C E R T I F I C A T I O N O F T R A N S L A T I O N

The undersigned, Richard Patner, whose address is 26357 Lexington Drive, Bonita Springs, FL 34135, United States of America, declares and states as follows:

I am well acquainted with the English and Japanese languages; I have in the past translated numerous Japanese documents of legal and/or technical content into English.

I have been requested to translate into English the attached Japanese Patent No. 6-51130 titled "**Light-guide plate for a surface lighting device using a spot light source.**"

To a copy of this Japanese document I therefore attach an English translation and my Certification of Translation.

I hereby certify that the attached English translation of Japanese Patent No. 6-51130 titled "**Light-guide plate for a surface lighting device using a spot light source**" is, to the best of my knowledge and ability, an accurate translation.

And I declare further that all statements made herein of my own knowledge are true, that all statements made on information and belief are believed to be true, and that false statements and the like are punishable by fine and imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

____________________	March 3, 2015
Richard Patner	Date

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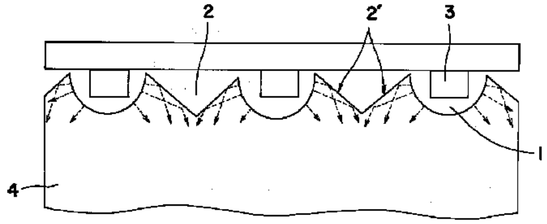
[54] [Title of Invention]

Light-guide plate for a surface lighting device using a spot light source

[57] [Abstract]

[Constitution] A light-guide plate (4) for a surface lighting device using spot light sources (3) that has roughly triangular notches (2) installed between installation depressions (1) on the lateral surface of said light-guide plate (4) that comprises a transparent plate with a plurality of spot light source installation depressions (1) installed on the lateral surface.



[Scope of Patent Claim]
[Claim 1] A light-guide plate for a surface lighting device using spot light sources in which roughly triangular notches are installed between installation depressions on the lateral surface of said light-guide plate that comprises a transparent plate with a plurality of spot light source installation depressions installed on the lateral surface.
[Claim 2] The light-guide plate for a surface lighting device of Claim 1 in which two sides of the roughly triangular notches have a curved form protruding outward.
[Claim 3] The light-guide plate for a surface lighting device of Claims 1 or 2 in which a plurality of projections or depressed holes are formed on one side of the transparent plate so as to decrease in size closer to the light source and to increase in size at greater distance from the light source.
[Claim 4] The light-guide plate for a surface lighting device of Claim 3 in which the opposite surface from the surface on which the projections or depressed holes are formed has been coarsened.
[Detailed Description of the Invention]
[0001]
[Field of Industrial Utilization] The present invention concerns a light-guide plate for a surface lighting device used in liquid crystal display devices, etc., especially a light-guide plate that uses a spot light source.
[0002]
[Related Art] Surface lighting devices are used in liquid crystal display devices and the like. In the mainstream type used at present, diffusion film (7), light-guide plate (4), and reflection film (8) are sequentially overlaid in a lateral view of the aforementioned display device, and a light source (6) is then deployed on the lateral surface, as shown in Figure 11 and Figure 12. The light-guide plate in this case comprises lattice points on one side of a conventional transparent flat plate with a dot pattern (10) shaped so as to decrease in size as the light source (6) is approached and with a plurality of projections or depressed holes formed. In many cases, the dot pattern (10) is formed on the surface (opposite surface) that faces the surface of observation (observation surface).
[0003] The light that enters from the lateral surface of the light-guide plate is transmitted while total reflection off the reflection surface and the observation surface is repeated. Some of that light is dispersed in a dot pattern and emitted to the observation surface. As shown in Figure 12, the dot pattern (10) becomes smaller as the light source (6) is approached, and the emission of uniform light over the entire surface of the observation surface becomes possible by increasing the pattern size with greater distance from the light source.
[0004] Part of the light that is dispersed by the dot pattern formed in the light-guide plate is also emitted on the reverse surface from the reflection surface. A reflection film is deployed on the reverse surface to effectively utilize this light. The light reflected here is again directed toward the observation surface. Similarly, a reflection means may be completed on the lateral surface member as well to raise the utilization efficiency of light.
[0005] In many cases, the dot pattern that is formed on the light-guide plate cannot be viewed from the observation surface. Consequently, a diffusion film is deployed on the observation surface of the light-guide plate so that the dot pattern is not observed. Diffusion films are also utilized to make the luminance of the illumination device more uniform over the entire surface.
[0006] Next, the light source is frequently a rod-shaped fluorescent tube that is deployed on the lateral surface of the aforementioned light-guide plate.
[0007] The technology of light-guide plates in such a surface lighting device has been disclosed in multiple cases. Examples include the method of formation by printing a dot pattern with light dispersing white ink and the method of formation of dot patterns as projections or depressed holes integrally with a transparent plate.
[0008] In recent years, liquid crystal display devices have been used in various types and manners. The most desirable fields are those in which low power consumption or small size is called for. Light emitting diodes are used as the light source in such cases. Light emitting diodes have lower driving power and permit miniaturization because of the simplicity of the power source in comparison to fluorescent tubes. Another benefit is the lower level of power consumption.
[0009] An example of a light-guide plate used in a surface lighting device that uses a spot light source such as a light emitting diode as the light source is presented in Figure 4. In this case, a depression (1) is installed on the lateral surface of the light-guide plate (4) where light enters to miniaturize the device so that this spot light source is incorporated. In this case as well, a dot pattern is formed from projections or depressed holes or through printing on the reflection surface similarly to the case in which a light beam source is used. In addition, since the luminance readily decreases when a spot light source is used, fine unevenness such as surface texturing or hair lines are formed

on the observation surface of the light-guide plate as well in order to intentionally inhibit light transmission. Deficient luminance is also offset by so doing.

[0010] A plurality of spot light sources is usually deployed on one lateral surface of the light-guide plate when using a spot light source such as that presented in Figure 4. The number of light sources used in a given device is determined following consideration of various factors, including the luminous surface area of the device, the required brightness, the luminance of the light source, and the allowable power consumption.

[0011]

[Problems Solved by the Invention] However, there are many cases in which low power consumption is the first requirement of illumination devices that use light emitting diodes as the light source. Thus, reducing the power consumption has been attempted by reducing the number of light emitting diodes used in a single illumination device to the greatest possible extent while maximizing the brightness in order to address this requirement.

[0012] However, uniform brightness cannot be maintained in an illumination device when the number of light emitting diodes is reduced. Specifically, in regions extremely close to the light emitting diodes, those near the light emitting diodes are extremely bright while sections between adjacent light emitting diodes are comparatively dark. Thus, an extreme bright/dark difference develops within a narrow region. Furthermore, the brightness is difficult to adjust via the dot size since the dot pattern of the light-guide plate must be as small as possible near the light source. Compensation of differences in brightness is quite challenging. In particular, differences in brightness tend to readily become greater since the light dispersion state relies on the directionality of the light that is incident on the dots when forming dot patterns as projections or depressed holes integrally with a light-guide plate.

[0013]

[Means of Solving the Problems] The results of various examinations by the inventors to resolve the aforementioned problems revealed that the creation of a notch section on the lateral surface of the light-guide plate separate from the depression created for the light source enabled light that is incident at said notch section to be reflected in the intraplanar direction, specifically in the direction of the lateral surface opposite the lateral surface of incidence. By so doing, uniform brightness could be realized, which completed the present invention.

[0014] Specifically, the light-guide plate for a surface lighting device pursuant to the present invention is characterized by the installation of roughly triangular notches between installation depressions on the lateral surface of said light-guide plate that comprises a transparent plate with a plurality of spot light source installation depressions installed on the lateral surface. Two sides of the aforementioned roughly triangular notches have a curved form protruding outward that is effective. In addition, a plurality of projections or depressed holes could be formed on one side of the transparent plate so as to decrease in size closer to the light source and to increase in size at greater distance from the light source, and coarsening of the opposite surface from the surface on which the projections or depressed holes are formed would be effective.

[0015] Figure 1 illustrates the principles of the present invention. In Figure 1, (1) denotes the depression for installation of the spot light source, (2) denotes the roughly triangular notches for light reflection. The light that is issued from the spot light source (3) is incident within the light-guide plate (4) via the spot light source installation depression (1). It diffuses radially, but some of the light is reflected off the lateral surfaces formed by the notches (2) as shown in Figure 1. The reflected light is directed toward the comparatively dark sections between adjacent spot light sources. The illumination enhances the uniformity of the comparatively dark sections between the spot light sources. In short, a state approximating that when a light beam light source is used can be approached through reflection of light from the spot light source off of notches.

[0016]

[Action] The present invention is explained in further detail below through diagrams. The notches that reflect light in the present invention reflect light broadly in a radial shape from the spot light source and have the function of approaching a light beam light source. Consequently, the shape of the notches is determined with consideration of the deployment of the spot light source that is used. Furthermore, the allowable depth of the notchs must be considered in some cases since the sections where notches are formed cannot be used as luminous surfaces of the illumination device.

[0017] Figure 7 illustrates examples of the shape of the roughly triangular notches. The two sides of the roughly triangular notches that form the notches may be straight, as shown in Figure 7 (A), or they may form smooth curves, as shown in Figure 7 (B). Furthermore, if the deployment of the light source and the allowable depth of the notch are suitable, the two sides may have an outwardly protruding parabolic shape, as shown in Figure 7 (C). Such a parabolic reflection surface acts to turn light from a spot light source into parallel beams of light. Consequently, the ability to utilize such effects as in Figure 7 (C) results in enhanced effects. The reflection surface need not be a perfect parabolic shape. It may approximate a parabola by an arbitrary curve such as an arc.

[0018] The lateral surface ((2') in Figure 1) into which the aforementioned the aforementioned roughly triangular notches have been cut may be smooth or coarsened. In addition, the light reflective film may be bonded or light reflective paint may be applied. For example, if the deployment of the spot light source and the allowable depth of the notch are suitable with an optical path of the reflected light source that has been optimally set, the lateral surface may be smoothened so as to have a mirrow-like reflection (complete reflection) or it may be subjected to further mirror-like treatment. Furthermore, uniform illumination could be realized, depending on the circumstances, by applying light reflective paint or by bonding reflective film to reduce the directional character of reflected light if establishment of the ideal optical path is difficult.

[0019] Next, the shape of the depression that incorporates the light source is determined by the shape of the light source that is used as well as by the directional character of light issued from the light source. If the light source is sufficiently small compared to light-guide plate and if it has a virtually isotropic directional character, completion of the semi-circular depression (1) as shown in Figure 1 would facilitate design of the shape of the roughly triangular notches (2) that are installed for reflection. In addition, if the light source is large compared to the light-guide plate, the shape of the depression would have to match the shape of the light source in order to reduce the size of the equipment. Finally, the shape of the depression onto which light is incident would have to be designed in order to raise the uniformity of the luminance of the surface of illumination equipment through optical correction if the directional character of light issued from the light source were extremely tilted in a given direction.

[0020] Making the lateral surface of the spot light source installation depression upon which light is incident would be preferable for raising the utilization efficiency, but coarsening when the light source has a directional character, as stated above, or raising the uniformity of the luminance when incident light is scattered within the light-guide plate may be completed as well.

[0021] Smooth formation of the observation surface of the light-guide plate pursuant to the present invention would be desirable for transmitting incident light to optical fibers, for example, from the lateral surface of the spot light source installation side, but when the distance of light transmission is short because of the shape of the illumination device or the deployment of the light source, fine unevenness such as surface texturing or hair lines would be formed on the observation surface to complete coarsening. This would intentionally lower the level of light transmission and brighten the illumination.

[0022] Next, the dot pattern formed on the light-guide plate pursuant to the present invention may be formed in the same manner as in conventional technology. Formation of a pattern such that the dots would grow steadily larger with greater distance from the light source would be best, and a pattern of dots whose size decreases as said lateral surface is approached would be preferable out of consideration of reflection off lateral surfaces other than the lateral surface of light source installation. In addition to the dot size, altering the dot pitch would be an additional means of deriving uniform luminance. The dot shape may be differentiated as round, oblong, or triangular based on deployment of the spot light source. When the dot pattern is formed from a large number of projections or depressed holes, the uniformity of the luminance could be enhanced further by making the shape of the plane surface that of round dots.

[0023] The dot pitch must be small enough so as to be indistinguishable by diffusion film deployed on observation side of the light-guide plate. The dot section brightens and the sections between dots darken, leading to uneven illumination, when the pitch enlarges. The largest permissible pitch cannot be universally stated because of the dependence of the thickness of the light-guide plate and the performance of diffusion films, but the pitch must become smaller as the light-guide plate becomes thinner.

[0024] Furthermore, the light utilization efficiency of the light-guide plate pursuant to the present invention can be raised in the same manner as that of conventional light-guide plates by instituting a reflection means on lateral surfaces other than the lateral surface on which light is incident. Techniques include affixation of a reflection film having a white- or mirror-surface to the lateral surface or printing white ink on the lateral surface.

[0025] The light-guide plate pursuant to the present invention is applied to spot light sources such as light emitting diodes or miniature light bulbs. Of course, other spot light sources may be used as well. Siting the light source at a position inside the depression, as shown by (1) in Figure 1, would pose no problems. The circumferential surfaces of the light source and the depression may be flush, or a gap may be opened between them. For example, if there is no

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