(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
7 September 2007 (07.09.2007)

PCT

(10) International Publication Number
WO 2007/100742 A1

(51) International Patent Classification:
G02F 1/13357 (2006.01) *G02B 5/30* (2006.01)
G02F 1/335 (2006.01)

(21) International Application Number:
PCT/US2007/004867

(22) International Filing Date:
23 February 2007 (23.02.2007)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
11/276,442 28 February 2006 (28.02.2006) US

(71) Applicant *(for all designated States except US)*: **3M INNOVATIVE PROPERTIES COMPANY** [US/US]; 3M Center, Post Office Box 33427, Saint Paul, Minnesota 55133-3427 (US).

(72) Inventors: **RICHARD, James T.**; 15 Drumlion Hill Road, Bolton, Massachusetts 01740 (US). **GEHLSEN, Mark D.**; 3M Center, Post Office Box 33427, Saint Paul, Minnesota 55133-3427 (US). **ANDERSON, Susan E.**; 3M Center, Post Office Box 33427, Saint Paul, Minnesota 55133-3427 (US).

(74) Agents: **JENSEN, Stephen C.** et al.; 3M Center, Office of Intellectual Property Counsel, Post Office Box 33427, Saint Paul, Minnesota 55133-3427 (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, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

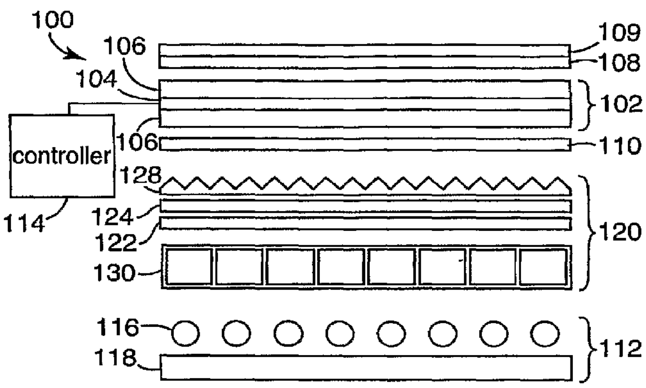
(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, 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).

Declarations under Rule 4.17:
— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

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: OPTICAL DISPLAY WITH FLUTED OPTICAL PLATE



(57) Abstract: A display system has a light source, a display panel and an arrangement of light management layers disposed between the light source and the display panel. The light source illuminates the display panel through the arrangement of light management layers. The arrangement of light management layers includes a fluted plate that has a front layer facing the display panel, a back layer facing the light source, and a plurality of connecting members connecting the front and back layers. In some embodiments the fluted plate includes a first light management layer, a cross member substantially parallel to, and spaced apart from, the first light management layer, and an arrangement of first connecting members connecting the cross member and the first light management layer.

WO 2007/100742 A1

OPTICAL DISPLAY WITH FLUTED OPTICAL PLATE

Field of the Invention

The invention relates to optical displays, and more particularly to display systems that are illuminated from behind, such as may be used in LCD monitors and LCD televisions.

Background

Liquid crystal displays (LCDs) are optical displays used in devices such as laptop computers, hand-held calculators, digital watches and televisions. Some LCDs include a light source that is located to the side of the display, with a light guide positioned to guide the light from the light source to the back of the LCD panel. Other LCDs, for example some LCD monitors and LCD televisions (LCD-TVs), are directly illuminated using a number of light sources positioned behind the LCD panel. This arrangement is increasingly common with larger displays, because the light power requirements, to achieve a certain level of display brightness, increase with the square of the display size, whereas the space available for locating light sources along the side of the display only increases linearly with display size. In addition, some LCD applications, such as LCD-TVs, require that the display be bright enough to be viewed from a greater distance than other applications, and the viewing angle requirements for LCD-TVs are generally different from those for LCD monitors and hand-held devices.

Some LCD monitors and most LCD-TVs are commonly illuminated from behind by a number of cold cathode fluorescent lamps (CCFLs). These light sources are linear and stretch across the full width of the display, with the result that the back of the display is illuminated by a series of bright stripes separated by darker regions. Such an illumination profile is not desirable, and so a diffuser plate is used to smooth the illumination profile at the back of the LCD device.

Currently, LCD-TV diffuser plates employ a polymeric matrix of polymethyl methacrylate (PMMA), poly(carbonate), cycloolefins, random copolymers of polymethylmethacrylate or polystyrene, combined with a variety of dispersed phases that include glass, polystyrene beads, and $CaCO_3$ particles. These plates often deform or warp after exposure to the elevated temperatures of the lamps. In addition, some diffusion plates are provided with a diffusion characteristic that varies spatially across its width, in an attempt to make the illumination profile at the back of the LCD panel more uniform. Such non-uniform diffusers are sometimes referred to as printed pattern diffusers. They are expensive to manufacture, and increase manufacturing costs, since the diffusing pattern must be registered to the illumination source at the time of assembly. In addition, the diffusion plates require customized extrusion compounding to distribute the diffusing particles uniformly throughout the polymer matrix, which further increases costs.

Furthermore, to prevent warping or other types of physical distortions, the diffuser plate has to be of a minimum thickness relative to its height and width. As the size of the display increases, this means that the diffuser plate also becomes increasingly thick, thus increasing the weight of the display.

Summary of the Invention

One embodiment of the invention is directed to a display system that has a light source, a display panel, and an arrangement of light management layers disposed between the light source and the display panel. The light source illuminates the display panel through the arrangement of light management layers. The arrangement of light management layers includes a fluted plate that has a front layer facing the display panel, a back layer facing the light source, and a plurality of connecting members connecting the front and back layers.

Another embodiment of the invention is directed to a light management unit that includes a fluted layer. The fluted layer has a first light management layer, a cross member substantially parallel to, and spaced apart from, the first light management layer and an arrangement of first connecting members connecting the cross member to the first light management layer.

These and other aspects of the present application will be apparent from the detailed description below. In no event, however, should the above summaries be construed as limitations on the claimed subject matter, which subject matter is defined solely by the attached claims, as may be amended during prosecution.

Brief Description of the Drawings

The invention may be more completely understood in consideration of the following detailed description of various embodiments of the invention in connection with the accompanying drawings, in which like reference numerals designate like elements, and wherein:

FIG. 1 schematically illustrates a display device that uses a fluted plate;

FIG. 2A schematically illustrates a fluted plate;

FIGs. 2B and 2C schematically illustrate fluted plates with attached optical films;

FIG. 3 schematically illustrates a fluted plate having a spatially variable single pass transmission;

FIG. 4 schematically illustrates a fluted plate having a spatially variable refractive index;

FIGs. 5A and 5B schematically illustrate fluted plates whose upper and lower layers have respectively spatially varying thicknesses;

FIGs 6A and 6B schematically illustrate fluted plates whose upper and lower layers have respectively spatially varying thicknesses;

FIGs. 7A, 7B, and 7C schematically illustrate fluted plates having flutes of different cross-sectional shape;

FIG. 8A schematically illustrates a top view of a fluted plate showing flutes arranged parallel;

FIG. 8B schematically illustrates a top view of a fluted plate showing sets of parallel flutes arranged perpendicularly;

FIGs. 9 and 10 schematically illustrate fluted plates with optically useful surface structure;

FIGs. 11A, 11B, 12A and 12B schematically illustrate various optical film arrangements that include a fluted plate;

FIGs. 13A and 13B schematically illustrate the construction of a fluted plate using a spine attached to an optical film;

FIGs. 14A and 14B schematically illustrate the construction of a fluted plate using a double-sided spine attached to optical films;

FIGs. 15 and 16 schematically illustrate different film arrangements built around a double-sided spine;

FIG. 17 schematically illustrates the construction of a fluted plate using first and second layers having interconnecting members; and

FIG. 18 schematically illustrates a display system having a heat transfer medium flow through flutes of the fluted plate.

While the invention is amenable to various modifications and alternative forms, specifics thereof have been shown by way of example in the drawings and will be described in detail. It should be understood, however, that the intention is not to limit the invention to the particular embodiments described. On the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the invention as defined by the appended claims.

Detailed Description

The present invention is applicable to liquid crystal displays (LCDs, or LC displays), and is applicable to LCDs that are directly illuminated from behind and to LCDs that are edge lit, for example, LCDs used in LCD monitors and LCD televisions (LCD-TVs).

The diffuser plates currently used in LCD-TVs are based on a polymeric matrix, for example polymethyl methacrylate (PMMA), polycarbonate (PC), or cyclo-olefins, formed as a rigid sheet. The sheet contains diffusing particles, for example, organic particles, inorganic particles or voids (bubbles). These plates often deform or warp after exposure to the elevated temperatures of the light sources used to illuminate the display. These plates also are more expensive to manufacture and to assemble in the final display device.

The present application discloses directly illuminated LCD devices that have an arrangement of light management layers positioned between the LCD panel itself and the light source. The arrangement of light management layers can include a diffuser layer whose transmission and haze levels are designed to provide a direct-lit LC display whose brightness is relatively uniform across the display.

A schematic exploded view of an exemplary direct-lit LC display device **100** is presented in FIG. 1. Such a display device **100** may be used, for example, in an LCD monitor or LCD-TV. The display device **100** is based on the use of an LC panel **102**, which typically comprises a layer of LC **104** disposed between panel plates **106**. The plates **106** are often formed of glass, and may include electrode structures and alignment layers on their inner surfaces for controlling the orientation of the liquid crystals in the LC layer **104**. The electrode structures are commonly arranged so as to define LC panel pixels, areas of the LC layer where the orientation of the liquid crystals can be controlled independently of adjacent areas. A color filter may also be included with one or more of the plates **106** for imposing color on the image displayed.

An upper absorbing polarizer **108** is positioned above the LC layer **104** and a lower absorbing polarizer **110** is positioned below the LC layer **104**. In the illustrated embodiment, the upper and lower absorbing polarizers are located outside the LC panel **102**. The absorbing polarizers **108, 110** and the LC panel **102** in combination control the transmission of light from the backlight **112** through the display **100** to the viewer. In some LC displays, the absorbing polarizers **108, 110** may be arranged with their transmission axes perpendicular. When a pixel of the LC layer **104** is not activated, it may not change the polarization of light passing therethrough. Accordingly, light that passes through the lower absorbing polarizer **110** is absorbed by the upper absorbing polarizer **108**, when the absorbing polarizers **108, 110** are aligned perpendicularly. When the pixel is activated, on the other, hand, the polarization of the light passing therethrough is rotated, so that at least some of the light that is transmitted through the lower absorbing polarizer **110** is also transmitted through the upper absorbing polarizer **108**. Selective activation of the different pixels of the LC layer **104**, for example by a controller **114**, results in the light passing out of the display at certain desired locations, thus forming an image seen by the viewer. The controller may include, for example, a computer or a television controller that receives and displays television images. One or more optional layers **109** may be provided over the upper absorbing polarizer **108**, for example to provide mechanical and/or environmental protection to the display surface. In one exemplary embodiment, the layer **109** may include a hardcoat over the absorbing polarizer **108**.

It will be appreciated that some type of LC displays may operate in a manner different from that described above. For example, the absorbing polarizers may be aligned parallel and the LC panel may rotate the polarization of the light when in an unactivated state. Regardless, the basic structure of such displays remains similar to that described above.

The backlight **112** includes a number of light sources **116** that generate the light that illuminates the LC panel **102**. Linear, cold cathode, fluorescent tubes, that extend across the display device **100**, are commonly used as the light sources **116** in the display device **100**. Other types of light sources may be used, however, such as filament or arc lamps, light emitting diodes (LEDs), lasers, flat fluorescent panels or external fluorescent lamps. This list of light sources is not intended to be limiting or exhaustive, but only exemplary.

The backlight **112** may also include a reflector **118** for reflecting light propagating downwards from the light sources **116**, in a direction away from the LC panel **102**. The reflector **118** may also be useful for recycling light within the display device **100**, as is explained below. The reflector **118** may be a specular reflector or may be a diffuse reflector. One example of a specular reflector that may be used as the reflector **118** is Vikuiti™ Enhanced Specular Reflection (ESR) film available from 3M Company, St. Paul, Minnesota. Examples of suitable diffuse reflectors include polymers, such as polyethylene terephthalate (PET), polycarbonate (PC), polypropylene, polystyrene and the like, loaded with diffusely reflective particles, such as titanium dioxide, barium sulphate, calcium carbonate and the like. Other examples of diffuse reflectors, including microporous materials and fibril-containing materials, are discussed in U.S. Patent 6,780,355 (Kretman et al.).

An arrangement **120** of light management layers is positioned between the backlight **112** and the LC panel **102**. The light management layers affect the light propagating from backlight **112** so as to improve the operation of the display device **100**. For example, an arrangement **120** of light management layers may include a diffuser layer **122**. The diffuser layer **122** is used to diffuse the light received from the light sources, which results in an increase in the uniformity of the illumination light incident on the LC panel **102**. Consequently, this results in an image perceived by the viewer that is more uniformly bright. The diffuser layer **122** may include bulk diffusing particles distributed throughout the layer, or may include one or more surface diffusing structures, or a combination thereof.

The arrangement of light management layers **120** may also include a gain diffuser, a layer that diffuses light generally in the viewing direction. In some embodiments a gain diffuser contains transparent particles that protrude from the surface of the film, thus providing optical power to light that passes through the particles. This reduces the divergence of the light, resulting in an increase in on-axis brightness, sometimes refered to as gain. Some types of gain diffusers are described in greater detail in U.S. Patent No. 6,572,961 (Koyama et al.).

The arrangement **120** of light management layers may also include a reflective polarizer **124**. The light sources **116** typically produce unpolarized light but the lower absorbing polarizer **110** only transmits a single polarization state, and so about half of the light generated by the light sources **116** is not transmitted through to the LC layer **104**. The reflective polarizer **124**, however, may be used to reflect the light that would otherwise be absorbed in the lower absorbing polarizer, and so this light may be recycled by reflection between the reflective polarizer **124** and the reflector **118**. At least some of the light reflected by the reflective polarizer **124** may be depolarized, and subsequently returned to the reflective polarizer **124** in a polarization state that is transmitted through the reflective polarizer **124** and the lower absorbing polarizer **110** to the LC layer **104**. In this manner, the reflective polarizer **124** may be used to increase the fraction of light emitted by the light sources **116** that reaches the LC layer **104**, and so the image produced by the display device **100** is brighter.

Any suitable type of reflective polarizer may be used, for example, multilayer optical film (MOF) reflective polarizers; diffusely reflective polarizing film (DRPF), such as continuous/disperse phase polarizers, wire grid reflective polarizers or cholesteric reflective polarizers.

Both the MOF and continuous/disperse phase reflective polarizers rely on the difference in refractive index between at least two materials, usually polymeric materials, to selectively reflect light of one polarization state while transmitting light in an orthogonal polarization state. Some examples of MOF reflective polarizers are described in co-owned U.S. Patent Nos. 5,882,774 (Jonza et al.). Commercially available examples of MOF reflective polarizers include Vikuiti™ DBEF-D200 and DBEF-D440 multilayer reflective polarizers that include diffusive surfaces, available from 3M Company, St. Paul, Minnesota.

Examples of suitable DRPF include continuous/disperse phase reflective polarizers as described in co-owned U.S. Patent No. 5,825,543 (Ouderkirk et al.), and diffusely reflecting multilayer polarizers as described in e.g. co-owned U.S. Patent No. 5,867,316 (Carlson et al.). Other suitable types of DRPF are described in U.S. Patent No. 5,751,388 (Larson).

Some examples of suitable wire grid polarizers include those described in U.S. Patent No. 6,122,103 (Perkins et al.). Wire grid polarizers are commercially available from, *inter alia*, Moxtek Inc., Orem, Utah.

Some examples of suitable cholesteric polarizers include those described in, for example, U.S. Patent No. 5,793,456 (Broer et al.), and U.S. Patent 6,917,399 (Pekorny et al.). Cholesteric polarizers are often provided along with a quarter wave retarding layer on the output side, so that the light transmitted through the cholesteric polarizer is converted to linear polarization.

The arrangement **120** of light management layers may also include a brightness enhancing layer **128**. A brightness enhancing layer is one that includes a surface structure that redirects off-axis light in a direction closer to the axis of the display. This increases the amount of light propagating on-axis through the LC layer **104**, thus increasing the brightness of the image seen by the viewer. One example is a prismatic brightness enhancing layer, which has a number of prismatic ridges that redirect the illumination light, through refraction and reflection. Examples of prismatic brightness enhancing layers that may be used in the display device include the Vikuiti™ BEFII and BEFIII family of prismatic films available from 3M Company, St. Paul, Minnesota, including BEFII 90/24, BEFII 90/50, BEFIIIM 90/50, and BEFIIIT.

The arrangement **120** of light management layers may also include a support layer **130**, which may be used for providing support to the other light management layers. In some arrangements, one of the other light management layers may be integrated with the support layer **130**. For example, some existing televisions include diffusing particles in a relatively thick (2-3 mm), rigid polymer sheet, thus combining the functions of providing support and optical diffusion into a single layer.

Support layer **130** advantageously includes a fluted plate, which is a plate that includes flutes, or spaces, between the two surfaces of the plate. A cross-sectional view of an exemplary fluted plate **200** is schematically illustrated in FIG. 2A. The fluted plate **200** includes a first layer **202** and a second layer **204**, with connecting members **206** connecting the first and second layers **202**, **204**. The open spaces **208** surrounded by the connecting members **206** and the first and second layers **202**, **204** may be considered to be flutes.

The fluted plate **200** is self-supporting and may, in some exemplary embodiments, be used to provide support to other light management layers. The fluted plate **200** may be made of any suitable material, for example organic materials such as polymers. For example, the fluted plate **200** may be formed using any suitable method, for example extrusion, molding, and the like.

The thickness of the fluted plate **200** and the size of the flutes **208** may be selected depending on the particular application. For example, the fluted plate may be a few mm thick, for example in the range of approximately 1 mm – 4 mm, or may be thicker. The fluted plate **200** may also be thinner, for example having a thickness of approximately 50 μm or more. Also, the center-to-center spacing of the flutes **208** may be selected to be any suitable value. For example, the spacing may be in the range of about 1-4 mm, or greater. In other embodiments, the flute spacing may be less, for example down to around 50 μm or less.

The use of a fluted plate may reduce the weight of a display system such as a television. For example, in a 40 inch LCD-TV, a conventional solid diffuser plate typically weighs about 2.3 lbs (1 kg), and accounts for about 5% of the overall weight of the television. A fluted plate weighs only a fraction of a comparable solid plate, commonly about 25%, and so a fluted plate would provide only about 1% of the overall weight of the television.

In addition, the fluted plate has the mechanical advantages of an "I-beam" with upper and lower plates separated by an air space and a connecting member. Accordingly, the fluted plate provides high resistance to warping and curling under the high illumination conditions typical in many display systems.

The directions of the flutes may be oriented in a desired direction with respect to the light sources. For example, if the light sources are elongated, as with most fluorescent lamps, the flutes may be oriented to be parallel to the light sources, or may be oriented to be not parallel. A specific orientation between the light sources and the flutes, for a given design of light source and fluted plate, may provide improved illumination uniformity and also improved thermal response, e.g. warp, curl, etc.

Suitable polymer materials for the fluted plate may be amorphous or semi-crystalline, and may include homopolymer, copolymer or blends thereof. Polymer foams may also be used. Example polymer materials include, but are not limited to: amorphous polymers such as poly(carbonate) (PC); poly(styrene) (PS); acrylates, for example acrylic sheets as supplied under the ACRYLITE® brand by Cyro Industries, Rockaway, New Jersey; acrylic copolymers such as isooctyl acrylate/acrylic acid; poly(methylmethacrylate) (PMMA); PMMA copolymers; cycloolefins; cylcoolefin copolymers; acrylonitrile butadiene styrene (ABS); styrene acrylonitrile copolymers (SAN); epoxies; poly(vinylcyclohexane); PMMA/poly(vinylfluoride) blends; atactic poly(propylene); poly(phenylene oxide) alloys; styrenic block copolymers; polyimide; polysulfone; poly(vinyl chloride); poly(dimethyl siloxane) (PDMS); polyurethanes; poly(carbonate)/aliphatic PET blends; and semicrystalline polymers such as poly(ethylene) (PE); poly(propylene) (PP); olefin copolymers, such as PP/PE copolymers; poly(ethylene terephthalate) (PET); poly(ethylene naphthalate)(PEN); polyamide; ionomers; vinyl acetate/polyethylene copolymers; cellulose acetate; cellulose acetate butyrate; fluoropolymers; poly(styrene)-poly(ethylene) copolymers; PET and PEN copolymers; and blends that include one or more of the polymers listed.

Some exemplary embodiments of the fluted plate **200** include polymer materials that are substantially transparent to light. Some other exemplary embodiments may include diffusive material in the fluted plate **200** using, for example, a polymer matrix containing diffusing particles. The polymer matrix may be any suitable type of polymer that is substantially transparent to visible light, for example any of the polymer materials listed above.

The diffusing particles may be any type of particle useful for diffusing light, for example transparent particles whose refractive index is different from the surrounding polymer matrix, diffusely reflective particles, or voids or bubbles in the matrix. Examples of suitable transparent particles include solid or hollow inorganic particles, for example glass beads or glass shells, solid or hollow polymeric particles, for example solid polymeric spheres or polymeric hollow shells. Examples of suitable diffusely reflecting particles include particles or beads of PS, PMMA, polysiloxane, titanium dioxide (TiO_2), calcium carbonate ($CaCO_3$), barium sulphate ($BaSO_4$), magnesium sulphate ($MgSO_4$) and the like. In addition, voids in the polymer matrix may be used for diffusing the light. Such voids may be filled with a gas, for example air or carbon dioxide.

Other additives may be provided to the fluted plate. For example, the fluted plate may include antioxidants, such as Irganox 1010 available from Ciba Specialty Chemicals, Tarrytown, New York. Other examples of additives may include one or more of the following: an anti-weathering agent, UV absorbers, a hindered amine light stabilizer, a dispersant, a lubricant, an anti-static agent, a pigment or dye, a nucleating agent, a flame retardant, a blowing agent, or nanoparticles.

The entire fluted plate **200** may be formed from diffusing material or selected portions of the fluted plate **200** may be made of diffusing material. For example, the first layer **202**, or the second layer **204**, may be formed of diffusing material while the remainder of the plate **200** is formed of some other material. In other embodiments, both the first and second layers **202**, **204** may be formed of diffusing material. When a fluted plate **200** formed of a diffusive material is used in a display system, such as is exemplified in FIG. 1, the fluted plate provides mechanical support as well as providing a diffusing function, so that a separate diffuser layer may be omitted.

In other exemplary embodiments, the fluted plate **200** may be provided with a diffuser layer **210**, for example as schematically illustrated in FIG. 2B. The diffuser layer **210** may be attached to either the first layer **202** or the second layer **204**. In addition, in some embodiments, there may be diffuser layers attached to each of the first and second layers **202, 204**. The diffuser layer **210** may be attached to the fluted plate **200** using an adhesive layer (not shown) or, in other embodiments, the diffuser layer **210** may itself be an adhesive layer attached to the fluted plate **200**.

Commercially available materials suitable for use in a diffusing layer include 3M™ Scotchcal™ Diffuser Film, type 3635-70 and 3635-30, and 3M™ Scotchcal™ ElectroCut™ Graphic Film, type 7725-314, available from 3M Company, St. Paul, Minnesota. Other commercially available diffusers include acrylic foam tapes, such as 3M™ VHB™ Acrylic Foam Tape No. 4920.

In some exemplary embodiments, the diffuser layer **210** has a diffusion characteristic that is uniform across its width, in other words the amount of diffusion experienced by light is the same for points across the width of the diffuser layer **210**.

The diffuser layer **210** may optionally be patterned, or supplemented with or replaced by an optional patterned diffuser **210a**. The optional patterned diffuser **210a** may include, for example, a patterned diffusing surface or a printed layer of diffuser, such as particles of titanium dioxide (TiO_2). The patterned diffuser **210a** may lie on the diffuser layer **210**, between the diffuser layer **210** and the fluted plate **200**. In addition, a patterned diffuser may be applied to a fluted plate **200** that is formed, at least partially, of diffusing material.

The fluted plate **200** may be provided with protection from ultraviolet (UV) light, for example by including UV absorbing material or material that is resistant to the effects of UV light. Suitable UV absorbing compounds are available commercially, including, e.g., Cyasorb™ UV-1164, available from Cytec

Technology Corporation of Wilmington, Del., and Tinuvin™ 1577, available from Ciba Specialty Chemicals of Tarrytown, N.Y. The fluted plate **200** may also include brightness enhancing phosphors that convert UV light into visible light.

Other materials may be included into the layers of the fluted plate **200** to reduce the adverse effects of UV light. One example of such a material is a hindered amine light stabilizing composition (HALS). Generally, the most useful HALS are those derived from a tetramethyl piperidine, and those that can be considered polymeric tertiary amines. Suitable HALS compositions are available commercially, for example, under the "Tinuvin" tradename from Ciba Specialty Chemicals Corporation of Tarrytown, N.Y. One such useful HALS composition is Tinuvin 622. UV absorbing materials and HALS are further described in U.S. Patent No. 6,613,819 (Johnson et al.).

In other embodiments, the fluted plate **200** may have two diffuser layers **210, 212** attached respectively to the first and second layers **202, 204** of the fluted plate **200**. The diffuser layers **210, 212** may each be applied directly to the respective layer **202, 204** of the fluted plate **200**, as is illustrated in FIG. 2C, or may be attached using a layer of adhesive (not shown).

The two diffuser layers **210, 212** may have the same diffusion properties, or may have different diffusing properties. For example, the diffuser layer **210** may possess a different transmission or haze level from the second diffuser layer **212**, or may be of a different thickness.

The optical properties of the fluted plate may be uniform across its width, but this is not necessary. In some exemplary embodiments, for example the fluted plate **300** shown in FIG. 3, the amount of diffusion imparted by the fluted plate **300** itself may spatially vary across the width of the plate **300**. This may be achieved, for example, by introducing bulk diffusing particles nonuniformly across an extruded fluted plate. The graph above the fluted plate shows a spatial variation in the single pass transmission, T. The single pass transmission is the fraction of incident light that is transmitted through the fluted plate **300**: higher levels of transmission indicate less diffusion and lower levels of transmission indicate more diffusion. In the illustrated example, the periodicity in the spatial variation of the transmission is equal to the separation distance between the connecting members **306**. Such a spatial variation in the diffusion may be useful for reducing nonuniformities in the brightness of the transmitted light due to the connecting members **306**. There is no requirement, however, that the variation in T have this periodicity, and the variation in T may have some other periodicity, or need not be periodic.

Another optical characteristic of the fluted plate that may vary across the fluted plate **400** is the refractive index of one or both of the first and second layers **402**, **404**, as is schematically illustrated in FIG. 4. Such a variation may be achieved, for example, by introducing a material of a different refractive index nonuniformly across an extruded fluted plate. The graph above the fluted plate **400** shows a spatial variation in the refractive index. In the illustrated example, the periodicity in the spatial variation of the refractive index is equal to the separation distance between the connecting members **406**. Such a spatial variation in the diffusion may be useful for reducing nonuniformities in the brightness of the transmitted light due to the connecting members **406**. There is no requirement, however, that the variation in the refractive index have this periodicity, and the variation in the refractive index may have some other periodicity, or need not be periodic.

In some exemplary embodiments, one or more of the layers of the fluted plate may have a thickness that varies across the plate. For example, in the fluted plate **500** schematically illustrated in FIG. 5A, the thickness of the first layer **502** varies from being relatively thin at the edges of the plate **500** to relatively thick at the center of the plate **500**, while the second layer **504** maintains a constant thickness across its width. A variation in the thickness of the first layer **502** may be used, *inter alia*, to provide additional strength to the plate or to provide a variation in the optical characteristics of the plate. In an illustrative example, where the first layer **502** contains a uniform concentration of bulk diffusive particles, a variation in the thickness of the first layer **502** may be used to provide a spatially varying diffusive characteristic. In the illustrated example, there is greater diffusion of the light passing through the center portion of the plate **500** than at the edge.

In other embodiments, the second layer **504**, or both the first and second layers **502, 504** may have a variable thickness. For example, as illustrated in FIG. 5B, a fluted plate **520** has a first layer **522** of uniform thickness and a second layer **524** of variable thickness. It will be appreciated that variations in the thickness of the first and/or the second layer **502, 504, 522, 524** may be periodic or non-periodic.

In some embodiments, the surfaces of the material surrounding the spaces or flutes may be parallel or perpendicular to the outer surfaces of the fluted plate, but this is not a necessary condition. In some exemplary embodiments, the surfaces of the first or second layer defining the flutes may be non-parallel to the upper surface of the fluted plate. This is schematically illustrated in FIG. 6A for one particular fluted plate **600**, in which the lower surface **602a** of the first layer **602** is non-parallel to the upper surface **604b** of the second layer **604**, at least for some of the flutes **608**. Consequently, the cross-sectional shapes of some of the flutes **608a** are not square or rectangular.

The lower surface of the flute may also be non-parallel to the lower surface of the second layer. For example, in the embodiment of FIG. 6B, the thicknesses of both the first and second layers **622, 624** are not uniform over the width of the plate **620**. In other exemplary embodiments, the first layer may be uniformly thick while only the second plate has a non-uniform thickness.

The flutes need not be quadrilateral in shape, and may take on other shapes. For example, in one exemplary embodiment schematically illustrated in FIG. 7A, the fluted plate **700** has triangle-shaped connecting members **706** connecting between the first and second layers **702, 704**. Consequently, the flutes **708** have a triangle cross-section also. In another exemplary embodiment, schematically illustrated in FIG. 7B, the fluted plate **720** has upper and lower layers **722, 724** that have sinusoidal inner surfaces **722a, 724a** defining the flutes **728**. The connecting members **726** are formed where the sinusoidal surfaces coincide.

In another exemplary embodiment, schematically illustrated in FIG. 7C, the fluted plate **730** has upper and lower layers **732, 734** that are connected together via curved connecting members **736**. In the illustrated embodiment, the curved connecting members **736** alternate between curving in one direction and the opposite direction, to produce a corrugated effect.

Many different cross-sections may be used for the connecting members and the flutes, in addition to those illustrated herein. Further, the illustrated embodiments are presented for purposes of illustration only, and there is no intention to limit the scope of the invention only to those cross-sections illustrated herein.

In some exemplary embodiments, for example the fluted plate **800** schematically illustrated in FIG. 8A which shows a top view of the plate **800**, the flutes **808** are linear and arranged parallel to each other. In other exemplary embodiments, for example the fluted plate **820** schematically illustrated in FIG. 8B, the flutes **828** are linear but are arranged with a first group of flutes parallel to each other and a second group of flutes **828** parallel to each other but perpendicular to the first group. In other embodiments, different flutes may lie at different angles to each other.

In some embodiments, the surface of the first or second layers may be flat, and provided with an anti-reflection coating. In other embodiments, the first and/or the second layer may provide some optical function. For example, the outer or inner surface of the first and/or second layers may be provided with a matte finish. In another exemplary embodiment, the first and second layers may be provided with some surface structure. For example, the fluted plate **900** schematically illustrated in FIG. 9 has first and second layers **902**, **904** attached together via connecting members **906**. In this particular embodiment, the upper surface **910** of the first layer **902** is provided with a series of prismatic ribs **912**. The ribs **912** may lie parallel to each other, in which case the surface **910** operates like a prismatic brightness enhancing layer, redirecting some off-axis light, exemplified by light ray **914**, to propagate in a direction more parallel to the axis **916**.

The fluted plate may have other types of surfaces. In another example, schematically illustrated in FIG. 10, the first layer **1002** of the fluted plate **1000** has an upper surface **1010** that comprises a series of lenses **1012** that provide optical power to the light **1014** passing through the plate. The lenses **1012** may, but are not required to, have a width equal to the spacing between the connecting members **1006**. The lenses **1012** may be lenticular lenses, stretching across the width of the plate **1000**. This type of lens is particularly well suited to a plate manufactured using an extrusion process. Other methods may be used to form the lenses **1012**, such as molding.

The fluted plate may be used for supporting other optical layers in a display. For example, one or more other layers may be attached to the fluted plate. The following examples are presented to illustrate some possible combinations of other layers with a fluted plate. FIG. 11A shows an arrangement **1100** of optical layers, having a fluted plate **1101** with a reflective polarizer layer **1110** attached to the upper surface of an upper layer **1102** of the fluted plate. The reflective polarizer layer **1110** may be attached using an adhesive, for example a clear adhesive or an optically diffusing adhesive. A prismatic brightness enhancing layer **1112** may be attached above the reflecting polarizer layer **1110**. In some exemplary embodiments, it may be desirable for at least some of the light to enter the brightness enhancing layer **1112** through an air interface or an interface going from a low to a high refractive index. Therefore, a layer of low index material, for example a fluorinated polymer, may be placed between the brightness enhancing layer **1112** and the next layer below the brightness enhancing layer **1112**.

In other exemplary embodiments, an air gap may be provided between the brightness enhancing layer **1112** and the layer below the brightness enhancing layer **1112**. One approach to providing the air gap is to include a structure on one or both of the opposing faces of the brightness enhancing layer **1112** and the layer below the brightness enhancing layer **1112**. In the illustrated embodiment, the lower surface **1114** of the brightness enhancing layer **1112** is structured with protrusions **1116** that contact the adjacent layer layer. Voids **1118** are thus formed between the protrusions **1116**, with the result that light entering into the brightness enhancing layer **1112** at a position between the protrusions **1116** does so through an air interface. In other embodiments, the reflecting polarizer layer **1110** may be omitted and the prismatic brightness enhancing layer **1112** attached directly to the fluted plate **1101**. In some embodiments, the fluted layer **1101** may provide optical diffusion, or a separate diffusing layer may be provided, for example attached to a lower layer **1104** of the fluted layer **1101** or attached to the first layer **1102** of the fluted layer **1101**, between (i) the fluted layer and (ii) the reflective polarizer layer **1110** and/or the prismatic brightness enhancing layer **1112**.

Other approaches to forming voids, and thus providing an air interface to light entering the brightness enhancing layer, may be used. For example, the brightness enhancing layer may have a flat lower surface, with the adjacent layer being structured with protrusions. These, and additional approaches, are discussed in U.S. Patent No. 7,010,212 (Emmons et al.). Any of the embodiments of a fluted plate discussed herein may be adapted to provide an air interface for light entering the brightness enhancing layer.

The order of the films attached to the fluted plate **1101** may be different. For example, a reflective polarizer layer **1110** may be attached to the prismatic surface of the brightness enhancing layer **1112**, and the brightness enhancing layer **1112** is attached to the fluted plate **1101**. This arrangement **1120** is schematically illustrated in FIG. 11B. Attachment of optical films to the prismatic surface of a brightness enhancing layer is further described in U.S. Patent No. 6,846,089 (Stevenson et al.).

An exemplary embodiment illustrating an arrangement **1200** in which one or more films are attached to the lower layer of the fluted plate is schematically illustrated in FIG. 12A. In this embodiment, a reflective polarizer **1210** is attached to the second layer **1204** of the fluted plate **1201**, and a prismatic brightness enhancing layer **1212** is attached to the first layer of the fluted plate **1201**. An optional diffuser layer **1214** may be attached to the lower surface of the reflective polarizer **1210**. In other embodiments, the fluted plate itself may provide some diffusion. In such a case, it may be desired that the fluted plate **1201** does not significantly depolarize the light that has passed through the reflective polarizer **1210**.

Another exemplary embodiment **1220** of a fluted plate **1201** attached to an arrangement of light management films is schematically illustrated in FIG. 12B. In this embodiment **1220**, a diffuser layer **1222** is attached to the fluted plate **1201**.

An intermediate layer **1224** is disposed on the diffuser layer **1222** and a prismatic brightness enhancing layer **1226** is disposed over the intermediate layer **1224**. The diffuser layer **1222** may be, for example, an acrylic foam tape: the foam tape deforms when the intermediate layer **1224** is pushed into the foam tape, creating a recessed region that the intermediate layer sits in. The intermediate layer **1224** may have an optical function: for example, the intermediate layer **1224** may be a reflective polarizer film. Examples of other suitable arrangements of light management films that may be used with a fluted plate are described in further detail in U.S. Application Publication No. 2006/0082699 (Gehlsen et al.).

In addition to molding, there exist other methods of manufacturing a fluted plate. One method is to attach a spine, that has connecting members already applied, to another optical film. This approach is schematically illustrated in FIGs. 13A and 13B. The spine **1302** has a cross member **1304** and an array of connecting members **1306**. The connecting members **1306** may be integrated with the cross member **1304**. For example, the spine **1302** may be formed by molding or extrusion. The spine **1302** may be formed from the same types of materials as discussed earlier for a fluted plate. Thus, the spine **1302** may be formed of optically transparent or optically scattering material.

An optical film **1310** is attached to the connecting members **1306**. The optical film may be any suitable type of film. For example, the film **1310** may be a prismatic brightness enhancing film, a diffuser film, a reflective polarizer film, a gain diffuser film, a lens film, an absorbing polarizer, a matte film or the like. In addition, the optical film **1310** may simply be a transparent film. Furthermore, optical films may also be attached to the spine **1302** below the cross member **1304**.

FIG. 13B shows the optical film **1310** attached to the connecting members **1306**. The film **1310** may be attached to the connecting members using any suitable method. For example, the lower surface **1312** of the film **1310** and/or the tips **1314** of the connecting members **1306** may be applied with an adhesive which is cured after the lower surface **1312** and the connecting member tips **1314** are placed in contact. In another approach, in which the film **1310** and connecting members **1306** are both formed of polymeric materials, the film **1310** and connecting members **1306** may be placed in contact before the respective polymeric materials have been fully cross-linked, and the film **1310** and connecting members **1306** are subsequently cross-linked together. Some other approaches may be used, for example contacting the optical film to the molten polymer immediately following extrusion to create a bond between the optical film and the flutes. In another approach, the flutes may be heated (post extrusion) and laminated at a later time. Also, a coextruded flute may also be employed whereby the flute is formed of one material as the matrix (non adhesive, structural member) with another material coextruded on the tip (adhesive type material).

After the film **1310** has been attached, the film **1310** and spine **1302** together form a plate having flutes **1316**.

In another embodiment, schematically illustrated in FIGs. 14A (elements separated) and 14B (elements attached together), a spine **1402** has sets of connecting members **1406a**, **1406b** on respective sides of a cross member **1404**. Two optical films **1410a**, **1410b** may be attached to the respective sets of the connecting members **1406a**, **1406b**. The optical films **1406a**, **1406b** may be any desired type of optical film, such as a transparent film, a diffuser film, a prismatic brightness enhancing film, a reflective polarizing film or the like.

After at least one of the films **1410a**, **1410b** has been attached to the spine **1402**, the films **1410a** and **1410b** and spine **1402** together form a plate having flutes **1416**.

One particular embodiment of an arrangement **1500** of optical films that includes a spine **1502** of the type illustrated in FIG. 14B, is schematically illustrated in FIG. 15. In this embodiment, a diffuser layer **1510** is attached to the lower connecting members **1506b** and a prismatic brightness enhancing layer **1512** is attached to the upper connecting members. A reflective polarizer layer **1514** may optionally be attached to the structured side of the prismatic brightness enhancing layer **1512**.

Another illustrative arrangement **1600** is schematically illustrated in FIG. 16, in which the reflective polarizer **1514** is positioned between the diffuser layer **1510** and the spine **1502**.

Another approach for attaching two layers together is to use layers that are interconnectable. For example, the two layers may be mechanically attachable to each other using an attaching mechanism like that used to seal food storage bags. An exemplary embodiment of such a mechanism is illustrated in FIG. 17, which shows parts of the upper and lower layers **1702, 1704**. Each layer **1702, 1704** has respective interconnecting members **1706, 1708** that are directed to the other layer. When the two layers **1702, 1704** are pressed together, the interconnecting members **1706, 1708** lock together to form the connecting members. The layers **1702, 1704** with respective interconnecting members **1706, 1708** may be formed, for example, using an extrusion process. The interconnecting members **1706** may be, but are not required to be, of the same shape as the interconnecting members **1708**.

Whether or not spines are used to connect the upper and lower layers, the fluted plate may be formed in a partially continuous process. The films forming the upper and lower layers, and the optional spine, may be taken off respective rolls and attached together. Once the layers are attached to one another, the resulting fluted product is relatively stiff. Individual plates can be cut from the continuous fluted product.

A fluted plate may be used to improve thermal management in a display system, such as a television display or monitor. An exemplary embodiment of display system **1800**, schematically illustrated in FIG. 18, includes one or more light sources **1802**, a fluted plate **1804**, an arrangement of light management layers **1806**, and a display panel **1808**. A coolant may flow through the flutes of the fluted plate **1804**, which results in a lower operating temperature of the display system. The coolant may be air and, in some embodiments, the air may flow through vertically oriented flutes due simply to natural convection. In other embodiments, the coolant may be forced through the flutes by a coolant circulator. For example, a fan **1810** may be used to force air through the flutes of the fluted plate **1804**. In other embodiments, a transparent fluid, such as water, may be forced through the flutes by a pump.

It will be appreciated that there are many different possible arrangement within the scope of the invention, in which different layers appear in different orders from bottom to top of the arrangement, or in different positions relative to the spine.

The present invention should not be considered limited to the particular examples described above, but rather should be understood to cover all aspects of the invention as fairly set out in the attached claims. Various modifications, equivalent processes, as well as numerous structures to which the present invention may be applicable will be readily apparent to those of skill in the art to which the present invention is directed upon review of the present specification. For example, free standing optical films may also be used within a display device alongside a fluted plate that is attached with other optical layers. Also, a display may use more than one fluted plate. The flutes of the multiple fluted plates may be arranged parallel to each other, or the flutes of one plate may be oriented non-parallel to the flutes of another fluted plate. The claims are intended to cover such modifications and devices.

WE CLAIM:

1. A light management unit for use between a display panel and a backlight, the light management unit having a display panel side for orienting towards the display panel and a backlight side for orienting towards the backlight, the unit comprising:

a fluted layer comprising a first light management layer, a cross member substantially parallel to, and spaced apart from, the first light management layer and an arrangement of first connecting members integral with the cross member, the first connecting members attached to the first light management layer.

2. A unit as recited in claim 1, wherein the first light management layer comprises one of a diffuser layer, a brightness enhancing layer, and a reflective polarizer layer.

3. A unit as recited in claim 1, further comprising a second light management layer attached to the fluted layer.

4. A unit as recited in claim 3, wherein an arrangement of second connecting members connects the second light management layer and the cross member.

5. A unit as recited in claim 3, wherein the second light management layer is connected to the first light management layer so that the first light management layer lies between the cross member and the second light management layer.

6. A unit as recited in claim 1, wherein the first connecting members are disposed on a display panel side of the cross member and extending from the cross member, the unit further comprising second connecting members disposed on a backlight side of the cross member, the second connecting members extending from the cross member, and further comprising a second light management layer attached to the second connecting members.

7. A display system, comprising:

a light source;

a display panel; and

an arrangement of light management layers disposed between the light source and the display panel so that the light source illuminates the display panel through the arrangement of light management layers, the arrangement of light management layers comprising a fluted plate, the fluted plate comprising a front layer facing the display panel, a back layer facing the light source and a plurality of connecting members connecting the front and back layers.

8. The system of claim 7, wherein the arrangement of light management layers comprises at least one of a reflective polarizer layer, a diffuser layer, and a prismatic brightness enhancement layer.

9. The system of claim 7, wherein at least a portion of the fluted plate is formed of a diffusing material.

10. The system of claim 7, wherein the arrangement of light management layers further comprises at least one of a diffuser layer, a reflecting polarizer layer, and a prismatic brightness enhancing layer.

11. The system of claim 7, wherein at least one of the front and back layers comprises a first light management layer.

12. The system of claim 11, wherein the first light management layer comprises at least one of a prismatic brightness enhancing layer, a diffuser layer, and a reflective polarizer layer.

13. The system of claim 11, wherein the connecting members comprise first and second connecting members, the first connecting members being attached to a cross member and connecting to the front layer, the second connecting members being attached to the cross member and connecting to the back layer,

the first light management layer being attached to one of the first connecting members and the second connecting members, and further comprising a second light management layer connected to the other of the first connecting members and the second connecting members.

14. The system of claim 7, further comprising a controller coupled to control an image displayed by the display panel.

15. The system of claim 7, wherein the display panel comprises a liquid crystal display (LCD).

16. The system of claim 7, further comprising a coolant circulator for forcing a cooling medium through flutes of the fluted plate.

17. A system as recited in claim 16, wherein the coolant circulator is a fan and the coolant is air.

18. A system as recited in claim 7, wherein flutes of the fluted plate are arranged vertically to permit natural convective passage of air therethrough.

19. A system as recited in claim 7, wherein the connecting members comprise first connecting members attached to the front layer and second connecting members attached to the back layer, the first connecting members interlocking with the second connecting members.

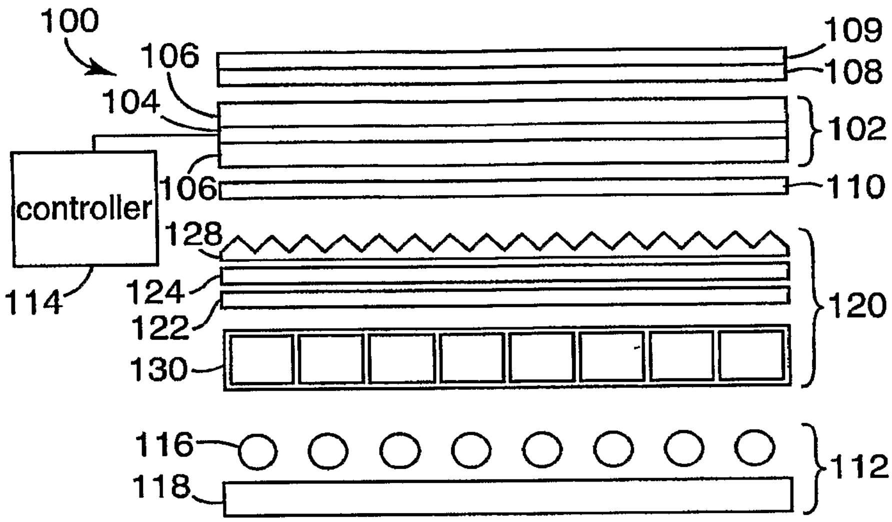


FIG. 1

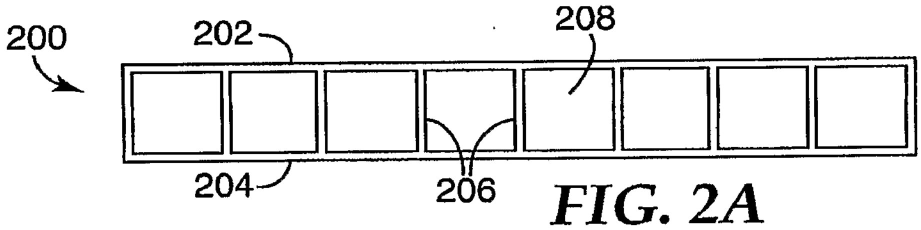


FIG. 2A

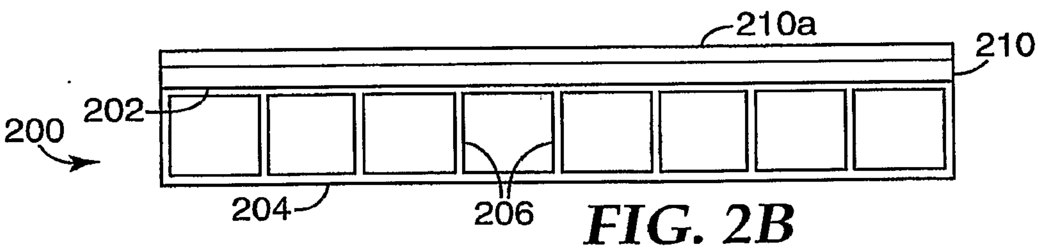


FIG. 2B

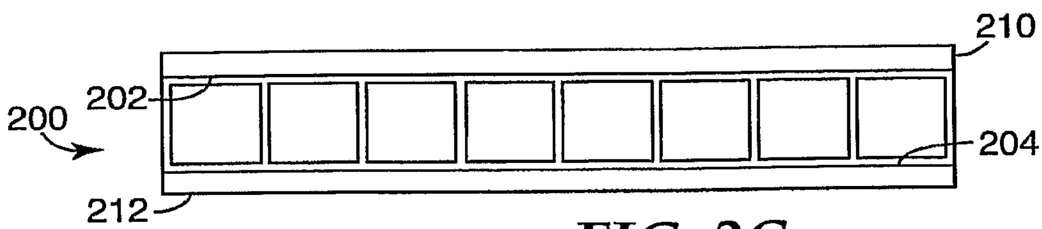


FIG. 2C

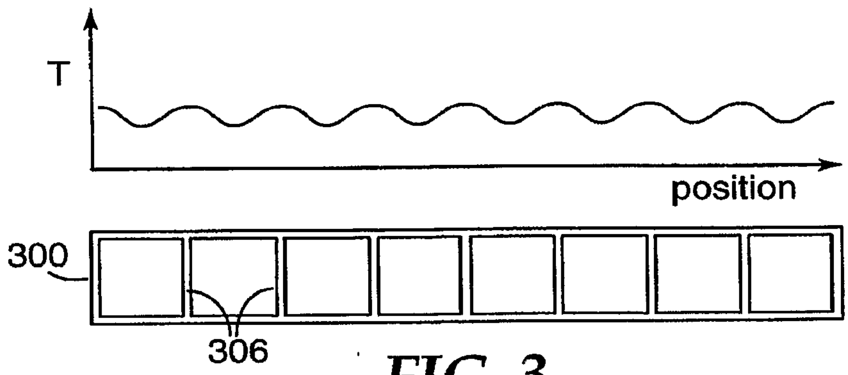


FIG. 3

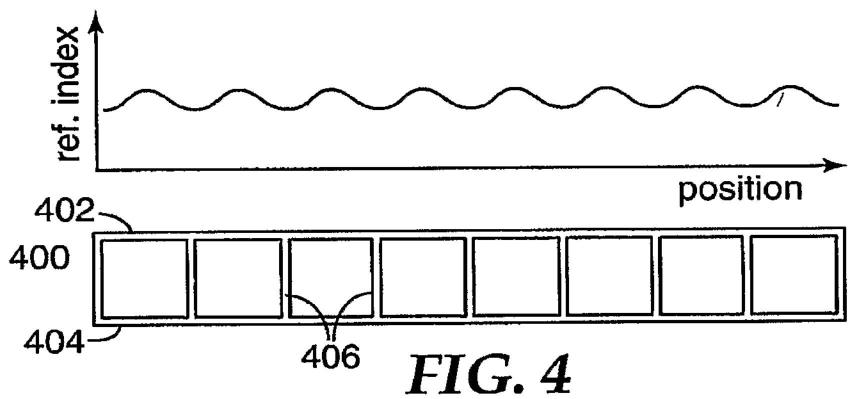


FIG. 4

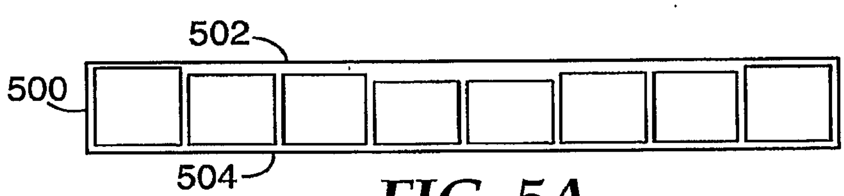


FIG. 5A

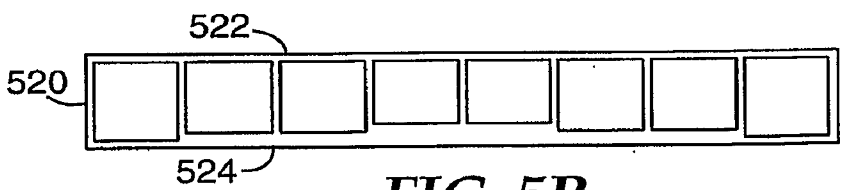


FIG. 5B

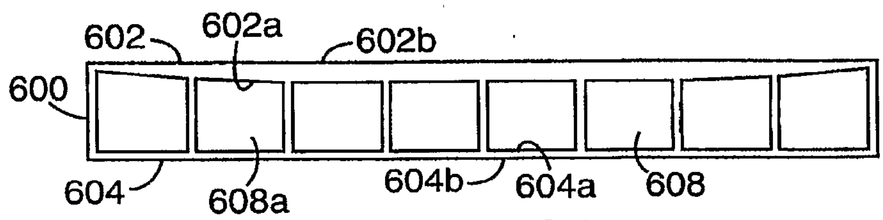


FIG. 6A

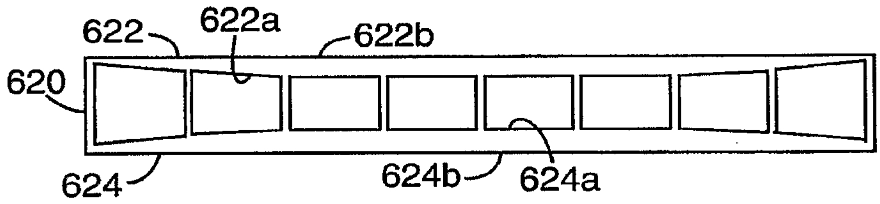


FIG. 6B

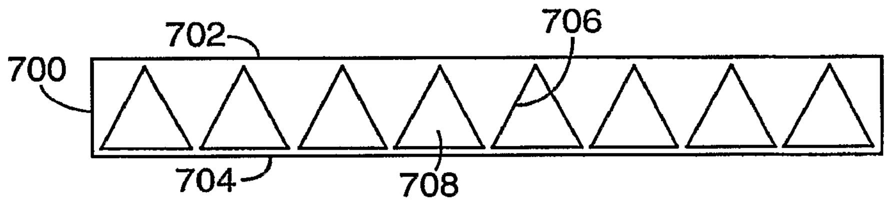


FIG. 7A

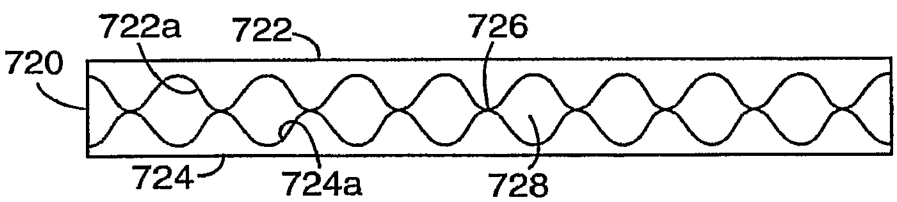


FIG. 7B

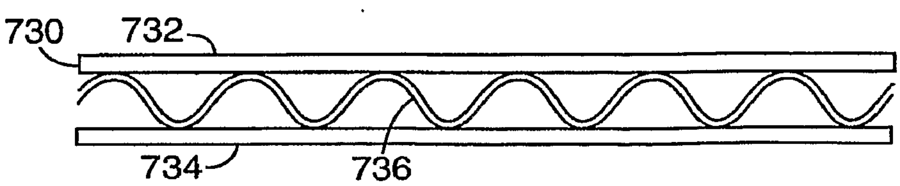


FIG. 7C

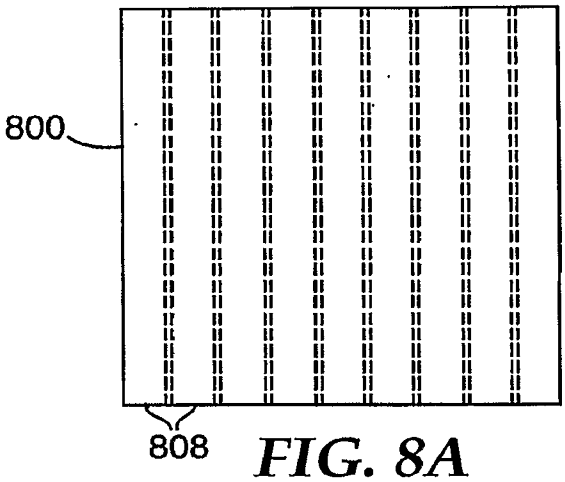


FIG. 8A

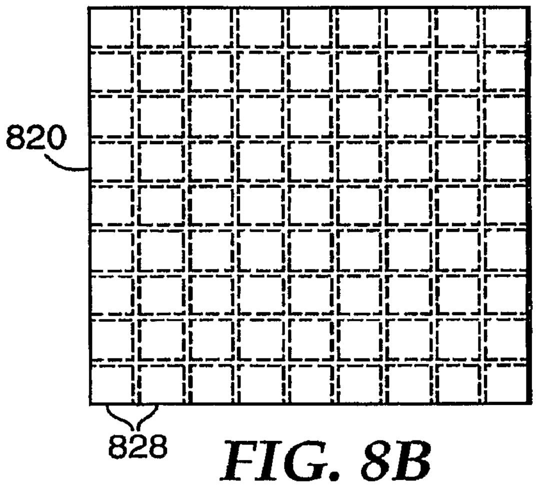


FIG. 8B

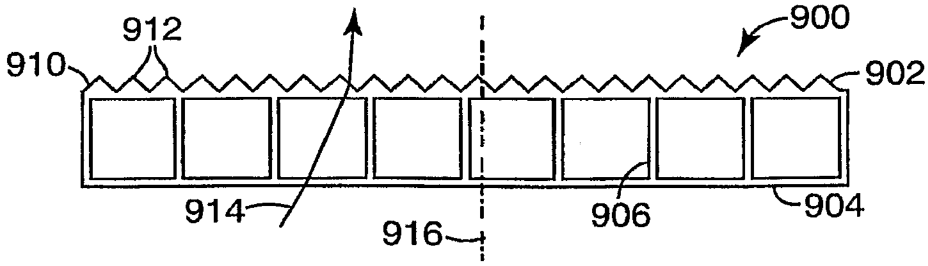


FIG. 9

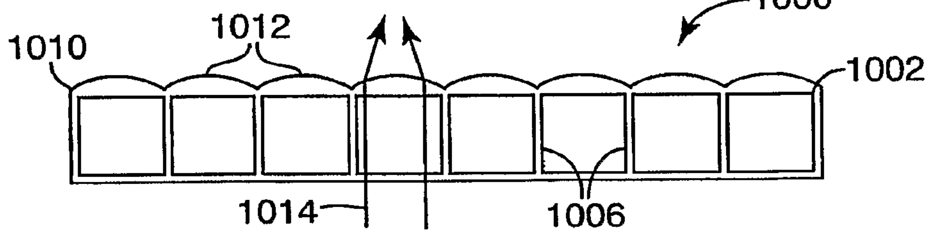


FIG. 10

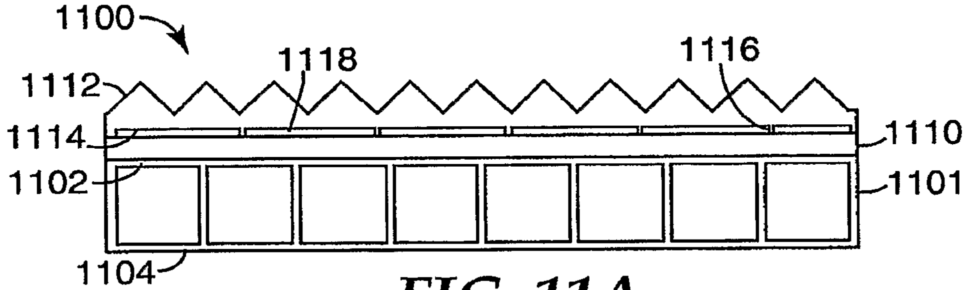


FIG. 11A

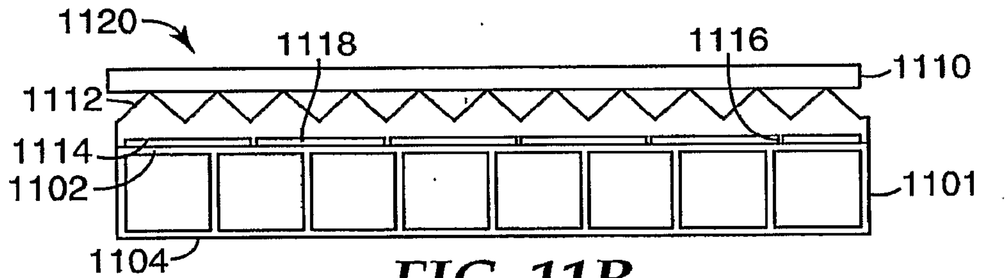


FIG. 11B

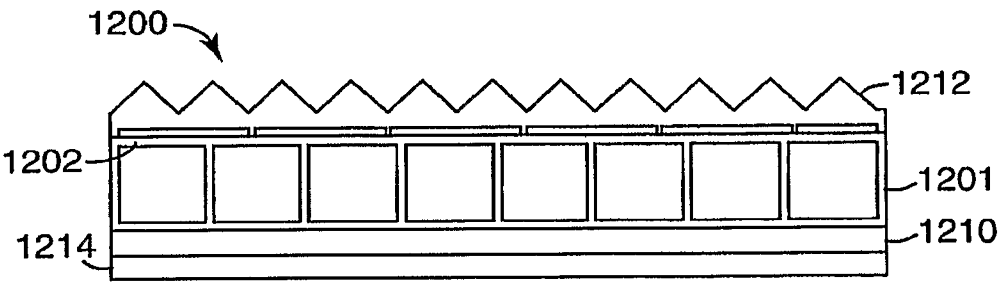


FIG. 12A

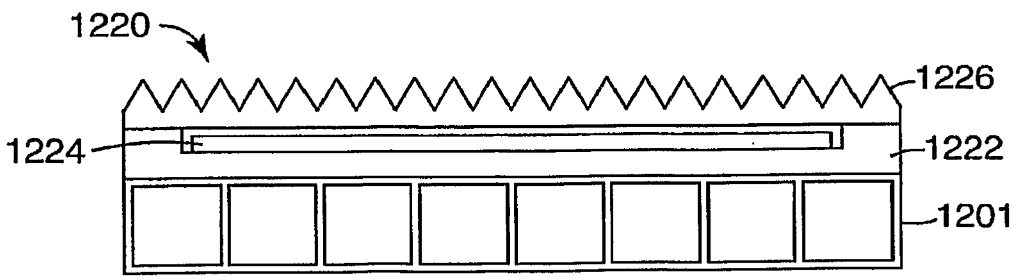


FIG. 12B

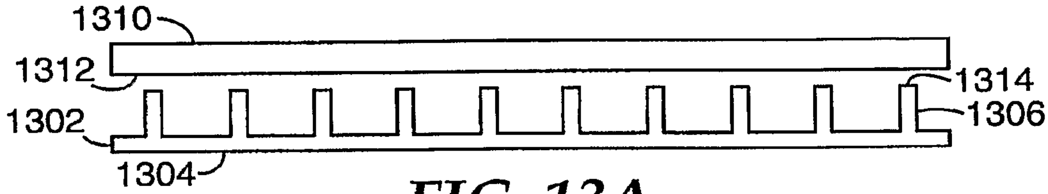


FIG. 13A

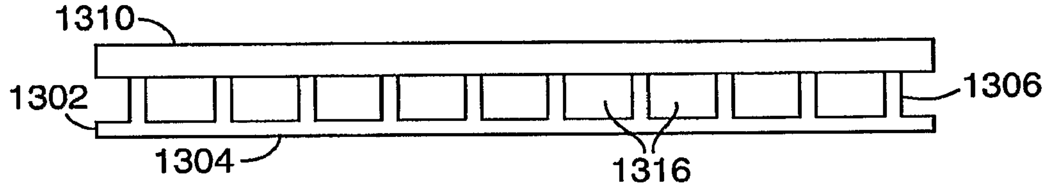


FIG. 13B

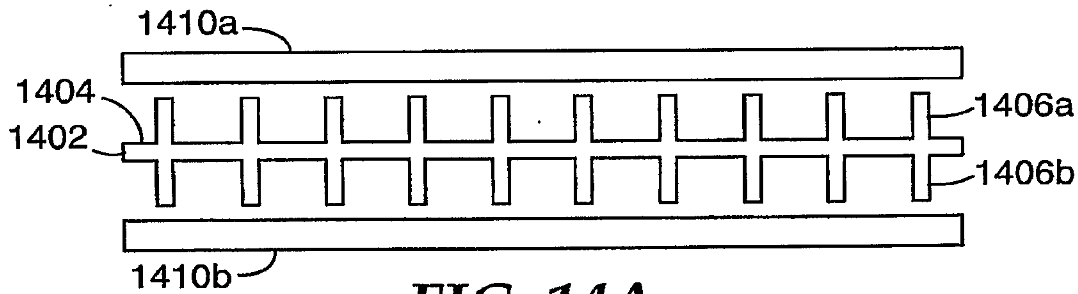


FIG. 14A

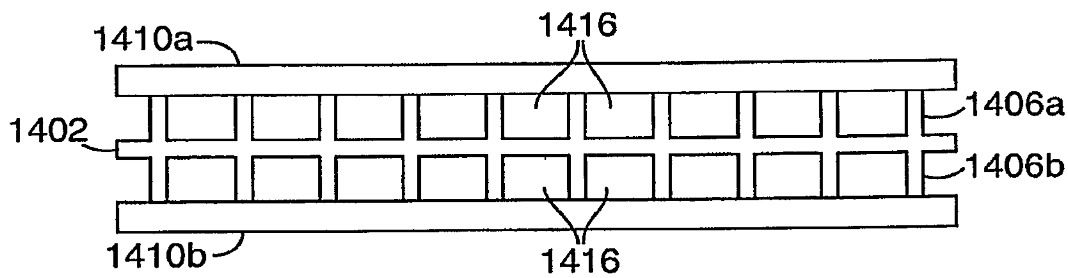


FIG. 14B

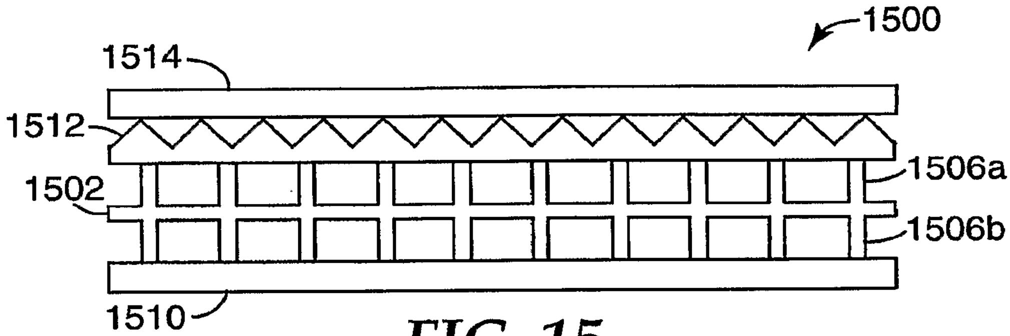


FIG. 15

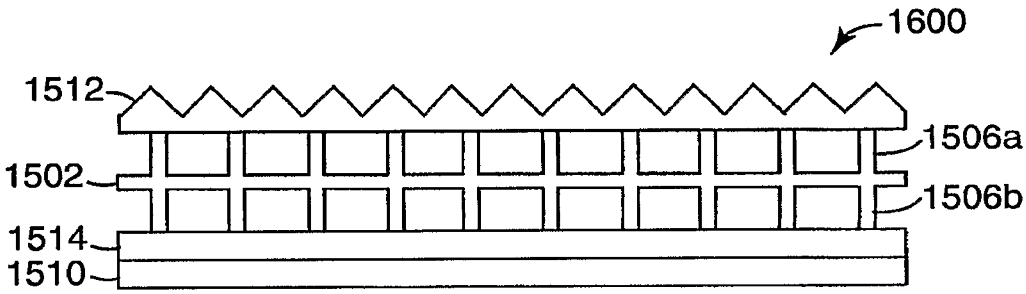


FIG. 16

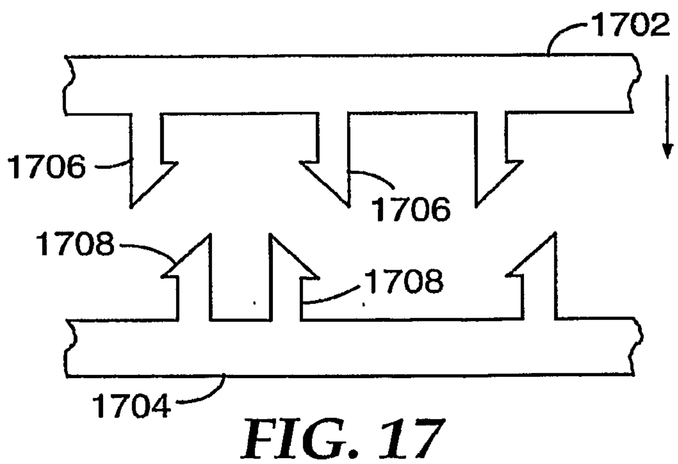


FIG. 17

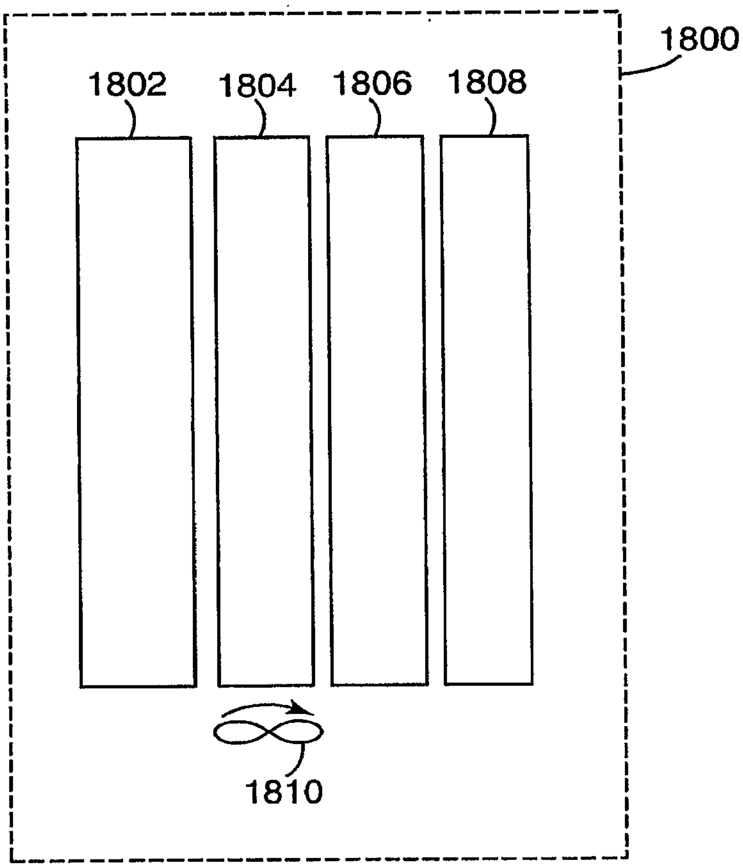


FIG. 18

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2007/004867

A. CLASSIFICATION OF SUBJECT MATTER

G02F 1/13357(2006.01)i, G02F 1/335(2006.01)i, G02B 5/30(2006.01)i

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)
IPC 8: G02F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean Utility models and applications for Utility Models since 1975
Japanese Utility models and applications for Utility Models since 1975

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKIPASS (KIPO internel) & keywords: ('layer" <or> "film") <and> ("member" <or> "pillar")

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 63-118718 A (TOYOTA MOTOR CORP.) 23 MAY 1988 See page 2; claims 1, 2; figures 1 - 4.	1, 7
A	US 5379139 A (SATO, MASAHIKO et al.) 3 JANUARY 1995 See abstract; column 3, line 3 - column 4, line 2; claim 1; figures 2(A) - (C), 4(A), 4(B).	1, 7
A	JP 2001-125111 A (SEIKO EPSON CORP.) 11 MAY 2001 See abstract; paragraphs 16 - 26; claim 1; figures 1, 3.	1, 7
A	US 4924243 A (SATO, MASAHIKO et al.) 8 MAY 1990 See abstract; column 2, line 46 - column 4, line 23; claim 1; figures 3, 5(A), 5(B).	1, 7

☐ Further documents are listed in the continuation of Box C. ☒ See patent family 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 application or patent 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 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	Date of mailing of the international search report
29 JUNE 2007 (29.06.2007)	**29 JUNE 2007 (29.06.2007)**

Name and mailing address of the ISA/KR
Korean Intellectual Property Office
920 Dunsan-dong, Seo-gu, Daejeon 302-701, Republic of Korea
Facsimile No. 82-42-472-7140

Authorized officer
PARK, Bong Ser
Telephone No. 82-42-481-5585

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/US2007/004867

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 63-118718 A	23.05.1988	None	
US 5379139 A	03.01.1995	JP63050817A2	03.03.1988
		US20030071957A1	17.04.2003
		US4874461A	17.10.1989
		US5379139A	03.01.1995
		US5952676A	14.09.1999
		US5963288A	05.10.1999
		US6493057BA	10.12.2002
		US6853431BB	08.02.2005
JP 2001-125111 A	11.05.2001	JP3882428B2	14.02.2007
US 4924243 A	08.05.1990	DE3784597T2	17.06.1993
		EP0258848A2	09.03.1988
		EP258848A3	21.09.1988
		EP258848B1	10.03.1993
		JP63063020A2	19.03.1988