein a fracturable layer of submicron size especially preferred amorphous selenium is formed on a softenable layer. The fracturable layer may be formed by other methods such as by cascading, dusting, etc., as shown in U.S. Pat. No. 3,520,681. The thickness of the fracturable layer is preferably less than about one micron, although 5 micron layers have been found to give good results for some materials. When a binder structure is used, the methods set forth in Middleton et al. U.S. Pat. No. 3,121,006 may be used to form the binder structure.

Referring now to FIG. 2, the imaging member is uniformly electrostatically charged, illustratively by means of a corona discharge device 14 which is shown to be traversing the member from left to right depositing a uniform charge on the surface of layer 13. For example, corona discharge devices of the general description and generally operated as disclosed in Vyverberg U.S. Pat. No. 2,836,725 and Walkup U.S. Pat. No. 2,777,957 have been found to be excellent sources of corona useful in the charging of member 10. Other charging techniques ranging from rubbing the member, to induction charging, for example, as described in Walkup U.S. Pat. No. 2,934,649 are available in the art. The surface charge potentials of layer 13 preferred for imaging herein may run from a few to as high as 400 volts. For positive polarity the potential should be from about 100 to 300 volts to yield optimum results. When using voltages of negative polarity, optimum results are obtained when the surface potential of layer 13 is from about 25 to 150 volts.

It should be noted that although the inventive steps hereof are described sequentially, the steps have various degrees of overlap. For example, the uniform exposure step hereof may take place during, as well as after charging.

Where substrate 11 is an insulating material, charging of the member, for example, may be accomplished by placing the insulating substrate in contact with a conductive member and charging as illustrated in FIG. 2. Alternatively, other methods known in the art of xerography for charging xerographic plates having insulating backings may be applied. For example, the member may be charged using double sided corona charging techniques where two corona charging devices on each side of the member and oppositely charged are traversed in register relative to member 10.

Referring now to FIG. 3, there is shown a uniform exposure of member 10 by actinic radiation 18. Suitable uniform exposure levels of this invention, generally are from about one to 10 times those of the imagewise exposure step explained in reference to FIG. 4. This uniform exposure is preferably from about 1 f.c.s. to about

1000 f.c.s. or more to provide for optimum quality images. Any suitable actinic electromagnetic radiation may be used. Typical types include radiation from ordinary incandescent lamps, X-rays, beams of charged particles, infrared, ultra violet and so forth.

For purposes of illustration, the surface electrical charges deposited in FIG. 2 are depicted as having moved into fracturable layer 13 in the uniform exposure step of FIG. 3. Although this representation is speculative, it is helpful for an understanding of the present invention to consider electrical charges to be more firmly bound to layer 13 by moving into layer 13 as a result of the uniform exposure step illustrated in FIG. 3.

Referring now to FIG. 4, member 10 is shown during the initial stages of being imagewise exposed to activating radiation 15 while member 10 is softened by the preferred mode of being immersed in a solvent liquid 19 for softenable layer 12. The liquid is held in container 20.

For purposes of illustration, the electrical charges in layer 13 are depicted as having moved out of layer 13 in the imagewise illuminated areas and into the softenable layer 12 leaving the unexposed areas of layer 13 the only areas with charge still residing in the fracturable layer 13. Again this representation is speculative but helpful for an understanding of the present invention.

It is thought that three phases actually occur in the imagewise exposure during softening step; namely, that (a) as illustrated, layer 12 is first softened and the charge on the imagewise exposed portions of layer 13 is injected or migrates into layer 12, (b) that the unexposed areas of layer 13, which still have charges residing in the fracturable layer then migrate to substrate 11, (c) which step is followed, when liquid solvent immersion is used, by the complete dissolving away of layer 12 washing away the unmigrated particles in the exposed areas.

As a preferred alternative, illustrated in FIG. 5A, the imagewise exposure step may be carried out while member 10 is softened by being subjected to the vapors of a solvent for layer 12. In this alternative, the imagewise exposure step, while or after the member has been softened by a solvent vapor, may be followed by a liquid solvent treatment step, for example, accomplished by temporarily contacting member 10 with a solvent for softenable layer 12, as illustrated in FIG. 5B, for example, by immersing member 10 in container 23 containing a liquid solvent 24 for layer 12. According to this preferred alternative embodiment, only phase (a) or phases (a) and (b) may occur while the member is in the solvent vapor, depending on the intensity of the solvent vapor treatment, with the remaining phase (b) and (c) or only phase (c), respectively, taking place in the subsequent liquid solvent treatment.

The duration of the solvent vapor treatment, preferred alternative mode of softening herein, varies depending on the solvent used, the vapor concentration, the material comprising layer 12, the imagewise exposure level and other factors, but preferably it is found to vary between about 1/2 second to about 10 seconds to produce images of optimum quality.

While it is preferred in many instances, for convenience, to imagewise expose while subjecting the member to a solvent vapor as illustrated in FIG. 5A, it is to be understood that imagewise exposure may also take

place after the member has been softened by solvent vapor, and while softenable layer 12 is still in a softened condition. The subsequent imagewise exposure should preferably follow the solvent vapor step within a few minutes in order to ensure sufficient softness of the softenable material.

If the duration of the imagewise exposure is longer than the time required for the photosensitive material to migrate to the substrate 11, for example, if the softenable material is already in a softened condition, then the migration time becomes the effective exposure time, eliminating the need for a timed mechanical shutter. This migration time can be as short as one-tenth of a second.

While softening by liquid solvent or vapor is preferred, any suitable means for softening the softenable layer during or prior to the imagewise exposure step may be used. Typical means include heat softening, for example, heating the softenable material to about 50°C. to about 80°C. from about 1 to about 10 seconds, and combinations of liquid solvent or vapor and heat. Also, while generally a definite softening step is part of the inventive system of this invention, such a softening step may be eliminated if the softenable layer is already in a softened condition, for example where a member has recently been constructed and the layer is still sufficiently soft as to not necessitate a specific softening step.

By either mode of this invention as illustrated in the drawings, in contrast to the teaching of U.S. Pat. No. 3,520,681, the effect, in imagewise exposed areas, of the image exposure while the softenable layer is soft is to dissolve away layer 12 and cause layer 13 to be washed away in these areas. In unexposed areas, however, layer 13 does not wash away but migrates to and adheres to substrate 11 which can be withdrawn from container 20 or 23 with an image pattern 22 of fracturable material adhering thereon, as illustrated in FIG. 5B. Image 22, in the form of the letter "A" is a positive image from a positive original. For example, the original could have been a large black or dark "A" on a substantially lighter or white background which by this inventive process produces, rather than a negative image as was taught by the prior art, a positive image constituted of portions of layer 13 which migrated to form the "A" on the background provided by substrate 11.

It is to be noted that the liquid solvent wash-away step, which is a part of the two preferred modes of practicing the invention illustrated in the drawings, which are preferred because they substantially completely remove the softenable material and unmigrated fracturable material which results in a high contrast image with no or low background and are simple, direct approaches which produce resultant images of excellent quality, is not necessary to produce a useable image hereby. For example, uniform charging with or without uniform exposure as described herein, and imagewise exposure while the softenable layer is soft, without a subsequent wash-away step produces a positive to positive useable migration image, and although layer 12 and illuminated areas of fracturable material are not thereby washed away, the image produced may be viewed by means of special display techniques, including, for example, focusing light reflected from the plate onto a viewing screen. Moreover, a liquid solvent may at any time thereafter be applied to such a migra-

tion image to convert it into a solvent wash-away image as illustrated in FIG. 6. In this regard, it is further noted that the liquid solvent applied need not be insulating; conductive liquids may be used.

It has also been found that illuminated areas of fracturable material of such a migration image may be removed by abrasion to yield a readily visible image, or the illuminated areas may be adhesively stripped off to yield complementary positive and negative images.

While it is not clearly understood why uniform charging, uniform exposure in some instances, softening of the softenable layer and imagewise exposure while the softenable layer is soft provides for enhanced positive to positive imaging according to this invention, it is theorized that the charges in the layer 13 are injected into layer 12 by the imagewise exposure step illustrated in FIGS. 4 and 5A because of the softened condition of layer 12 due, in the preferred modes of operation, to the presence of solvent in layer 12 and thus the particles in the exposed areas of layer 13 lose their migration force before they reach the substrate 11. Thus, the only portions of fracturable layer 13 which have a force to migrate to the substrate are those corresponding to unexposed areas of layer 13.

As illustrated in the examples, this novel method of positive to positive imaging works not only with the layered configuration illustrated in FIG. 1 but also with the binder type structure where the photosensitive fracturable material 13, preferably in particulate form, is dispersed in layer 12.

Generally solvents 19, 24 and 26, used for softening layer 12 herein, should preferably be a solvent for layer 12 but not for layers 13 and 11 and should have high enough electrical resistance to prevent the material of layer 13 from losing its charge before it can reach substrate 11. Typical solvents for use for the various materials which may comprise layer 12, a partial listing which is found herein, include acetone, trichloroethylene, chloroform, ethyl ether, xylene, dioxane, benzene, toluene, cyclohexane, 1,1,1-trichloroethane, pentane, n-heptane, trichlorotrifluoroethane available under the designation Freon 113 from DuPont, M xylene, carbon tetrachloride, thiophene, diphenyl ether, p-cyamine, sis-2,2-dichloroethylene, nitromethane, n,n-dimethyl formamide, ethanol, ethyl acetate, methyl ethyl ketone, ethylene dichloride, methylene chloride, trans 1,2-dichloroethylene, Super Naphthalite available from Buffalo Solvents and Chemicals and mixtures thereof.

The following examples further specifically define the present inventive positive to positive imaging system. The parts and percentages are by weight unless otherwise indicated. All exposures are from a tungsten filament photoflood light source. The examples below are intended to illustrate various preferred embodiments of the imaging system of this invention.

EXAMPLE I

A plate 10 as illustrated in FIG. 1 is prepared by roll coating about a 2 micron layer of Staybelite Ester 10 on Mylar film having a thin transparent aluminum coating. A fracturable layer of selenium, about 0.2 microns in thickness is deposited on layer 12 by the inert gas deposition process of application Ser. No. 423,167, now abandoned.

Member 10 is then electrostatically charged in darkness to a positive surface potential of about 60 volts by

means of a corona discharge device. The charged plate is then exposed uniformly at about 10 f.c.s.

The member is then exposed in the dark to a positive optical image with the intensity in the illuminated areas being about 10 f.c.s. and the exposure time being governed by the softening time of about 1 second, while the member is immersed in vapors of 1,1,1-trichloroethane, the exposure taking place with the member positioned about 2 inches above the liquid surface with the liquid contained in about a 2 liter beaker containing about 100 cc. of the solvent liquid in the bottom thereof. The member is exposed to the vapors for about 2 seconds longer to cause migration of the fracturable material to the aluminized Mylar substrate in image configuration, and then removed from the beaker.

The member is then immersed in cyclohexane for about 2 seconds to wash away the Staybelite and the unmigrated fracturable material, and removed. A dense, high resolution, continuous tone, faithful and positive selenium fracturable material image of the optical image is thereby formed on the aluminized Mylar substrate to form a directly visible image which may also be used as a projection transparency.

EXAMPLE II

Example I is followed except that layer 12 is Piccotex 100, the solvent vapor is Freon 113 and the developer liquid is 1,1,1-trichloroethane.

EXAMPLE III

The first two paragraphs of Example I are followed.

In the dark the charged member is submerged in liquid Freon 113 and exposed to an optical image of intensity of 100 f.c., the exposure time being governed by the migration time of about 1/10 of a second. After about three seconds the member is removed. An image is formed as in Example I.

EXAMPLE IV

Zinc oxide available under the designation Florence Green Seal No. 8 from the New Jersey Zinc Co. having a particle size of about 1/2 micron, carried by about 50 micron diameter glass beads, is cascaded several times across the surface of about a 2 micron Staybelite Ester 10 layer overlying aluminized Mylar, the Staybelite being softened with Freon 113 vapor between cascading to form about a 1 micron thick layer of zinc oxide in or on the Staybelite.

The member is then uniformly electrostatically charged to a surface potential of about -50 volts by means of a corona discharge device. The member is then exposed to a negative optical image, the exposure in light struck areas being about 50 f.c.s. while subjecting, as described in Example I, the member to a weak atmosphere of a vapor of the solvent Freon 113 for about 10 seconds.

The member is then immersed in Freon 113 for about 3 seconds and then removed to form a negative image comparable to the one formed in Example I and of a higher quality than the image formed from a control member uniformly charged, exposed and liquid solvent developed as taught by U.S. Pat. No. 3,520,681.

EXAMPLE V

Monolite Fast Blue GS having a particle size of about

½ micron, carried by about 50 micron diameter glass beads, is cascaded across the surface of about a 2 micron Staybelite Ester 10 layer overlying aluminized Mylar, the Staybelite being softened with Freon 113 vapor between cascading to form about a 1 micron thick layer of phthalocyanine particles in or on the Staybelite.

The member is then uniformly electrostatically charged to a surface potential of about -60 volts by means of a corona discharge device and then image-wise exposed, the exposure in light struck areas being about 40 f.c.s. while the member, as described in Example I, is subjected to a weak atmosphere of a vapor of the solvent Freon 113 for about 5 seconds.

The member is then immersed in Freon 113 for about 3 seconds and removed to produce an image comparable in quality to that produced in Example I and of a higher quality than the image produced from a control member processed by the uniform charge, exposure and liquid solvent development steps taught by the prior art.

Although specific components and proportions have been stated in the above description of preferred embodiments of the positive to positive imaging system hereof, other suitable materials as listed herein may be used with similar results. In addition, other materials and other configurations of the imaging member may be provided and variations may be made in the various processing steps to synergize, enhance and otherwise modify the system. For example, various plasticizers, additives, moisture and other "proofing" agents may be added to the softenable materials as desired.

It will be understood that various other changes in the details, materials, steps and arrangements of the members which have been herein described and illustrated in order to explain the nature of the invention will occur to and may be made by those skilled in the art upon a reading of this disclosure and such changes are intended to be included within the principle and scope of this invention.

What is claimed is:

1. An imaging method comprising the steps of: providing an imaging member comprising a supporting substrate and an overlayer of electrically insulating softenable material containing electrically photosensitive material wherein a sufficient amount of electrically photosensitive material is spaced apart from said substrate to allow a migration image to form, and softenable material capable of being softened sufficiently to allow migration of said electrically photosensitive material through said softenable material toward said substrate; uniformly exposing said member to activating electromagnetic radiation before or during the softening step whereby electrically photosensitive material selectively migrates relatively more in the areas relatively less exposed during the imagewise exposure step below than the photosensitive material in the areas relatively more exposed during the imagewise exposure step below; softening the softenable material at least sufficient to allow migration of the electrically photosensitive material through the softenable material upon formation of the electrostatic latent image below; uniformly electrostatically charging said member; and

exposing said member to an imagewise pattern of activating electromagnetic radiation during or after said softening step while the softenable material is in a soft condition whereby upon said imagewise exposure said electrically photosensitive material selectively migrates in depth in said softenable material in imagewise configuration toward said substrate to form a migration image.

2. An imaging method according to claim 1 wherein said uniformly exposing step is accomplished in the interval from the beginning of the charging step to the completion of the imagewise exposure step said uniformly exposing step is relatively less as compared to the imagewise exposure step.

3. An imaging method according to claim 1 wherein said softenable layer is of a thickness in the range between about 1 micron and about 4 microns.

4. An imaging method according to claim 1 wherein said electrically photosensitive material comprises photoconductive material.

5. An imaging method according to claim 4 wherein said photoconductive material comprises amorphous selenium.

6. An imaging method according to claim 1 wherein said softening of said softenable material is accomplished by exposing said material to a solvent capable of at least softening said softenable material.

7. An imaging method according to claim 6 wherein the exposing of said softenable material to a solvent is accomplished by contacting said softenable material with a liquid solvent.

8. An imaging method according to claim 6 wherein the exposing of said softenable material to a solvent is accomplished by contacting said softenable material with a vapor of a solvent.

9. An imaging method according to claim 8 wherein said material is exposed to said solvent vapor for a period of time between about ½ second and about 10 seconds in duration.

10. An imaging method according to claim 8 including an additional step comprising exposing said softenable material to a liquid solvent.

11. An imaging method according to claim 1 wherein said softenable material is softened by heating said material.

12. An imaging method according to claim 11 wherein said softenable material is heated to a temperature between about 50°C. and about 80°C. for between about 1 and about 10 seconds.

13. An imaging method according to claim 1 wherein said electrically photosensitive material comprises a material selected from the group consisting of phthalocyanine, zinc oxide and mixtures thereof.

14. An imaging method according to claim 1 wherein at least portions of the softening step and imagewise exposure step occur simultaneously.

15. An imaging method according to claim 1 wherein imagewise exposure is at an exposure level between about 1 f.c.s. and about 100 f.c.s.

16. An imaging method according to claim 1 wherein said electrically photosensitive material is in the form of a fracturable layer contiguous the non-substrate surface of said softenable material and spaced apart from said substrate.

17. An imaging method according to claim 16 wherein said fracturable layer is permeable to a solvent capable of at least softening said softenable material.

18. An imaging method according to claim 16 wherein said fracturable layer is not greater than about 1 micron in thickness.

19. An imaging method according to claim 1 wherein said electrically photosensitive material is dispersed throughout said softenable material.

20. An imaging method according to claim 1 including an additional step comprising uniformly exposing said member to activating electromagnetic radiation before the softening step whereby electrically photosensitive material selectively migrates relatively more in the areas relatively less exposed during the imagewise exposure step than the photosensitive material in the areas relatively more exposed during the imagewise exposure step.

21. An imaging method according to claim 20 wherein said uniformly exposing step is accomplished in the interval from the beginning of the charging step to the completion of the imagewise exposure step whereby electrically photosensitive material selectively migrates relatively more in the areas relatively less ex-

posed during the imagewise exposure step than the photosensitive material in the areas relatively more exposed during the imagewise exposure step.

22. An imaging method according to claim 20 wherein said uniform exposure in illuminated areas is at an exposure level of between about 1 f.c.s. and about 1,000 f.c.s. and said imagewise exposure is at an exposure level between about 1 f.c.s. and about 100 f.c.s.

23. An imaging method according to claim 20 wherein said electrically photosensitive material comprises a material selected from the group consisting of phthalocyanine, zinc oxide, amorphous selenium, azo dyes, indigo and mixtures thereof.

24. An imaging method according to claim 1 wherein said softening of said softenable material is accomplished by exposing said material to a liquid solvent capable of first softening and then dissolving said softenable material whereby subsequent to said softening the softenable material and the unmigrated electrically photosensitive material are washed away.

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