

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
13 April 2006 (13.04.2006)

PCT

(10) International Publication Number
WO 2006/039142 A1

(51) International Patent Classification:
G02B 5/04 (2006.01) **G02B 6/00** (2006.01)

(21) International Application Number:
PCT/US2005/033557

(22) International Filing Date:
19 September 2005 (19.09.2005)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
10/956,566 1 October 2004 (01.10.2004) US

(71) Applicant (for all designated States except US): **EASTMAN KODAK COMPANY** [US/US]; 343 State Street, Rochester, NY 14650-2201 (US).

(72) Inventor; and

(75) Inventor/Applicant (for US only): **LEE, Junwon** [US/US]; 1556 Oakmonte Boulevard, Webster, NY 14580 (US).

(74) Common Representative: **EASTMAN KODAK COMPANY**; 343 State Street, Rochester, NY 14650-2201 (US).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

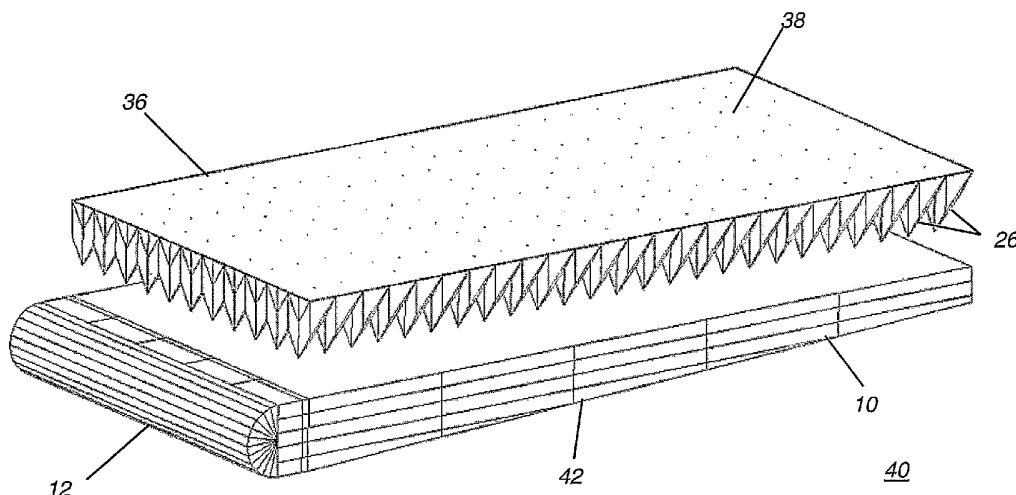
(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

- with international search report
- before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: TURNING FILM USING A TWO-DIMENSIONAL ARRAY OF ROOF PRISM



(57) Abstract: The invention generally relates to an optical turning film (36) for providing light redirection, comprising: (a) an input surface for accepting incident light comprising a plurality of roof prism structures arranged in a two-dimensional array; and, (b) a substantially planar output surface (38). The use of turning film (36) configured with an array of roof prism structures (26) eliminates the need for a structure having separate bottom prism.

TURNING FILM USING A TWO-DIMENSIONAL ARRAY OF ROOF PRISM

FIELD OF THE INVENTION

5 This invention generally relates to display illumination articles for enhancing luminance from a two-dimensional surface and more particularly relates to a two-dimensional turning film employing an array of roof prism structures to redirect light from a light guiding plate.

BACKGROUND OF THE INVENTION

10 While LCD displays offer a compact, lightweight alternative to CRT monitors, there are many applications for which LCD displays are not satisfactory due to a low level of brightness, or more properly, luminance. The transmissive LCD used in conventional laptop computer displays is a type of backlit display, having a
15 light-providing surface positioned behind the LCD for directing light outwards, towards the LCD. The light-providing surface itself provides illumination that is essentially Lambertian, that is, having an essentially constant luminance over a broad range of angles. With the goal of increasing on-axis and near-axis luminance, a number of brightness enhancement films have been proposed for redirecting a portion
20 of this light having Lambertian distribution toward normal, relative to the display surface. Among proposed solutions for brightness or luminance enhancement for use with LCD displays and with other types of backlit display types are the following:

25 U.S. Patent No. 5,592,332 (Nishio et al.) discloses the use of two crossed lenticular lens surfaces for adjusting the angular range of light in an LCD display apparatus;

 U.S. Patent No. 5,611,611 (Ogino et al.) discloses a rear projection display using a combination of Fresnel and lenticular lens sheets for obtaining the desired light divergence and luminance;

30 U.S. Patent No. 6,111,696 (Allen et al.) discloses a brightness enhancement film for a display or lighting fixture. With the optical film disclosed in the '696 patent, the surface facing the illumination source is smooth; the opposite surface has a series of structures, such as triangular prisms, for redirecting the illumination angle. The film disclosed in the '696 patent refracts off-axis light to provide a degree of correction for directing light at narrower angles. However, this

film design works best for redirecting off-axis light; incident light that is normal to the film surface may be reflected back toward the source, rather than transmitted;

U.S. Patent No. 5,629,784 (Abileah et al.) discloses various embodiments in which a prism sheet is employed for enhancing brightness, contrast
5 ratio, and color uniformity of an LCD display of the reflective type. In an embodiment disclosed in the '784 patent, the brightness enhancement film similar to that of the Allen et al. '696 patent is arranged with its structured surface facing the source of reflected light for providing improved luminance as well as reduced ambient light effects. Because this component is used with a reflective imaging device, the
10 prism sheet of the '784 disclosure is placed between the viewer and the LCD surface, rather than in the position used for transmissive LCD systems (that is, between the light source and the LCD);

U.S. Patent Application Publication No. 2001/0053075 (Parker et al.) discloses various types of surface structures used in light redirection films for LCD
15 displays, including prisms and other structures;

U.S. Patent No. 5,887,964 (Higuchi et al.) discloses a transparent prism sheet having extended prism structures along each surface for improved back-light propagation and luminance in an LCD display. As is noted with respect to the Allen et al. '696 patent mentioned above, much of the on-axis light is reflected rather than
20 transmitted with this arrangement. Relative to the light source, the orientation of the prism sheet in the Higuchi et al. '964 disclosure is reversed from that used in the '696 disclosure. The arrangement shown in the '964 disclosure is usable only for small, hand-held displays and does not use a Lambertian light source;

U.S. Patent No. 6,356,391 (Gardiner et al.) discloses a pair of optical
25 turning films for redirecting light in an LCD display, using an array of prisms, where the prisms can have different dimensions;

U.S. Patent No. 6,280,063 (Fong et al.) discloses a brightness enhancement film with prism structures on one side of the film having blunted or rounded peaks;

30 U.S. Patent No. 6,277,471 (Tang) discloses a brightness enhancement film having a plurality of generally triangular prism structures having curved facets;

U.S. Patent No. 5,917,664 (O'Neill et al.) discloses a brightness enhancement film having "soft" cutoff angles in comparison with conventional film types, thereby mitigating the luminance change as viewing angle increases;

U.S. Patent No. 5,839,823 (Hou et al.) discloses an illumination system with light recycling for a non-Lambertian source, using an array of microprisms; and,

U.S. Patent No. 5,396,350 (Beeson et al.) discloses a backlight
5 apparatus with light recycling features, employing an array of microprisms in contact with a light source for light redirection in illumination apparatus where heat may be a problem and where a relatively non-uniform light output is acceptable.

While conventional approaches, such as those noted in the disclosures
10 mentioned hereinabove, provide some measure of brightness enhancement at low viewing angles, these approaches have some shortcomings. Some of the solutions noted above are more effective for redistributing light over a preferred range of angles rather than for redirecting light toward normal for best on-axis viewing. Conventional brightness enhancement film solutions have a directional bias, working best for
15 redirecting light in one direction. For example, a brightness enhancement film may redirect the light path in a width direction relative to the display surface, but have little or no effect on light in the orthogonal length direction. As a result, multiple orthogonally crossed sheets must be overlaid in order to redirect light in different directions, typically used for redirecting light in both horizontal and vertical directions
20 with respect to the display surface. Necessarily, this type of approach is somewhat a compromise; such an approach is not optimal for light in directions diagonal to the two orthogonal axes.

As disclosed in the patent literature listed above, brightness enhancement articles have been proposed with various types of refractive surface
25 structures formed on the top surface of a substrate material, including arrangements employing a plurality of protruding prism shapes, both as matrices of separate prism structures and as elongated prism structures, with the apex of prisms both facing toward and facing away from the light source. For the most part, these solutions still exhibit directional bias, requiring the use of multiple sheets in practical applications.

30 One problem with existing backlight systems for portable equipment relates to the need to redirect light from a compact source, such as a CCFL bulb, uniformly over a two-dimensional surface, wherein the light source is positioned at one edge of the two-dimensional surface. Conventional light guide panels perform this function using printed dot patterns or etched surfaces in combination with a

diffusion film to diffuse light from the edge source and provide uniform backlight illumination. Directional turning films, such as that provided with the HSOT (Highly Scattering Optical Transmission) light guide panel available from Clarex, Inc., provide an improved solution for providing a uniform backlight of this type, without
5 the need for diffusion films or for dot printing in manufacture. HSOT light guide panels and other types of directional turning films use arrays of prism structures, in various combinations, to redirect light from a light guiding plate toward normal, relative to the two-dimensional surface.

Referring to Fig. 1, the overall function of a light guiding plate 10 is
10 shown. Light from a light source 12 is incident at an input surface 18 and passes into light guiding plate 10, which is typically wedge-shaped as shown. The light propagates within light guiding plate 10 until Total Internal Reflection (TIR) conditions are frustrated and then, possibly reflected from a reflective surface 42, exits light guiding plate at an output surface 16. This light then goes to a turning film
15 22 and is directed to illuminate a light-gating device 20 such as an LCD or other two-dimensional backlit component.

For distributing the light along a two-dimensional surface, light guiding plate 10 and its support components are typically designed to provide both redirection of the light and some amount of collimation that reduces divergence of the
20 beam angle. For example, U.S. Patent No. 5,854,872 entitled "Divergent Angle Rotator System and Method for Collimating Light Beams" to Tai discloses a light guiding plate that uses an array of elongated microprisms to redirect and collimate light from one or more light sources. In the device disclosed in the Tai '872 patent, the light guiding plate has a first set of prism structures on the light output side
25 elongated in one direction to provide collimation and a second set of prism structures on the opposing side elongated in the orthogonal direction and providing collimation and TIR reflection. Referring to Fig. 2, the arrangement of crossed prism structures is shown for a light guiding plate 10 of this type. Turning film 22 on output surface 16 provides redirection of light toward the normal viewing axis V. The light output from
30 light guiding plate 10 can have a relatively high off-axis angle. Bottom prisms 24 provide collimation in the orthogonal direction. The orthogonal relationship of prism structures on top and bottom surfaces provides a controllable degree of collimation of the output light.

There are a number of variations applied to the basic arrangement represented in Fig. 2. For example, U.S. Patent No. 6,576,887 entitled "Light Guide for use with Backlit Display" to Whitney et al. discloses a light guide optimized for uniformity, in which structures on the output surface of a turning film 22 may be randomly distributed to provide a more uniform output. U.S. Patent No. 6,707,611 entitled "Optical Film with Variable Angle Prisms" to Gardiner et al. discloses adaptation of an optical turning film with an arrangement that reduces perceived ripple.

Referring to Figs. 3A and 3B, there is shown, from two different, approximately orthogonal perspectives, the overall function of a prism 60 for redirecting light, such as would be performed by a conventional turning film. Light entering prism 60 at an incident point P1 is refracted and reflected from a point P2 on a bottom facet 62 by Total Internal Reflection (TIR), then escapes prism 60 at a point P3. It is significant to note that prism 60 provides this turning function effectively in one direction, the Y-direction in the coordinate system shown in Figs. 3A and 3B. In an orthogonal direction, the X-direction of Figs. 3A and 3B, prism 60 is ineffective for light collection, resulting in a large divergence along the X-direction. For this reason, as Fig. 2 and as both Tai '872 and Whitney et al. '887 disclosures cited above show, two separate orthogonally disposed sets of prisms are employed in conventional solutions for light redirection. One set of prisms provides collimation of the light, the other set provides beam redirection for a direction. While this arrangement is workable, it can be appreciated that there would be cost and size advantages to an illumination solution that provides both collimation and beam redirection in a single optical component, particularly where such a solution provides improved on-axis luminance. With increased demands for more compact packaging of electronic display apparatus and for improved brightness, and with little promise of dramatic improvement to existing light-scattering approaches for backlight delivery, there is a compelling need to seek out unconventional solutions for light redirection along a two-dimensional surface, particularly well suited to backlighting applications.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a two-dimensional backlighting solution that is simpler than conventional solutions and provides both
5 redirection and collimation in a single component. With this object in mind, the present invention provides a turning film for providing light redirection comprising a two-dimensional array of roof prism structures.

It is a feature of the present invention that it provides both light
10 collimation and light redirection from a single array structure.

It is an advantage of the present invention that it can provide a more compact solution for displays than conventional brightness enhancement films provide, and combines the functions of light collimation and light redirection from a single component.

15 It is a further advantage of the present invention that it provides higher levels of on-axis brightness than are available using conventional turning film solutions.

These and other objects, features, and advantages of the present invention will become apparent to those skilled in the art upon a reading of the
20 following detailed description when taken in conjunction with the drawings wherein there is shown and described an illustrative embodiment of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

While the specification concludes with claims particularly pointing out and distinctly claiming the subject matter of the present invention, it is believed that
5 the invention will be better understood from the following description when taken in conjunction with the accompanying drawings, wherein:

Figure 1 is a block diagram side view showing the basic redirection function of an existing light guiding plate with separate collimation and redirection mechanisms;

10 Figure 2 is a perspective view showing one conventional arrangement for LCD illumination using separate collimation and redirection mechanisms;

Figures 3A and 3B are perspective views showing the overall behavior of prism structures in a conventional turning film;

Figures 4A and 4B are perspective views showing the overall behavior of roof
15 prism structures in a turning film according to the present invention;

Figures 5A and 5B are perspective views showing the geometrical arrangement of a roof prism structure according to the present invention;

Figure 6 is a perspective view of an array of roof prism structures on a turning
film of the present invention;

20 Figure 7 is an alternate perspective view of an array of roof prism structures on a turning film of the present invention;

Figure 8 is a perspective view of an array of roof prism structures on a turning film of the present invention;

Figure 9 is a top perspective view showing a turning film according to the
25 present invention, as used with a light guiding plate;

Figure 10 is a bottom-side perspective view showing a turning film according to the present invention, with its orientation when used with a light guiding plate; and,

Figure 11 is a graph comparing luminance characteristics of the turning film of the present invention with luminance provided by conventional brightness
30 enhancement articles.

DETAILED DESCRIPTION OF THE INVENTION

The present description is directed in particular to elements forming part of, or cooperating more directly with, apparatus in accordance with the invention.

5 It is to be understood that elements not specifically shown or described may take various forms well known to those skilled in the art.

Roof prisms, also termed dach prisms, provide right-angle deflection of incident light in various applications and are widely used in binoculars and other optical apparatus, particularly where compact packaging is desirable. As one
10 example, U.S. Patent No. 6,667,997 entitled "Optical Module and Method of Making the Same" to Nasu et al. discloses the deployment of a roof prism in a semiconductor laser module. Linear arrays of roof prisms have been disclosed for use in optical writing apparatus, such as that described in U.S. Patent Application Publication 2003/0007067 entitled "Imaging Device Array, Optical Writing Unit and Image
15 Forming Apparatus" by Masuda et al.; in U.S. Patent No. 5,907,438 entitled "Imaging Device" to Fujita et al.; and in Japanese Patent Application JP2003337300 entitled "Image-Formation Optical System, Optical Writing Unit, and Image Forming Apparatus" by Masuda et al. A two-dimensional array of roof prism structures used for directing light to a sensor is disclosed in U.S. Patent Application 2003/0218125
20 entitled "Sensor Using Roof Mirror/Roof Prism Array Scale and Apparatus Equipped with the Sensor" by Igaki et al.

Thus, as shown in the patent literature cited above, linear and two-dimensional arrays of roof prisms have been employed to redirect light in support of corresponding arrays of photosensitive components or arrays of image-recording
25 components in specialized applications. However, probably due to their relatively complex arrangement of surfaces, roof prism arrays have been overlooked for use in backlighting illumination systems. As is shown in the following description, the roof prism array not only provides a solution that simplifies the design of support components for light guide plate 10 (Figs. 1 and 2) and helps to reduce component
30 count for backlight illumination. At the same time, a roof prism array also provides unanticipated improvements in on-axis luminance.

The background section above described the light redirection capability of conventional prism 60 structures with reference to Figs. 3A and 3B. Referring now to Figs. 4A and 4B there is shown, by comparison, the behavior of a

roof prism structure 26 for handling light incident on a receiving facet 52 at incident point P1. The light is refracted, then reflected from a roof facet 30, and then exits at an output facet 56. For understanding the functions of roof prism structure 26 in the present invention, it is instructive to compare the behavior of conventional prism 60 of Figs. 3A and 3B with roof prism structure 26 of Figs. 4A and 4B. Relative to the X-Y-Z coordinate axes shown, conventional prism 60 redirects light rays along the Y-direction. However, conventional prism 60 does not collect light along the X-direction. Thus, a turning film article using conventional prism 60 structures must be used in combination with a separate mechanism for collimating light in the X-direction. In contrast, roof prism structure 26 of the present invention provides both collimation of light along the Y-axis, thereby reducing the divergence angle of light relative to the Y-axis, and redirection of the light toward the Z-axis. The present invention takes advantage of this dual-function capability of roof prism structures 26 in order to provide a turning film that does not require a supplementary collimation film.

Parameters of particular interest for determining the behavior of roof prism structure 26 include the following:

- (i) index of refraction. In general, the material of which roof prism structure 26 is formed should have an index of refraction of 1.4 or greater.
- (ii) ridge angle α . This parameter gives the inclination angle of a ridge 31 that is formed at the intersection of roof facets 30, relative to a normal to output facet 56. Ridge angle α grows shallower with increasing height of roof prism structure 26, relative to output facet 56. The recommended range for ridge angle α is 35 – 45 degrees.
- (iii) peak angle β . This parameter refers to the angle at which roof facets 30 intersect at ridge 31. The recommended range is 60 – 80 degrees.

Figs. 5A and 5B are provided to assist in visualizing the overall geometrical shape of roof prism structure 26. As shown in Figs. 5A and 5B, roof prism structure 26 can be considered as if formed by joining two constituent prisms: a roof section 34 and a base section 32. In an actual embodiment, roof prism structure 26 is molded or otherwise formed as a single piece, rather than being formed from two separate component prisms; Figs. 5A and 5B are an aid to visualization only. Base section 32 in the embodiment of Figs. 5A and 5B has the shape of a diagonally

sectioned rectangular cube. Roof section 34 has a roof shape with two slanting roof facets 30.

Referring to Figs. 6, 7, and 8, there are shown perspective views of a turning film 36 in various embodiments of the present invention, from the light input side. As these figures show, turning film 36 has, over its input surface, a number of
5 of roof prism structures 26 arranged in a two-dimensional array. Turning film 36 has an output surface 38 that is substantially planar. Referring back to Figs. 4A and 4B, output facet 56 for each roof prism structure 26 lies along output surface 38 of turning film 36. Roof facets 30 are inclined inward, toward light guiding plate 10 (Figs. 1 and
10 2) at ridge angle α (Fig. 4A). The inclination of ridge angle α is relative to a normal to turning film 36.

As is shown in Fig. 8, the pitch P between roof prism structures 26 should be approximately equal to width W of prism structures 26. The recommended range for pitch P is 20~100 microns. The width W also has same range. The distance
15 between two adjacent peaks of prism structure 26 also has approximately equal range. The height H ranges from 20~200 microns.

Referring to Fig. 9 and to the bottom perspective view of a display apparatus 64 in Fig. 10, there are shown different perspective views of an illumination system 40 using turning film 36 of the present invention. Light from light guiding
20 plate 10 is directed toward turning film 36, as described above. Turning film 36 provides both collimation and redirection of the light received, providing light at output surface 38 for backlighting or other functions. The use of turning film 36 configured with an array of roof prism structures 26 eliminates the need for a structure having separate bottom prisms 24, as was shown in Fig. 2.

25 Fabrication Methods

Turning film 36 of the present invention is preferably fabricated from a flexible, transparent material, most preferably from a polymeric material. There are a number of suitable polymers having high light transmission properties, and being inexpensive and adaptable to microreplication processes. Suitable materials include
30 polyolefins, polyesters, polyamides, polycarbonates, cellulosic esters, polystyrene, polyvinyl resins, polysulfonamides, polyethers, polyimides, polyvinylidene fluoride, polyurethanes, polyphenylenesulfides, polytetrafluoroethylene, polyacetals, polysulfonates, polyester ionomers, and polyolefin ionomers. Copolymers and/or

mixtures of these polymers can be used. The array of roof prism structures 26 can be formed by various molding methods, including extrusion film casting, for example. In extrusion film casting, a polymer or polymer blend is melt extruded through a slit die, T-die, coat-hanger die, or other suitable mechanism. The extruded web having the preferred geometry is then rapidly quenched to below its glass solidification temperature upon a chilled casting drum so that the polymer retains the shape of the roller geometry. The film of the invention may also be manufactured by vacuum forming around a pattern, injection molding of the lenses using UV curable materials coated on a web then cured, and embossing in a polymer web.

10 Luminance Improvements

Luminance curves 46, 48, 50, and 54 in Fig. 11 compare relative luminance for a range of angles for turning film 36 of the present invention against conventional brightness enhancement film solutions currently used for display backlighting applications. Curves 46 and 48 show the luminance characteristics of turning film 36 at orthogonal angles relative to output surface 38. Curves 50 and 52 show the luminance characteristics of conventional films. As is seen from Fig. 11, there is a substantial gain in on-axis luminance for turning film 36 when compared against components currently in use.

Thus, it can be seen that turning film 36 of the present invention not only provides, in a single article, the functions of both collimation and redirection, but also provides improved on-axis brightness over conventional types of brightness enhancement solutions.

The invention has been described in detail with particular reference to certain preferred embodiments thereof, but it will be understood that variations and modifications can be effected within the scope of the invention as described above, and as noted in the appended claims, by a person of ordinary skill in the art without departing from the scope of the invention. For example, a number of different arrangements of roof prism structures 26 are possible within turning film 36. Roof prism structures 26 could vary dimensionally over a range. An uneven spatial distribution could be beneficial for improved uniformity. Turning film 36 of the present invention could be used with a number of different light sources, including lasers, LEDs, or CCFL sources. Turning film 36 could be used with other types of components for conditioning uniformity and brightness, including diffusers, polarizers, etc. Turning film 36 is compatible with any of a number of light-gating

devices 20, including spatial light modulators, such as LCDs and Digital Micromirror Devices (DMDs), also termed Digital Light Processing (DLP) components.

Thus, what is provided is an apparatus and method for forming two-dimensional turning film employing an array of roof prism structures to collect and
5 redirect light from a light guiding plate.

PARTS LIST

- 10. Light guiding plate
- 12. Light source
- 5 14. Light redirecting surface
- 16. Output surface
- 18. Input surface
- 20. Light gating device
- 22. Turning film
- 10 24. Bottom prisms
- 26. Roof prism structure
- 28. Output face
- 30. Roof facet
- 31. Ridge
- 15 32. Base section
- 34. Roof section
- 36. Turning film
- 38. Output surface
- 40. Illumination system
- 20 42. Reflective surface
- 44. Bottom surface
- 46, 48, 50, 54. Luminance curve
- 52. Receiving facet
- 56. Output facet
- 25 60. Prism
- 62. Bottom facet
- 64. Display apparatus

CLAIMS

- 5 1. An optical turning film for providing light redirection, comprising:
 (a) an input surface for accepting incident light comprising a plurality
 of roof prism structures arranged in a two-dimensional array; and,
 (b) a substantially planar output surface.
- 10 2. An optical turning film according to claim 1 wherein, relative to a
normal to the output surface of the turning film, roof prism facets for the roof prism
structures are inclined at an angle between 25 and 60 degrees.
- 15 3. An optical turning film according to claim 1 wherein said, relative
to a normal to the output surface of the turning film, roof prism facets for the roof
prism structures are inclined at an angle between 35 and 45 degrees.
- 20 4. An optical turning film according to claim 1 wherein roof prism
facets for each of the roof prism structures intersect at an angle between 50 and 100
degrees.
- 25 5. An optical turning film according to claim 1 wherein roof prism
facets for each of the roof prism structures intersect at an angle between 60 and 80
degrees.
- 30 6. An optical turning film according to claim 1 fabricated from any of
a group of materials including polyolefins, polyesters, polyamides, polycarbonates,
cellulosic esters, polystyrene, polyvinyl resins, polysulfonamides, polyethers,
polyimides, polyvinylidene fluoride, polyurethanes, polyphenylenesulfides,
polytetrafluoroethylene, polyacetals, polysulfonates, polyester ionomers, polyolefin
ionomers, copolymers, and polymer mixtures.
7. An optical turning film for providing light collimation along a first
direction and light redirection in a second direction substantially orthogonal to the

first direction, the optical turning film comprising a plurality of roof prism structures arranged in a two-dimensional array, wherein each roof prism structure comprises:

- (i) an output facet substantially coplanar with the output surface of the turning film;
 - 5 (ii) an input facet for accepting incident light, the input facet substantially orthogonal to the output facet;
 - (iii) roof facets meeting at a ridge, the roof facets intersecting at a peak angle in the range from about 60 to about 80 degrees;
- wherein the roof facets are inclined, relative to a normal to the output facet, at a ridge
- 10 angle between about 25 and 60 degrees from normal.

8. An optical turning film according to claim 7 wherein the roof facets are inclined, relative to a normal to the output facet, at a ridge angle between about 35 and 45 degrees from normal.

15

9. An optical turning film according to claim 7 fabricated from any of a group of materials including polyolefins, polyesters, polyamides, polycarbonates, cellulosic esters, polystyrene, polyvinyl resins, polysulfonamides, polyethers, polyimides, polyvinylidene fluoride, polyurethanes, polyphenylenesulfides,

20 polytetrafluoroethylene, polyacetals, polysulfonates, polyester ionomers, polyolefin ionomers, copolymers, and polymer mixtures.

10. An illumination system for providing light from a surface comprising:

25

- (a) a light source;
 - (b) a light guiding plate comprising:
 - (i) an input edge for accepting incident light from the light source;
 - (ii) an output surface for providing redirected light;
 - (iii) a reflecting surface for directing light incident thereon toward
- 30 the
- output surface as redirected light;
- (c) a turning film optically coupled with the output surface of the light guiding plate, the turning film comprising a plurality of roof prism structures arranged in a two-dimensional array.

11. An illumination system according to claim 10 wherein, relative to a normal to the output surface of the turning film, roof prism facets for the roof prism structures are inclined at an angle between 25 and 60 degrees.

5 12. An illumination system according to claim 10 wherein said, relative to a normal to the output surface of the turning film, roof prism facets for the roof prism structures are inclined at an angle between 35 and 45 degrees.

10 13. The illumination system of claim 10 wherein roof prism facets for each of the roof prism structures intersect at an angle between 60 and 80 degrees.

14. The illumination system of claim 10 wherein said turning film is fabricated from any of a group of materials including polyolefins, polyesters, polyamides, polycarbonates, cellulosic esters, polystyrene, polyvinyl resins, polysulfonamides, polyethers, polyimides, polyvinylidene fluoride, polyurethanes, polyphenylenesulfides, polytetrafluoroethylene, polyacetals, polysulfonates, polyester ionomers, polyolefin ionomers, copolymers, and polymer mixtures.

15. A display apparatus comprising:
20 (a) a display device for forming an image;
 (b) an illumination system for providing light to the display device comprising:

 (i) a light source;
 (ii) a light guiding plate comprising:
25 (1) an input edge for accepting incident light from the light source;

 (2) an output surface for providing redirected light;
 (3) a reflecting surface for directing light incident thereon toward the output surface as redirected light;

30 (iii) a turning film optically coupled with the output surface of the light guiding plate, the input surface of the turning film comprising a plurality of roof prism structures arranged in a two-dimensional array.

16. A display apparatus according to claim 11 wherein the display device comprises a liquid crystal display.

5 17. The display apparatus according to claim 15 wherein, relative to a normal to the output surface of the turning film, roof prism facets for the roof prism structures are inclined at an angle between 25 and 60 degrees.

10 18. The display apparatus according to claim 15 wherein said, relative to a normal to the output surface of the turning film, roof prism facets for the roof prism structures are inclined at an angle between 35 and 45 degrees.

15 19. The display apparatus of claim 15 wherein roof prism facets for each of the roof prism structures intersect at an angle between 60 and 80 degrees.

20 20. The display apparatus of claim 15 wherein said turning film fabricated from any of a group of materials including polyolefins, polyesters, polyamides, polycarbonates, cellulosic esters, polystyrene, polyvinyl resins, polysulfonamides, polyethers, polyimides, polyvinylidene fluoride, polyurethanes, polyphenylenesulfides, polytetrafluoroethylene, polyacetals, polysulfonates, polyester ionomers, polyolefin ionomers, copolymers, and polymer mixtures.
can be used.

25

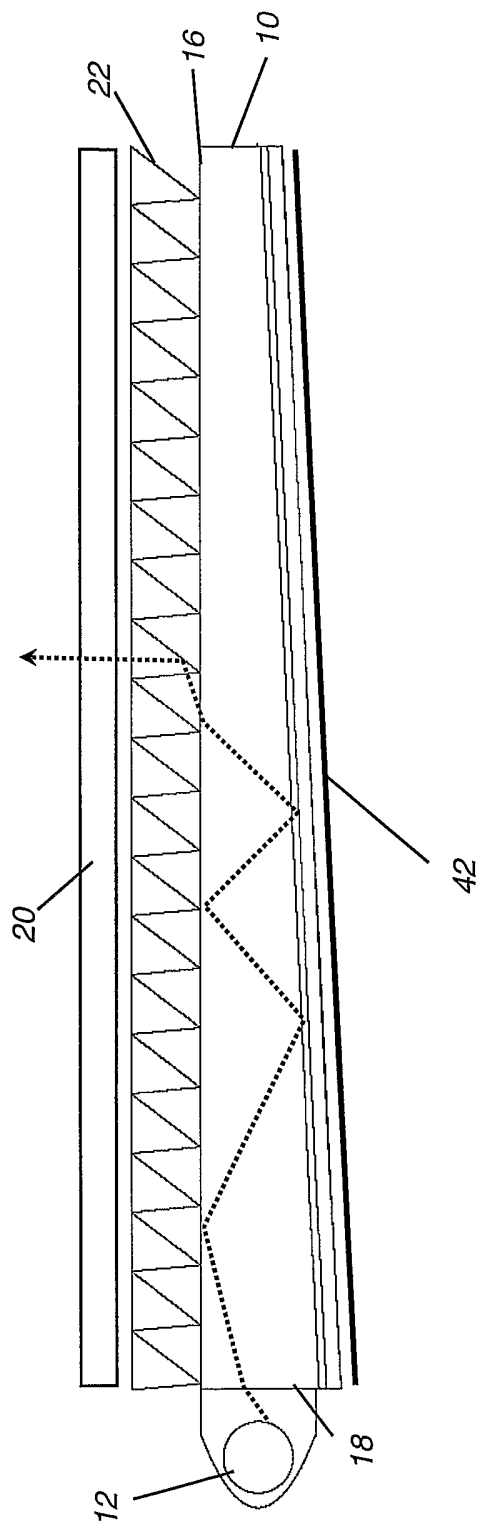


FIG. 1
PRIOR ART

2/11

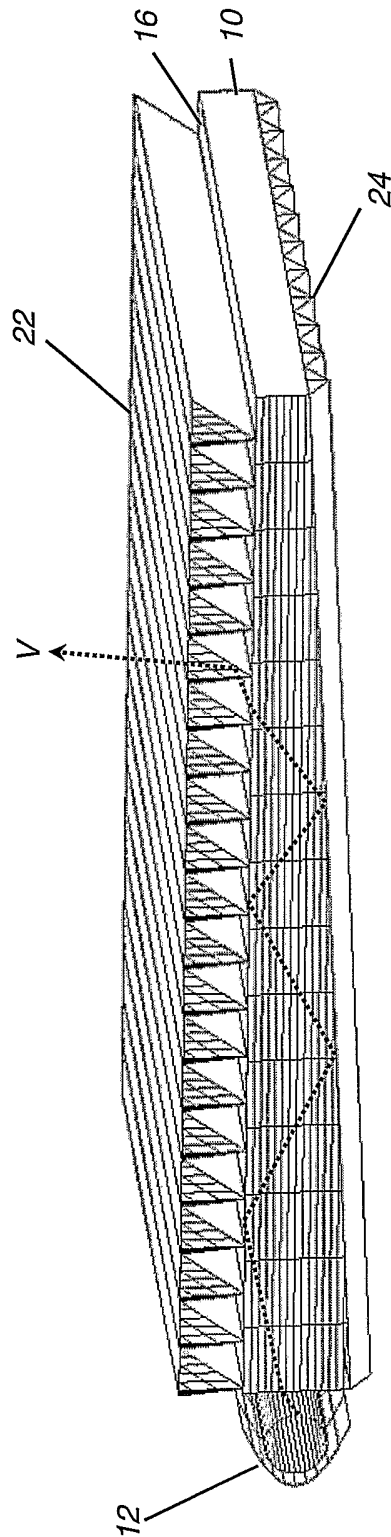


FIG. 2
PRIOR ART

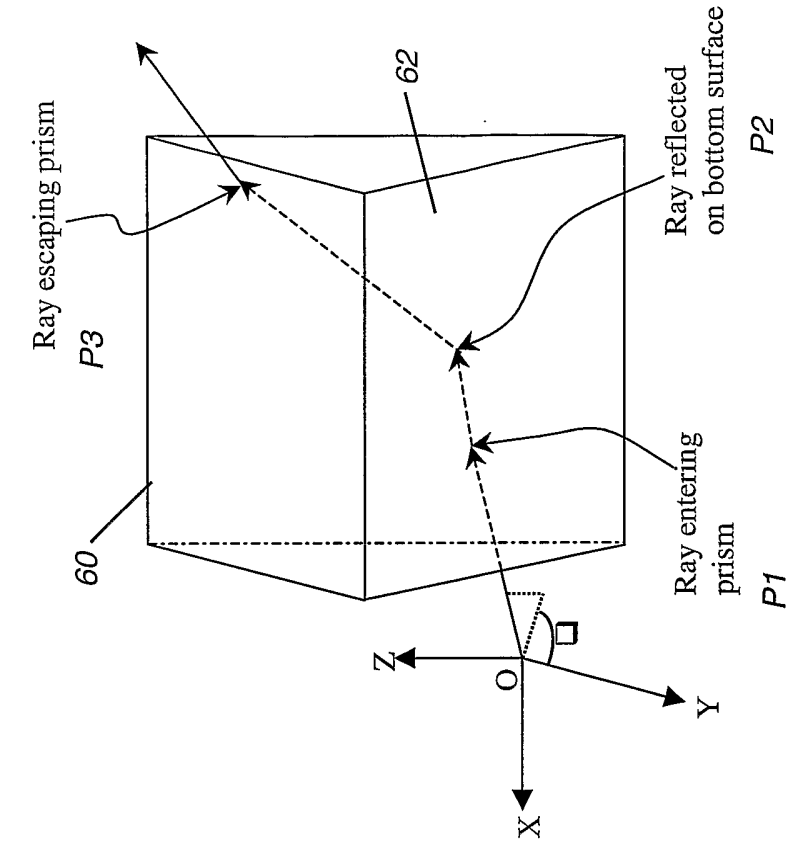


FIG. 3A

PRIOR ART

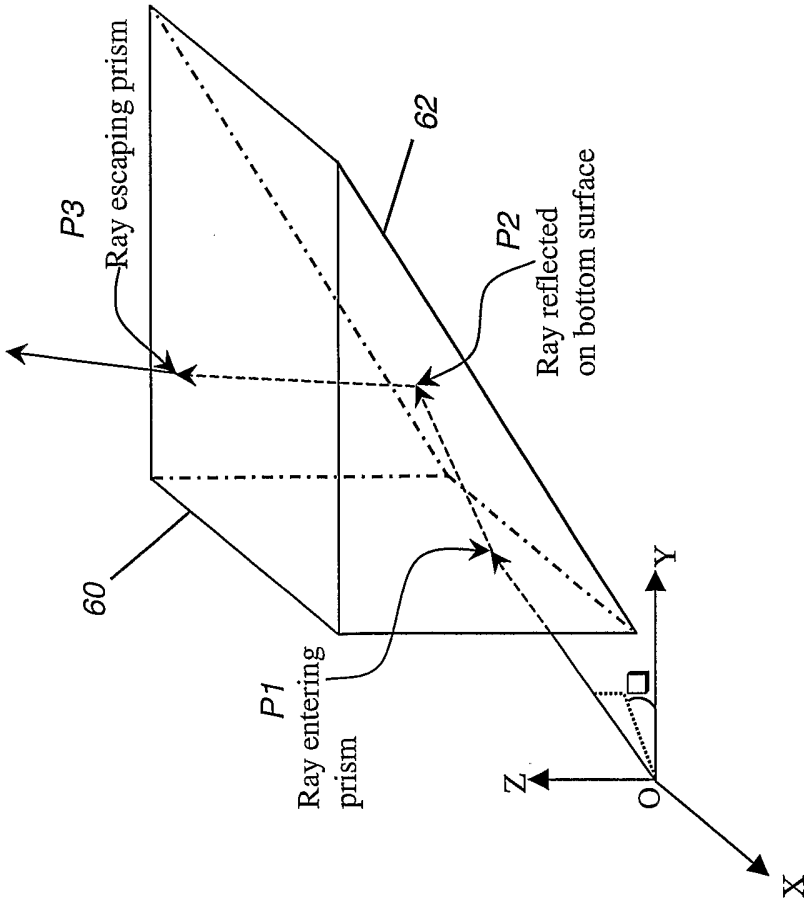


FIG. 3B

PRIOR ART

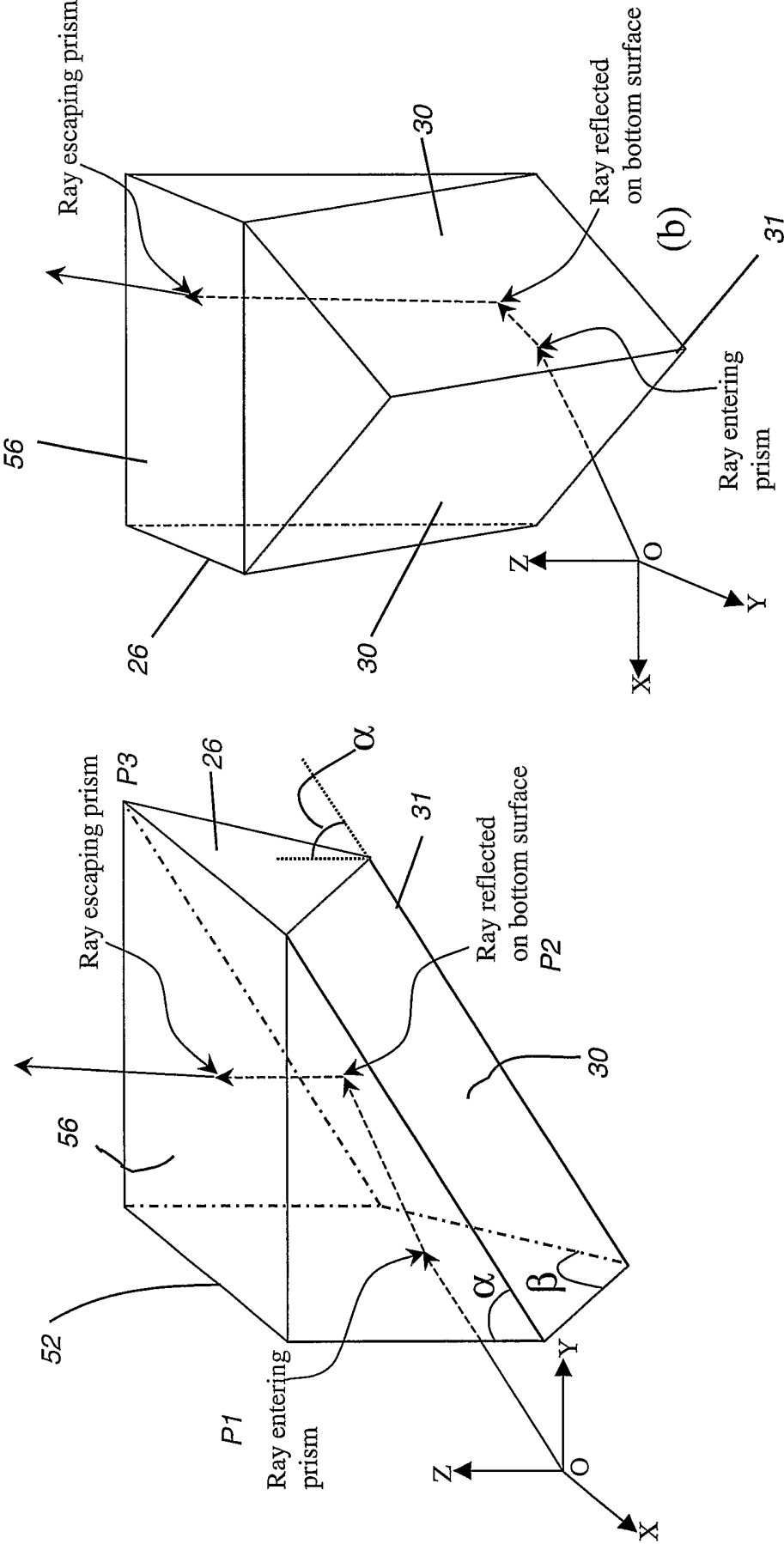


FIG. 4B

FIG. 4A

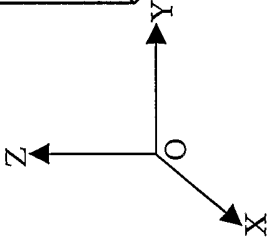
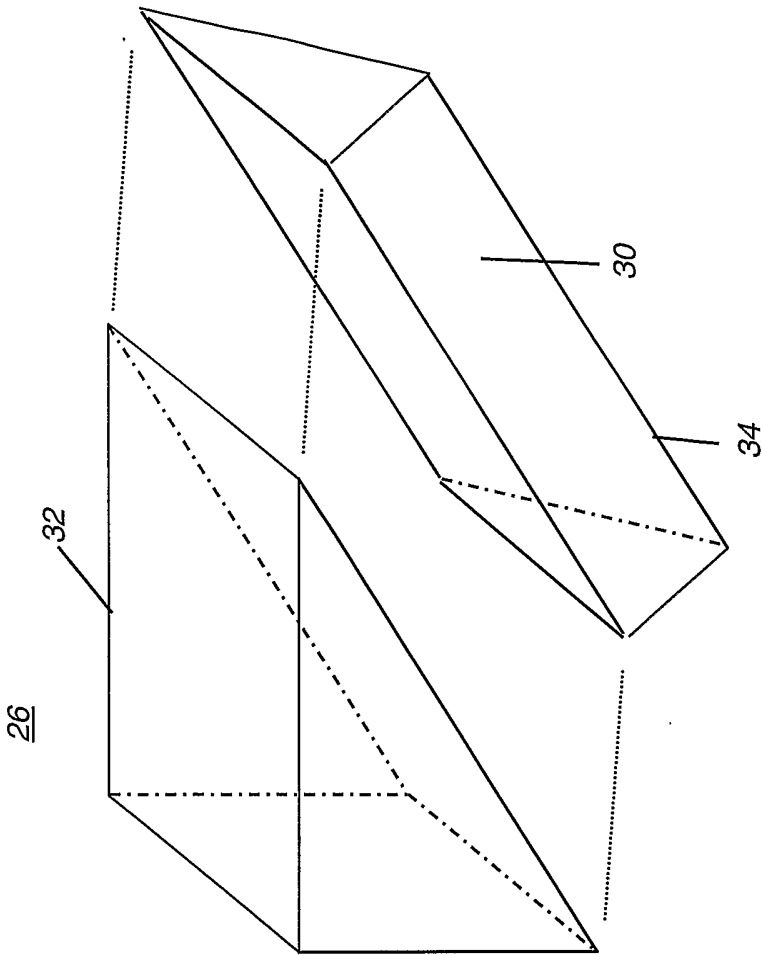


FIG. 5A

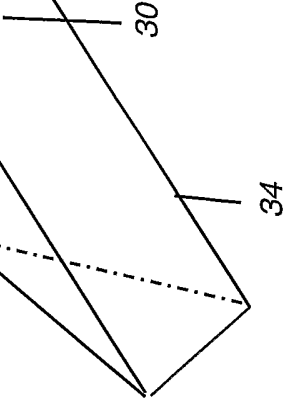
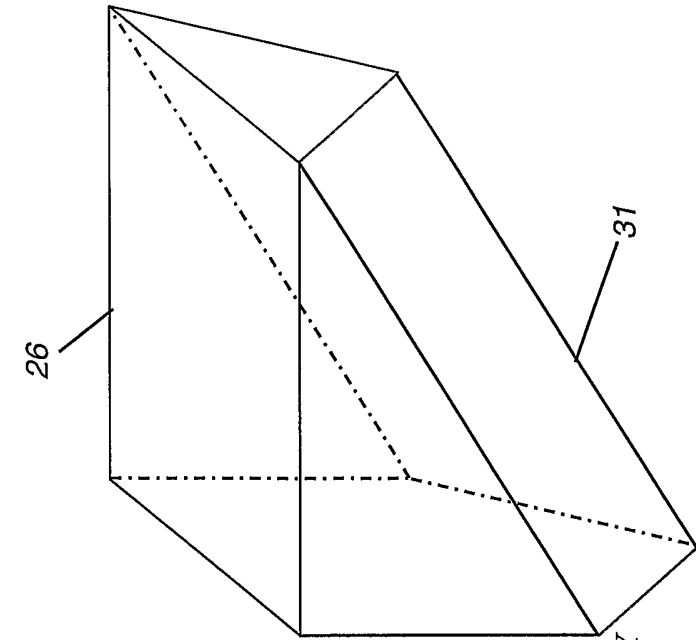


FIG. 5B

6/11

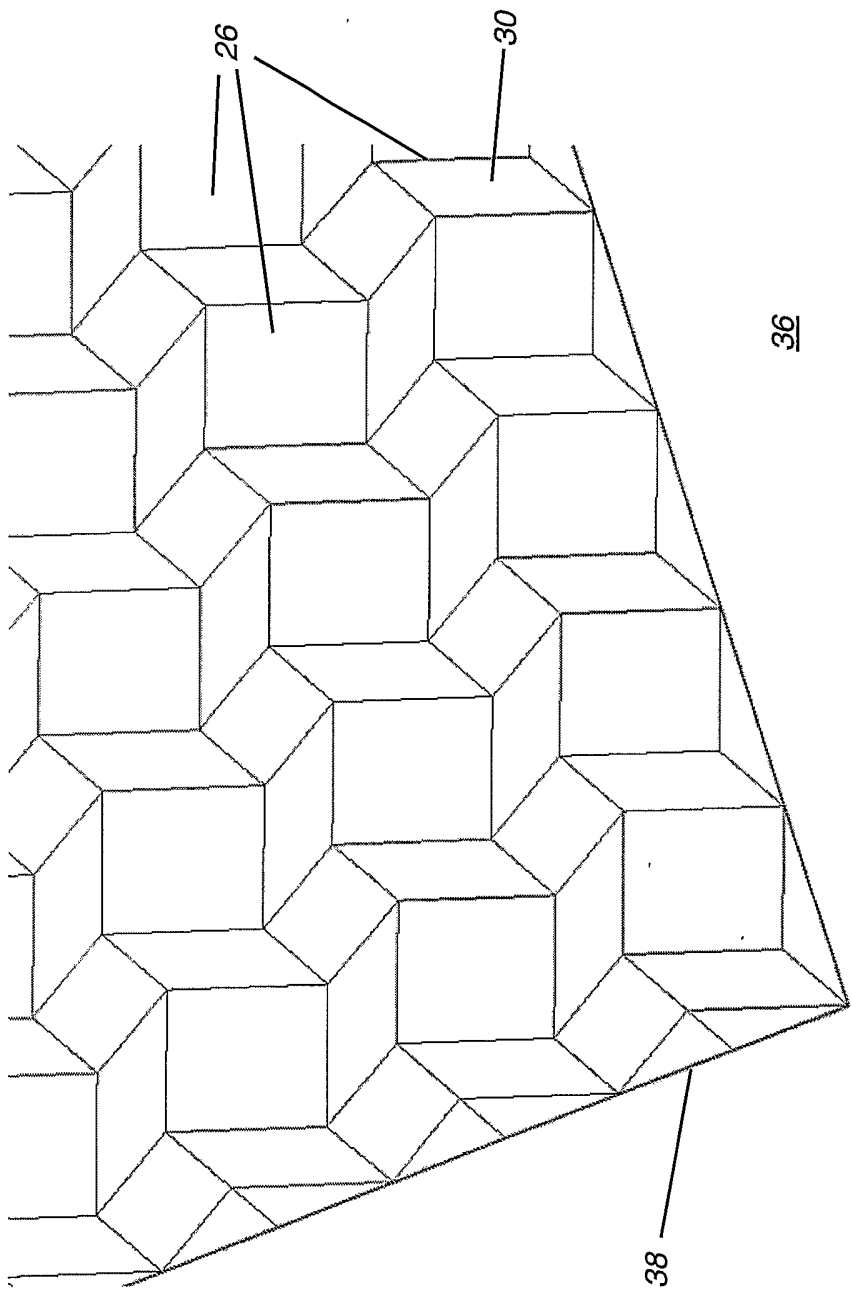


FIG. 6

7/11

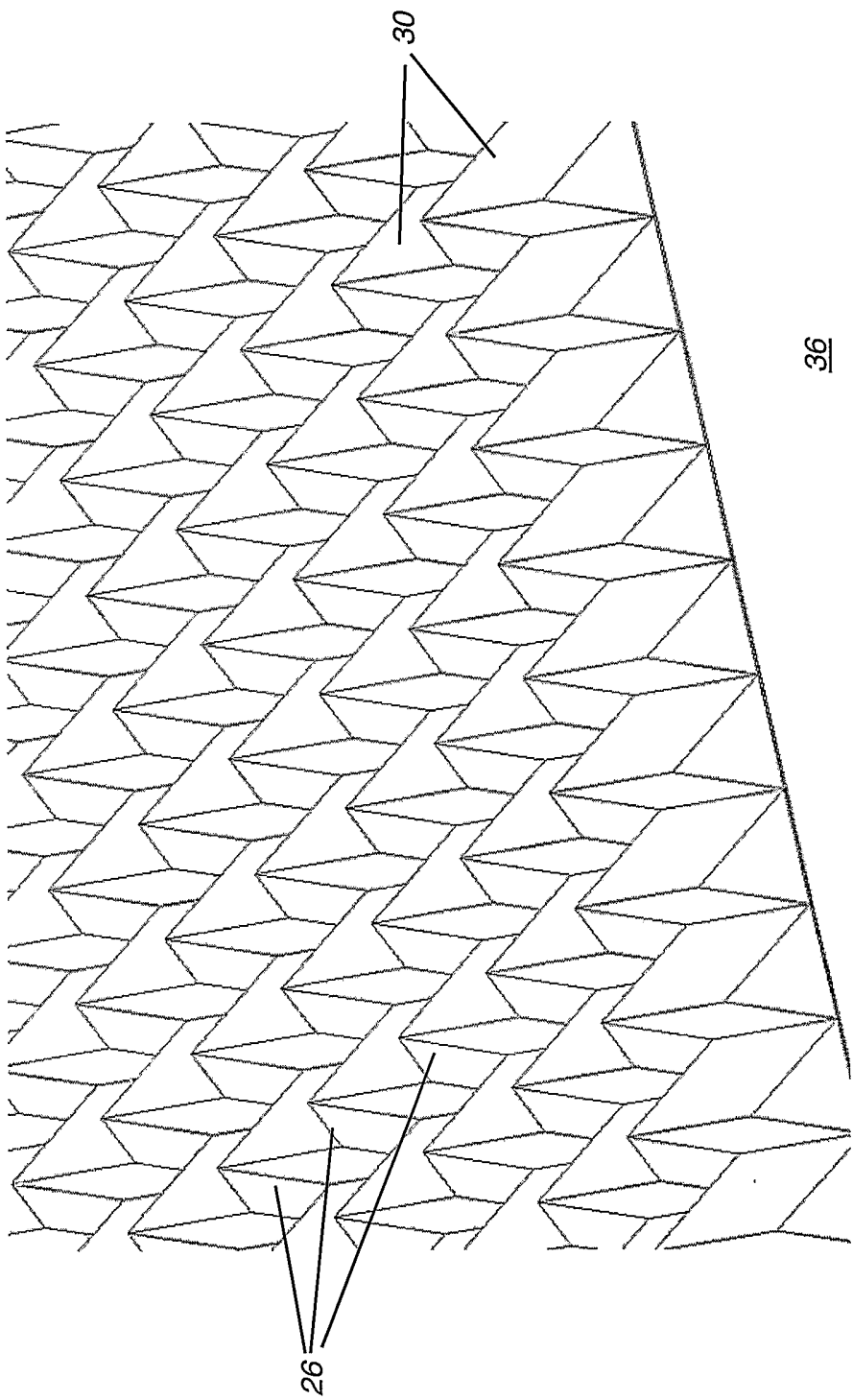


FIG. 7

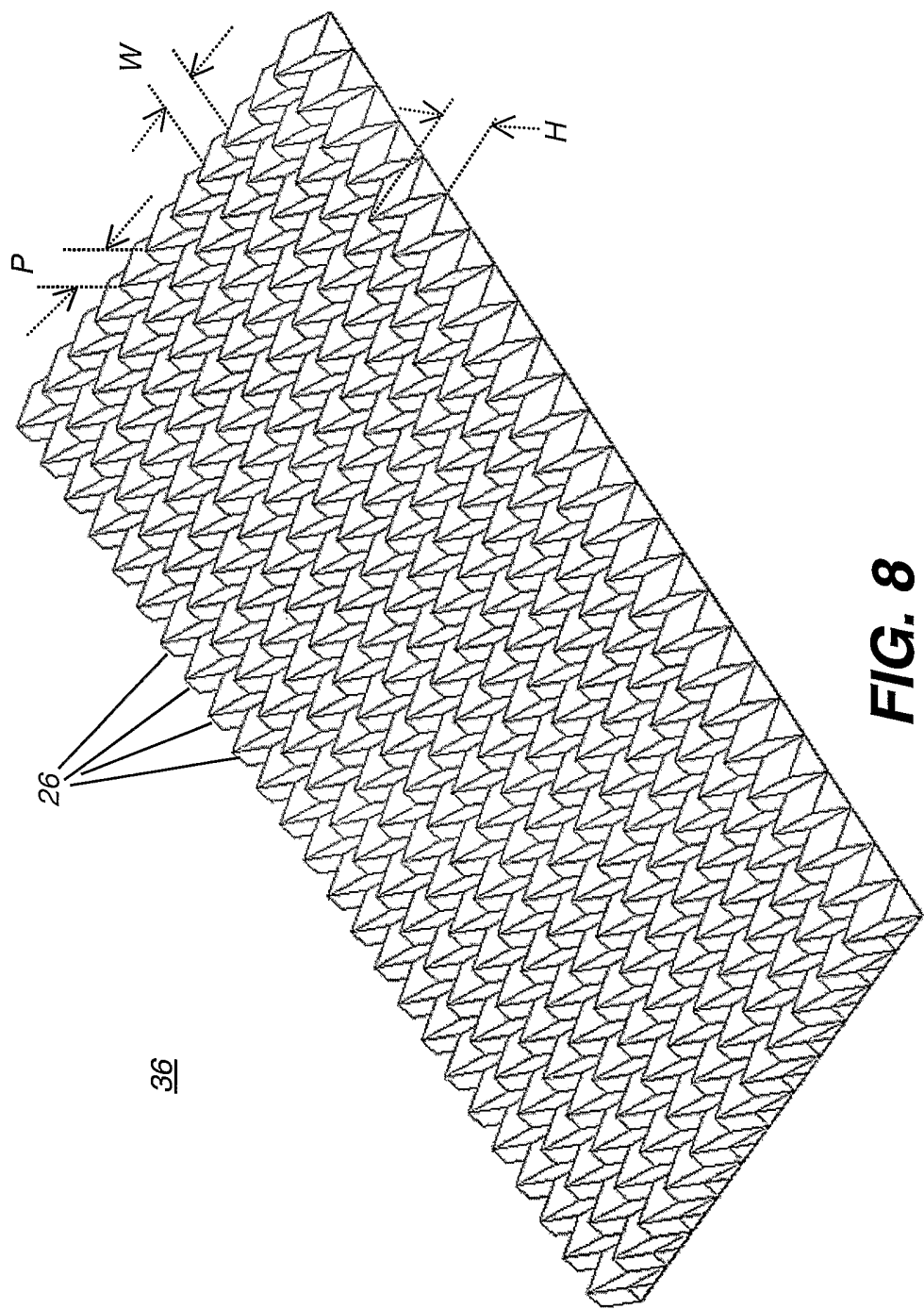


FIG. 8

9/11

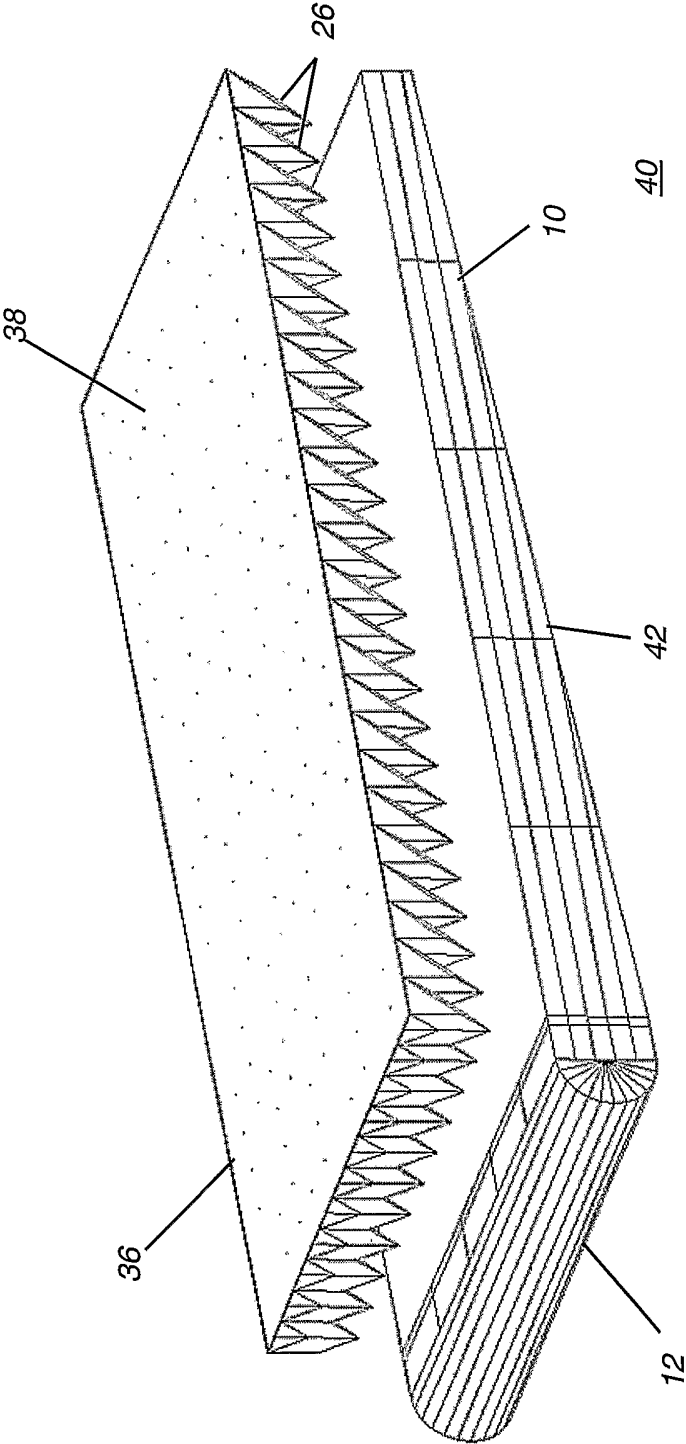


FIG. 9

10/11

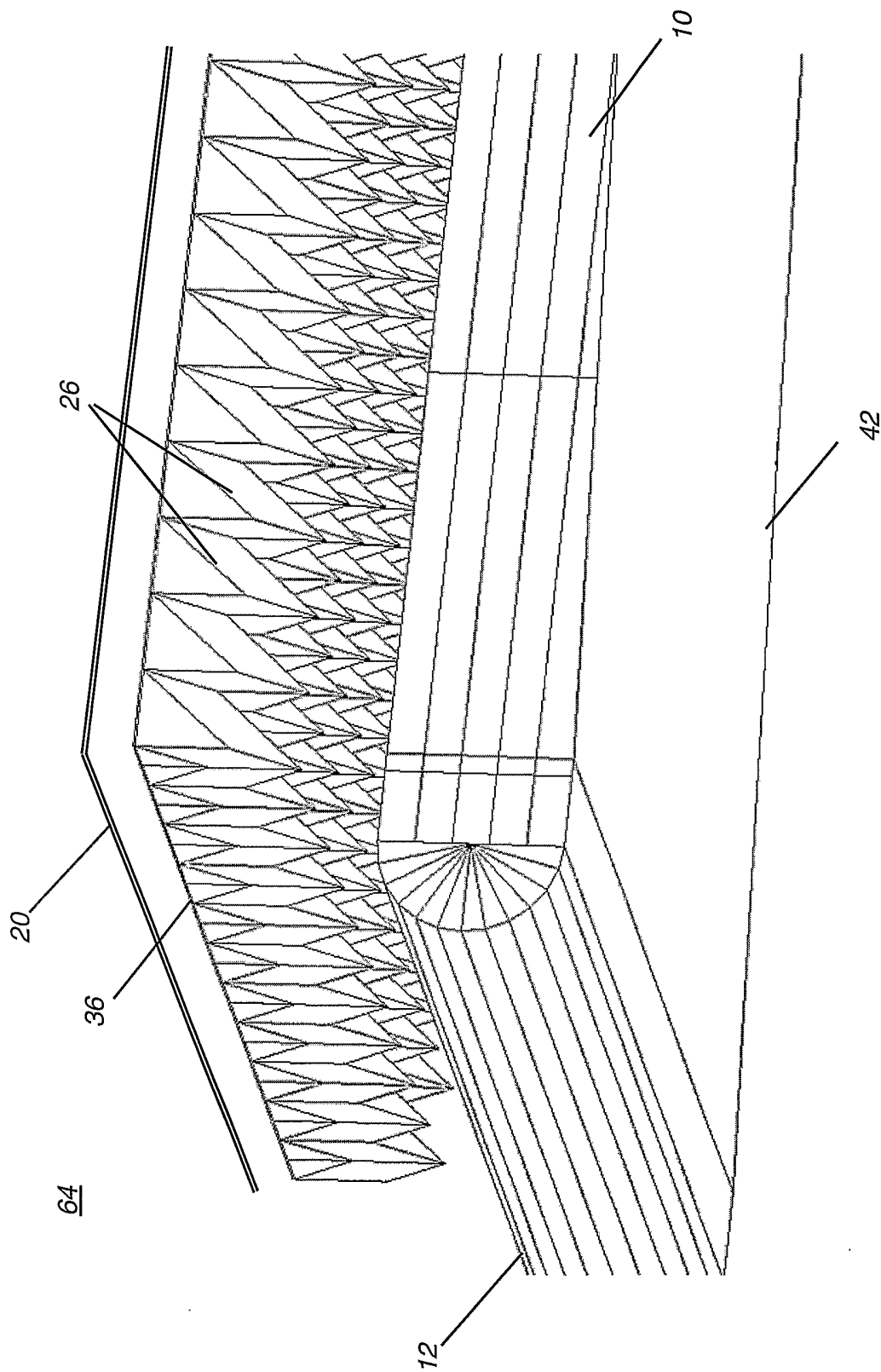


FIG. 10

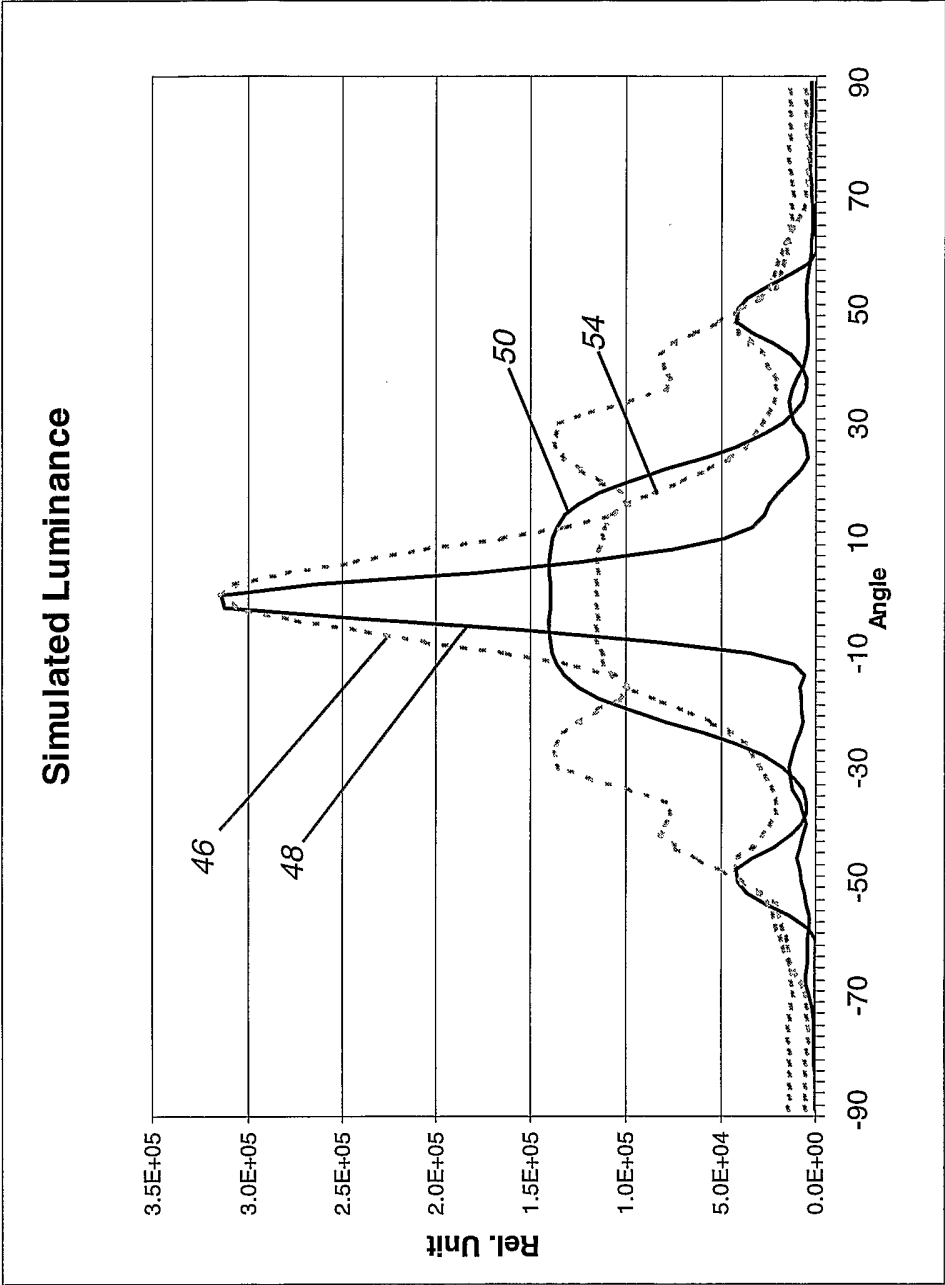


FIG. 11

INTERNATIONAL SEARCH REPORT

International Application No

PCT/US2005/033557

A. CLASSIFICATION OF SUBJECT MATTER

G02B5/04 G02B6/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

G02B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3 829 680 A (JONES B,US) 13 August 1974 (1974-08-13) abstract column 7, paragraph 4 column 4, line 48 - column 5, paragraph 2 figures 3-5	1-9
X	PATENT ABSTRACTS OF JAPAN vol. 1995, no. 08, 29 September 1995 (1995-09-29) -& JP 07 114025 A (SHARP CORP), 2 May 1995 (1995-05-02) abstract; figures 1,2 ----- -/--	1-5, 7, 8, 10-13, 15-19



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

* Special categories of cited documents :

- *A* document defining the general state of the art which is not considered to be of particular relevance
- *E* earlier document but published on or after the international filing date
- *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- *O* document referring to an oral disclosure, use, exhibition or other means
- *P* document published prior to the international filing date but later than the priority date claimed

- *T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- *&* document member of the same patent family

Date of the actual completion of the international search

25 January 2006

Date of mailing of the international search report

02/02/2006

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

Moroz, A

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US2005/033557

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 300 263 A (HOOPMAN ET AL) 5 April 1994 (1994-04-05) abstract column 1, paragraph 2 column 3, paragraphs 2,3 figures 2,13 -----	1-20
X	US 5 396 350 A (BEESON ET AL) 7 March 1995 (1995-03-07) abstract columns 1,2 column 14 figures 2-12,15-18 -----	1-20
X	US 6 277 471 B1 (TANG SHIH CHIEH) 21 August 2001 (2001-08-21) abstract column 2, line 26 - column 3, last paragraph figures 2,3 -----	1-20

INTERNATIONAL SEARCH REPORT

International Application No

PC17US2005/033557

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 3829680	A	13-08-1974	AU 6286873 A	29-05-1975
			CA 989791 A1	25-05-1976
			DE 2357060 A1	30-05-1974
			GB 1457443 A	01-12-1976
			JP 49083281 A	10-08-1974
			JP 54057790 U	21-04-1979
JP 07114025	A	02-05-1995	NONE	
US 5300263	A	05-04-1994	EP 0666797 A1	16-08-1995
			JP 3207859 B2	10-09-2001
			JP 8503171 T	09-04-1996
			WO 9409974 A1	11-05-1994
			US 5519539 A	21-05-1996
US 5396350	A	07-03-1995	AT 180322 T	15-06-1999
			AU 1087795 A	23-05-1995
			CA 2174528 A1	11-05-1995
			CN 1136349 A	20-11-1996
			DE 69418617 D1	24-06-1999
			DE 69418617 T2	03-02-2000
			DK 727028 T3	08-11-1999
			EP 0727028 A1	21-08-1996
			ES 2132597 T3	16-08-1999
			FI 961880 A	03-05-1996
			GR 3030897 T3	30-11-1999
			JP 2706574 B2	28-01-1998
			JP 8511129 T	19-11-1996
			SG 47942 A1	17-04-1998
			WO 9512782 A1	11-05-1995
			US 5428468 A	27-06-1995
US 6277471	B1	21-08-2001	NONE	