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Remarks:
Amended claims in accordance with Rule 137(2) EPC.

(54) High Efficiency LED lighting unit

(57) A LED (Light Emitting Diode) Lighting Unit, which can be installed in a new luminaire or mounted as a retro-fit lamp in existing devices. Complete with necessary optic system, heatsink for heat dissipation and power supply, allows direct replacement of conventional lighting devices, with better illumination and energy saving performances.

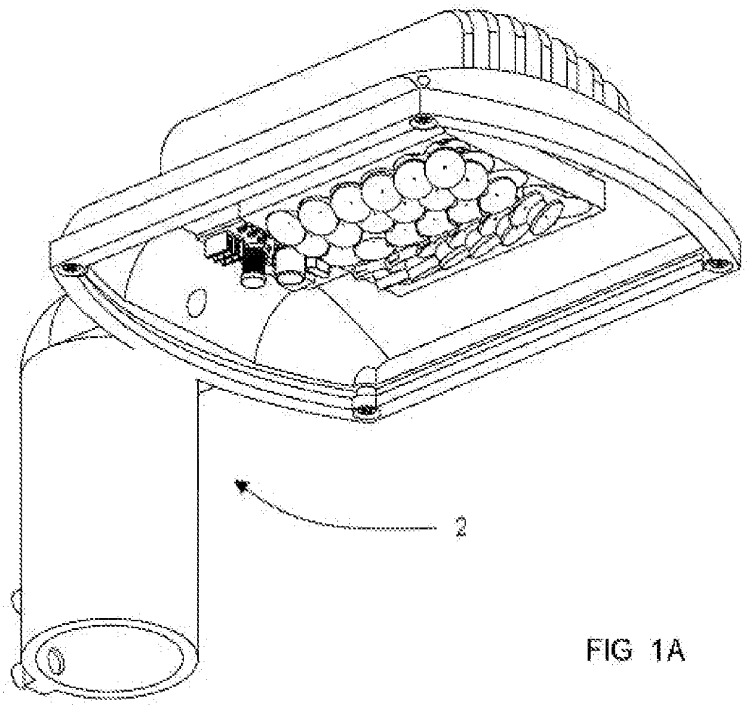

FIG 1A

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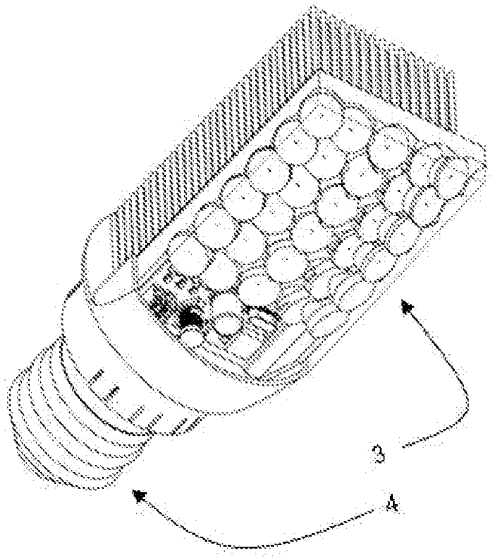

FIG 1B

Description

[0001] The present invention relates to a Lighting Unit with high brightness power LEDs (Light Emitting Diode), for general illumination of outdoor and indoor areas. In particular the present invention relates to roadway and wide area lighting.

[0002] The evolution in opto electronic technology allows to reach a continuously increasing light efficiency of LED devices, thus making it possible their use in general lighting and wide area lighting applications. In addition to higher light efficiency, main benefits of Light Emitting Diodes are: extremely long life, less maintenance costs, high reliability, lower disability glare, lower light pollution, better chromaticity range, higher overall efficiency that means energy saving.

[0003] The innovations mentioned in the present document grant all these benefits and improvements in extremely small size: that means a LED lamp design able to replace the standard lamps without replacement of the complete existing luminaire. Furthermore, the reduced dimensions of this Lighting Unit allow to replace old luminaires with a new and smaller one with better illumination performances. In fact, reduced dimensions and optic elements designed for each LED of the cluster, with a combination of reflectors and non-imaging lens, allow to obtain an optimized photometric solid, based on specific requirements such as uniformity, low disability glare, low light pollution etc.).

[0004] The present invention relates to lighting devices for general illumination. In particular, present invention concerns replacement of conventional lamps with innovative ones based on a cluster with a certain number of opto semiconductors (LED - Light Emitting Diode) with high luminous flux. Exact number of LEDs depends on total luminous flux required by the application and depends on LED type. Furthermore the present invention proposes the replacement of a conventional lighting device (luminaire) with one containing a LED Lighting Unit, with better lighting performances, therefore energy saving, and reduced dimensions.

[0005] High Efficiency LED Lighting Unit includes the following sub components:

1) A cluster construction unit where a certain number of LEDs are installed (light emitting diodes as naked chips or packaged);
2) A substrate which grants thermal dissipation (in order to keep LED junction temperature within the working limits) and galvanic insulation;
3) Dedicated Optic system per each LED;
4) High efficiency electronic power supply; This LED Lighting Unit can be installed into a specific lighting and heat sinking device (luminaire) to be mounted on the top of a pole or into a mechanic housing with standard Edison base or non-standard base (retrofit lamp). Both variants are completed with a secondary optic element which provides chemical/physical protection, mechanic/electric shield.

[0006] The High Efficiency Lighting Unit based on solid state lighting technology (LED - Light Emitting Diode) can replace conventional lighting sources (incandescent, halogen, fluorescent, high intensity discharge, high pressure etc.).

[0007] The overall efficiency of lighting devices is the major factor in light source evaluation. Overall efficiency is strongly influenced by the optic design, in particular the portion of all generated light which is useful for a given application. Using radial sources in roadways illumination, for example, the light intensity has to be balanced in order to have luminance and illuminance uniformity over the flat roadway surface. Application of LED clusters allows to have a light intensity divided on several punctual sources. Such intrinsic feature, associated with primary optic designed with dedicated reflector and lens per each single LED, helps to trace an optimized photometric solid of the lamp, based on specific requirements (uniformity, low disability glare, less lighting pollution etc.).

[0008] The optic system, designed according to Non-imaging optics (NIO) principles, optimizes the light radiation from the source to the target.

[0009] Most conventional light sources (incandescent, halogen, fluorescent, high discharge, high pressure etc.) are by their own nature almost omnidirectional sources, and several reflection/refraction phases are required to obtain a kind of light flux directionality. The NIO optic system described in the present invention foresees only one reflection and a smooth refraction, minimizing the loss of light intensity associated to the optic system.

[0010] The thermal system concerns a substrate which grants electrical connection of live parts, electrical insulation between heatsink and live components, and , on the other hand, achieves the necessary dissipation of the heat generated by normal working of LEDs and electronic components. The LEDs should also be mounted on specific heat spreaders made by high thermal conductivity material, which improves the thermal efficiency of the system. Additionally, a high efficiency heatsink allows to decrease the temperature thanks to natural (free) convection or forced air ventilation. In the luminaire installation the lighting device main body provides itself to the necessary heat transfer with the ambient air.

[0011] High power LEDs require to be driven with the right current/voltage. A proper high efficiency power supply exploits the same thermal system described before to reach this target, with electronic components mounted onto a proper substrate.

[0012] Moreover, a mechanic disjunction system is required for the lamp installation of the LED Lighting Unit (so called retro-fit lamp), in order to reach the right orientation of the luminous flux to the surface to be illuminated.

[0013] A clear understanding of the various advantages and features of the present invention, as well as the contruction and operation of conventional components

and mechanisms associated with the present invention, will become more readily apparent by referring to the examplary, and therefore non-limiting, embodiments illustrated in the following drawings which accompany and form a part of this patent application.

FIG 1A is an isometric view of a lighting device **2**, with inside mounted the LED Lighting Unit according to the present invention.

FIG 1B shows an isometric view of a lamp mounted with the LED Lighting Unit according to the present invention, with a standard Edison base, in retro-fit configuration, to be installed in already existing luminaries. The mentioned Edison base is an example and therefore non-limiting the use on other standard and non standard bases or plugs. In FIG 1B the two main elements are shown: the base **4** and the lamp body **3.**

FIG 2A shows an exploded view of the main subcomponents of the luminary: how the LED Lighting Unit **1** has been installed inside the lighting device body **21.**

FIG 2B shows, through an exploded view, the lamp main elements: the LED Lighting Unit **1** has been mounted on the heat sink **32.** A transparent cover **31** and a disjunction element **5** complete the lamp.

FIG 3A is a further exploded view of the LED Lighting Unit, showing how the LEDs **102**, the substrate **101**, the primary optic system **103**, **104**, and the power supply **105** are installed inside the lighting and heatsinking device body **21.** The secondary optic **23** closes and protects the assembly, and it is fixed by means of a ring **24** and screws **25.**

FIG 3B is a further exploded view of a lamp construction accomodating the LED Lighting Unit. In this case the substrate **101** containing the LED cluster **102** is mounted onto a heasink **32**, together with the power supply **105;** the heatsink is than fixed to the tubular element **51.** The lamp body is completed by the primary optic system **103**,**104**, and by the transparent cover **31.**

FIG 4A is a cross longitudinal section view showing the LED chips or the packaged LEDs **102**, the substrate **101** and the electronic power supply **105** installed inside the lighting device **21** which has also a heat dissipation function. The lighting device **21** is placed on the top of luminary pole **60** and fixed through the locking system **26.** The primary optic includes the elements **103**, **104.** The secondary optic complete the luminary with elements **23**, **24**, **25.**

FIG 4B is a cross-sectional view highlighting the reciprocal position of sub components: the LED chips or packaged LEDs **102** are organized in a cluster and mounted on a substrate **101**, as well as electronic components **105** of the electronic power supply which adapts/converts the input voltage and current into the right output values to drive the LEDs. The substrate **101** is electrically insulated but thermally conductive towards the heatsink **32**, and it should be made by any material with high thermal conductivity and high insulation power. On the substrate containing LEDs, a related cluster of parabolic reflectors **103** is placed. Together with a cluster of lenses **104,** this is the primary optic system of the Lighting Unit. It is completed with a transparent cover **31** which has double function of secondary optic and sealing for all the electrical components. The tubular element **51** is fixed on the heat sink **32** and, together with toothed wheel **53**, the spring **52** and the thread cut end-cup base **54**, defines the disjunction system **5.** This disjunction system grants the free relative rotation of the lamp body **3** to the base **4**, allowing the correct positioning of the lamp to the target surface to be illuminated.

FIG 5 describes in detail the main components of the optic system **103** and **104.** The LED lighting source **102** is coincident to the focus of the parabolic reflector **110**, in order to collect all lighting rays in a defined direction and to prepare the light flux for the lens **111** and for the secondary optic **31.** Each lens is designed specifically for the lighting path associated to the relevant LED source.

FIG 6 shows the Polar candela distribution plot for the LED Lighting Unit of the present invention and an example of the relevant illuminance map.

FIG 7 shows the high efficiency AC/DC converter **105** with galvanic insulation; this power supply drives the LEDs **102** connected in some serial/parallel strings. The LED chips are connected by means of wire bonding **112** directly on a top layer and soldered or glued on a specific substrate which provides electrical connection, high thermal conduction and high insulation power towards the heatsink (for example: ceramic substrates, thick film technology, insulation layer(IMS), thermally conductive adhesive layer).

FIG 8 shows the technical solution in case of packaged LEDs assembly. These LEDs can be soldered or glued directly on the heatsink through a specific slug; furthermore the electric connection should be made by one or more dedicated layers **113.**

In **FIG 9** it can be seen how the lamp body **3** is able to rotate towards the base **4.** Such reciprocal rotation is necessary to allow the angular position tuning of lamp body **3** while the base **4** is completely screwed

in the socket. In fact, in this condition the base **4** is locked into the lighting device but the body lamp **3** can be rotated in order to reach the desidered position (for example parallel to the roadway surface).

[0014] On structural point of view the tubular element **51** is fixed on the lamp body **3**, and, simultaneously, it engages the toothed wheel **53** fixed on the base **4.** Such coaxial assembly of components **51** and **53** grants the required mechanical resistance over flexion and axial loads.

[0015] During screwing or unscrewing of the lamp, the teeth **531** of the ring **53** are engaged with tooth **511** of the tubular element **51.**

Claims

1. High Efficiency LED Lighting Unit, comprising:

a. Flat base structure built with at least one substrate with high thermal conductivity able to dissipate heat and eventually to arrange the electrical connection. The above said flat base structure is able to receive at least one light emitting diode semiconductor (LED) in packaged version, eventually connected to an overlaid layer.
b. High efficiency electronic power supply able to take advantage of the heat sink said at point 1.d for the heat dissipation;
c. Dedicated optic system per each single LED.
d. Thermal system for heat dissipation, eventually including a fan for the forced air ventilation, or different cooling system such as fluid cooling, phase change, Peltier cells, heat pipes etc.

2. The same device claimed at point 1, wherein the thermal system for heat dissipation said at point 1.d is replaced by said lighting device body **21**, and furthermore the said secondary optic is substituted by elements **23**, **24**, **25.**

3. Device claimed at point 1, wherein said LEDs at point 1.a are naked chips connected through wire bonding to a specific dedicated layer.

4. Device claimed at point 2, wherein said LEDs at point 1.a are chips connected through wire bonding to a specific dedicated layer.

5. Device claimed at point 1, wherein packaged LEDs said at point 1.a should be soldered or glued directly on the said heatsink.

6. Device claimed at point 1, wherein the said LED chips at point 3 should be soldered or glued directly on the said heatsink.

7. Device claimed at point 3, wherein the said chip LEDs should be soldered or glued on at least one heat spreader made of high thermal conductivity material in order to improve the thermal response of the system.

8. Device claimed at point 1, equipped with any standard or non standard base for lighting lamp.

9. Devices claimed at point 1 and 3 equipped with mechanic fixing/locking system according FIG 9.

Amended claims in accordance with Rule 137(2) EPC.

1. A lamp construction comprising:

a high efficiency LED lighting unit (1) mounted on a heat sink (32),
a transparent cover (31) and
a disjunction element (5),

wherein
the high efficiency LED lighting unit (1) comprises:

A flat base structure built with at least one substrate (101) with high thermal conductivity able to dissipate heat and arrange electrical connection,
LED chips or packaged LEDs (102) organized in a cluster and mounted on substrate (101) and Electronic components (105) of high efficiency power supply also mounted on substrate (101),
Characterised in that the high efficiency LED lighting unit also comprises a related cluster of parabolic reflectors (103), placed on substrate (101) toghether with the cluster of lenses (104) forming a dedicated optic system for each single LED; and
The disjunction system (5) comprises a thread cut end-cup base (54), a spring (52), a tubular element (51) fixed on the heat sink (32) of a lamp body (3) of the lamp construction, and a toothed wheel (53) which is fixed on a base (4) of the lamp construction, wherein the lamp body (3) is able to rotate towards the base (4) allowing angular position tuning of the lamp body (3) while the base (4) is completely screwed in a socket, and the tubular element (51) engages the coaxially assemble toothed wheel (53) so that during screwing or unscrewing of the lamp, teeth (531) of the toothed wheel (53) are engaged with a tooth (511) on the tubular element (51) .

2. The same lamp construction claimed at point 1, wherein the high efficiency LED lighting unit (1) comprises, in place of the substrate (101), at least one

metal stripe (heat spreader) onto which are attached (soldered or glued) LED chips or packaged LEDs. This metal stripe(s) is attached on the top of a heat-sink (32) by means of a thin thermally conductive material with electrical isolation properties. The metal stripe (heat spreader) provides also electrical connection for a cluster of LEDs arranged onto it.

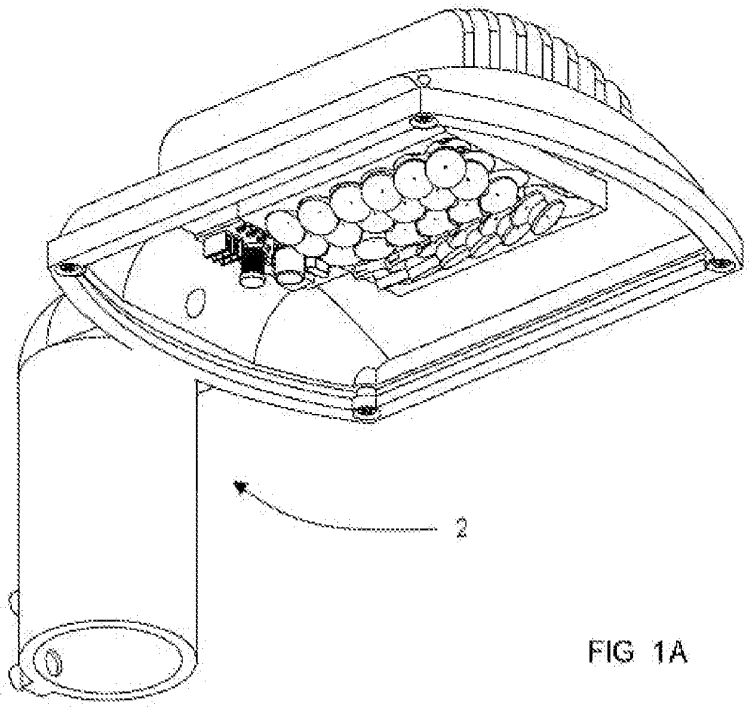

FIG 1A

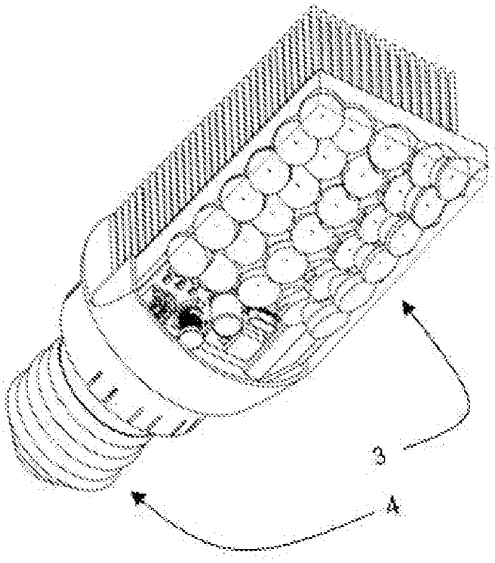

FIG 1B

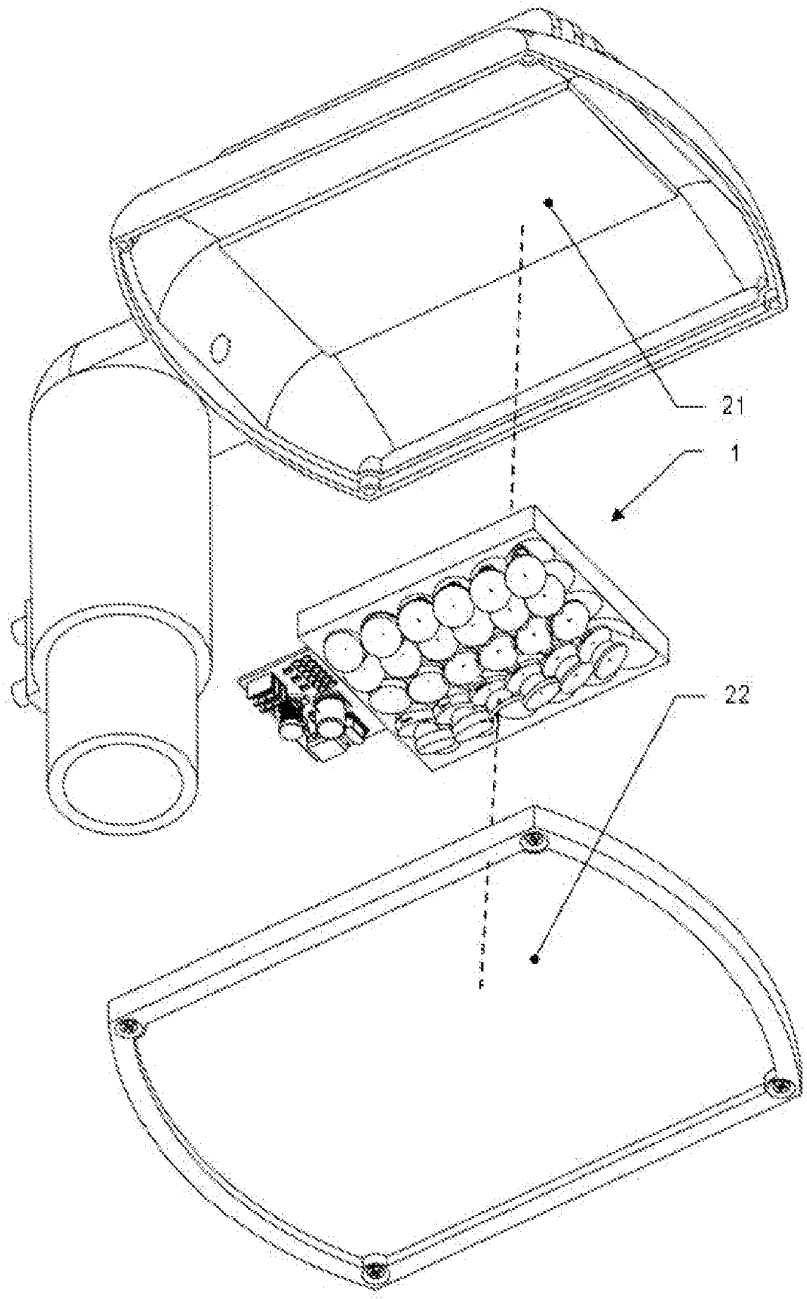

FIG 2A

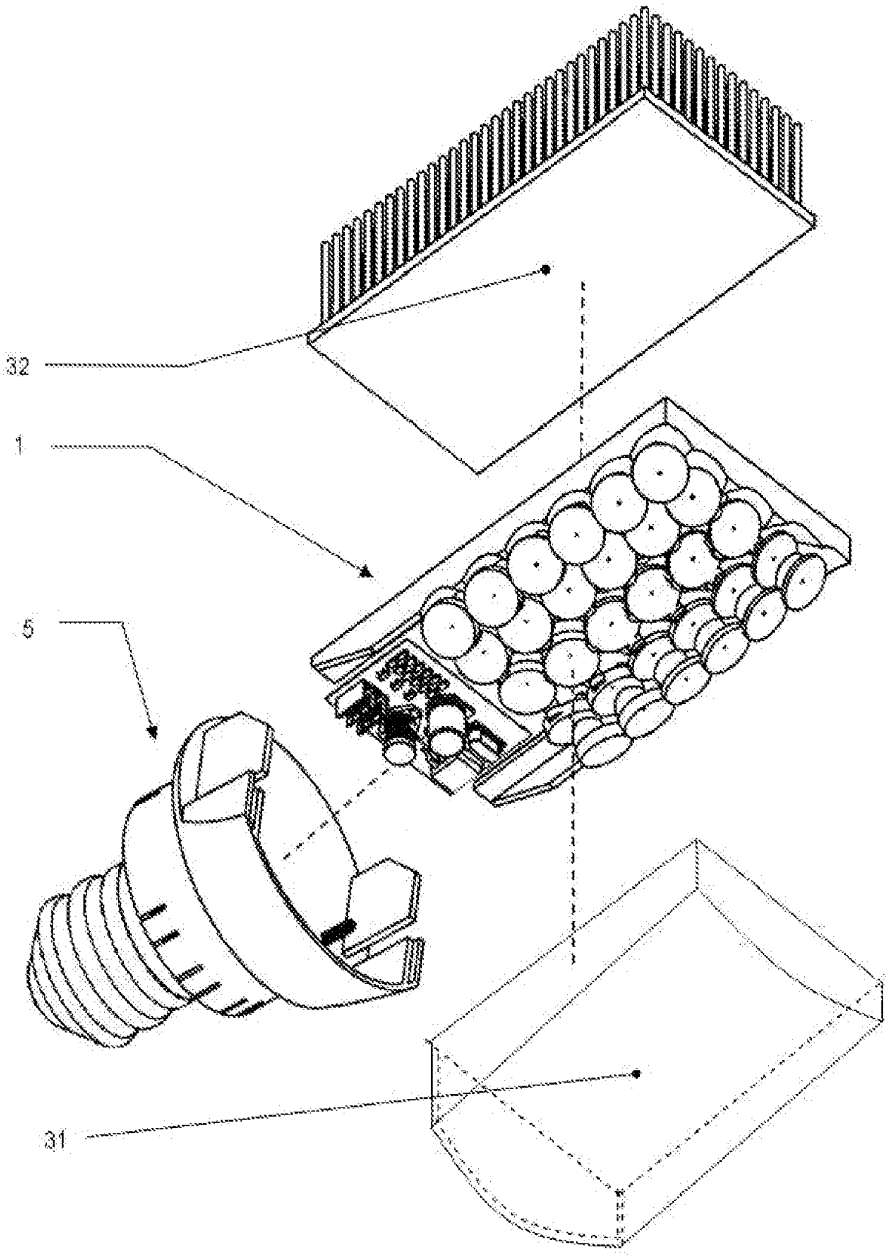

FIG 2B

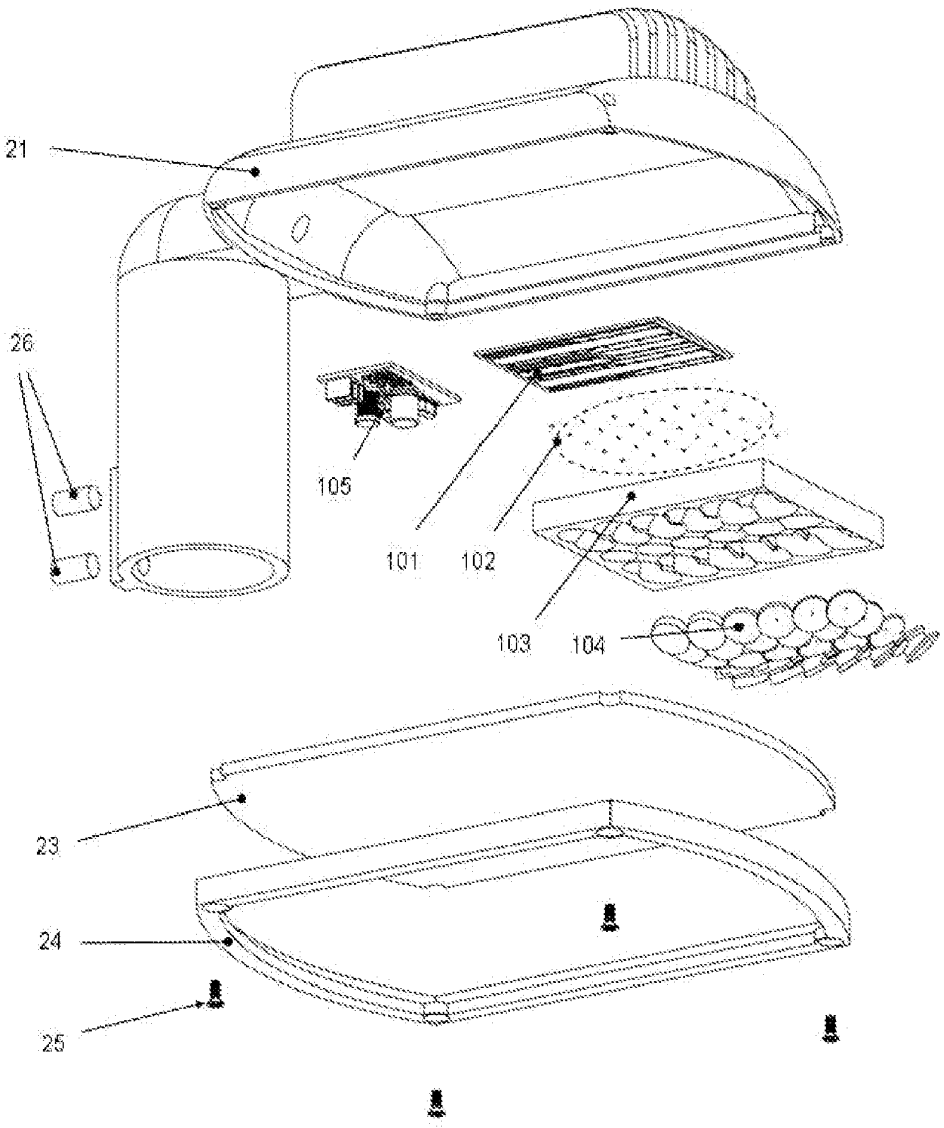

FIG 3A

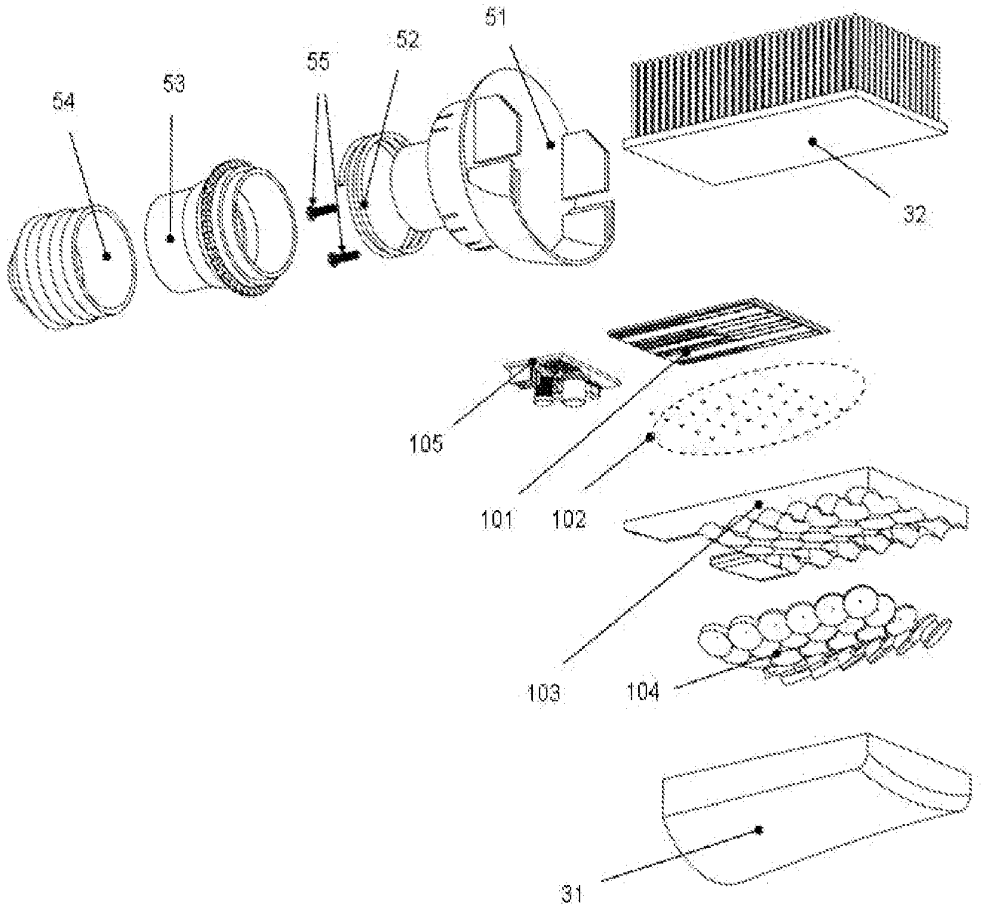

FIG 3B

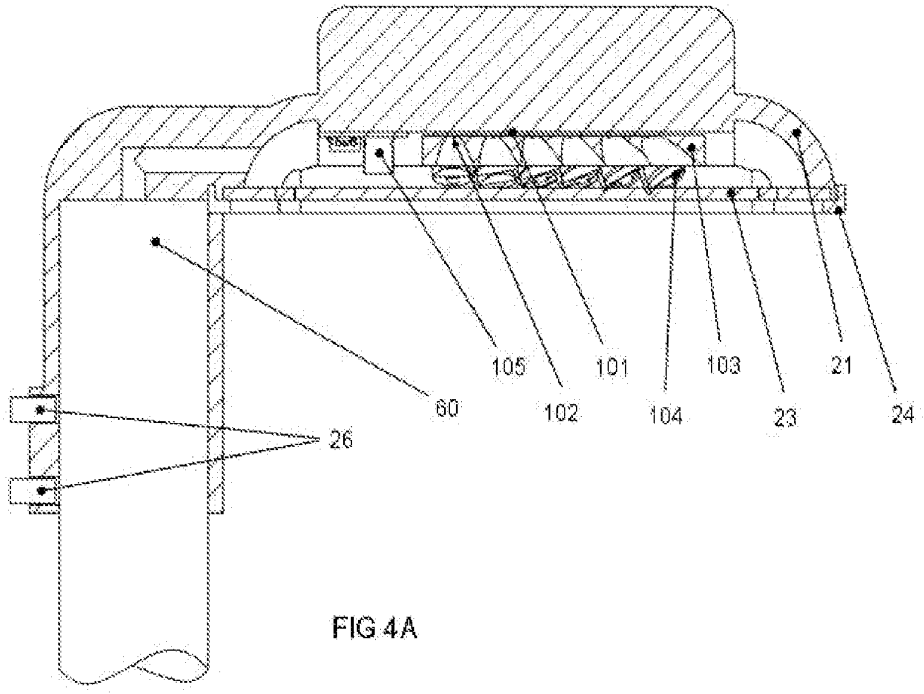
105
101
103
21
60
102
104
23
24
26

FIG 4A

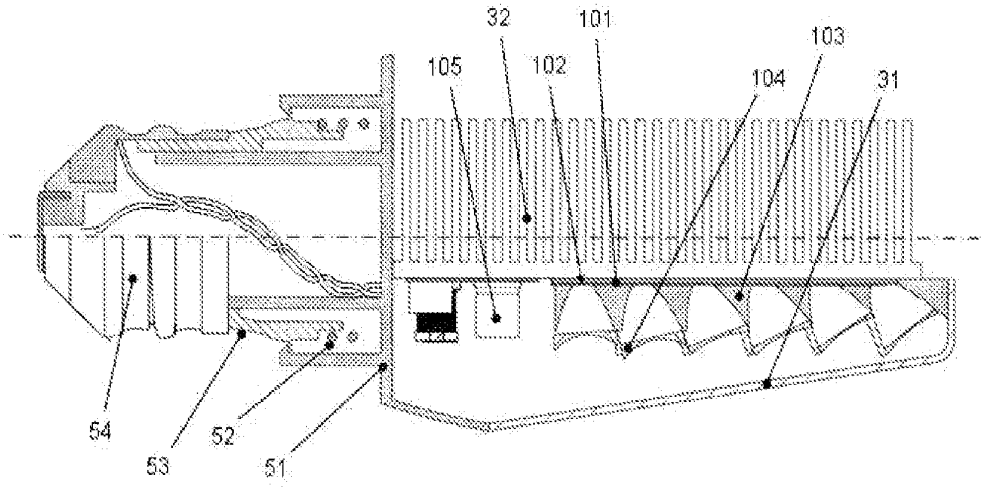
32
101
103
105
102
104
31
54
53
52
51

FIG 4B

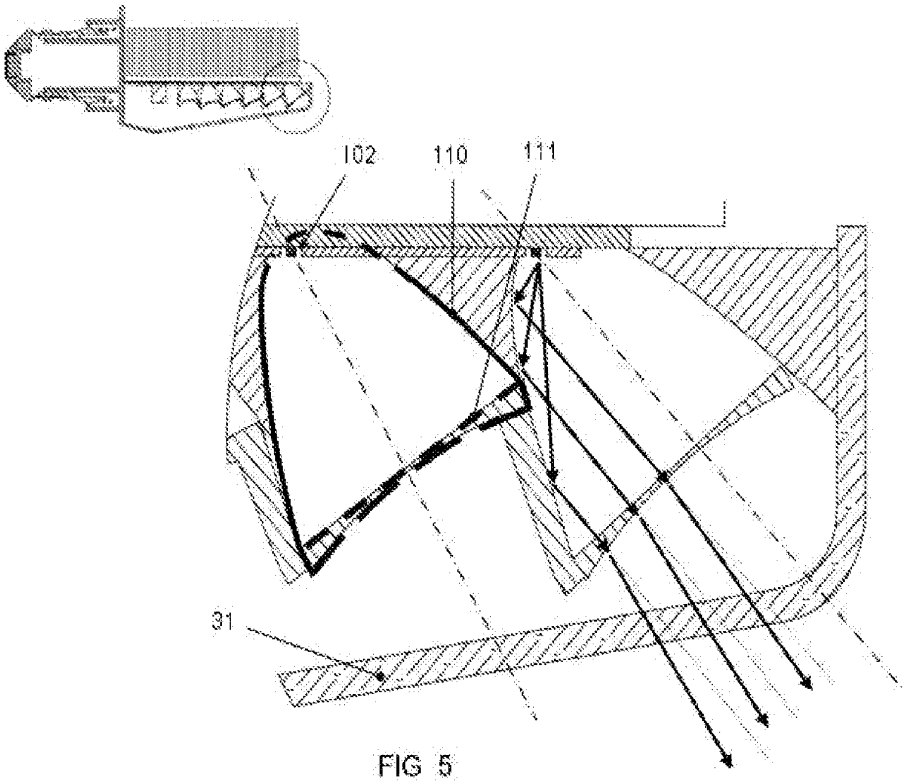

FIG 5

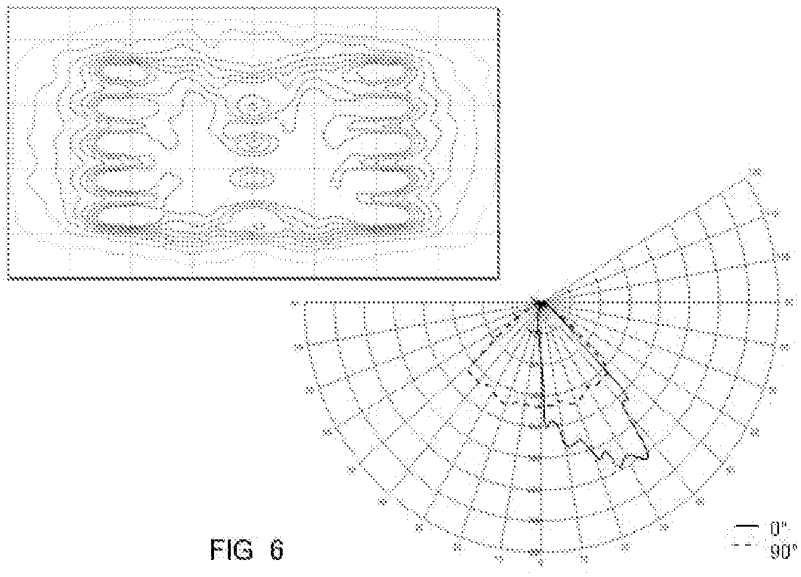

FIG 6

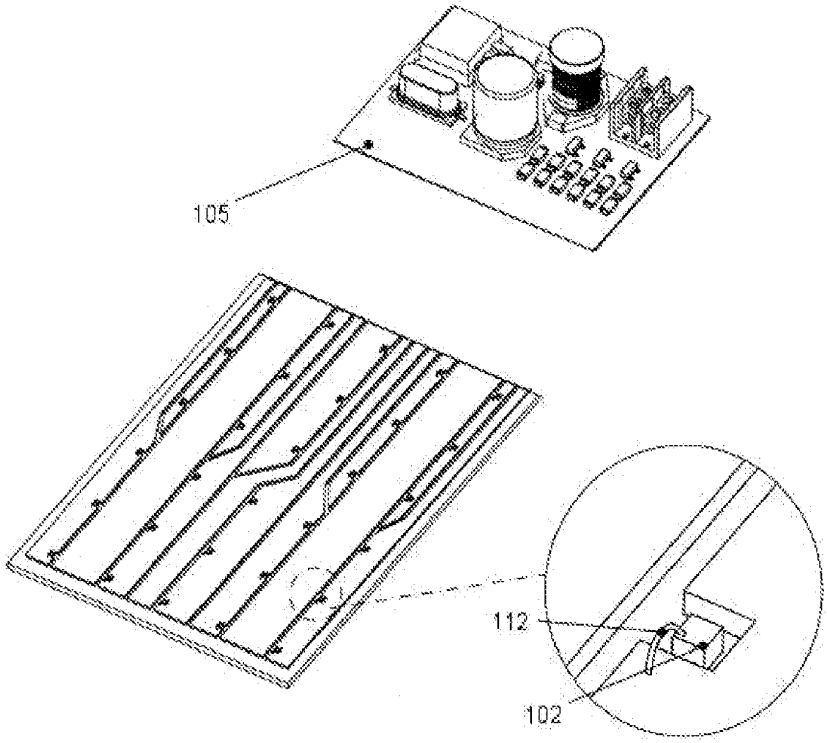

FIG 7

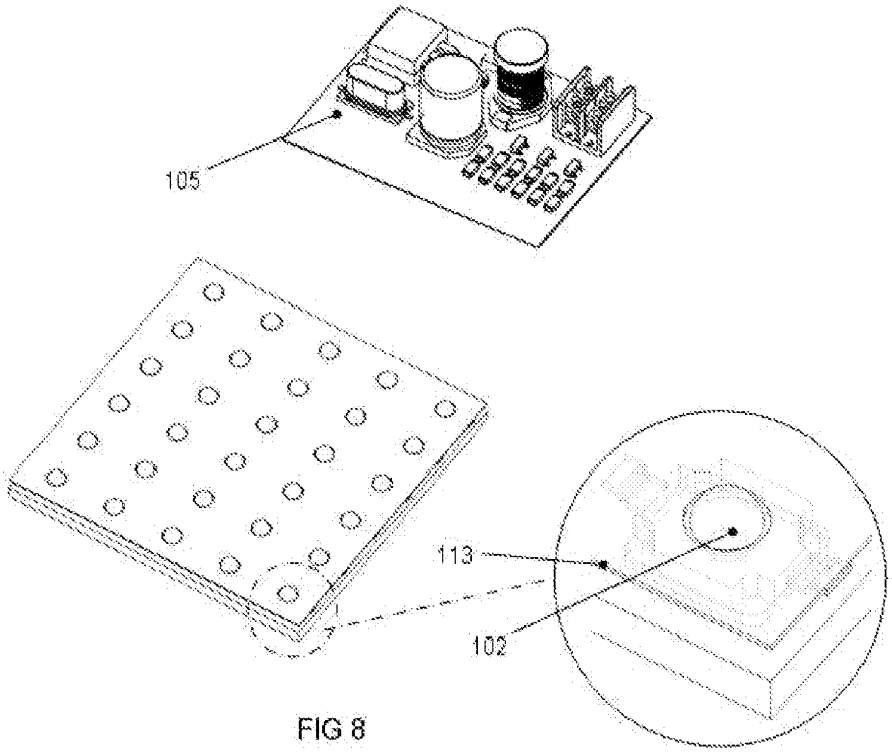

FIG 8

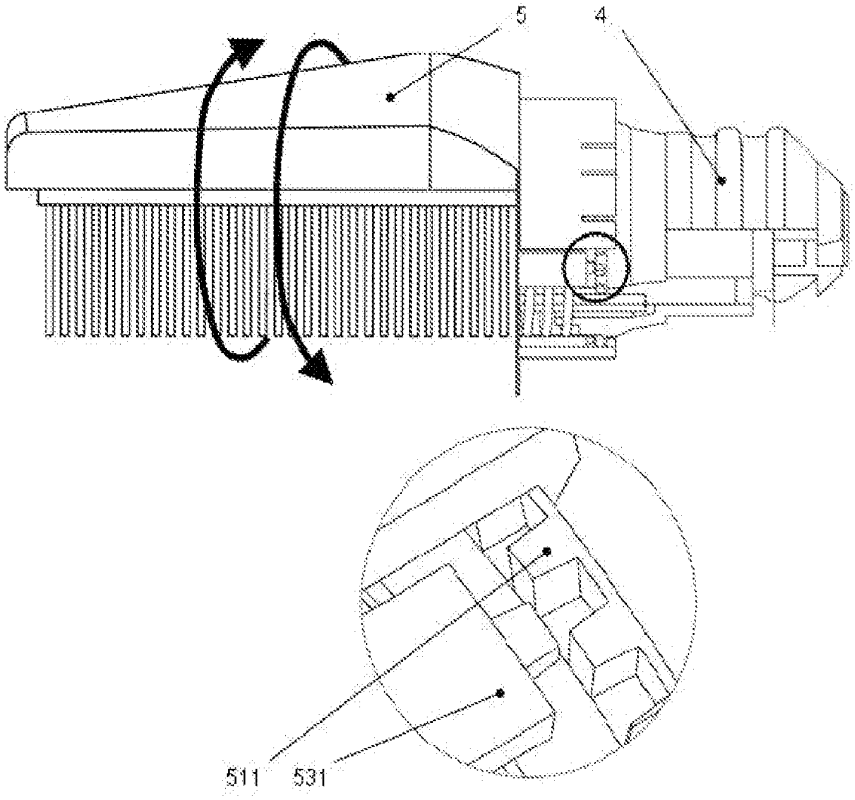

FIG 9

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EUROPEAN SEARCH REPORT

Application Number
EP 08 16 1584

DOCUMENTS CONSIDERED TO BE RELEVANT

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X	WO 2008/055422 A (SHENZHEN GASUN ENERGY TECHNOLO [CN]; WANG JI AN [CN]) 15 May 2008 (2008-05-15) * abstract; figures 1,3 *	1-9	INV. F21S8/08 F21V21/14 ADD. F21Y101/02 F21W131/103
X	EP 1 760 393 A (NURIPLAN CO LTD [KR]) 7 March 2007 (2007-03-07) * paragraph [0034] - paragraph [0045] * * figures 3,7 *	1-9	
X	US 7 338 186 B1 (WU CHUNG [TW] ET AL) 4 March 2008 (2008-03-04) * column 2, line 16 - column 3, line 29 * * figures 1-4 *	1-9	
E	WO 2008/100124 A (VARGAS MACIEL LAURA PATRICIA [MX]) 21 August 2008 (2008-08-21) * abstract; figures 1-5,20 *	1	
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	27 November 2008	Allen, Katie

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 08 16 1584

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27-11-2008

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