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3,218,926

METHOD OF FORMING LIGHT MODIFYING DISPLAY REPRESENTATIONS
HAVING DIFFERENTLY ORIENTED POLARIZING AREAS

Filed Feb. 4, 1959

2 Sheets-Sheet 1

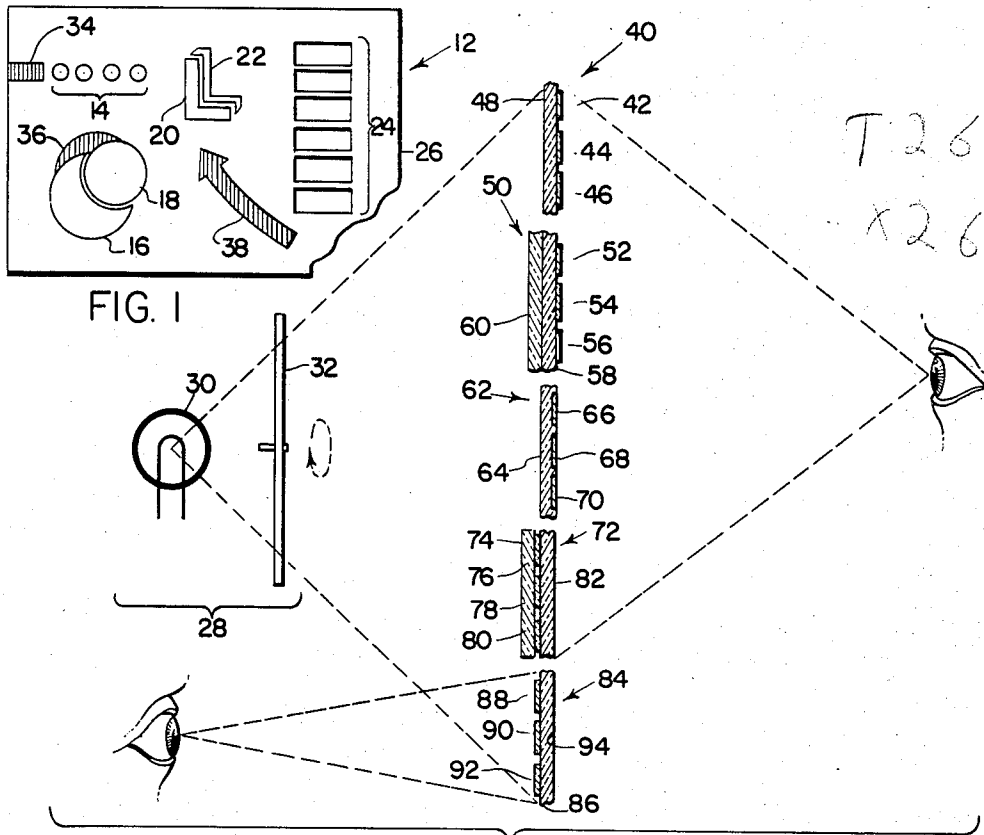


FIG. 2

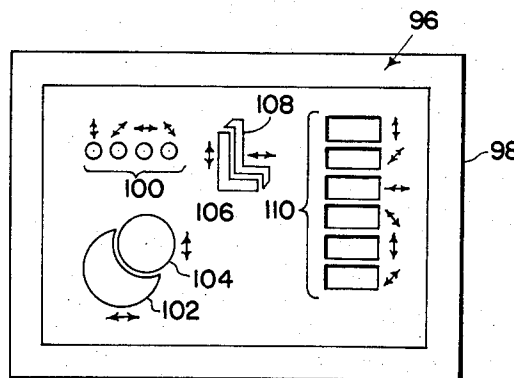


FIG. 3

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2 Sheets-Sheet 2

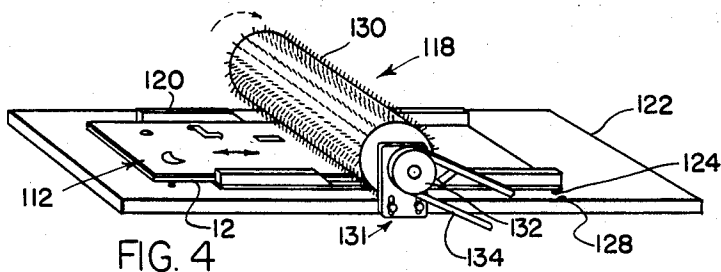


FIG. 4

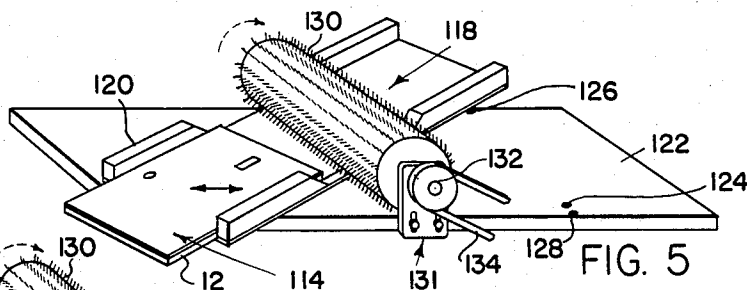


FIG. 5

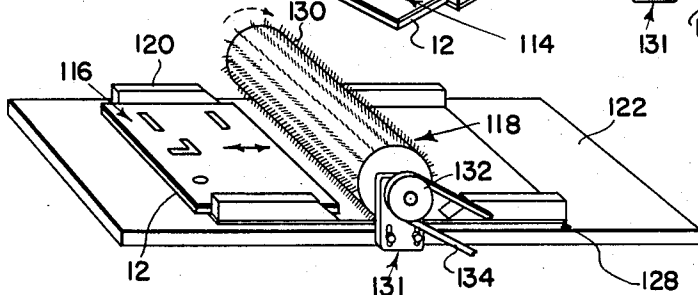


FIG. 6

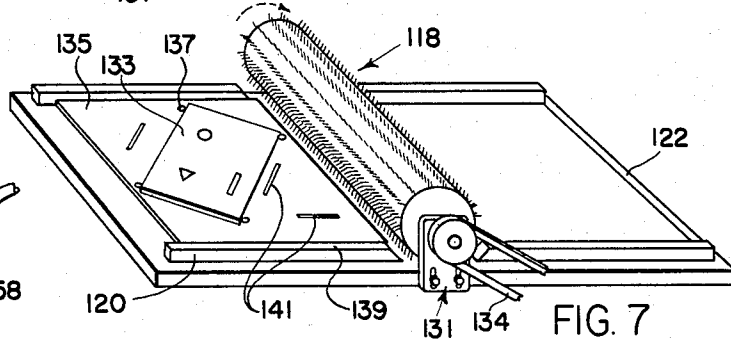


FIG. 7

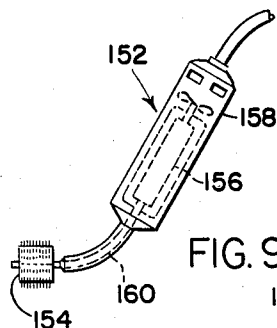


FIG. 9

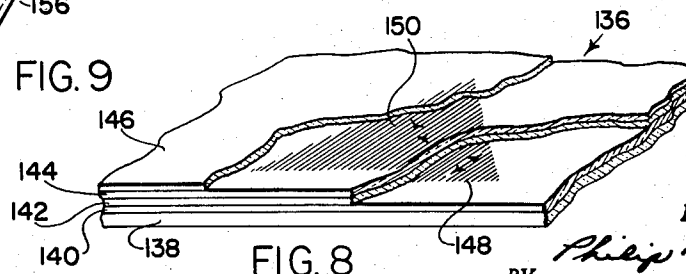


FIG. 8

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ATTORNEYS

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3,218,926

METHOD OF FORMING LIGHT MODIFYING DISPLAY REPRESENTATIONS HAVING DIFFERENTLY ORIENTED POLARIZING AREAS

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Filed Feb. 4, 1959, Ser. No. 791,116
2 Claims. (Cl. 88—65)

The present invention relates to an improved method for forming light-polarizing display representations and other light-polarizing materials, to products produced by the method, and to related apparatus.

Display representations of the type contemplated are in part disclosed in my copending patent applications, Serial No. 308,096 and Serial No. 540,460, now U.S. Patent No. 2,977,845, and may, for example, include such effects as moving objects, liquids, fire and smoke in motion, changing facial expressions, color changes, design changes, message changes and the like.

A principal object of the present invention is to provide a process which makes available displays employing light polarization on a practicable, low-cost, large quantity, production basis where heretofore, to the best of my knowledge, no process providing these advantages has existed; in other words, to provide a process for making displays employing anisotropic materials and axially changing polarized light, which is relatively simple and rapid of performance and, accordingly, economical. Other objects are to provide a process of the character described which, to a large extent, uses conventional, readily procurable and reasonably priced materials and employs operations bearing a certain similarity to operations with which the display artist and fabricator are entirely familiar; to provide a process in which such materials additional to said conventional materials as may be involved are also readily available and reasonably priced and can be employed by any worker in the display field who is of average intelligence and dexterity; to provide a process which does not necessitate the use of any unduly expensive manufacturing equipment; to provide novel products relating to methods disclosed herein; and to provide apparatus adapted to produce said products.

Other objects of the invention will in part be obvious and will in part appear hereinafter.

The invention accordingly comprises the apparatus possessing the construction, combination of elements and arrangement of parts and the several steps and the relation and order of one or more of such steps with respect to each of the others, and the product possessing the features, properties and the relation of elements which are exemplified in the following detailed disclosure, and the scope of the application of which will be indicated in the claims.

For a fuller understanding of the invention, reference should be had to the accompanying drawings, in which:

FIGURE 1 is a diagrammatic front view of a display representation produced by the process of the invention;

FIG. 2 is a diagrammatic side view, partly in cross-section, of various display structures produced by the process of the invention which also illustrates their proper relation to a source of polarized light and to the viewer;

FIG. 3 illustrates a silk screen or masking type of device for use in the process of the invention;

FIGS. 4, 5, 6 and 7 are diagrammatic perspective views of apparatus for treating a display to provide different orientations in certain areas for change effects;

FIG. 8 is a perspective view of a multilayer film material of the invention bearing two images; and

FIG. 9 is a side view of a handtool adapted to provide

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molecular orientation for use in the process of the invention.

In reviewing the literature with respect to use of light-polarizing materials in the display field it is immediately apparent that the cutting, orienting, fitting together, over-laying, and bonding of pieces of birefringent, light-polarizing, and support materials are usually if not invariably involved. Where the display is designed to produce a considerable variety of effects, many such pieces are required and the aforesaid operations of cutting, fitting, etc., can be very extensive, tedious and time-consuming and hence expensive, in terms of labor at least, and unadapted to quantity production. In other words, the great amount of handwork necessary has been a discouraging factor to the use of light-polarizing materials in this fields. Where any reduction of this handwork has been suggested, as occasionally has occurred in alternate proposals, the materials required in the simplified method have, of themselves, generally been too expensive for practical usage or have possessed some other drawback. It is with the aforesaid background in mind that the methods described herein are presented as largely overcoming these previous disadvantages and thereby making the use of light-polarizing materials available to the display field on a quantity-production and economical price basis, namely, on the only basis which can be considered in this field from a commercial viewpoint. It may be observed, in this connection, that light-polarizing areas having lower density ratios and a less exacting optical quality than are customarily required of commercial polarizers may be entirely satisfactory for use in the display field.

The term "display" or "display representation," as employed herein, is intended to apply to any pictorial or other representation, image, print, or area which may be produced by the method disclosed. While primarily referring to displays in the conventional sense, as customarily employed for public and commercial purposes such as in the advertising field, the representations might be of a type designed primarily for consumer use, i.e., of a utilitarian or an artistic or aesthetic nature, or, again, they might merely be in the form of panels, devoid of pictorial or other subject matter, and the present invention is intended to comprehend any of the foregoing categories.

Referring to FIG. 1, a diagrammatic representation of the display 12 produced by the process of the invention is illustrated. No particularly significant message or design is shown, it being the intention principally to indicate that various portions of the representation are capable of changing in appearance or that they differ from one another in a manner to be described. Design areas 14, 16, 18, 20, 22 and 24 are what may be termed "change areas" because they are anisotropic and undergo a change in appearance in response to axially changing polarized light or contribute to a change in appearance in some other element. These areas are formed on or within a supporting sheet material 26 which, assuming a light source positioned behind the representation, is translucent in portions surrounding the areas or which, assuming a light source in front of the representation, is to a degree reflecting. Inasmuch as a rear-lighted display representation probably has the greater utility because it is adapted to be positioned in restricted locations such as a window or counter of a commercial establishment, it will be assumed that the light source is located behind the display representation unless otherwise indicated. The light source comprises means for polarizing emitted light rays and for changing the polarizing direction of these rays in a given manner. An example of a light source in this category is shown in FIG. 2 wherein the light source 28 includes a bulb 30 and a

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rotatable light-polarizing filter 32 positioned in front of the bulb, motivating means for the filter being a heat motor or an electric motor (not shown).

Further referring to FIG. 1, the display representation 12 also includes other design areas 34, 36 and 38 rendered in a conventional medium, i.e., a translucent dye, printing ink or pigment applied by any known printing technique from a plate or other medium such as by lithography, silk screen or the like. The background material or surrounding area 26 may also be similarly formed and may contain pictorial matter or a continuous tone or color according to the character of the display representation, it being understood that all parts of the representation are parts of an overall design concept and that both conventional and "change areas" may cooperate with one another to provide effects of motion or change. As mentioned, no particular design is intended in FIG. 1, but, in response to axially changing polarized light, the balls 14 will appear to move outwardly from muzzle 34, design elements 16 and 18 will appear and disappear or change in color, the letter "L" 20 and its shaded portion 22 will alternately appear and disappear or undergo color change, and a flowing movement of densities or color will appear in the areas 24.

Various possible formations of the "change areas" are illustrated by the fragmentary sections of display representations shown in FIG. 2, the sections being functionally positioned with respect to a polarizing light source 28. It is to be understood that each section is preferably to be considered as a part of a complete individual display and that each would have at least an individual polarizing light source associated therewith and be separately viewable. The grouping of the sections with a single light source is merely to avoid showing an individual light source with each section and the necessity of presenting a separate figure for each example. Referring now in detail to each of the display sections illustrated in which the various anisotropic areas described are the "change areas" of the representation, section 40 comprises light-polarizing areas 42, 44 and 46 having relatively different polarizing directions formed on transparent portions of an isotropic translucent display sheet 48. For a modified color effect, the sheet 48 may be birefringent. Section 50 comprises light-polarizing areas 52, 54 and 56 having relatively different polarizing directions formed on transparent portions of translucent display sheet 58. A birefringent layer 60, i.e., a half-wave plate, is bonded to sheet 58. Section 62 comprises a transparent, molecularly orientable display sheet 64 having relatively differently oriented light-polarizing areas 66, 68 and 70 formed therein. Section 72 comprises a transparent support 74 which may or may not include display subject matter, relatively differently oriented birefringent areas 76, 78 and 80 formed on clear areas of support 74, and a uniformly light-polarizing layer 82. Alternatively, for a somewhat different effect, support 74 would be omitted and the birefringent areas formed on layer 82. Each of the above-described "change areas" preferably has a light-diffusing formation or structure on or within its external surface nearest the viewer. This external surface is generally to be considered of a uniform consistency. However, it may be streaked or lenticulated or otherwise patterned by an orientation-providing means and can also have an image-forming ink or dye printed thereon. Section 84 represents a fragment of a reflecting type of display and comprises a transparent support 86 having relatively differently oriented light-polarizing areas 88, 90 and 92 and reflecting surface 94. Support 86 may or may not be birefringent, depending upon the intended effect. While the "change areas" of the first three light-transmitting sections (from top to bottom) are located on the sides of the sections remote from the light source and toward the viewer, they could be formed on the opposite sides and might preferably be thus located for obtaining certain effects. Although the sections are shown as flat, it is to

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be understood that they may be curved or otherwise depart from a planar form. The foregoing constructions are merely illustrative of many such which can be provided by the process to be described hereinafter and all can be utilized to furnish interesting and striking color, change or animation effects.

Turning now more particularly to the actual practices of forming the display representations on a production basis, it has already been noted that conventionally rendered areas of the display, where such areas are included, i.e., the areas 34, 36 and 38 of FIG. 1, can be produced by known printing techniques such as lithography or silk screen which employ printing plates or other printing media and which are adapted to quantity production. It is generally to be assumed that the representations, for example, a large run thereof, are first printed with whatever subject matter of this nature they are to include. The delineation of areas to be occupied by the "change areas" is also provided at this time by printing their outlines or simply by leaving the areas blank. In some instances, for pictorial reasons, printed subject matter, i.e., configurations, color, etc., may also be introduced by the aforesaid printing operations into the "change areas."

Upon completing the formation of any printed areas, as above described, or in the event that no such areas are to be included and the entire display is to be composed of the "change areas," the run of sheet material is ready for treatment to provide the latter areas in the portions designated therefor. If the supporting material 26 has a rough or porous surface, a sizing or filler substance such as a quick-drying varnish or cellulose lacquer may first be applied to advantage, particularly to prevent absorption of a solution to be subsequently applied. If the surface requires treatment for improving its adhesive characteristics relative to the solution or applied film to be used in forming the "change areas," a subcoat may be applied for the purpose. In general, application of a proper solution to the surface of the material 26 for forming the "change areas" is described herein as a procedure having the wider field of usage. However, as shown in FIG. 2, a preformed film of an orientable material, represented by section 62, can be employed either alone if of sufficient thickness and rigidity or, if a thin film, bonded to a supporting material. In either case it is the portions adjacent the surface which are oriented.

Either the entire surface of the material 26 or merely the areas 14 through 24 may be treated to improve the adhesive properties thereof relative to the solution to be applied for the change effect, i.e., the surface may constitute a hydrolyzed cellulosic material. Assuming, for example, the change-providing solution to be an aqueous solution of a hydroxyl-containing vinyl polymer such as polyvinyl alcohol and the supporting material to be cellulose acetate, the subcoat is a hydrophilic substance as for example, a carboxy- or sulpho-substituted benzal of polyvinyl alcohol or a substance comprising cellulose nitrate. If the "change areas" are to be light polarizing, an aqueous solution of a dichroic stain or dye, i.e., an iodine or iodide stain or a direct cotton dye, is either incorporated in the change-providing solution or it is added to the areas after the solution has been applied, hardened, and preferably oriented. A dichroic dye, as employed herein, is one capable of differentially absorbing the components of an incident beam of light depending upon the vibration direction of the components. The dichroic stain or dye may be of a neutral tone or of any selected color. Dichroic dyes of a plurality of colors may also be employed in the "change areas." Suitable dichroic dyes comprise those having sulfonic acid groups, phenolic hydroxyl groups, or carboxylic acid groups, examples of which are Niagara Sky Blue 6B (C.I. 518), Solophenyl Fast Blue Green BL 200% (C.I. 520), Solantine Red 8BL (C.I. 278), Chlorantine Fast Red 5B, Solantine Pink 4BL (C.I. 353), Solantine Yellow 4GL (Portotype 53), Pyrazoline Orange 5G, Stilbene

Yellow 3GA (C.I. 622) and Eriofom Violet 2R. Other substances, suitable for use in the form of a liquid coating for ultimate conversion to an anisotropic or light-polarizing coating, and with the addition of a plasticizer as required, comprise a polyvinyl acetal, polyvinyl alcohol plus a cross-linking agent and a mordant or a reaction product thereof, polyvinyl trifluoroacetate, modified cellulose triacetate, ethyl cellulose, regenerated cellulose, etc. A suitable mordant may comprise a linear, high molecular weight, water-soluble, basic nitrogen-containing polymer selected from the class consisting of a polyvinyl acetal an amino aldehyde, deacetylated chitin, a β -diethylamino-ethylmethacrylate polymer and a polyvinyl pyridine quaternary ammonium salt. The cross-linking agent may, for example, be one selected from the class consisting of boric acid, dimethylolurea, glyoxal and diphenyl diisocyanate. If the supporting material 26, of itself, possesses adequate adhesion characteristics, the subcoat may be omitted, it being necessary only to insure that the surface is completely clean. Materials suitable for use as the supporting sheet material, with or without subbing as the need may be, comprise, for example, cellulose acetate, cellulose acetate butyrate, cellulose triacetate, polystyrene, polyethylene, vinyl resins, glass, or, if a reflection type of display is contemplated, a metal such as aluminum or steel, fibre board, plywood, or some other material treated with a reflecting coating.

After the change-providing solution, for example, a solution comprising polyvinyl alcohol, has been applied, preferably in the form of a somewhat viscous coating material to the areas 14 through 24 and solidified to a given degree, as by the application of heat thereto, the display is ready to be treated for obtaining various desired orientation of the coating within the areas. By "orientation" is meant, broadly, a state of molecular or minute particle alignment which is characterized by anisotropism and which, at least in part, is adapted to provide the change effect. In a preferred embodiment of the present invention this consists of providing various molecular orientations of an at least partially solidified coating solution in the "change areas." A preferred solution for the purpose is one comprising a linear, high molecular weight hydroxyl-containing vinyl polymer of which polyvinyl alcohol or a derivative is particularly suitable.

The change-providing solution is applied to the supporting sheet material 26 by any of several methods. If a large part of the display is to be made up of the "change areas," and assuming that the solution contains no polarizing stain or dye or that no polarizing film such as polarizer 82 is to be placed across the face of the display, the entire surface can be treated with the solution as by a spraying, brushing, or immersion operation. If but a few or a medium number of "change areas" are to be included and not too great care is required to limit the solution strictly within the confines of the "change areas," it can well be applied by a brush or as a spray directly to each of the areas. If it is imperative to register the solution precisely with each designated area which, of course, would be the case if it contained a stain or a dye and might otherwise be preferable also as, for example, to build up the area to the height of a mask, to be described below, a stencil or silk screen, or a combination of stencil and screen, is prepared having open portions corresponding generally to the areas to be coated with the solution. The screen or stencil is superimposed on the display sheet, including a bolting cloth or the like as required, the sheet being positioned on a flat surface or bed and the solution flowed, sprayed, brushed or squeegeed through the openings. The sheet is held either vertically or horizontally if the spray or brush method is used and is preferably held horizontally if the flow or squeegee method is employed. A stencil or silk screen 96 for applying the coating of the "change areas" 14 through 24 of FIG. 1 is shown in FIG. 3, the device being mounted in a frame 98, the protruding inner edges of which also serve to properly position

the underlying sheet 26. The open portions 100 through 110 will be noted as similar in configuration and location to the areas 14 through 24 of the display 12 of FIG. 1.

When the change-providing solution has been applied through the stencil and/or screen openings to the proper areas of the supporting sheet 26, as above described, the solution is solidified or hardened to a proper degree, merely by standing at room temperature or at a more rapid rate by an application of heat and circulating air. Hardening should proceed at least slightly beyond the tacky state and the areas are then ready for orientation. As shown in the orientation-providing apparatus of FIGS. 4, 5 and 6, a series of thin, wear-resistant masks 112, 114 and 116 of a transparent plastic such as an acetate or a metal, each preferably conforming in outside dimensions to the display 12, is employed in overlying fixed relation therewith, each mask having an opening or specially arranged openings for subjecting the "change areas" of the display surface selectively to applications of an orientating force or mechanical stress as, for example, to a preferably power-driven, orientation-providing element 118 at various chosen angles. The angles are controlled by guide means 120, adjustably mounted as, for example, by a central pivot (not shown) on a table 122. Positioning indicia 124, 126 and 128 are provided for establishing proper angular position. As illustrated, the orientation-providing element 118 comprises a power-driven, rotatable, cylindrical, friction-applying component as, for example, a brush-like member having at least moderately-stiff and closely-spaced protrusions such as bristles 130 composed, for example, of nylon, of a natural fibre, of a metal, or of some other natural or synthetic substance, but sufficiently flexible and so arranged as too penetrate the mask openings, if need be, and apply an orienting frictional force or stress to the "change areas." For this type of orientation-providing means, it may be desirable to make each mask opening slightly larger in the direction of rotation of said means than the underlying "change area" to insure contact with and orientation of the complete area or a coating of the solution can be built up in the "change areas" using a stencil for applying the solution, as previously described.

Alternatively, assuming supporting sheet 26 to be flexible or slightly deformable, it is first positioned on a yielding or resilient supporting material, i.e., of a sponge rubber, and each mask is compressibly clamped thereto. The areas of the sheet 26 underlying the mask openings are thus forced into the openings to become substantially coplanar with the upper surface of the mask. A vacuum blanket could be employed preliminarily for a somewhat similar purpose. Formation of sheet 26 in this manner facilitates contact of the orientation-providing means with the "change areas." Driving means for the element 118 are represented by the pulley 132 and belt 134, it being understood that an electric motor (not shown) is employed therewith.

The proper rotational speed of the element 118 is dependent upon such factors as the composition of the change-providing coating, its degree of solidification, the nature of the protrusions 130 and their spacing, the pressure employed, etc. For example, a rotational speed of approximately 6000 to 7000 r.p.m. has been found to be effective in conjunction with a substantially solidified coating formed from an aqueous solution of polyvinyl alcohol in the formation of an efficient anisotropic "change area," a relatively light pressure of the orientation-providing element being employed, but these speeds are in no sense arbitrary and very slow speeds are possible assuming incomplete solidification and adequate frictional contact. For this type of orientable material, it may be desirable that the orientation-providing element 118 shall generate a certain amount of frictional heat and provide both a softening and what may be considered as a drawing or shearing action or stress to obtain the desired molecular orientation. Care must be exercised

to insure a coating of proper thickness in the formation of a light polarizer to allow ample material for the orientation operation, thicknesses of from 0.0005" to 0.005" providing a good working range. Adjustable limit stop means such as slots and tightening bolts 131 are preferably included to control the spacing of element 118 from the floor of guide means 120 whereby the pressure of element 118 on the coating can be controlled and whereby display sheet materials of various thicknesses can be accommodated for treatment. Spring, weighted or other, loading of the element 118 may be employed to provide a constant selected pressure on the surface to be oriented. In some cases, use of an abrasive substance such as a powder with the orientation-providing means may facilitate obtaining the desired orientation and surface texture. It will be understood that a resilient mounting of element 118 would also permit it to "follow" a curved or irregular surface.

In FIG. 7 a modification of the orientation-providing apparatus or device is illustrated in which a mask-covered display 133 is mounted at a selected angle on a slidable carrier or platform 135 by positioning means such as pins 137. The carrier 135 is moved substantially at an angle of 90° to the axis of the powered element 118 between the guides 139. The carrier is adapted to accommodate displays of various sizes mounted thereon at various angles. Index marks 141 on the carrier indicate preferred angles for positioning the display thereon.

Assuming the coating solution for the "change areas" to have been either undyed (unstained) or dyed (stained) polyvinyl alcohol or a derivative, a brief application of the orientation-providing element 118 to the solidified coating at a given constant pressure provides a desired molecular orientation capable of producing a significant modification of incident light. The double-headed arrow on the upper surface of each mask indicates the direction of molecular orientation which would be provided at the angular relationships of the display 12 and element 118 illustrated. It will be understood that the display sheet could be a continuous strip composed of a plurality of areas such as that encompassed by the sheet material 26 and that the finally treated areas would then be cut apart from such a strip.

The openings shown in each of the masks of FIGS. 4, 5 and 6 will be understood as relating to the specific "change areas" shown in FIG. 1. For example, the mask 112 of FIG. 4 leaves uncovered the "change areas" 16, 14 (third from the left), 22, and 24 (third from the top) and permits a longitudinal orientation thereof; the mask 114 of FIG. 5 exposes the "change areas" 14 (fourth from the left) and 24 (fourth from the top) of FIG. 1 to a diagonal orientation, i.e., at 45° to the aforesaid longitudinal orientation; and the mask 116 of FIG. 6 permits orientation of the "change areas" 14 (first from the left), 20, 24 (first and fifth from the top), and 18 of FIG. 1 at 90° to that obtained by mask 114. Assuming that the "change areas" are to be light polarizing and that a dichroic dye or stain has not been included in the polyvinyl alcohol solution prior to its being applied to the sheet 26, an aqueous solution of the dye or stain of a desired concentration and color, or of a neutral tone, is now applied directly to the coated and oriented areas, preferably using the masks 112, 114, and 116, or their equivalents, superimposed on the display 12 for this purpose. Of course, if the areas are to be merely birefringent, no dichroic dye need be applied thereto. While but three possible orientations are provided by the angular relationships of the masks shown in FIGS. 4, 5 and 6, it will be noted that four such orientations are required for the display of FIG. 1 (as indicated by the double-headed arrows in FIG. 3) and that an additional mask to provide a 45° angular orientation opposite to that of FIG. 5, namely, at 90° thereto, would be required. It is to be understood that the "change areas" may also comprise

only a single orientation, or they may include orientations in excess of the four shown.

After completing the aforesaid operations for molecular orientation of the "change areas," the display 12 is separated from the last of the masks to be used and, after the "change areas" have been thoroughly dried, as by an application of circulating heated air, a protective coating of a transparent surfacing solution such as a lacquer, i.e., a commercial lacquer of a cellulosic or nitrate type, can advantageously be applied to the "change areas" to the entire display surface. If the protective coating is to be applied only to the "change areas," it is thus applied by a spray or brushing operation prior to removal of each mask. In addition to protecting the "change area" from weather, soil, etc., the coating may serve to improve its optical homogeneity, i.e., to return the "change area," which has possibly undergone a certain amount of abrasion tending to render it light diffusing, to, or at least sufficiently toward, the transparent state which it possessed when the change-providing solution was first applied. A certain amount of diffusibility may, however, be desirable. To insure best optical homogeneity and performance, it is desirable that the refractive indices of the change-providing and surfacing coating materials should be as similar as possible. As an alternate or supplemental procedure, the "change areas" are buffed to polish them or restore them toward transparency, as the need may be. Buffing may be performed with or without an overlying mask in position. If a single mask is used, it includes openings for all of the areas to be buffed.

It may, for example, be of advantage to form two or more differently oriented birefringent or light-polarizing change-providing layers in superimposed relation within a given "change area." This can readily be accomplished by coating a second layer of an orientable substance such as a solution comprising polyvinyl alcohol over the previously oriented or oriented-and-dyed first layer, as the case may be. The first layer may contain a cross-linking agent or other substance tending to prevent penetration of the second solution thereinto, which might impair its orientation, or it may have had an essentially insoluble subcoat applied to its outer surface. The change-providing solution for the second layer is preferably applied by using the same mask as that employed in applying the solution to form the first layer, or it can be applied without using a mask as above described with reference to applying the first layer. The second layer is oriented by the orientation-providing element 118 but in a different direction, i.e., at 90° to that of the underlying first layer. It is then stained or dyed to render the area light polarizing. Orientation of the first layer could be provided at the angle shown in FIG. 5, namely, at 45° to the horizontal. The second layer would then be subjected to orientation with the guide means rotated to a position also at 45° to the horizontal but a 90° to the direction shown.

The foregoing method of applying a solution of an orientable material to a base, orienting the material, rendering it light polarizing by an application of a dichroic dye or stain, applying a second coating of the first named solution or one generally similar, orienting the coating in a different direction, and rendering it also light polarizing may be somewhat extended in its application to form, in terms of a light-polarizing dye or stain, two differently oriented light-polarizing images, i.e., photographic images. These images may be employed for change or animation effects or even for stereoscopic purposes when observed with properly oriented light-polarizing viewing means. Where more than two superimposed light-polarizing layers or images are desired it would also, of course, be possible to form them by repeating the procedures described above to provide a different orientation of each layer. In any such constructions it is necessary that at least an underlying layer, and preferably that the surface layer as well, be rendered clearly transparent, as above described.

It will be understood that where substantially entire areas of superimposed differently polarizing layers are to be formed from superimposed liquid coatings which are solidified and oriented no overlying masking means would be required, the complete surface of each layer being subjected to the orienting device 118. FIG. 8 illustrates such a construction 136, the assembly, for example, being in the form of a transparency and comprising a base 138, a molecularly oriented coating 140 comprising, for example, polyvinyl alcohol, a subcoat 142 of a lacquer, or the like, a second and differently molecularly oriented coating 144 and a surface coating 146. One image 148 is rendered in a dichroic stain or dye on coating 140 and a second image 150 is also rendered in a dichroic stain or dye on coating 144. The subcoat 142 may be omitted assuming coating 140 to have a large content of a cross-linking agent, to be dried rapidly, or to be otherwise rendered substantially unaffected as to its orientation by the second coating 142. It is to be understood that layer 140 may, alternatively, be a preformed, molecularly oriented film laminated to base 138 and that subcoat 142 or coating 144 may be formed thereon.

While FIG. 3 has been described as a stencil and/or a silk screen for applying a viscous change-providing solution comprising polyvinyl alcohol to "change areas" of a display sheet, it may also be regarded as illustrative of a single thin mask which would be overlaid only once on the display sheet 26 to control all of the various orientations of the "change areas." In this instance, the double-headed arrows in FIG. 3 indicate the directions in which the orientation-providing means is to be applied within each of the openings 100 through 110. In FIG. 9 a portable type of orientation-providing device 152, preferably for use with a single mask of the aforesaid type, is shown. The device comprises a rotatable, brush-like, orientation-providing element 154, generally similar to a shortened version of element 118, above described, driven by a motor 156 and enclosed in a casing 158. The axis of the element 154 is angularly disposed relative to the axis of the motor shaft for convenience of operation. A flexible connecting shaft 160 provides the aforesaid angular relationship of the axes, but other means such as proper gearing or a friction or pulley drive may be employed for the purpose. The device 152 is actually a handtool which permits the element 154 to be moved across each "change area" in any given direction, either freely or by guide means (not shown), to provide the orientations desired. While the element 154 may be applied independently of a mask, it will be apparent that a mask serves to exactly define the edges of the "change areas" and that the directional arrows located beside each opening of the mask immediately indicate the proper directions of orientation to be provided, both of which greatly facilitate a more rapid and precise operation.

While directions of orientation have thus far been described as linear, it is perfectly feasible to orient the "change areas" in curved directions as, for example, by freehand use of the handtool 152, or in conjunction with curved guide means therefor, or by a modification of the orientation-providing device of FIGS. 4, 5 and 6 in which, for instance, the guide means 120 is rotated while a sheet material, coated with an orientable surface, is moved linearly into contact with the orientation-providing element 118. It is to be understood that the latter element is not limited to the rotatable, friction-applying means shown. Thus, for example, it may, instead, be an oscillating element, vibrating back and forth very rapidly, or it may be a fixed or translationally movable element, as of a squeegee type having a resilient surface of rubber or the like beneath which the display 12 is caused to undergo relative movement, with or without a mask applied thereto, according to the objective. Although a less preferred method, the present invention is also intended to comprehend the application of a solvent or other relaxing medium through the openings of a mask

to an oriented layer to modify the orientation thereof. Where the application of a polarizing dichroic stain or dye to an oriented coating by a dipping or immersion method has been described, it will be appreciated that areas of the display which are to remain free of the dye would be protected by a resist or a mask affixed thereto for the purpose. Surfacing materials nonreceptive to the dichroic dye, i.e., water-repellent materials, may thus be employed to whatever degree is desired in portions of the display, exclusive of the "change areas." The change-providing coating solution may, alternatively, be applied by a resist method instead of using a screen or a stencil. Assuming the "change areas" of the display material to be pretreated so as to be receptive to the coating solution, and other areas to be nonreceptive thereto, the entire surface could be subjected to the solution which would then be wiped away or otherwise removed from the nonreceptive areas.

The masking procedures described herein are also adapted to be used in forming a type of light-polarizing material having a plurality of polarizing orientations which differs from that previously described. Thus, for example, the mask represented by FIG. 3 or each of the masks of FIGS. 4, 5 and 6, in sequence, is placed on a surface to be oriented, namely, on a suitable surface of plastic, glass or metal, and an orientation-providing device such as a buffing roll of a fabric, or of sponge-rubber, or one of the devices 118 or 154, is applied to the surface, through the mask openings, in different prescribed directions to obtain an oriented condition of the surface. A solution of a dichroic dye or dyes is then applied to the surface, for example, again through the mask openings or by the aforementioned resist method, and brought to a proper state of orientation during its change from a liquid condition, i.e., during its solidification. The mask is then removed, a protective lacquer applied, preferably to the entire surface, and a sheet material having a plurality of differently oriented light-polarizing areas is thus produced. Another procedure contemplates the application, through the mask openings, or an orientation-providing means which is itself composed of the material to be oriented. In this instance, oriented portions of the orientation-providing means would be deposited on the sheet material.

Where aqueous solutions of potentially birefringent or polarizing substances have been described herein for application to the supporting material, it is possible to package these solutions in proper bottles, cans, or the like, or to package the ingredients of a solution as a dry mixture of a powder or flake, for ready distribution to the display industry. Thus, for example, an aqueous solution of proper viscosity, preferably employing distilled water as a solvent and comprising polyvinyl alcohol and one or more of such ingredients, previously described, as a plasticizer, a dichroic dye, a mordant, and a cross-linking agent, together with a preservative or a fungicide and, possibly, a small amount of an alkali to achieve a pH of at least seven to prevent gelation, might readily be prepared and made available to the trade. In addition to the constructions described at length herein, certain of the steps involved are adapted to the production of a linear sheet polarizer as, for example, by applying a solution comprising a hydroxyl-containing vinyl polymer such as polyvinyl alcohol to a substantially isotropic base, molecularly orienting the solidified solution by applying a mechanical stress to the surface either by a moving element, such as the above-described cylindrical means or belt, or a fixed element, as of a squeegee type, applying a transparent surface coating if required to meet optical or surface-protection standards, and, at a stage prior to adding the surface coating, adding a dichroic dye to the polymer. A circular polarizer may be made by a similar method but employing a quarter-wave material as the base or bonded thereto.

It is further contemplated that both the coating and its

orientation direction may be provided as a single step. Assuming, for example, the solution to be of a type comprising preformed elongated particles such as a plurality of relatively short, molecularly oriented filaments of a hydroxyl-containing vinyl polymer, preferably pretreated with a dichroic dye, and suspended in a proper, non-solvent, colloidal or viscous carrying medium, application in a given direction to a transparent base sheet from a brush, i.e., a hand-held brush dipped in the solution, provides an orientation of the particles in the direction of the brush strokes. A colloidal suspension of light-polarizing or polarizable crystals or metallic particles could similarly be applied. Or, a viscous, quick-setting solution comprising polyvinyl alcohol or other suitable molecularly orientable substance is applied across the surface of a carrying sheet, at the same time undergoing sufficient solidification to provide its orientation by reason of the relative movement of the sheet and applying means and the adhesion of the partially solidified solution to the sheet surface and the solution applying or dispensing means, respectively.

The apparatus of FIG. 4, omitting the mask, would be eminently suitable for forming a sheet polarizer and, assuming a continuous supply of the coated base or supporting material, means such as a powered moving belt or takeup roll and slip clutch (not shown) for moving the material forwardly at a constant speed would be included. The speed of this movement, taken with the surface characteristics, compressive force, and movement of element 118, or the frictional effect of a fixed element in its stead, and the characteristics of the coating itself, serve to determine the orientation provided as well as the surface texture obtained. Where the orientation-providing element is, for example, a smooth surfaced roller or a fixed squeegee, it is quite likely that no abrasion of the surface of orientable coating or film need occur to obtain a satisfactory orientation.

Where translucency, only, is essential as, for example, in the production of a panel having a decorative or glare-reducing function, or both, a supporting material having a diffusing property such as a vinyl sheet having a suspension of diffusing particles therein, a sheet of fibre glass, or the like, may be employed for carrying the solidified and oriented solution.

A further modification of the method disclosed herein contemplates an embossed or relief type of supporting material, printed or not according to the design requirements, which, after coating with a potentially anisotropic substance and solidifying the coating, is subjected to an orientation-providing device of a type previously described. In this instance, use of a mask on the material during application of the solution by either a brushing or a surface wetting technique and during the orientation operation is not necessary as only the "highs" of the embossed material would be contacted. These areas would then be processed, namely, dyed and surface treated as required, and would constitute the "change areas" of the display. Treatment of both sides of the embossed supporting material in the manner described is also readily possible inasmuch as the low areas of one side constitute the high areas of the other which, in effect, would provide a sheet composed entirely of "highs" and easily adapted to at least two orientations on a production basis. A wide moving belt having a frictional surface is a suitable orientation-providing device for use with this type of display construction, where it is desired, for example, to orient all, or a large number, of areas of one side similarly and simultaneously.

Since certain changes may be made in the above process, apparatus and product without departing from

the scope of the invention herein involved, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. A rapid and economical method of producing a large volume of identical light modifying display materials which include a plurality of differently oriented areas adapted, when subjected to axially changing polarized light, to exhibit visible change effects such as an animation sequence, said method comprising the steps of preparing a plurality of perforated plates, the perforations of which are identified with different portions of phases of said effects, said perforations being adapted to the application of an orienting mechanical force therethrough, applying an unoriented but molecularly orientable material adapted, when oriented, to modify incident polarized light to a sheet material providing a supporting surface, placing a first of said plates on said surface so that said perforations are aligned with said orientable material, applying a mechanical stress in a first given direction through said perforations to a surface of said orientable material to render it molecularly oriented in said direction, removing said first plate and placing a second of said plates on said surface with a plurality of differently arranged perforations thereof in alignment with different areas of said orientable material than those which were aligned with the perforations of said first plate, applying a mechanical stress in a second and different direction through said perforations to said orientable material to render it molecularly oriented in said different direction, and repeating said steps, using additional differently perforated plates and additional different areas of said orientable material while applying a mechanical stress each time in a different direction, until the display material is completed.

2. A method of producing display materials, as defined in claim 1, wherein the perforations of said plates are so prepared in relative lateral arrangement as to insure that the areas of said material subjected to said mechanical stress in a given direction through said perforations of one plate are in abutting relation to the areas subjected to said mechanical stress in a different direction through the perforations of a succeeding plate.

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