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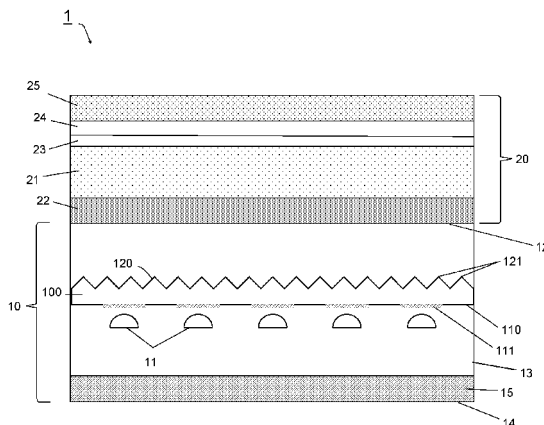
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(54) **Title:** OPTICAL SYSTEM FOR LIGHTING DEVICE, LIGHTING DEVICE AND METHOD OF CONTROLLING THE DEVICE

[bilingual text]



(57) **Abstract:** The invention relates to an optical System (100) for a lighting device having one or more sources (11) of visible and/or ultraviolet radiation which consist of light-emitting diodes, especially for backlighting a liquid-crystal display screen, comprising: a first substantially planar optical element (100) transparent to said radiation and intended to be installed between said sources and a substantially planar diffuser that makes the normal luminance uniform, the first optical element being approximately parallel to the diffuser and being capable of contributing to making the normal luminance output by the diffuser uniform. Said first optical element (100) is capable of sectorizing the normal luminance output by the diffuser, and/or the optical System includes a second substantially planar optical element transparent to said radiation, which is intended to be installed between the first element and the diffuser, being approximately parallel to said first optical element, the second optical element being capable of sectorizing the normal luminance output by the diffuser. The invention also relates to the lighting device and to a method of controlling this device.

[bilingual text]

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[text cut off] a first optical element (100) substantially planar and transparent to said radiation intended to be installed between said sources and a substantially planar diffuser which homogenizes the normal luminance, the first optical element being substantially parallel to the diffuser and being able to contribute to the homogenization of the normal luminance out of the diffuser. Said first optical element (100) is capable of sectorizing the normal luminance output by the diffuser, and/or the optical System includes a second substantially planar optical element that is transparent to said radiation, which is intended to be installed between the first element and the diffuser, being approximately parallel to said first optical element, the second optical element being capable of sectorizing the normal luminance output by the diffuser. The invention also relates to the lighting device and a method for controlling this device.

OPTICAL SYSTEM FOR LIGHTING DEVICE, LIGHTING DEVICE AND METHOD OF CONTROLLING THE DEVICE

The present invention relates to an optical system, and more particularly, to an optical system for a lighting device, such a lighting device and a method of controlling the device.

Rear lighting or backlighting devices ("backlight" or BLU for "Backlighting Unit") are widely used for liquid crystal screens, also called LCD screens ("Liquid Crystal Display") used for the display. On direct lighting screens, the light sources, placed inside the lighting device, illuminate in a direction substantially perpendicular to the LCD screen.

It appears that the light thus emitted is not sufficiently homogeneous, thus presenting excessive contrasts. Also, various optical elements are commonly placed between these light sources and the LCD screen.

The first optical element is usually a rigid diffuser intended to homogenize the normal luminance, and followed by a set of optical films responsible in particular for redirecting the light, distributing it as evenly as possible, and then selecting the appropriate polarization.

The light sources used in these backlighting devices are conventionally gas-discharge, most often tubes or fluorescent lamps. Some are cold cathode, commonly called CCFL for "Cold Cathode Fluorescent Lamp," others with hot cathode called HCFL for "Hot Cathode Fluorescent Lamp," or even with a dielectric barrier called DBDFL for "Dielectric Barrier Discharge Fluorescent Lamp."

The increase in the luminous efficiency (measured in lumen/watt) of light-emitting diodes (LEDs) now makes it possible to consider their use in lighting or backlighting devices.

The use of these light-emitting diodes makes it possible in particular to obtain improved color rendering compared to that obtained with the light sources commonly used.

However, known conventional light-emitting diode backlighting devices are bulky, in particular very thick, typically with a thickness of the order of 50 mm.

Document EP1594172 proposes a device for general lighting or backlighting with light-emitting diodes for LCD screens with an improved luminance profile and color uniformity. This lighting device comprises:

- rows of side-emitting light-emitting diodes, a system of reflectors for each diode consisting of a specular ring all around the diode and a reflector in the form of a circular disc above each diode, the light rays thus being sent towards the bottom before being redirected towards the diffuser,
- a first diffuser in the form of a plastic film located at a first distance from the diodes, for example 15 mm,
- a second diffuser, corresponding to the conventional rigid diffuser, located at a second distance from the diodes, the first distance being between 25% and 75% of the second distance, for example 35 mm.

This device is admittedly more compact and with improved luminance homogeneity, but its structure is complex, its electricity consumption relatively high, and its optical functionalities limited. For example, in a backlighting application of an LCD display system (monitor, television, etc.), the dynamic contrast, defined as the ratio of the luminances between two disjointed areas within a given image, is limited.

The object of the invention is therefore to propose a lighting device, in particular with light-emitting diodes, which, while being compact and capable of homogenizing the luminance, is also economical and/or with new optical functionalities, and/or of simpler design in order to remedy at least one of the aforementioned drawbacks.

To this end, the structure proposes a lighting device with sources of visible and/or ultraviolet radiation consisting of light-emitting diodes, in particular for backlighting a liquid crystal display screen, and comprising an optical system. The optical system comprises a first optical element substantially planar and transparent to said radiation intended to be installed between said sources and a substantially planar diffuser that homogenizes the normal luminance, the first optical element being substantially parallel to the diffuser and being able to contribute to homogenizing the normal luminance out of the diffuser.

The first optical element is capable of sectorizing the normal luminance at the output of the diffuser and/or the optical system comprises a second optical element that is capable of sectorizing the normal luminance at the output of the diffuser, said second element being substantially planar and transparent to said radiation and being intended to be installed between said first element and the diffuser, being substantially parallel to said first optical element.

The first optical element according to the invention makes it possible to reduce the distance between the sources and the rigid diffuser while maintaining a uniform normal luminance at the output of the diffuser.

In the device of the prior art, the applicant has found that it was not possible to adjust the luminance locally by adjusting the power emitted by each diode. Thus, the light emitted by each diode illuminates the entire surface. In other words, lowering (respectively increasing) the power of a diode darkens (respectively brightens) the entire surface relatively evenly.

However, the applicant has found that such a local adjustment of the luminance is necessary to better control the electrical consumption of the device and in the application of backlighting of an LCD display system (monitor, television, etc.), essential to improving the dynamic contrast.

The first optical element according to the invention, alone or in combination with the second optical element, has the double function:

- of reinforcing the homogenization of the luminance, so that, for each row of point sources (or each extended source occupying a row), the average of the normal luminance profile along a direction orthogonal to the sources is sufficiently wide, meaning that the curve of total luminance along a direction orthogonal to the sources is then sufficiently planar,

- to control the sectorization of the normal luminance, so that, for a given row of point sources (or a given extended source occupying a row), the average of the profile of the normal luminance along a direction orthogonal to the sources does not mix significantly with the average luminance profile of a neighboring row (or of a neighboring source).

Thanks to these combined functions, the local adjustment of the luminance is then obtained simply by switching a source, a row of sources, or even a group of sources on or off, or by modulating the power of source(s) on one or more specific areas. For example, one or more groups of sources are controlled in a defined order and/or over a defined duration, the sources being extended or preferably punctual for the finest adjustment possible. In the case of point sources, each group belongs to the same row or to several adjacent rows, independently of the other sources. Each point or extended source can also be controlled independently of the other sources.

This local adjustment of the luminance also makes it possible to limit the electrical consumption of the general lighting or backlighting device by lighting only the area or areas useful for the desired result.

For dynamic display applications (monitor, television, etc.), this local adjustment makes it possible in particular to reduce motion blur, thus providing a better perception of fast-moving scenes.

It is easy and simple to insert the optical system according to the invention with its dual function in a lighting device. Moreover, the luminance is admittedly sectorized, but the sources are not totally uncorrelated with each other in order to ensure the homogeneity of the normal luminance at the output of the diffuser.

Indeed, the optical system differs from a radical sectorization solution, which would consist of partitioning the sources by placing black or opaque walls, a solution that would not make it possible to obtain a satisfactory homogenization of the luminance, even by placing an additional diffuser just after the sources.

The (quasi) point sources are light-emitting diodes. The sources can emit in the visible and/or in the near ultraviolet; in the latter case, means are then added for converting the wavelength in the visible, such as a phosphor-type layer, for example placed on one of the faces of the diffuser.

As a light-emitting diode, one can choose:

- a diode having two main directions of emission oblique with respect to the emitting surface of the diode giving the shape of a batwing, the two directions being, for example, centered on angles between 20 and 40° and between -20 and -40° with half-angles at the top of the order of 10° to 20°,
- or, advantageously, a (quasi) Lambertian emission diode.

Furthermore, it is unnecessary to provide a light recirculation system by a system of reflectors of the type such as that of the prior art described above.

The first and the second elements forming the optical system according to the invention can also be supplied separately, be sold as a kit, be ready to be assembled.

The sectorization can preferably be evaluated by a simple method of calculating a so-called normalized minimum area parameter A defined by the following

relationship:
$$A = \frac{\frac{1}{2} \int |L(x) - R(x)| dx}{\int L(x) dx}, \text{ where}$$

$L(x)$ is the average along a row of lit point sources or a single lit extended source (occupying a row) of the normal luminance profile as a function of position x transverse to said row or said extended source, the normal luminance being measured at the output of the diffuser and for said row or said extended source,

$R(x)$ is a rectangular profile as a function of position x transverse to said row or to said extended source, of a width equal to the spacing P between said lit extended source and another adjacent extended source or between said lit row and an adjacent row of point sources, the height of $R(x)$ being such that $\int R(x) dx = \int L(x) dx$, the function $R(x)$ being centered on the lit extended source or on the row of lit point sources, the parameter A being less than or equal to 0.7, preferably less than or equal to 0.5, even more preferably less than or equal to 0.4.

The homogeneity of the normal luminance can preferably be evaluated by the simple measurement of the contrast in luminance C given by the relationship

$$C = \left| \frac{L1-L2}{L1+L2} \right|, \text{ where}$$

L1 corresponds to the average normal luminance measured at the output of the diffuser and using a first mask with rectangular openings positioned above the sources, each of the openings being centered on a distinct extended light source or on a distinct row of point light sources, and each of the openings being of a width equal to one third of the spacing P between the extended source and an adjacent extended source or between said row and an adjacent row of point sources,

L2 corresponds to the average normal luminance measured at the output of the diffuser and using a second mask with rectangular openings positioned between the sources, each of the openings thus being centered between two adjacent extended light sources or between two adjacent rows of point sources, each of the openings being of a width equal to one third of the spacing P, the luminance contrast C being less than or equal to 0.7, preferably less than or equal to 0.3 or 0.2, even more preferably less than or equal to 0.05.

Since the spacing P can be variable, the openings of the masks are then adapted accordingly for the measurement of the contrast in luminance C defined above.

Advantageously, for the sake of simplification and/or to facilitate assembly, it may be preferred that said first element have a length substantially equal to the length of the diffuser or of the extended source, and preferably a width substantially equal to that of the diffuser.

It is thus preferred for the first optical element, like the second one, to be in one piece rather than in several pieces, each piece being associated with an extended source or with a row of point sources.

The second element can preferably be close to said first element and possibly be in contact or glued. Preferably, the first optical element alone fulfills the functions of enhancing the luminance and controlling the sectorization.

In a preferred embodiment, one of the main faces of the first or of the second optical element is predominantly optically smooth, and the other of the main faces comprises a repetition of at least one pattern, in particular a geometric pattern and/or patterns distributed regularly or randomly, with a height greater than or equal to 500 nm and a width greater than or equal to 2 μm . The repeated pattern is used preferentially for the sectorization.

More particularly, the absolute value of the slope of said pattern can be, on average, greater than or equal to 10° , preferably 30° . Preferably, the distance between the optically smooth face and the base of the pattern is greater than or equal to 1 mm.

If two elements are used, the second element can preferably be made of a material with a refractive index substantially greater than or equal to the first element, in particular approximately 1.5, for the wavelength of the radiation emitted by the sources.

In this last embodiment, the pattern can be chosen from one or the following:

- an elongated pattern (two-dimensional, "2D"), the absolute value of the slope of which is, on average, greater than or equal to 10° , preferably 30° , in particular a prism, preferably with an apex angle substantially equal to 90° or lenticule (cylindrical section, etc.),
- a three-dimensional pattern ("3D") hollow or in relief, in particular of the pyramidal type, preferably with a base with a width in the order of a millimeter and an angle of the apex less than 140° , even more preferably less than 110° ,
- a Fresnel lens type pattern.

The repeated pattern can be over the entire associated main face or only in areas preferably offset with respect to the sources. In the area or areas, the elongated elements can be essentially contiguous. It is preferably arranged so that these elements have the ability to redirect radiation forwards having a relatively high angle with respect to the normal to the main face, for example, an angle greater than or equal to 60°, or 45°, or even 30°.

The repeated pattern can be attached to said main face, in particular in the form of a layer with the repeated pattern, preferably mineral and transparent layer, and in particular embossed with a mask replicating said pattern.

Alternatively or cumulatively, at least one texturized or roughened area of the main face of the first or the second optical element includes the repeated pattern.

This area can be etched with acid, sandblasted when the first or the second optical element is glass, or even be a printed area when the first or the second optical element is laminated glass or embossable plastic. This area can also be obtained by using any other mechanical and/or chemical surface treatment.

For homogenization, said first optical element may comprise at least one diffusing area capable of diffusing radiation with an incident angle less than or equal to 10°, or 20°, or even 30°, relative to the normal to the first element.

Preferably, said diffusing area is on one of the main faces of the first element.

Preferably, in order to avoid excessively annoying bright points that are particularly accentuated when the light sources are point-like, it is chosen to place the diffusing area or areas facing the sources.

According to a preferred design, the diffusing area or diffusing areas are:

- added to a main face of the first element, in particular in the form of an essentially mineral discontinuous diffusing layer,
- and/or the diffusing area or areas are texturized or rough areas of said face, in particular acid-etched or sandblasted areas when the first optical element is glass, or printed areas when the first optical element is a glass laminate or embossable plastic, or areas obtained by any other mechanical and/or chemical surface treatment.

The diffusing area or areas, preferably discontinuous, can be between 10 and 30 mm wide.

The diffusing areas can in particular be in the form of discs. They are then preferentially associated with pyramids as patterns.

The areas can even more preferably be strips parallel to one another. They are then preferentially associated with elongated patterns of the prism, lenticule, or Fresnel lens type.

The diffusing character of each diffusing area can be quantified by a conventional haze measurement, using a Hazemeter. Each diffusing area can produce, for example, a haze preferably greater than or equal to 40%, even more preferably 70%, or even 90%.

A diffusing area according to the invention can be formed, for example, by depositing a mineral diffusing layer, for example, by screen printing.

A diffusing layer composed of particles agglomerated in a binder, as described in the French patent application published under number FR 2 809 496, is preferably chosen.

In one embodiment of the invention, the diffusing layer comprises, dispersed in a binder, mineral diffusing particles in particular with an average diameter of between 0.3 and 2 microns, and which comprise, preferably and essentially, nitrides, carbides, or oxides, the oxides being preferably chosen from silica, alumina, zirconia, titanium, cerium, or a mixture of at least two of these oxides.

The binder can preferably be chosen from mineral binders, such as potassium silicates, sodium silicates, lithium silicates, aluminum phosphates, and glass frits.

When the desired thickness of the deposited layer is greater than 2 microns, a screen-printing type deposition process is used. When the thickness of the layer is less than 4 microns, the deposition is preferably carried out by flow-coating or spraying.

Furthermore, if the sources emit mainly in the visible, undesired ultraviolet radiation can be emitted by the sources, in particular in the wavelength range of 250 to 400 nm, [and] can reach plastic optical film(s), which, over time, eventually damages them.

Also preferably, the rigid diffuser and/or the diffusing layer of the optical system can ensure the cutting off of ultraviolet radiation, in particular over the range of wavelengths from 250 to 400 nm, while being sufficiently transparent to visible light.

In an advantageous configuration, the diffusing layer can comprise particles that absorb ultraviolet radiation in the range of 250 to 400 nm, said absorbing particles being constituted by oxides with properties of absorption of ultraviolet radiation.

According to one characteristic, the particles absorbing ultraviolet radiation are chosen from one or the mixture of the following oxides: titanium oxide, vanadium oxide, cerium oxide, zinc oxide, manganese oxide.

Advantageously, the absorbent particles have an average diameter of at most 2 μm .

The absorbent particles can represent 1 to 8%, or even 1 to 20%, of the weight of the binder, diffusing particles and absorbing particles mixture.

According to another characteristic, the optical structure has a

transmission ratio of radiation at 365 nm and 450 nm $\frac{T_{365}}{T_{450}}$ less than 60%, and/or a transmission ratio of radiation at 315 nm and 450 nm $\frac{T_{315}}{T_{450}}$ less than 30%.

According to one embodiment of the diffusing layer absorbing radiation from 250 to 400 nm, the layer comprises glass frit as a binder, alumina as diffusing particles, and titanium oxide as absorbent particles in proportions of 1 to 8% by weight of the mixture, the absorbent particles having an average diameter of at most 0.1 μm .

The first, like the second optical element, according to the invention, can preferably be rigid for a better hold, be a plastic (in polymethyl methacrylate or PMMA, polycarbonate or PC) or preferably be mineral, in particular glass, less sensitive to heat and UV radiation (yellowing, ageing) than plastic.

The optical element may have a light transmission T_L greater than or equal to 90% of the radiation from the source. The same is true for the second optical element.

One can preferably choose extra-clear glass, having a light transmission T_L at least equal to 91% with the illuminant D65, and preferably at least equal to 91.50%, for glass with an optical index of 1.52 ± 0.04 .

There are also extra-clear glasses that are already texturized, in particular laminated and printed, such as the ALBARINO-P glass marketed by the company SAINT-GOBAIN GLASS, one of whose faces is at least partially texturized, and has inverted pyramid patterns. This glass thus texturized can be used for sectorization and then preferably be coated with a discontinuous diffusing layer, for example, on the opposite face. The texturized part(s) can also form diffusing areas for homogenization.

It can also be sandblasted glass or glass that has undergone an acid cleaning, such as the SATINOVO glass marketed by the company SAINT-GOBAIN GLASS, the frosted face of which (preferably partially frosted, in particular in strips) is faceted with random patterns. This glass thus texturized can be used for sectorization and then preferably be coated with a discontinuous diffusing layer, for example, on the opposite face. The texturized part(s) can also form diffusing areas for homogenization.

The maximum thickness of the optical system according to the invention can be less than or equal to 6 mm, preferably between 1 and 4 mm.

The invention further proposes a lighting device comprising:

- the sources of visible and/or ultraviolet radiation, which are located at a given distance d_l from a so-called rear planar reflector, and substantially parallel to each other,
- a diffuser serving for the homogenization of the normal luminance,
- the optical system as defined above.

The reflector is generally referred to as white. It is preferably a diffuser that is substantially Lambertian in reflection.

The lighting device according to the invention may incorporate one and/or another of the following characteristics:

- the distance between the reflector and the diffuser is less than 35 mm, preferably less than or equal to 30 mm, and even more preferably less than or equal to 25 mm,
- the distance d_1 is less than or equal to 15 mm, preferably substantially equal to 10 mm, a distance d_2 between the sources and the optical system is less than or equal to 10 mm, preferably substantially equal to 5 mm, a distance d_3 between the system optics and the diffuser is less than or equal to 15 mm, preferably substantially equal to 10 mm,
- the point sources can, for example, be organized according to a rectangular, square, or hexagonal mesh network,
- the sources are light-emitting diodes, preferably in rows substantially parallel to said repeated pattern, possibly in a chosen network of the prism or lenticular type,
- the sources are light-emitting diodes, preferably with Lambertian emission and arranged facing the diffusing areas, in particular centered on the diffusing areas.

The diffusing character of the diffuser can be quantified by a conventional haze measurement, using a Hazemeter, for example, the Hazegard System XL-211 from the company BYK GARDNER.

The diffuser may present a haze greater than 90%, or even 95%. The diffuser can be in the form of a plastic plate, such as a polycarbonate or an acrylic polymer containing mineral fillers in the mass, the plate having, for example, a thickness of 2 mm.

The diffuser may preferably comprise a transparent support, in particular a glass, and a diffusing layer on one of the faces of said support, preferably of the same nature as the possible diffusing area or areas on the optical element.

To reinforce the homogeneity, the diffusing layer of the diffuser can advantageously have:

- an (average) thickness that varies according to the coverage area on the surface;

- and/or variable overlap density; for example, by carrying out a deposit by screen printing, the density of points also being able to vary from a completely covered area to an area of dispersed points, the transition being gradual or not.

Naturally, in an advantageous embodiment, the diffusing structure further comprises, after the diffuser, an element for redirecting the light towards the normal to the substrate, of the "BEF" type ("Brightness Enhancing Film").

One chooses, for example, the plastic film comprising a smooth lower face and an upper face with grooves having an apex angle of 90°. For example, this is the BEF-3M9050 film sold by the company 3M.

And, preferably, it also comprises a reflective polarizer placed on the "BEF" type element. These are, for example:

- a reflective polarizer of the birefringent multilayer type (based on polyethylene naphthalate or 'PEN'), for example, a film of the "DBEF" type ("Dual Brightness Enhancing Film") marketed by the company 3M),
- a reflective polarizer of the dispersed birefringent phase type,
- a reflective polarizer of the cholesteric liquid crystal type (for example, those marketed by the companies MERCK, 3M, NITTO DENKO, or WACKER),
- a reflective polarizer of the wire-grid type (for example, those marketed by the company MOXTEK).

There are multiple applications for the devices described above.

They are intended to be integrated into a wall, facade, or door of a building, are intended to equip a transport vehicle, or any other land, water, or air vehicle, and/or are intended for street furniture or interior furnishings, such as a bus shelter, display, jewelry display, showcase, shelving unit, furniture front.

Finally, the invention relates to a method for sequentially controlling the rows of diodes in the lighting device according to the invention serving for a liquid crystal display screen and/or method for sequentially controlling a group of diodes in the lighting device according to the invention serving for a liquid crystal display screen.

Other advantages and characteristics of the invention will appear in the remainder of the description with reference to the appended drawings in which:

- Figures 1a and 1b illustrate a lighting device in a first embodiment of the invention;
- Figures 2a, 2b, and 3 represent respectively two top views of the diodes and masks used for the measurement of L1 and L2 and graphs of the luminance contrast C as a function of the width d of the diffusing areas of an optical system according to the invention and for a comparative example without an optical system;
- Figures 4 and 5 respectively represent graphs illustrating the method for calculating the normalized minimum area parameter A and its evolution as a function of the width d of the diffusing areas and for a comparative example without an optical system;
- Figures 6 and 7 show variants of the optical system for a lighting device according to the invention.

For the sake of clarity, the relative dimensions of the elements are not respected.

Figure 1a illustrates a lighting device 1, in particular rear, intended for example to be used in an LCD screen. This device can also be suitable as a general lighting device (architectural, signage, decorative lighting, in a vehicle, a building, urban development, etc.).

The lighting device 1 comprises an enclosure 10 comprising:

- light sources 11 preferably (quasi) point, arranged in rows,
- an upper part 12 which is open and from which the light emitted by the sources 11 propagates,
- white reflective side walls 13 and a bottom 14 (lower or rear part) against which is arranged a white reflector 15 intended to reflect, on the one hand, the light which is directed towards the rear, and, on the other hand, the light which has not been transmitted forward, for example, the reflected light.

An optical structure 20 is attached to the open upper part 12 and held together by mechanical fastening means, not shown, such as clipping means cooperating with the enclosure 10 and the structure, or else kept in place by means of mutual engagement, not shown, such as a groove provided on the periphery of the surface of the structure cooperating with a peripheral rib of the enclosure.

The optical structure 20 comprises:

- a diffuser, for example, a surface diffuser, formed of a transparent support 21 preferably made of glass and a diffusing layer 22, preferably mineral, with a thickness between 3 and 20 μm , and arranged on the lower face (side of the enclosure) or top of the substrate 21, these two elements 21, 22 making it possible to homogenize the light,
- a diffusing film 23, formed of a plastic film, generally made of polyethylene terephthalate (PET), having on its external face an organic layer sufficiently rough to reinforce the diffusion of the rigid diffuser, this plastic film also being known to redirect the light towards the front, i.e. towards the normal to the diffuser,
- a "BEF" type element 24, for example a plastic film, which has a smooth lower face and an upper face with grooves having an angle at the top of 90° to redirect the light further forwards,
- and on the upper face of the "BEF" type element 24, a reflective polarizer 25 (called "DBEF"), for example, of the birefringent multilayer type, or as a variant of the dispersed birefringent phase type, of the cholesteric liquid crystal type, or even of the wire-grid type.

The quasi-point sources 11 are light-emitting diodes, for example with Lambertian emission, and arranged in several rows forming a rectangular mesh network emitting, for example, in red, green, or blue.

For a 50 cm by 60 cm device, 8 rows of diodes are used, each spaced 6 cm apart.

Furthermore, a first optical element 100 is placed between the sources 11 and the rigid diffuser 21 to both reinforce the homogeneity of the normal luminance L (while reducing the total thickness of the enclosure by bringing the diodes closer to the diffuser) and to sufficiently sectorize the normal luminance L from one row to another.

The distance d_1 between the reflector 15 and the sources 11 is less than or equal to 15 mm, in this example substantially equal to 10 mm.

The distance d_2 between the sources 11 and the optical system 100 is less than or equal to 10 mm, in this example substantially equal to 5 mm.

The distance d_3 between the optical system 100 and the diffuser 21 is less than or equal to 15 mm, in this example substantially equal to 10 mm.

The total height of the enclosure 10 is in this example approximately 28 mm.

The system 100 consists of a plastic or preferably a glass substrate, 3 mm thick. Its upper face 120 is texturized, for example by printing a laminated glass, to obtain the grooves 121 of the prism type with a triangular section, with an apex angle of preferably 90° , of height h_1 equal to 1 mm for example. The absolute value of the slope is on average greater than 10° . For its part, its lower face 110 has, preferably locally, diffusing areas 111, for example, in the form of layers 111 in strips parallel to each other, of given width d , and opposite the diodes 11. These areas 111 diffuse at least the radiation 30 having an incident angle of less than 30° as shown in figure 1b.

As a variant, the diffusing areas can be:

- microgrooves also made by printing laminated glass
- or even roughness, produced by acid etching or sandblasting, roughness defined by the parameter R_a between 0.5 and 5 μm with a Gaussian filter with a cut-off length equal to 0.8 mm and determined over a measurement length equal to 5 mm.

The diffusing layer 22, 111 can comprise a binder and diffusing particles, whose nature of the material and their volume make it possible to let the wavelengths of the visible domain pass while diffusing the light.

The diffusing particles are preferably mineral particles such as oxides, nitrides, or carbides. Among the oxides, the choice can be directed towards silica, alumina, zirconia, titanium, cerium, or the mixture of at least two of these oxides. They have an average diameter of between 0.3 and 2 μm .

The binder is chosen from mineral binders, such as potassium silicates, sodium silicates, lithium silicates and aluminum phosphates, glass frits.

The diffusing layer 22, 111 is deposited by any technique known to those skilled in the art, such as by screen printing, by coating with a paint, by dip-coating, by spin-coating, by spraying, or by flow-coating.

To assess the homogeneity of the normal luminance, the contrast in luminance C is measured.

Figures 2a and 2b describe a possible method for measuring the parameter C.

The contrast in luminance C is given by the relationship $C = \left| \frac{L1-L2}{L1+L2} \right|$.

L1 corresponds to the average normal luminance measured at the output of the diffuser using a first mask 16 with rectangular openings positioned just above the diodes 11. Each of the openings is centered on a separate row of diodes 11. Each of the openings has a width equal to P/3, i.e. 2 cm.

L2 corresponds to the average normal luminance measured at the output of the diffuser using a second mask 16' with rectangular openings positioned between the rows of diodes. Each of the openings is centered between two rows of diodes 11. Each of the openings has a width equal to P/3, i.e. 2 cm.

Figure 3 shows a first curve 50 giving the evolution of the contrast in luminance C as a function of the width d of the diffusing areas for the optical element 100 and a second comparative curve 50' giving the contrast in luminance without the optical element.

The luminance contrast C is less than or equal to 0.7, even in the absence of diffusing areas against 0.95 without an optical element. C is less than or equal to 0.1 for widths d chosen between 15 mm and 45 mm. C is less than 0.05 (about 0.02) around 20 mm, which is the preferred value for the width d.

With an apex angle of 60° and/or a thickness between the lower face and the base of 4 mm and/or a pattern height of 2 mm and/or a hexagonal lattice device, the results are essentially the same, C being of the order of 0.02 for a width d around 20 mm.

By replacing the diffusing bands with disks of the same width, a luminance contrast C of the order of 0.2 is obtained.

The sectorization is evaluated by a so-called normalized minimum area parameter A defined by the following relationship:

$$A = \frac{\frac{1}{2} \int |L(x) - R(x)| dx}{\int L(x) dx}$$

where L(x) corresponds to the average, along a single row of lit diodes, of the profile of the normal luminance as a function of the position x transverse to the lit diodes, the normal luminance being measured at the output of the diffuser, where R(x) is a rectangular profile based on the x position transverse to the diodes whose width is equal to the spacing P between said lit row and an adjacent row of diodes, its height being such that $\int R(x) dx = \int L(x) dx$ and the R(x) function being centered on the lit row of diodes.

L(x) and R(x) are shown in figure 4.

Figure 5 shows a first curve 60 giving the evolution of the so-called normalized minimum area parameter A as a function of the width d of the diffusing areas for the optical element 100 and a second comparative curve 60' giving the parameter A without the optical element.

The so-called normalized minimum area parameter A is less than or equal to 0.6, even in the absence of diffusing areas against 0.95 without the optical element. A is less than or equal to 0.4 from 8 mm in width, the curve being relatively planar from this value. Width values between 10 and 30 mm, preferably around 20 mm, are preferred. As a result, the dynamic contrast will be significantly improved.

Figures 6 and 7 show two variants of optical system 200, 300 for lighting device according to the invention.

In a first variant 200, there are on the upper face 120 (and/or as a variant on the lower face 110), diffusing areas 122 between the grooves 121. The diffusing areas 122 can be, for example, microgrooves also made by printing a laminated glass or roughness of the order of a micron made by acid etching or by sandblasting.

This configuration is particularly suitable for emission diodes (LEDs) of the batwing type 11' having main lateral emission directions. The majority of the radiation from the diodes 40' is rectified towards normal. A reduced part of the radiation from the diodes 30' is diffused.

In a second variant 300, there are placed on the lower face 110 between the diffusing areas 111' textures of the Fresnel lens type, typically of a height and width between 10 μm and a few mm.

The diffusing areas can be, for example, strips of diffusing layers or even microgrooves 122 also made by printing a laminated glass or even roughness of the order of a micron made by acid etching or by sandblasting.

Other variants not shown are possible:

- the grooves 121 are replaced by hollow and/or raised three-dimensional elements, in particular of the pyramidal type,
- the sources can be fluorescent tubes,

The optical element 100, 200, 300 and/or the optical structure 20, in particular the rigid diffuser 21, can comprise additional functions presented below.

The diffusing layer 22 can preferably also comprise oxide particles with ultraviolet radiation absorption properties, in particular over the range of 250 to 400 nm, such as titanium, vanadium, cerium, zinc, manganese oxide, or a mixture of these oxides. These absorbent particles have a diameter of at most 2 μm .

The absorbent particles can also constitute all or part of the diffusing particles when the latter are oxides; thus, they play the role of both absorbing particles and diffusing particles.

The proportions of the binder, as well as of the diffusing and absorbing particles, are adapted according to the light transmission and the diffusing power desired and the performance to be achieved for breaking in the ultraviolet.

The index of the diffusing particles and of the absorbing particles is advantageously greater than 1.7 and that of the binder is preferably less than 1.6.

The diffusing and absorbing layer 22 in the ultraviolet is deposited by any technique known to those skilled in the art, such as by screen printing, by coating with a paint, by dip-coating, by spin-coating", by spraying, or even by flow-coating.

Three examples are given below of a layer that diffuses and absorbs in the ultraviolet, which, once deposited on the glass substrate, has a thickness of 4 μm , the glass substrate having an average thickness of 2 mm.

Each example is formed from a mixture of binder (product VN821BJ marketed by the company FERRO), diffusing particles (alumina type CRI marketed by BAIKOWSKI), and absorbent particles (particles of TiO_2 of 30 nm of diameter marketed by ROSSOW).

Table 1 below provides for each of the examples (referenced Ex_a , Ex_b , Ex_c) the percentages by weight of the components of the mixture forming the deposited layer.

Table 1

	Ex_a	Ex_b	Ex_c
Binder	49%	48%	46%
Diffusing particles	50%	50%	50%
Absorbent particles	1%	2%	4%

The glass substrate 21 is thus used as a support substrate for the diffusing layer 22 in order to produce the optical structure 20 absorbing in the ultraviolet, which is associated with the enclosure 10 to form the backlighting device 1.

Measurements have been made on the absorption of ultraviolet radiation over the range of 200 to 400 nm of the diffusing structure 20 when the latter is traversed by the illumination supplied by the device 1.

In particular over the range of 315 to 400 nm, the increase in the absorption performance of the layer 111 was observed as a function of the increase in the absorbent particles for the examples Ex_a to Ex_c , while comparing this absorption for a diffusing structure without absorbing particles.

The comparative example marked as Ex_{ref} is formed by 50% of the binder and 50% of alumina diffusing particles of the examples above; it does not at all perform the function of absorbing radiation over this range of wavelengths.

Table 2 below summarizes these measurements by giving the average transmission of the radiation over the range from 315 to 400 nm, the measurements having been made with a detector placed perpendicular to the surface of the structure, in particular with a photo-radiometer of the "Delta OHM-HD 9021/UVA" type.

Table 2

$E_{x_{ref}}$	100%
E_{x_a}	63%
E_{x_b}	46%
E_{x_c}	33%

Like layer 22, diffusing layer 11 can absorb UV.

CLAIMS

1. Lighting device with sources of visible and/or ultraviolet radiation (11, 11') consisting of light-emitting diodes, in particular for backlighting a liquid crystal display screen, and with an optical system (100, 200, 300) comprising a first optical element (100 to 300) substantially planar and transparent to said radiation, intended to be installed between said sources and a diffuser (21, 22) that is substantially planar, which homogenizes the normal luminance, the first optical element being substantially parallel to the diffuser and being capable of contributing to homogenizing the normal luminance at the output of the diffuser, characterized in that said first optical element is capable of sectorizing the normal luminance at the output of the diffuser, and/or the optical system comprises a second optical element substantially planar and transparent to said radiation, intended to be installed between said first element and the diffuser while being substantially parallel to said first optical element, the second optical element being capable of sectorizing the normal luminance at the output of the diffuser.
2. Lighting device according to Claim 1, characterized in that the homogeneity of the normal luminance at the output of the diffuser is evaluated by defining a luminance contrast C given by the following relationship

$$C = \left| \frac{L1 - L2}{L1 + L2} \right|,$$

where L1 corresponds to the average normal luminance measured at the output of the diffuser and using a first mask (16) with rectangular openings positioned above the sources, each of the openings being centered on a distinct extended light source or on a distinct row of point light sources, and each of the openings being of a width equal to one third of the spacing P between the extended source and an adjacent extended source or between said row and an adjacent row of point sources,

where L2 corresponds to the average normal luminance measured at the output of the diffuser and using a second mask (16') with rectangular openings positioned between the sources, each of the openings being centered between two adjacent extended light sources or between two adjacent rows of point sources and each of the openings being of a width equal to one third of the spacing P, the luminance contrast C being less than or equal to 0.7, preferably less than or equal to 0.3.

and in that the sectorization is evaluated with a so-called normalized minimum

area parameter A defined by the following relationship:
$$A = \frac{\frac{1}{2} \int |L(x) - R(x)| dx}{\int L(x) dx},$$

where L(x) is the average along a row of lit point sources or a single lit extended source of the normal luminance profile as a function of position x transverse to said row or said extended source, the normal luminance being measured at the output of the diffuser and for said row or said extended source,

where R(x) is a rectangular profile as a function of position x transverse to said row or to said extended source, of a width equal to the spacing P between said lit extended source and another adjacent extended source or between said lit row and an adjacent row of point sources, the height of R(x) being such that $\int R(x) dx = \int L(x) dx$, the function R(x) being centered on said lit extended source or on said row of lit point sources, the parameter A being less than or equal to 0.7, preferably less than or equal to 0.5.

3. Lighting device according to any one of Claims 1 or 2, characterized in that said first optical element and/or the second optical element has a length substantially equal to the length of the diffuser or of the extended source, and preferably a width substantially equal to that of the diffuser.
4. Lighting device according to any one of Claims 1 or 2, characterized in that one of the main faces (110, 120) of the first or of the second optical element is mainly optically smooth, and the other of the main faces (120, 110) comprises a repetition of at least one pattern (121, 121'), in particular a geometric pattern and/or patterns distributed regularly or randomly, with a height greater than or equal to 500 nm and a width greater than or equal to 2 μm .

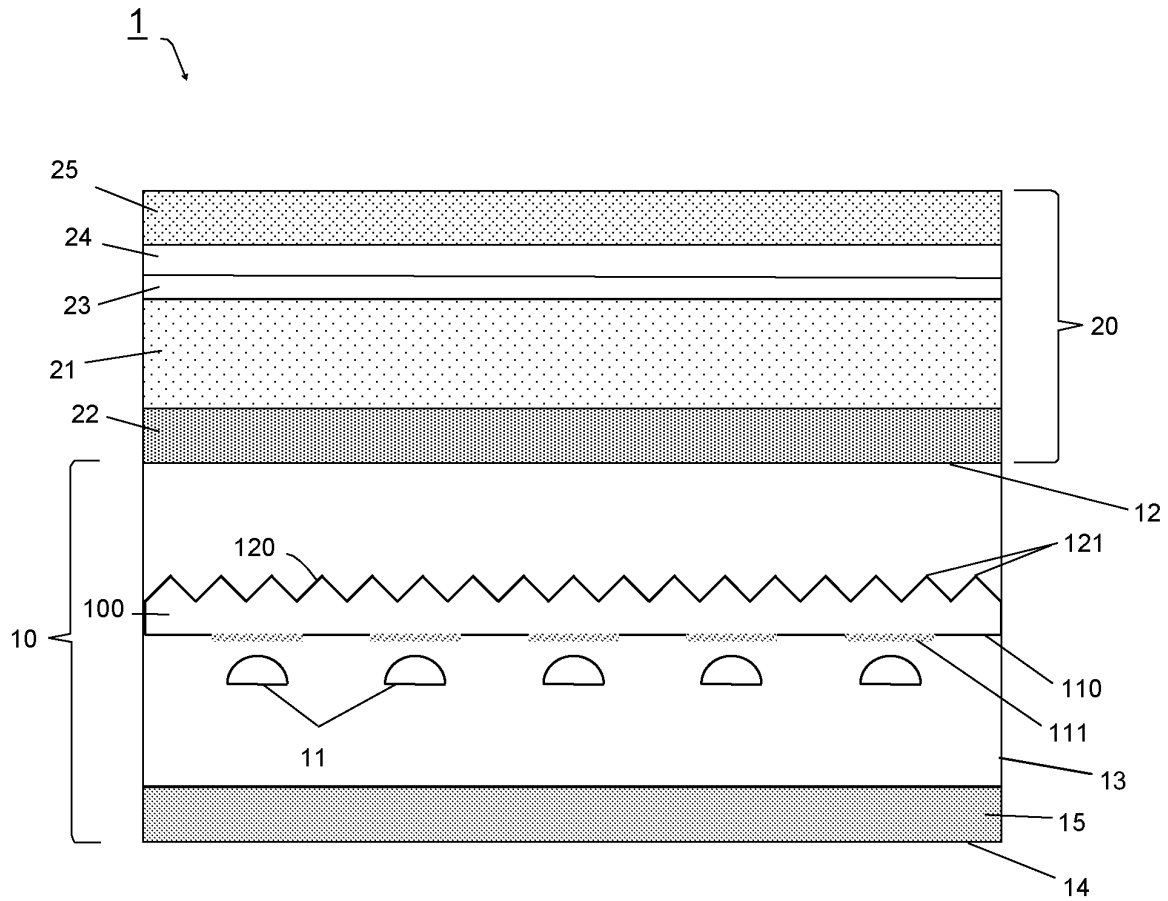
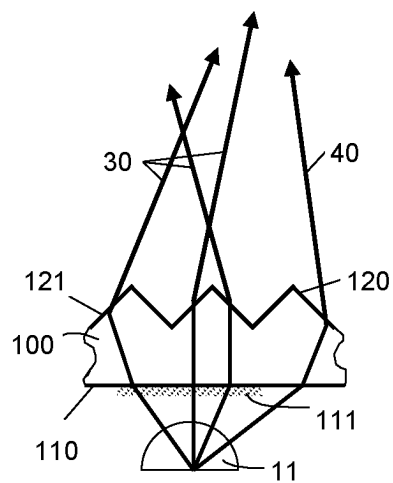
5. Lighting device according to Claim 4, characterized in that the pattern is chosen from at least one of the following patterns:
 - an elongated pattern whose absolute value of the slope is on average greater than or equal to 10° , in particular a prism or lenticule,
 - a three-dimensional pattern, hollow or in relief, in particular of the pyramidal type,
 - a Fresnel lens type pattern.
6. Lighting device according to one of Claims 4 or 5, characterized in that the repeated pattern (121, 121') is applied to said main face, in particular in the form of a layer with said repeated pattern, and/or characterized in that at least one texturized or rough area of the main face of the first or second optical element includes said repeated pattern, said area being in particular acid-etched or sandblasted when the first or second optical element is glass or being a printed area when the first or the second optical element is laminated glass or embossable plastic.
7. Lighting device according to one of Claims 4 to 6, characterized in that the first element (111, 122, 111') comprises a diffusing area or areas arranged on the main face between said patterns and/or on the opposite main face.
8. Lighting device according to Claim 7, characterized in that the diffusing area or areas (111, 122, 111') are attached to a main face of the first element, in particular in the form of an essentially mineral discontinuous diffusing layer, and/or the diffusing area or areas are texturized or rough areas of said main face, in particular acid-etched or sand-blasted areas when the first optical element is glass, or printed areas when the first optical element is laminated glass or embossable plastic.
9. Lighting device according to one of Claims 7 or 8, characterized in that the diffusing area or areas (111, 122, 111'), preferably discontinuous and in the form of strips, have a width of between 10 and 30 mm.
10. Lighting device according to one of Claims 7 to 9, characterized in that the diffusing area or areas (111) are diffusing layers that comprise:

- a binder, which is preferably chosen from mineral binders, such as potassium silicates, sodium silicates, lithium silicates, aluminum phosphates, and glass frits,
 - mineral diffusing particles dispersed in the binder, which preferably comprise nitrides, carbides, or oxides, the oxides being preferably chosen from silica, alumina, zirconia, titanium, cerium, or being a mixture of at least two of these oxides, the diffusing particles having an average diameter of between 0.3 and 2 μm .
11. Lighting device according to one of Claims 7 to 10, characterized in that the diffusing area or areas comprises particles absorbing ultraviolet radiation in the range from 250 to 400 nm, said absorbing particles being constituted by oxides with properties of absorption of ultraviolet radiation chosen from one or a mixture of the following oxides: titanium oxide, vanadium oxide, cerium oxide, zinc oxide, manganese oxide; in particular, it comprises glass frit as a binder, alumina as diffusing particles, and titanium oxide as absorbent particles in proportions of 1 to 8% by weight of the mixture, the absorbent particles having an average diameter of at most 0.1 μm .
12. Lighting device according to one of the preceding claims, characterized in that the first optical element and/or the second optical element are essentially made of mineral material, in particular glass, in particular an extra-clear glass for the visible, a printed laminated glass, acid etched glass, sandblasted glass.
13. Lighting device according to one of the preceding claims, characterized in that the thickness of the first optical element is less than or equal to 6 mm, preferably between 1.5 and 4 mm.
14. Lighting device (1) according to one of the preceding claims comprising:
- the sources of visible and/or ultraviolet radiation (11, 11'), which are located at a given distance d_1 from a so-called rear planar reflector (15), and substantially parallel to each other,
 - the diffuser (21, 22) serving for homogenization of the normal luminance,

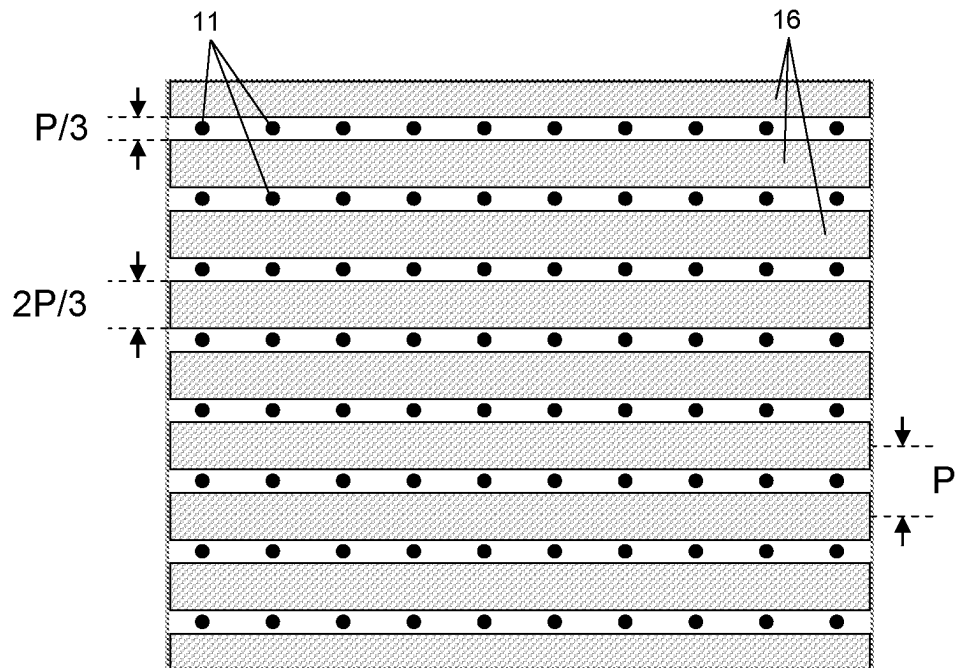
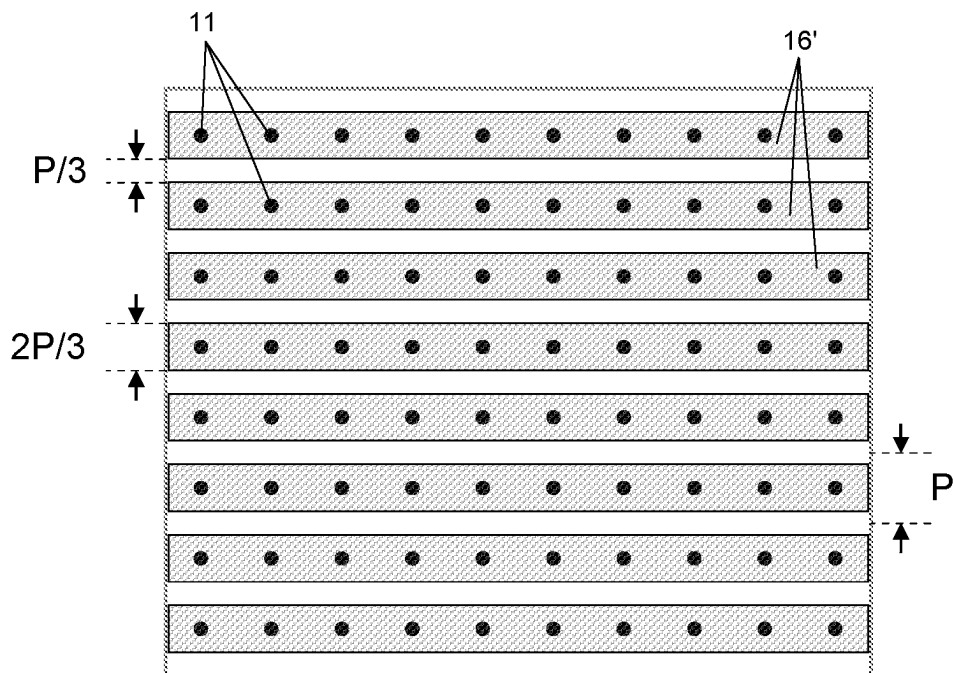
- said optical system (100 to 300).
15. Lighting device (1) according to Claim 14, characterized in that the distance between the reflector (15) and the diffuser (21) is less than 35 mm, preferably less than or equal to 30 mm.
 16. Lighting device (1) according to any one of Claims 14 to 15, characterized in that the distance d1 is less than or equal to 15 mm, preferably substantially equal to 10 mm, and/or in that a distance d2 between the sources (11, 11') and the optical system (100 to 300) is less than or equal to 10 mm, preferably substantially equal to 5 mm, and/or in that a distance d3 between the optical system and the diffuser (21) is less than or equal to 15 mm, preferably substantially equal to 10 mm.
 17. Lighting device (1) according to any one of the preceding claims, characterized in that the sources are light-emitting diodes, preferably with Lambertian emission (11, 11') and arranged facing the diffusing areas, in particular centered on the diffusing areas.
 18. Lighting device (1) according to any one of the preceding claims, characterized in that the diffuser comprises a transparent support (21), in particular glass and a diffusing layer (22) on one of the faces of said support, preferably of the same nature as the possible diffusing area or areas on the first optical element.
 19. Lighting device (1) according to any one of the preceding claims, characterized in that it forms a device for backlighting, in particular a liquid crystal display screen, such as a television or a monitor, and comprises above the diffuser possibly a diffusing film (23), an element for redirecting the light towards the normal to the substrate (24), and a reflective polarizer (25).
 20. Device according to any one of the preceding claims, characterized in that it is intended to be integrated into a wall, façade, or door of a building, intended to equip a transport vehicle, or any other land, water, or air vehicle, and/or intended for street furniture or interior furnishings, such as a bus shelter, display, jewelry display, showcase, shelving unit, furniture front.

21. Method for sequentially controlling the rows of diodes and/or a group of diodes in the lighting device according to one of the preceding claims serving for a liquid crystal display screen.

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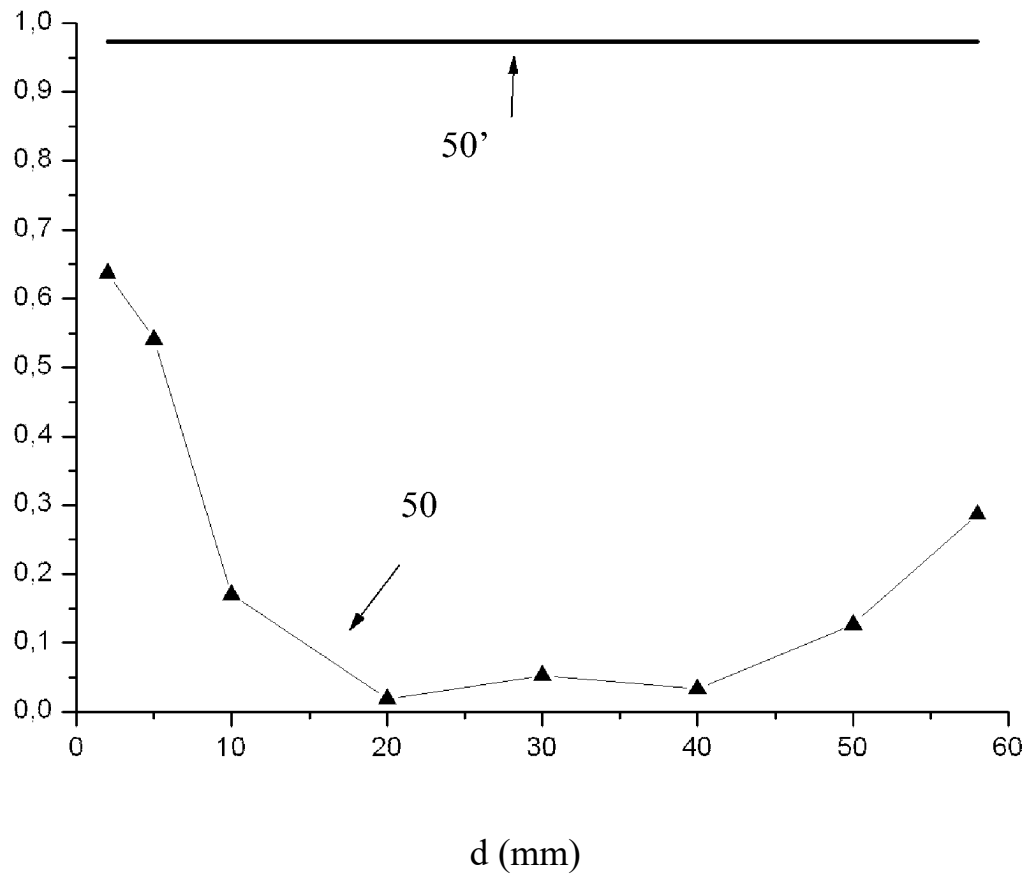
**Figure 1a****Figure 1b**

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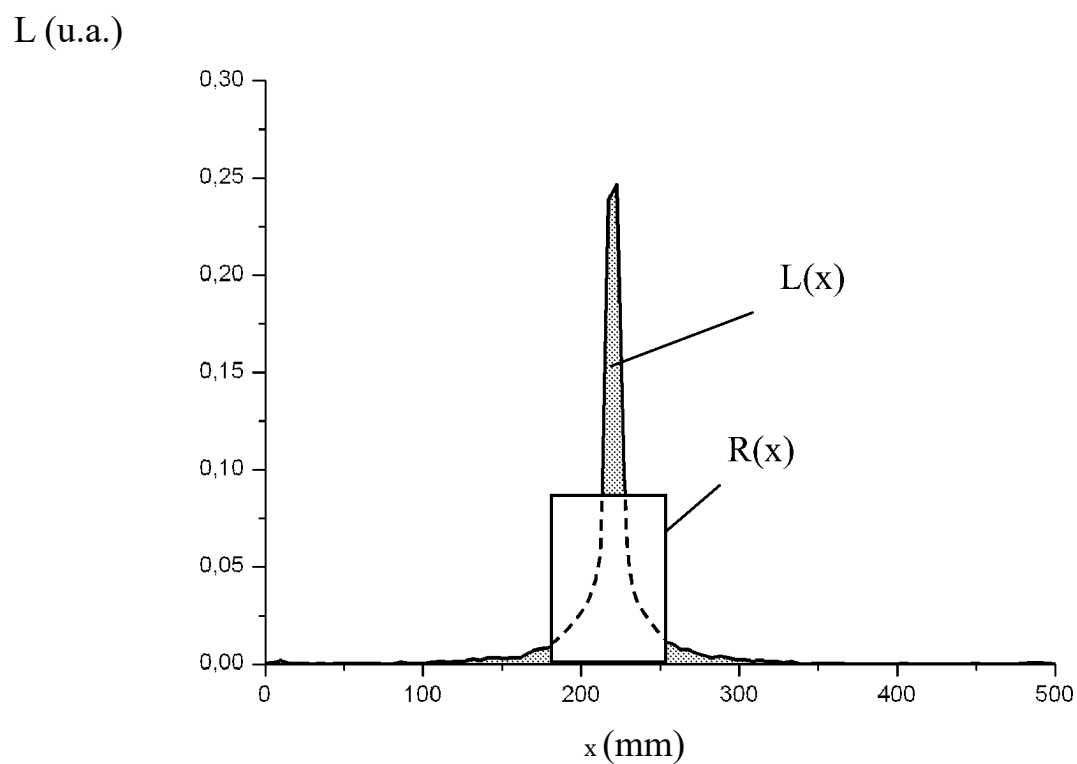
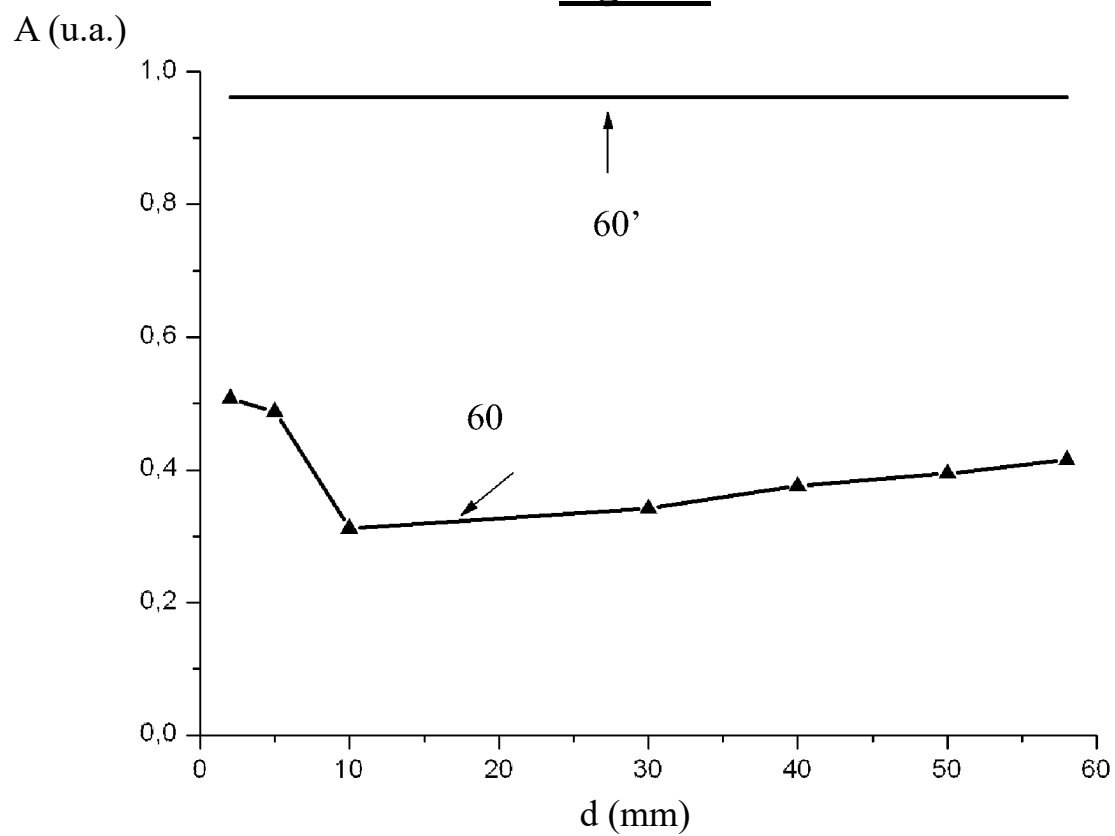
**Figure 2a****Figure 2b**

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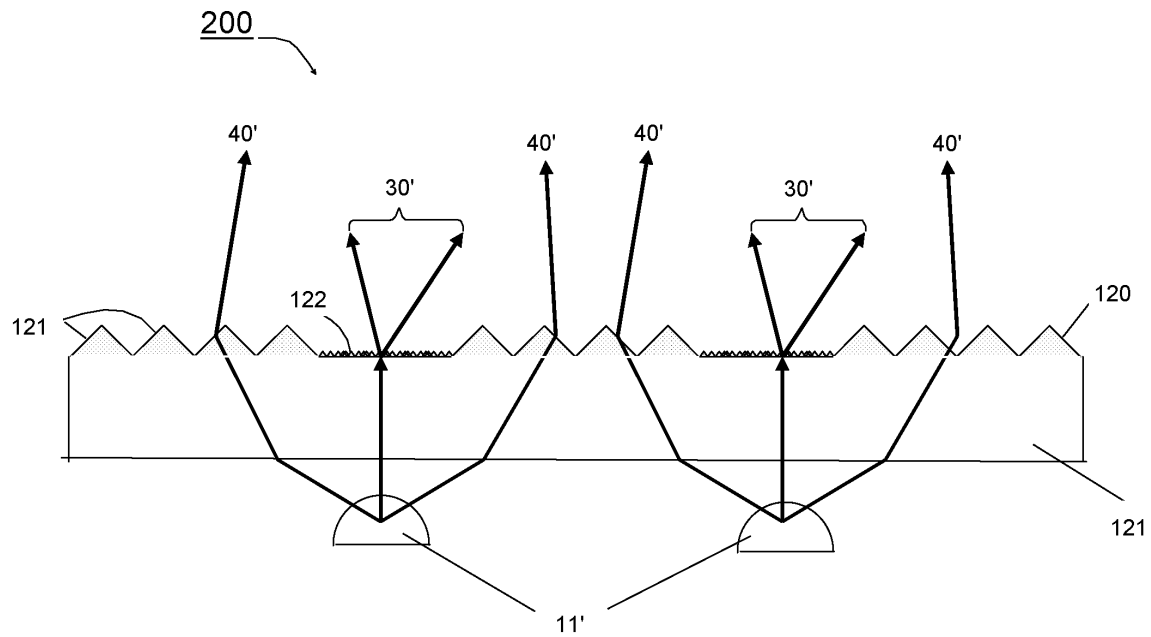
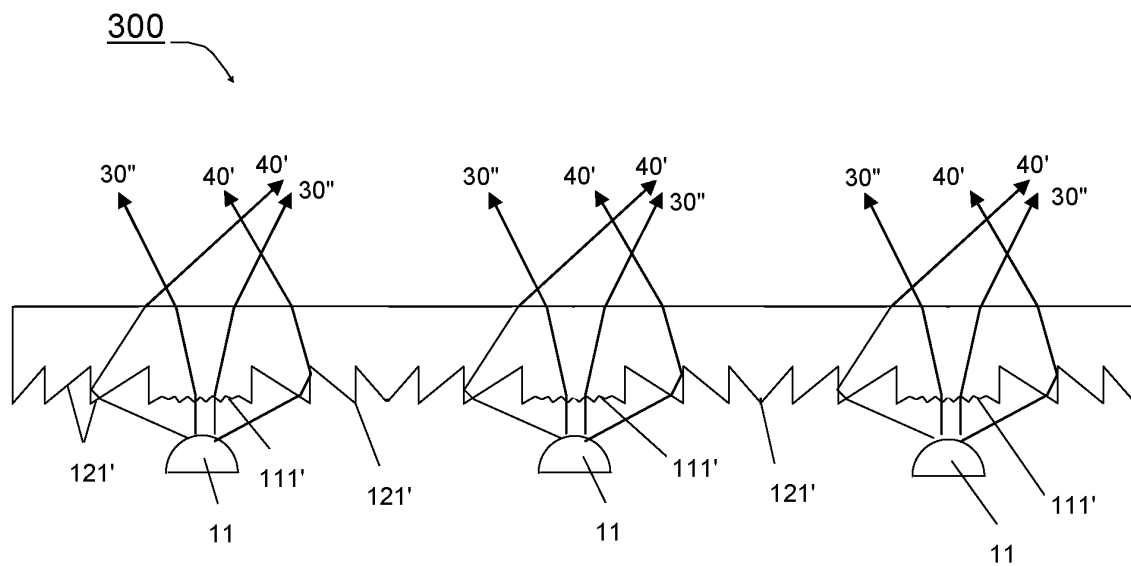
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**Figure 3**

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**Figure 4****Figure 5**

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**Figure 6****Figure 7**

INTERNATIONAL SEARCH REPORT

International application No
PCT/FR2007/051720

A. CLASSIFICATION OF SUBJECT MATTER , INV. G02F1/13357 G02B6/00

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

B. FIELDS SEARCHED

Minimum documentation searched (classification System followed by classification symbols)
G02F G02B

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

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

EPO-Internal, WPI Data

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Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2005 327600 A (TOPPAN PRINTING CO LTD) 24 November 2005 (2005-11-24) abstract figures 2,3 claims 4-6,10	1-7, 12-21
Y	paragraphs [0010], [0020], [0039] -[0050] -----	8-11
X	US 2005/128745 AI (PAO YU-NAN [TW] ET AL) 16 June 2005 (2005-06-16) paragraphs [0029] - [0031] figures 1A,1B,2,3A	1-3, 14-21
Y	-----	8,9
Y	FR 2 881 844 A (SAINT GOBAIN GLASS FRANCE SA [FR]) 11 August 2006 (2006-08-11) the whole document ----- -/-	10,11

X	Further documents are listed in the continuation of Box C.	X	See patent family annex.
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Date of the actual completion of the international search		Date of mailing of the international search report	
November 26, 2007		12/06/2007	
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INTERNATIONAL SEARCH REPORT

International application No
PCT/FR2007/051720

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	US 2005/180169 AI (SAITOH GOROH [JP] ET AL) August 18, 2005 (08-18-2005) figures 25,26,31-33 paragraph [0170] - paragraph [0187] -----	1-21

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Information on patent family members

International application No
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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RAPPORT DE RECHERCHE INTERNATIONALE

Demande internationale n°
PCT/FR2007/051720

A. CLASSEMENT DE L'OBJET DE LA DEMANDE

INV. G02F1/13357 G02B6/00

Selon la classification internationale des brevets (CIB) ou à la fois selon la classification nationale et la CIB

B. DOMAINES SUR LESQUELS LA RECHERCHE A PORTE

Documentation minimale consultée (système de classification suivi des symboles de classement)

G02F G02B

Documentation consultée autre que la documentation minimale dans la mesure où ces documents relèvent des domaines sur lesquels a porté la recherche

Base de données électronique consultée au cours de la recherche internationale (nom de la base de données, et si cela est réalisable, termes de recherche utilisés)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERES COMME PERTINENTS

Catégorie*	Identification des documents cités, avec, le cas échéant, l'indication des passages pertinents	no. des revendications visées
X	JP 2005 327600 A (TOPPAN PRINTING CO LTD) 24 novembre 2005 (2005-11-24) abrégé figures 2,3 revendications 4-6,10	1-7, 12-21
Y	alinéas [0010], [0020], [0039] – [0050] -----	8-11
X	US 2005/128745 AI (PAO YU-NAN [TW] ET AL) 16 juin 2005 (2005-06-16) alinéas [0029] - [0031] figures 1A,1B,2,3A	1-3, 14-21
Y	FR 2 881 844 A (SAINT GOBAIN GLASS FRANCE SA [FR]) 11 août 2006 (2006-08-11) le document en entier ----- -/--	8,9 10,11

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Date à laquelle la recherche internationale a été effectivement achevée		Date d'expédition du présent rapport de recherche internationale	
26 novembre 2007		06/12/2007	
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Demande internationale n°
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C(suite). DOCUMENTS CONSIDERES COMME PERTINENTS

Catégorie *	Identification des documents cités, avec, le cas échéant, l'Indication des passages pertinents	no. des revendications visées
A	JP 08 320489 A (TOSHIBA LIGHTING & TECHNOLOGY) 3 décembre 1996 (1996-12-03) le document en entier -----	1-21
A	US 2005/180169 AI (SAITOH GOROH [JP] ET AL) 18 août 2005 (2005-08-18) figures 25,26,31-33 alinéa [0170] - alinéa [0187] -----	1-21

Formulaire PCT/ISA/210 (suite de la deuxième feuille) (avril 2005)

RAPPORT DE RECHERCHE INTERNATIONALE

Renseignements relatifs aux membres de familles de brevets

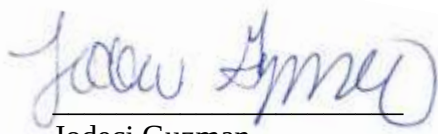
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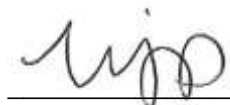
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City of New York, State of New York, County of New York

I, Jodeci Guzman, hereby certify that the document “**WO2008025909A1**” is, to the best of my knowledge and belief, a true and accurate translation from French into English.


Jodeci Guzman

Sworn to before me this
May 5, 2023


Signature, Notary Public

Stamp, Notary Public