

- [54] **MANIFOLD IMAGING APPARATUS**
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- [73] Assignee: **Xerox Corporation, Stamford, Conn.**
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Related U.S. Application Data

- [62] Division of Ser. No. 838,193, July 1, 1969, Pat. No. 3,653,892.
- [52] U.S. Cl. **355/5, 355/16**
- [51] Int. Cl. **G03g 15/00**
- [58] Field of Search **355/5, 16, 17, 44; 96/1.3, 1.4**

References Cited

UNITED STATES PATENTS

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|-----------|--------|----------------|----------|
| 3,196,765 | 7/1965 | Walkup..... | 355/5 |
| 3,168,857 | 2/1965 | Hutto, Jr..... | 355/5 |
| 3,438,772 | 4/1969 | Gundlach..... | 96/1.3 X |

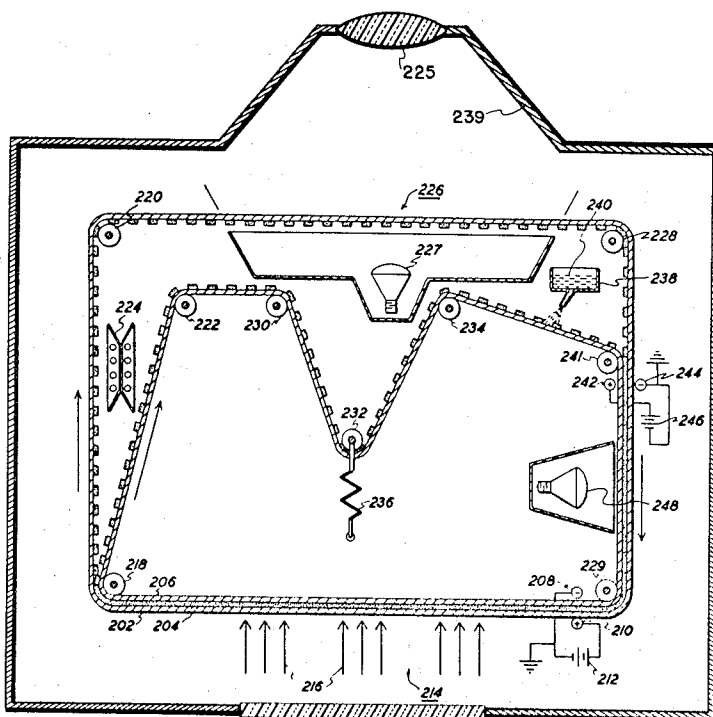
3,519,344 7/1970 Clark et al. 355/5

Primary Examiner—Robert P. Greiner
Attorney—James J. Ralabate, Raymond C. Loyer et al.

[57] **ABSTRACT**

An imaging apparatus wherein a reusable imaging layer comprising a cohesively weak electrically photosensitive imaging material is sandwiched between a donor sheet and a receiver sheet, subjected to an electric field and exposed to an imagewise pattern of electromagnetic radiation to which it is sensitive. The donor and receiver sheets are then separated thereby fracturing the imaging layer in imagewise configuration. The imaging layer is rendered reusable by recombining the sandwich, subjecting it to an electric field while flood exposing the imaging layer to electromagnetic radiation to which it is sensitive. The apparatus is provided with a viewing station for viewing a positive or negative image.

11 Claims, 5 Drawing Figures



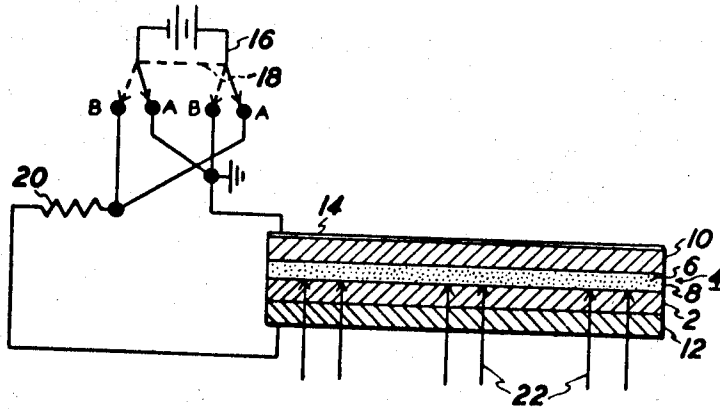


FIG. 1A

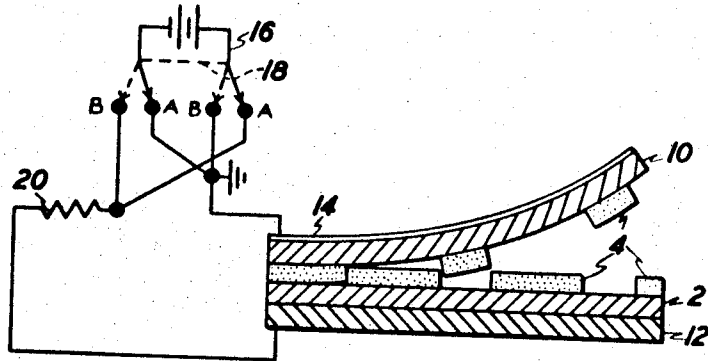


FIG. 1b

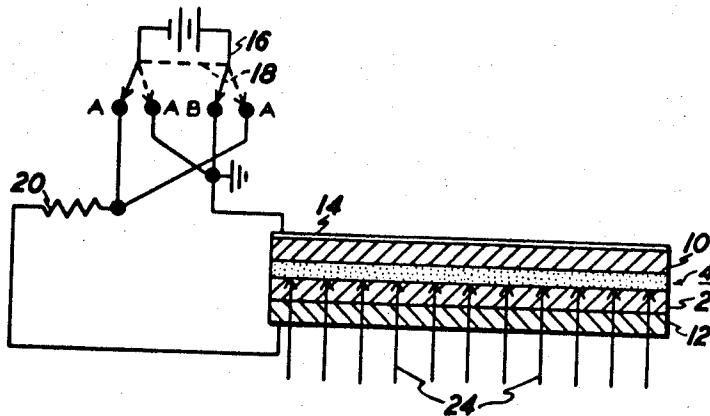


FIG. 1c

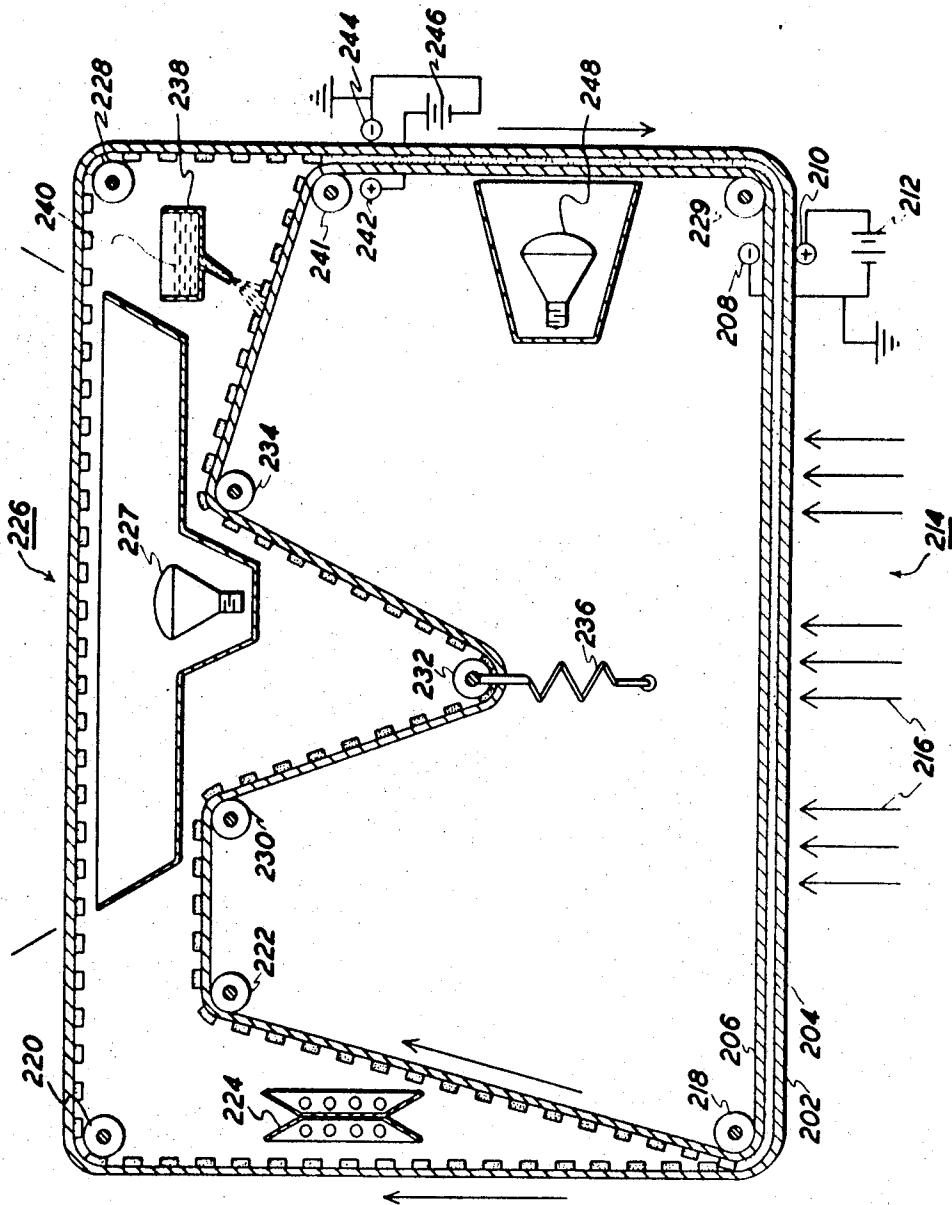


FIG. 2

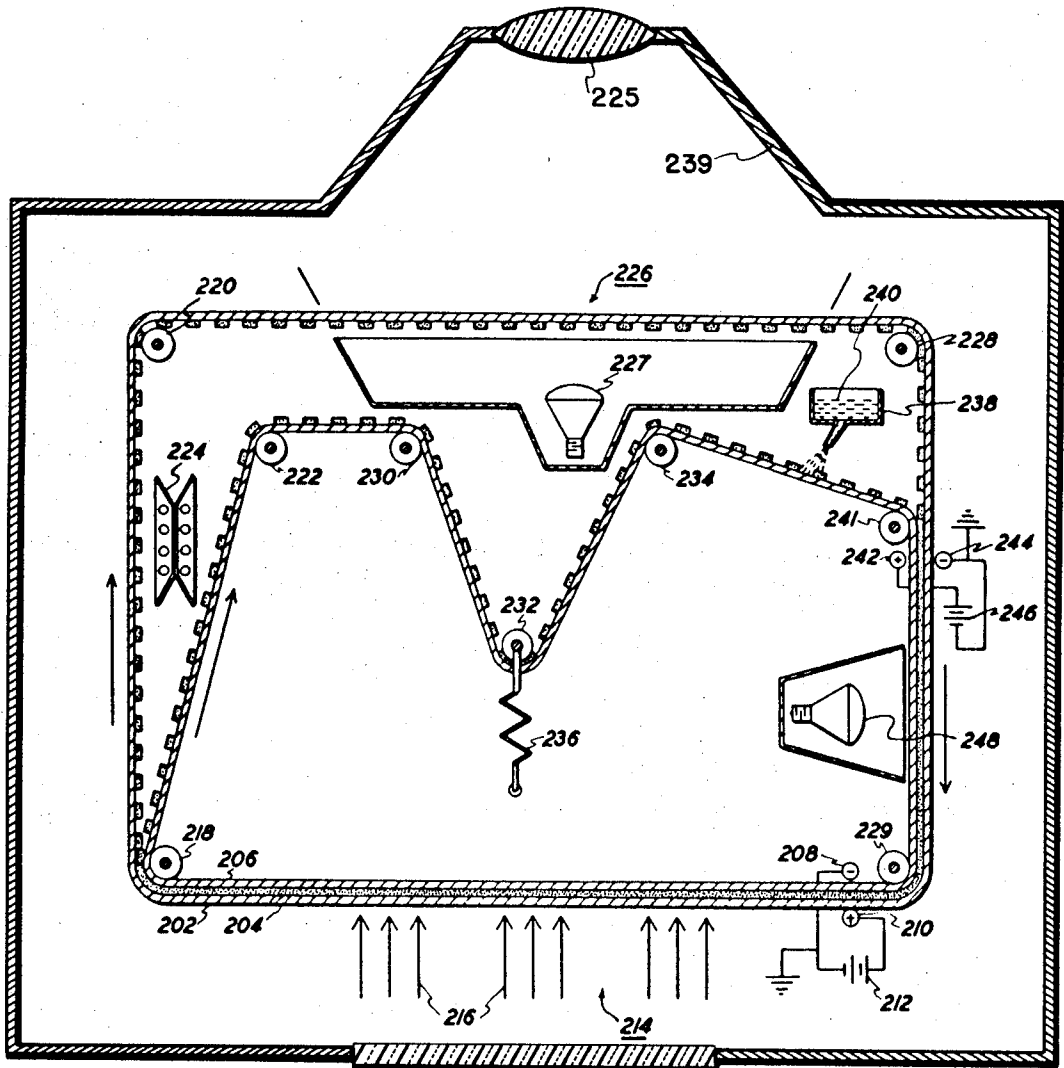


FIG. 3

MANIFOLD IMAGING APPARATUS
CROSS REFERENCE TO RELATED
APPLICATIONS

This application is a division of applicant's copending application Ser. No. 838,193, filed July 1, 1969 in the U.S. Patent Office, now U.S. Pat. No. 3,653,892.

BACKGROUND OF THE INVENTION

The present invention relates in general to imaging and more specifically, to a process for the formation of images by layer transfer in image configuration which process provides for a reusable imaging layer.

The imaging systems of the prior art, for example, the xerographic and the photographic type of recording employ materials which once used to form the image can no longer be used to form subsequent images. Although the modern xerographic method employs a reusable photoconductor, the imaging material, that is the toner, must be replenished in the process since the amount of toner employed to produce an image is lost from the imaging system. The photographic method of image recording has been advantageously used, but it also has similar limitations. For example, the photographic material such as the silver halide emulsions can be employed only once and after having formed an image is lost from the imaging system.

In addition to the irretrievable loss of imaging material in the prior imaging methods, the development of the image has also involved complicated and cumbersome, although automated, development techniques. In one form of xerography, developer containing toner is cascaded across the xerographic plate to develop the required image. Transfer of the toner to a print-out record sheet or other substrate is required. This xerographic technique has been found to be excellent for reproduction of typewritten and other line copy images but the system remains excessively complicated due to the image development and transfer techniques. The photographic method has its limitations since film must be removed from the imaging device, that is the camera, and developed for subsequent printing. The instant picture camera of the diffusion transfer type has its use in graphic displays, but image development remains expensive and subject to many variables.

Continuous image display has been accomplished by several systems as, for example, the cathode ray tube in television communication and the light-pen input and plotting often used in the display consoles of electronic computers. However, such systems become very expensive and require processing circuitry, which render the systems both complex and expensive.

Copending application Ser. No. 708,380 filed Feb. 26, 1968 in the U.S. Patent Office describes an imaging system utilizing a manifold sandwich comprising an electrically photosensitive material between a pair of sheets. In this imaging system, an imaging layer is prepared by coating a layer of electrically photosensitive imaging material onto a substrate. In one form the imaging layer comprises a photosensitive material such as metal-free phthalocyanine dispersed in a cohesively weak insulating binder. This coated substrate is called the donor. When needed, the imaging layer is rendered cohesively weak. The process step of weakening the imaging layer is termed activation and in most cases the imaging layer is activated by contacting it with a swelling agent, solvent, or partial solvent for the imaging

layer or by heating. This step may be eliminated, of course, if the layer retains sufficient residual solvent after having been coated on the substrate from a solution or paste or is sufficiently cohesively weak to fracture in response to the application of light and electrical field. After activation a receiver sheet is laid over the surface of the imaging layer. An electrical field is then applied across this manifold sandwich while it is exposed to a pattern of light and shadow representative of the image to be reproduced. Upon separation of the donor substrate or sheet and receiver sheet, the imaging layer fractures along the lines defined by the pattern of light and shadow to which the imaging layer has been exposed. Part of the imaging layer is transferred to one of the sheets while the remainder is retained on the other sheet so that a positive image, that is, a duplicate of the original is produced on one sheet while a negative image is produced on the other.

A manifold imaging system has now been discovered which provides for a reusable electrically photosensitive imaging layer. In addition, there is provided an image display system capable of continuous operation without the need to supply fresh imaging material.

SUMMARY OF THE INVENTION

It is, therefore, an object of this invention to provide an imaging system which overcomes the above noted disadvantages.

Another object of this invention is to provide a layer transfer imaging system which provides relatively high quality positive images.

Another object of this invention is to provide an imaging system wherein the imaging material can be rendered reusable for the formation of subsequent images.

Another object of this invention is to provide a negative or positive image display method using inexpensive and uncomplicated equipment.

These and other objects are accomplished in accordance with this invention by an imaging process wherein a cohesively weak electrically photosensitive imaging layer is fractured in imagewise configuration and subsequent to viewing the image the separated portions of the imaging layer are brought together again.

By proper treatment, the imaging layer is recombined into a continuous layer which is reusable to form subsequent images. As in the prior art manifold imaging process, an electric field is placed across the manifold sandwich and the imaging layer is exposed to electromagnetic radiation to which it is sensitive. After imagewise exposure the manifold sandwich is separated whereby the imaging layer is fractured in imagewise configuration and exposed to view. After the images produced have been used, the imaging layer is recombined by reforming the manifold sandwich, preferably in exact image registration, and the sandwich is subjected to a second electric field of opposite polarity to the electric field employed to produce the first image. While subjected to the second electric field, the imaging layer is flood exposed to electromagnetic radiation to which the imaging layer is sensitive whereupon the imaging layer recombines and is ready for subsequent imagewise exposure and sandwich separation to produce another image. In those instances wherein the imaging materials are no longer cohesively weak when recombined as, for instance, when the image is fixed to the substrate, they are rendered cohesively weak by

treatment with an activator as will be more fully explained below.

The process of this invention may be employed to produce individual images on cut sheets or may be employed to produce images on a continuous belt or web. The use of a continuous belt or web is particularly desirable in a continuous image display system. That is, a donor web and a receiver web having sandwiched therebetween a cohesively electrically photosensitive imaging layer is fed between a series of rollers in a revolving pattern while along the path of travel there is placed various operational stages such as electrical charging of the sandwich, imagewise exposure of the imaging layer, separation of the donor and receiver webs, a display section where the image may be viewed and a recombination stage wherein the sandwich is reformed, an electric field of reverse polarity applied to the sandwich while the imaging layer is flood exposed to the electromagnetic radiation, whence the reformed sandwich is returned to the imagewise exposure station. In either system, that is cut sheet or continuous web, there is no need to supply fresh imaging material as the imaging material employed to display an image is fully recovered for use in subsequent image formation. By means of the manifold layer transfer imaging process, a positive and a negative image is quickly and simultaneously produced without the need of a separate development or image transfer step. The positive or negative image can thus be viewed immediately upon sandwich separation.

In the manifold layer transfer imaging process, the imaging layer comprises any suitable electrically photosensitive materials. Typical organic materials include: quinacridones such as: 2,9-dimethyl quinacridone, 4,11-dimethyl quinacridone, 2,10-dichloro-6,13-dihydro-quinacridone, 2,9-dimethoxy-6,13-dihydroquinacridone, 2,4,9,11-tetrachloroquinacridone, and solid solutions of quinacridones and other compositions as described in U.S. Pat. No. 3,160,510; carboxamides such as: N-2''-pyridyl-8,13-dioxidaphtho-(2,1-2',3')-furan-6-carboxamide, N-2''-(1'',3'',5''-triazyl-8,13-dioxodaphtho-(2,1-2',3')-furan-6-carboxamide, anthra-(2,1)-naphtho-(2,3-d)-furan-9,14-dione-7, -(12'-methyl-phenyl)carboxamide; carboxanilides such as: 8,13-dioxidaphtho-(2,1-2',3')-furan-6-carbox-p-methoxy-anilide, 8,13-dioxidaphtho-(2,1-2',3')-furan-6-carbox-p-methylanilide, 8, 13-dioxidaphtho-(2,1-2',3')-furan-6-carbox-p-cyanoanilide; triazines such as: 2,4-diamino-triazine, 2,4-di (1'-anthraquinonyl-amino)-6-(1''-pyrenyl)-triazine, 2,4-di (1'-anthraquinonylamino)-6(1''-naphthyl)-triazine, 2,4-di (1'-naphthyl-amino)-6-(1'-perylene)-triazine, 2,4,6-tri (1',1'',1'''-pyrenyl) triazine, 2,4,6-tri (1',1'',1'''-pyrenyl) triazine; benzopyrrocolines such as: 2,3-phthaloyl-7,8-benzo-pyrrocoline, 1-cyano-2,3-phthaloyl-7,8-benzopyrrocoline, 1-cyano-2,3-phthaloyl-5-nitro-7,8-benzopyrrocoline, 1-cyano-2,3-phthaloyl-5-acetamido-7,8-benzopyrrocoline; anthraquinones such as: 1,5-bis-(betaphenylethylamino) anthraquinone, 1,5-bis-(3'-methoxypropylamino) anthraquinone, 1,5-bis-(benzylamino) anthraquinone, 1,5-bis-(phenylbutylamino) anthraquinone, 1,2,5,6-di(c,c'-diphenyl)-triazoleanthraquinone, 4-(2'-hydroxyphenylmethoxyamino) anthraquinone; azo compounds such as: 2,4,6-tris(N-ethyl-N-hydroxy-ethyl-p-aminophenylazo) phloroglucinol, 1,3,5,7-tetra-

hydroxy-2,4,6,8-tetra(N-methyl-N-hydroxyethyl-p-amino-phenylazo) naphthalene, 1,3,5, trihydroxy-2,4,6-tri (3'-nitro-N-methyl-N-hydroxymethyl-4'-aminophenylazo) benzene, 3-methyl-phenyl-4-(3'-pyrenylazo)-pyrazolin-5-one, 1-(3'-pyrenylazo)-2-hydroxy-3-naphthanilide, 1-(3'-pyrenylazo)-2-naphthol, 1-(3'-pyrenylazo)-2-hydroxypyrene, 1-(3'-pyrenylazo)-2-hydroxy-3-methyl-xanthene, 2,4,6-tris (3'-pyrenylazo)phloroglucinol, 2,4,6-tris (1'-phenanthrenylazo) phthloroglucinol, 1-(2'-methoxy-5'-nitro-phenylazo)-2-hydroxy-3'-nitro-3-naphthanilide; salts and lakes of compounds derived from 9-phenylxanthene, such as: phosphotungstomolybdic lake of 3,6-bis (ethylamino)-9,2'-carboxyphenyl xanthenonium chloride, barium salt of 3,2'-toluidineamino-6,2''-methyl-4''-sulphophenyl-amino-9,2'''-carboxyphenylxanthene; phosphomolybdic lake of 3,6-bis (ethylamino)-2,7-dimethyl-9,2'-carbethoxyphenylxanthenonium chloride; dioxazines such as: 2,9-dibenzoyl-6,13-dichloro-triphenodioxazine, 2,9-diacetyl-6,13-dichlorotriphenodioxazine, 3,10-dibenzoylamino-2,9-diisopropoxy-6,13-dichlorotriphenodioxazine, 2,9-difuroyl-6,13-dichlorotriphenofluorescein, aluminum lake of 2,4,5,7-tetrabromo-10,11,12,13-tetrachloro fluorescein; diazo compositions such as: N,N'-di[1-(1'-naphthylazo)-2-hydroxy-8-naphthyl] adipdiamide, N,N'-di-1-(1'-naphthylazo)-2-hydroxy-8-naphthyl succindiamide, bis-4,4'-(2''-hydroxy-8''-N,N'-diterephthalo-mide-1-naphthylazo) biphenyl, 3,3'-methoxy-4,4'-diphenyl-bis (1''-azo-2''-hydroxy-3''-naphthanilide); pyrenes such as: 1,3,6,8-tetra-cyanopyrene, 1,3-dicyano-6,8-dibromopyrene, 1,3,6,8-tetraaminopyrene, 1-cyano-6-nitropyrene; phthalocyanines such as: beta-form metal-free phthalocyanine, copper phthalocyanine, tetrachloro phthalocyanine, the "x" form of metal-free phthalocyanine as described in U.S. Pat. No. 3,357,989; metal salts and lakes of azo dyes, such as: calcium lake of 6-bromo-1(1'-sulfo-2-naphthylazo)-2-naphthol, barium salt of 6-cyano-1(1'-sulfo-2-naphthylazo)-2-naphthol, calcium lake of 1-(2'-azonaphthalene-1'-sulfonic acid)-2-naphthol, calcium lake of 1-(4'-ethyl-5'-chloroazobenzene-2'-sulfonic acid)-hydroxy-3-naphthoic acid; and mixtures thereof. Typical electrically photosensitive inorganic compositions include cadmium sulfide, cadmium sulfoselenide, zinc oxide, zinc sulfide, sulphur, selenium, mercuric sulfide, lead oxide, lead sulfide, cadmium selenide, titanium dioxide, indium trioxide and the like. In addition to the aforementioned organic materials, other organic materials which may be employed in the imaging layer include polyvinylcarbazole; 2,4'-bis(4,4'diethylaminophenyl)-1,3,4-oxadiazole; N-isopropylcarbazole and the like. Other electrically photosensitive materials useful in the process of this invention are listed in copending application Ser. No. 708,380 filed Feb. 26, 1968 which is incorporated herein by reference. It is also to be understood that the electrically photosensitive particles themselves may consist of any suitable one or more of the aforementioned electrically photosensitive materials, either organic or inorganic, dispersed in, in solid solution in, or copolymerized with, any suitable insulating resin whether or not the resin itself is photosensitive. This particular type of particle may be particularly desirable to facilitate dispersion of the particle, to prevent undesirable reactions

between the binder and the photosensitive material or between the photosensitive and the activator and for similar purposes. Typical resins of this type include polyethylene, polypropylene, polyamides, polymethacrylates, polyacrylates, polyvinyl chlorides, polyvinyl acetate, polystyrene, polysiloxanes, chlorinated rubbers, polyvinylpyrene, polyacrylonitrile, epoxies, phenolics, hydrocarbon resins and other natural resins such as resin derivatives as well as mixtures and copolymers thereof.

The "x" form phthalocyanine is preferred because of its excellent photosensitivity although any suitable phthalocyanine may be used to prepare the imaging layer of this invention. The phthalocyanine used may be in any suitable crystal form. It may be substituted or unsubstituted both in the ring and straight chain portions. Reference is made to a book entitled "Phthalocyanine Compounds" by F. H. Moser and A. L. Thomas published by the Reinhold Publishing Company, 1963 edition, for a detailed description of phthalocyanines and their synthesis. As above noted, any suitable phthalocyanine may be used to prepare the photoconductive layer of the present invention. Typical phthalocyanines are listed in compending application Ser. No. 708,380 referred to above.

The basic physical property desired in the imaging layer is that it be frangible as prepared or after having been suitably activated. That is, the layer must be sufficiently weak structurally so that the application of electrical field combined with the action of actinic radiation on the electrically photosensitive material will fracture the imaging layer. Further, the layer must respond to the application of field the strength of which is below that field strength which will cause electrical breakdown or arcing across the imaging layer. Another term for "cohesively weak," therefore, would be "field fracturable."

The imaging layer serves as the photosensitive element of the system as well as the colorant for the final image produced. Other colorants such as dyes and pigments may be added to the imaging layer so as to intensify or modify the color of the final images when color is important. Preferably, the imaging layer is selected so as to have a high level of response while at the same time being intensely colored so that a high contrast image can be formed by the high gamma system of this invention. The imaging layer may be homogeneous comprising, for example, a solid solution of two or more pigments with one or more pigments being electrically photosensitive and at least one pigment being electrically photoinsensitive. The imaging layer may also be heterogeneous comprising, for example, pigment particles dispersed in a binder.

One technique for achieving low cohesive strength in the imaging layer is to employ relatively weak, low molecular weight materials therein. Thus, for example, in a single component homogeneous imaging layer, a monomeric compound or a low molecular weight polymer complexed with a Lewis acid to impart a high level of photoreponse to the layer may be employed. Similarly, when a homogeneous layer utilizing two or more components in solid solution is selected to make up the imaging layer, either one or both of the components of the solid solution may be a low molecular weight material so that the layer has the desired low level of cohesive strength. This approach may also be taken in connection with the heterogeneous imaging layer. Although

the binder material in the heterogeneous system may in itself be photosensitive it does not necessarily have this property. Materials may be selected for use as this binder material solely on the basis of physical properties without regard to their photosensitivity. This is also true of the two component homogeneous system where photoinsensitive materials with the desired physical properties can be used. Any other technique for achieving low cohesive strength in the imaging layer may also be employed. For example, suitable blends of incompatible materials such as a blend of a polysiloxane resin with a polyacrylic ester may be used either as the binder layer in a heterogeneous system or in conjunction with a "homogeneous" system in which the photoresponsive material may be either one of the incompatible components (complexed with a Lewis acid) or a separate and additional component of the layer. The thickness of the imaging layer, whether homogeneous or heterogeneous, ranges from about 0.2 microns to about 10 microns generally about 0.5 microns to about 5 microns and preferably about 2 microns.

The ratio of photosensitive pigment to binder by volume in the heterogeneous system may range from about 10 to 1 to about 1 to 10 respectively but it has generally been found that properties in the range of from about 1 to 4 to 2 to 1 respectively produce the best results and, accordingly, this constitutes a preferred range.

The binder material in the heterogeneous imaging layer or the material used in conjunction with the electrically photosensitive material in the homogeneous layer, where applicable, may comprise any suitable cohesively weak insulating material or materials which can be rendered cohesively weak. Typical materials include: microcrystalline waxes such as: Sunoco 1290, Sunoco 5825, Sunoco 985, all available from Sun Oil Co.; Parafint RG, available from the Moore and Munger Company; paraffin waxes such as: Sunoco 5512, Sunoco 3425, available from Sun Oil Co.; Sohio Parawax available from Standard Oil of Ohio; waxes made from hydrogenated oils such as: Capitol City 1380 wax, available from Capitol City Products, Co., Columbus, Ohio; CasterWax L-2790, available from Gaker Caster Oil Co.; Vitikote L-304, available from Duro Commodities; polyethylenes such as: Eastman Epolene N-11, Eastman Epolene C-12, available from Eastman Chemical Products, Co.; Polyethylene DYJT, Polyethylene DYLT, Polyethylene DYNF, Polyethylene DYDT, all available from Union Carbide Corp.; Marlex TR 822, Marlex 1478, available from Phillips Petroleum Co.; Epolene C-13, Epolene C-10, available from Eastman Chemical Products Co.; Polyethylene AC8, Polyethylene AC612, Polyethylene AC324, available from Allied Chemicals; modified styrenes such as: Piccotex 75, Piccotex 100, Piccotex 120, available from Pennsylvania Industrial Chemical; Vinylacetate-ethylene copolymers such as: Elvax Resin 210, Elvax Resin 310, Elvax Resin 420, available from E. I. duPont de Nemours & Co., Inc., Vistanex MH, Vistanex L-80, available from Enjay Chemical Co.; vinyl chloride vinyl acetate copolymers such as: Vinylite VYLF, available from Union Carbide Corp.; styrene-vinyl toluene copolymers; polypropylenes; and mixtures thereof. The use of an insulating binder is preferred because it allows the use of a larger range of electrically photosensitive pigments.

A mixture of microcrystalline wax and polyethylene is preferred because it is cohesively weak and an insulator.

When the imaging layer is not sufficiently cohesively weak to allow imagewise fracture, it is desirable to include an activation step in the process of this invention. The activation step may take many forms such as heating the imaging layer thus softening it or applying a substance to the surface of the imaging layer or including a substance in the imaging layer which substance lowers the cohesive strength of the layer or aids in lowering the cohesive strength. The substance so employed is termed an "activator." Preferably, the activator should have a high resistivity so as to maintain electrical fields in the electrically photosensitive layer of the manifold sandwich. Accordingly, it will generally be found to be desirable to purify commercial grades of activators so as to remove impurities which might impart a higher level of conductivity. This may be accomplished by running the fluids through a clay column or by employing any other suitable purification technique. Generally speaking, the activator may consist of any suitable material having the aforementioned properties. For purposes of this specification and the appended claims, the term activator shall be understood to include not only materials which are conventionally termed solvents but also those which are partial solvents, swelling agents or softening agents for the imaging layer. The activator can be applied at any point in the process prior to separation of the manifold sandwich.

It is generally preferable that the activator have a relatively low boiling point so that fixing of the resulting image can be accomplished upon evaporation of the activator. If desired, fixing of the image can be accomplished more quickly with mild heating at most. It is to be understood, however, that the invention is not limited to the use of these relatively volatile activators. In fact, very high boiling point non-volatile activators including silicone oils such as dimethyl-polysiloxanes and very high boiling point long chain aliphatic hydrocarbon oils ordinarily used as transformer oils such as Wemco-C transformer oil, available from Westinghouse Electric Co., have also been successfully utilized in the imaging process. Although these less volatile activators do not dry off by evaporation, image fixing can be accomplished by contacting the final image with an absorbent sheet as paper which absorbs the activator fluid. In short, any suitable volatile or non-volatile activator may be employed. Typical activators include Sohio Odorless Solvent 3440, an aliphatic (kerosene) hydrocarbon fraction, available from Standard Oil Co. of Ohio, carbon tetrachloride, petroleum ether, Freon 214 (tetrafluorotetrachloropropane), other halogenated hydrocarbons such as chloroform, methylene chloride, trichloroethylene, perchloroethylene, chlorobenzene, trichloromonofluoromethane, tetrachlorodifluoroethane, trichlorotrifluoroethane, ethers such as diethylether, diisopropyl ether, dioxane, tetrahydrofuran, ethyleneglycol monoethyl ether, aromatic and aliphatic hydrocarbons such as benzene, toluene, xylene, hexane cyclohexane, mineral spirits and white mineral oil, vegetable oil such as coconut oil, babussu oil, palm oil, olive oil, castor oil, peanut oil and neats-foot oil, decane, dodecane and mixtures thereof. A deodorized mineral spirit solvent, such as Sohio Odorless Solvent 3440 is preferred because it is odorless, non-toxic and has a relatively high flash point.

Another class of activators are called "thermo-solvents." A thermo-solvent is an ingredient in the electrically photosensitive imaging layer which is solid at ordinary room temperatures but which melts slightly above room temperature. When melted this material is a solvent or at least a partial solvent or swelling agent for the imaging layer. By employing a thermosolvent and heating the manifold sandwich, the liquid renders the imaging layer cohesively weak and capable of clearing sharply along the edges of the imagewise pattern to which the imaging layer has been exposed. Usually the thermo-solvent is incorporated into the manifold sandwich as a separate layer but in contact with the electrically photosensitive imaging layer. The thickness of the thermo-solvent layer is normally in the range of from about 3 to about 10 microns.

The thermo-solvents useful in the process of this invention are low-melting materials which are solid at room temperature below that of the lowest melting point material of the imaging layer.

Preferred thermo-solvents are those which melt at temperatures below 175°F. Particularly good results are obtained with long chain petroleum waxes with from about 18 to about 30 carbon atoms in a chain. Typical low melting waxes include octadecane, nonadecane, eicosane, heneicosane, docosane, tricosane, tetracosane, pentacosane, hexacosane, heptacosane, octacosane, nonacosane triacontane, and mixtures thereof. If desired, these low melting waxes may be mixed with other materials such as higher melting waxes. Typical thermo-solvents which can be dispersed in a binder or used alone where suitable include m-terphenyl, chlorinated terphenyl, perchloro hydrocarbons, polybutylenes, biphenyl and mixtures thereof. The thermo-solvents can be mixed with suitable binders when desired and such binders include the low melting waxes described above in the imaging layer binder materials listed above.

Although the imaging layers may be prepared as self-supporting films, normally these layers are coated onto a sheet referred to as the donor sheet or substrate. For convenience the combination of imaging layer and donor sheet is referred to as the donor. The electrically photosensitive material may be added directly to a binder material and dispersed as, for example, by ball milling or by heating the binder to a temperature above its melting point and dispersing the pigments in the fluid binder material by simple mixing. After blending the ingredients of the imaging layer, the desired amount is coated on a substrate. In a particularly preferred form of the invention an imaging layer is coated onto a transparent, electrically insulating donor sheet.

The donor sheet and receiver sheet may comprise any suitable electrically insulating or electrically conducting material. Insulating materials are preferred since they allow the use of high strength polymeric materials. Typical insulating materials include polyethylene, polypropylene, polyethylene terephthalate, cellulose acetate, paper, plastic coated paper, such as polyethylene coated paper, vinyl chloride-vinylidene chloride copolymers and mixtures thereof. Mylar (an extracted polyester film formed by the condensation reaction between ethylene glycol and terephthalic acid available from E. I. duPont de Nemours & Co., Inc.) is preferred because of its durability and excellent insulative properties. Not only does the use of this type of high strength polymer provide a strong substrate for the

positive and negative images formed on the donor substrate and receiver sheet but, in addition, it provides an electrical barrier between the electrodes and the imaging layer which tends to inhibit electrical breakdown of the system while the manifold sandwich is subjected to an electric field. The donor sheet and receiver sheet may each be selected from different materials. Thus, a manifold sandwich can be prepared by employing an insulating donor sheet while a conductive material is employed as a receiver sheet. It is preferred that both the donor and receiver sheets be dimensionally stable over all operational conditions of temperature, humidity and mechanical handling stresses. Either one or both should be flexible to permit separation and recombination along a cylindrical surface to minimize shearing action and air entrapment in the photosensitive layer.

As stated above, according to the process of this invention, the imaging layer is subjected to an electrical field. The electrical field can be applied in many ways. Generally the sandwich is placed between electrodes having different electrical potential. Also, an electrical charge can be imposed upon one or both of the donor and receiver sheet before or after forming the sandwich by any one of several known methods for inducing a static electrical charge into a material. Static charges can be imposed by contacting the sheet or substrate with an electrically charged electrode. Alternatively one or both sheets may be charged using corona discharge devices such as those described in U.S. Pat. No. 2,588,699 to Carlson, U.S. Pat. No. 2,777,957 to Walkup, U.S. Pat. No. 2,885,556 to Gundlach or by using conductive rollers as described in U.S. Pat. No. 2,980,834 to Tregay et al., or by frictional means as described in U.S. Pat. No. 2,297,691 to Carlson or other suitable apparatus.

Thus, the electrical field can be provided by means known to the art for subjecting an area to an electrical field. The electrodes employed may comprise any suitable conductive material and may be flexible or rigid. Typical conductive materials include: metals such as aluminum, brass, steel, copper, nickel, zinc, etc., metallic coatings on plastic substrates, rubber rendered conductive by the inclusion of a suitable material therein, or paper rendered conductive by the inclusion of a suitable material therein or through conditioning in a humid atmosphere to insure the presence therein of sufficient water content to render the material conductive. Conductive rubber is preferred because of its flexibility. In the process of this invention wherein the imaging layer is exposed to activating electromagnetic radiation while positioned between electrodes one of the electrodes must be at least partially transparent. The transparent conductive electrode may be made of any suitable conductive transparent material and may be flexible or rigid. Typical conductive transparent materials include cellophane, conductively coated glass, such as tin or indium oxide coated glass, aluminum coated glass, or similar coatings on plastic substrates. NESA, a tin oxide coated glass available from Pittsburgh Plate Glass Co., is preferred because it is a good conductor and is highly transparent and is readily available. In the process of this invention wherein the donor or receiver is composed of conductive material, each may also be employed as the electrodes by which the imaging layer is subjected to an electrical field. That is, either when employed as an electrode one of the donor

sheet and receiver sheet may serve a dual function in the process of this invention.

The strength of the electrical field applied across the manifold sandwich depends on the structure of the manifold sandwich and the materials used. For example, if highly insulating receiver and donor substrate materials are used, a much higher potential difference may be applied than if relatively conductive donor and receiver sheets are used. The field strength required may, however, be easily determined. If too large a potential is applied, electrical breakdown of the manifold sandwich will occur allowing arcing between the electrodes. If too little potential is applied, the imaging layer will not fracture in imagewise configuration. By way of example, if a 3 mil Mylar receiver sheet and a 2 mil Mylar donor sheet are used, potentials as high as 20,000 volts may be applied between the electrodes. The preferred field strengths across the manifold sandwich are, however, in the range of from about 2,000 volts per mil to about 7,000 volts per mil of electrically insulating material. Since relatively high potentials are utilized, it is desirable to insert a resistor in the circuit to limit the flow of current. Resistors on the order of from about 1 megohm to about 20,000 megohms are conventionally used.

Whether the positive image is formed on the donor sheet or the receiver sheet depends on the imaging layer materials used and the polarity of the applied field. It has been found in general, however, if the donor side electrode is held at a positive potential with respect to the receiver side electrode that the positive image is formed on the donor sheet and a negative image is formed on the receiving sheet. That is, the illuminated portions of the imaging layer adhere to the receiver sheet and the non-illuminated areas of the imaging layer adhere to the donor sheet. It has also been found, in general, that when the imaging layer is coated onto a donor sheet, the best quality images are produced by exposing through the donor sheet.

A visible light source, an ultraviolet light source or any other suitable source of electromagnetic radiation may be used to expose the imaging layer of this invention. The electrically photosensitive material is chosen so as to be responsive to the wavelength of the electromagnetic radiation used. It is to be noted that different electrically photosensitive materials have different spectral responses and that the spectral response of many electrically photosensitive materials may be modified by dye sensitization so as to either increase or narrow the spectral response of a material to a peak or to broaden it to make it more panchromatic in its response. The amount of electromagnetic radiation required is dependent upon the sensitivity of the electrically photosensitive material employed. Generally the exposure required to produce an image upon sandwich separation will be sufficient for flood illumination upon sandwich recombination.

BRIEF DESCRIPTION OF THE DRAWINGS

The advantages of this improved method of imaging will become apparent upon consideration of the detailed disclosure of the invention especially when taken in conjunction with the accompanying drawings wherein:

FIG. 1 is a side sectional view of a manifold sandwich in the performance of the process steps of this invention.

FIG. 2 is a side sectional view of a continuous automatic image display system employing a manifold sandwich in the process of this invention.

FIG. 3 is a side-sectional view of another embodiment of the continuous automatic image display system of FIG. 2.

DETAILED DESCRIPTION OF THE DRAWINGS

Referring now to FIG. 1 of the drawings, there is seen the three essential operative steps of the process of this invention. In FIG. 1a there is shown a manifold sandwich between a pair of electrodes, one of which is transparent, to allow exposure of the imaging layer to electromagnetic radiation, that is a light image. Thus, in FIG. 1a there is shown a donor sheet 2, in this case a transparent sheet such as Mylar upon which is coated an imaging layer 4 comprising electrically photosensitive material 6 dispersed in a cohesively weak insulating binder 8. Imaging layer 4 can also be rendered cohesively weak by application of activator or heated when a thermo-solvent is included in the sandwich. Overlying the imaging layer is receiver sheet 10 which may be either transparent or opaque. An electric field is placed across the manifold sandwich by means of a pair of electrodes 12 and 14. Electrode 12 in this case is a transparent tin oxide coated glass which is commercially available under the trade name NESA. Although convenient, it is not necessary to use a transparent electrode to provide an electric field. An electric field can be provided by contacting the insulating donor sheet with electrical charge bearing means such as a coronotron. Imagewise exposure can then take place on the charged donor sheet and a receiver sheet subsequently placed over the imaging layer. An electric field is then established across the sandwich. Electrode 14 can be any convenient electrically conducting material and can be a conductive metal foil laminated to a film or the receiver sheet itself in those cases in which the receiver sheet is electrically conductive. The electric field is provided by a potential source 16 which is connected to the switch 18 and resistor 20. An electrical field is thus applied across the manifold set, and the imaging layer is exposed to light image 22 to be reproduced. Referring now to FIG. 1b, there is illustrated the results of separating the manifold sandwich while under an electric field whereby imaging layer 4 fractures in imagewise configuration. Thus, the exposed portions of imaging layer 4 adhere to the receiver sheet 10 while the unexposed portions of imaging layer 4 adhere to donor sheet 2. By separating the sandwich, the imaging layer is fractured and the positive and negative images are exposed to view and may be used for the purpose intended. After use, the donor sheet and receiver sheet with their respective portions of the imaging material adhering thereto are recombined as shown in FIG. 1c. If necessary the imaging material may be rendered cohesively weak prior to recombining the manifold sandwich by applying thereto an activating liquid, vapor or heat. Receiver 10 is laid over donor sheet 2 preferably in image registration. That is, it is preferred that the respective negative and positive portions of the image are brought together so that the imaging material contacts the surface of the opposite sheet to which it adheres. It is also preferred that after the sandwich is recombined the imaging layer is subjected to a force to remove trapped air and to assure good contact between the donor and receiver sheets with the imaging materials.

This may be accomplished by passing a roller such as a soft rubber roller over the surface of the sandwich or subjecting the sandwich to ultrasonic radiation. After the sandwich is recombined, an electric field is established across the sandwich which is opposite in polarity to the field employed during imagewise exposure. Thus, as shown in FIG. 1c the manifold sandwich comprising donor sheet 2, imaging layer 4 and receiver sheet 10 is subjected to an electric field from power source 16 through switch 18 which is now placed in position B providing opposite polarity to that of the electric field established during imagewise exposure as shown in FIG. 1a. Although the imaging layer can now be imagewise exposed to electromagnetic radiation while subjected to this polarity, the images obtained are not as high quality as when subjected to flood illumination at this step. Thus, while subjected to the electric field, the imaging layer is flood exposed by light rays 24. After exposure, usually equivalent in amount to that employed in the brightest areas in the imagewise exposure step, the electric field can be removed and the manifold sandwich is ready for subsequent image exposure, separation and recombination. Thus, without supplying fresh imaging material numerous different images can be formed with the same imaging material in accordance with the process of this invention.

Referring now to FIG. 2, there is shown an image display system employing the process of this invention. The process is shown as a continuous cyclic system. In such a process it is preferred that the donor and receiver portions of the manifold sandwich comprise insulating or dielectric materials such as polystyrene or polyethylene terephthalate as described above. If conductive materials are employed in the continuous cyclic system, then insulating barriers must be employed in each web so as to interrupt the electric field between the imagewise exposure step and the step of recombining the manifold sandwich. In FIG. 2 there is shown a continuous belt or web donor sheet 202 carrying with it imaging layer 204. A continuous web or belt 206 is a receiver which completes the manifold sandwich. An electric field is applied across the manifold sandwich through electrodes 208 and 210 which are connected to potential source 212. Although FIG. 2 shows the manifold sandwich not coming in contact with either electrode 208 or 210 since the donor and receiver sheets are preferably insulating materials they may contact one or both electrodes bearing the charging operation. Preferably the sandwich will contact the electrodes which will serve as a guide and be spaced apart to prevent binding. With the high potential employed, effective electrical contact is usually assured by ionization of the air between the electrodes and the manifold sandwich.

Alternatively, the charging electrodes may be a corona discharge device as described in U.S. Pat. No. 2,777,957 to Walkup and U.S. Pat. No. 2,836,725 to Vyverberg. A pair of conductive rollers may be used in place of electrodes 208 and 210; alternatively a sharp edge or a friction charging device such as a fur covered roller may be used.

The sign of the charge as shown on electrodes 208 and 210 may also be reversed, the electrode 208 being made positive and electrode 210 being made negative. The charge bearing manifold sandwich passes between electrodes 208 and 210 and moves to exposure station 214 where it is exposed to light image 216. Light image

216 may be produced by projecting light through a transparency or by projecting light reflected from an opaque subject. In a continuous operation, the light image preferably is projected through a slit in such a manner that there is little or no relevant movement between the projected light image and the manifold sandwich. Depending upon the sensitivity of the electrically photosensitive material employed, the speed of the webs can range from 1 to 8 inches per second. The manifold sandwich then passes roller 218 whereupon the direction of travel of the donor sheet and the receiver sheet diverge. That is, the donor sheet 202 is directed over roller 220 while the receiver sheet 206 is directed over roller 222 thus allowing the manifold sandwich to separate and fracture the imaging layer. As stated above, the imaging layer fractures in imagewise configuration providing a negative image on one of the donor and receiver sheets and a positive image on the other sheet.

Optionally, either or both of the images may be fixed to its respective substrate by, for example, heat as shown in FIG. 2 by heater 224. Image fixation at this point allows greater flexibility in the design of the image display system such that the images may be contacted by rollers and other handling equipment without damage. Systems designed so as not requiring any contact of the image can be employed thereby obviating the need for fixing the image. The donor sheet, with one of the negative or positive images thereon, continues to image viewing station 226 which is preferably provided with a lighted background by means of incandescent light 227. The image may be viewed directly or employed as a transparency in a projection device which can be stationed at viewing station 226. A typical projection system, 225, is shown in FIG. 3 which system includes appropriate lenses for projecting the image onto a suitable screen capable of rendering the light pattern visible and in proper focus. Separate drive means can be associated with the system or rollers 220, 222, 228, 229 and the other rollers shown can also act as drive wheels.

It is to be noted that the display system as embodied in FIG. 2 can be operated on a continuous or discontinuous basis. Thus, the image produced may be viewed while stationary at imaging station 226 or it may be viewed as it moves from roller 220 to roller 228. After passing roller 228, the donor sheet with the accompanying image thereon is transported to a point which brings it into contact with receiver sheet 206. Receiver sheet 206 travels from roller 222 to roller 230, take-up roller 232 and idler roller 234. Roller 232 may be spring loaded by attaching spring 236 to the axle of the roller thus providing proper tension of the web. Roller 232 may be recessed so that only the edges of web 206 are contacted by the roller. Preferably, contact between web 206 and roller 232 is limited to areas outside of the useful image. By extending the path of travel of receiver sheet 206, it is recombined with donor sheet 202 in approximate image registration such that the portions of the imaging material on receiver sheet 206 contacts the vacant portions of donor sheet 202. Prior to recombining the manifold sandwich, the proper physical properties are imparted to the imaging material by applying an activator to the imaging layer. Although the activator may be applied by any suitable technique such as with a brush, with a smooth or rough surface roller, by flow coating, by vapor condensation

or the like, FIG. 2 diagrammatically illustrates the application of activator fluid 238 being sprayed onto imaging layer 204 from container 240. An activator may be applied to either or both donor and receiver sheets to impart the proper physical properties to the imaging material prior to reforming the manifold sandwich. Alternatively, the sandwich may be permanently maintained in an "activated" state by incorporating a non-volatile plasticizer in the photoconductive layer 204. Still another practical solution is the use of a sealed chamber in which activating (plasticizer) vapors are maintained. A moderate degree of sealing is desirable also from the standpoint of maintaining a dust-free operation, as the accumulation of dust will progressively degrade the image in an obvious way. A typical chamber suitable for either vapor sealing or maintaining a dust-free operation is shown in FIG. 3 by structure 239. After an activator has been applied to the receiver sheet and imaging material thereon, the receiver sheet is brought into contact with donor sheet 202 by being brought over roller 241. An electric field is established across the manifold sandwich through electrodes 242 and 244 which are connected to a source of potential 246. In FIG. 2 the polarity of the electric field is opposite to that employed during the image exposure step. Alternatively, electrodes 242 and 244 may be replaced by idler rollers which form a guide for the manifold sandwich and an electric field may be provided by separate electrodes or conductive rollers or any other means conventionally employed to provide an electric field across the sandwich. After sandwich formation and a reverse field potential is applied, the imaging layer is flood exposed to electromagnetic radiation shown in FIG. 2 as incandescent light source 248. Imaging layer 204 may be flood exposed from either the donor or receiver side. After flood exposure, the imaging layer can be employed in a subsequent cycle of the system whereby it is exposed to an imagewise pattern of electromagnetic radiation and fractured by the separation of the manifold sandwich as described above.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The following examples further specifically illustrate the present invention. The examples below are intended to illustrate various preferred embodiments of the improved imaging method. The parts and percentages are by weight unless otherwise indicated.

EXAMPLE I

A commercial metal-free phthalocyanine is first purified by o-dichlorobenzene extraction to remove organic impurities. Since this extraction yields the less sensitive beta crystalline form, the desired "x" form is obtained by dissolving about 100 grams of beta in approximately 600 cc. of sulfuric acid, precipitating it by pouring the solution into about 3,000 cc. of ice water and washing with water to neutrality. The thus purified alpha phthalocyanine is then salt milled for 6 days and desalted by slurring in distilled water, vacuum filtering, water washing and finally methanol washing until the initial filtrate is clear. After vacuum drying to remove residual methanol, the "x" form phthalocyanine thus produced is used to prepare the imaging layer according to the following procedure: About 5 grams of the "x" form phthalocyanine is added to about 5 grams of Algol Yellow GC, 1,2,5,6-di(C,C'-diphenyl) thia-

zole-anthraquinone, C. I. No. 67300, available from General Dyestuffs, and about 2.8 grams of purified Watchung Red B, 1-(4'-methyl-5'-chloroazobenzene-2'-sulfonic acid)-2-hydroxy-3-naphthoic acid, C. I. No. 15865, available from E. I. duPont de Nemours & Co., which is purified as follows: approximately 240 grams of the Watchung Red B is slurried in about 2,400 milliliters of Sohio Odorless Solvent 3440, a mixture of kerosene fractions available from the Standard Oil Company of Ohio. The slurry is then heated to a temperature of about 65°C. and held there for about one-half hour. The slurry is then filtered through a glass sintered filter. The solids are then reslurried with petroleum ether (90° to 120° C.) available from Matheson, Coleman and Bell Division of the Matheson Company, East Rutherford, N.J. and filtered through a glass sintered filter. The solids are then dried in an oven at about 50°C.

About eight grams of Sunoco Microcrystalline Wax Grade 5825 having an ASTM-D-127 melting point of 151°F. and about two grams Paraffint R. G., a low molecular weight paraffinic material, available from the Moore & Munger Company, New York City and about 320 milliliters of petroleum ether (90° to 120°C.) and about 40 milliliters of Sohio Odorless Solvent 3440 are placed with the pigments in a glass jar containing one-half inch flint pebbles. The mixture is then milled by revolving the glass jar at about 70 r.p.m. for about 16 hours. The mixture is then heated for approximately 2 hours at about 45°C. and allowed to cool to room temperature. The mixture is then ready for coating on the donor substrate. The paste-like mixture is then coated in subdued green light on 2 mil Mylar (a polyester formed by the condensation reaction between ethylene glycol and terephthalic acid available from E. I. duPont de Nemours & Co., Inc.) with a No. 36 wire wound drawdown rod to produce a coating thickness when dried of approximately 7½ microns. The coating and 2 mil Mylar sheet is then dried in the dark at a temperature of about 33°C. for one-half hour. A receiver sheet also of 2 mil Mylar is placed over the donor. The receiver sheet is lifted up and the imaging layer activated by the application of light-weight household mineral oil with a wide camel's hair brush saturated with the oils. The receiver sheet is then lowered back down and a roller is rolled slowly over the closed manifold sandwich with light pressure to remove excess solvent. The manifold sandwich is placed donor side down on the tin oxide surface of a NESA glass plate and a black paper electrode is placed over the receiver. The electrodes are connected to a 9,000 volt d.c. power supply in series with a 5,500 megohm resistor with the NESA glass being the positive electrode and the black opaque electrode being the negative electrode. With the voltage applied, a white incandescent light image is projected upward through the NESA glass with an illumination of approximately 0.05 foot-candle applied for five seconds for a total incident energy of about 0.25 foot-candle seconds. After exposure, the receiver sheet together with the opaque electrode is peeled from the set with the potential source still connected. Upon separation the imaging layer fractures in imagewise configuration yielding a pair of excellent quality images with a duplicate of the original on the donor sheet and a reversal or negative image on the receiver sheet. The receiver sheet is then replaced on the donor sheet and the imaging layer redistributed by running a squeegee

across the receiver sheet by hand with light pressure. The opaque electrode is then replaced over the receiver sheet and the electrodes are connected to the power source at opposite terminals than were employed during the image exposure step. With the potential of about 9,000 volts, the imaging layer is flood exposed with white incandescent light with illumination of approximately 0.04 foot-candles applied for 5 seconds for a total incident energy of 0.20 foot-candle seconds. After exposure, the electrodes are disconnected from the power supply and reconnected with the terminals switched again so that the NESA glass is again the positive electrode and the opaque black paper electrode being negative. With a potential of 9,000 volts between the electrodes, the imaging layer is exposed as above to a white incandescent light image of different subject matter than was employed above. After exposure, the receiver sheet together with the opaque electrode is peeled from the set with the potential source still connected yielding a pair of excellent quality images with a duplicate of the original on the donor sheet and a reversal of the original on the receiver sheet. This procedure is repeated fifteen times and, in each instance, a pair of images are obtained.

EXAMPLES II-VI

Five donor substrates are coated according to the procedure of Example I except that only phthalocyanine is employed and at the ratio of phthalocyanine pigment to binder material of 5 to 1 in Example II, 1 to 4 in Example III, 1 to 5 in Example IV, 1 to 5 in Example V and 1 to 10 in Example VI. When these donors are imaged and reimaged according to the procedure of Example I, all produced dense high resolution images with the exception of Example VI which produces a coating of lower reflection density and noticeably lower resolution.

EXAMPLES VII-XI

Five donors are prepared according to the procedure of Example I and imaged and reimaged according to the procedure given in that example with the exception that the following activators are used in each example. In Example VII the activator is Sohio Odorless Solvent 3440, Example VIII is activated with carbon tetrachloride; Example IX is activated with Freon 214 (tetrachlorotetrafluoropropane); Example X is activated with Dow Corning Silicone Oil DC 200 (dimethylpolysiloxane), and Example XI is activated with a transformer oil (a very high boiling point long chain aliphatic oil available from Westinghouse Electric Company under the trade name Wemco-C). In each of these examples the activators are operable and upon imaging, sandwich recombination and reimaging produce high quality images upon each separation of the manifold sandwich. In the case of Example VII and Example VIII, the final images are heated mildly to dry off the activator and harden the image. In these examples fresh activator is applied to the imaging material of each image before the manifold sandwich is recombined. In the case of Examples X and XI, the non-drying activator maintains the image in a wet condition and the manifold sandwich is reformed without the addition of fresh activator.

EXAMPLE XII

An imaging material is prepared by incorporating ap-

proximately 1.5 parts of the "x" form of phthalocyanine prepared as in Example I and approximately 1.5 parts of purified Benzidene Yellow available from Hilton Davis Company of Cincinnati, Ohio as Benz Yellow 30-0535. The Benzidene Yellow is purified by slurring the pigment in 1.5 liters of a mixture of 50 percent isopropanol and 50 percent Sohio Odorless Solvent 3440. The slurry is heated to 75°C. and stirred for one-half hour. The mixture is then filtered and washed with isopropanol then allowed to dry.

The mixture of pigments is premilled as in Example I and a binder solution prepared as in Example I then added to the premilled pigments. The materials are then heated to a temperature of 65° for about 2 hours and are then cooled to room temperature. About 60 milliliters of isopropanol is then added to the mixture, and the mixture is milled as in Example I for about 30 minutes. The paste-like mixture is then coated on 3 mil Mylar as in Example I and then activated with a solution prepared by dissolving a chlorinated polyphenyl available from Monsanto Company, St. Louis Mo. as Aroclor 5442 and 500 cc. of Sohio Odorless Solvent 3440 to form a 10 percent solution by weight. A manifold sandwich is formed and the imaging layer is exposed to imagewise light and to an electric field as in Example I. Upon separation of the sandwich, a pair of images are produced. Before the activator evaporates from the imaging material forming the pair of images, the manifold sandwich is recombined, subjected to an electric field of opposite polarity and flood exposed to light. Imagewise exposure under an electric field is repeated as above yielding a subsequent pair of high quality images of different subject matter than the first image produced upon separation of the manifold sandwich.

EXAMPLE XIII

The procedure of Example I is repeated except that the receiver sheet employed is a clear sheet of cellophane instead of Mylar. The same results as obtained in Example I are obtained with the cellophane although image registration is more inexact over a large number of cycles.

EXAMPLE XIV

The imaging material of Example I is coated on the polyethylene surface of a polyethylene coated paper. After drying the donor sheet and imaging layer is passed between a pair of roller electrodes which are connected to a 10,000 volt d.c. power supply under subdued light. The charged donor is then exposed to a white incandescent light image and the electrical charge drained from the donor sheet by grounding. The donor sheet is then placed between a pair of metal electrodes together with aluminum foil receiver sheet in contact with the imaging layer. Prior to placing the receiver sheets on the imaging layer, the imaging layer is activated with Sohio Odorless Solvent 3440. The electrodes are connected to a 9,000 volt d.c. power supply with the donor side electrode being made positive. With the potential applied the sandwich is separated yielding a pair of excellent quality images. The imaging layer is reconstituted by recombining the manifold sandwich between the electrodes and applying a 9,000 volt potential between the electrodes wherein the donor side electrode is made negative. The manifold sandwich is then removed from between the electrodes

after the system is grounded. The manifold sandwich is separated and the donor sheet with the imaging layer coated thereon is ready for use in subsequent imaging steps as described above upon drying the imaging layer.

EXAMPLE XV

An imaging layer comprising electrically photosensitive material dispersed in a binder is first prepared. About 100 parts of "Naphthol Red B" which is 1-(2'-methoxy-5'-nitrophenyl)-2-hydroxy-3''-nitro-3-naphthanilide, C. I. No. 12355 is dissolved in reagent grade ethylenediamine. The solution is filtered immediately through coarse filter paper, and the filtrate mixed with an equal volume of reagent grade isopropanol. The Naphthol Red B precipitates in the alcohol and is removed by means of a centrifuge. After separating the ethylenediamine and alcohol, the electrically photosensitive material is washed and filtered with successive amounts of isopropanol, a 2:1 volume mixture of isopropanol and deionized water and five washings with deionized water until the filtrate is neutral. Finally, the material is washed with dimethylformamide and methanol in succession until the filtrates have a pale yellow color. The Naphthol Red B is then dried at 40°C. under vacuum.

A binder material is presented by combining about 1.5 parts of Parafint RG, a low molecular weight paraffinic material available from the Moore & Munger Co., about 3 parts of polyethylene DYL T available from Union Carbide Corp.; about 0.5 parts of a vinylacetate-ethylene copolymer available as Elvax 420 from E. I. duPont de Nemours Inc., and about 2.5 parts of a modified polystyrene available as Piccotex 100 from Pennsylvania Industrial Chemical Company with about 15 parts of Sohio Odorless Solvent 3440. The mixture is heated until all is dissolved and then cooled. About 45 parts of isopropyl alcohol is added and the mixture is milled in a ball mill for 15 minutes together with about 2.5 parts of Naphthol Red B. The resulting imaging material is then coated on a 3 mil Mylar sheet with a doctor blade set at a gap of 4.4 mils to produce a donor. The donor is dried at a temperature of about 90°C. After drying the imaging layer, it is activated with Sohio Odorless Solvent 3440 and incorporated into a manifold sandwich as described in Example I. The imaging layer is exposed to a pattern of white incandescent light as in Example I. Upon separation of the sandwich under an electric field, there is produced a pair of excellent quality red colored images. The sandwich is recombined, subjected to an electric field of reverse polarity to the first field and flood illuminated with white incandescent light as in Example I. Subsequent images are produced by repeating the above described sequence of activation and imaging under an electric field.

EXAMPLE XVI

The procedure of Example I is repeated except that the Parafint RG is replaced with 2.0 grams of Icosane MW 282 ($\text{CH}_3(\text{CH}_2)_{18}\text{CH}_3$), a high molecular weight aliphatic material available from Eastman Kodak Co. After coating on 2 mil Mylar and dried at about 33°C. for one-half hour, the coating is allowed to cool to room temperature. A receiver sheet of 2 mil Mylar is placed over the coated donor and placed donor side down on the tin oxide surface of a NESA glass plate. Hot air from a conventional hair dryer is directed onto

the sandwich and the NESAs glass plate, which causes the Icosane to melt.

A carbon black-in-binder coated paper electrode is placed over the receiver. The electrodes are connected to a 9,000 volt d.c. power supply in series with a 5,500 megohm resistor with the NESAs glass being the positive electrode and the black opaque electrode being the negative electrode. With the voltage applied, a white incandescent light image is projected upward through the NESAs glass with an illumination of approximately 0.04 foot-candles applied for 5 seconds for a total incident energy of about 0.2 foot-candle seconds. After exposure, the receiver sheet is pulled from the set with the potential source still connected. Upon separation, the imaging layer fractures in imagewise configuration yielding a pair of images. The sandwich materials are allowed to cool by removal of the heat supplied by the hair dryer. The receiver sheet is replaced on the donor sheet and the heat re-applied by the hair dryer. While heated, the layers are redistributed by running a squeegee across the receiver sheet by light hand pressure. The opaque electrode is then replaced over the receiver sheet and the electrodes are connected to the power supply at opposite terminals than were employed during the image exposure step. With the potential of about 9,000 volts, the imaging layer is flood exposed with white incandescent light for 0.2 foot-candle seconds. After exposure and continued heating, the electrodes are disconnected from the power supply and reconnected with the terminals switched to make the NESAs electrode positive and the black opaque paper electrode negative. With a potential of 9,000 volts between the electrodes, the imaging layer is again exposed to a different subject matter than the original exposure. After exposure and with continued heating, the receiver sheet together with the opaque electrode is peeled from the donor sheet with the 9,000 volts still applied. A pair of images is formed with the donor duplicating the original and a reversed image being formed on the receiver sheet. This procedure may be repeated using heat to provide activation.

Although specific components and proportions have been stated in the above description of preferred embodiments of the invention, other typical materials as listed above, if suitable, may be used with similar results. In addition, other materials may be added to the mixture to synergize, enhance, or otherwise modify the properties of the imaging layer. For example, various dyes, spectral sensitizers or electrical sensitizers such as Lewis acids may be added to the several layers.

Other modifications and ramifications of the present invention will occur to those skilled in the art upon a reading of the present disclosure. These are intended to be included within the scope of the invention.

What is claimed is:

1. An apparatus comprising means for cyclically advancing a manifold set comprising an electrically photosensitive imaging layer, said layer being structurally fracturable in response to the combined effect of an applied electric field and exposure to electromagnetic radiation to which it is sensitive, said layer being sandwiched between a donor sheet and a receiver sheet, at least one of said donor and receiver sheets being at least partially transparent to electromagnetic radiation to which said imaging layer is sensitive, means to apply

a first electric field across said imaging layer, means to expose the imaging layer to electromagnetic radiation to which it is sensitive, means to separate said receiver sheet from said donor sheet thereby fracturing, in image configuration, said imaging layer providing a positive image on one of said donor and receiver sheets and a negative image on the other, means for viewing at least one of said images, means for recombining said sandwich, means to apply a second electrical field of reversed polarity from said first field across said sandwich and means for flood exposing said imaging layer subsequent in said cycle to said second electrical field and prior to said first electrical field.

2. An apparatus of claim 1 further including a means for applying an activator to at least one of said donor and receiver sheets subsequent to passing said viewing means in their cyclic path of travel.

3. The apparatus of claim 1 further including projecting means to project at least one of said images.

4. The apparatus of claim 2 wherein said means for subjecting said imaging layer to an electric field comprises charged rollers in contact with said donor and receiver sheets.

5. The apparatus of claim 1 further including fixing means to fix at least one of said images on at least one of said donor and receiver sheets.

6. The apparatus of claim 1 wherein said advancing means for said manifold set comprises rollers over which said set travels in its cyclical path.

7. The apparatus of claim 1 wherein the cyclical path of said receiver sheet is extended in order to recombine said manifold set substantially in image registration.

8. The apparatus of claim 1 wherein said flood exposure means is positioned to expose said imaging layer through said receiver sheet.

9. An apparatus comprising a dust-tight chamber, means for cyclically advancing a manifold set comprising an electrically photosensitive imaging layer, said layer being structurally fracturable in response to the combined effect of an applied electric field and exposure to electromagnetic radiation to which it is sensitive, said layer being sandwiched between a donor sheet and a receiver sheet, at least one of said donor and receiver sheets being at least partially transparent to electromagnetic radiation to which said imaging layer is sensitive, means to apply a first electric field across said imaging layer, means to expose the imaging layer to electromagnetic radiation to which it is sensitive, means to separate said receiver sheet from said donor sheet thereby fracturing, in image configuration, said imaging layer providing a positive image on one of said donor and receiver sheets and a negative image on the other, means for viewing at least one of said images, means for recombining said sandwich, means to apply a second electrical field of reversed polarity from said first field across said sandwich and means for flood exposing said imaging layer subsequent in said cycle to said second electrical field and prior to said first electrical field.

10. The apparatus of claim 9 wherein said chamber is activator vapor-tight.

11. The apparatus in claim 9 further including projection means to project at least one of said images.

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