March 10, 1964 | M. H. KRUGER | 3,124,311

LIGHTING

Filed Dec. 18, 1961 | 2 Sheets-Sheet 1

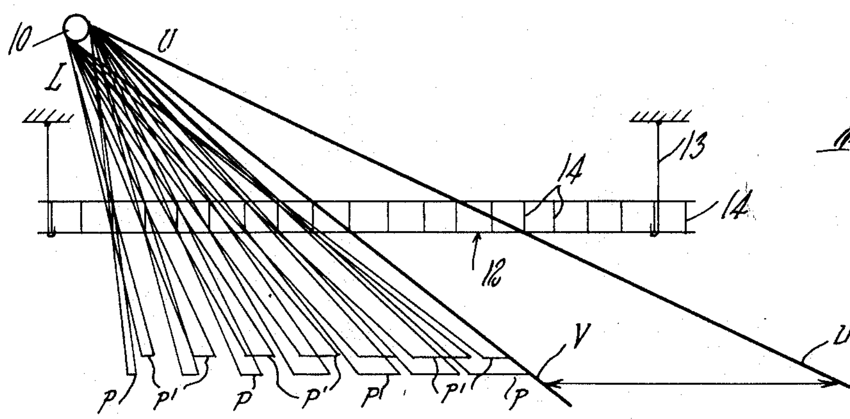

Fig. 1.

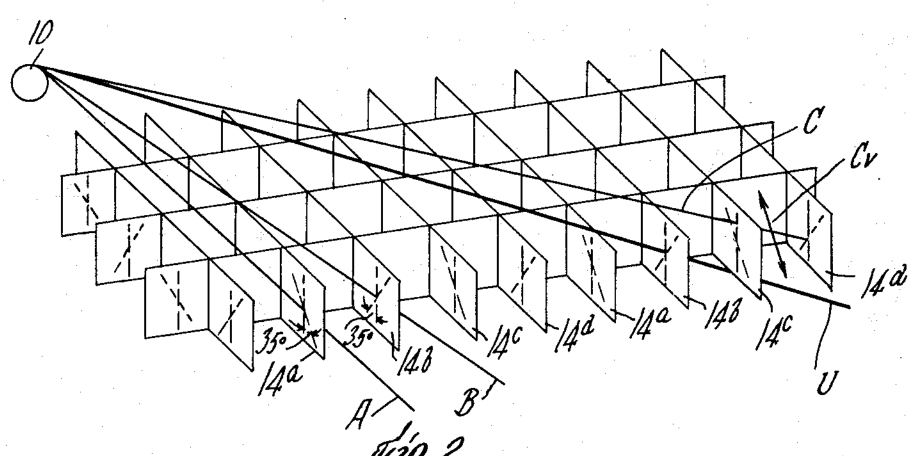

Fig. 2.

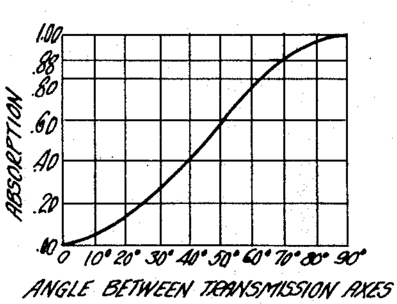

Fig. 3.

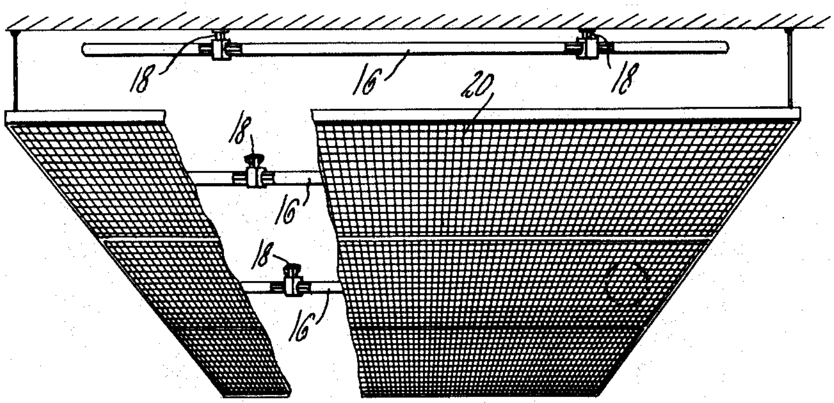

Fig. 4.

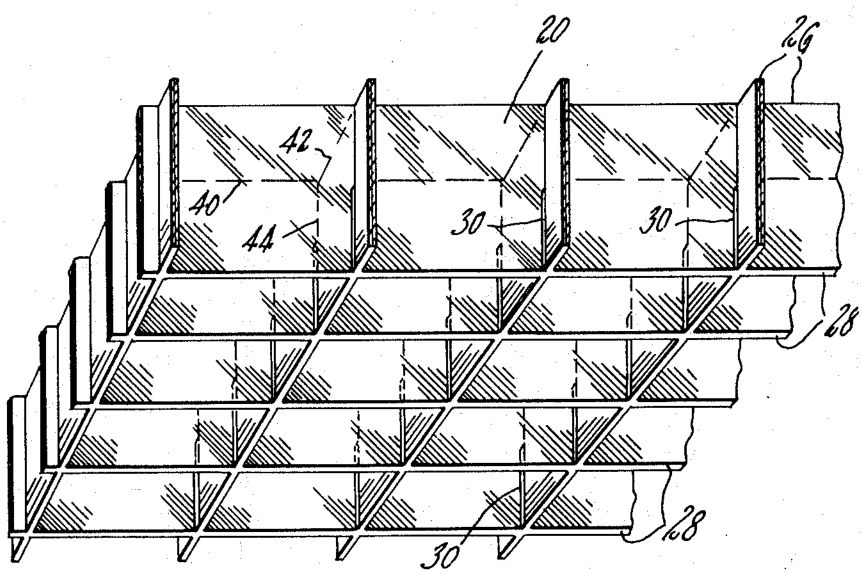

Fig. 5.

United States Patent Office

3,124,311

Patented Mar. 10, 1964

1

3,124,311
LIGHTING

Michael Henry Kruger, Chestnut Hill, Mass., assignor to Smithcraft Corporation, Chelsea, Mass., a corporation of Massachusetts

Filed Dec. 18, 1961, Ser. No. 160,087
12 Claims. (Cl. 240—78)

This invention relates to reducing glare from lights in a ceiling and to producing decorative lighting effects.

It is well known that bright light shining into one's eyes is uncomfortable and tiring. Such light comes directly from light sources and by specular reflection from illuminated surfaces.

One of the principal objectives of the present invention is to maximize the amount of light passing through a light controller while minimizing both reflected and direct glare.

Another principal objective is to provide a light-controlling member having means which cooperate to present an unusual decorative appearance.

Another objective of this invention is to provide a simple construction whereby improved lighting is achieved.

According to my invention a series of horizontally spaced-apart, vertically extending wall portions are comprised of polarizing material, successive wall portions having transmission axes disposed at substantial angles to each other. These cooperate to cause light at extremely low angles from a ceiling to be cut off except for a very small residue which can serve a decorative function, light at intermediate angles to be virtually entirely polarized and light at higher angles to be partially polarized.

As will be explained, particular orientation of the transmission axes, relative to the vertical, of successive wall portions can yield particular benefits and polarizing material heretofore considered defective because of haziness can have an added, desirable cooperative function while lessening the expense of the light-controlling member.

According to the invention, the polarizing wall member edges present a grid or other geometric pattern of very thin, glare-free but bright decorative lines against the relatively dark background produced by superposed polarizing wall portions. Also, one wall portion enables the seeing of the surface of the next wall portion, but none further, thereby producing an unusual appearance of depth.

FIG. 1 is a diagrammatic cross-sectional view of a light source and an embodiment of the light-controlling member of the invention;

FIG. 2 is a diagrammatic, perspective view illustrating a preferred orientation of the transmission axes of wall portions of a light-controlling member;

FIG. 3 is a diagram showing the relation of the light absorption factor with respect to the angle between transmission axes of superposed polarizers;

FIG. 4 is a perspective view of a ceiling defined by a preferred embodiment, viewed from below; and

FIG. 5 is a magnified, perspective view of the portion of the embodiment of FIG. 4 which is circled, showing the visual effects produced by it.

Referring to FIG. 1, a light source **10** is shown spaced vertically above an egg-crate louver **12**. The latter is supported by means **13** from the ceiling and is comprised of two crossed sets of parallel, vertically arranged, equally spaced-apart slat wall members **14** of polarized material, adjacent parallel slat members having their transmission axes disposed at substantial angles to each other.

With this egg-crate member a definite light cut-off limit U is defined by that line of sight which can be projected through the upper limit of the light source, the top edge

2

of one slat member **14** and the bottom edge, not of the second but of a third slat member in the series, numbered away from the light bulb. Light emitted at lesser angles to the horizontal is virtually entirely absorbed while that light which passes through the member at greater angles is entirely polarized, up to that line of sight V at a greater angle with the horizontal, which can be projected through the upper limit of the light source, the top edge of one slat member and the bottom edge of a second slat member in the series numbered away from the light source. At steeper angles to the horizontal some light rays pass between wall members without impinging on them, as unpolarized light; but at angles up to the vertical, the light is at least partially polarized, as indicated in the diagram where P and P′ denote increments of polarized light from the upper and lower limits of the bulb respectively.

This polarized light produced by the walls helps reduce glare according to the principles which follow:

Normal light returning from any illuminated surface comprises two parts. One part is diffused and this presents no problem of discomfort. The other part is specularly reflected, even where the surface does not appear mirror-like, as with white paper. This latter part of light is polarized by the action of its reflection because its component which vibrates in the plane of incidence (the plane of incidence being that plane which passes through the ray and the normal to the surface the ray strikes) is absorbed while its component vibrating in a plane perpendicular to the plane of incidence is reflected. Thus, the reflecting surface acts as a polarizer having an axis of transmission parallel to the surface. The degree of polarization depends upon the particular angle of incidence and the nature of the surface. For instance, with smooth glass having an index of refraction of 1.54, the light is perfectly polarized if the angle of incidence is 57° (measured from the normal), this characteristic angle being known as the polarizing angle. When the angle of incidence is different from 57°, the polarization of the reflected light is incomplete, and the further the departure from the polarizing angle, the less completely is the reflected light polarized.

It will thus be seen that by prepolarizing light which strikes such a surface to eliminate vibrations in the direction perpendicular to the plane of incidence, little or no reflected glare will be produced.

I have realized that although adjacent portions of light be reversely polarized with the light-controlling member as described, each portion can help reduce glare. One reason for this is that although the art has been most concerned with glare coming from horizontal reflective surfaces, there are, in areas to be illuminated, many vertical surfaces and surfaces at partial angles which produce glare, such as windows, bright walls, partitions and furnishings, so that even if light is polarized so as to vibrate only in the horizontal direction, when incident upon a surface having a vertical component, glare will be reduced. Thus, light polarized either vertically or horizontally is helpful.

But my invention also permits the achieving of greater effectiveness against glare from horizontal surfaces than from vertical which is desirable when the glare problem is mostly created by horizontal surfaces. Referring to the embodiment of FIG. 2, slat wall member **14*a*** has its transmission axis oriented to the left of vertical by 35° as seen in the figure; the next wall member in the series, wall **14*b***, has its transmission axis oriented to the right of vertical 35°; the third in this series **14*c***, like the first, has its transmission axis oriented at 35° to the left and the fourth, **14*d***, like **14*b*** is oriented 35° to the right.

Light ray A passing through wall member **14*a*** is reduced to light vibrating only in the plane 35° left of the vertical, all light components perpendicular to this plane having been removed. Now if this light be reflected by a horizontal surface, all vertical components of the light will be absorbed and only horizontal components will be reflected. Since the transmitted portion of ray A is comprised only of light vibrating in a plane angled at 35° to the vertical, then its component vibrating in the vertical plane is proportional to the cosine of the angle 35°. Since the cosine of 35° is 0.82, then about 82 percent plus of the incident light can be absorbed and diffused by the horizontal reflective surface and less than 18 percent of the polarized light (9 percent of the original light) would then be reflected at the optimum angle of incidence. Thus, horizontal glare is drastically reduced.

Similarly, light ray B on passing through wall member 14*b* is reduced to components vibrating in a plane angled at 35° to the right of vertical and similarly 82 percent of that light can be asborbed by a horizontal surface.

The light ray C has an angle to the horizontal less than the cut-off limit U and impinges first upon wall member 14*c*, the passing light being polarized so that it vibrates in the plane 35° to the left of the vertical as indicated by vector C_v. This ray then impinges upon wall member 14*d* having its transmission axis oriented 35° to the right of vertical. Accordingly, there is a 70° angle between the transmission axes of these wall members (14*c* and 14*d*).

Referring to the graph of FIG. 3, it will be seen that the amount of light absorption of superposed polarizers is not directly proportional to the angle between their transmission axis, but rather is governed by the curve as shown. It will be seen when the angle between axes is 70°, the absorption factor is 0.88 so that virtually all of the light is absorbed, and the residue is only the small amount of 12 percent of the polarized light or 6 percent of the ray's initial intensity. With a fluorescent source this residue is colored blue and will provide a decorative appearance to the light-controlling member. The embodiment of FIG. 2, therefore, not only has the advantages of FIG. 1, obtaining the same distribution of polarized light, but also it is more effective against glare from horizontal surfaces than from vertical surfaces.

Referring to FIGS. 4 and 5, a plurality of fluorescent light bulbs 16 are mounted on the structural ceiling by supports 18 and the visible ceiling is defined by the light-controlling member 20 suspended vertically below the lights. The member 20 provides spaced-apart walls of polarizing material, the transmission axes of adjacent parallel walls being disposed at substantial angles.

This particular embodiment is of the egg-crate type having two crossing sets of parallel, generally horizontally aligned, spaced-apart, vertical slat members. Each slat has notches along one edge and crossing slats having their notches interengaged in the usual member. In this embodiment these slats are ¾ inch wide, .050 inch thick and spaced at ¾ inch centers. Each slat is Polaroid J Film, made by the Polaroid Corporation, comprised of a very thin polarized, colored film sandwiched between two relatively thick layers of clear cellulose acetate, into a self-supporting slat, the surfaces of which are shiny.

In line with the explanation given above for FIG. 1, there are three distinct illuminating effects. At very low angles to the horizontal up to a first limit line, all light is cut off saving a tiny bluish residue. From this limit line to a second, all light is polarized so its capacity to reflect is drastically reduced; this light even when viewed directly is of a lesser intensity due to the absorption of certain of its components, so even its direct glare effect is attenuated. And at angles greater than this second limit, the light is mixed, polarized and direct, enabling high efficiency transmisison with some conditioning.

An unusual effect is obtained with this egg-crate louver at angles greater than the cut-off limit as shown in FIG. 5.

The outer layers of cellulose acetate of the slats have their upper and lower edges exposed to transmit light. The upper edges 26 receive light from sources 16 and the clear cellulose acetate conducts it by internal reflection to the lower edges 28 imposing a pattern of visible fine, bright but not glaring lines in the undersurface, contrasted against the relatively dark background of the slat member wall surfaces produced by the superposed polarizers. Similarly, fine vertical bright lines occur at the notch surfaces 30 of the slats (these in FIG. 5 being shown exaggerated in width). The same effect can be obtained when the polarizing film is laminated between layers of glass or other plastics which have a capacity for internal reflection.

When the slats edges are cut roughly, they appear brighter than if smoothly ground.

Referring again to FIG. 5, the next adjacent louver cube such as that defined by lines 40, 42 and 44 is visible through each of the slats when viewed from the appropriate angle, imparting a distinctive appearance of depth to the light-controlling member.

Where the slat surfaces are shiny so as to be internally reflective, low intensity images of adjacent cubes and of remote light sources can be visible at some angles in the outer shiny surfaces.

It will be appreciated that various other constructions can be employed while realizing certain of the benefits of the invention. Thus, horizontal lenses can be combined between the wall members; wall members may extend in only one direction, not criss-crossed; they can be integrally molded; they can be curved or angled relative to the vertical, as long as they have a component in the vertical direction, and they can be in any other geometrical design so long as the wall members are effectively superposed with respect to low angle illumination.

Any kind of linear ("dichroic") polarizing material can be employed. One kind is a plastic film of .003" thickness having its polarizing ability produced by a suspension of oriented crystals in the plastic film. This film produces a haze due to the interface between the tiny crystals and the matrix plastic which, while regarded disadvantageous in the polarizing art has distinct advantages in the present invention. It diffuses some light in the wall members in the cut-off region, ligtening the appearance thereof which is advantageous where absolutely dark ceilings are not desired.

Another suitable film is so-called molecular polarizer formed by orienting long molecules of the plastic itself, which has less haze, but which can be made hazier by introduction of crystals, or by allowing the product to vary rather than obtaining strict linearity of the molecules.

It will be appreciated that the desirability of haziness removes criticality of control of the process of making the polarizing film and enables it to be made very economically for the present purposes.

As noted above, either of these polarizing sheets can be laminated between walls of clear or tinted but preferably internally reflective shiny surfaced material such as cellulose acetate or glass to produce self-supporting polarizers, or the thin sheets may be inserted into a precast structure; or they can be self-supporting.

What is claimed is:

1. A room light quality control member supported below a lighting source for controlling the quality of illumination of a room area below said source, said light quality control member being comprised of a horizontal array of successive spaced-apart wall portions of dichroic polarizing material, each portion having an extent with a substantial vertical component, these wall portions being relatively aligned so that adjacent wall portions are superposed relative to light rays emitted from said light source at large angles to the vertical, and being so spaced apart and related that light rays moving downwardly at smaller angles to the vertical pass through one only of said portions, being thereby polarized to reduce glare reflected from objects in the room being illuminated, adjacent wall portions having their transmission axes disposed at substantial angles to each other, each group of three adjacent wall portions defining a cut-off angle for preventing the

passage to the room area of light making large angles with the vertical, said array having a substantial horizontal extent so that rays from selected portions of said lighting source fall upon a multiplicity of said wall portions at angles to the vertical larger than said cut-off angle.

2. The light quality control member of claim 1 wherein openings are provided between at least some of said wall portions through which light can pass unabsorbed directly from said source to the room area below.

3. The light quality control member of claim 1 comprising two sets of parallel, adjacent elongated wall members, said sets being mounted to cross each other.

4. The light quality control member of claim 1 wherein said wall portions each comprises a layer of polarizing film and on at least one side a relatively greater thickness of internally reflective, light-transmitting material having exposed light-transmitting upper and lower edges, adapted to receive and transmit light interiorly between said upper and lower edges whereby light incident on said upper edges produces bright lines in the visible lower edges of said member, contrasted against the relatively dark appearance of the wall portions produced by the superposed polarizer effect.

5. The light quality control member of claim 4 wherein said wall portions are defined by slats each of which comprises a layer of polarizing material sandwiched between two layers of light-transmitting, surface reflective material, said slats being arranged in the form of an egg-crate louver having notched slots interengaged, the surfaces of said notches being light-transmitting producing bright vertical lines contrasted against said dark wall portions.

6. The light quality control member of claim 1 for combination with an illuminating fluorescent bulb ceiling fixture spaced above said member, the adjacent, horizontally arrayed, superposed, wall portions of said member having an efficiency of less than 100 percent for absorbing through polarization light incident on said superposed wall portions, the surfaces of said wall portions being positioned to be visible from the room below at angles less than said cut-off angle so that residue light passing through said superposed polarizing wall portions provides a decorative lighting effect.

7. The light quality control member of claim 1 wherein each of the wall portions has its transmission axis oriented to have its major component vertical, and alternate wall

portions having their axes turned in opposite directions with respect to the vertical.

8. The light-controlling member of claim 1 wherein said polarizing material has a distinct haze, which, by illumination from said light source, lightens the appearance of said wall portions.

9. The light quality control member of claim 3 wherein said wall members are defined by two sets of parallel vertically arranged elongated slat members joined together in egg-crate form to define a grid, said slat members having shiny surfaces and being comprised at least in part of light-transmitting, dichroic polarizing sheet, adjacent parallel slat members having their transmission axes disposed at substantial angles to one another said slat members being positioned so that some light rays making small and intermediate angles to the vertical pass through one slat member, said rays being thereby polarized to reduce glare reflected from objects being illuminated, and said slat members being positioned so that light rays making larger angles to the vertical are intercepted by two slat members and are substantially absorbed by them.

10. The light quality control member of claim 9 wherein the oppositely directed edges of the slats are adapted to transmit light and the slat members at least in part are internally reflective to transmit light from edge to edge thereby to produce a contrasting pattern of light lines against the dark background provided by said superposed polarizing wall portions when viewed at large angles to the vertical.

11. The light quality control member of claim 10 wherein said slat members comprise laminates of a polarizing film and transparent, shiny surfaced plastic layers, on oppositely directed surfaces thereof, the edges of said layers being exposed to transmit light.

12. The light quality control member of claim 2 in which said wall portions are provided by at least two sets of generally parallel, adjacent elongated wall members, said sets being mounted to cross each other to provide polarized light in a corresponding number of directions.

References Cited in the file of this patent

UNITED STATES PATENTS

2,263,684	Ryan	Nov. 25, 1941
2,692,939	Crowther	Oct. 26, 1954
2,927,994	Guth	Mar. 8, 1960