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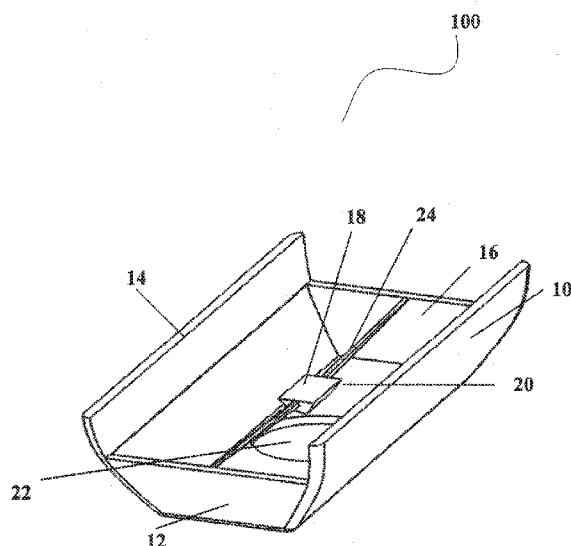


Fig. 1

(57) Abstract: The present invention discloses a light distribution device (100) for an optical system, which includes: a reflection unit through which at least part of edge light among emitting light from a light source (26) of the optical system is reflected directly to a light reception surface of the optical system, wherein the edge light is the light that deviates from the normal direction of the emitting light; and a light uniformization (18) unit through which central light among the emitting light from the light source and light reflected from the reflection unit to the light uniformization unit are directed to the light reception surface, so as to form together with the reflected light from the reflection unit a desired light spot with uniform illumination on the light reception surface. The invention further discloses an optical system equipped with the light distribution device and a method for manufacturing the light distribution device. Uniform illumination and hence an improved optical efficiency can be achieved for the optical system equipped with the light distribution device according to an embodiment of the invention.



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LIGHT DISTRIBUTION DEVICE AND MANUFACTURING METHOD THEREOF, AND OPTICAL SYSTEM INCLUDING THE DEVICE

Field of the Invention

5 [0001] The present invention generally relates to the field of optical technologies and in particular to a light distribution device for an optical system, the optical system including the light distribution device and a method for manufacturing the light distribution device.

10 Background of the Invention

[0002] As is well known, a suitable light distribution device is desired in an optical system of an optical lighting system, and light from a light source is directed by the distribution device to a specific light reception surface so as to obtain lighting spots satisfying various lighting requirements. In some specific application fields, for
15 example, in streetlight lighting, projector lighting systems, etc., light emitting from an optical source is required to be distributed so as to form a desired rectangular lighting spot on a light reception surface.

[0003] Desired lighting is achieved in some existing lighting systems by means of a light distribution device for light distribution. For example, "Free-form surface reflector for uniform lighting", by DING Yi and GU Pei Fu, Optics Proceedings, vol. 27, no.3,
20 March, 2007, pp.540-544, discloses a solution for achieving uniform lighting through light distribution by a single free-form surface reflector. In the disclosed solution, a set of partial differential equations useful for calculation of a free-form surface of the reflector are derived dependent upon a known luminescence feature of a light source and a desired lighting requirement, and specific form parameters of the free-form
25 surface of the single free-form surface reflector are derived directly with a numeral solution method so as to obtain the single free-form surface reflector capable of achieving uniform lighting, and the free-form surface reflector is a light distribution device of a lighting system.

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Summary of the Invention

[0004] An embodiment of the invention provides a light distribution device for an optical system to improve the optical efficiency of the light distribution device, so that

uniform illumination distribution on a light reception surface can be achieved in the optical system equipped with the light distribution device according to the embodiment of the invention.

5 [0005] An embodiment of the invention provides a light distribution device for an optical system, which includes:

a reflection unit through which at least part of edge light among emitting light from a light source of the optical system is reflected directly to a light reception surface of the optical system, which edge light being the light that deviates from the normal direction of the emitting light; and

10 a light uniformization unit through which central light among the emitting light from the light source and light reflected from the reflection unit to the light uniformization unit are directed to the light reception surface, so as to form together with the reflected light from the reflection unit a desired light spot with uniform illumination on the light reception surface.

15 [0006] An embodiment of the invention further provides an optical system including the above light distribution device.

[0007] An embodiment of the invention still further provides a method for manufacturing the above light distribution device, which includes:

20 providing a reflection unit, wherein the reflection unit is configured to directly reflect at least part of edge light among emitting light from a light source of the optical system to a light reception surface of the optical system, which edge light being the light that deviates from the normal direction of the emitting light; and

25 providing a light uniformization unit, wherein the light uniformization unit is configured to direct central light among the emitting light from the light source and light reflected from the reflection unit to the light uniformization unit to the light reception surface, so as to form together with the reflected light from the reflection unit a desired light spot with uniform illumination on the light reception surface.

Brief Description of the Drawings

30 [0008] The object, features and advantages of the invention will become more apparent from the descriptions of the embodiments of the invention taken in conjunction with the drawings throughout which identical or like reference numerals denote identical or like functional components and in which:

[0009] Fig.1 illustrates a simplified perspective view of configuration of a light distribution device according to an embodiment of the invention;

[0010] Fig.2 illustrates a side view of a lighting system which employs the light distribution device according to the embodiment of the invention as illustrated in Fig.1;

5 [0011] Fig.3 illustrates a schematic diagram of a light path in an operation state of the lighting system which employs the light distribution device according to the embodiment of the invention as illustrated in Fig.1;

[0012] Fig.4A and Fig.4B illustrate comparative charts of light distribution curves of optical systems with and without the light distribution device according to the
10 embodiment of the invention, respectively;

[0013] Fig.5 illustrates an illumination chart of a test result of a lighting test on the road surface by a streetlight lighting system equipped with a light distribution device according to the embodiment of the invention; and

[0014] Fig.6 illustrates a schematic flow chart of a method for manufacturing the light
15 distribution device according to the embodiment of the invention as illustrated in Fig.1.

Detailed Description of the Invention

[0015] Illustrative embodiments of a light distribution device 100 according to an embodiment of the invention and a lighting system 200 equipped with the light
20 distribution device 100 will be described in conjunction with Fig.1 to Fig.3.

[0016] As illustrated in Fig.1 to Fig.3, the light distribution device 100 includes a reflection unit consisted of four free-form surface reflection sub-units 10, 12, 14 and 16. At least part of edge light among emitting light from a light source 26, which deviates from the normal α - α direction of the emitting light, is reflected directly to a light
25 reception surface S-S by the reflection unit. The light distribution device 100 further includes a light uniformization unit 18. Central light among the emitting light from the light source 26 and light reflected from the reflection unit to the light uniformization unit 18 are directed to the light reception surface S-S by the light uniformization unit 18, so as to form together with the reflected light from the reflection unit a desired light
30 spot on the light reception surface S-S. In this embodiment, the four free-form surface reflection sub-units 10, 12, 14 and 16 included in the reflection unit form a reflection space β (also referred to as a “reflection cup” in some cases), that is, a space in which the light from the light source 26 is reflected through the reflection unit to reach the light reception surface S-S so as to form the desired light spot.

[0017] Referring to the schematic diagram of a light path illustrated in Fig.3, the at least part of the edge light among the light emitting from the light source 26 of the lighting system 200, which deviates from the normal α - α direction of the emitting light (denoted with the light A and the light F in Fig.3), is reflected directly to the light reception surface S-S through the four free-form surface reflection sub-units 10, 12, 14 and 16 (not shown) of the reflection unit which constitute the reflection space β , so as to form the desired light spot. The central light among the light emitting from the light source 26 within a range of a certain angle θ with respect to the normal α - α direction of the emitting light (that is, light at an angle with respect to the normal α - α direction within the range of being smaller than or equal to θ , denoted with the light C and the light D in Fig.3) is reflected through the light uniformization unit 18. A part of the reflected central light, the light C, reaches directly the light reception surface S-S for forming the desired light spot, while the other part of the reflected light, the light D, reaches the free-form surface reflection sub-unit 14 and is further reflected through the free-form surface reflection sub-unit 14 of the reflection unit to the light reception surface S-S for forming the desired light spot. As can be apparent from Fig.3, the edge light among the light from the light source 26, which deviates from the normal α - α direction of the emitting light, refers to light at an angle with respect to the normal α - α direction within the range of being larger than θ , that is, other light than the central light. Another part of the light emitting from the light source 26 (denoted with the light G in Fig.3) is reflected through the reflection sub-unit 10 of the reflection unit, and then is incident onto and further reflected through the light uniformization unit 18 to be directed to the light reception surface S-S for forming the desired light spot.

[0018] Still another part of the light among the edge light of the light from the light source 26 (denoted with the light B and the light E in Fig.3) is incident directly on the light reception surface S-S without reflection by the reflection unit and/or the light uniformization unit 18. Thus in this embodiment, the light A to G from the light source 26 is reflected through the reflection unit, reflected through the light uniformization unit, reflected through both the reflection unit and the light uniformization unit, and incident directly, respectively, so as to form the final desired light spot with uniform illumination on the light reception surface S-S.

[0019] In contrast, only a reflection unit is arranged in an existing light distribution device, and a central bright spot is present in a resulting light spot formed on a light reception surface of an optical system. The central bright spot results primarily from at least two parts of light: one part is central light among emitting light of a light source, which is incident directly onto the light reception surface, and the other part is the light

obtained through reflecting some of the emitting light of the light source onto the light reception surface through the reflection unit. As mentioned above, the light uniformization unit 18 is arranged in the light distribution device 100 according to the embodiment of the invention to process the light possibly resulting in the central bright spot to remove the central bright spot, and thereby improving illumination uniformity of the light spot resulting on the light reception surface and improving the optical efficiency.

[0020] In the operation of the above light distribution device 100 according to the embodiment of the invention illustrated in Fig.1 to Fig.3, the central light among the light emitting from the light source 26 is the light at an angle with respect to the normal α - α direction of the emitting light within the range of being smaller than or equal to θ , and the edge light among the light emitting from the light source 26 is the light deviating from the normal α - α direction of the emitting light, that is, the light at an angle with respect to the normal α - α direction of the emitting light within the range of being larger than θ . As can be appreciated by those skilled in the art, the angle θ is related to conditions including the luminescence feature of the light source 26, the desired lighting requirement, etc. For example, if the light source 26 is an LED light source, then the lighting angel of the emitting light therefrom can be selected as an appropriate angel as needed in practice, e.g., around 80° to 180° , and the angle θ is related to the area of the relatively bright central spot formed on the light reception surface S-S by the central light from the LED light source 26 in the case that the light uniformization unit 18 is not arranged. The area of the relatively bright central spot is the area for which decentralization by the light uniformization unit 18 is to be carried out so as to obtain a desired light spot with uniform illumination on the light reception surface S-S. Similarly, the light emitted from the light source 26 and reflected through the reflection unit (in the case that the light uniformization unit 18 is not arranged) to form the central bright spot on the light reception surface S-S is also related to the conditions including the luminescence feature of the light source 26, the desired lighting requirement, etc. Characteristics, e.g., the reflection capability, of the light uniformization unit 18 for use, can be determined based upon a condition predetermined from the luminescence feature of the light source 26, the desired lighting requirement, etc., of the optical system, and thus, an appropriate construction of the light uniformization unit 18, e.g., its shape, size, material, etc., can be determined. As mentioned above, the conditions of the luminescence feature of the light source 26, the desired lighting requirement, etc., may vary from one optical system to another, and accordingly, the light distribution device 100 according to the embodiment of the

invention may be configured differently. Those skilled in the art can conceive corresponding designs as needed in practice, and detailed descriptions thereof will be omitted here.

[0021] In the above embodiment illustrated in Fig.1 to Fig.3, part of the edge light of the light from the light source 26 (denoted with the light B and the light E in Fig.3) is incident directly onto the light reception surface S-S without reflection through the reflection unit and/or the light uniformization unit 18. Alternatively, the light distribution device 100 can be structured appropriately, so that all the edge lights are directed to the light reception surface S-S after being processed through the reflection unit and/or the light uniformization unit 18.

[0022] Furthermore, in the embodiment illustrated in Fig.1 to Fig.3, the light uniformization unit 18 does not process directly the edge light among the emitting light of the light source 26 but further reflects the edge light (denoted with the light G in Fig.3) reflected through the reflection unit. Alternatively, the light distribution device 100 can be structured appropriately, so that the light uniformization unit 18 can reflect directly part of the edge light of the emitting light of the light source 26.

[0023] In some alternative embodiments, it is also acceptable that part of the light from the light source 26 (not shown) is not incident finally onto the light reception surface S-S or incident onto the light reception surface S-S but makes no contribution to the formation of the resulting lighting spot. As can be appreciated by those skilled in the art, the light distribution device 100, for example, the form surface shape and size of the reflection unit, the shape and size of the light uniformization unit 18, etc., can be structured appropriately, so that this part of light will have no influence upon the formation of the desired light spot.

[0024] In the embodiments illustrated in Fig.1 to Fig.3, the light uniformization unit 18 is arranged in the reflection space β (i.e., the “reflection cup”) formed of the four free-form surface reflection sub-units 10, 12, 14 and 16 of the reflection unit, and thus the reflection unit can further reflect the reflected light that it receives from the light uniformization unit 18 to the light reception surface S-S (denoted with the light D in Fig.3). In an alternative embodiment, the light uniformization unit 18 is not arranged in the reflection space β . The arrangement of the light uniformization unit 18 can be varied variously based upon the embodiment illustrated in Fig.1 to 3. For example, the light uniformization unit 18 can be arranged farther from the light source 26 to extend beyond the reflection space β , and the light reflected by the light uniformization unit 18 (denoted with the light D in Fig.3) will not be further reflected through the reflection

unit. Alternatively, the light uniformization unit 18 can be arranged closer to the light source 26. Improved illumination uniformity can be achieved as long as the light uniformization unit 18 is adapted to decentralize the central bright spot to be formed on the light reception surface S-S. As can be appreciated by those skilled in the art, the location relationship of the light uniformization unit 18, the light source 26 and the reflection unit can be devised dependent upon the specific feature and lighting demand of the optical system, and detailed descriptions thereof will be omitted here.

[0025] Fig.4A illustrates a light distribution curve of an optical system without a light distribution device according to the embodiment of the invention, and Fig.4B illustrates a light distribution curve of an optical system with the light distribution device according to the embodiment of the invention. In the curves illustrated in the Figures, the abscissa denotes an angle, and the ordinate denotes light intensity. Areas surrounded by the curves and the abscissa denote light flux (lumen or lm). As can be apparent from the light distribution curve in Fig.4A, when the light distribution device according to the embodiment of the invention is not used, light intensity in the central normal direction is high, so that central illumination is not uniform and a central bright spot may be present on the light reception surface. After the light distribution device according to the embodiment of the invention is used, the central light intensity is distributed more uniformly, and the central bright spot is removed, thereby improving the optical efficiency, as illustrated in Fig.4B.

[0026] Fig.5 illustrates an illumination chart of a test result of a lighting test on the road surface by a streetlight lighting system equipped with the light distribution device 100 according to the embodiment of the invention. In the test, the light distribution device 100 according to the embodiment of the invention is installed at an LED module serving as the light source 26 to constitute the lighting system for simulation of an application in road lighting, that is, for simulation of an illumination distribution on the light reception surface (the road surface in this example). The LED module has the light flux of 11lm (lumen), power of 1 watt and a distance of 1 meter from the light reception surface. Fig.5 illustrates an iso-illumination distribution curve on the light reception surface in the vertical lighting direction of the light source LED module of the lighting system, where X and Y denote horizontal and vertical coordinates of the light reception surface, respectively, and the coordinate origin (0, 0) denotes a vertical projection of the light source LED module on the light reception surface.

[0027] Values of identical illumination are connected with curves in accordance with the test result, and different curve profiles in Fig.5 denote different illumination values in Lux (lumen/square meter) denoted on the left of the iso-illumination distribution

curve. As can be apparent from Fig.4, the illumination values at the center of the light reception surface are distributed relatively uniformly, and a generally rectangular lighting spot with uniform illumination comes into being, thus showing the effect of the light uniformization unit 18 for decentralizing the central bright spot formed of the emitting light of the light source. Therefore, the optical efficiency of the streetlight lighting system equipped with the light distribution device 100 according to the embodiment of the invention can be improved, so as to comply well with the relevant national streetlamp standard, for example, the Urban Road Lighting Design Standard of CJJ45-2006.

[0028] In addition to the improved optical efficiency of the lighting system, advantageous effects that can be obtained through the light distribution device according to the embodiment of the invention further include, but will not be limited to, an improved large power driving capability of the optical system equipped with the light distribution device. Since the light distribution device according to the embodiment of the invention can make effective use of the light from the light source to form the desired light spot with uniform illumination, a light source having lower power can be used for the lighting system equipped with the light distribution device according to the embodiment of the invention as compared with an existing similar lighting system for the same resulting lighting spot to be obtained, thereby reducing the cost of the lighting system. Furthermore, the improved optical efficiency of the lighting system can result in extended lifetime of the light distribution device and hence the entire lighting system.

[0029] The embodiments of the light distribution device according to the invention and the optical system equipped with the light distribution device have been described in conjunction with Fig.1 to Fig.5. It shall be noted that the specific structural configuration, types of optical constituent elements, various specific parameters, etc., of the light distribution device and the optical system mentioned in these embodiments are merely illustrative but shall not be taken as being limitative of the invention. Those skilled in the art can appreciate that the invention can further include various alternative embodiments.

[0030] For example, in the above embodiments illustrated in Fig.1 to Fig.3, the light uniformization unit 18 is arranged to be capable of reflection so as to decentralize the central bright spot which might otherwise be formed on the light reception surface S-S by the emitting light of the light source 26 in the case that the light uniformization unit 18 were not arranged, thereby achieving uniform illumination of the resulting desired light spot. However, As can be appreciated by those skilled in the art, the light uniformization unit 18 can alternatively be arranged to be capable of refraction to

operate by the refraction principle so as to decentralize the central bright spot which might otherwise be formed on the light reception surface by the emitting light of the light source 26 in the case that the light uniformization unit 18 were not arranged, thereby achieving uniform illumination of the resulting desired light spot. Obviously, it is also feasible that the light uniformization unit 18 can be arranged to be capable of both reflection and refraction to operate by the refraction and refraction principles so as to decentralize the central bright spot which might otherwise be formed on the light reception surface by the emitting light of the light source 26 in the case that the light uniformization unit 18 were not arranged. The specific configuration of shape, size, etc., of the light uniformization unit 18 capable of reflection and/or refraction can be devised by those skilled in the art dependent upon the specific feature and light demand of the optical system, and detailed descriptions thereof will be omitted here.

[0031] The light uniformization unit 18 is designed in the shape of a triangular in the above embodiments. However, it can alternatively be designed in the shape of a quadrangular prism, a pentagonal prism, a cylinder, an elliptical cylinder or other polyhedron shapes, a shape formed of a single free-form surface, etc. Various forms of the light uniformization unit 18 can be acceptable as long as it has the function of decentralizing the central bright spot which might otherwise be formed on the light reception surface by the emitting light of the light source 26 in the case that the light uniformization unit 18 were not arranged, thereby achieving uniform illumination of the resulting desired light spot. Furthermore, the light uniformization unit 18 is in the form of a single optical element in the above embodiments. Alternatively the light uniformization unit 18 can be devised to be composed of several optical sub-elements as needed.

[0032] Furthermore, the reflection unit is constituted of the four free-form surface reflection sub-units 10, 12, 14 and 16 in the above embodiments. However, the number of the free-form surface reflection sub-units and their free-form surface conformations will not be limited thereto. For example, the number of the free-form surface reflection sub-units can be any arbitrary number larger or smaller than four, and the shapes of the free-form surfaces can also be arbitrary, e.g., a rectangular form surface, a hyperbolic form surface, a parabola form surface, etc., as need in practice. Correspondingly, the reflection space β formed of the reflection sub-units can be a cuboid, a cube, a sphere, an ellipsoid, other symmetric or asymmetric polyhedron, etc. The respective reflection sub-units 10, 12, 14 and 16 forming the reflection unit can take identical or different free-form surface forms. As can be readily appreciated, the reflection unit can be formed of a single reflection sub-unit in the case that the reflection space β is a sphere, an

ellipsoid, etc.

[0033] It shall be noted that a bottom plate 20 is arranged below the reflection space β formed of the free-form surface reflection sub-units 10, 12, 14 and 16 in the embodiment illustrated in Fig.1 to Fig.3. The bottom plate 20 can be designed as an additional reflection surface for reflecting upward part of stray light incident thereon from the light source 26, so that this part of light will be directed directly or through the reflection unit and/or the light uniformization unit 18 to the light reception surface S-S so as to form the desired light spot, thereby further improving the efficiency of the optical system. Of course, the bottom plate 20 can alternatively be incapable of reflection but act as a mechanical component for installation of the reflection unit and the light uniformization unit 18 onto the light source 26. As illustrated in Fig.1, there is opened on the bottom plate 200 a hole 22 through which the light from the light source 26 is directed into the reflection space β . As can be readily appreciated, the light from the light source 26 can be directed into the reflection space β even without arranging the bottom plate 200. From the point of view of mechanical installation, the reflection unit and the light uniformization unit 18 may be installed onto the light source 26 otherwise instead of being through the bottom plate. For example, the reflection unit and the light uniformization unit 18 can be installed directly onto a constituent component of the light source 26, e.g., the housing thereof, etc., through a support rod, an adhesive, etc. Apparently, the bottom plate 20 is an optional constituent component in the embodiment illustrated in Fig.1 to Fig.3 according to the invention.

[0034] As can be apparent from Fig.1 to Fig.3, the light uniformization unit 18 and the reflection unit are coupled through the support rod 24 and are installed integrally above the light source 26. However, the invention will not be limited to this, and the light uniformization unit 18 can be coupled with the reflection unit in any other appropriate installation way in other alternative embodiments. For example, the light uniformization unit 18 and the reflection unit can be connected in a fixed way or in a removable way through, for example, a hinge connection, a tenon connection, etc. Alternatively, the reflection unit and the light uniformization unit 18 can be formed integrally and then be installed together with the light source 26. Alternatively, the reflection unit and the light uniformization unit 18 as separate components can be installed together with the light source 26 respectively. Furthermore in the embodiments illustrated in Fig.1 to Fig.3, the reflection space β formed of the reflection unit is arranged above the light source 26 and has a size larger than that of the light source 26. As can be appreciated by those skilled in the art, the positional relationship and size relationship between the reflection space β formed of the reflection unit and the light source 26 will not be limited to the

embodiment of Fig.1 to Fig.3, as long as the light from the light source 26 can be directed to the light reception surface S-S through the light distribution device 100 according to the embodiment of the invention so as to form the desired light spot. For example, the light source 26 can alternatively be arranged in the reflection space β , so that the reflection space β will surround the light source 26.

[0035] Furthermore, the surfaces of the reflection unit and the reflection space β can be processed as smooth surfaces or surfaces with micro structures. Alternatively, these surfaces can be coated with a reflective film, e.g., a silver film, an alumina film, etc., to thereby enhance the reflectivity of the respective reflection surfaces.

[0036] The light distribution device 100 according to the embodiment of the invention can be applicable to any suitable type of light source 26, including but not limited to an LED device, an incandescent-lamp light source, a haloid-lamp light source, a laser light source, etc. Correspondingly, various lighting systems, for example, a streetlight lighting system, a household lighting system (e.g., various lamps, etc.), a factory (e.g., a warehouse, etc.) lighting system, a military lighting system, a lighting system for a projector, a lighting system for a Digital Micro Device (DMD), a lighting system for a liquid crystal display panel, etc., can be built of various types of light sources 26 equipped with the light distribution device 100 according to the embodiment of the invention. Therefore, the various lighting systems equipped with the light distribution device 100 according to the embodiment of the invention shall also be regarded as falling within the scope of the invention.

[0037] Furthermore, the optical system 200 equipped with the light distribution device 100 according to the embodiment of the invention can be implemented separately, or several such optical systems can be implemented in combination, to thereby satisfy various needs. Moreover, several light distribution devices 100 according to the embodiment of the invention can be arranged (e.g., in an array) to distribute light for a single light source 26 as needed in practice.

[0038] Fig.6 illustrates a schematic diagram of a flow chart of a method for manufacturing the light distribution device 100 according to the embodiment of the invention as illustrated in Fig.1. As illustrated in Fig.6, there is provided in the step S610 the reflection unit through which the at least part of the edge light among the emitting light from the light source of the optical system, which deviates from the normal direction of the emitting light, is directed to the light reception surface of the optical system. There is provided in the step S620 the light uniformization unit through which the at least part of the central light among the emitting light from the light source

is directed to the light reception surface so as to form together with the reflected light from the reflection unit the lighting spot on the light reception surface. Therefore, the method for manufacturing the light distribution device 100 according to the embodiment of the invention shall also be regarded as falling within the scope of the invention.

[0039] As can be appreciated by those skilled in the art, the above embodiments have been described in connection with the lighting system equipped with the light distribution device according to the invention, but of course the light distribution device according to the invention can be applicable to various optical systems as long as the light distribution device is required in the optical systems to direct the light from the light source to the specific light reception surface so as to form the optical image (e.g., the light spot, etc.).

[0040] Although the invention has been disclosed in the descriptions of the embodiments of the invention, it shall be appreciated that those skilled in the art can devise various modifications, adaptations or equivalents of the invention without departing from the spirit and scope of the invention. These modifications, adaptations or equivalents shall also be regarded as falling within the scope of the invention.

WHAT IS CLAIMED IS:

1. A light distribution device for an optical system, comprising:

a reflection unit through which at least part of edge light among emitting light from a light source of the optical system is reflected directly to a light reception surface of the optical system, which edge light being the light that deviates from the normal direction of the emitting light; and

a light uniformization unit through which central light among the emitting light from the light source and light reflected from the reflection unit to the light uniformization unit are directed to the light reception surface, so as to form together with the reflected light from the reflection unit a desired light spot with uniform illumination on the light reception surface.

2. The light distribution device according to claim 1, wherein:

the light uniformization unit is arranged in a reflection space formed of the reflection unit, so that the reflection unit reflects light it receives from the light uniformization unit to the light reception surface.

3. The light distribution device according to claim 1 or 2, wherein:

the light uniformization unit is capable of reflection and/or refraction.

4. The light distribution device according to claim 3, wherein:

the light source is any one of an LED device, an incandescent-lamp light source, a haloid-lamp light source and a laser light source.

5. The light distribution device according to claim 3, wherein:

the light uniformization unit is formed of any one of shape forms of a prism, a cylinder, an elliptical cylinder and a single free-form surface.

6. The light distribution device according to claim 3, wherein:

the reflection unit and the light uniformization unit are formed integrally.

7. An optical system comprising the light distribution device according to any one of claims 1 to 6, wherein the optical system is configured with the light distribution device or with an array of a plurality of the light distribution devices.

8. The optical system according to claim 7, wherein the optical system is any one of:

a streetlight lighting system, a household lighting system, a factory lighting

system, a military lighting system, a lighting system for a projector, a lighting system for a liquid crystal display, and a lighting system for digital micro device.

9. A method for manufacturing the light distribution device for the optical system according to any one of claims 1 to 6, comprising:

providing a reflection unit, which reflection unit being adapted to reflect directly at least part of edge light among emitting light from a light source of the optical system to a light reception surface of the optical system, wherein the edge light is the light that deviates from the normal direction of the emitting light; and

providing a light uniformization unit, which light uniformization unit being adapted to direct central light among the emitting light from the light source and light reflected from the reflection unit to the light uniformization unit to the light reception surface, so as to form together with the reflected light from the reflection unit a desired light spot with uniform illumination on the light reception surface.

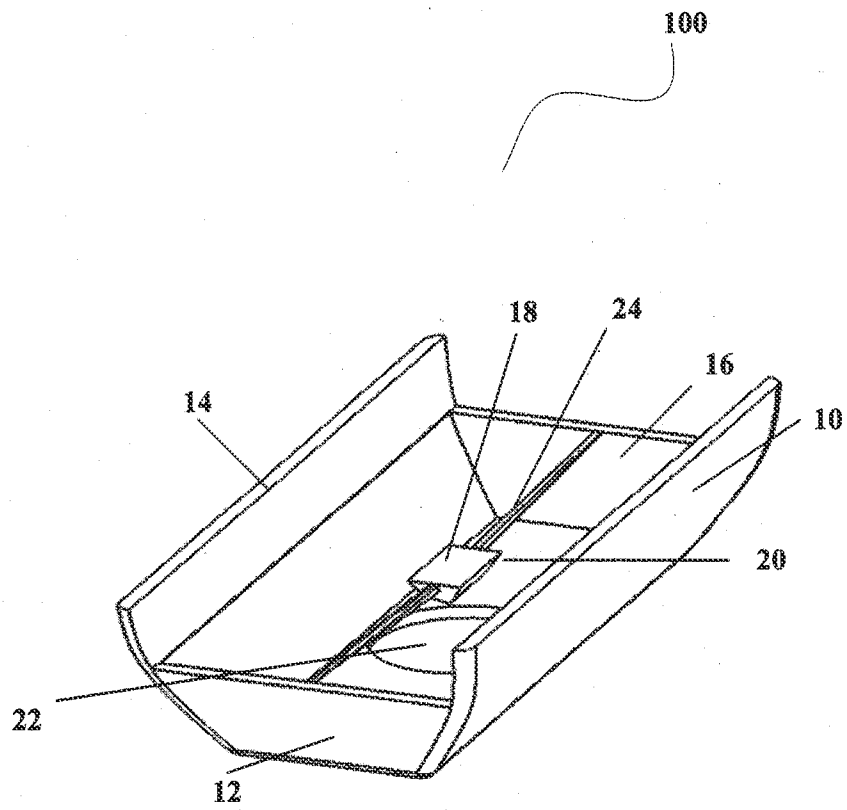


Fig. 1

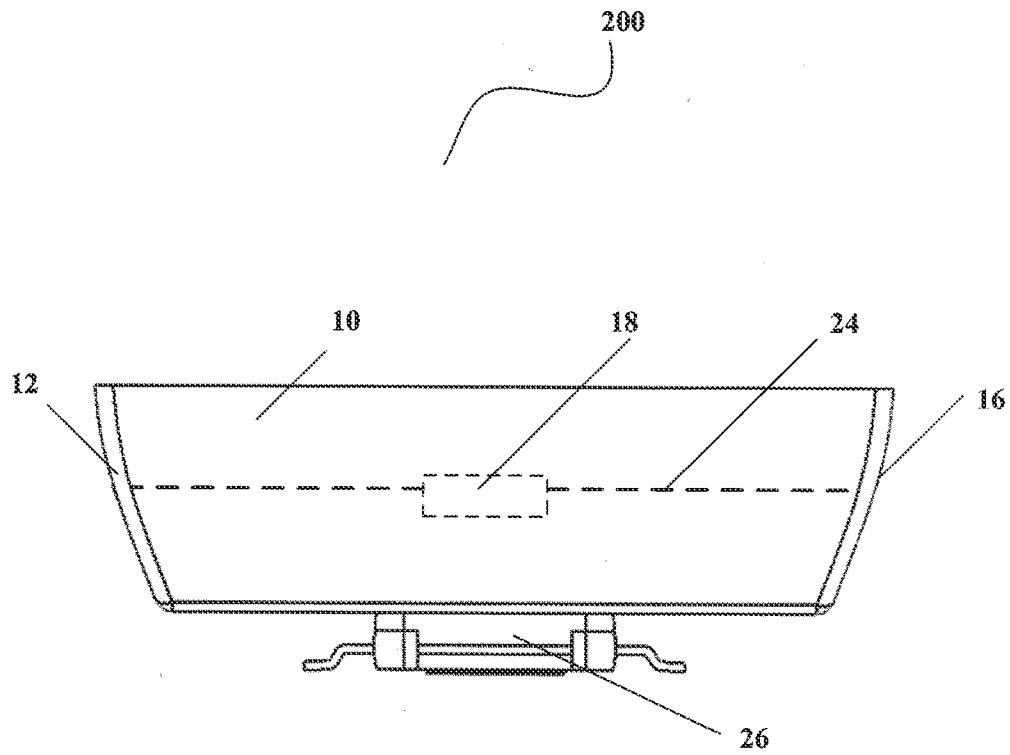


Fig. 2

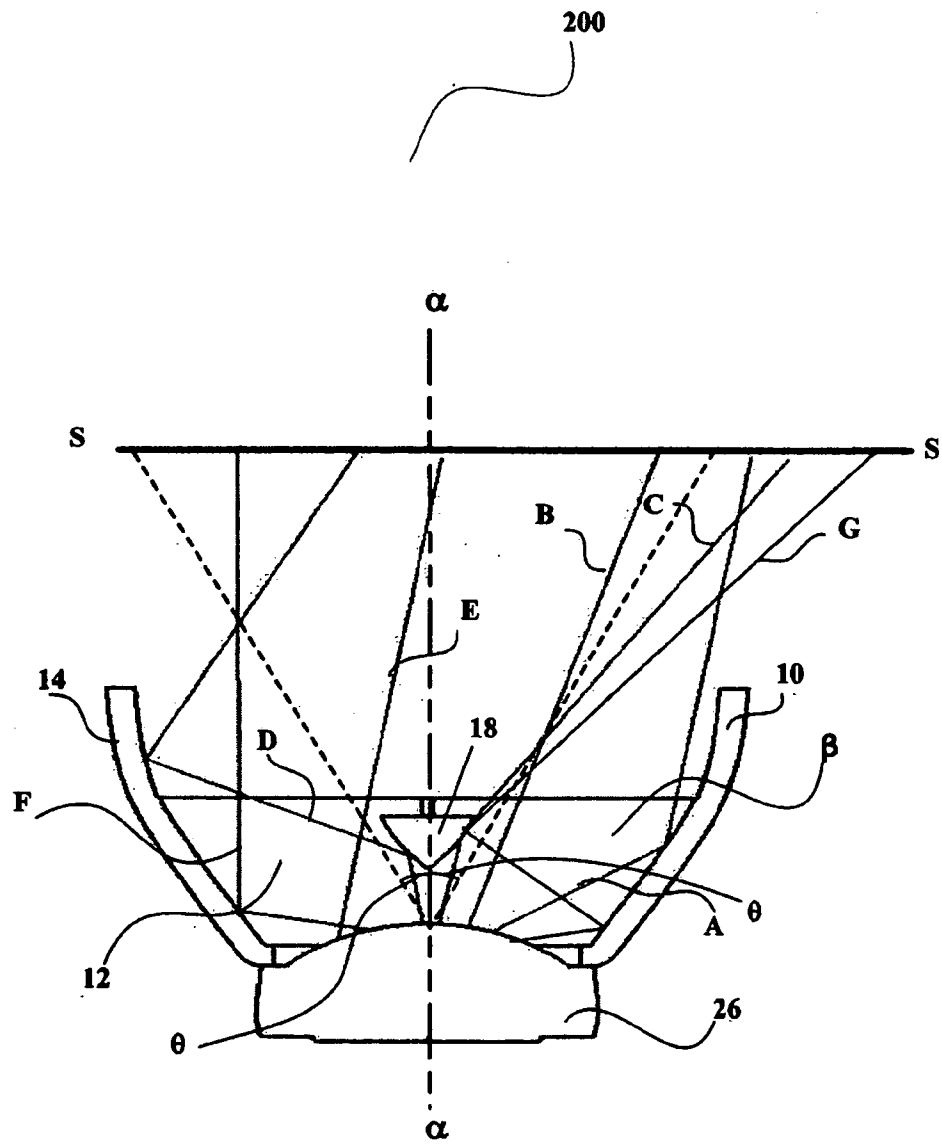
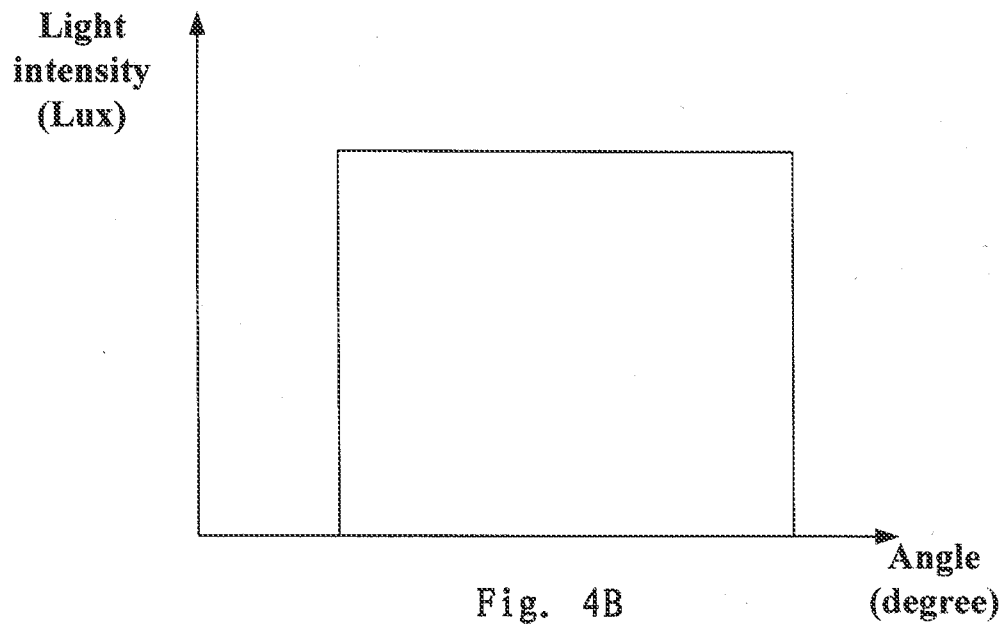
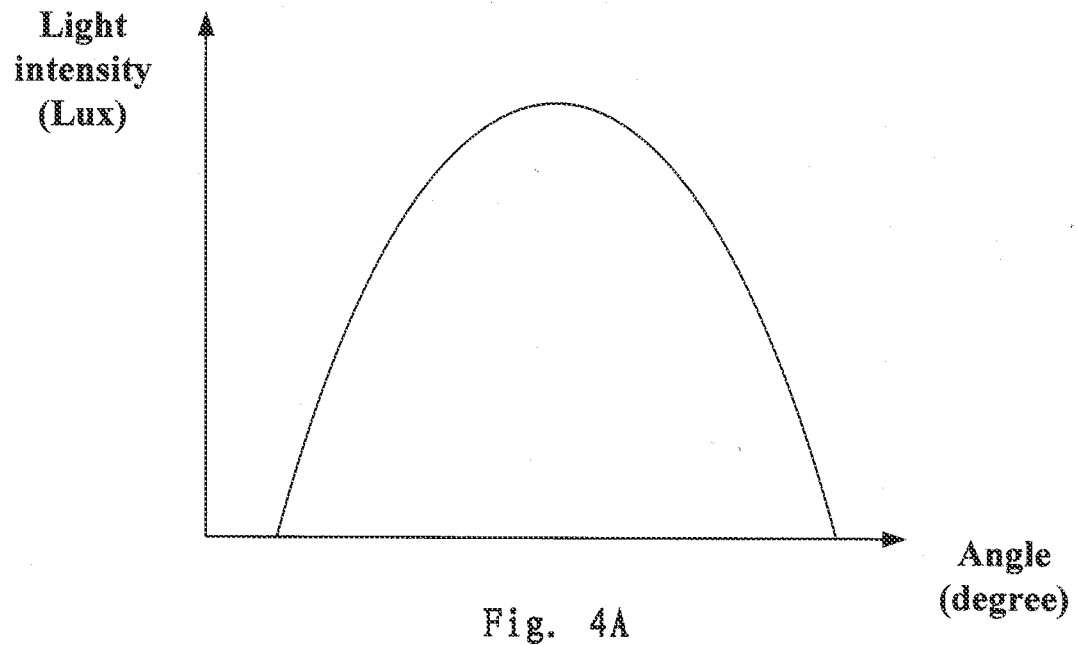


Fig. 3



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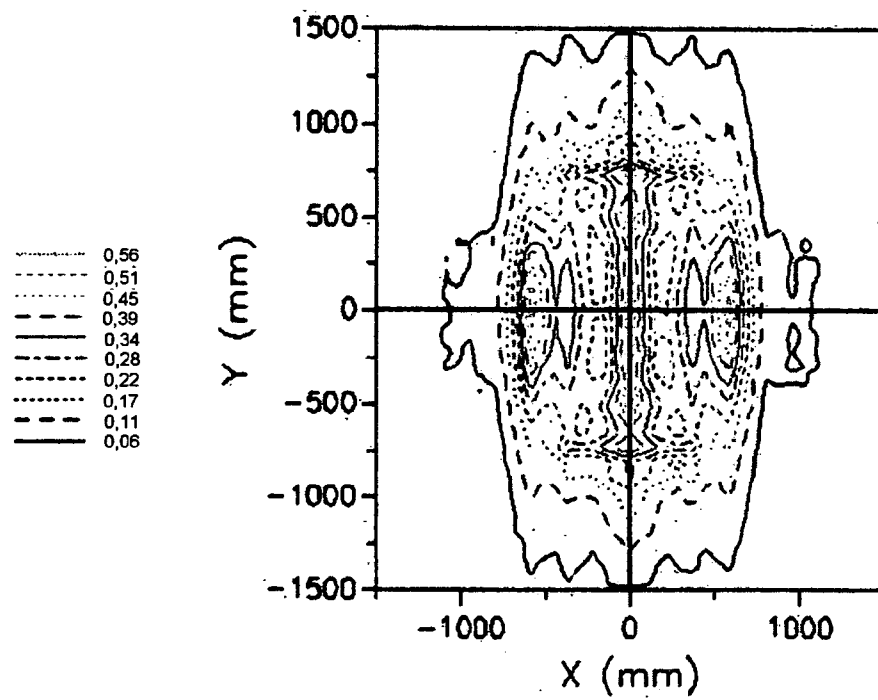
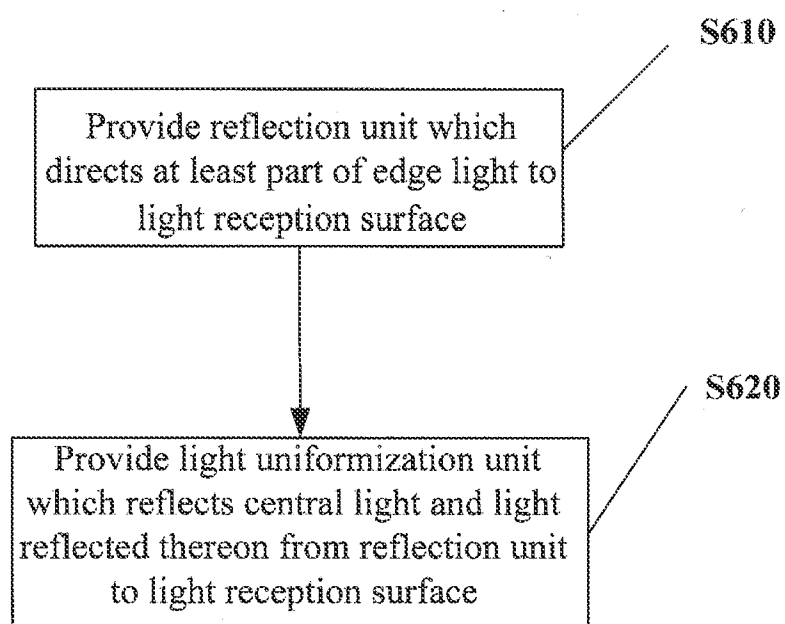


Fig. 5

**Fig. 6**

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2009/067389

A. CLASSIFICATION OF SUBJECT MATTER

INV. F21V7/00 F21V13/04
ADD.

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)

F21V

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.
X	FR 2 913 484 A1 (LYRACOM SARL [FR]) 12 September 2008 (2008-09-12) page 4, line 13 - page 15, line 18 figures 1,15	1-9
X	DE 299 06 717 U1 (ZUMTOBEL STAFF GMBH [AT]) 24 August 2000 (2000-08-24) page 2, line 12 - page 5, line 12 figure 2a	1-9
X	EP 0 369 338 A2 (TRILUX LENZE GMBH & CO KG [DE]) 23 May 1990 (1990-05-23) column 4, line 14 - column 6, line 54 figures 3,4,6	1-9
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☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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Date of the actual completion of the international search

19 April 2010

Date of mailing of the international search report

28/04/2010

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INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2009/067389

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category ²	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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E	DE 20 2009 006291 U1 (LI CHIA MAO [TW]) 25 February 2010 (2010-02-25) paragraph [0002] - paragraph [0012] figures 2-5 -----	1-9

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2009/067389

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