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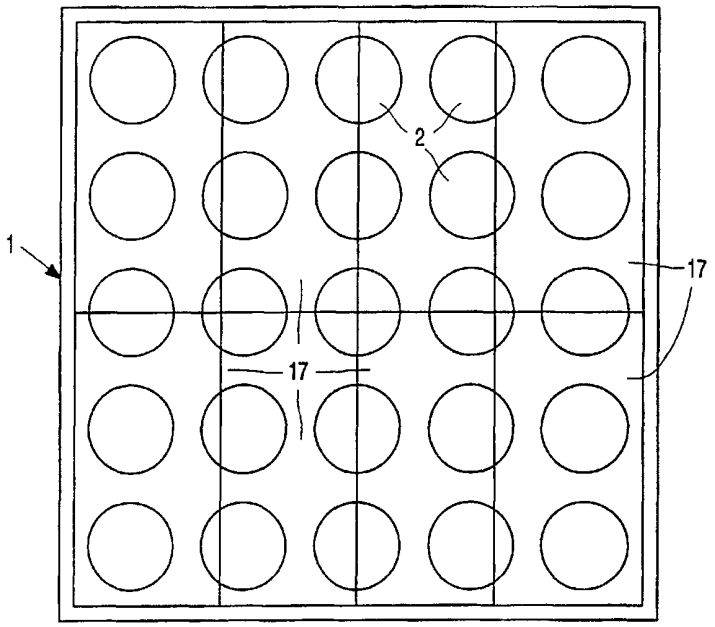
(54) Title: LUMINAIRE, OPTICAL ELEMENT AND METHOD OF ILLUMINATING AN OBJECT



(57) Abstract: A luminaire comprising a set of light sources (3), in particular LEDs, which are arranged predominantly in a first plane, and a set of substantially identical optical elements (7) arranged predominantly in a second plane extending parallel to the first plane. The position of one of the light sources with respect to an optical element (7) opposite said light source differs from the position of a further light source with respect to an optical element opposite said light source.

WO 01/16524 A1

Luminaire, optical element and method of illuminating an object .

The invention relates to a luminaire comprising a set of light sources and a set of optical elements. The luminaire in question is one wherein, in particular, the light sources consist of light-emitting diodes (LEDs).

Such a luminaire can be used, for example, as a street lighting or to illuminate objects in shop-windows. As LEDs are becoming more and more efficient and powerful, the possibilities of using LEDs for said purposes are continuously increasing, whereby the number of LEDs necessary for the required light output is continually decreasing. It is known to position each LED behind an optical element or lens of its own, so that the light of each LED can be directed at the street or object to be illuminated.

A drawback of such a luminaire resides in that the light distribution of a separate LED with the associated lens often is not uniformly distributed, which is caused by the fact that the LED's incident light on the lens is not uniformly distributed. Since the total light beam is a sum of these individual, not uniformly distributed light beams, the end result too is an ununiformly distributed light beam.

It is an object of the invention to alleviate the above drawbacks and to provide a luminaire with a more uniformly distributed light beam.

To achieve this, the luminaire in accordance with the invention comprises a set of light sources which are predominantly situated in a first plane, and a set of substantially identical optical elements which are predominantly situated in a second plane which is substantially parallel to the first plane, the position of at least one light source with respect to an optical element opposite said light source differing from the position of one of the other light sources with respect to an optical element opposite said other light source. As the position of the individual LEDs with respect to the optical element directing the light thereof is always different, the effect is the same as that obtained when one optical element is illuminated in different places by different LEDs. Therefore, the result is a more uniformly distributed light incidence on the optical elements and hence a more uniformly distributed outgoing light beam. Another advantage of the invention resides in that the number of light sources can be selected independently of the number of optical elements. As a result, the light

intensity of the luminaire can be more readily adapted by adding or removing light sources, or by switching them on or off, without the desired light pattern being influenced.

Preferably, the set of light sources and the set of optical elements each form a matrix, which matrices have substantially equal dimensions, while the number of rows and/or columns of two matrices are different. An embodiment wherein the number of rows and/or columns of one matrix exceeds the number of rows and/or columns of the other matrix by one yields a good result in practice. By means of such a matrix arrangement, a luminaire can be obtained which can be readily manufactured.

Preferably, the light sources are collimated light sources. By so directing the light from each LED that parallel beams are obtained, by means of reflection and/or refraction, before it is incident on the set of optical elements, a more accurate light distribution of the outgoing beam can be attained.

Preferably, the optical elements are rectangular, and border on each other over at least a part of their circumference. By virtue thereof, it can be ensured that the entire light beam emitted by the set of LEDs passes the set of optical elements, so that no light is lost.

Preferably, the optical elements are provided, on one or both sides, with facets having different angles of inclination. The angles of inclination are preferably calculated from the illumination pattern with which the object should be illuminated. By virtue thereof, it is possible to bring about a very complex and accurate light distribution to meet the particular requirements of the user. Such optical elements even enable text to be projected.

In a preferred embodiment, the optical elements have a sawtooth structure, the facets being formed by substantially parallel prisms. A prism, viewed in a direction in the plane of the optical element, preferably has curved sides. Such prisms can be readily provided on a lens or a lens matrix by means of metal-removing tools.

The invention also relates to an optical element which is provided, on one or both sides, with facets, which facets have different angles of inclination.

The invention also relates to a method of illuminating an object, wherein a set of light sources are positioned predominantly in a first plane, and a set of substantially identical optical elements are positioned predominantly in a second plane which is substantially parallel to the first plane, at least one light source being arranged with respect to an optical element opposite said light source, in a position which differs from the position of one of the other light sources with respect to an optical element opposite said other light source.

These and other aspects of the invention will be apparent from and elucidated with reference to the embodiments described hereinafter.

In the drawings:

Fig. 1 is a diagrammatic plan view of a known luminaire;

Fig. 2 is a sectional view, taken on the line II-II, of the luminaire shown in Fig. 1;

Fig. 3 shows an optical element;

Fig. 4 is a diagrammatic plan view of a luminaire; and

Fig. 5 diagrammatically shows the effect of the luminaire shown in Fig. 4.

Fig. 1 diagrammatically shows a plan view of a known luminaire, and Fig. 2 is a cross-sectional view thereof, taken on the line II-II. The luminaire comprises a box-shaped housing 1 accommodating 25 LED modules 2. These modules each include a light-emitting diode (LED) 3 and a collimator lens 4, which brings the rays of the LED into a parallel beam by means of reflection and refraction. The outgoing parallel light beam extends substantially parallel to the axis of symmetry 5 of the LED module 2. Each of these LED modules 2 has an axis of symmetry 5, which axes extend in mutually parallel directions.

The housing 1 has a cover 6 which is provided with 25 optical elements or lenses 7 whose axes of symmetry coincide with the axes of symmetry 5 of the LED modules 2. The exit plane of each lens 7 is provided with a sawtooth-shaped structure 8 for deflecting the outgoing light generated by the relevant LED 3. The individual lenses 7 may be oriented such that the deflected beams extend in parallel directions. It is alternatively possible, however, to orient individual lenses 7 in such a manner that a different, desired illumination pattern is obtained, as is shown, for example, in Fig. 1. Moreover, sawtooth-shaped structures having a different deflection power may also be used, for the different LED modules 2. It is alternatively possible to apply different types of LEDs 3, so that a desired color and/or intensity pattern can be obtained.

Fig. 3 shows a rectangular optical element 17 which can be applied in the invention. Said optical element 17 is comprised of a flat plate of a transparent material wherein a row of prisms 18 is provided on one side by means of milling. These prisms 18 may also be provided on both sides of the optical element. At each milling location, the surface of the optical element has an angle α which is different for each prism 18, and an angle β which

varies, along the length of a prism 18, in accordance with a certain function, so that the prism, viewed in a direction in the plane of the optical element, is curved. The direction wherein the light from the LED is deflected thus depends upon the location where the light ray enters the optical element. The angles α and the variation of the angle β are calculated by means of a computer from the required light pattern to be generated on the object to be illuminated. This pattern may be very complex; it has even been found possible to project text by means of such optical elements.

Such an optical element, or a matrix for such an element, can be readily manufactured by clamping a rectangular piece of material on a milling machine at a certain angle α and subsequently milling out a first prism, whereby the milling cutter follows a path which determines the variation of the angle β. Next, all subsequent prisms are milled out in a corresponding manner.

In accordance with Fig. 4, 25 LED modules 2, as shown in Figs. 1 and 2, are arranged in a 5x5 matrix in a housing. In this case, however, the cover is not formed by a corresponding 5x5 matrix of lenses but by a 2x4 matrix of identical, rectangular optical elements 17 as shown in Fig. 3.

If the number of rows and columns of the light source matrix is referred to as, respectively, Ns_r and Ns_c, and the interspace between the LEDs in both directions is referred to as, respectively, Ws_r and Ws_c, and the number of rows and columns of the lens-matrix is referred to as, respectively, Nl_r and Nl_c, and the dimensions of the optical elements are referred to as, respectively, Wl_r and Wl_c, then the following equation applies, provided both matrices have the same dimensions:

$Ns_r \times Ws_r = Nl_r \times Wl_r$

$Ns_c \times Ws_c = Nl_c \times Wl_c$

which determines the relationship between the dimensions of the optical elements and the distance between the LED modules.

In this exempla, the following applies:

$Ns_r = 5$, $Ns_c = 5$, $Nl_r = 2$ and $nl_c = 4$.

As a result of such an arrangement, the LED modules 2 are always in a different position with respect to an optical element 17, and the effect of this arrangement is comparable to the effect obtained if all LED modules would be positioned, with very little interspace, behind one optical element 17, as is shown in Fig. 5. This arrangement, however, would be physically impossible due to the dimensions of the LED modules 2. In this manner, a very

uniform illumination of the optical element 17, and hence a very uniformly distributed light beam, are achieved.

The intended result can be achieved by choosing the number of rows and columns of the LED matrix and the lens matrix to be different, i.e. $Ns_r \neq Nl_r$ and $Ns_c \neq Nl_c$, an optimum result being theoretically obtained by choosing the number of rows and columns such that the difference between them is only 1. Production-technical reasons, however, may argue in favor of different numbers.

CLAIMS:

1. A luminaire comprising a set of light sources which are predominantly situated in a first plane, and a set of substantially identical optical elements which are predominantly situated in a second plane which is substantially parallel to the first plane, the position of at least one light source with respect to an optical element opposite said light source differing from the position of one of the other light sources with respect to an optical element opposite said other light source.

2. A luminaire as claimed in claim 1, characterized in that the set of light sources and the set of optical elements each form a matrix, which matrices have substantially equal dimensions, while the number of rows and/or columns of the two matrices are different.

3. A luminaire as claimed in claim 2, characterized in that the number of rows and/or columns of one matrix exceeds the number of rows and/or columns of the other matrix by one.

4. A luminaire as claimed in any one of the preceding claims 1 to 3, characterized in that the light sources are collimated light sources.

5. A luminaire as claimed in any one of the preceding claims 1 to 4, characterized in that the light sources are light-emitting diodes (LEDs).

6. A luminaire as claimed in any one of the preceding claims 1-5, characterized in that the optical elements are rectangular.

7. A luminaire as claimed in any one of the preceding claims 1 to 6, characterized in that the optical elements border on each other over at least a part of their circumference.

8. A luminaire as claimed in any one of the preceding claims 1 to 7, characterized in that the optical elements are provided, on one or both sides, with facets having different angles of inclination.

9. A luminaire as claimed in claim 8, characterized in that the optical elements have a sawtooth structure, the facets being formed by substantially parallel prisms.

10. A luminaire as claimed in claim 9, characterized in that a prism, viewed in a direction in the plane of the optical element, has curved sides.

11. An optical element which is provided, on one or both sides, with facets, characterized in that said facets have different angles of inclination.

12. An optical element as claimed in claim 11, characterized in that the optical element has a sawtooth structure, the facets being formed by substantially parallel prisms.

13. An optical element as claimed in claim 11 or 12, characterized in that a prism, viewed in a direction in the plane of the optical element, has curved sides.

14. A method of illuminating an object, wherein a set of light sources are arranged predominantly in a first plane, and a set of substantially identical optical elements are arranged predominantly in a second plane, which is substantially parallel to the first plane, at least one light source being arranged, with respect to an optical element opposite said light source, in a position which differs from the position of one of the other light sources with respect to an optical element opposite said other light source.

15. A method as claimed in claim 14, characterized in that the optical elements are provided, on one or both sides, with facets having different angles of inclination, said angles of inclination being calculated from the illumination pattern with which the object is to be illuminated.

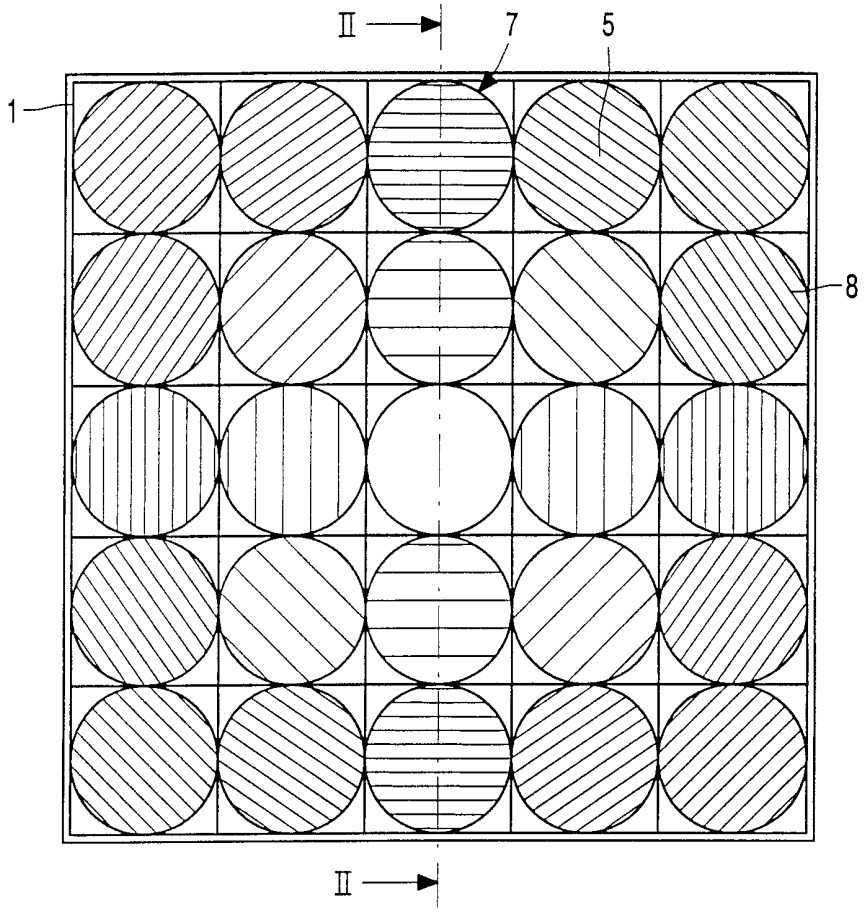


FIG. 1

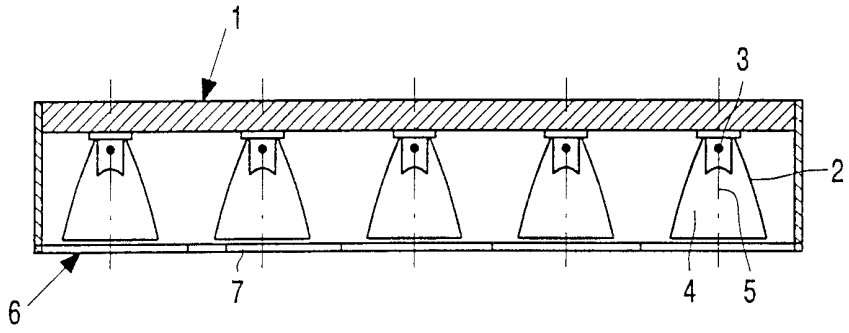


FIG. 2

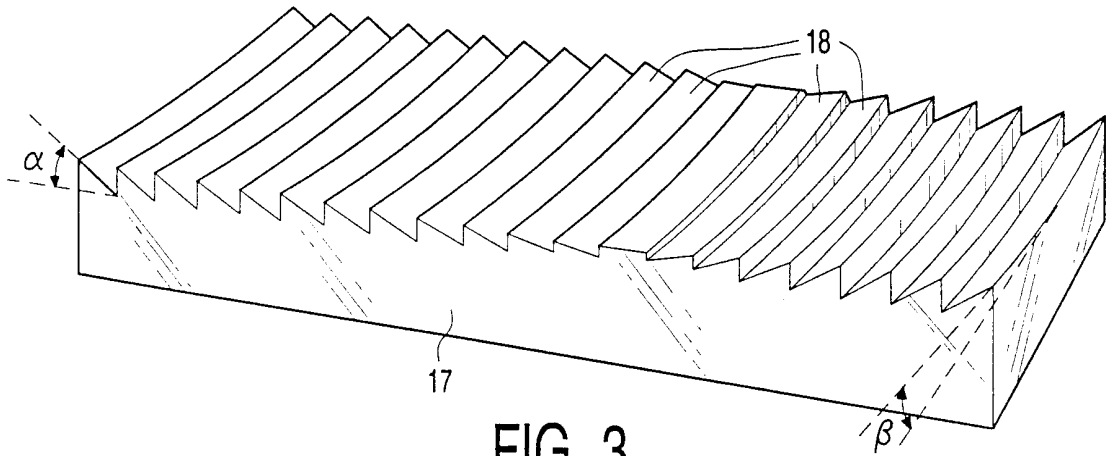


FIG. 3

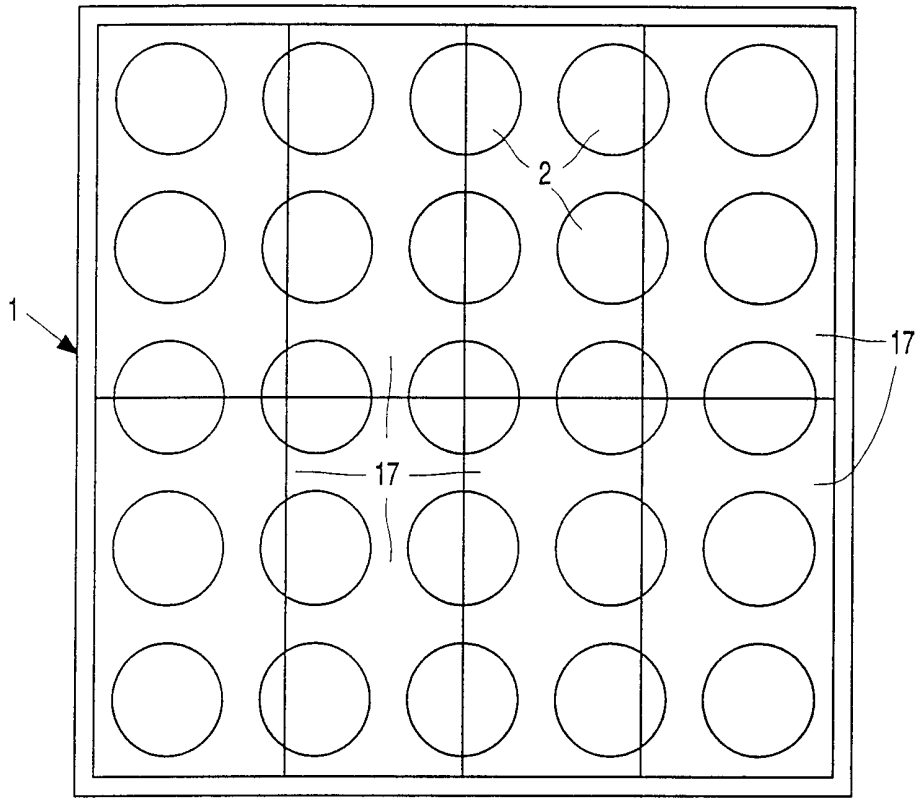


FIG. 4

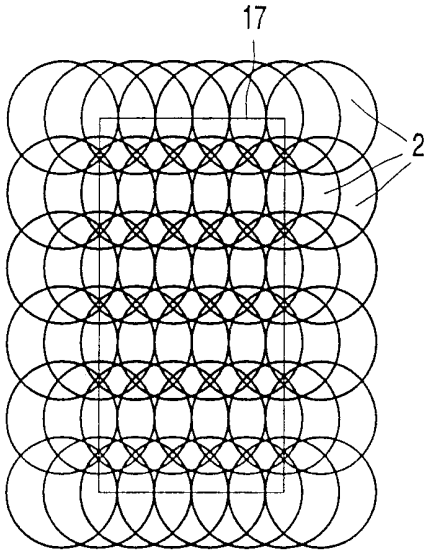


FIG. 5

INTERNATIONAL SEARCH REPORT

Interr. ial Application No
PCT/EP 00/07693

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 F21K7/00

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)
IPC 7 F21K F21V G08G F21Q B60Q

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,X	WO 99 50596 A (MIZEROV MIKHAIL NIKOLAEVICH ;SKVORTSOV YURY SERGEEVICH (RU); SUETO) 7 October 1999 (1999-10-07) page 3, line 27 - line 32 page 8, line 15 - line 35 page 9, line 21 - line 24 page 11, line 11 - line 12 figures 3,6,11,12 ---	1,2,5-9, 11,12, 14,15
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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
13 November 2000	22/11/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Prévot, E

4

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INTERNATIONAL SEARCH REPORT

Interr ıal Application No
PCT/EP 00/07693

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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A	page 3, line 27 -page 4, line 11 claims 1,3 figures 1-5	14,15

4

INTERNATIONAL SEARCH REPORT

Information on patent family members

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