

- [54] **PHOTODECORATING SHEET MATERIAL WITH MATCHED COLORED DESIGNS**
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UNITED STATES PATENTS

3,698,899	10/1972	Giberstein.....	96/38.1
3,445,234	5/1969	Cescon et al.	96/90 R
2,009,586	7/1935	McLellan.....	96/38.1
2,041,853	5/1936	Mollo et al.	96/38.1
2,084,792	6/1937	De Maria.....	96/38.1
2,491,386	12/1949	Miller et al.	96/38.2
2,541,178	2/1951	Slifkin.....	96/91 R

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[57] **ABSTRACT**

A process for color decorating sheet material with a design, which material will be used to form an article by assembling multiple pieces of the designed sheet material, whereby the shapes of the pieces are laid out on sheet material in closely-spaced arrangement and the pieces are then cut from the sheet material, is improved by

- a. either before or after cutting out the pieces, coating the sheet material with a photosensitive composition capable of generating color subsequent to exposure to activating light,
- b. exposing the coated shapes to activating light through a light modulating means which registers at least a portion of the desired design on the shaped piece, the piece design being one which matches with an adjacent piece in the assembled article, and
- c. color stabilizing the design by fixing the coating after registration of a latent design or after color has been generated.

Such a process permits minimum waste of sheet material and maximum convenience in accurately matching piece designs in an assembled article.

21 Claims, No Drawings

PHOTODECORATING SHEET MATERIAL WITH MATCHED COLORED DESIGNS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to an improved process for the colored photodecoration of various sheet materials. More particularly, it is directed to the improvement in a process for color decorating shaped pieces of sheet material, a multiplicity of which are to be used in assembling an article by laying out, in closely-spaced arrangement on suitable sheet material, the shapes of pieces to be used in the assembly, and cutting out the piece shapes, wherein the improvement is the use of photosensitive compositions as a coating on the piece shapes and producing the desired colored design on the shaped pieces such as by photoactivation of the photosensitive compositions with light modulating means such that the piece design matches with an adjacent piece in the assembled article.

2. Prior Art

Current practice in making an article of a multiplicity of pieces having a recurrent design that extends from piece to piece is exemplified by shoe manufacture which involves printing a design continuously on a roll of synthetic or natural leather or other suitable material, laying out the pieces for many sizes of shoe on the material and cutting them out. Layout requires harmonious matching either continuously or symmetrically of the recurrent design on pieces that are to be located adjacent to each other in the finished article of manufacture. For instance, left and right shoe uppers or "vamps" should be mirror images of each other, and heel covers should join to the vamp so that the seam is hidden. In some designs, indicia must appear at a toe, an instep or a heel. Such layout requires considerable planning and foresight.

In achieving harmonious effects, the contours of certain pieces that are laid out tend to be far apart with a substantial amount of sheet material in-between. The greater the repeat length of the recurrent design, the greater is the effort to avoid wasting such material. Many sizes are laid out together so that there are many ways to fit little pieces between big pieces. Wherever possible, contours are oriented transversely or on a bias to save material. Nevertheless, the presence of a recurrent design on a decorated roll of sheet material, such as leather for shoes, cloth for garments, and plastic for slip covers, introduces some waste which is in addition to the unavoidable basic waste due to irregular contours of individual pieces and occasional imperfections in the sheet material.

U.S. Pat. Nos. 2,537,097 and 2,541,178 describe the dyeing of textile materials by the use of light-sensitive diazo salts. Colored designs are produced upon rolls of cloth and pieces of cloth by impregnating the material with a light-sensitive composition, exposing to light according to a pattern to be reproduced, and developing the colors in either a graduated (continuous tone) or non-graduated design in an atmosphere of moist ammonia at a suitable temperature.

U.S. Pat. No. 3,445,234 describes the use of photosensitive materials for image formation on various substrates including fabrics, paper, plastic and polymeric films, glass, wood and metals. U.S. Pat. No. 3,658,543 discloses the use of aerosol dispensed photosensitive materials for the decoration of metal, wood, cloth, pa-

per, plastic, glass and leather. None of these processes provide a sequence which involves obtaining the piece goods in desired predetermined shapes and decorating them with matched designs so that they may be assembled in a harmonious combination in a finished article of manufacture.

It is an object of this invention to provide a decorating process that will reduce the cutting waste normally arising from a recurrent design, thereby conserving sheet material.

Another object of this invention is to simplify the laying out and cutting of pieces of sheet material so as to reduce the skill and the time required.

A further object of this invention is to permit rapid accessibility to popular fashion patterns by photographically placing matched recurrent designs on pieces of sheet material befitting their harmonious assembly into a finished article of manufacture according to a predetermined pattern.

Still another object of this invention is to provide a process for placing colored designs on materials by incorporating in coating compositions ordinarily used on such materials the photosensitive components of this invention and thus avoiding additional coating steps or the necessity of other more expensive means of imparting colored designs to such articles.

SUMMARY OF THE INVENTION

In summary this invention is to an improvement in a process for decorating, with a colored design, material to be used in preparing an article from a multiplicity of pieces, by laying out on sheet material shapes of the pieces to be used in assembling the article and cutting out the pieces, the improvement comprising

- a. coating the material with a photosensitive composition capable of generating color subsequent to exposure to activating light;
- b. exposing the coated shapes to activating light through a light-modulating means such that at least a portion of the design is registered on a shaped piece of said material to produce the portion of the colored design which matches an adjacent piece within the assembled article; and
- c. color stabilizing the design by fixing the coating after registration of a latent design or after color has been generated.

There can be advantageously included in the process of this invention the optional step of

- d. overcoating the designs, either before or after assembly of the pieces into a finished article of manufacture, with protective material capable of absorbing activating light for color generation.

This invention is also directed to a method for producing an assembled article of manufacture wherein contained pieces of sheet material bear a matched design, which method includes the steps above plus one or more steps of assembling the pieces into the article of manufacture.

This invention is also directed to articles of manufacture bearing a design matched from one component piece to another, or among a multiplicity of pieces, upon which matched designs have been placed by the above described process.

DESCRIPTION OF THE INVENTION

The Photodecorating System

The choice of a photo-imaging system for placing

matched designs on pieces of sheet material is not critical to this invention. Various radiation-responsive imaging systems that produce a colored product through reactions of one or more components may be used herein. Photo-imaging systems that require aqueous application of chemicals for color formation or color stabilization are not generally suitable for use in this invention for placing matched designs on sheet material that may be sensitive to moisture such as leather, wood, and textile fabrics and therefore subject to dimensional changes that make precise registration of matched designs impossible. For application to many polymer, glass or metal substrates, however, aqueous systems may be used.

Representative suitable systems are the well known diazo systems which require moist ammonia development; dry diazo systems; fast print-out dye imaging systems of Horizons, Incorporated based on the light sensitivity of halocarbons; leuco dye systems; and "bleach-out" systems. These and other non-silver systems suitable for use in this invention can be found in Jaromir Kosar's book *Light-Sensitive Systems*, John Wiley & Sons, Inc. 1965, Chapters 6 and 8. In addition, photosensitive processes such as the 3M Dry Silver process may be used.

Another suitable system employs the light sensitive solutions containing organic haloform compounds and a dye described in U.S. Pat. Nos. 3,305,361; 3,366,480; and 3,434,835.

Preferred are those systems that permit convenient color stabilization or fixation of the design after it is generated by activating light. Typical is the heat-developable, heat-fixable photographic system developed by S. D. Warren Company, described in U.S. Pat. Nos. 3,394,391-5; 3,410,687; and 3,413,121. Particularly preferred as photosensitive coatings are the light-sensitive leuco dye compositions containing a photooxidant component as described in U.S. Pat. Nos. 3,445,234; 3,585,038; and 3,598,592. Expedients that have been suggested for the deactivation of imaging systems in the unexposed areas, thereby fixing the image, include

1. removing one or more of the imaging components, as by volatilization; see U.S. Pat. No. 3,042,516 and U.S. Pat. No. 3,413,121;

2. volatilizing a plasticizing solvent; see U.S. Pat. No. 3,445,234;

3. employing a rigidifying binder for the imaging components which can be temporarily softened by heat sufficiently to permit the components to move and react in response to radiation; see U.S. Pat. No. 3,630,736;

4. incorporating a deactivating agent into the unexposed area to be fixed, as by spraying, dipping or coating; see U.S. Pat. No. 3,445,234;

5. generating a deactivating agent in situ, including photochemically; see U.S. Pat. No. 3,390,996 and U.S. Pat. No. 3,445,233, and thermally; see U.S. Pat. No. 3,390,995; and

6. deactivation by photopolymerization of an unsaturated plasticizer; see U.S. Pat. No. 3,615,454, or an unsaturated imaging component; see U.S. Pat. No. 3,056,673.

These patents describe suitable photosensitive compositions. Normally for photodecoration use, such compositions contain one or more imaging components in a polymeric binder which can contain a plasticizer

and which serves to thicken or adhere the composition to a sheet material. The binder can also serve as a matrix so that the mixture can be cast, extruded or otherwise formed into an imageable coating. Preferred are light-transparent and film-forming polymers such as ethyl cellulose, polyvinyl alcohol, polyvinyl chloride, polystyrene, polyvinyl acetate, poly(methyl methacrylate), cellulose acetate, cellulose butyrate, cellulose acetate butyrate, cellulose nitrate, chlorinated rubber, copolymers of the above vinyl monomers and gelatin. Binder or matrix amounts vary from about 0.5 part to about 200 parts, preferably 3 to 15 parts, by weight per part of combined weight of the imaging component or components.

Binders containing special agents or fillers can be used in order to improve such properties as abrasion resistance or surface gloss of the final article in which the pieces of photodecorated sheet material are incorporated. Binders of this sort are currently in use in the leather industry. They are broadly classified as urethane clears and vinyl clears and are suitable for use as the binder component in photosensitive compositions suitable for this invention providing the binder ingredients do not interfere with image-forming or fixing.

Representative of suitable commercially available leather binders or top finishes are General Tire and Rubber Co.'s CV 270, CV 940 and CVX 3040; United Finish Co.'s U-6366 Urethane Clear and KC-10-925 Vinyl Clear; Fleming-Joffe Ltd.'s U-5573 and 8925 CAB 10 percent + SC; United Finish Co.'s Permalon KC-10-662 Vinyl Clear, Permuthane U-5900 Clear Urethane, Permuthane U-5057 Clear Urethane, and Permuthane U-4849 Clear Urethane; and Du Pont Co.'s 56060 Laminating Adhesive, 46960 Adhesive and C-1924-2 Non-yellowing Urethane.

In practicing this invention, preference is given to imaging systems which permit convenient fixation of the colored design in situ, i.e., without chemical aftertreatment of the photogenerated image. Particularly preferred is the process wherein a deactivating agent is generated in situ by photochemical or thermal means. Such systems can, with the use of a latent image, be stabilized or fixed, prior to color development, and can also be fixed simultaneously with photoactivation.

A preferred system of this type is disclosed in U.S. Pat. No. 3,390,996 wherein the composition has a suitable dual response to light. It consists essentially of (1) an organic color-generator, (2) a photo-oxidant, and (3) a redox couple which consists of (a) a reductant component capable of undergoing a photo-initiated redox reaction with the oxidant component, and (b) an oxidant component which, when photo-activated, undergoes with the reductant component a photo-initiated redox reaction which produces a reducing agent. When irradiated with a pattern of light at one wavelength, normally in the ultraviolet range, the organic color-generator and the photo-oxidant react to form a visible image in a design corresponding to the pattern of light. The unexposed areas remain uncolored or have a light color characteristic of the unexposed coating. The unexposed areas of the coating are color-stabilized or fixed by exposure to light of a second wavelength, normally in the visible range, which causes the redox couple to produce a reducing agent which reacts with the photo-oxidant, thereby blocking further reaction of the photo-oxidant with the color-generator.

Another preferred composition for use in this invention is disclosed in U.S. Pat. No. 3,390,994 wherein the photo-oxidant is a hexaarylbiimidazole, which absorbs light in the range of about 250 to 370 mu in the ultraviolet. The redox couple consists of pyrenequinone or 9,10-phenanthrenequinone as oxidant and a lower alkyl ester of nitrilotriacetic acid or nitrilotripropionic acid as reductant. In combination, the quinone is reduced to a hydroquinone when irradiated with visible light in the range of 380 and 500 mu. U.S. Pat. No. 3,658,543, discloses as preferred reductant in improved photosensitive compositions an acyl ester of triethanolamine such as triethanolamine triacetate optionally mixed with a lower alkyl ester as in U.S. Pat. No. 3,390,994.

More specifically, the above patent application discloses preferred photosensitive compositions suitable for use in the present invention containing one or more of the following:

a. A reductant portion of the redox couple which is 10-100 percent triethanolamine tripropionate or triethanolamine triacetate (with the latter more preferred) and 90-0 percent 3,3',3''-nitrotri-propionic acid, trimethyl ester.

b. Aminotriarylmethanes containing at least two p-dialkylamino-substituted phenyl groups having ortho to the methane carbon atoms a substituent which is alkyl, alkoxy or halogen.

c. A hexaarylbiimidazole of the class 2,2'-bis(o-substituted phenyl)-4,4'-5,5'-tetraarylbiimidazole.

d. As the oxidant portion of the redox couple 9,10-phenanthrenequinone in combination with a mixture of 1,6-pyrenequinone and 1,8-pyrenequinone.

e. Binders, with cellulose acetate butyrate the preferred binder.

f. Plasticizers, with alkyl arenesulfonamides preferably present and a mixture of N-ethyl-p-toluenesulfonamide and o-phenylphenol condensed with ethylene oxide, a particularly preferred mixture.

Other leuco dye types suitable for the generation of a variety of colors according to this invention are described in U.S. Pat. Nos. 3,395,018, 3,390,997 and 3,445,234. Mixtures of leuco dyes may be used herein.

In another embodiment, a system is used that is photo-imageable and heat-fixable in situ. A preferred system of this type is described in U.S. Pat. No. 3,390,995 in which a composition capable of forming color by light activation similar to those in the aforementioned photo-fixable systems contains, instead of photosensitive redox couple, an organic compound capable of forming a reducing agent by heat.

Normally, the practice of this invention requires making up a coating formulation to be applied to the sheet material. In addition to the active imaging and fixing components, there are usually present, as may be required, solvents for the photo-imaging components, binders, plasticizers and such other components as are present. Such solvents are volatile at ordinary pressures. Representative of suitable solvents are amides such as N,N-dimethylformamide and N,N-dimethylacetamide; alcohols such as methanol, ethanol, 1-propanol, 2-propanol, butanol and ethylene glycol; esters such as methyl acetate and ethyl acetate; aromatics such as benzene, o-dichlorobenzene and toluene; ketones such as acetone, methyl ethyl ketone and 3-pentanone; aliphatic halocarbons such as methylene

chloride, chloroform, 1,1,2-trichloroethane, 1,1,2,2-tetrachloroethane and 1,1,2-trichloroethylene; miscellaneous solvents such as dimethylsulfoxide, pyridine, tetrahydrofuran, dioxane, dicyanocyclobutane and 1-methyl-2-oxo-hexamethyleneimine; and mixtures of these solvents in various proportions as may be required to attain solutions. It is often beneficial to leave a small residue of solvent in the dried composition so that the desired degree of imaging can be obtained upon subsequent irradiation. Ordinary drying such as that employed in film casting results in the retention of ample solvent to give a composition with good photosensitivity. The compositions so produced are dry to the touch and stable on storage at room temperature. Moisture of the air is absorbed by many of the compositions, particularly those comprising an acid salt of an aminotriarylmethane or cellulosic substrates, and serves as a suitable solvent.

As stated above, solvent mixtures are also beneficial since multicomponent solvent systems allow for customized drying parameters. A suitable solvent system for cellulose acetate butyrate polymers useful as a coating solvent consist of:

butyl acetate	20%
ethyl acetate	10%
isopropanol	20%
n-butanol	10%
toluene	40%

This particular system gives improved flow-out and drying parameters and allows streak-free coatings to be made. Similarly effective as a solvent is a 1/1 mixture of isopropanol and toluene.

Other useful multicomponent solvent systems include ternary mixtures consisting of 80-90 percent of a methanol/2-propanol mixture (10/1 ratio) and 10-20 percent acetone; or 42.5 percent acetone, 18.5 percent ethyl acetate and 39 percent toluene; and a 6-component system containing 15 percent acetone, 17.7 percent ethyl acetate, 15.2 percent ethanol, 4.9 percent butanol, 23 percent toluene and 24.3 percent hexane.

THE PROCESS

A suitable composition is coated upon sheet material either before or after it is cut. Coating is normally done before cutting for convenience. The term "cutting" is employed in its broad sense.

By "cutting" is meant dividing a bulk form of the material into pieces. Bulk form can actually be quite thick, for example, steel plate or a finished piece of lumber several inches thick. The thickness of the sheet material can vary along its length or from one sheet to another. The means of dividing a bulk form, even the bulk form itself, are not critical to the invention.

Representative of suitable sheet material are leather; poromerics, plastics, polymeric materials such as vinyl polymers and copolymers, polyolefins, polypropylene, acrylics, polyvinylacetate and polyvinylchloride; textile fabrics; glass; wood; cellulose derivatives such as cellulose acetate butyrate; and metals. The sheet material must be an inert substrate for the photosensitive materials and preferably should not dissolve the active components but absorb them and retain sufficient solvent to provide a medium for rapid image formation upon irradiation.

In applying a solution to leather, fabrics or to the surface of rigid substrates such as glass, wood or metals, the solution can be sprayed, brushed, applied by a roller or an immersion coater, flowed over the surface, picked up by immersion or spread by other means. Complete coverage of the substrate can be attained or a pattern of the light-sensitive composition can be applied to the substrate. In impregnating porous leather, for example, with the preferred light-sensitive compositions described above, concentrations of solution and pick-up by the leather are controlled so as to provide from about 0.01 milligram to about 5.0 milligrams per square inch of substrate of the triarylmethane leuco dye and equivalent amount of the hexarylbimidazole. Images of greater and lesser intensity of color can be produced by the application of greater and lesser amounts of the leuco dye to the substrate. For coating flexible sheet material such as thin leather and cloth, there can be used such typical devices for continuously laying down wet films as nip-fed three-roll reverse-roll coating heads, gravure coaters, trailing blade coaters, knife overroll, 4-roll pan fed and Mayer bar coating heads. The wet thickness is adjusted such that the dry thickness after solvent removal is in the desired range, about 0.05-1.5 mils usually.

The substrates bearing a solution of the compositions utilized herein can be dried simply at room temperature. They can also be dried under vacuum at room temperature, by forced air solvent evaporation, or at elevated temperatures, as by radiant heating. With the preferred compositions of U.S. Pat. No. 3,390,994 the upper temperature limit is important in combination with exposure time. A short exposure to heat of 90°C. may not be detectably harmful, while several hours' exposure to this heat may reduce the light sensitivity of the composition. The coated sheet material is normally stored in the dark at room temperature and is periodically tested to determine its retention of photosensitivity. Exposure to a 275 watt sun lamp preferably yields a contrast of at least 0.4 optical density units with less than 20 percent variation for periods from 1 to 10 days.

Means to generate matching designs on pieces of the sheet material can include those normally employed to produce patterns of light such as stencils, templates and photographic negatives or positives that are used in contact with a photosensitive surface. Other means can be used at a distance from the photosensitive surface, for example, a photographic system capable of projecting one or more images at a time such as the systems described in U.S. Pat. Nos. 3,212,396; 3,387,532; 3,391,601; 3,401,594 and 3,661,461. The desired designs in the form of modulated patterns of light can be generated from live models by reflection optics, by transmission of light through photographic negatives and the like using enlargement or reduction in size or by a combination of images from different sources.

Light modulating means are prepared such that there is generally a means for each piece to be decorated, and each means corresponds exactly to the design to be placed on each shaped piece cut from the material. A means can be used more than once, however. A particular photographic negative can be reused in contact registration or projection registration with more than one piece of sheet material whenever decorations are to be duplicated or applied as mirror images. A particular negative can be used with different pieces or with

the same piece of sheet material provided a portion of its photosensitive surface is protected from exposure to activating light during prior use of the negative, thereby reserving the protected area for subsequent exposure. Furthermore, if a negative is larger than pieces to be decorated, selected portions of it can be moved into proper registration with successive pieces to photodecorate each of them with matching designs. A single negative, in fact, bearing a recurrent design is sufficient to decorate many pieces with matching recurrent designs. According to the process of this invention, however, there is always a proper means to place in proper registration with the proper piece of photosensitized sheet material according to a predetermined pattern.

Positioning of the modulated pattern of light on the surface of a piece of sheet material coated with a photosensitive composition is normally accomplished by moving either the light modulating means or the piece relative to each other until reaching a desired registration of one upon the other. Projection systems can usually be redirected for example by internal adjustment of optical parts such as mirrors or lenses. By similar positioning of a second modulated pattern of light that bears a matched relationship to the first-mentioned pattern upon the surface of a second piece of sheet material, there can be produced matched designs on each of the two pieces. The third, fourth and other pieces, when part of the system to be assembled, are handled in the same way. Another way that designs on two pieces can match is by being identical or mirror images of each other on two pieces that may have the same contour or mirror-like contours. Mirror symmetry is often required for example in right and left shoes, sleeves, lapels, gloves, and other such articles. Related or continuous designs are required for articles containing paired parts readily subject to comparison because the parts are next to each other or are otherwise positioned such that comparison is made. In accordance with its use herein, the term "adjacent" is meant to include such parts as are contiguous, next to each other, or otherwise located in a position of comparison. Matching of recurrent designs on different pieces can, however, become a matter of artistry, when a particular element of a recurrent design on one piece is to be placed in a novel but harmonious relationship to an element or elements of a recurrent design on another piece of sheet material in the finished article of manufacture. For example, a repeated continuous tone image of a person may be harmoniously associated with repeated background or logo information on an adjacent piece of sheet material. Other types of matching can be devised by those skilled in the designing arts.

Film negatives to be used in contact with pieces of sheet material are preferred means for generating matching designs. They are readily obtained by photographing the various parts of a three-dimensional mock-up model of the finished article of manufacture desired, either in its assembled form or as disassembled pieces.

Alternatively, model pieces need not be photographed directly if molds are required for post-decorative finishing operations on each piece. For example, embossing may be needed to provide smooth or grained leather finish, stitching detail, pinking, perforations, overlap or folded or bound edges on a pair of shoes. The prepared molds for embossing can be indi-

vidually photographed to obtain full-size negatives which show just the contour shapes of the various pieces of each shoe size. In one system, these negatives are hand-painted to form simple matching designs using ordinary touch-up paints for film negatives. The unpainted negatives can also be overlaid with a second negative bearing an overall recurrent design. The two negatives together in proper registration can comprise the means to generate sought after matching designs of color by the process of this invention.

Laying out the desired contour shapes of the pieces on the sheet material normally proceeds after working up a three-dimensional model of each size required. The model or pattern is disassembled into a multiplicity of pieces of the same or different shapes and areas and the contour shape of each piece of each size is laid out on a substrate in a close packing arrangement with minimum waste of substrate surface, usually first on paper rather than on the final sheet material. The contour shapes are placed as close to one another as practicable. This normally results in adjacent contours touching or nearly touching each other. Pieces can be positioned and oriented relative to each other to take advantage of similarities in negative and positive curvatures of different pieces. They can be laid out transversely, in the sheet direction, or on a bias to save space, fitting small pieces between big pieces wherever possible. Pieces of different sizes can be intermingled. This results in minimum waste determined primarily by the contours or shapes of the collective component parts that are desired.

Cutting dies can be prepared according to the layout for cutting the pieces for each size. The coated sheet material is die-cut as laid out on paper with minimum waste. Multiple breadths or thicknesses of sheet material can be cut together where practicable to save time or effort. Where the thickness of material permits, other means of cutting, even scissors, can be used.

With the preferred photosensitive compositions photodecoration is achieved by placing the cut pieces in registration with the corresponding selected means of generating matching patterns. Registration can be carried out either before or after the cut pieces are assembled into a finished article of manufacture. Means for generating matched designs such as photographic negatives can be prepared that are sufficiently flexible to assume the same proportional curvature as the pieces to be decorated after such pieces are assembled into a three-dimensional article. Normally, however, pieces are photodecorated singly or in groups while flat, prior to final assembly. A preferred procedure is to place each cut piece in turn in registration with the proper film negative and expose through the negative with activating light of a suitable wave-length for sufficient time to develop the desired color. Color stabilization is normally carried out as soon as possible. Using one of the light- or heat-fixable systems known in the art like those described in the patents cited above, it is convenient to use the ambient light or the heat associated with a subsequent finishing step necessary to the production of the assembled article of manufacture. Chemical fixation as in silver halide or diazo processing can, of course, be used as can any of the above-mentioned fixation methods depending on its compatibility with the imaging system. When the dyes imparting color to the matched designs are not light-fast, an ultraviolet screening agent can be incorporated into

further coatings in the finishing operations to stabilize the color of the matched designs for the life of the article. Such screening agents are well-known in the art and can be selected to suit a particular imaging system. Chemical fixing agents can similarly be incorporated into such topcoats.

Such further coatings can also contain coloring agents, such as pigments or soluble dyes, to impart additional overall color and modify the color already generated during photodecoration, thereby producing novel two-color or multi-color designs. Additional images and colorful embellishments to the basic matched design can also be added by recoating with the same or different photosensitive compositions and re-exposing to activating light through suitable light-modulating means to produce novel color and design effects.

As pointed out above, the process of this invention conserves sheet material by utilizing close-packing of individual areas to be photodecorated with matched designs, thus permitting minimum waste inherent in current cutting practice. Other advantages over continuous printing of roll goods include the following:

1. More rapid accessibility of popular fashion patterns (which is important in allowing manufacturers to produce latest fashion effects without delays caused by unavailability of specific printing equipment, such as gravure cylinders) even permitting pattern formation by the consumer at the point of sale.

2. Potential reduction of inventory by preparing preferred patterns on location rather than having the printing done at a remote location, and by printing individual vamps of shoes, for example, making it possible to commit quantities of substrate to a preferred pattern at the last possible moment.

3. Ability to produce images fitted to particular shapes, such as vamps, heels, belts, etc., thus making it very simple to position and orient the article for photodecoration after it has been cut, eliminating need for a high degree of skill in cutting the pattern from a large printed roll of material.

As used herein in association with laying out and cutting pieces, the term "with minimum waste" means arranging the piece shapes to be cut out as close to one another as practicable. The process of this invention normally results in contiguous contours, adjacent and touching, that are positioned and oriented relative to each other to take advantage of similarities in negative and positive curvatures. The process of this invention also results in reduced material loss because no designs need be present on the sheet material at the time it is cut. The process of this invention also avoids the necessity of having to space or orient related pieces according to a predetermined pattern. For example, left and right shoe uppers need not be spaced a repeat length apart and oriented in the direction of the belly lines of a reptile pattern. "With minimum waste" implies freedom to lay out pieces transversely or at any inclination to the sheet direction, and frequently results in uninterrupted cutting lines from piece-to-piece. Defects in the sheet material may interfere, such things as hard and soft spots in leather, fat wrinkles, even holes, but the minimum waste is primarily determined by contours or shapes of the collective component parts that are desired.

As used herein in association with designs, the term "matched" means designs which bear spatial relationship to each other by virtue of their positions or loca-

tions on individual pieces of sheet material. If the two pieces have identical contours or have contours that are mirror images, "matched" designs are observed to be in the same or mirror-opposite positions on each piece. If the two pieces are related by function so as to be adjacent in a finished article rather than by symmetry of use, the two pieces are placed in the same relative positions that they will assume in the finished article. Their designs are matched if a design feature such as the repeat length of a recurring design on either piece is continued onto the adjacent piece. Not knowing their intended function in a finished article merely calls for more elaborate testing of two given test pieces. They are (1) rotated to align repeat directions on the two pieces, of which there may be more than one on each piece, and (2) repeatedly touched at different points on their perimeters until a design feature on one piece is found to be continuous across their point of contact as in testing adjacent pieces. Other tests can be devised by those skilled in the art to determine if designs on test pieces are matched.

The following example further illustrates this invention.

EXAMPLE 1

A photosensitive coating composition is prepared from the following ingredients:

Isopropanol and toluene (1/1 mixture)	600	ml
Polyethyleneoxide adduct of o-phenylphenol (Average formula $C_6H_5 - C_6H_4 - O(CH_2CH_2O)_{2.25}H$)	11.4	g
N-ethyl-p-toluenesulfonamide (Monsanto Chemical Company - Santicizer-3)	13.0	g
2,2'-Bis(o-chlorophenyl)-4,4',5,5'-tetrakis(m-methoxyphenyl)imidazole	4.180	g
Dodecylbenzenesulfonic Acid (Richardson Company Richonic Acid B)	7.0	g
Tris (4-diethylamino-o-tolyl)methane	0.90	g
Pyrenequinone (a 1:1 mixture of 1,6- and 1,8-isomers)	0.03	g
9,10-Phenanthrenequinone	0.468	g
Triethanolamine Triacetate	4	ml
Trimethyl 3,3',3''-nitritoltripropionate	6	ml
Vinyl Clear (United Finish Co.'s Permalon KC10-925)	610	g

The above composition is coated onto a sheet of vinyl shoe upper material (General Tire and Rubber Company's cellular vinyl suede on sateen fabric) and dried at room temperature to a thickness of 0.5 mil. Molds are prepared of each of the pieces of vinyl disassembled from a mock up of a model shoe. The molds of each vinyl piece are prepared to impart an overall grained leather finish, stitching detail and perforations using mold-making equipment provided by Compo Industrial, Inc. for use with Compo-Fit Machine Model D. The molds are then photographed full-sized on film negatives.

The contour of each piece used in the models is then transferred and laid out with minimum waste of space on paper, ignoring the surface decoration already applied to each piece by the pattern maker. Cutting dies are prepared for each piece in each size. The coated sheet material is tested satisfactorily for photosensitivity and is then die-cut according to the layout on paper. The pieces are then ready for embossing.

The desired recurrent designs are hand-painted on the film negatives using high density touch-up paints. The decoration applied by the pattern maker to the model is used as a guide to achieve matching of the designs on the negatives of those pieces that are to be ad-

acent or located symmetrically on the right and left shoes of each size.

The cut pieces are then photodecorated by placing the selected film negative in proper registration with the coated surface of a selected piece, and exposing through the negative with blue fluorescent ultraviolet light for 15 seconds. The deep blue design thus produced on each photodecorated piece is photofixed by exposure to an intense Xenon visible light source for one to two minutes. Decoration is completed by embossing the shoe pieces with heat between pressure plates in a Compo-Fit Model D machine. The shoes are fabricated and finished by applying an overall clear top finish to impart gloss and scuff resistance. An ultraviolet screening agent is incorporated into the top finish to stabilize the color of the recurrent design for the life of the shoe.

The process of this invention can be advantageously employed in a variety of applications. It is suitable as stated above for use with a variety of substrates and can be employed to impart for example an advertising logo for uniforms, or for a continuous tone photographic design. Particularly suitable uses are the application of matched designs such as that of a reptile skin, to leather, vinyl or polymeric substrate for use in manufacturing shoes and gloves, and for the application of designs, such as wood grain characteristics, to wood or metal.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. In a process for color decorating sheet material with a design by coating the sheet material with a photosensitive composition capable of generating color subsequent to exposure to activating light, exposing the coated sheet material to activating light, and color stabilizing the resulting design by fixing the coating, the sheet material to be used to form an article by assembling multiple pieces of the designed sheet material, whereby the pieces are cut from the sheet material in closely-spaced arrangement, the improvement wherein the material is exposed to activating light through a light modulating means which registers at least a portion of the design on a piece cut from the sheet material so as to match with at least one second piece cut from the sheet material with minimum waste.

2. A process of claim 1 wherein the photosensitive composition is applied to the sheet material before the pieces are cut.

3. A process of claim 1 wherein the photosensitive composition is applied to the pieces of sheet material after they are cut out.

4. A process of claim 1 wherein the photosensitive composition is one which generates color directly on exposure to activating light.

5. A process of claim 1 wherein the photosensitive coating is over-coated with protective material capable of absorbing activating light.

6. A process of claim 1 wherein the sheet material is wood, leather, vinyl or a polymeric material.

7. A process of claim 1 wherein the fixing process is chemical fixation.

8. A process of claim 1 wherein the fixing process is heat fixation.

9. A process of claim 1 wherein the fixing process is carried out with light of a wavelength different from the activating light.

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10. A process of claim 1 wherein the coated shapes are sequentially exposed to activating light through different modulating means to produce a combined design.

11. A process of claim 8 wherein the heat fixation occurs during dielectric embossing.

12. In a process for producing an assembled article of manufacture bearing a colored design, from a multiplicity of pieces, comprising laying out on a sheet material shapes of the pieces to be used in the assembly, cutting out the pieces, and assembling the pieces into the article, in which the sheet material is decorated with a design by coating the sheet material with a photosensitive composition capable of generating color subsequent to exposure to activating light, exposing the coated sheet material to activating light, and color stabilizing the resulting design by fixing the coating, the improvement wherein the material is exposed to activating light through a light modulating means which registers at least a portion of the design on a piece cut from the sheet material so as to match with at least one second piece cut from the sheet material with minimum waste.

13. A process of claim 12 wherein the photosensitive

composition is applied to the sheet material before the pieces are cut.

14. A process of claim 12 wherein the photosensitive composition is applied to the pieces of sheet material after they are cut out.

15. A process of claim 12 wherein the photosensitive coating is over-coated with protective material capable of absorbing activating light.

16. A process of claim 12 wherein the photosensitive composition is one which generates color directly on exposure to activating light.

17. A process of claim 12 wherein the fixing process is chemical fixation.

18. A process of claim 12 wherein the fixing process is heat fixation.

19. A process of claim 10 wherein the fixing process is carried out with light of a wavelength different from the activating light.

20. A process of claim 12 wherein the sheet material is wood, leather, vinyl or a poromeric material.

21. A process of claim 18 wherein the heat fixation occurs during dielectric embossing.

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