

BACKLIGHTING DEVICE FOR AN INFORMATION DISPLAY ELEMENT
OF A PORTABLE OBJECT

The present invention relates to a backlighting device for an information display element of a portable object such as a wristwatch. The backlighting device comprises a light guide plate having a front face and a rear face, a light reflector located on the rear face of the light guide plate and a source of visible light. This source of visible
5 light feeds light beams at the edge or boundary of the light guide plate. These light beams spread in the light guide plate between its two faces to be directed for illumination of the display screen located above the front face of the light guide plate. The device comprises further a layer located from the side of the front face of the light guide plate intended to face a rear face of the display element of the portable object.
10 Said layer has at least one zone with partial opacity decreasing from a limit located close to the boundary area of the light guide plate, which receives the light beams of the light source. This allows the intensity of the light crossing said zone to be attenuated.

In the case of an object such as a wristwatch, the display element is
15 understood to be a watch face, on which the hands indicate the time, a liquid crystal-type display screen, where time, text or image information can be displayed, or a combination of watch face and screen.

Devices for illumination from the back, which are referred to as backlighting devices, for display screens in particular of the liquid crystal type have already been
20 described in the prior art. Such devices are encountered in particular in objects such as cordless mobile phones, portable computers or other types of portable objects in current use.

In these objects of relatively large dimension, it is generally simple to illuminate a display element uniformly from the back over its entire visible surface. To do this,
25 illumination from the back is achieved by one or a plurality of light sources disposed to face layers of a light guide plate. These light sources feed light beams into the light guide plate so that the light is directed towards the display element. With several light sources spaced at a relatively substantial distance in relation to the visible portion of the display element, the display element can be illuminated relatively uniformly.

30 In the case of a wristwatch, it is difficult to provide several light sources to illuminate the display element from the back, since the area available inside the case is limited. Since the number of components to be mounted in said case must be reduced to fulfil all the desired functions of the watch, a single light source is generally provided to ensure illumination of the display element.

In the case of a traditional backlighting device, this light source is mounted in the case of the watch below the display element in a position close to the visible portion of the display element. Even if the light source is partially concealed below the display element, its radiation of light causes a halo around the position of the light source, which is visible to the outside via the display element.

Illumination of the display element from the back is therefore not uniform, since the light intensity of this halo is greater than the light intensity illuminating the rest of the display element. This is major disadvantage of such a backlighting device, if it is provided, for example, to fit an upmarket type of watch.

The document US 2,823,476 describes a backlighting device of a watch dial. This device includes a light guide plate at the boundary of which is located a light source for spreading light beams into the plate between a rear face and a front face of said plate. A compensating film is placed on the front face of the light guide plate in order to make homogeneous the luminosity of the watch dial. The opacity of said compensating film is decreasing from the edge of the plate which receives light beams.

For realizing said compensating film, it is firstly necessary to spread a photographic emulsion on the film, to place it on the device, to switch on the light source, and to develop the emulsion in a black room in order to obtain a zone with a decreasing opacity. All these operations are relatively complicated and costly to obtain such a compensating film, which is a drawback.

Therefore, the main aim of the invention is to remedy the above-mentioned disadvantages by providing a backlighting device for an information display element of a portable object, which allows the illumination of the display element to be uniform, in particular in a zone located around the light source, and easy to be realized.

On this basis, the invention relates to an aforementioned backlighting device for an information display element of a portable object such as a wristwatch, which is characterised in that the zone with partial opacity is obtained by a shading white or silver dye applied to the layer or integrated into the layer, or by a semi-transparent metal covering of variable thickness, or by a metal covering pierced by a plurality of holes of varying diameter and spacing, which are smaller in size than the resolution of the human eye, or by a metal covering formed from a plurality of metal dots of varying diameter and spacing so that light beams are partially reflected and returned into the light guide plate to reduce the losses of useful photons.

An advantage of the backlighting device according to the invention lies in the fact that the halo caused by a light source located below and close to the visible portion of the display element is attenuated by the zone with decreasing opacity

obtained by such a dye or such a covering. Hence, it is possible, because of this zone of decreasing opacity, to illuminate the display element of the portable object uniformly, which can also depend on the angle of vision of the display element.

Therefore, a single light source can be sufficient to illuminate the display element. This
5 light source can be a light emitting diode, which is mounted on a printed circuit board and is located in a compartment open at the top of a crosspiece mounted on the printed circuit board.

Naturally, as the light intensity of this halo decreases when moving away from the light source to a determined distance from this source, the partial opacity of the
10 zone of the layer must also decrease when moving away from said source. This decrease in opacity of the zone, which extends to a given distance on the layer, can be non-linear, since the decrease in intensity of the halo as a function of the distance is also non-linear.

The zone with decreasing partial opacity is preferably obtained by a dye
15 applied to or integrated into the layer, or by an offset, or by a semi-transparent metal covering of variable thickness, or by a metal covering pierced by a plurality of holes or formed by metal dots of variable diameter and spacing as a function of the resolution of the human eye. The dye used can be a colour shade of black or white or silver. This dye is, for example, the ink applied by a printing machine. The white colour can be
20 used advantageously where the layer with the partially opaque zone forms an integral part of the front face of the light guide plate for a diffuse reflection of a portion of the light to be redistributed in the light guide plate.

The layer with the partially opaque zone can also be a light diffuser film or a light rectifier film located on the front face of the light guide plate.

25 Advantageously, on its periphery, the light guide plate has a rounded corner covered by a light-reflecting layer, which can be a completely opaque white paint coating or a metal covering. The light emitting diode is thus disposed below the rounded corner in order to feed the light beams in a vertical direction. In this way, the beams are reflected by the reflecting layer at the edge of the light guide plate in order
30 to spread into the light guide plate between the front and rear faces.

A joint of silicon material can also join the upper portion of the light emitting diode to a lower surface of the rounded corner of the printed circuit board in order to limit optical losses. This joint is selected to have an intermediate refractive index between the refractive index of the transparent material of the light emitting diode and
35 the refractive index of the light guide plate.

The aims, advantages and features of the backlighting device for an information display element of a portable object will be more clearly evident from the

following description of at least one embodiment of the invention in association with the drawings, wherein:

Figure 1 shows a three-dimensional exploded view of the backlighting device according to the invention;

5 Figures 2a and 2b show a plan view and a three-dimensional view of the backlighting device according to the invention with all the elements assembled;

Figures 3a and 3b show a plan view of two embodiments of the diffuser film of the backlighting device according to the invention;

10 Figure 4 shows a schematic view in partial section of a first embodiment of the backlighting device according to the invention at the level of the light source;

Figure 5 shows a schematic view in partial section of a second embodiment of the backlighting device according to the invention at the level of the light source; and

15 Figure 6 shows a simplified graph of the light intensity of the light emanating from the backlighting device without attenuation and with attenuation of intensity as a function of the distance from the light source.

In the following description, those elements of the backlighting device that are well known to the person skilled in the art in this technical field will not be explained in detail. The embodiment described specifically relates to a backlighting device for an information display element of a wristwatch. This display element can be a liquid
20 crystal translucent-type screen or a watch face with sections transparent to visible light.

Figure 1 shows a three-dimensional exploded view of an embodiment of the backlighting device 1 for fitting a wristwatch. In this embodiment, the backlighting device 1 for an information display element (not shown) firstly comprises a printed
25 circuit board 3, on which a light source such as a vertically illuminating light emitting diode 2 and at least one electronic component 4 are fixed. The light emitting diode is fed by a power source (not shown) such as a battery or accumulator, which is electrically connected to the printed circuit board 3.

A crosspiece 12 in the form of a frame made of plastic material, preferably
30 black or white in colour, is detachably mounted on the printed circuit board. This crosspiece is positioned by means of fitting means formed by legs 26 in contact with the edge of the printed circuit board 3. A compartment 5 on the outer section of the crosspiece is provided to house the light emitting diode. This compartment has a number of vertical walls partially surrounding said diode 2.

35 This compartment could naturally also be provided with vertical walls that completely surround the light emitting diode to enable it to only feed light beams in a

vertical direction. An opaque frame (not shown) could also be inserted between the walls of the compartment and the light emitting diode.

The backlighting device 1 for a display element also comprises a light guide plate 7, a diffuse (specular) or mirror-type light reflector 6 mounted on the rear face of the light guide plate and a layer having a partially opaque zone 10' disposed between the front face of the light guide plate and the display element. A lens arrangement 7', which may be of nanometre or other size, for example, is provided on one portion of the front face of the light guide plate 7. This lens arrangement could also be provided on a portion of the rear face of the light guide plate 7.

The light guide plate 7 also has a rounded corner 8, which is covered with an opaque white paint coating or a metal covering. The light emitting diode 2 in its compartment 5 is disposed just below the rounded corner at the edge of the light guide plate. The light emitting diode feeds light beams vertically in the direction of the rounded corner, so that these beams are reflected in a diffuse manner by the white paint coating or in the manner of a mirror by the metal covering. After reflection at the rounded corner, the light beams spread between the front and rear faces of the light guide plate to be reflected by the reflector and deflected by the nanometre lens arrangement.

The light guide plate 7 with its nanometre lens arrangement can be made of PC (polycarbonate) or PMMA (polymethylmethacrylate).

In this embodiment, the layer with the partially opaque zone is a flexible light diffuser film 9, on which a flexible light rectifier film 11 can be mounted. This flexible light rectifier film 11 can be a T-BEF 90/24 film manufactured by 3M. This rectifier film is composed of micro-prisms on its front or rear face to rectify and orient the light towards the display element. Lines of micro-prisms can preferably be disposed perpendicularly to the axis of light transmission in the light guide plate for better rectification of the light and to maximise its intensity. Two rectifier films with crossed prism lines could also be used to maximise the light intensity in a pre-defined angle of vision of the display element.

The partially opaque zone extends over the diffuser film 9 to a limit 25, which represents a boundary line of the visible portion of the display element up to a determined distance d_1 from the light source, as may be seen more clearly by referring to Figures 3a and 3b. This distance d_1 can depend on a natural angle of vision of the display element, which is not necessarily perpendicular to the display element in the case of a wristwatch.

It should be noted that the visible portion of the display element is preferably defined by an opaque raised support of the watch glass (not shown), which holds the

display element. In case where the raised support and the bezel or case of the watch are essentially transparent, it can be necessary to provide a partially or completely opaque layer 10, for example with black colour as shown in Figure 3b, on the diffuser film 9 surrounding the visible portion of the display element.

- 5 The light intensity of the halo, which is caused by the light source and is visible from outside the display element, decreases non-linearly from the limit 25 up to a distance d_1 , from which the light intensity is essentially uniform. In view of this, the opacity of the zone must therefore decrease non-linearly, like the light intensity of the halo, from the limit 25 up to a distance d_1 from the light source to ensure a uniform
10 illumination of the entire display element. The partial opacity of the zone can be about 80% from the limit 25 to 0% at the distance d_1 .

Figure 6 shows a simplified representation of the light intensity across the display element as a function of the distance in relation to the position of the light source. It can be seen that the light intensity of the halo decreases non-linearly as far
15 as a distance d_1 , from which it may be considered that the light intensity is more or less constant. Without a layer with a partially opaque zone, the light intensity through the display element is shown by curve a. With this layer, the light intensity is shown as uniform by curve b attenuated by said opaque zone, as shown by the hatched section. As a result of this, the opacity at each point of the zone must correspond to the level of
20 intensity shown on curve a.

The partially opaque zone 10', shown in a simplified manner in Figures 1, 3a and 3b, on the diffuser film 9, can be obtained by a dye deposited on or integrated into the flexible film of the diffuser, or by an offset. The dye used can be a colour shade of black, silver or white. This black dye is ink applied by a printing machine, for example.
25 In the case of a black colour, the light passing through the partially opaque zone is partly absorbed but lost, whereas with a white colour, the light is partially reflected in a diffuse manner and returned into the light guide plate to reduce the losses of useful photons. These recovered photons can be directed towards other less luminous zones of the light guide plate 7.

30 In place of a dye, the partially opaque zone 10' can also be obtained by a semi-transparent metal covering of variable thickness, or by a metal covering pierced by a plurality of holes of variable diameter and spacing as a function of the resolution of the human eye, or by a metal covering formed by a plurality of metal dots of variable diameter and spacing, which are obtained via a template with pierced holes. This
35 metal covering can be made by a vacuum metallisation process and the holes of the thin covering or of the template can be pierced by a laser beam or other photolithographic process.

As shown in Figure 3b, it can be provided that the diffuser film includes another zone with partial opacity so to produce a particular pattern 19, for example at least one alphabetic character, at least one symbol or a picture in the background of the display element. According to the opacity variation of said zone, a monochrome picture can be
5 represented.

The partially opaque zone can, of course, be formed by a different layer from the diffuser film. This zone can be formed directly on the front face of the light guide plate, on the rectifier film 11 or on the rear face of the display element. In the case of a zone on the light guide plate, it would be preferable to select a white dye shading from
10 a limit corresponding to the boundary line of the visible portion of the display element from the side of the light source. With this white colour deposited directly on the light guide plate, the light is partially reflected in a diffuse manner and thus allows useful photons to be recovered, as explained above.

Since the backlighting device must be easily manipulated in assembly
15 operations in a wristwatch case, all the elements forming it must be assembled beforehand. To do this, with reference to Figure 1, the crosspiece in the form of frame 12 firstly comprises a first inside shoulder 13 having two flexible fingers 15 disposed on side walls of the first shoulder 13. The reflector 6 and the light guide plate 7 are held between a support face of the first shoulder and the two flexible fingers 15.

20 The crosspiece also comprises a second inside shoulder 14 above the first shoulder 13, in the case where it is provided to mount a diffuser film 9 and/or a rectifier film 11. The diffuser film 9 is firstly placed in abutment against the second shoulder and is held by means of a tab 20 inserted into a housing 16 of a side wall of the second shoulder. The rectifier film 11 is then placed in abutment against the diffuser
25 film 9 and is held, as in the case of the diffuser film, by means of a tab 21, which is also inserted into the housing 16. In this way, all the light transmitting or reflecting elements are held in the crosspiece, which is itself assembled on the printed circuit board, on which the light emitting diode 2 is fixed.

The reflector 6, the light guide plate 7, the diffuser film 9 and the rectifier film 11
30 each have a surface area greater than or equal to the surface area of the visible portion of the display element.

It is also evident from Figure 1 that the diffuser film, on which the zone with decreasing opacity has been provided, has a section of the diffuser film, which is located on the rounded corner 8. This section of the diffuser film is covered with a
35 completely opaque black layer 10, which extends as far as the limit of the start of the zone with decreasing opacity, as shown also in Figure 3a.

A clearer impression of the shape of the backlighting device with all its elements assembled can be seen from Figures 2a and 2b. The elements forming said device in Figures 2a and 2b will not be described, since they have already been described above in particular with reference to Figure 1.

5 Two variants of the backlighting device are additionally explained with reference to Figures 4 and 5. Those elements explained above naturally have identical reference numerals and will only be explained in a simplified manner.

The backlighting device shown in partial section comprises the printed circuit board 3, the light emitting diode 2 fixed to the printed circuit board, the crosspiece 12
10 with the compartment 5 of the diode 2, the reflector 6, the light guide plate 7, the diffuser film 9 and finally the rectifier film 11.

As shown in Figure 4, the light emitting diode 2 is positioned at a short distance from the rear face of the light guide plate directly below the rounded corner. An air gap thus separates the upper face of the diode 2 from the rounded corner 8. An edge of
15 the reflector 6 comes to lie flush with an upper edge of the compartment. The edge of the reflector could preferably be directly on the edge of the light outlet of the light emitting diode so as not to lose the reflected light through the rounded corner.

Because of the zone 10' of partial opacity decreasing as the distance from the diode increases, the light F_L redirected and oriented by all the light transmitting and
20 reflecting elements has an intensity, which is essentially equal at every point to thus illuminate the display element uniformly.

In a variant shown in Figure 5, a joint made of silicon 17 is provided to join the upper portion of the light emitting diode 2 to a lower surface of the rounded corner of the printed circuit board. The joint preferably has an intermediate refractive index
25 between the refractive index of the transparent material of the light emitting diode and the refractive index of the light guide plate.

The portions of the crosspiece 12, which define the compartment 5, in which the light emitting diode 2 is completely housed, can define a completely opaque cage. This allows to avoid to have parasitic light effects if the bezel or case of the watch is
30 transparent.

It would, of course, also be conceivable to place the diode in the same plane as the light guide plate so that it feeds light beams via an edge of the light guide plate in a horizontal direction. In this case, the light guide plate is no longer provided with a rounded corner.

35 Working from the above description, numerous variants of the backlighting device may be conceived by a person skilled in the art without departing from the framework of the invention as defined by the claims. One or more other partially

opaque zones can be provided on the layer in the case where it is desirable to intentionally attenuate the light intensity to give particular effects through the display element. These other zones can be located from the side of the front or rear face of the light guide plate. Said partially opaque zones can be realized by a dye of bright
5 colour. A possible provision for the device is to only use the reflector with the light guide plate, on which one or more partially opaque zones are provided, to limit production costs. The reflector and the plate may form only a single element.

CLAIMS

1. Backlighting device (1) for an information display element of a portable object such as a wristwatch, said device comprising a light guide plate (7) having a front face and a rear face, a light reflector (6) located on the rear face of the light guide plate, a source of visible light (2) feeding light beams to a boundary or edge of the light guide plate, which spread in the light guide plate between its two faces, and a layer
5 located from the side of the front face of the light guide plate intended to face a rear face of the display element of the portable object, said layer having at least one zone (10') with partial opacity decreasing from a limit (25) located close to the boundary area of the light guide plate, which receives the light beams of the light source, in
10 order to attenuate the intensity of the light crossing said zone, characterised in that the zone with partial opacity is obtained by a shading white or silver dye applied to the layer or integrated into the layer, or by a semi-transparent metal covering of variable thickness, or by a metal covering pierced by a plurality of holes of varying diameter and spacing, which are smaller in size than the resolution of the human eye, or by a
15 metal covering formed from a plurality of metal dots of varying diameter and spacing so that light beams are partially reflected and returned into the light guide plate to reduce the losses of useful photons.
2. Backlighting device (1) according to claim 1, characterised in that the partial opacity of the zone decreases non-linearly from the limit close to the edge of
20 the light guide plate.
3. Backlighting device (1) according to claim 2, characterised in that the layer with the partially opaque zone (10') forms an integral part of the front face of the light guide plate (7) or is used like a polarising film for the display element.
4. Backlighting device (1) according to claim 2, characterised in that the
25 layer with the partially opaque zone (10') is a light diffuser film (9) or a light rectifier film (11) located on the front face of the light guide plate.
5. Backlighting device (1) according to one of the preceding claims, characterised in that it comprises a single light source, such as a light emitting diode, to illuminate the display element from the back.
- 30 6. Backlighting device (1) according to claim 4, characterised in that it comprises a crosspiece (12) forming a frame, in which the reflector (6), the light guide plate and a diffuser are held, and a printed circuit board (3) on which is fixed the light source, which is a light emitting diode, and in that a compartment (5) is cut into the periphery of the crosspiece to house the light emitting diode (2), the crosspiece being
35 detachably mounted and positioned by fitting means (26) on the printed circuit board.

7. Backlighting device (1) according to claim 6, characterised in that the crosspiece (12) comprises two flexible fingers (15) disposed on side faces of a first inside shoulder (13) to hold the reflector (6) and the light guide plate (7) inserted between a support face of the first shoulder and each flexible finger.

5 8. Backlighting device (1) according to claim 7, characterised in that above the flexible fingers (15), the crosspiece comprises a second inside shoulder (14) to receive a flexible diffuser film (9), which is held by means of a tab (20) inserted into a housing (16) cut into a side face of the second shoulder of the crosspiece, and in that a flexible transparent light rectifying film (11) is located on a diffuser film and held by
10 another tab (21) in the housing (16) of the second shoulder.

9. Backlighting device (1) according to one of the preceding claims, characterised in that on its periphery, the light guide plate (7) has a rounded corner (8) covered by a light-reflecting layer (8') and an arrangement (7') of micro-prisms or lens of nanometre size on a section of its front or rear face, and in that the light source,
15 such as a light emitting diode (2), is disposed below the rounded corner in order to feed the light beams in a direction perpendicular to the rear face of the light guide plate so that said beams are reflected by the reflecting layer at the edge of the light guide plate and spread into the light guide plate between the front and rear faces.

10. Backlighting device (1) according to claim 9, characterised in that a
20 portion of a diffuser film (9) is located on the rounded corner (8), that the portion of the diffuser film is covered with a completely opaque black layer (10), which extends as far as the limit of the start of the zone with decreasing opacity, and in that the rounded corner is covered with an opaque white layer or with a metal covering.

11. Backlighting device (1) according to claim 6, characterised in that the
25 light emitting diode (2) is housed in the compartment of the crosspiece comprising side walls, which partially or completely surround said diode from an upper surface of the printed circuit board (3), and in that an edge of the reflector comes to lie flush with an upper edge of the compartment.

12. Backlighting device (1) according to claim 6, characterised in that a joint
30 of silicon material (17) joins the upper portion of the light emitting diode (2) to a lower surface of the rounded corner of the printed circuit board, said joint having an intermediate refractive index between the refractive index of the transparent material of the light emitting diode and the refractive index of the light guide plate (7).

13. Backlighting device (1) according to claim 1, characterised in that the
35 light guide plate (7), the reflector (6) and the partially opaque zone form a single element.

14. Backlighting device (1) according to claim 1, characterised in that it includes one or more other zones with partial opacity (19) on the layer to attenuate voluntarily the light intensity through these other zones in order to produce a particular effect or pattern through the display element.