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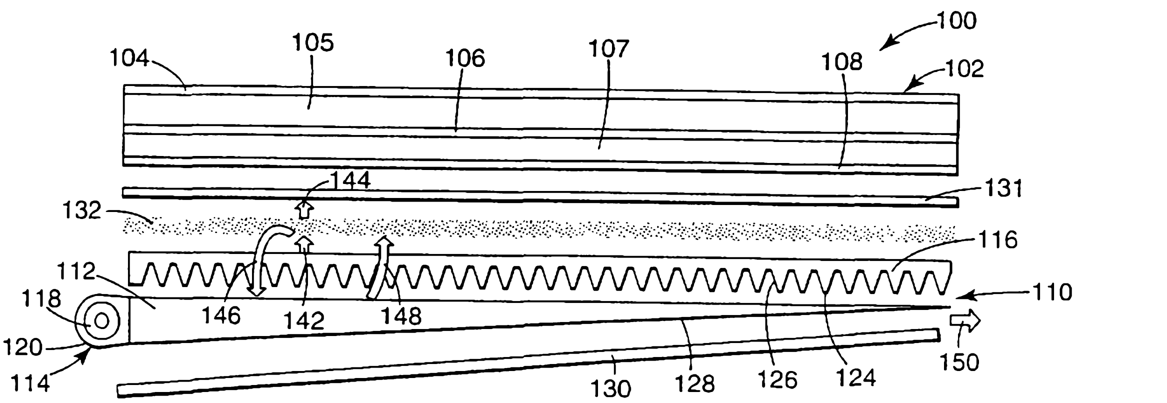
(54) Title: DISPLAY ILLUMINATION DEVICE AND METHOD OF ENHANCING BRIGHTNESS IN A DISPLAY ILLUMINATION DEVICE



(57) Abstract: An illumination device (110) including a lightguide (112) operates under the principle of frustrate total internal reflection. The illumination device (120) includes optical elements and combinations of optical elements for enhancing the apparent brightness of the lightguide (112).

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DISPLAY ILLUMINATION DEVICE AND METHOD OF ENHANCING BRIGHTNESS IN A DISPLAY ILLUMINATION DEVICE

BACKGROUND OF THE INVENTION

Field of the Invention

The invention relates generally to display illumination devices suitable for use in passive displays and more particularly to a backlight illumination device and a method of enhancing brightness in an illumination device.

Description of the Related Technology

Backlit display devices, such as liquid crystal display (LCD) devices, commonly use a wedge-shaped lightguide. The wedge-shaped lightguide couples light from a substantially linear source, such as a cold cathode fluorescent lamp (CCFL), to a substantially planar output. The planar output is then coupled to the LCD.

The performance of a display device is often judged by its brightness. From a subjective standpoint relatively small increases in overall brightness are not easily perceived by the end user of the display device, but it is possible to measure relatively small increases in brightness objectively. While not directly appreciated by the end user, a display with an objectively measured increase in overall brightness of only a small percentage, for example, perhaps as little as 1 percent, is perceived as being significantly better by the designer of the product using the display. This is because the designer can allocate less power to the display device, yet still achieve an acceptable level of brightness. For battery powered, portable devices, this translates to longer running times.

The alternatives for increasing display brightness include using more or brighter light sources. Counter to the ability to decrease the power allocation to the display device, additional light sources and/or brighter light sources consume more energy, which for portable devices this correlates to decreased battery life. Also, adding light sources to the device may increase the product cost and can lead to reduced reliability of the device.

Brightness is also enhanced by more efficiently using the light that is available within the display device, i.e., to direct more of the available light within the display along a preferred viewing axis. A number of mechanisms have been employed within display devices to improve display device efficiency. For example, brightness enhancing films having prismatic structures are frequently used to direct light that would otherwise not be viewed along the viewing axis. A typical flat panel display device may use several different films to provide an overall bright, high contrast display with substantially uniform output along the preferred viewing directions. Surface diffusers or bulk diffusers are sometimes used to mask defects in the output of the lightguide, but most diffusers scatter light from the viewing axis and therefore reduce on-axis brightness.

Lightguide improvements have also contributed to improved brightness in display devices. Typical lightguides extract light by diffusion and may be enhanced by geometric recycling. Light rays entering the lightguide encounter diffusing elements, typically a pattern of white dots applied to a surface of the lightguide, and are diffusively extracted by scattering from the lightguide. Other light rays are totally internally reflected within the lightguide until encountering a diffusing element. Losses are encountered in these processes, and because the light is diffusely extracted, without any collimation, on-axis brightness is lower. With enhancement, the diffuse light rays may be directed more on axis, in a quasi-collimation process, which results in enhanced on-axis brightness.

Another method of extracting light from a lightguide is by use of frustrated total internal reflection (TIR). In one type of frustrated TIR the lightguide has a wedge shape, and light rays incident on a thick edge of the lightguide are totally internally reflected until achieving critical angle relative to the top and bottom surfaces of the lightguide. These sub-critical angle light rays are then extracted, or more succinctly refract from the lightguide, at a glancing angle to the output surface. To be useful for illuminating a display device, these light rays must then be turned substantially parallel to a viewing, or output, axis of the display device. This turning is usually accomplished using a turning lens or turning film.

A turning lens or turning film typically includes prism structures formed on an input surface, and the input surface is disposed adjacent the lightguide. The light rays exiting the lightguide at the glancing angle, usually less than 30° to the output surface, encounter the prism structures. The light rays are refracted by a first surface of the prism structures and are reflected by a second surface of the prism structures such that they are directed by the turning lens or film in the desired direction, e.g., substantially parallel to a viewing axis of the display.

Lightguides, and their corresponding illumination systems, that operate using the principle of frustrate TIR are often referred to as one-pass backlights. This is because the light exiting the lightguide is not redirected back to the lightguide as is done in a recycling lightguide. Recycling lightguides generally extract light by diffuse reflection from a carefully designed pattern of diffuse dots formed on to the bottom surface of the lightguide. Behind the pattern a diffuse, but highly reflective sheet, is placed, but is not laminated. Above the lightguide (toward the LC module) is placed a diffuse sheet and potentially the afore-mentioned optical films for directing the light rays along the preferred viewing axis and to control the polarization of the light. Light rays that do not exit at the proper angle and/or of the wrong polarization are generally reflected back into the lightguide, where they scatter and change polarization as a result of encountering either the diffuse pattern and/or the back side reflector. This reflection, or recycling of light rays, causes the cavity to become brighter, as more light rays of the proper angle orientation and polarization are emitted.

SUMMARY OF THE INVENTION

In accordance with the invention, an illumination system including a lightguide that operates under the principle of frustrate total internal reflection includes optical elements and combinations of optical elements for enhancing the apparent brightness of the lightguide.

In a first aspect of the invention, an illumination device includes a light source and a lightguide coupled to the light source. The lightguide is arranged to extract light by frustrated total internal reflection. A turning film is coupled to an output of the lightguide and is arranged to redirect the light rays from the output surface of the lightguide through the turning film. An optical element is coupled to the turning film, and the optical element includes an optical structure that transmits light rays having a first characteristic and reflects light rays having a second characteristic. A reflector is coupled to a back surface of the lightguide, and lights rays having the second characteristics are reflected by said optical element through the turning film and into the lightguide, and at least a portion of said reflected light rays reemerge from the lightguide having the first characteristic.

In another aspect of the invention, a display device includes a liquid crystal display module. A diffuser is coupled to the liquid crystal display module, and a reflective polarizer is coupled to an input of the diffuser. A turning film is coupled to an input of the reflective polarizer and to a lightguide. The lightguide operates under the principle of frustrate total internal reflection for directing light rays from a light source through a output surface. A reflector is coupled to a back surface of the lightguide. The reflective polarizer transmits light rays having a first polarization and reflects light rays having a second polarization. The reflected light rays are reflected through the turning film and into the lightguide, and at least a portion of the reflected light rays are reflected by the reflector at the back surface and reemerge from the lightguide having the first polarization.

In still another aspect of the invention, a method of enhancing brightness in a display device, wherein the display device includes a liquid crystal display assembly and an illumination source, and the illumination source has a lightguide that extracts light rays according to the principle of frustrate total internal reflection, includes the steps of injecting light rays having a first polarization orientation and a second polarization orientation into the lightguide at an input surface; turning light rays exiting an output surface of the lightguide to a direction substantially normal to the output surface;

transmitting light rays having the first polarization orientation; reflecting light rays having the second polarization orientation back toward the lightguide; randomizing the reflected light rays to produce a portion of the reflected light rays having the first polarization orientation; and transmitting the portion of light rays.

BRIEF DESCRIPTION OF THE DRAWINGS

The many advantages and features of the present invention will become apparent to one of ordinary skill in the art from the following detailed description of several preferred embodiments of the invention with reference to the attached drawings wherein like reference numerals refer to like elements throughout and in which:

Fig. 1 is a schematic illustration of a display device;

Fig. 2 is a schematic illustration of a display device in accordance with a preferred embodiment of the present invention;

Fig. 3 is a perspective view of reflective polarizer suitable for use in the display device illustrated in Fig. 2;

Fig. 4 is a perspective view of an alternative reflective polarizer suitable for use in the display device illustrated in Fig. 2;

Fig. 5 is a schematic illustration of an illumination device adapted in accordance with an alternate embodiment of the invention;

Fig. 6 is a schematic illustration of an illumination device adapted in accordance with an alternate embodiment of the invention;

Fig. 7 is a schematic illustration of an illumination device adapted in accordance with an alternate embodiment of the invention;

Fig. 8 is a schematic illustration of an illumination device adapted in accordance with an alternate embodiment of the invention; and

Fig. 9 is a schematic illustration of an illumination device adapted in accordance with an alternate embodiment of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention is described in terms of several preferred embodiments, and particularly, in terms of a turning film suitable for use in a backlit illumination device typically used in flat panel display devices, such as a laptop computer display or a desktop flat panel display. The invention, however, is not so limited in application and one of ordinary skill in the art will appreciate that it has application to virtually any optical system, for example, to projection screen devices and flat panel televisions. Therefore, the preferred embodiments described herein should not be taken as limiting of the broad scope of the invention.

With reference to Fig. 1, a display 10 is illustrated with a multilayer liquid crystal display assembly 12, which may include a front polarizer 14, a glass layer 15, a liquid crystal layer 16, a glass layer 17 and a rear polarizer 18. The display 10 may also include a display illumination device 20 that has a lightguide 22, a light source assembly 24 and a turning film 26. The light source assembly 24 may include a cold cathode fluorescent tube (CCFT) light 28 disposed within a reflector housing 30 adjacent an input surface 32 of the lightguide 22.

The turning film 26 has an input surface 34 formed with a plurality of prism structures 36 disposed toward an output surface 36 of the lightguide 22. Disposed adjacent a back surface 38 of the lightguide 22 is a reflector 40. A diffuser 42 may be disposed between the turning film 26 and the display assembly 14 to masks defects or non-uniformities. The lightguide 22 itself may be a wedge or slab and/or modifications of each.

The edge-coupled light propagates from the input surface 32 toward an end surface 33, confined by TIR. The light is extracted from the lightguide 22 by frustration of the TIR. A ray confined within the lightguide 22 increases its angle of incidence relative to the plane of the top and bottom walls, due to the wedge angle, with each TIR bounce. Thus, the light eventually refracts out of each of the output surface 36 and the back surface 38 because it is no longer contained by TIR. The light refracting out of the back surface 38 is either specularly or diffusely reflected by the reflector 40 back toward and largely through the lightguide 22. The turning film 26 is arranged to redirect the light rays exiting the output surface 36 along a direction substantially parallel to a preferred viewing direction. The preferred viewing direction may be normal to the output surface 36, but will more typically be at some angle to the output surface 36.

The light rays exiting the turning film 26 are generally illustrated by ray bundle 44 having light rays of a first polarization orientation (a) and a second polarization orientation (b). These light rays are diffused upon passing through the diffuser 42 and enter the display assembly 12. By normal operation of the display assembly 12, the light rays having the first polarization orientation (a) are transmitted (arrow 45) by the display assembly 12 while the light rays having the second polarization orientation (b) are absorbed, which is indicated by the arrow 46 exiting from the side of the display assembly 12. Therefore, assuming no losses within display 10, by design only half of the available light rays entering the lightguide reach the viewer.

With reference now to Fig. 2, a display 100 is illustrated with a multilayer liquid crystal display assembly 102, which may include a front polarizer 104, a glass layer 105, a liquid crystal layer 106, a glass layer 107 and a rear polarizer 108. The display 100 also includes a display illumination device 110 that has an lightguide 112, a light source assembly 114 and a turning film 116. The light source assembly may include a cold cathode fluorescent tube (CCFT) light 118 disposed within a reflector housing 120 adjacent an input surface 122 of the lightguide 112.

The turning film 116 has an input surface 124 formed with a plurality of prism structures 126 disposed toward an output surface 126 of the lightguide 112. Disposed adjacent a back surface 128 of the lightguide 112 is a reflector 130. A diffuser 131 is disposed between the turning film 116 and the display 102 to masks defects or non-uniformities.

The display 100 may further include a reflective polarizer 132 disposed between the turning film 116 and the display assembly 102. The reflective polarizer 132 may be a multilayer reflective polarizer 134 as shown in Fig. 3, or may be a continuous reflective polarizer 136 constructed from a substantially birefringent continuous phase including dispersed therein a substantially non-birefringent disperse phase disposed therein as shown in Fig. 4. The reflective polarizer 132 may further be a cholersteric polarizer or a birefringent film retarder.

Referring first to Fig. 3, the illustrative multilayer reflective polarizer 134 is made of alternating layers (ABABAB...) of two different polymeric materials. These are referred to as material "A" and material "B" throughout the following discussion. The two materials may be extruded together and the resulting multiple layer (ABABAB...) material stretched approximately 5:1 along one axis (illustrated as "X"), and not stretched appreciable 1:1 along the other axis (illustrated as "Y"). The X axis is referred to as the "stretched" direction and the Y axis is referred to as the "transverse" direction.

The B material may have a nominal index of refraction (n=1.64 for example) which is not substantially altered by the stretching process. The A material has the property of having the index of refraction altered by the stretching process. For example, a uniaxially stretched sheet of the A material will have one index of refraction (n=1.88 for example) associated with the stretched direction and a different index of refraction (n=1.64 for example) associated with the transverse direction. By way of definition, the index of refraction associated with an in-plane axis (an axis parallel to the surface of the film) is the effective index of refraction for plane polarized incident light whose plane of polarization is parallel to that axis.

Thus, after stretching the multilayer stack (ABABAB...) the material shows a large refractive index difference between layers (delta n=1.88-1.64=0.24) associated with the stretched direction. While in the transverse direction, the associated indices of refraction between layers are essentially the same (delta n=1.64-1.64=0.0). These optical characteristics cause the multilayer laminate to act as a reflecting polarizer that will transmit the polarization component of the incident light that is correctly oriented with respect to the transmission axis (illustrated as "T"). The light that emerges from the reflective polarizer 134 is referred to as having a first polarization orientation (a).

The light that does not pass through the reflective polarizer 134 has a polarization orientation

(b) that differs from the first polarization orientation (a). Light exhibiting this polarization orientation will encounter the index differences which result in reflection of this light. The structure and function of multilayer reflective polarizer 134 is more fully described in commonly assigned United States Patent No. 5,828,488 the disclosure of which is hereby expressly incorporated herein by reference.

Referring to Fig. 4, reflective polarizer 136 may include a substantially continuous matrix 138 of a birefringent material into which is disposed a discontinuous or disperse phase 140. The birefringence of the continuous phase is typically at least about 0.05 and may be between about 0.1-0.2. The indices of refraction of the continuous and disperse phases are substantially matched (i.e., differ by less than about 0.05) along a first of three mutually orthogonal axes, and are substantially mismatched (i.e., differ by more than about 0.05) along a second of the three mutually perpendicular axes. The indices of refraction along the match axis should differ by less than about 0.01-0.03, while the indices of refraction along the mismatch axis should differ by more than at least 0.07 and preferably in excess of 0.2.

The mismatch in refractive indices along a particular axis has the effect that incident light polarized along that axis will be substantially scattered resulting in a significant amount of reflection. By contrast, incident light polarized along an axis in which the refractive indices are matched will be spectrally transmitted or reflected to a much lesser degree.

The disperse phase 140 may have an oriented rod-like geometry as shown in Fig. 4, although other geometries may be utilized. One method for forming the structure shown is to form the continuous phase 138 into which are included spherical particles of the disperse phase 140 into a film, and then stretching the film along one axis to orient and extend the spherical particles into the rod-like structures shown. It may also be possible to extrude the components to form both the continuous phase 138 and the disperse phase 140. The structure and function of reflective polarizer 136 is more fully described in commonly assigned United States Patent No. 5,783,120 the disclosure of which is hereby expressly incorporated herein by reference.

Referring again to Fig. 2, the lightguide 112 may extract light by the principle of frustrated total internal reflection as described above. The light rays exiting the output surface of the lightguide 112 are turned by the turning film 116 substantially along a preferred viewing direction of the display 102.

The light rays exiting the turning film 116 are generally illustrated by ray bundle 142, are randomly polarized, and for example, contain light rays of the first polarization orientation (a) and the second polarization orientation (b). The light rays of the first polarization orientation (a) are transmitted by the reflective polarizer 132. These light rays are illustrated by ray bundle 144. The light rays having the second polarization orientation (b) are reflected back towards the turning film 116 and the lightguide 112 and are represented by ray bundle 146.

The light rays contained in ray bundle 146 will re-enter the lightguide 112 and be reflected by reflector 130 with some portion of this light being randomized in terms of both direction and polarization. Thus, a portion of these light rays will reemerge from the lightguide having the first polarization orientation (a) and are illustrated by ray bundle 148. The light rays of the ray bundle 148 add to the light rays of the ray bundle 144 adding to the overall apparent brightness of the display 100. Some absorption losses occur, and are illustrated by the ray bundle

150, however, because of the reflective polarizer 132, very few of the light rays exiting the lightguide 112 are absorbed by the dichroic absorptive polarizer 108.

Fig. 5 shows a display 200 similar in construction to the display 100. Like reference numerals are used to illustrate like elements of both the display 100 and the display 200.

As shown in Fig. 5, the turning film 116 and the reflective polarizer 132 are replaced by the combined turning film/reflective polarizer 202. The combined turning film/reflective polarizer 202 may be formed by lamination of a reflective polarizer 204, such as the reflective polarizer 132, to a turning film 206, such as the turning film 116. Alternatively, beginning with a reflective polarizer, the turning film structure may be formed directly onto the reflective polarizer using radiation or ultraviolet (UV) curing processes. It is further possible to form the turning prims structure by embossing a skin surface portion of the reflective polarizer.

Fig. 6 shows a display 300 similar in construction to the display 100. Like reference numerals are used to illustrate like elements of both the display 100 and the display 300.

In Fig. 6, the reflective polarizer 132 and the diffuser 131, as described in connection with Fig. 2, are replaced by the combined diffuser/reflective polarizer 302. The combined diffuser/reflective polarizer 302 may be formed by lamination of a reflective polarizer 306, such as the reflective polarizer 132, to a diffuser 304, such as the diffuser 131. As described above, various alternative manufacturing methods, such UV curing or embossing may also be used to form the combined diffuser/reflective polarizer 302. The diffusive properties of the diffuser/reflective polarizer 302 may also be established by the inclusion of diffusive particles in an outer layer of the reflective polarizer or by providing a coating of diffusive particles onto the reflective polarizer.

Fig. 7 shows a display 400 similar in construction to the display 100. Like reference numerals are used to illustrate like elements of both the display 100 and the display 400.

In Fig. 7, the turning film 116, the reflective polarizer 132 and the diffuser 131, as illustrated in Fig. 2, are replaced by the combined element 402. The combined element 402 may be formed by laminating together a turning film 404, such as turning film 116, a reflective polarizer 406, such as the reflective polarizer 132, and a diffuser 408, such as the diffuser 131. The combined element 402 may also formed using UV or radiation curing techniques to form the turning prisms structures wherein the skin material further contains bulk diffusing material.

Fig. 8 shows a display 500 similar in construction to the display 100. Like reference numerals are used to illustrate like elements of both the display 100 and the display 500.

In Fig. 8, the rear polarizer 108, the diffuser 131 and the reflective polarizer 132, as illustrated in Fig. 2, are replaced by the combined element 502. The combined element 502 may be formed by laminating together a rear polarizer 504, such as rear polarizer 108, a diffuser 506, such as the diffuser 131, and a reflective polarizer 508, such as the reflective polarizer 132. It will be appreciated that other techniques for forming the combined element 502 may be used.

Fig. 9 shows a display 600 similar in construction to the display 100. Like reference numerals are used to illustrate like elements of both the display 100 and the display 600.

In Fig. 9, the rear polarizer 108, the diffuser 131, the reflective polarizer 132 and the turning film 116, as illustrated in Fig. 2, are replaced by the combined element 602. The combined element 602 may be formed by laminating together a rear polarizer 602, such as rear polarizer 108, a diffuser 604, such as the diffuser 131, a reflective polarizer 606, such as the reflective polarizer 132, and a turning film 608, such as turning film 116. Alternatively, a combined element, such as combined element 502 may be formed, and then this element laminated to a rear diffuser, such as rear diffuser 108. It will be appreciated that still other techniques for forming the combined element 602 may be used.

In each of the embodiments shown in Figs. 5-9, the combined optical element improves apparent display brightness by reflecting light rays having a second polarization orientation (b) back toward and substantially into the lightguide 112 where these light rays are randomized in polarization and direction. A portion of these randomized light rays reemerge from the lightguide having the first polarization orientation (a). Because light rays having the first polarization orientation (a) are transmitted through the liquid crystal display device 102, more light rays ultimately emerge from the display enhancing the brightness of the display. Moreover, the combination of optical elements may reduce the thickness and weight of the display device, and may reduce optical defects resulting from optical coupled of adjacent optical elements in the display.

Modifications and alternative embodiments of the invention will be apparent to those skilled in the art in view of the foregoing description. This description is to be construed as illustrative only, and is for the purpose of teaching those skilled in the art the best mode of carrying out the invention. The details of the structure and method may be varied substantially without departing from the spirit of the invention, and the exclusive use of all modifications which come within the scope of the appended claims is reserved.

CLAIMS

What is claimed is:

1. An illumination device comprising:

a light source,

a lightguide, the lightguide having an input surface, an output surface and a back surface, the light source being incident to the input and wherein the lightguide operates under the principle of frustrate total internal reflection for directing light rays from the light source and entering the lightguide at the input surface to exit the lightguide through the output surface in a substantially uniform manner;

a turning film coupled to the output surface of the lightguide, the turning film including a plurality of prism structures arranged on an input surface of the turning film for redirecting the light rays from the output surface of the lightguide through the turning film and from an output surface of the turning film;

at least one optical element coupled to the turning film, said optical element including an optical structure that transmits light rays having a first characteristic and reflects light rays having a second characteristic;

a reflector coupled to the back surface of the lightguide; and

wherein lights rays having the second characteristics are reflected by said optical element through the turning film and into the lightguide, and at least a portion of said reflected light rays reemerge from the lightguide having the first characteristic.

2. The illumination device of claim 1, wherein the first characteristic comprises a first polarization and the second characteristic comprises a second polarization different from the first polarization.

3. The illumination device of claim 1, wherein the first characteristic comprises a first angular range and the second characteristic comprises a second angular range different from the first angular range.

4. The illumination device of claim 1, wherein the at least one optical element comprises a reflective polarizer.

5. The illumination device of claim 1, wherein the at least one optical element is formed integral with the turning film.

6. The illumination device of claim 1, wherein the at least one optical element comprises in combination a reflective polarizer and a diffuser.

7. The illumination device of claim 1, wherein the at least one optical element comprises in combination a brightness enhancing prism film and a reflective polarizer.

8. The illumination device of claim 7, wherein the reflective polarizer is coupled to an output surface of the brightness enhancing prism film.

9. The illumination device of claim 1, wherein the at least one optical element is laminated to the output surface of the turning film.

10. The illumination device of claim 1, wherein the at least one optical element comprises in combination a

diffusive reflective polarizer and an absorbing polarizer.

11. The illumination device of claim 10, wherein the at least one optical element is laminated to the output surface of the turning film.

12. The illumination device of claim 1, wherein the at least one optical element is formed integral with the turning film.

13. The illumination device of claim 12, wherein the at least one optical element comprises in combination a cholersteric polarizer and a birefringent film retarder.

14. A display device comprising:

a liquid crystal display module, the liquid crystal display module having an input polarizer and an output polarizer;

a diffuser, the diffuser being coupled to the input polarizer of the liquid crystal display module;

a reflective polarizer, the reflective polarizer being coupled to an input of the diffuser;

a turning film, the turning film being coupled to an input of the reflective polarizer;

a lightguide, the lightguide having an input surface, an output surface and a back surface,

a light source, the light source being incident to the input surface of the lightguide and wherein the lightguide operates under the principle of frustrate total internal reflection for directing light rays from the light source and entering the lightguide at the input surface to exit the lightguide through the output surface in a substantially uniform manner;

a reflector coupled to the back surface of the lightguide; and wherein the reflective polarizer transmits light rays having a first polarization and reflects light rays having a second polarization, said reflected light rays being reflected through the turning film and into the lightguide, and at least a portion of said reflected light rays being reflected by the reflector at the back surface and reemerging from the lightguide having the first polarization.

15. A display device comprising:

a liquid crystal display module, the liquid crystal display module having an input polarizer and an output polarizer;

a combined diffuser/reflective polarizer, the combined diffuser/reflective polarizer being coupled to the input polarizer of the liquid crystal display module;

a turning film, the turning film being coupled to an input of the combined diffuser/reflective polarizer;

a lightguide, the lightguide having an input surface, an output surface and a back surface;

a light source, the light source being incident to the input surface of the lightguide and wherein the lightguide operates under the principle of frustrate total internal reflection for directing light rays from the light source and entering the lightguide at the input surface to exit the lightguide through the output surface in a substantially uniform manner;

a reflector coupled to the back surface of the lightguide; and

wherein the combined diffuser/reflective polarizer transmits light rays having a first polarization and reflects light rays having a second polarization, said reflected light rays being reflected through the turning film and into the lightguide, and at least a portion of said reflected light rays being reflected by the reflector at the back surface and reemerging from the lightguide having the first polarization.

16. The display device of claim 15, wherein the combined diffuser/reflective polarizer comprises a laminate including a diffuser and a reflective polarizer film.

17. The display device of claim 15, wherein the combined diffuser/reflective polarizer comprises a diffusive structure formed in an output surface of a reflective polarizer film.

18. A display device comprising:

a liquid crystal display module, the liquid crystal display module having an input polarizer and an output polarizer;

a diffuser, the diffuser being coupled to the input polarizer of the liquid crystal display module;

a combined turning film/reflective polarizer, the combined turning film/reflective polarizer being coupled to an input of the diffuser;

a lightguide, the lightguide having an input surface, an output surface adjacent the combined turning film/reflective polarizer and a back surface;

a light source, the light source being incident to the input surface of the lightguide and wherein the lightguide operates under the principle of frustrate total internal reflection for directing light rays from the light source and entering the lightguide at the input surface to exit the lightguide through the output surface in a substantially uniform manner;

a reflector coupled to the back surface of the lightguide; and

wherein the combined turning film/reflective polarizer transmits light rays having a first polarization and reflects light rays having a second polarization, said reflected light rays being reflected into the lightguide, and at least a portion of said reflected light rays being reflected by the reflector at the back surface and reemerging from the lightguide having the first polarization.

19. The display device of claim 18, wherein the combined turning film/reflective polarizer comprises a laminate of a turning film and a reflective polarizing film.

20. The display device of claim 18, wherein the combined turning film/reflective polarizer comprises turning prisms formed in an input surface of a reflective polarizer.

21. A display device comprising:

a liquid crystal display module, the liquid crystal display module having an input polarizer and an output polarizer;

a combined diffuser/turning film/reflective polarizer, the combined diffuser/turning film/reflective polarizer being coupled to the input polarizer of the liquid crystal display;

a lightguide, the lightguide having an input surface, an output surface adjacent the combined diffuser/turning film/reflective polarizer and a back surface;

a light source, the light source being incident to the input surface of the lightguide and wherein the lightguide operates under the principle of frustrate total internal reflection for directing light rays from the light source and entering the lightguide at the input surface to exit the lightguide through the output surface in a substantially uniform manner;

a reflector coupled to the back surface of the lightguide; and wherein the combined diffuser/turning film/reflective polarizer transmits light rays having a first polarization and reflects light rays having a second polarization, said reflected light rays being reflected into the lightguide, and at least a portion of said reflected light rays being reflected by the reflector at the back surface and reemerging from the lightguide having the first polarization.

22. The display device of claim 21, wherein the combined diffuser/turning film/reflective polarizer comprises a laminate of a diffuser, a turning film and a reflective polarizing film.

23. The display device of claim 21, wherein the combined diffuser/turning film/reflective polarizer comprises turning prisms formed on an input surface of a reflective polarizer and a diffuser structure formed on an output surface of the reflective polarizer.

24. A method of enhancing brightness in a display device, the display device including a liquid crystal display assembly and an illumination source, the illumination source having a lightguide that extracts light rays according to the principle of frustrate total internal reflection; the method comprising:

injecting light rays having a first polarization orientation and a second polarization orientation into the lightguide at an input surface;

turning light rays exiting an output surface of the lightguide to a direction substantially normal to the output surface;

transmitting light rays having the first polarization orientation;

reflecting light rays having the second polarization orientation back toward and substantially through the lightguide;

randomizing the polarization orientation of said reflected light rays to produce a portion of said reflected light rays having the first polarization orientation; and

transmitting said portion of light rays.

25. The method of claim 24, wherein the step of reflecting light rays comprises providing a reflective polarizer between the liquid crystal display assembly and the illumination source.

26. The method of claim 24, wherein the step of reflecting light rays comprises providing a combined turning film/reflective polarizer between the liquid crystal display assembly and the illumination source.

27. The method of claim 24, wherein the step of reflecting light rays comprises providing a combined diffuser/reflective polarizer between the liquid crystal display assembly and the illumination source.

28. The method of claim 24, wherein the step of reflecting light rays comprises providing a combined diffuser/turning film/reflective polarizer between the liquid crystal display assembly and the illumination source.

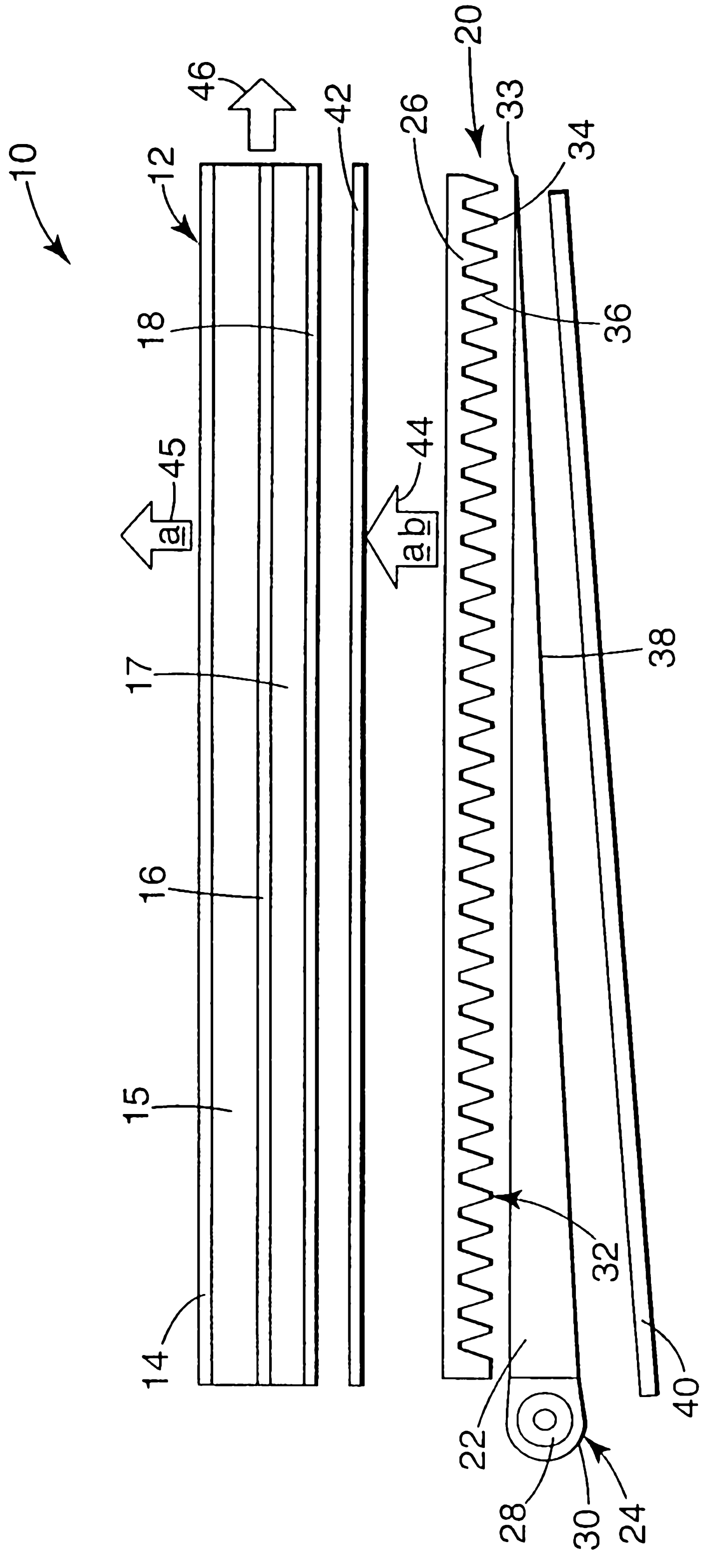

Fig. 1

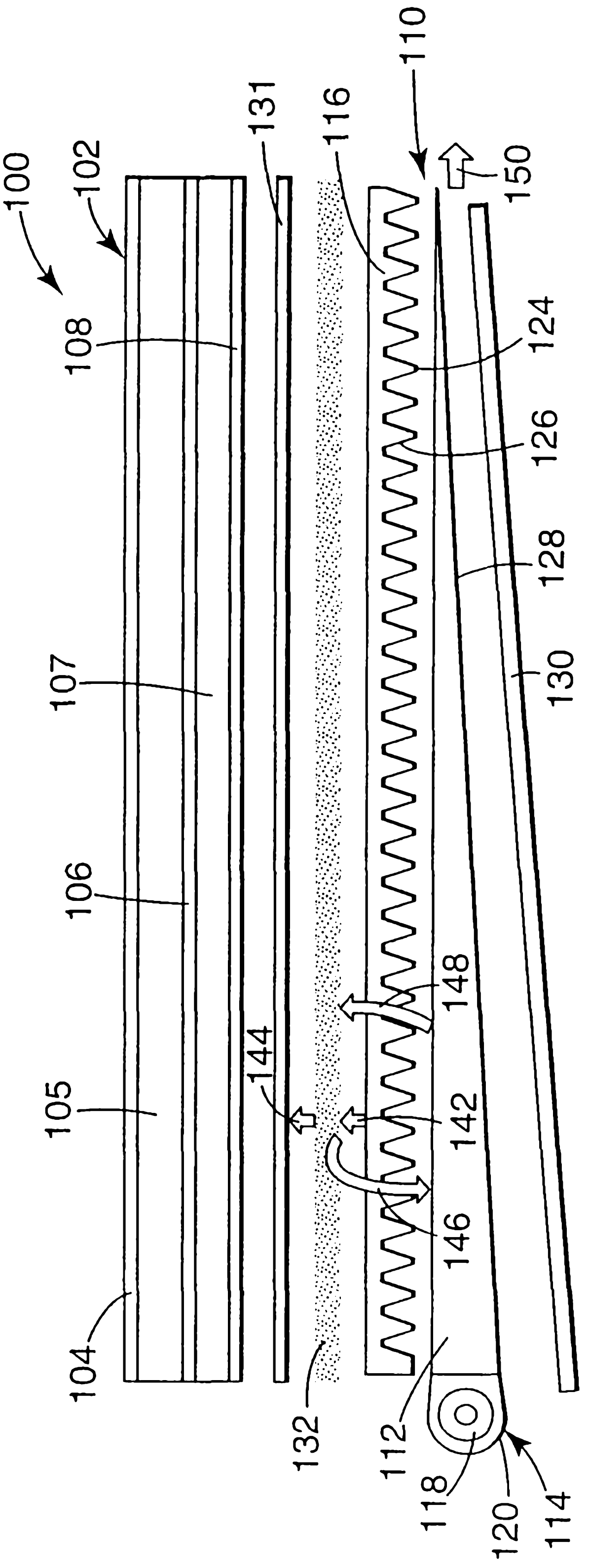
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Fig. 2

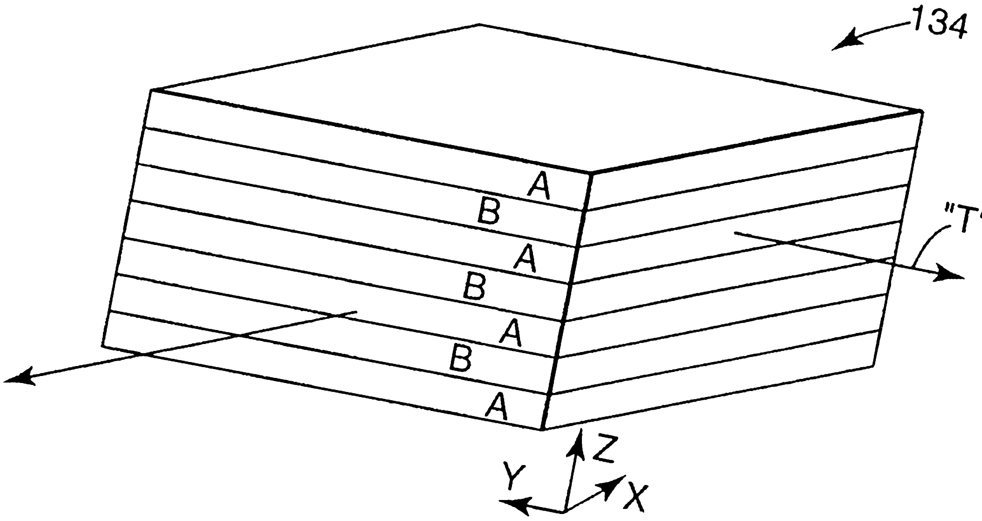

Fig. 3

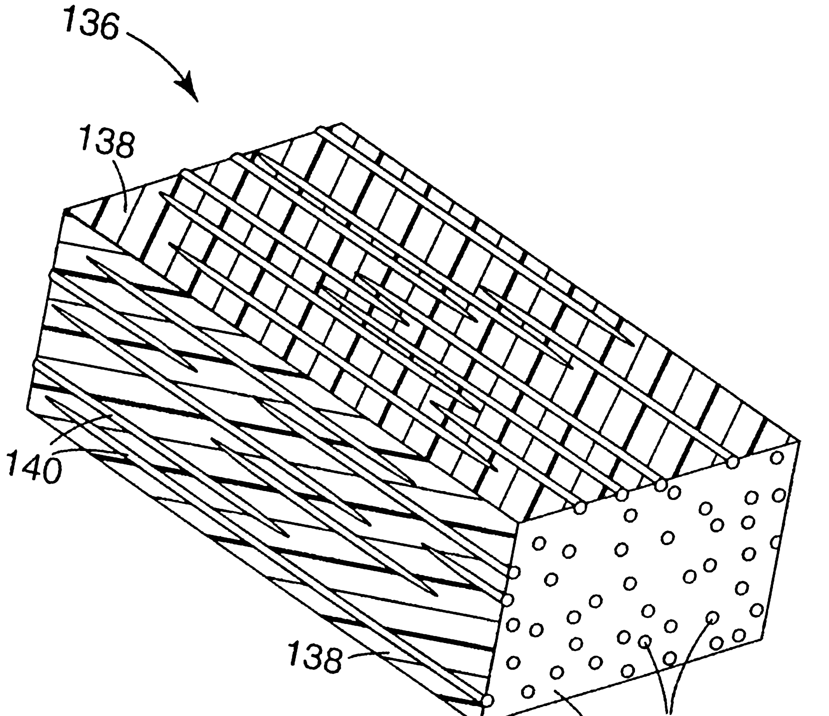

Fig. 4

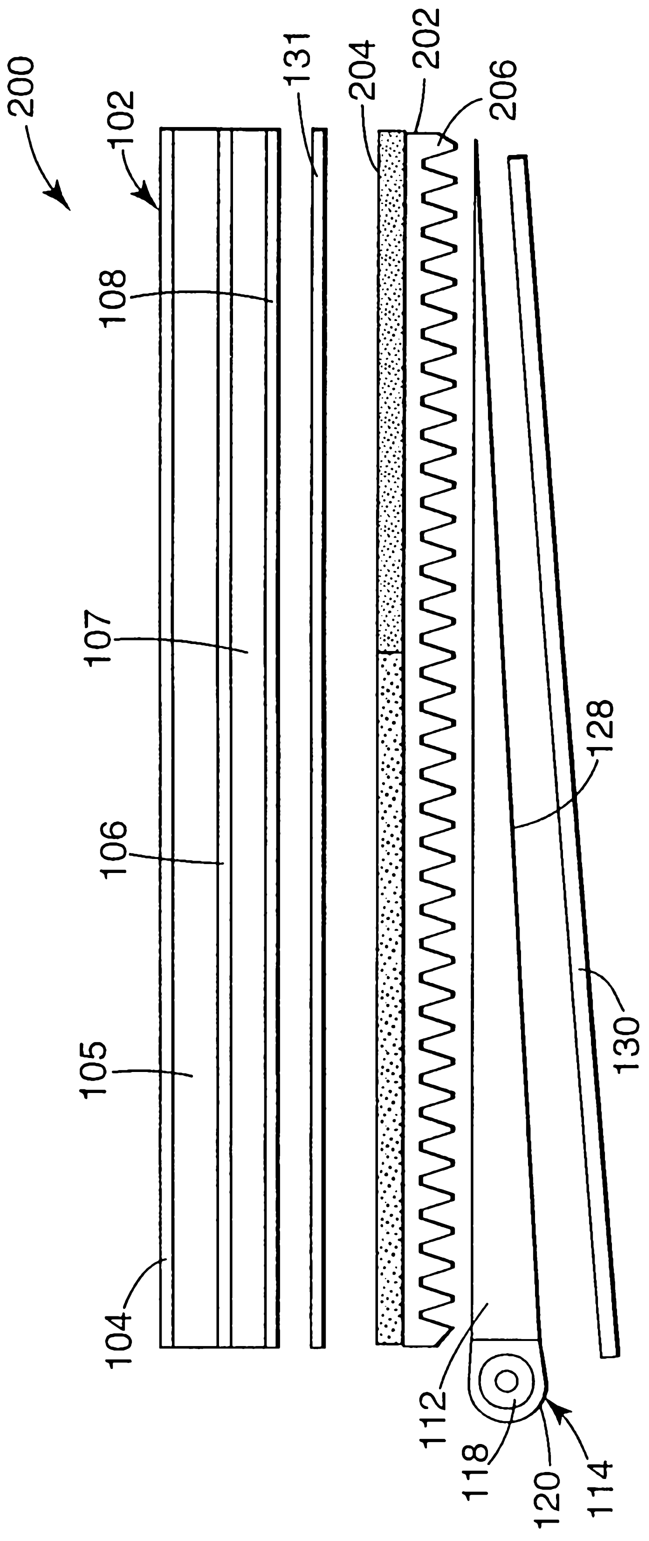
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Fig. 5

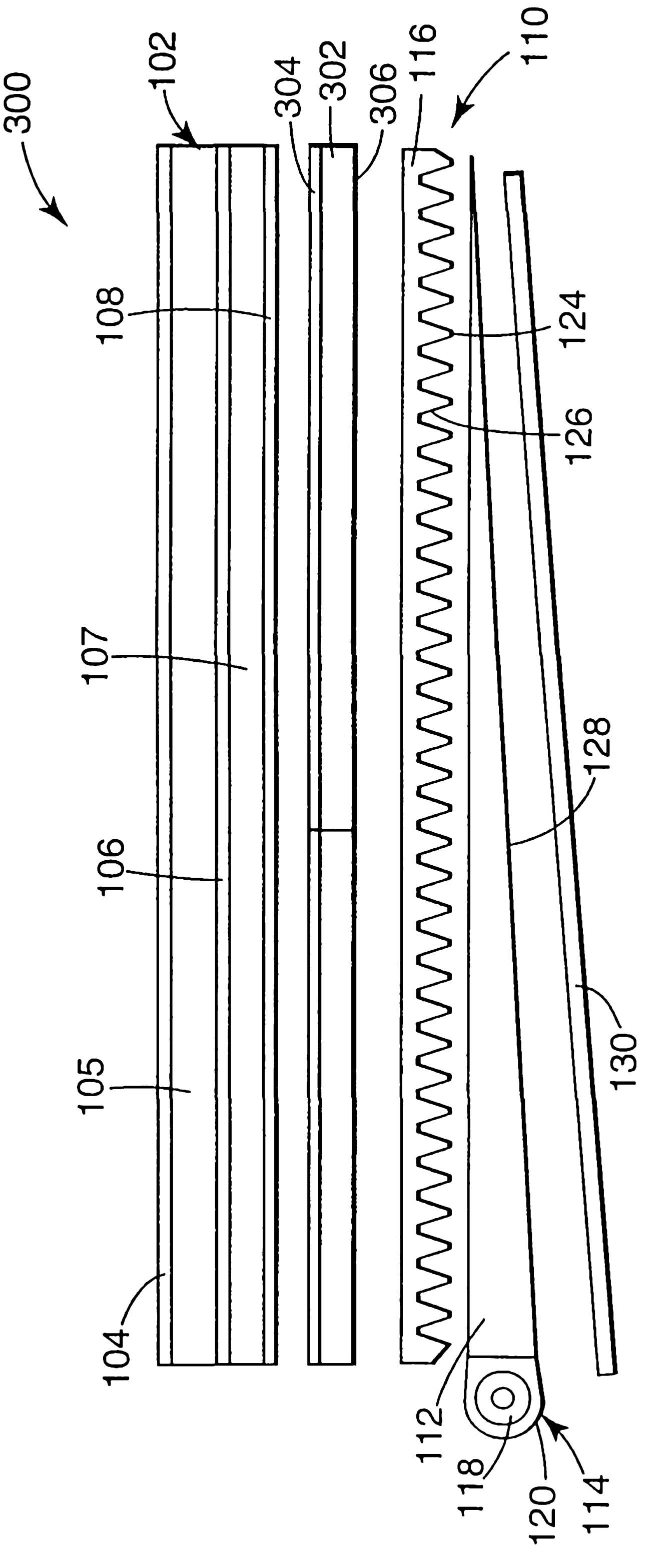
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Fig. 6

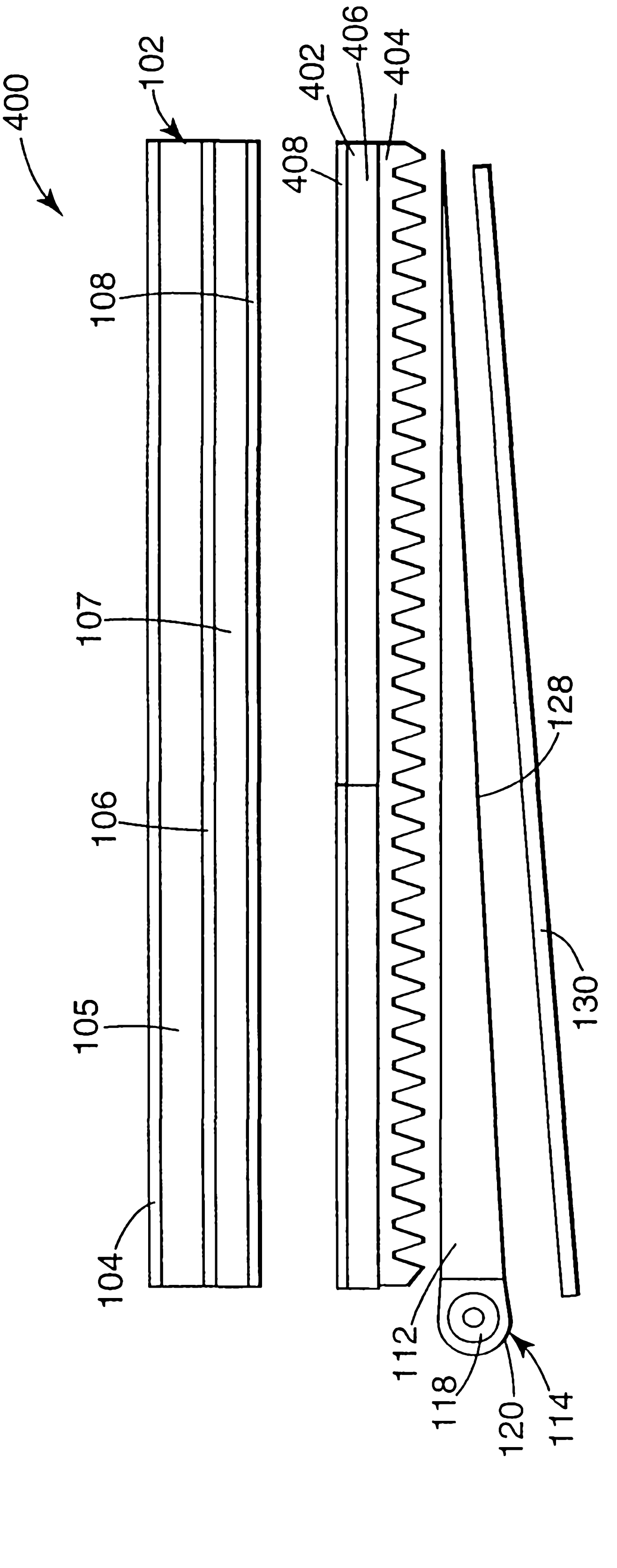
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Fig. 7

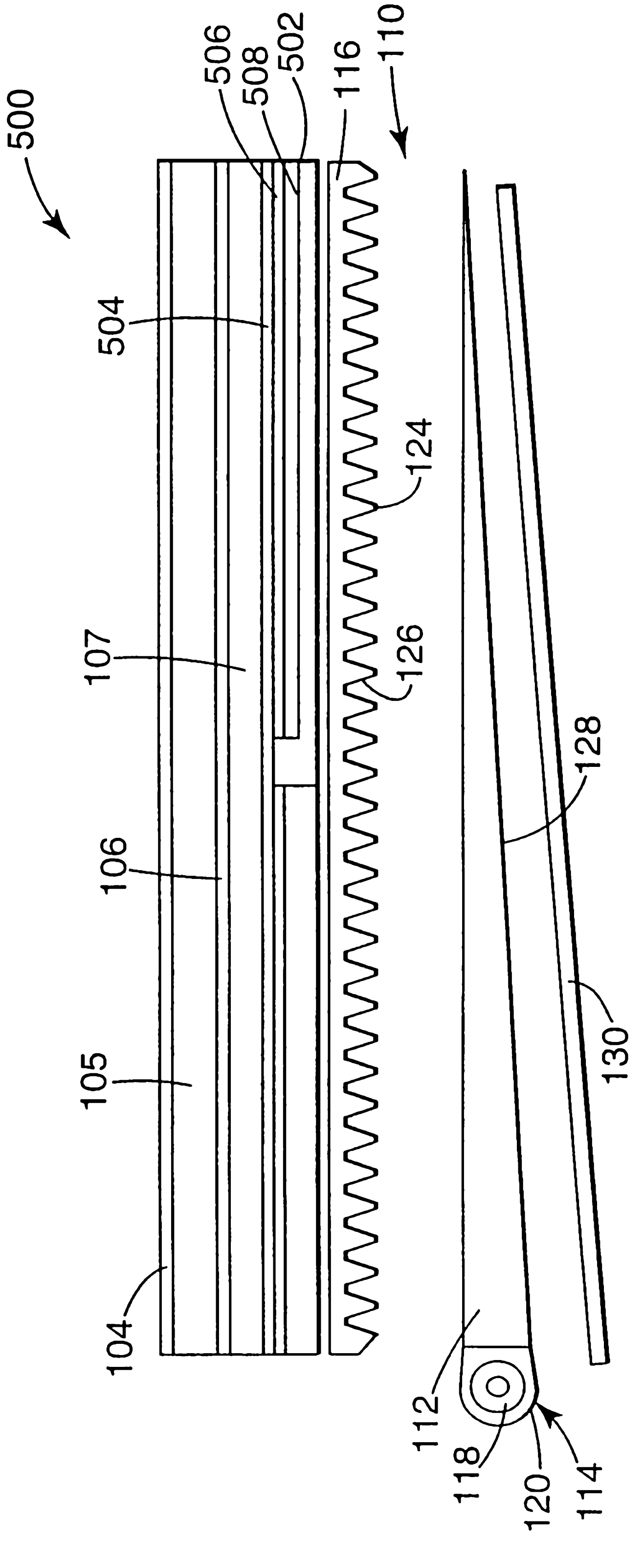
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Fig. 8

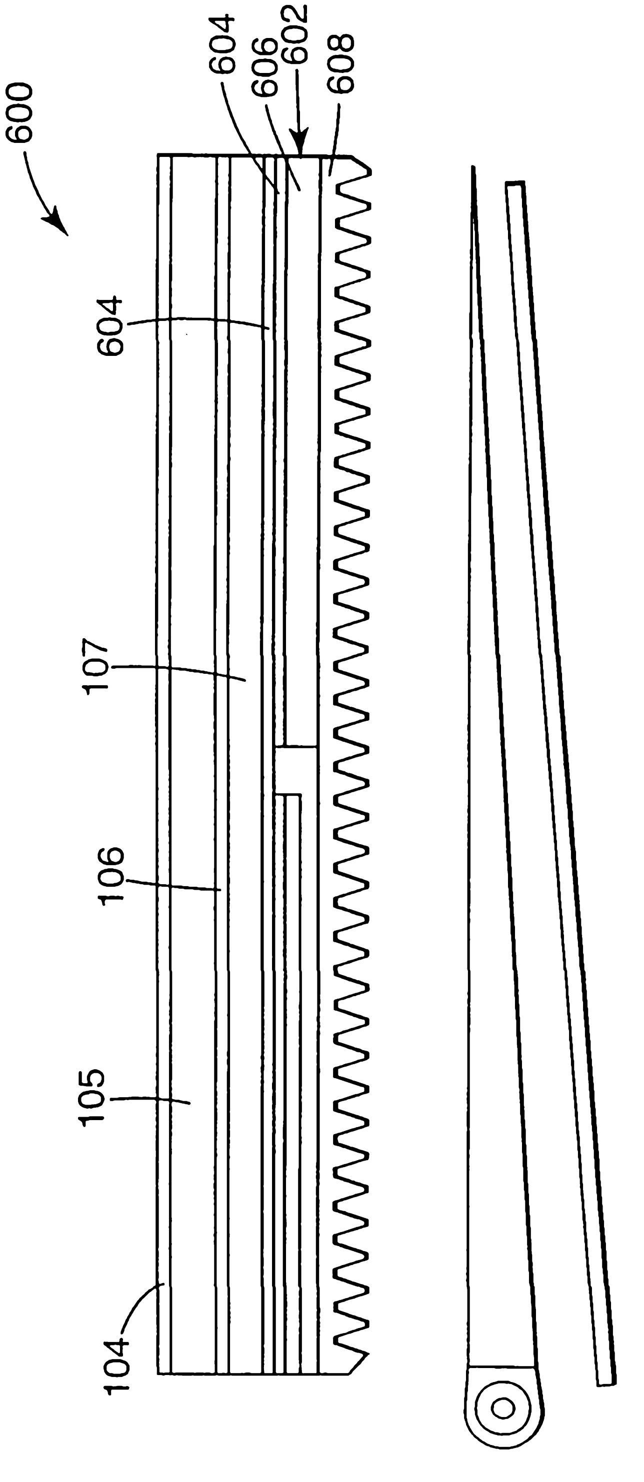

Fig. 9