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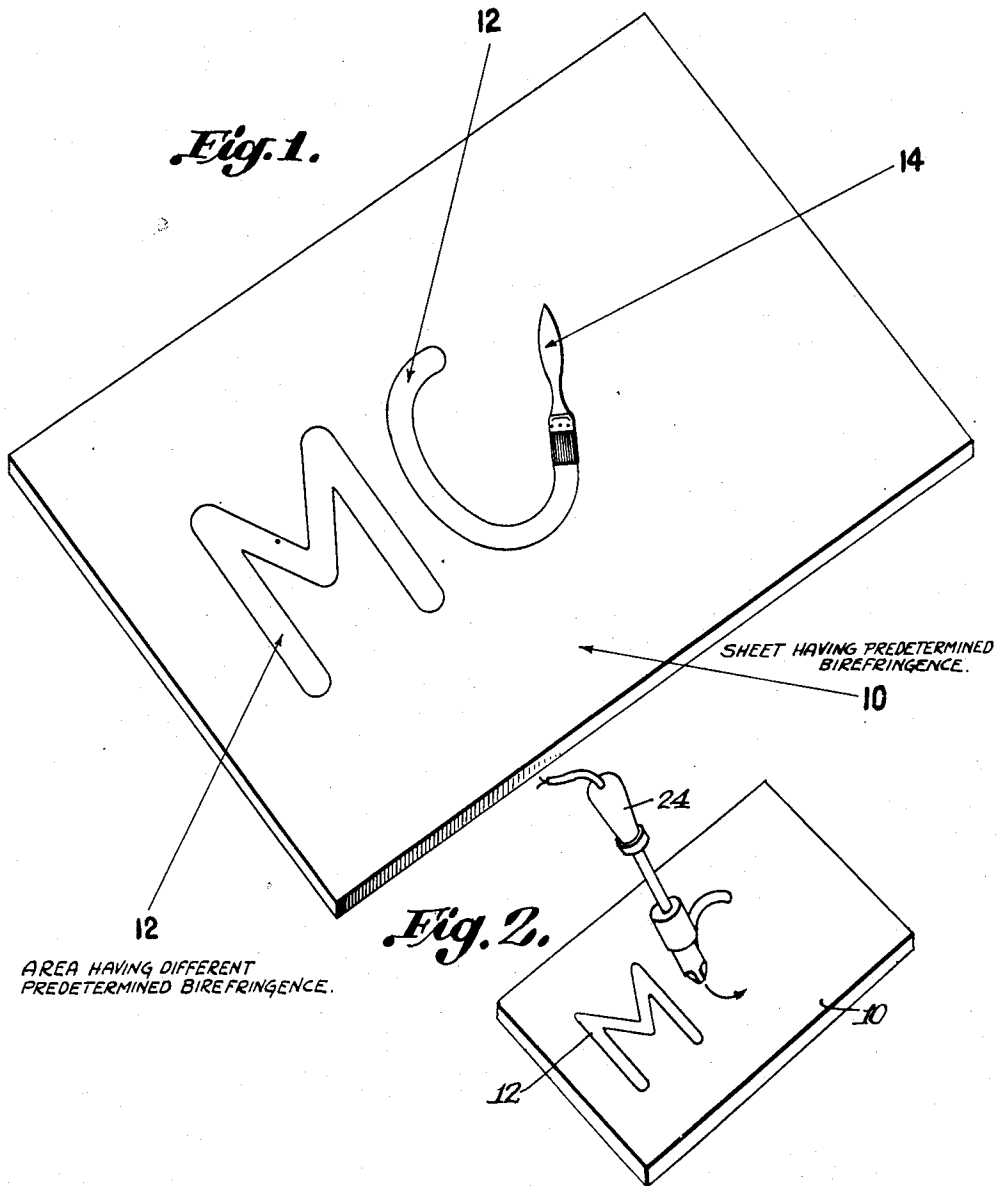
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MATERIAL HAVING VARYING BIREFRINGENCE AND METHOD OF MANUFACTURE

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## MATERIAL HAVING VARYING BIREFRINGENCE AND METHOD OF MANUFACTURE

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7 Claims. (Cl. 40—130)

This invention relates to a new and improved material having varying birefringence and to the method of manufacture thereof.

An object of the invention is to provide a sheet or film of birefringent material having predetermined areas thereof possessing a different birefringence from that of the remainder of the sheet or film.

Further objects of the invention are to provide a material of the character described comprising birefringent plastic material, such for example as ethyl cellulose; to provide a material of the character described wherein the areas of different birefringence comprise indicia, designs, letters, numerals or the like, such for example as halftone prints or reproductions from photographs and the like; to provide a material of the character described wherein the areas of different birefringence constitute a unitary, indivisible structure with the remainder of the sheet or film; and to provide a material of the character described wherein substantially the only difference between the sheet as a whole and the said areas of different birefringence is in the optical properties of the said sheet and said areas.

Other objects of the invention are to provide a method for altering the birefringence of predetermined areas of a sheet of birefringent material which comprises softening said areas by applying to the said areas a small amount of a solvent, or a plasticizer, or a swelling agent for said sheet, or heating said areas, or embossing said areas; to provide a sheet or similar birefringent article for use in the process of the invention to which there may have been imparted a predetermined birefringence, and to alter that birefringence in the manner described.

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

The invention accordingly comprises the several steps and the relation 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 nature and objects of the invention, reference should be had to the following detailed description taken in connection with the accompanying drawing, in which Fig. 1 represents somewhat diagrammatically and in perspective the product and process of the invention, and Fig. 2 represents similarly a modification of the invention.

Various of the sheet-like or film-like forms of plastics commercially available possess birefringence, in many cases to a high degree. This arises from the manner in which the sheets or films are formed, and may be due to an orientation of the micells entering into the structure of the sheets.

This invention contemplates the use of such of the commercially available birefringent materials as may be adapted to the process herein-after described. In addition, it is intended that other birefringent materials may be employed. It is, for example, possible to alter the birefringence of a sheet of plastic material, such for example as a sheet of ethyl cellulose, with or without a plasticizer content, by subjecting the sheet to heat, so that the sheet becomes soft, and then stretching the sheet so as to impart to it a predetermined strain. The sheet is then permitted to cool while the strain is maintained and, upon cooling, the sheet is found to possess a high degree of birefringence. This birefringence may be controlled by controlling the temperature and degree of extension to which the sheet is subjected. It is also possible to impart a similarly controlled, predetermined birefringence to plastic materials by softening them through the application of a plasticizer or a solvent or swelling agent and then extending them and maintaining them under strain while the plasticizer or solvent volatilizes or the sheet hardens to an extent sufficient to permit the sheet to retain its shape and form. It is also possible to impart a high degree of birefringence to plastic material by extruding the material from an orifice or die under such conditions that a high degree of micellular orientation is obtained.

Throughout this specification and the claims the term "birefringence" shall be understood as meaning retardation per unit thickness. For example a sheet of material having a thickness of .010 of an inch, may function as a half-wave retardation plate. Another sheet of material of the same thickness may function as a full wave retardation plate. The second sheet is understood to have a higher birefringence than the first sheet. Throughout this specification and the claims, reference to an alteration in the birefringence in the sheet of material is to be understood as meaning an alteration in its retardation properties without appreciable alteration in its thickness. By this is meant that after a predetermined desired birefringence has been imparted to the plastic sheet, as for example in the manner described, further alteration in the bire-

fringence of predetermined portions or areas of the sheet in the manner hereinafter to be described is to be understood as being accomplished without substantial alteration in the thickness of the sheet including the areas treated to alter their birefringence. The action of altering the birefringence of the sheet is intended to include treatment whereby the degree of molecular orientation of the sheet is changed. Speaking generally, where a sheet of material employed in the present invention possesses a high birefringence, its molecules will be substantially oriented in a predetermined direction and if the birefringence of certain portions or areas of that sheet is reduced as for example in the manner hereinafter described the reduction in birefringence will generally be accompanied by a disorientation of the molecular structure of the sheet. It should be understood, however, that in the processes described in connection with the alteration of the birefringence of the sheet of material treated as a whole, and more particularly where the birefringence of the sheet is predeterminedly increased by, for example, heating the sheet and then stretching it to effect substantial molecular orientation of the sheet, the thickness of the sheet may be decreased. Thus a sheet which was substantially isotropic or a low fractional wave retardation sheet such for example as a sixteenth-wave retardation sheet may be altered so as to become for example a full wave or a wave and a half retardation sheet of even less thickness than the original sheet. It will be obvious that under such conditions the birefringence of the sheet, which is to be understood as being its retardation per unit thickness, will have been very greatly increased.

Any of the processes herein described or any other process which imparts a predetermined desired birefringence to the transparent or translucent plastic or similar material employed in this invention is adapted for use in connection with the preparation of the birefringent element. Suitable materials adapted to one or more of the preceding processes and to the process of the present invention are cellulosic materials such for example as cellulose nitrate, cellulose acetate, cellulose acetate compounds, ethyl cellulose and the like; vinyl compounds such for example as polymerized vinyl chloride, polymerized vinyl acetate and mixtures thereof, such as the material sold under the trade name "Vinylite," and other similar compounds, such for example as polystyrene resins, and other resinous or plastic materials.

In the drawing, 10 represents generally a sheet or block or film possessing a predetermined desired birefringence. This invention contemplates a method of altering the birefringence of such an element over predetermined areas thereof by softening said areas by applying thereto a solvent, or a plasticizer or a swelling agent, for the birefringent material, or by heating said areas, or embossing them. The effect of the application of such a solvent or plasticizer or heat or pressure is apparently to cause a disorientation, to some extent at least, of the micells of the sheet or film.

In Fig. 1, 12 indicates an area to which a solvent has been applied, as for example by the brush 14. The degree of alteration of the birefringence of the sheet 10 may be controlled by controlling the quantity of solvent applied to the sheet. If, for example, the sheet be relatively thick and only a small amount of solvent be ap-

plied to the areas 12, then the orientation of the micells of the sheet may be destroyed only adjacent the surface to which the solvent has been applied. If more solvent be applied so that it soaks into or penetrates the sheet to greater depth, the destruction or alteration of the birefringent properties of the sheet over the area to which the solvent has been applied will be increased.

What has been said with respect to the use of a solvent is equally applicable to the employment of a plasticizer, or swelling agent, or to the use of heat. In the latter case, as shown in Fig. 2, a heated element such as a rod 24 or plate bearing the desired design may be held against the birefringent sheet 10 until the desired alteration in birefringence has been effected, as for example in the area 12.

Solvents, plasticizers and swelling agents have been mentioned as suitable for use in the process of the present invention. Each acts to release the strain in the birefringent sheet throughout the area of application of the solvent, plasticizer, or swelling agent. The solvent acts to release the strain by forming a solution of the material comprising the sheet. The plasticizers act to release the strain by softening the material of the birefringent sheet, as do the swelling agents.

It will be apparent that various designs, indicia, numerals, letters, etc. may be formed on the sheet by painting with a solvent, or by applying a plasticizer or swelling agent or heat. The solvent itself may be colorless, as may the sheet, and it may be desirable to perform the painting operations in polarized light with the sheet positioned so that its principal optical directions are at predetermined angles to the direction of vibration of the polarized beam in which the sheet is viewed. Under these circumstances, the birefringence of the sheet itself may impart a predetermined color characteristic to the transmitted beam, and the application of the solvent, or swelling agent, or heat, or plasticizer, to the sheet with the corresponding alteration in the birefringence of predetermined areas thereof results in an alteration in the color characteristics of the beam transmitted through those areas. In this manner the worker, such for example as the artist who is employing the process, may see the effect of the application on the birefringent sheet as he works, and he may control the degree of alteration in the birefringence of the sheet 10.

The finished product comprises a unitary sheet of plastic material, different areas thereof possessing different birefringence, but in all other respects the sheet may be identical over all areas thereof for, with the evaporation of the solvent, the other physical properties of the area to which it has been applied may revert substantially to those of the sheet itself. This will not be the case where varying birefringence has been imparted to the sheet by pressure or embossing.

In one form of the invention, the areas of the birefringent material acted upon may, together, form a half-tone reproduction. Pictures in the nature of photographic reproductions may be printed in solvent on the sheet and these may be vividly apparent in varying colors when the sheet is viewed in polarized light.

The product of the present invention is of great use in advertising display devices employing a polarizer and an analyzer with a birefringent sheet therebetween in connection with the projection of beams of light possessing varied

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color characteristics. It may also be useful in connection with scientific instruments of various types employing polarized light in connection with the study of photoelastic effects and the like.

It will be understood that any solvent of the plastic sheet may be applied in the process of the invention, as may any plasticizer or swelling agent which sufficiently softens the area to which it is applied to alter the birefringence thereof.

Since certain changes in carrying out the above process, and certain modifications in the article which embody the invention may be made without departing from its scope, it is intended that all matter contained in the above description or shown in the accompanying drawing shall be interpreted as illustrative and not in a limiting sense.

It is also to be understood that the following claims are intended to cover all of the generic and specific features of the invention herein described, and all statements of the scope of the invention which, as a matter of language, might be said to fall therebetween.

Having described my invention, what I claim as new and desire to secure by Letters Patent is:

1. A process for the formation of a design in plastic material having a predetermined birefringence caused by the orientation of the micellar structure of the said plastic, which design is visible in polarized light, comprising heating only the areas of said material forming the said design to alter the birefringence thereof by altering the micellar orientation of the plastic material forming the said areas.

2. A process for the formation of a design in plastic material comprising imparting to the said material a predetermined birefringence by causing a predetermined orientation of the micellar structure of the said plastic, and altering the micellar orientation of such areas only of the said plastic material as comprise the said design by softening said areas by applying thereto a material from the class consisting of the solvents, plasticizers and swelling agents for said

plastic material, whereby the birefringence of said areas is altered.

3. A process comprising applying to predetermined areas of a birefringent plastic a solvent for said plastic to an extent that the birefringence of said areas is altered without substantial alteration in the other physical properties of said plastic.

4. As a new article of manufacture, a sheet of birefringent plastic, predetermined areas of said plastic having a predetermined birefringence, and other predetermined areas of said plastic having a birefringence differing predeterminedly therefrom, all of said areas being of substantially the same thickness, the corresponding principal optical directions of all said areas being substantially parallel.

5. As a new article of manufacture, a sheet of birefringent plastic, predetermined areas of said plastic having a predetermined birefringence, and other predetermined areas of said plastic having a birefringence differing therefrom, said difference in birefringence being due to differences in the degree of micellar orientation within said areas.

6. As a new article of manufacture, a sheet of birefringent plastic, predetermined areas of said plastic having a predetermined birefringence, and other predetermined areas of said plastic having a birefringence differing therefrom, said areas of differing birefringence being arranged to form a predetermined design when said sheet is viewed in polarized light, the corresponding principal optical directions of all said areas being substantially parallel.

7. A sheet of birefringent plastic material having predetermined areas of different birefringence from that of the remainder of said sheet, the degree of micellar orientation of said areas differing from that of the remainder of said sheet, said areas being of such size and shape and being so positioned as to impart to a beam of polarized light transmitted by said sheet predetermined differing color characteristics forming a design in the nature of a half-tone print.

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