

April 20, 1948.

E. H. LAND ET AL

2,440,106

LIGHT-POLARIZING IMAGE AND METHODS FOR FORMING THE SAME

Filed April 26, 1946

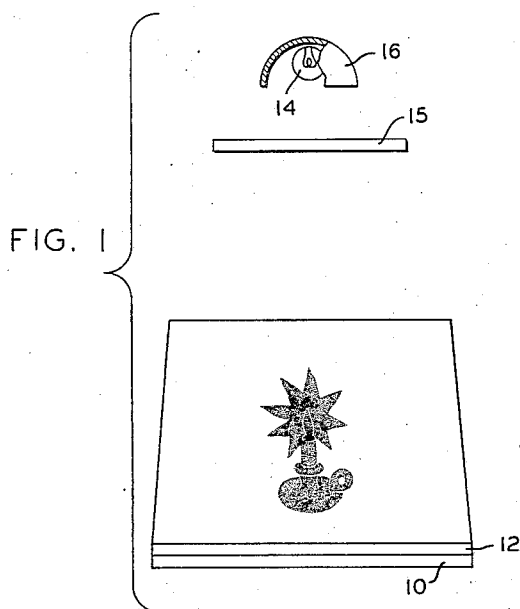


FIG. 2

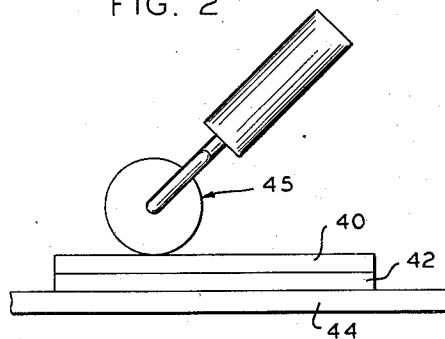


FIG. 3

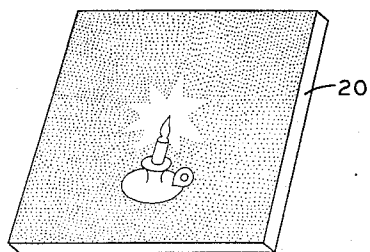
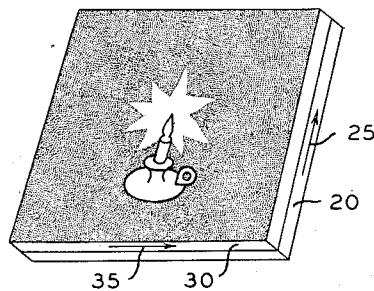


FIG. 4



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## UNITED STATES PATENT OFFICE

2,440,106

LIGHT-POLARIZING IMAGE AND METHODS  
FOR FORMING THE SAME

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Application April 26, 1946, Serial No. 665,084

9 Claims. (Cl. 95—6)

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This invention relates to novel methods for forming light-polarizing materials and particularly has reference to forming light-polarizing images in transparent, hydrophilic, molecularly oriented, linear polymeric plastics.

This application is in part a continuation of our copending application Serial No. 434,568, filed March 13, 1942, for Light polarizers and methods and materials for forming the same.

Important objects of the invention are to provide methods for forming light-polarizers and light-polarizing images by predeterminedly incorporating an oxidizing compound or agent in a linear polymeric plastic element or sheet and treating the sheet with a material or agent which is oxidized in the presence of the oxidizing compound to produce a dichroic stain in any portion of the sheet containing the oxidizing agent, the molecules of the sheet in any portion thereof containing the oxidizing agent being substantially oriented at some stage of the method; and to provide methods of the foregoing character wherein the oxidizable material is an iodide or a mixture of iodides from which iodine is released by an oxidation reaction with the oxidizing agent, and wherein the oxidizing reaction is brought about in the presence of a solvent for the oxidizing agent as for example an acid and particularly by reacting the oxidizing agent with an acid solution of an iodide or mixture of iodides.

Other objects of the invention are to provide processes of the character described which are particularly adapted for the reproduction from photographic negatives of light-polarizing or dichroic images in molecularly oriented plastic materials and particularly for the formation of dichroic images in such materials and their combination as superposed right- and left-eye stereoscopic images.

Still further and yet more specific objects are to provide a new process for forming light-polarizing material through the employment of light-sensitive materials, particularly to utilize the direct action of light on plastics which are capable of having their molecules oriented and which have been rendered light-sensitive as a step in the formation of light-polarizing images therein; and to provide a process wherein suitable sheet plastic is rendered light-sensitive, differentially exposed to light and treated with an agent adapted to react with the exposed material to produce a dichroic stain such as iodine in the sheet, at least the portions of said sheet penetrated by the dichroic stain being molecularly oriented at some stage of the process; as well as to provide a

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process wherein the differential exposure of the light-sensitized plastic takes place through a photographic or other negative and the resulting exposed portions are developed to a dichroic stain which will constitute a positive reproduction of the negative.

Yet other more specific objects of the invention are to provide a process for forming light-polarizing material by introducing an oxidizing compound or agent into a linear polymeric plastic in predetermined portions of the plastic whereby to provide an image formed of the oxidizing agent, and then utilizing the oxidizing agent to form a dichroic stain in the portions of the plastic in which it is incorporated, at least those portions of the plastic containing the dichroic stain having their molecules substantially oriented at some stage of the process; as well as to provide a process for the reproduction of a photographic negative image as a light-polarizing positive image by subjecting a suitable plastic sheet to differential imbibition of a solution of an oxidizing compound or agent to form a positive image in the sheet in terms of the oxidizing agent and then treating the sheet with a material oxidized by said oxidizing agent to provide a dichroic stain in the portions of said sheet containing said oxidizing compound, and especially to carry out such practices by providing a positive image in the form of a wash-off gelatin relief, saturating the relief with an oxidizing agent and printing on the plastic sheet with the treated wash-off relief whereby to provide an image in the sheet comprising the oxidizing agent.

Other objects and advantages will in part appear and in part be pointed out in the course of the following descriptions of the invention, which are given as non-limiting examples in connection with the accompanying drawings, in which:

Fig. 1 is a diagrammatic view illustrating a convenient arrangement for carrying out the process of the invention wherein light-polarizing images are formed in light-sensitive plastic material and shows the exposure of a sheet of a suitably sensitized plastic through a photographic negative;

Fig. 2 is a diagrammatic view representing a step in the process of the invention utilizing a wash-off relief in the formation of a light-polarizing image;

Fig. 3 is a diagrammatic perspective view illustrating an image-carrying element having a light-polarizing image formed therein in accordance with either of the practices described in connection with Fig. 1 or Fig. 2; and

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Fig. 4 is a view similar to Fig. 3 showing the element of Fig. 3 as it appears when viewed through a suitable analyzer having its polarizing axis at right angles to the polarizing axis of the element.

As has been indicated in the objects of this invention, several practices may be employed for the purpose of forming light-polarizing images in transparent, hydrophilic, linear polymeric plastics. All of these practices generically involve the introduction or incorporation of an oxidizing compound or agent within plastic material, especially sheet material, and the utilization of this oxidizer to the end of staining the plastic with a dichroic stain.

A preferred process and one which is admirably suited for explaining the invention and especially the fundamentals thereof is illustrated in connection with Fig. 1 and comprises three main steps—treatment of a sheet of the desired material with a suitable light-sensitive material, exposure of the sensitized sheet to light and the formation of an image in the sheet comprising an oxidizing agent, followed by treatment of the sheet with an agent, which when oxidized, produces a dichroic stain in the exposed areas of the sheet. In addition to these steps, it may be desirable in some cases to add a fourth step comprising treatment of the stained sheet in an intensifier bath. Particular novelty lies in the fact that the stain which constitutes the image is produced by reaction between the oxidizable agent and the light-sensitive material in the exposed areas of the sheet.

Suitable sheet materials which may be used in carrying out any of the practices of the invention include plastics, particularly a plastic from the class consisting of the linear, hydrophilic polymers, such for example as polyvinyl alcohol, polyvinyl acetal and regenerated cellulose. Of the materials falling within this class, the preferred material is polyvinyl alcohol, and images formed in suitably prepared sheets of that material possess the highest dichroism and hence are most suitable in the production of superimposed right- and left-eye stereoscopic images.

For best results, the molecules, at least on the surface of the plastic sheet, should be substantially oriented in a predetermined direction. This may conveniently be accomplished by softening the sheet, as for example by subjecting it to heat, and then stretching or extending the sheet until suitable orientation of the molecules has been obtained. In the case of polyvinyl alcohol, a sheet formed by casting may be placed in condition for the formation of dichroic images therein by extending to from two to four or five times its length.

Several specific examples and formulae, relating to the various practices of the invention, will now be given, but it is to be understood that they are intended to be illustrative only and are in no way to be construed as limiting the invention to the specific times, proportions or percentages given. It should, moreover, be particularly noted that many variations may be made in any of the steps of the invention, provided that said variations are compensated for in the other said steps, as will be described in more detail hereinafter.

By way of illustration, the invention will be described with reference to a sheet of polyvinyl alcohol, and it will be assumed that the molecules therein have already been substantially oriented. The first step in the preferred process is to render the sheet light-sensitive, and this may be done

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conveniently by imbibing the sheet in a solution containing the desired light-sensitive agent. Among the materials found suitable for this purpose, the preferred materials comprise dichromates, such for example as ammonium dichromate, potassium dichromate and sodium dichromate, with ammonium dichromate being preferred for the reason that it is the most soluble. The just-described dichromates may be used singly or a mixture of two or more of them may be employed as the light-sensitive agent. Dichromates are particularly useful as light-sensitive agents in carrying out the present invention since these materials are good oxidizers.

The solvent for the light-sensitive agent may be simply water, but this is not wholly satisfactory for the reason that it tends to penetrate the sheet too rapidly and thus tends to soften it unduly. It is preferable, therefore, to add to the solution a liquid which is miscible therewith but is a non-solvent of the plastic as well as non-reactive with the other chemicals present, and which accordingly tends to slow penetration of the sheet and thus aid in maintaining its stiffness. Suitable examples include acetone, methanol and ethylene glycol, and the volume thereof used may vary anywhere up to approximately 99% of the total volume of solvent present.

The proportion of sensitizing agent to solvent may vary within a wide range, from as low as 1 to 2% to as high as 40% based on the volume of solvent, provided the variation is compensated for by variation of the time of treatment approximately inversely to the proportion of sensitizing agent. Said time of treatment may vary from a few seconds upward but should preferably continue only long enough to permit the solution to penetrate the surface of the sheet uniformly for a short distance, and in no case should the sheet be allowed to soak so long that it softens unduly. It has also been found desirable to add a wetting agent such, for example, as soap or dihexyl sodium sulfosuccinate in order both to accelerate the sensitizing treatment and to promote uniform sensitization.

A satisfactory sensitizing bath has the formula immediately given:

#### Formula I

|                     |     |    |
|---------------------|-----|----|
| Water               | cc. | 75 |
| Acetone             | cc. | 25 |
| Ammonium dichromate | gm. | 16 |
| Wetting agent       | gm. | 1  |

With a solution of approximately the foregoing formula, a sufficient time of treatment will be about two to three minutes, and the sheet should then be taken from the solution and the excess liquid wiped off or otherwise removed from its surface.

The next step of the process is to expose the sensitized sheet to the action of light. If the process is to be used to form a dichroic image of a photographic negative or the like, the exposure should be through the negative to be reproduced, as for example in the manner indicated in Fig. 1, wherein sensitized sheet 10 is represented as mounted under a photographic negative 12 and exposed to light rays emanating from light source 14 provided with a conventional reflector 16. Light source 14 may emit primarily white light or primarily ultra-violet light, and the time of exposure may vary considerably, depending on the intensity of the light, the distance between it and the sheet, and the degree to which the sheet was

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sensitized, as pointed out above. If, for example, an R2 Photoflood bulb mounted approximately six inches from the surface of sheet 10 be used as the light source, a sheet sensitized as described above for two to three minutes should be sufficiently exposed in from forty to sixty seconds.

It should be noted that during the exposure, and particularly in the case of exposure for a long period, it may be advisable to shield sheet 10 from the infra red rays emanating from the light source, as by means of a suitable filter 15. If it is desired to print by means of the ultra-violet rays emanating from source 14, element 15 should also include filtering material for visible light, and the exposure time should be increased to about five minutes, owing to the uniform absorption of the ultra-violet light by negative 12.

The effect of the exposure of the sensitized sheet of the invention to light is to harden the surface of the sheet approximately proportionally to the degree of exposure. As will be seen from Fig. 1, the degree of exposure varies according to the variations of density in negative 12, i. e., more light is transmitted by the lighter areas of the negative than by the darker areas. The result is that the surface of sheet 10 is hardened to a varying degree corresponding inversely to the density of negative 12. In other words, where the negative is lightest, sheet 10 is most exposed and most hardened, and where the negative is darkest, sheet 10 is relatively unexposed and remains relatively soft. Thus the dichromate in the soft or relatively unexposed portions of the sheet may be readily washed out of the sheet whereas the dichromate in the hardened or heavily exposed portions of the sheet is removed with difficulty. When the sheet is washed, following exposure, the effect produced is to leave an image therein in terms of an oxidizing agent, that is in terms of the dichromate or mixture of dichromates used for sensitizing purposes.

As intimated, the next step in this embodiment of the process is to eliminate unexposed light-sensitive material from sheet 10. This may be done in the present example by a simple washing with water to remove the dichromate from the unhardened areas of the sheet, and the time of washing varies more or less according to the degree of sensitizing and the time of exposure, the important factors being that all unexposed dichromate should be removed but that the washing should not continue so long that the highlights of the picture are washed out or the exposed dichromate affected. It is for this reason that the sensitizing treatment is preferably confined to the surface of the sheet; the unexposed dichromate may then be removed in as short a time as possible. For a sheet sensitized and exposed as described above, the washing should be completed in approximately two minutes, but it must be emphasized that this time is by no means critical and may be varied considerably without appreciably altering the result.

The next step in the process is to treat the exposed and washed sheet with an agent or composition in solution form which is somewhat analogous in its action to a photographic developer in that it reacts with the exposed material in the sheet to give an image in terms of a reaction product. This reaction product is a dichroic stain resulting from an oxidation reaction between the oxidizing agent in the sheet, which in the practice under immediate discussion is the exposed dichromate remaining therein, and an oxidizable material in the so-called developing

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solution. The dichroic stain thus formed substantially replaces the oxidizing agent, that is to say, portions of the sheet in which an oxidizing agent was present prior to the oxidation treatment just described contain substantially only a dichroic stain following such treatment.

The oxidation treatment is readily carried out with a material which is oxidized by the oxidizing agent in the sheet to give a dichroic stain and which is dissolved in a solvent material mutual to said oxidizing agent. An iodide or mixture of several iodides provides an oxidizable material of the character desired and when the same is reacted with the oxidizing agent in the sheet in the presence of a solvent also common to the oxidizing agent, for example an acid, iodine is released from the iodide or mixture of iodides to form a dichroic stain, the released iodine replacing the oxidizing agent. The iodide or iodides should be water soluble and are preferably contained in a solution which is rendered acidic.

These characteristics in the developer may conveniently be secured either by using an alkali iodide, particularly ammonium iodide or an alkali metal iodide such, for example, as potassium iodide or sodium iodide, and adding one or more acids to the solution, preferred acids being hydrochloric and hydrobromic acids. Alternatively, other acids such, for example, as sulphuric, nitric, phosphoric, or acetic acid may be used. Other iodides may be employed, for example, ferrous iodide or cerous iodide, or an iodide solution which is naturally acidic such, for example, as hydriodic acid, may be employed.

It has already been pointed out that the result of the exposure step illustrated in Fig. 1 is to harden the surface of the sensitized sheet differentially, depending upon the optical density of the photographic negative at any given point. It follows, therefore, that after the exposed sheet has been washed, the amount of dichromate remaining therein will similarly vary differentially over its entire area. Then when the sheet is subjected to the oxidation treatment, the iodine stain absorbed in any particular area will depend upon the amount of dichromate present in that area. That is to say, the stain will be relatively intense in the areas where there is considerable dichromate, namely the areas corresponding to light areas in the original negative. Conversely, there will be relatively little dichromate in the areas corresponding to the dark areas in the negative, and the amount of stain absorbed therein will therefore be substantially less. In other words, the final product of the oxidation step of the operation will be a positive reproduction in light-polarizing areas of the original negative image represented by element 12 in Fig. 1.

As is the case with the other agents and steps of this invention, the composition of the developing solution which contains the oxidizable material may vary to a considerable extent, depending both on the results desired and on the way in which the preceding steps were carried out. For example, if the sheet was sensitized in a concentrated solution and exposed for a relatively long period, a concentrated developing solution may be used, but if the sheet was sensitized in a dilute solution and exposed for a short time, the developing solution and time of treatment therewith must be correspondingly modified. Similarly, the particular acid used affects the time of the oxidation reaction, use of a strong acid like hydrochloric requiring a shorter treating time than one containing a

weak acid like acetic. Several examples and formulae will be given, therefore, but it is to be understood that they are intended as illustrative only and the percentages and proportions therein are in no sense to be considered as critical.

A typical developing solution may be made up as follows:

#### Formula II

|                         |     |      |
|-------------------------|-----|------|
| Water                   | cc. | 1000 |
| Acetone                 | cc. | 80   |
| Hydrochloric acid (33%) | cc. | 1.5  |
| Ammonium iodide         | gm. | 11.6 |
| Potassium iodide        | gm. | 1.6  |
| Boric acid              | gm. | 9.2  |

The acetone in the above formula is used for the same purpose as in the sensitizing bath, namely, to maintain the stiffness of the sheet by preventing over-penetration by the solvent. As explained above, any similarly acting agent may be substituted therefor, and the percentage thereof is optional and merely approximate. It has been found that the mixed iodides appear to give better results than either alone, but either may be used alone, and it will be noted that the total amount thereof should preferably be about 1%. Said percentage, however, is by no means critical. On the contrary, it is possible to vary the iodide content from as low as .5% up to the saturation point, about 40%.

The hydrochloric acid content in the developing or treating solution used in the formation of the dichroic stain should be kept relatively low, for otherwise it tends to attack and destroy the dichromate in the sheet. If, however, an oxidizing acid such as sulphuric or nitric is substituted for the hydrochloric, the amount thereof may be substantially higher. The boric acid appears to aid in controlling the color of the finished print.

A suitable dichroic image will be formed in a sheet sensitized and exposed as described above after about one minute in a developing composition of approximately the above formula, and the resulting print will have relatively even characteristics and shading. If a more contrasty print is desired, it may be obtained by adding to the developing solution a suitable reducing agent, which will suppress any free iodine or iodide ion in the solution and remove or destroy any stain accidentally produced thereby in the unexposed areas of the sheet, thus lightening the light areas in the print and so increasing its contrast. It is also desirable to add to the developing solution a weak alkali, which will act as a buffer for the acid and thus aid in keeping uniform the action of the developing solution by maintaining the pH value thereof relatively constant.

Either a reducing agent or an alkali or both together may be used for the above purposes, and a suitable compound for use in this connection is an appropriate photographic developer which will act both as an alkali and as a reducing agent. A suitable developer of this character comprises:

#### Formula III

|                            |     |     |
|----------------------------|-----|-----|
| Water                      | cc. | 500 |
| Monomethyl p-aminophenol   | gm. | 2.5 |
| Sodium sulfite, desiccated | gm. | 30  |
| Hydroquinone               | gm. | 2.5 |
| Alkali                     | gm. | 20  |
| Potassium bromide          | gm. | 5   |

Water to make 1 liter.

A developing compound of the character given in Formula III is known to the art and specific reference thereto will be found in the handbook entitled, *Photographic Chemicals and Solutions*, Crabtree and Matthews, American Photographic Publishing Company, Boston, Massachusetts, 1938, at page 290, and under the heading "(DK-60)." The quantity of the compound set forth in Formula III to be added to the developing solution depends largely on the degree of contrast desired in the prints, but in general it may be stated that satisfactory results are obtained by using approximately the following illustrative formula:

#### Formula IV

|                         |     |      |
|-------------------------|-----|------|
| Water                   | cc. | 1000 |
| Acetone                 | cc. | 100  |
| HCl (38%)               | cc. | 2    |
| Ammonium iodide         | gm. | 10   |
| Potassium iodide        | gm. | 2    |
| Boric acid              | gm. | 10   |
| Compound of Formula III | cc. | 40   |

As in the preceding case, a suitable dichroic image will be formed in a sheet sensitized and exposed as described above after about one minute in the just-noted solution. If desired, however, the degree of contrast may be increased by then treating the sheet in an intensifying solution containing a reducing agent and preferably also a weak alkali. This treatment will further bleach and clear up the light areas, but care must be taken not to continue it so long that the highlights or other areas are affected. Ordinarily a minute should be sufficient, and a suitable illustrative formula for such a bath is as follows:

#### Formula V

|                         |     |     |
|-------------------------|-----|-----|
| Water                   | cc. | 160 |
| Acetone                 | cc. | 25  |
| HCl (38%)               | cc. | 5   |
| Boric acid              | gm. | 2   |
| Potassium iodide        | gm. | .5  |
| Compound of Formula III | cc. | 15  |

When the foregoing steps are completed, the print need only be wiped or otherwise dried and will then be finished. It will have approximately the appearance illustrated in Fig. 3, wherein print 20 bears a positive reproduction in dichroic areas of the image of negative 12, but the image will be relatively faint when viewed as in Fig. 3 without an analyzer. This is due to the fact that print 20, speaking in terms of optics, is merely an imperfect polarizer, which absorbs some of the light vibrating in one direction proportionally to the variations in density of its stained areas, but transmits the remainder of that component and all of the component vibrating in the opposite direction. In order, therefore, to see the image thereon properly, it should be viewed through a suitable crossed analyzer.

Such an arrangement is shown in Fig. 4, wherein a polarizing element 30 of uniform polarizing characteristics is shown superimposed on print 20, with its polarizing axis at right angles to that of the print, as indicated by arrows 25 and 35. The result is that analyzer 30 absorbs all of that component of the light which is freely transmitted by print 20. On the other hand, the analyzer transmits the other component of the light, which is the component differentially absorbed by the print, and will thus cause the image on print 20 to appear in as complete detail and with as high a degree of clarity as a photographic print of nega-

tive 12 produced by conventional photographic methods. Conversely, if analyzer 30 were rotated through ninety degrees with respect to print 20, it would then act to absorb the remainder of the component differentially absorbed by the print, with the result that the image would disappear and the combined elements would appear substantially uniformly transparent.

The process of the invention is well adapted to the production of dichroic stereoscopic images. For example, the image shown in Figs. 3 and 4 may be assumed to be one image of a stereoscopic pair. In that event the other image should be reproduced on a plastic sheet having its molecules oriented substantially at right angles to the direction of molecular orientation in sheet 20. The two sheets may then be superimposed with the images thereon in relative stereoscopic registry, and the resulting composite image will have a three-dimensional effect when viewed through proper polarizing viewing means, in accordance, for example, with Patent No. 2,203,687.

The terms "dichroism" and "dichroic" as used herein and in the claims are intended to refer to the property of polarizing transmitted light by differential absorption according to vibration direction. It will be noted that in its simplest form the process of the invention may be practiced to produce a uniform dichroic light-polarizing sheet. This may be done, for example, by sensitizing a sheet of the desired molecularly oriented plastic, exposing the sheet uniformly to light, and then treating as described above to produce a uniform dichroic stain therein. It is to be understood that this and similar modifications of the process of the invention are to be construed as coming within the scope thereof.

It should be pointed out that it is not at all essential to the practice of this invention that the various steps of the preferred process thereof be carried out continuously. For example, the sensitizing treatment may take place at an entirely different time from the remainder of the process. It should also be noted that these sheets are relatively low in light sensitivity, and that only moderate care need be taken to protect them from exposure to extraneous light while carrying out the other steps of the process of the invention.

The foregoing practices involving the use of a light-sensitive oxidizing agent provide a relatively simple process by which dichroic images may be easily and readily formed. However, it is to be kept in mind that the invention has for a concept the use of any oxidizing agent which will release a dichroic stain from a solution of a suitable oxidizable material and the incorporation of the oxidizing agent in predetermined portions of a suitable plastic by practices other than those described as depending upon the ability of an exposed light-sensitive oxidizer to substantially remain in the plastic while the unexposed oxidizer is removed by washing. Thus, the inventive concept comprehends in addition to oxidizing agents which are sensitive to light, the use of relatively light-insensitive oxidizing agents incorporated or introduced into a sheet of a suitable plastic. Many oxidizing agents in addition to the dichromates and including inorganic and organic materials are known and all are included within the scope of this invention. As a few illustrative examples of suitable inorganic materials of this character, mention may be made of metallic salts such as ferric salts, for example ferric chloride, and cupric salts, for example cupric sulfate, cupric chloride and cupric nitrate, as well as

sodium salts of oxidizing acids such as sodium perchlorate and sodium perborate. Examples of organic oxidizing agents suitable for use with this concept of the invention may be found in p-benzoquinone and other quinones. The oxidizing agents disclosed may be employed singly or a mixture of several of the same may be used.

Preferably the oxidizing agent should be water soluble and all of those just named are of this character. An oxidizing agent may be predeterminedly introduced into a suitable plastic sheet by imbibition from a water solution. On treatment of a sheet in which one or more oxidizing agents have been imbibed with any of the treating or developing solutions heretofore described in connection with the preferred practice, a dichroic stain in the form of iodine will replace the oxidizing agent.

In dichroic image formation, a water solution of an oxidizing material or mixture of such materials is preferentially imbibed into the sheet from a saturated wash-off gelatin relief to provide a desired image comprising an oxidizing agent. Following introduction of the oxidizing agent into the plastic sheet, the sheet is treated in any of the developing solutions heretofore mentioned. A water solution of from 2% to 5% concentration of any of the materials just mentioned is suitable for use in carrying out these practices.

A gelatin wash-off relief which carries a positive reproduction of a photographic negative image may be prepared in accordance with conventional practices. For example, such a wash-off relief may be formed in the manner set forth in Patent No. 2,315,373, issued March 30, 1943, to Edwin H. Land, for Process for forming light-polarizing images. Briefly, the relief is made by printing through a photographic negative onto suitable wash-off relief film. In this regard, the printing step illustrated in connection with Fig. 1 for forming an image comprising an oxidizing agent in light-sensitive plastic sheet is similar to that employed for exposing wash-off relief film if wash-off relief film is considered as substituted for the sheet 10.

Following development of the wash-off relief, which is carried out by standard procedure, the relief is saturated in a water solution of the desired oxidizing agent or agents. Usually, one or two minutes will be sufficient to suitably saturate the wash-off relief.

The developed wash-off relief, which is illustrated in Fig. 2 by the reference numeral 40, following its saturation with the oxidizing agent is placed in face to face contact with the surface of the plastic sheet in which the dichroic image is to be formed whereby to print such image on the sheet. The relief and the plastic sheet are pressed into contact, a convenient method for carrying out such a step being illustrated in Fig. 2 wherein the developed and saturated relief 40 is shown superposed with the relief side thereof upon the oriented surface of a sheet of polyvinyl alcohol 42. Fig. 2 as a matter of convenience shows the two elements 40 and 42 supported on a flat surface such as the surface 44 and any device such as a rubber roller 45 or squeegee pressing the two sheets evenly together. The relief and the plastic sheet should be allowed to remain in contact for several minutes during which time the oxidizing agent will transfer from the relief to the plastic sheet in well-understood manner.

Since the amount of the oxidizing agent held by the relief varies in accordance with the thickness of the gelatin layer at each particular point,

the oxidizing agent will be differentially imbibed into the plastic sheet proportionally to the thickness of the relief, and because the variation in the thickness of the relief corresponds to the variation in density of the original photographic negative image from which the relief was produced, a positive reproduction of the negative image in terms of the oxidizing agent will be formed in the sheet 42.

Having formed an image of an oxidizing agent in the plastic sheet by imbibition, the next step in this embodiment of the invention is to convert this image to a dichroic image. This may be conveniently done by treating the sheet in the manner already disclosed in any one of the heretofore described developing solutions containing the oxidizable material, for example, in an acid solution of an iodide or mixture of iodides. Following dichroic image formation which takes place in a manner like that already set forth, the sheet may be washed and dried. The effect of this process is to provide a dichroic image in oriented plastic sheet similar to that disclosed in connection with Figs. 2 and 3. A pair of images produced in this manner and forming a left-eye image and a right-eye image may be superposed upon each other to provide a stereoscopic image which may be viewed through suitable viewing devices.

As stated in connection with the process employing a light-sensitive oxidizing agent, the invention may be practiced to produce a uniform dichroic light-polarizing sheet by imbibing a solution of a relatively light-insensitive oxidizing agent throughout the sheet and then treating the sheet and imbibed oxidizing agent to create a dichroic stain.

When forming light-polarizing images by preferential imbibition of an oxidizing agent in plastic sheet, it is also to be noted that it is not essential to the practice of the invention that the various steps of the process described in connection therewith be carried out continuously. For example, the imbibition of the oxidizing agent in the plastic sheet may take place at an entirely different time from the remainder of that process.

The term "oxidizing agent" as used in the specification and claims is to be understood as meaning a single oxidizing material or a mixture of several oxidizing materials.

It should be understood that many types of images other than photographic negatives may be reproduced by this process, such for example as a negative or positive of any other partially light-transmitting type or an opaque object of which it is desired to make a silhouette. The invention is particularly adapted, for example, to the reproduction of stencils, drawings, half-tones, printed matter and the like. Negative 12 in Fig. 1 should be considered, therefore, as representative of any such similar medium which will differentially absorb the light incident on the sensitized sheet, and the reproductions therefrom made by the process of this invention will be positive reproductions, that is to say, the light values therein will be reversed with respect to said negative.

As has been previously stated, the foregoing description is merely illustrative of one or more operative forms of the processes of the present invention. It must again be emphasized that each step therein is a variable, and that none of the ingredients, times or proportions given for any step is critical except in so far as it may be made so by the other variables. It follows, therefore, that great variation is possible and that virtually any

degree thereof in one or more steps can be compensated for in the other steps.

Since certain changes may be made in carrying out the above process without departing from the scope of the invention, it is intended that all matter contained in the above description shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. The process which comprises treating a carrier sheet with a dichromate solution to render it light-sensitive, exposing said sensitized sheet to light through a differentially light-transmitting medium, removing the unexposed dichromate therefrom, and treating said sheet with an acid solution of an iodide which reacts with said dichromate to give a dichroic image as an oxidation product.

2. The process which comprises treating a sheet of a molecularly oriented transparent, hydrophilic, linear polymeric plastic with a dichromate solution to render it light-sensitive, exposing said sensitized sheet to light through a differentially light-transmitting medium, removing the unexposed dichromate therefrom, and treating said sheet with an acidic iodide solution which reacts with the dichromate therein to produce a dichroic stain.

3. The process which comprises imbibing a sheet of a substantially oriented, transparent, hydrophilic, linear polymeric plastic in a dichromate solution for a time such that only a relatively thin layer on the surface of said sheet is penetrated by said solution, exposing said sheet to light through a differentially light-transmitting medium, removing the unexposed dichromate therefrom, and then developing the exposed dichromate in an acidic iodide solution which reacts with the dichromate to produce a dichroic stain in the exposed areas of said sheet.

4. The process which comprises treating a sheet of predeterminedly molecularly oriented polyvinyl alcohol with a dichromate solution to render it light-sensitive, exposing said sensitized sheet to light through a differentially light-transmitting medium, removing the unexposed dichromate therefrom, and treating said sheet with an iodide in an acid medium whereby the iodide is oxidized by the exposed dichromate to iodine to form an image in iodine in said carrier.

5. The process which comprises treating a sheet of predeterminedly molecularly oriented polyvinyl alcohol with a dichromate solution to render it light-sensitive, exposing said sensitized sheet to light through a differentially light-transmitting medium, removing the unexposed dichromate therefrom, and then treating said sheet with an acidic iodide solution which reacts with the exposed dichromate therein to produce a dichroic stain in the exposed areas thereof.

6. The process which comprises treating a sheet of predeterminedly molecularly oriented polyvinyl alcohol with a dichromate solution to render it light-sensitive, exposing said sensitized sheet to light through a differentially light-transmitting medium, removing the unexposed dichromate therefrom, and then treating said sheet with a solution containing an acid and at least one water-soluble iodide salt adapted to react with said exposed dichromate to produce a dichroic stain in the exposed areas of said sheet.

7. The process which comprises treating a sheet of predeterminedly molecularly oriented polyvinyl alcohol with a dichromate solution to render it light-sensitive, exposing said sensitized sheet to

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light through a differentially light-transmitting medium, removing the unexposed dichromate therefrom, and then treating said sheet with a solution containing an acid and at least one water-soluble iodide salt adapted to react with said exposed dichromate to produce a dichroic stain in the exposed areas of said sheet, said solution containing also a relatively weak alkali in sufficient quantity to maintain substantially constant the pH value thereof.

8. The process which comprises treating a sheet of predeterminedly molecularly oriented polyvinyl alcohol with a dichromate solution to render it light-sensitive, exposing said sensitized sheet to light through a differentially light-transmitting medium, removing the unexposed dichromate therefrom, and then treating said sheet with a solution containing an acid and at least one water-soluble iodide salt adapted to react with said exposed dichromate to produce a dichroic stain in the exposed areas of said sheet, said solution containing also a reducing agent.

9. The process which comprises treating a sheet of predeterminedly molecularly oriented polyvinyl alcohol with a dichromate solution to render it light-sensitive, exposing said sensitized sheet to light through a differentially light-transmitting medium, removing the unexposed dichromate therefrom, and then treating said sheet with an acidic iodide solution which reacts with the exposed dichromate therein to produce a dichroic stain in the exposed areas thereof, said solution also containing an agent which is adapted to slow the penetration into the sheet of said solution

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whereby to restrain softening of the sheet, said agent being substantially unreactive with the ingredients of said solution and said dichromate and also being a nonsolvent of polyvinyl alcohol.

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