(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 500 960 A1**

(12) **EUROPEAN PATENT APPLICATION published in accordance with Art. 158(3) EPC**

(21) Application number: **91915978.0**

(22) Date of filing: **12.09.91**

(86) International application number: **PCT/JP91/01211**

(87) International publication number: **WO 92/04648 (19.03.92 92/07)**

(51) Int. Cl.[5]: **G02B 6/00**, G02F 1/1335, G09F 9/00

(30) Priority: **12.09.90 JP 241538/90**

(43) Date of publication of application: **02.09.92 Bulletin 92/36**

(84) Designated Contracting States: **DE FR GB IT**

(71) Applicant: **MITSUBISHI RAYON CO., LTD.**
3-19, Kyobashi 2-chome Chuo-Ku
Tokyo 104(JP)

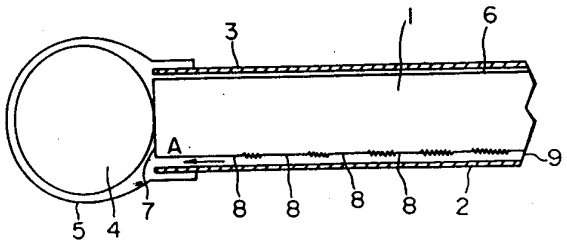
(72) Inventor: **OHE, Makoto, Tokyo Res. Lab.**
Mitsubishi Rayon Co., Ltd., 3816, Noborito
Tama-ku, Kawasaki-shi, Kanagawa 241(JP)
Inventor: **CHIBA, Issei, Tokyo Res. Lab.**
Mitsubishi Rayon Co., Ltd., 3816, Noborito
Tama-ku, Kawasaki-shi, Kanagawa 241(JP)

(74) Representative: **Clifford, Frederick Alan**
MARKS & CLERK 57/60 Lincoln's Inn Fields
London WC2A 3LS(GB)

(54) **ELEMENT OF PLANE SOURCE OF LIGHT.**

(57) An element of plane source of light used for an apparatus of plane source of light, and particularly the one suitably used as a background illuminating means such as a liquid crystal display element. The element of plane source of light of the invention is characterized by a directive light emitting function of either the light-emitting surface or the opposite surface of a transparent light conductor which permits the light to go out in a tilted direction relative to the direction in which the light travels, the light being incident from the light-incidence surface of the transparent light conductor, and a control function which uniformizes the brightness of light emitted from the light-emitting surface over the whole light-emitting surface. The invention provides a very thin element of plane source of light which helps maintain a uniform brightness on the whole light-emitting surface and which emits light of a high brightness.

FIG.4



EP 0 500 960 A1

TECHNICAL FIELD

The present invention relates to a surface light source element used for a surface light source device, in particular, to a surface light source element which can be used as a back light device for a liquid crystal display element.

TECHNICAL BACKGROUND

Conventionally, a structure which comprises a tubular lamp as a light source located at the focal point of a paraboloid of revolution type of reflector and an opalescent diffusing plate located above the lamp, is generally used. Such a device is improved by adjustment of the shape of the reflector or of the diffusion coefficient of the diffusing plate.

There exists a device having a combination of a tubular lamp and a light guide with a shape which is simulated by an approximation of a point-like source of light and is formed in the shape of the approximated curve so that lights in a direction are emitted, a device having a light guide the thickness of which varies along the advance direction of light, a device using a lenticular member having angles of prisms which vary according to the distance from a light source, and a device having a combination of these elements.

Recently, surface light source elements have been used as liquid crystal display elements. However, the display device, which uses a conventional surface light source element to obtain a high quality display, requires a thick surface light source element. In particular, a surface light source element for a large display of 10 to 12 inches requires a thickness of 20 to 30 mm. Therefore, it is impossible to function as a thin surface light source element.

Various edge-light types of surface light source devices have been proposed. Each of the devices has a transparent light guide comprising a plate-shape transparent material such as an acrylic resin. Light incident on an edge portion of the transparent light guide is then emitted from the upper or lower surface of the light guide. However, such a large liquid crystal display device with a size of 10 to 12 inches results in a display with darkness corresponding to the distance from the light source or an uneven display, so that a display of high quality cannot often be obtained.

In order to solve this problem, a light guide having a thickness which varies according to the distance from a lamp, or a member which varies light path geometrically, is provided. However, such a member requires a precise processing to form a specific shape, and high processing costs. Furthermore, the member provides a low utilization rate of light.

Recently, Japanese Patent Application Laid-open No. (Tokukai-Hei) 1-245220 discloses a surface light source element which is an edge-light type. The surface light source element has a light guide with a layer of a light diffusing material which is applied or adhered on the surface thereof opposed to a light emitting surface or on a light diffusing surface of a provided member. The density of the provided light diffusing material increases as the distance from the light incident portion increases. Japanese Patent Application Laid-open No. (Tokukai-Hei) 1-107406 discloses a surface illuminating device which can uniformly illuminate the whole surface of a light diffusing plate. The device has a plurality of piled transparent plates, each of which has a different pattern of fine dots (light diffusing material) thereon.

Since a non-light-transmissive inorganic material (e.g., white pigment such as titanium oxide or barium sulfate) is used, a loss of light occurs to lower the luminance of the emitted light.

Oe has reported a light diffusing device which comprises a light guide, a diffusing layer provided on the light guide through a layer having a middle characteristic between those of the light guide and the diffusing layer, and a light regulation member for obtaining a uniform emitting light on the diffusing layer, in Japanese Utility Model Application Laid-open No. (Jitsukai-Sho) 61-171001 and in United States Patent No. 4729068.

The inventors have proposed a surface light source element which is an edge-light type, as described in Japanese Patent Application Laid-open Nos. (Tokukai-Hei) 1-244490 and 1-252933. The element has a lens-like surface or a satin finished surface provided on at least one of a light emitting surface of a light guide and the opposed surface thereof, and a light regulation member having a light reflecting pattern which corresponds to the reciprocal of an emitting light distribution and a light diffusing plate provided on the emitting surface of the light guide.

The light diffusing device and the surface light source element using the light regulation member show excellent effects regarding the uniformity of the emitted light. The device and the element, however, cannot reuse the light which is reflected by the emitting light regulating member, so that the luminance of the emitted light lowers near the minimum value of the luminance before regulation.

The object of the present invention is to provide a very thin type of surface light source element which

can supply emitted light with a uniform and high luminance.

DISCLOSURE OF THE INVENTION

The surface light source element according to the present invention comprises a transparent light guide (1) which has a side end surface as a light incident surface, a surface perpendicular to the light incident surface as a light emitting surface, and a light reflecting layer provided on an opposed surface to the light emitting surface; and a diffusing member (2) for diffusing light from the light emitting surface of the transparent light guide; wherein at least one of the light emitting surface and the opposed surface of said transparent light guide has a directional light emitting function which radiates the incident light from the light incident surface of the transparent light guide in an oblique direction to the incident light and has a regulation function which makes the luminance of the light through the light emitting surface uniform over the whole surface thereof.

Generally, the amount of light from the light emitting surface which is incident on the light guide decreases as the distance from the light incident surface increases due to light emitting through the light emitting surface and light absorption inside the light guide. In the surface light source element according to the present invention, the ratio of the flat areas increases as the distance from the light incident surface decreases. Therefore, even if the transparent light guide is thin, it is possible to emit light with a uniform luminance over the entire emitting surface on the basis of the incident light. The incident light into the transparent light guide is not wasted and has a high utilization rate. Consequently, it is possible to produce emitted light having a high luminance without increasing the wattage of the light source. Therefore, the present invention provides a very thin type of surface light source element which can supply an emitting light with a uniform and high luminance.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1 (a) and (b) are sectional views showing a construction of a conventional surface light source element.

FIG. 2 is a view showing the change of luminance to the distance from the light incident surface of various kinds of surface light sources.

FIG. 3 is a partially fragmentary and perspective view showing a back light device incorporating a surface light source element according to an embodiment of the present invention.

FIG. 4 is a partially sectional view taken along line IV-IV of FIG. 3.

FIGS. 5 (a)-(e) are schematic views showing embodiments of plan patterns of flat areas.

FIGS. 6 (a)-(c) are schematic sectional views showing various kinds of lens units.

FIGS. 7 and 8 are partially sectional views showing modified embodiments of the surface light source element of the present invention.

FIG. 9 is a schematic side view showing a modified embodiment of a back light device.

FIG. 10 is a graph showing an area ratio distribution of flat areas in a pattern formed on a mold for manufacturing a light guide used for embodiments of the present invention.

FIGS. 11 (a) and (b) are plan views showing a manufactured light guide.

FIG. 12 is a graph showing a measurement result of a luminance distribution of the respective surface light source elements.

FIG. 13 is a schematic view showing a method for measuring directional emitting angles of a manufactured surface light source element.

FIGS. 14 (a) and (b) are graphs showing a measurement result of directional emitting angles of a manufactured surface light source element.

BEST MODE OF CARRYING OUT THE INVENTION

The surface light source element of the present invention will be described in detail.

First, the basic principle of a surface light source element according to the present invention will be explained. The refractive indexes n of a transition from light guide to air are approximately 1.4 to 1.6. In the system of edge-light of which the incident surface 7 is perpendicular to an emitting surface 6 as shown in FIG. 1 (a), light theoretically cannot radiate from the emitting surface 6 when the critical angle of incidence is about 45°. In FIG. 1(a), the numeral 4 indicates a light source such as a fluorescent lamp, the numeral 5 indicates the reflector therefor, and the numeral 2 indicates reflective surface formed at the opposed side of the emitting surface 6 of the light guide 1.

The emitting surface 6 is generally formed to be a surface 6a treated in light diffusion or the reflective surface 2 is formed to a diffusing reflective surface 9a.

The inventors have studied diffusing treatment for at least the surfaces of a light guide and the opposed surface thereof, in order to increase the amount of emitted light. Consequently, it has been found that a method using surface roughening on these surfaces as uniformly as possible and a method using a plurality of lens units for radiating light in a predetermined direction is effective rather than the method of using application of a light diffusing material on at least one of the surface of the light guide and the opposed surface thereof or the method of using formation of a light diffusing material layer on the surface when an acrylic plate is made by polymerization.

A surface light source element which comprises a light guide with a roughened surface, a fluorescent lamp with a surrounded silver-evaporated polyester film as a reflector provided on an end surface thereof, and a white film as a reflective member provided in contact with the roughened surface, was made to measure the luminance of the light emitted therefrom. Consequently, the luminance of the emitted light decreases as the distance from the fluorescent lamp increases. When the distance is 70 to 80 times the thickness of the light guide, the luminance is about 1/10 that at the distance zero. This is shown by the line 1 in FIG. 2. The inventors have proposed uniformization of luminance by a light transmissive sheet for regulating the emitting light in Japanese Patent Application Laid-open Nos. (Tokukai-Hei) 1-244490 and 1-252933, as described above.

According to the method, it is possible to make the luminance of the emitted light uniform. However, this method lowers the value of luminance of the overall emitted light to about 1/10 to 1.5/10 of that near the incident end portion. In this method, utilization of the incident light energy passing through the light guide was not performed efficiently. This is shown by the line 2 in FIG. 2. The reason for this is that the light transmissive sheet for regulating the emitting light can cut the emitting light but cannot reuse the cut light because of a regulating pattern reflecting the light.

Therefore, the inventors have developed a surface light source element so as to use the incident light as efficiently as possible, in view of the above situation. In the surface light source element, light emission is not performed by using the regulating pattern of the light transmissive sheet for regulating the emitted light, or by applying a light diffusing material on the opposed surface of the light emitting surface so that the density of the material is greater as the distance from the light incident portion is greater, as disclosed in Japanese Patent Application Laid-open No. (Tokukai-Hei) 1-245220. In the surface light source element, a transparent light guide which was reported in Japanese Patent Application Laid-open Nos. (Tokukai-Hei) 2-17, 2-84618 and 2-176629 and emits a large amount of light, and an interface for reflection having a small optical loss of light are used to regulate the amount of emitted light so as to make the luminance value on the light emitting surface uniform.

That is, in the surface light source element according to the present invention, roughened surfaces or a plurality of lens units, each of which has a directional light emitting function which radiates the incident light from the light incident surface of the transparent light guide at an oblique direction to the incident light, are provided on at least one of the light emitting surface and the opposed surface thereof; and flat areas are provided on the roughened surfaces or the plural lens units so that the ratio of the flat areas thereon increases as the distance from the light incident surface decreases, thereby the transparent light guide has a regulation function which makes the luminance of the light through the light emitting surface uniform over the whole surface thereof. Accordingly, it is possible to increase the value of luminance of overall emitted light to about 3/10 of that near the incident end portion and to obtain a surface light source element showing a uniform luminance value over the entirety of the light emitting surface. This is shown by the line 3 in FIG. 2.

EMBODIMENT

The surface light source element of the present invention will be described concretely via the embodiments.

Surface light source element

FIG. 3 shows an embodiment of a back light device incorporating a surface light source element according to the present invention. FIG. 4 shows a partially sectional view taken on line IV-IV of FIG. 3.

The device comprises a light guide 1 with a rectangular plate shape, a film-like light diffusing member 3 provided over the light emitting surface 6 thereof, a light source 4 such as a fluorescent lamp provided on the side end surface (a light incident surface 7) of the light guide 1, and a reflector 5 for holding the light

source 4 and reflecting light to the incident surface by the reflective surface provided on the inner surface thereof. The opposite side of the light emitting surface 6 of the light guide 1 has a light reflective layer 2.

The surface light source element according to the present invention is characterized in that roughened surfaces or a plurality of lens units, each of which has a directional light emitting function which radiates the incident light from the light incident surface of the transparent light guide in an oblique direction to the incident light, are provided on at least one of the light emitting surface and the opposed surface thereof; and flat areas are provided on the roughened surfaces or the plural lens units so that the ratio of the flat areas thereon increases as the distance from the light incident surface decreases, thereby said transparent light guide has a regulation function which makes the luminance of the light through the light emitting surface uniform over the entire surface thereof.

In this embodiment, flat areas 8 are provided on the roughened opposed surface 9 to the light emitting surface 6, so that the flat areas 8 are more numerous as the distance from the light incident surface 7 decreases, as shown by arrow A in FIG. 4.

The increasing ratio of the flat areas in the light guide can be selected, changed and determined appropriately according to the shape or pattern of the flat areas, the material or shape of the light guide, the kind of the light source, the treatment degree of the light emitting or reflecting surface or the like.

Pattern examples of the flat areas are shown in FIGS. 5 (a) to (e). In every example, the area ratio of the flat areas 8 becomes increases as a position is nearer the light incident surface 7, as shown by arrow A in FIG. 5.

The diffusing member 3 which can be used for the present invention may be any structure or material which can diffuse light from the light guide nondirectionally. The diffusing member 3 can be provided on the light guide 1 by the end portion of the light guide adhering to the diffusing member 3 by an adhesive, by compulsory close contact through pressure, or by merely positioning the diffusing member 3 on the light guide. Furthermore, it is possible to laminate the light guide 1 and the diffusing member 3 directly or through a layer of air.

The light guide 1 in the present invention can be obtained by a transparent resin such as an acrylic resin, a polycarbonate resin or a vinyl chloride resin. In particular, it is preferable to use an acrylic resin having a large transmission coefficient of visible light. The method of molding the light guide 1 can be selected or changed appropriately.

The light source 4 in the present invention is not limited. A fluorescent lamp or a filament lamp which is a continuous tubular light source, a plurality of point-like sources of light arranged along the incident surface, or a light source device comprising a combination of a light transmissive member which can receive light through a side surface and a light source provided near the end portion incident surface of the light transmissive member, can be used as a light source.

The reflecting layer 2 of the surface light source element according to the present invention can be formed by laminating a reflecting film or the like which comprises a film and an evaporated metal such as Ag, Al or the like. It is preferable to use a reflecting material having a high reflectivity.

In this invention, the light guide requires at least one of the light emitting surface 6 and the opposed surface being roughened, or a plurality of lens units being formed. Furthermore, it is necessary to provide flat areas on the roughened surface or on the surface on which a plurality of lens units are formed, so that the ratio of the flat areas thereon increases as the distance from the light incident surface decreases.

In a preferred embodiment of the present invention, the surface of the flat areas 8 in the light guide 1 is preferably an optically flat surface, in particular, to be a mirror surface. The incident light with an incident angle more than the critical reflective angle to the optical flat surface can be reflected almost without loss.

Since the light does not leak, it is possible to use the light effectively to increase the luminance of the entire light emitting surface.

The shape of the lens unit which is used in the present invention is not limited. For example, a lens unit with a shape proposed in Japanese Patent Application Laid-open No. (Tokukai-Hei) 2-17 by the inventors can be used. Lenses 20 having various shapes are shown in FIGS. 6(a) and (b).

The roughened surface which is used in the present invention preferably has a haze value of not less than 30%, and more preferably, not less than 50% in the roughened surface portion.

The surface light source element according to the present invention is not limited to the above embodiment. Various changes or modifications in form and details may be made therein. For example, in the above embodiment, flat areas 8 are provided on the roughened surface 9 opposed to the light emitting surface 6. However, flat areas 8 can be provided on the roughened light emitting surface 6, as shown in FIG. 7. It is possible to provide a structure so that the area ratio of the flat areas thereon increases as the distance from the light incident surface 7 decreases, as shown by arrow A in FIG. 7.

Furthermore, it is possible to provide the flat areas on both roughened surfaces of the light emitting

DOCKET ALARM

Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

Real-Time Litigation Alerts

Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

Advanced Docket Research

With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

Analytics At Your Fingertips

Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

LAW FIRMS
Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

FINANCIAL INSTITUTIONS
Litigation and bankruptcy checks for companies and debtors.

E-DISCOVERY AND LEGAL VENDORS
Sync your system to PACER to automate legal marketing.