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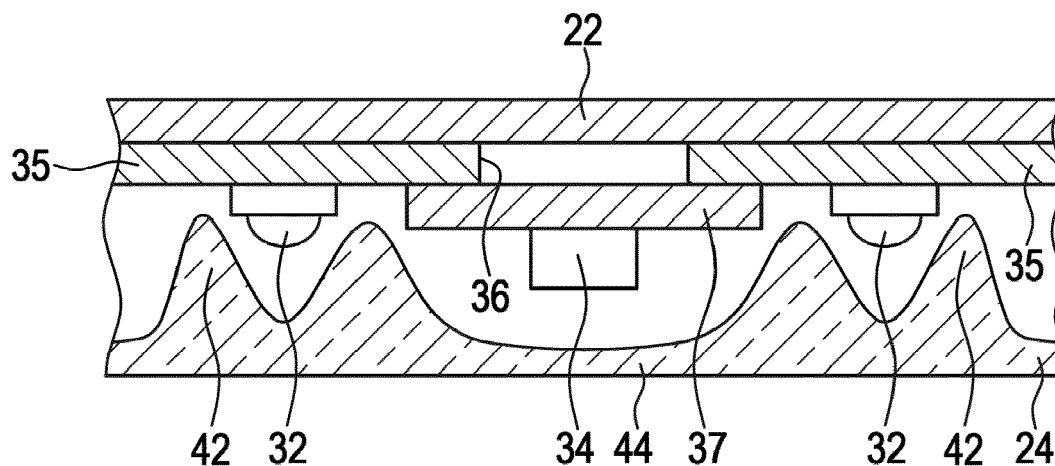
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(54) **Lamp with integrated camera**

(57) A lamp with a support for at least one light source and at least one image sensor having beam forming means for directing light from the light source into some direction to obtain a given light distribution and at least

one optical imaging element for projecting images onto the image sensor can be very efficiently produced, if the beam forming means and the optical imaging element are supported by a common carrier.

Fig. 9



Description

Field of the invention

[0001] The invention relates to a lamp for example for lighting a street, a place or the like. The lamp has a support, supporting at least one light source and at least one image sensor. Beam forming means direct light from the light source to obtain a given light distribution. The lamp further comprises at least one optical imaging element for projecting images onto the image sensor.

Description of the related art

[0002] CN 200920013082 discloses a street lamp with a housing. The housing has an opening into which a surveillance camera is fitted. For mounting the lamp with the camera it is sufficient to attach the housing to a lamp post and to provide the electrical connections.

[0003] US 2009/0185376 discloses a street lamp. The street lamp has a housing with a transparent cover. In the housing is a printed circuit board supporting a light source and an image sensor of a camera. The camera has a casing for positioning a lens group in a defined distance to the image sensor of the camera.

Summary of the invention

[0004] The invention is based on the observation that the integration of the camera in a common housing with the components for lighting the street like lampshade, light source and the like as suggested in US 2009/0185376 facilitates the production and operation if compared to the suggestion of CN 200920013082. The problem to be solved by the invention is to provide a lamp with an integrated camera and further reduced manufacturing costs.

[0005] Solutions of the problem are described in the independent claims. The dependent claims relate to further improvements of the invention.

[0006] The lamp comprises at least a support, supporting at least one light source and at least one image sensor. The lamp has at least one beam forming means for directing light emitted by the light source to obtain a given light distribution. The beam forming means may be for example a lens and/or a reflector. The lamp further comprises at least one optical imaging element for projecting images from outside the lamp onto the image sensor, for example a lens and/or an aperture. The beam forming means and the optical imaging element are arranged on a common carrier. This permits an easy manufacturing of the lamp, because it is sufficient to place the beam forming means and the optical imaging element on the common carrier and to position the common carrier relative to the light source(s) and the image sensor. The common carrier is a common reference for the orientation of the beam forming elements and the optical imaging element, thus the respective optical axes are aligned by

design when placing the beam forming elements and the optical imaging element on the common carrier. The adjustment of the optical axes is thus included in the assembly step and a subsequent manual alignment of the camera with the light beam of the light source subsequent to the assembly of the lamp is avoided.

[0007] The lamp preferably comprises a housing with at least one housing body and an at least partially transparent cover.

[0008] The light source can be a LED and is preferably mounted on a printed circuit board. The support may support for example multiple LEDs. Some of the LEDs may have different emission spectra. For example may some (at least one) LED emit visible light and some (at least one) other LED emit IR-light. The image sensor may be mounted on the same printed circuit board, serving as support. Printed circuit boards typically have a body of some non conducting material, like for example some epoxy compound. The printed circuit board may alternatively comprise a metal body or core to provide an efficient heat transfer from the LEDs to e.g. some heat sink. The heat sink can be integrated in the housing body.

[0009] The support may preferably comprise a thermally conducting layer or area supporting the at least one light source and a thermally insulating layer or area, for example of some epoxy compound, supporting the image sensor. On the one hand this allows an efficient cooling of the light source and on the other hand to avoid a direct transfer of heat to the image sensor, thereby enhancing the signal to noise ratio in the signal provided by the image sensor. Thermally insulating is any material that provides a lower heat conductivity as the thermally conducting layer or material supporting the at least one light source. Thus in one example, the LED(s) as light source(s) could preferably be mounted on an area of the support that comprises a metal layer for transferring heat from the light source(s) to some heat sink and an area of some plastic, e.g. epoxy compound, supporting the image sensor to thermally decouple the light source(s) from the image sensor.

[0010] The thermally conducting area is preferably in a surface-to-surface connection with a heat sink, for example a housing body. The thermally insulating area is preferably not in a surface-to-surface connection with the heat sink. In particular if the rear surfaces of the thermally conducting area and thermally insulating area are in a common plane, it is preferred if the heat sink has an at least substantially plane surface being in surface-to-surface contact the thermally conducting area and a recess spanning over the rear side of the thermally insulating area. Thereby, heat from the light source(s) may be dissipated via the heat sink and at the same time the heat transfer to the at least one image sensor may be reduced, yielding longer lifetime of the light source(s) and an enhanced signal to noise ratio of the image sensor.

[0011] The at least one light source and the at least one image sensor may be mounted to a common printed circuit board. The printed circuit board may comprise a

first layer with a first thermal conductivity coefficient κ_1 (e.g. $\kappa_1 \geq 0,25 \text{ W cm}^{-1} \text{ K}^{-1}$ at 273K). The first layer may include for example a metal core, in particular an aluminum core. On the front side of the first layer may be at least one LED as light source. Thus the heat produced when operating the light source may be transferred to some heat sink, e.g. the housing body, by the first layer. The first layer may have a preferably through hole like opening. The front side and/or rear side the opening may be closed by a second layer with a second thermal conductivity coefficient κ_2 , being smaller than the first thermal conductivity coefficient κ_1 , ($\kappa_2 < \kappa_1$). For simplicity, the first layer can be considered as thermally conducting and the second layer as thermally insulating. For example may the second layer comprise some epoxy compound. The image sensor is preferably be supported by the second layer and thus be thermally decoupled from the first layer. The signal to noise ration of the image sensor is thereby enhanced. In addition stray light from the light sources, falling on the image sensor may be reduced.

[0012] The image sensor may e.g. be a CCD (Charge - Coupled Device) or a CMOS (Complementary Metal Oxide Semiconductor) image sensor.

[0013] In a preferred embodiment are the light source (s), the image sensor, the beam forming means and the optical imaging element for projecting the image on the image sensor arranged on the support. Thus, the support is the common carrier. This permits to use extremely precise and quick pick and place machines for the assembly of the electronic and optical components of the lamp. A later alignment of the optical axis of the light source to the optical axis of the image sensor can thus be avoided.

[0014] The transparent cover may include the beam forming means and the optical imaging element for projecting an image. Thus the transparent cover may be the common carrier. Such a transparent cover can be injection molded with very high precision. As the beam forming means and the optical imaging element for projecting an image are integrated in the transparent cover the number of parts is reduced and their optical axes can be aligned without manually adjusting their positions and/or orientations.

[0015] The transparent cover may have at least one protrusion facing the support. The protrusion is preferably arranged between the optical axes of the image sensor and the light source. These protrusions inhibit or at least reduce reflections of light from the light source by the transparent cover on the image sensor, i.e. stray light.

[0016] In particular if the beam forming means include a lens, the optical imaging element for projecting an image on the image sensor may have the same mapping function and can thus be identically shaped. This further reduces the manufacturing costs. If the mapping function yields a distorted image on the image sensor, the distortion can be corrected by mapping the image obtained by the image sensor with the inverse the mapping function. It is sufficient to map the image obtained by the image sensor with the inverse of the non linear term of the map-

ping function to reduce the distortions. The correction can be done some microcontroller like a digital signal processor or a computer.

[0017] The lamp may comprise more than one image sensor, for example two or more image sensors. In front of each image sensor is a corresponding optical imaging element. This permits to obtain pictures from two or more perspectives and thereby to enhance object recognition. The object recognition may be used for of traffic surveillance, for example to distinguish between different types of vehicles, like cars, trucks, motorcycles, bicycles and the like. A further application for could be people counting, e.g. at stadium entrances. In addition distances can be calculated.

[0018] At least one of the optical imaging elements may be an asymmetric lens. This permits to capture images of different angular ranges and/or magnifications with the different image sensors, although the image sensors are supported by the common support and the optical imaging elements are as well supported by the common carrier, even if the support and the carrier have plane mounting surfaces.

[0019] The lamp includes preferably driving means for driving the light source(s) and/or the at least one image sensor. These driving means can be integrated on a single chip and/or on at least one printed circuit board. The driving means are preferably thermally isolated from the light source(s), e.g. positioned in a separate compartment. This permits to reduce a heat transfer from the light sources to the driving means. The driving means may accomplish image data processing as well as forwarding the image data to some monitoring or control station. Further, the separate compartment can support the housing.

Description of Drawings

[0020] In the following the invention will be described by way of example, without limitation of the general inventive concept, on examples of embodiments with reference to the drawings.

Figure 1 shows a street lamp.

Figure 2 shows an exploded view of head of a street lamp.

Figure 3 shows a section of a street lamp.

Figure 4 shows detail A of figure 3.

Figure 5 shows a detail of an alternative lamp.

Figure 6 shows a detail of an alternative lamp.

Figure 7 shows a detail of an alternative lamp.

Figure 8 shows a detail of an alternative lamp.

Figure 9 shows a detail of an alternative lamp.

Figure 10 shows a detail of an alternative lamp.

[0021] The lamp 10 in figure 1 is mounted to a lamp post 5 on some ground 4. The lamp 10 has a compartment 12 supporting a housing 20 with a housing body 22 and a transparent cover 24 (cf. fig. 2 to 4). The housing body supports a printed circuit board 30 and may have a rim 26 for defining the position of the printed circuit board 30 in the housing body. The rim 26 as well defines the orientation and the position of the transparent cover 24 relative to the housing body 22, like indicated in figures 2 and 3. On the printed circuit board 30 are LEDs 32 as light sources and for example two CCD-type image sensors 34. Light from the light sources 32 is directed by beam shaping elements 42 (see fig. 2 to 8) into some given direction to obtain a desired light distribution on the ground 4 below the lamp 10. The lighted ground 4 and objects on the ground 4 reflect this light. Light reflected by the ground 4 or objects between the ground 4 and the lamp 10 can thus be projected as an image of the ground 4 and/or the object on the image sensor 34. The image sensors 34 convert the projected image into some electrical signal which can be further processed by a controlling unit. The controlling unit may be part of some driving means for driving and controlling at least one image sensor 34 and or at least one light source 32. The controlling unit may store such captured images and/or transmit the images via some data bus to a main controller. The driving means can be positioned in the compartment 12 supporting the housing 20. Thereby the driving means can be thermally insulated from the light sources 32. The section as depicted in figure 3 shows for the purpose of simplicity only a reduced number of light sources 32 and image sensors 34, but corresponds in principle to the depiction of figure 2.

[0022] For projecting the image on the image sensor 34 an optical imaging element 44 is placed in front of the image sensor 34 (cf. figure 4). In the depicted example of figure 4 the beam shaping element 42 and the optical imaging element 44 are each lenses, which are incorporated into transparent cover 24. Thus, the transparent cover 24 is a common carrier for the beam shaping element 42 and the optical imaging element 44. The transparent cover 24, the beam shaping element 42 and the optical imaging element 44 can thus be manufactured by single process, for example injection molding. A further advantage of such integration of the beam shaping elements 42 and the optical imaging element 44 is that the orientation and position of the optical axis 43 of the beam shaping element 42 and optical axis 45 of the optical imaging element 44 are defined by their common manufacturing process and there is thus no need for a difficult and time consuming adjusting process of the optical axes 43, 45 of the camera and the light beam emitted by the lamp.

[0023] In the detail in figure 4 the beam shaping ele-

ment 42 and the optical imaging element 44 have the same imaging function. This imaging function is in practice a result of a desired light distribution of the lamp 10, which may vary from application to application and may yield severe distortions of the image projected on image sensor 34 by the optical imaging element 44. These distortions can be reduced by applying the inverse mapping of the imaging function to the image captured by the image sensor. The inverse mapping can be performed by some controlling unit, for example a controlling unit inside the housing or some external controlling unit. Different from the depicted examples may the beam shaping element(s) and the optical imaging element(s) have different mapping functions and thus different shapes.

[0024] In figure 5 a detail of slightly different street lamp is depicted. A light source 32 (a LED) and an image sensor 34 are mounted to a printed circuit board 30 as support. A beam shaping element 42 and an optical imaging element 44, briefly as well referred to as "lenses", are preferably directly attached to the printed circuit board 30 in front of the light source 32 and in front of the image sensor 34, respectively. In this example the printed circuit board 30 is a common carrier for the beam shaping element 42, the optical imaging element 44, the light source 32 and the image sensor 34. These components can be placed quickly and very accurately with standard pick and place machines. The orientations of the components are defined by the surface of the support, i.e. in this example the mounting surface 31 of the printed circuit board 30. It is thus not necessary to adjust the orientations of the components after they are placed. In front of the lenses 42, 44 is the transparent cover 24. The distance c between the light source and the image sensor is preferably bigger or equal to the $d1 \cdot \sin(\alpha) + d2 \cdot \sin(\beta)$ wherein $d1$ is the distance between the light source and the transparent cover, α is half of the angle of beam spread of the combination of the light source 32 and the beam shaping element 42, $d2$ is the distance between the image sensor and the transparent cover and β half of the aperture angle of the optical imaging element 44. Such chosen distances permits to avoid that light from the light source is reflected by the transparent cover on the image sensor.

[0025] In figure 6 a detail of slightly different street lamp is depicted. The difference with respect to the previous examples is that the transparent cover has a protrusion 50. The protrusion 50 permits a steeper entrance angle of the light emitted by the light source 32. Thereby reflections at the transparent cover that might hit the image sensor and thus reduce the quality of the captured image can be avoided or at least reduced. The protrusion 50 has a light source facing surface. The light source facing surface may couple light, e.g. the edge beam 61 of the light source 32 into the transparent cover. The transparent cover may have a recess 53 at the opposite side for coupling out the light and for directing it towards an object to be lighted, e.g. ground 4.

[0026] Figure 7 depicts a further embodiment for arranging beam shaping elements, like the one indicated

with reference numeral 42 and optical imaging elements, like the one indicated with reference numeral 44 on or more precisely at a common carrier 40. The common carrier can be supported by the housing body 22.

[0027] Figure 8 depicts an example for mounting a light source, like a LED 32 and an image sensor 34 to a common printed circuit board 30. The printed circuit board has a first layer 35 with a first thermal conductivity coefficient κ_1 (e.g. $\kappa_1 \geq 0,25 \text{ W cm}^{-1} \text{ K}^{-1}$) at 273K). The first layer may include for example an aluminum ($\kappa_{Al} = 2,38 \text{ W cm}^{-1} \text{ K}^{-1}$ at 273K) core. On the ground facing side of the first layer 35 is a LED 32, thus the heat produced when operating the light source 32 may be transferred to some heat sink, e.g. the housing body, by the first layer 35. The first layer 35 has through hole like opening 36. The rear side of the opening 36 is closed by a second layer 37 with second thermal conductivity coefficient κ_2 , wherein $\kappa_2 < \kappa_1$. For example may the second layer 37 comprise some epoxy compound. A typical thermal conductivity coefficient for a glass epoxy compound is in the order of $6 \cdot 10^{-3} \text{ W cm}^{-1} \text{ K}^{-1}$. The image sensor 34 may be supported by the second layer 37 and thus be thermally decoupled from the first layer and thereby from the light source 32. The signal to noise ration of the image sensor 34 is thereby enhanced. In the depicted example is the second layer 37 positioned at the opposite of side of the light source 32 on the first layer 35. The image sensor 34 faces into the same direction as the light source 32. Thus, the image sensor 34 protrudes into the through hole 36 and stray light on the image sensor is reduced.

[0028] The detail in figure 9 shows a housing body 22 as heat sink, being in a surface-to-surface contact with the rear side of a first layer 35 of a printed circuit board. On the front side of the first layer 35 are light sources 32. The first layer 35 has a first thermal conductivity coefficient κ_1 . The first layer 35 has a through hole like opening 36, being bridged by a second layer 37 having a second first thermal conductivity coefficient κ_2 (preferably $\kappa_1 > \kappa_2$). The second layer 37 overlaps the opening 36 and is mounted to the front side of the first layer 35. The second layer 37 supports an image sensor 34. Thus, the image heat transfer from the light sources 32 to the image sensor is reduced. In this sense, the image sensor 34 is thermally decoupled from the light sources 32. A transparent cover 24 with integrated beam forming means 42 and an optical imaging element 44 faces the light sources 32 and the image sensor 44. Detail in figure 9 shows only one image sensor 34, but of course may the full lamp comprise more than only one image sensor 34, preferably being mounted similarly as the depicted one.

[0029] The detail in figure 10 shows a housing body 22 as heat sink, being in a surface-to-surface contact with a first area 38 of the rear side of a printed circuit board 35. Two light sources 32 are mounted to the front side 31 of the first area 38. An image sensor 34 is mounted in between of the light sources 32 on a second area 39 of the printed circuit board 30. The heat sink is not in surface-to-surface contact with the second are of the

printed circuit board, as a recess 23 spans over the second area 39. The boundary between the first area and the second area 39 is sketched by dashed lines 33

5 List of reference numerals

[0030]

4	ground
5	lamp post
10	lamp
12	compartment
20	housing
22	housing body/heat sink
24	transparent cover
26	rim/support structure
30	printed circuit board/support
31	mounting surface / front side
32	light source / LED
33	dashed line
34	image sensor
35	first layer
36	opening
37	second layer
38	first area
39	second area
40	carrier
42	beam shaping element / lens
43	optical axis of light source
44	optical imaging element /lens
45	optical axis of image sensor /camera
50	protrusion
53	recess for coupling out light

62 edge beam

Claims

1. A lamp (10) for lighting a street, comprising at least:
 - a support (30), supporting a at least one light source (32) and at least one image sensor (34),
 - at least one beam forming means (42) for directing light being emitted by the light source (32) to obtain a given light distribution,
 - at least one optical imaging element (44) for projecting images onto the image sensor (34),**characterized in that** the beam forming means (42) and the optical imaging element (44) are arranged on a common carrier (24, 30, 40).

2. The lamp of claim 1,
characterized in that the support is a printed circuit board (30).

3. The lamp of claim 1 or 2
characterized in that the support (30) is the common carrier.

4. The lamp of claim of any one of the preceding claims
characterized in that the lamp further comprises a housing (20) with at least one housing body (22) and an at least partially transparent cover (24).

5. The lamp of claim 4,
characterized in that the transparent cover (24) includes the beam forming means (42) and the optical imaging element (44) for projecting an image as common carrier.

6. The lamp of any one of the preceding claims,
characterized in that the lamp (10) comprises at least one driving means for driving at least one of the at least one light source (32) and the at least one image sensor (34), wherein the driving means are thermally isolated from the at least one light source (32).

7. The lamp of claim 6 with one of claims 4 or 5,
characterized in that the driving means are positioned in a separate compartment (12), wherein the separate compartment (12) is configured for being attached to a lamp post (5) and wherein the separate compartment (12) supports the housing (20).

8. The lamp of any one of the preceding claims
characterized in that, the at least one light source (32) and the at least one

image sensor (34) are mounted on a front side (31) of a first area 38 of the support (30), wherein a rear side of said at least one first area (38) is in a surface-to-surface contact with at least one heat sink (22).

9. The lamp of claim 8
characterized in that the heat sink (22) has a recess on its support facing side, such that the heat sink (22) is not in a surface-to-surface contact with at least one second area 39 of the rear side of the support (30), supporting the least one image sensor (34).

Fig. 1

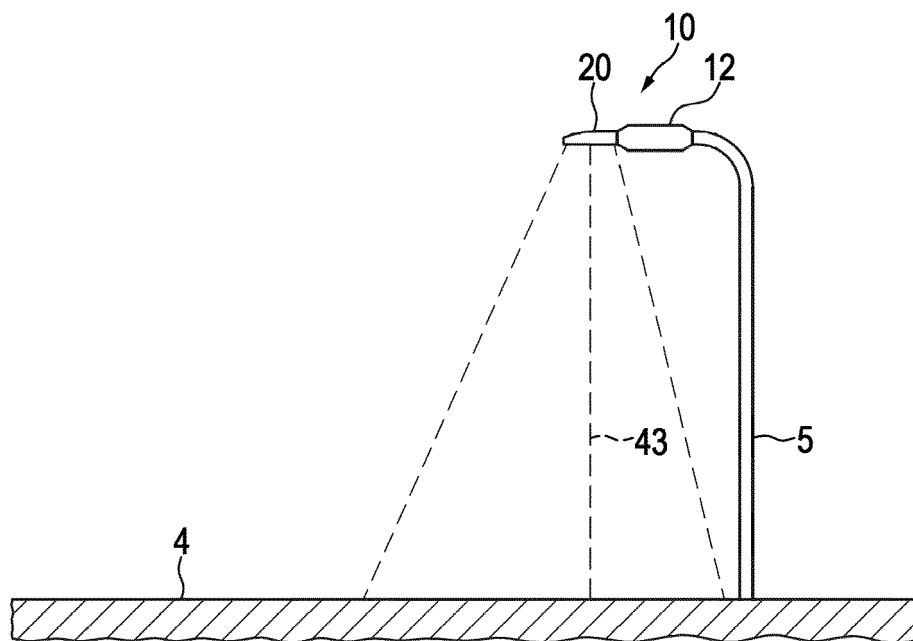


Fig. 2

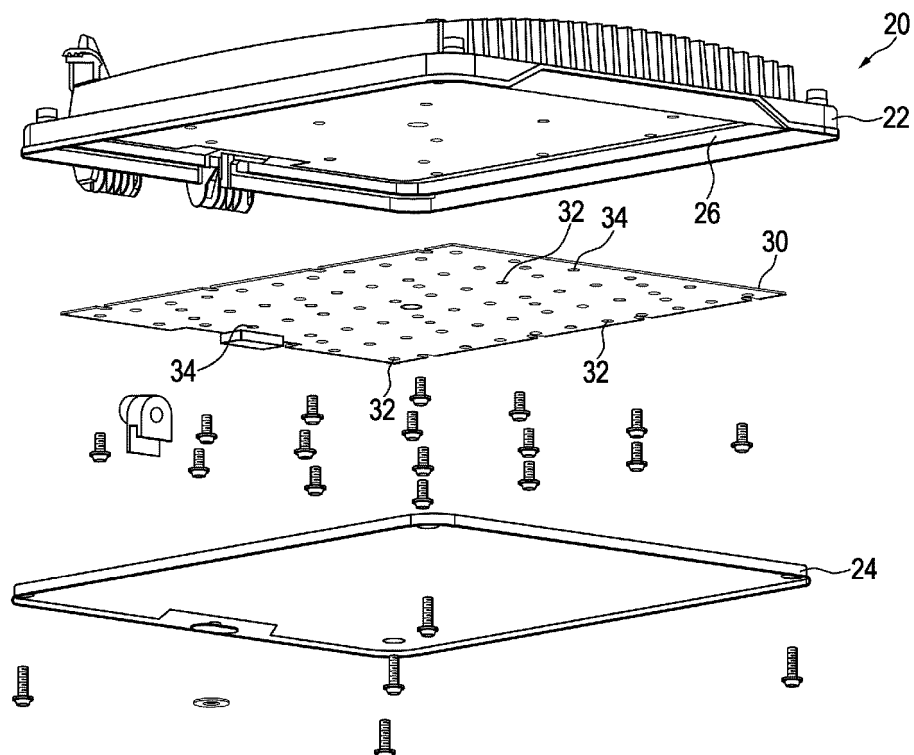


Fig. 3

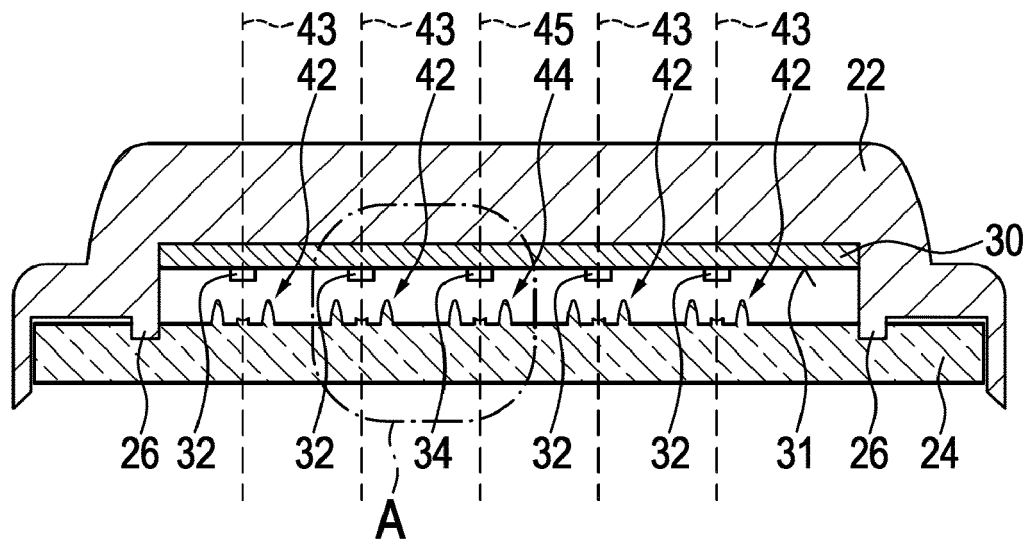


Fig. 4

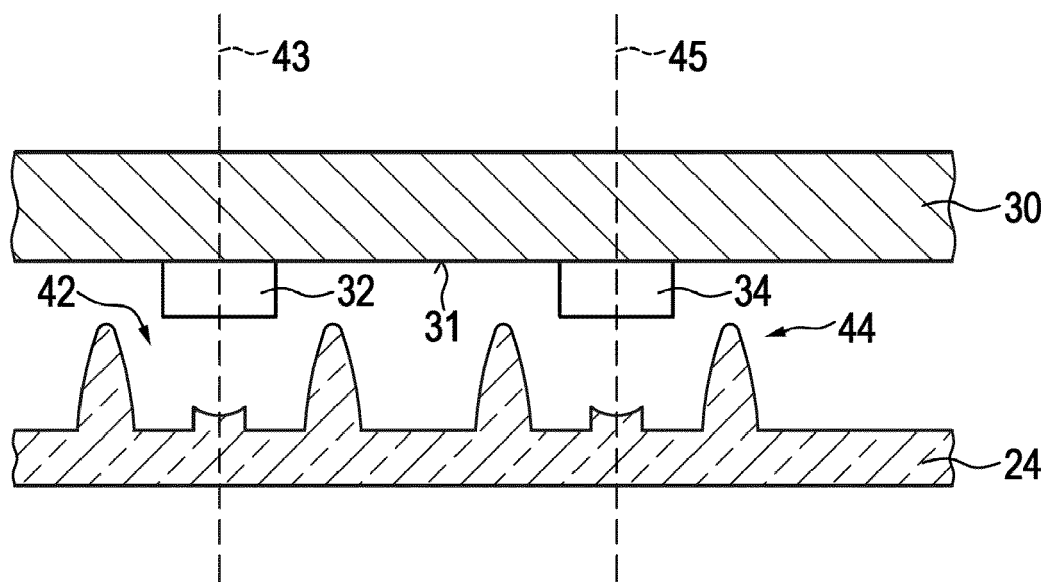


Fig. 5

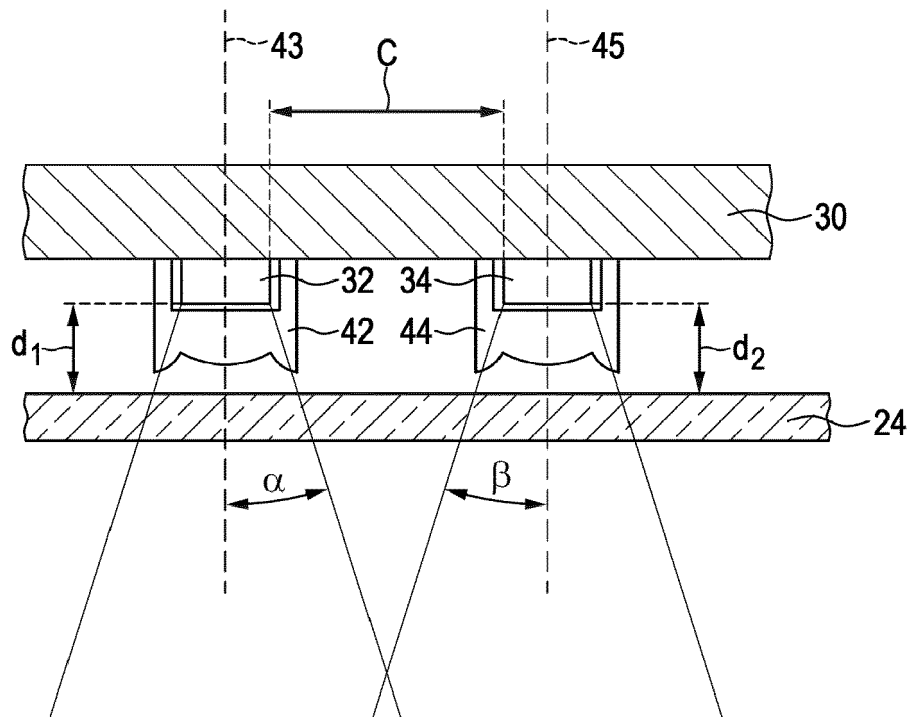


Fig. 6

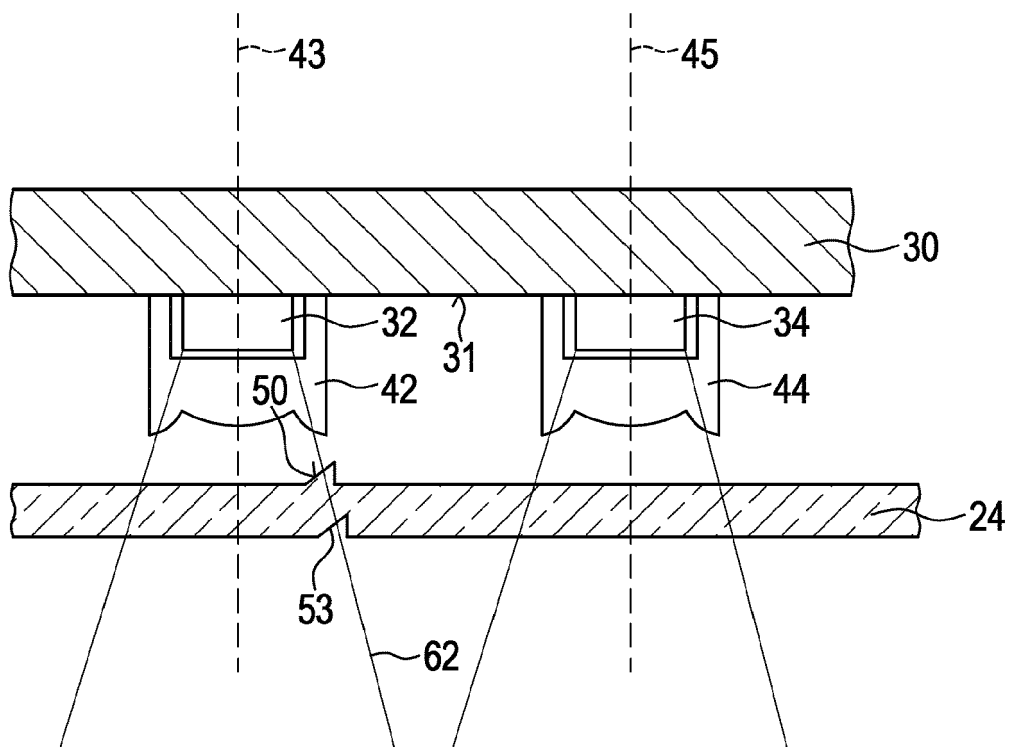


Fig. 7

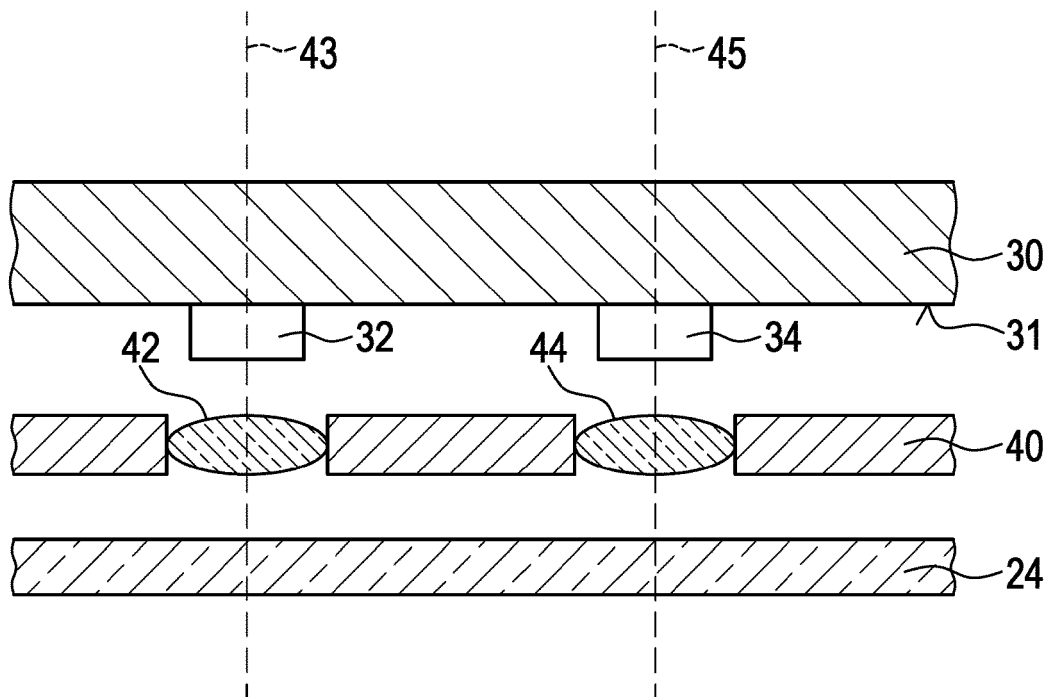


Fig. 8

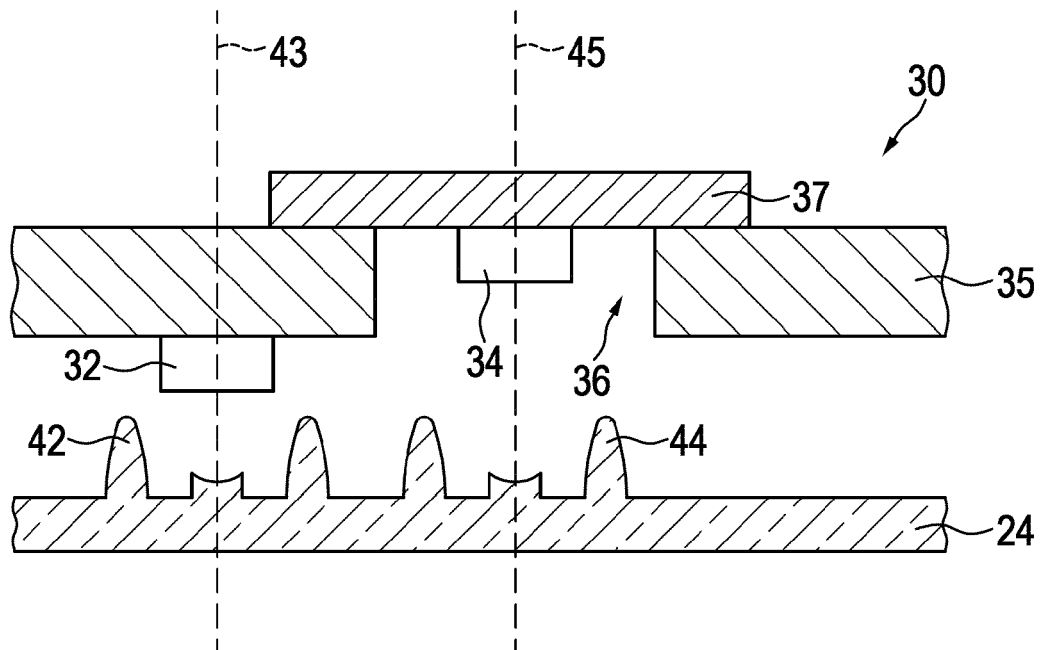


Fig. 9

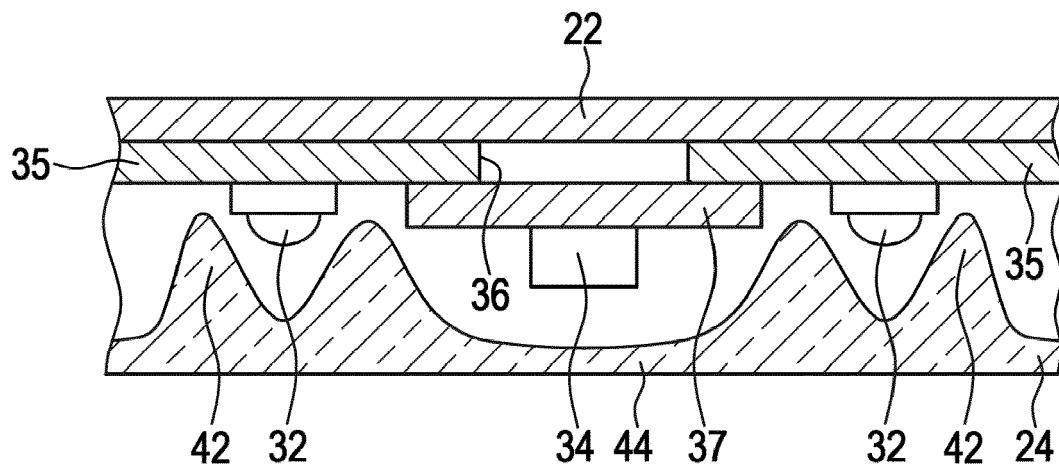
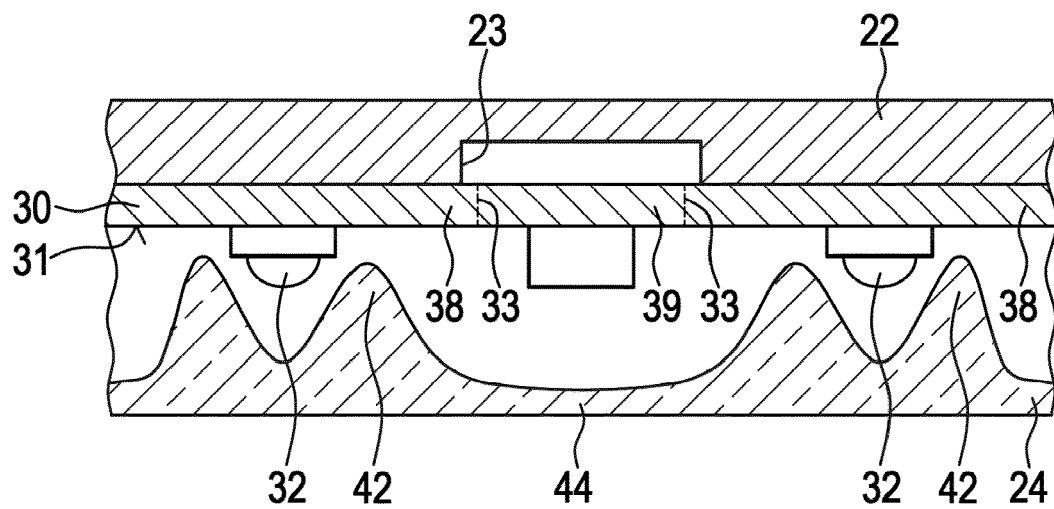


Fig. 10





EUROPEAN SEARCH REPORT

Application Number
EP 12 15 1446

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2010/277082 A1 (REED WILLIAM G [US] ET AL) 4 November 2010 (2010-11-04) * paragraphs [0003], [0005], [0008], [0010] * * paragraphs [0038], [0042] * * paragraph [0047] - paragraph [0051] * * figures 1-4 *	1-5,8,9	INV. F21V33/00 F21S8/08 F21V23/04 G08B13/196
X	WO 2011/049435 A1 (LEDS PROGRESS HOLDING BV [NL]; VAN DE VRIE QUINTEN [NL]) 28 April 2011 (2011-04-28) * page 1 * * page 3, line 25 - page 5, line 11 * * page 6, line 13 - page 7, line 11 * * figures 1,2,3A,5 *	1-4,8,9	ADD. F21W131/103 F21W131/105
X	WO 2011/067749 A1 (LED NET LTD [IL]; VADAI EPHRAIM [IL]; SHEFI AMIT [IL]; HERBST TZVIKA []) 9 June 2011 (2011-06-09) * page 10, line 11 - line 15 * * page 10, line 28 - page 12, line 5 * * page 19, line 22 - line 25 * * page 20, line 12 - line 14 * * page 21, line 7 - line 28 * * figures 2,3,5,7A,15B,19,21 *	1-4,6-8	TECHNICAL FIELDS SEARCHED (IPC) F21S H04N G08B F21V
X,D	US 2009/185376 A1 (YU SHENG-JUNG [TW]) 23 July 2009 (2009-07-23) * paragraph [0011] - paragraph [0016] * * figures 1,2 *	1-4	
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 2 July 2012	Examiner Arsac England, Sally
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

 3
EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 12 15 1446

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02-07-2012

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2010277082 A1	04-11-2010	KR 20120032472 A	05-04-2012
		US 2010277082 A1	04-11-2010
		WO 2010127138 A2	04-11-2010

WO 2011049435 A1	28-04-2011	NL 1037416 C	27-04-2011
		NL 1038327 C	25-08-2011
		WO 2011049435 A1	28-04-2011

WO 2011067749 A1	09-06-2011	US 2011134239 A1	09-06-2011
		WO 2011067749 A1	09-06-2011

US 2009185376 A1	23-07-2009	CN 101493204 A	29-07-2009
		US 2009185376 A1	23-07-2009

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- CN 200920013082 [0002] [0004]
- US 20090185376 A [0003] [0004]