SR T4039W DP SEARCH ROO
OR 2,237,566

April 8, 1941. E. H. LAND 2,237,566

VARIABLE DENSITY WINDOW

Filed Nov. 10, 1938

T 2556

Fig. 1.

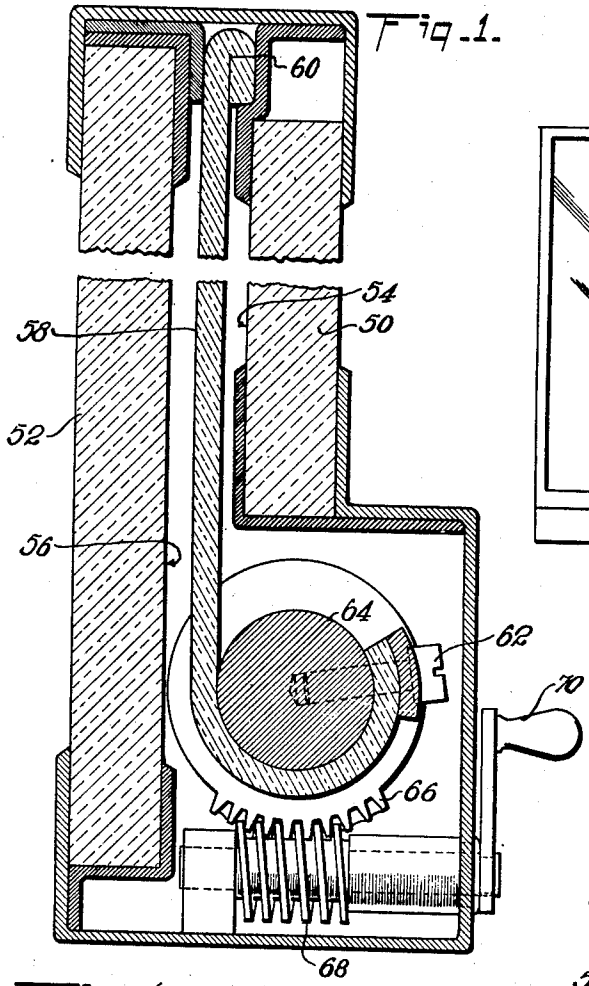


Fig. 2.

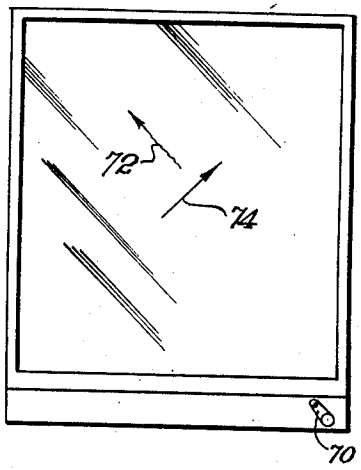


Fig. 3.

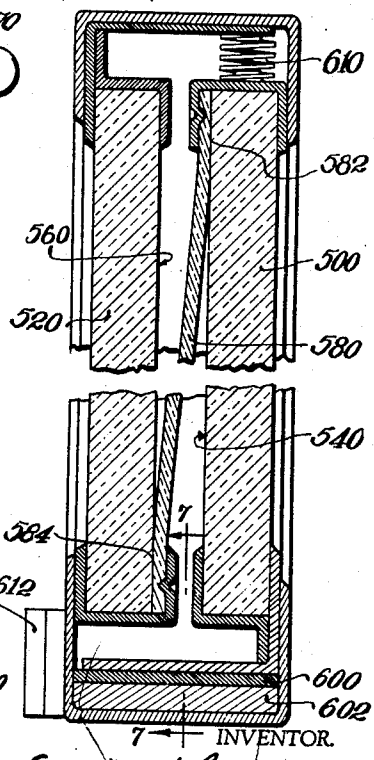
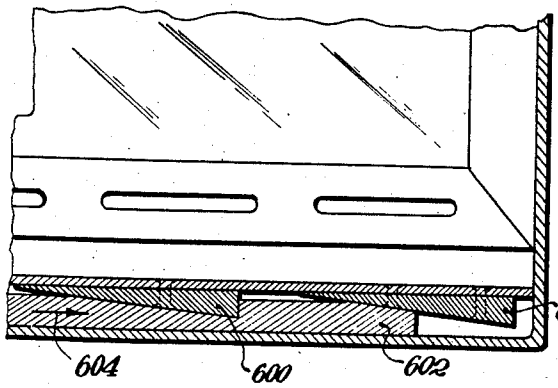


Fig. 4.



INVENTOR.
Edwin H. Land
BY
Brown & Jones
ATTORNEYS

65

SEARCH ROC

Patented Apr. 8, 1941

2,237,566

UNITED STATES PATENT OFFICE

2,237,566

VARIABLE DENSITY WINDOW

Edwin H. Land, Boston, Mass., assignor to Polaroid Corporation, Dover, Del., a corporation of Delaware

Application November 10, 1938, Serial No. 239,796

5 Claims. (Cl. 88—65)

This invention relates to variable density windows.

An object of the invention is to provide a variable density window comprising a plurality of overlying light-polarizing elements and means associated therewith for controlling at will the amount of light transmitted thereby.

A further object of the invention is to provide a variable density window of the character described wherein one of the light-polarizing elements is fixedly positioned and the other element movable with respect thereto.

A still further object of the invention is to provide such a window wherein the movable element is movable linearly with respect to the fixed element and wherein the motion of the movable element imparts a predetermined stress or strain to material showing photoelastic effects and positioned between the polarizing elements.

A still further object is to provide such a window wherein the light-polarizing elements are fixedly positioned with respect to each other and the density of the window as a whole is altered by altering the tension on a sheet of material showing photoelastic effects and positioned between the polarizing elements.

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

The invention accordingly comprises an article of manufacture possessing the features, properties, and the relation of elements which will be exemplified in the article hereinafter described 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 is a view in section of one form of the invention;

Fig. 2 is a view in front elevation of the device shown in Fig. 1;

Fig. 3 is a view in section of a still further modification of the invention; and

Fig. 4 is a view, partially in elevation and partially in section, of the device shown in Fig. 3 taken along the line 7—7.

Heretofore, when it has been necessary or desirable to reduce the intensity of light transmitted by a window in a dwelling, vehicle, or the like, the desired result has been accomplished by drawing across the window a supplemental translucent or opaque substance, such as a shade or curtain or blind. Speaking generally this has resulted in an impairment or complete destruction of the clarity of the image visible through the window, or at least through those portions of the window over which the shade or blind has been drawn. As a result it has been found that frequently a considerable portion of the window area performs no useful function, except on rare occasions. This is particularly true in railroad vehicles, where the upper portion of the window almost invariably remains covered by an opaque curtain or screen, only the lower portion being usefully employed. So also in dwellings it is frequently customary to leave a shade or curtain drawn over a considerable portion of the window area or to hang drapes or curtains or similar light-obstruction elements so as to block appreciable portions of the window areas.

The control of light intensity at the windows has thus been accomplished frequently by a restriction of the window aperture usefully employed. In other cases it has been accomplished by drawing across the window a curtain, screen or the like which completely destroys the transparency of the window unit and makes it impossible for a person positioned within the vehicle, dwelling or the like to see through the window.

It is an object of the present invention to provide a variable density window of a character such that the intensity of the light transmitted thereby may be controlled accurately from a predetermined maximum to complete cut-off, if desired, without obstructing the clarity of the image transmitted by the window, at least until the point of substantially complete cut-off is reached. This may be accomplished by providing a pair of overlying light-polarizing elements each preferably substantially the size of the full window aperture and by the provision of means for moving a transparent element, for example one of the polarizing elements with respect to the other of the elements, so that the intensity of the light transmitted by the combination of elements may be controlled.

In one form of the invention the movable element may be slidably mounted with respect to the fixedly positioned polarizing element, and the two elements may have their polarizing axes positioned at right angles to each other or parallel to each other, and preferably in a direction or directions substantially at 45° to the direction of motion of the movable element with respect to the fixed element. For example, if the movable element is to be moved vertically, the polar-

izing axis of the fixed element may be inclined at an angle of 45° to the vertical in the plane of the element, and the polarizing axis of the movable element may be similarly inclined and may be either parallel to or at right angles to the axis of the fixed element.

With such a structure an intermediate transparent layer, showing photoelastic effects when extended, may be employed between the two polarizing elements, and this layer may preferably be of such a character that when it is subjected to an extension of predetermined amount it becomes a half-wave plate or shows half-wave retardation, and hence causes a rotation in the plane of polarization of light transmitted by the polarizing element nearest the light source such that the direction of vibration of that light is rotated through an angle of 90°. Under these circumstances, if the two polarizing elements were positioned to block light initially, the stress or strain in the intermediate layer will result in a combination of elements such that the window transmits incident light, whereas if the elements were positioned initially to transmit a maximum of light, the strain in the intermediate layer would result in a condition such that the incident light is blocked by the two polarizing elements.

In this form of the invention the intermediate layer may be extended independently of any motion of the polarizing elements, or it may be so affixed to the polarizing elements as to be responsive to relative linear motion of one of said elements with respect to the other.

It will be apparent that a preferred structure contemplates the provision of surfaces of relatively large area, as the intensity of light transmitted through the entire window should preferably vary simultaneously over all portions of the window area. This implies the use of light-polarizing material of large surface area. Such a material is available under the trade name "polaroid," one form of which, for example, comprises a suspension of polarizing particles in a light-transmitting medium, the particles being oriented with their polarizing axes parallel and so distributed throughout the medium as to impart substantially uniform polarization to a transmitted beam. A preferred form of this material for use in the present invention is a high concentration of polarizing crystals, such as crystals of iodosulfate of quinine or iodosulfate of cinchonidine in a very thin film or layer of a light-transmitting plastic, preferably the material sold under the trade name "Vinylite XYSG." Films of this material of less thickness than .0003 inch have been found to be excellent polarizers. Such films are now available in areas at least as great as any desired for use in the present invention.

It may be desirable to employ films or sheets of the above type laminated to or between sheets of glass or other rigid light-transmitting supporting media, and the use of such polarizing means is preferred. It is to be understood, however, that any other light-polarizing elements of large area, or adapted to be assembled to form large areas, may be employed in the present invention. It will be apparent that for satisfactory results the sheets or films of polarizing material employed should be relatively thin and highly efficient, and if it is necessary to piece out the area by lamination or by overlapping smaller areas of polarizers the materials employed should be of a character such that large areas may be produced without the appearance of unsightly overlaps.

Where a photoelastic bonding material is to be employed in the product of the present invention, suitable materials for use as the cementing or binding layer may comprise such materials as those sold under the trade names "Lucite" or "Vinal," or polymerized incomplete polyvinyl acetal resins, acrylic acid esters, and the like.

The preferred embodiments of the invention are shown in the drawing.

One form of the invention is shown in Figs. 1 and 2. In this form the invention comprises two superimposed elements, preferably glass plates **50**, **52**, each providing a polarizing surface, preferably in the form of a thin adherent film **54**, **56**. These films are preferably on the inner faces of their supporting plates. Each of the plates and its associated film may be mounted, as shown in Fig. 1, fixedly in the frame of the vehicle or dwelling in which the window is employed.

Between the elements **50** and **52** there is provided a layer of a material **58** showing photoelastic effects when subjected to extension. This material may comprise, for example, a polymerized incomplete polyvinyl acetal resin, such as the material sold as Vinal, an acrylic acid ester or the like. It is preferably present in such thickness as to show substantially a half-wave retardation when subjected to a predetermined stress or strain.

Such a stress may be imparted to the sheet **58** by means of the apparatus shown in Fig. 1. The upper edge of the sheet may be firmly held as at **60** between the frames of the window elements. The lower edge of the sheet may be affixed by any suitable means **62** to a roller element **64** in the base of the inner window element. The roller **64** may be provided with a gear **66** adapted to mesh with a worm **68** which in turn may be driven by rotation of the handle **70**.

The polarizing films **54**, **56** are preferably so positioned that their polarizing axes, indicated generally by the arrows **72**, **74**, are at right angles to each other and at angles of 45° to the direction of extension of the element **58**. Under these circumstances the strain set up in the material **58**, which is a directional strain corresponding to the direction of extension of the element, will be at an angle of 45° to each of the polarizing axes, and if the material **58** acts as a half-wave retardation plate, it will cause a 90° rotation in the direction of vibration of polarized light transmitted by either of the elements **54**, **56**. Thus, if the axes **72**, **74** are at right angles, the window as a whole will be most nearly opaque when no strain is on the material **58**, and the window as a whole will transmit the most light when the strain on the material **58** is such that it acts as a half-wave plate.

The material **58** is preferably selected of such thickness that a relatively slight extension, for example less than one inch, will impart to it the desired stress. It is preferably also resilient or rubber-elastic, i. e., it tends to return to its initial unstrained state when the tension is released. If desired, stops may be provided in connection with the roller **64** to prevent too great a stress being applied to the element **58**. Under certain circumstances, and where it is desired to impart color to the light traversing the window elements, the sheet **58** may be stretched a considerably greater amount, for example so that it no longer acts as a half-wave device.

A still further modification of the invention is

SEARCH ROOM

shown in Figs. 3 and 4. In this form two window elements **500** and **520** are provided, each coated on its inner face with a polarizing layer **540**, **560**. Intermediate the window elements there is provided a resilient, extensible element **580**, adapted when stretched a predetermined amount to function as a half-wave plate. This sheet **580** is affixed along one of its edges to the window element **500**, as at **582**, and along its opposite edge to the window element **520**, as at **584**.

One of the window elements, for example the element **500**, is mounted for vertical motion, linear and parallel to the fixedly mounted element **520**. This motion may be accomplished in any suitable manner, for example by supporting the element **500** on one or more cam members **600**, which in turn rest upon a sliding bar or rack **602** provided, as shown in Fig. 4, with similar and cooperating cam surfaces.

Motion of the bar **602** to the right in Fig. 4, i. e., in the direction of the arrow **604**, results in a camming action which raises the window element **500**, moving it with respect to the element **520** so as to impart the desired stretch to the sheet **580**. Motion of the bar **602** in the other direction permits the window element **500** to fall to its initial position, thus relieving the stress on the element **580**. If desired spring means **610** may be provided to insure a prompt return of the element **500** to its lower position.

Knob means **612** may be provided affixed to the bar **602** to facilitate motion thereof.

It is to be understood that the polarizing axes of the elements **560** and **540** are positioned preferably in the same manner as those of the elements **56** and **54** in the device shown in Fig. 4 and that the stress applied to the sheet **580** is similar in the results achieved to that applied to the sheet **58**.

In any of the devices shown in Figs. 1, 2, and 3 and 4, the space between the window elements and surrounding the extensible sheet may be filled, if desired, with a liquid lubricant. Preferably the liquid should have a low vapor pressure and an index of refraction approximately that of the extensible sheet. A very thin film of liquid is adequate. It may even be present initially in the extensible sheet and be worked or pressed therefrom in the assembly and operation of the device.

Any of the devices shown and described may be actuated by motor means (not shown) remotely controlled in any suitable way. For example, all the windows of a car or dwelling may be adapted to be simultaneously operated and the intensity of light transmitted accurately controlled from a central control station. All such modifications are to be deemed within the scope of the invention.

Although the window elements in Figs. 1, 2, 3 and 4 are shown as permanently mounted in the dwelling, vehicle or the like, it is to be understood that they and their associated and related elements, for example the entire assemblage shown in Fig. 1, may be mounted for motion wth respect to the dwelling or vehicle wall, so that the window may be opened and air admitted to the dwelling or vehicle.

Since certain changes may be made in the above article and different embodiments of the invention could be made without departing from the scope thereof, 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 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 variable density window for illumination purposes comprising, in combination, frame means providing a window aperture of substantial area, a plurality of sheet-like, light-polarizing elements at least of substantially the same area as said aperture, means for mounting said elements in substantially parallel relation within said frame, a sheet of light-transmitting, resilient material at least of substantially the same area as said aperture adapted when subjected to a predetermined stress to function as a half-wave retardation device, means for mounting said sheet between and overlying said polarizing elements, and releasable means for subjecting said material to said predetermined stress to vary the amount of light transmitted by said window.

2. A variable density window for illumination purposes comprising, in combination, frame means providing a window aperture of substantial area, a plurality of sheet-like, light-polarizing elements at least of substantially the same area as said aperture, means for mounting said elements in substantially parallel relation within said frame, a sheet of light-transmitting, resilient material at least of substantially the same area as said aperture adapted when subjected to a predetermined extension to function as a half-wave retardation device, means for mounting said sheet between and overlying said polarizing elements, and releasable means for subjecting said material to said predetermined extension to vary the amount of light transmitted by said window, said polarizing elements being positioned with their transmission axes at angles of substantially 45° to the direction in which said extending force is applied.

3. A variable density window for illumination purposes comprising, in combination, frame means providing a window aperture of substantial area, a plurality of sheet-like light-polarizing elements at least of substantially the same area as said aperture, means for mounting said elements in substantially parallel relation within said frame, a sheet of light-transmitting, resilient material at least of substantially the same area as said aperture positioned between and overlying said polarizing elements and adapted when subjected to a predetermined extension to function as a half-wave retardation device, means for mounting one end of said sheet within said frame, and releasable means mounted in said frame for subjecting said material to said predetermined extension to vary the amount of light transmitted by said window.

4. In combination, frame means providing a window aperture, a plurality of sheet-like, light-polarizing elements at least of substantially the same area as said aperture, means for mounting said elements in substantially parallel relation within said frame with their transmission axes in predetermined relative angular relation, said mounting means permitting linear movement of one of said elements, means for moving said movably mounted element with respect to the other without changing the relative angular relation of the transmission axes thereof, and means com-

prising a sheet of light-transmitting, resilient material capable of showing photoelastic effects under stress positioned between said elements, said sheet being secured at one end within said frame, the opposite end being secured to said movable element.

5. A variable density window comprising, in combination, frame means providing a window aperture of substantial area, means providing a light-polarizing surface at least of substantially the same area as said aperture and positioned within said frame means, means providing a second light-polarizing surface positioned substantially parallel with and overlying said first-mentioned surface, light-transmitting material positioned between said polarizing surfaces and adapted, when subjected to a predetermined strain, to function as a half-wave plate, said material being secured at one end to one of said light-polarizing surfaces and at the opposite end to the other of said light-polarizing surfaces, and means for moving at least one of said light-polarizing surfaces with respect to the other of said light-polarizing surfaces for subjecting said material to said predetermined strain.

EDWIN H. LAND.