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— as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(H))

[Continued on next page]

(54) Title: IRRADIATION EQUIPMENT FOR CCTV CAMERAS

(57) Abstract: An irradiating device intended for imaging device, containing irradiation sources, wherein a carrier holds the irradiation sources being divided into at least two sub-groups, whereas the first sub-group has n irradiation sources and the second sub-group has n2 irradiation sources, and where the centroid of the effective radiating area of the irradiation sources of each sub-group is on the plane of a toroidal circular ring shape.

Figure 1
Published:

- with international search report (Art. 21(3))
Irradiation equipment for CCTV cameras

Field of the invention

The technical solution of the invention is the irradiation equipment intended for imaging device with selective irradiation level to individual areas of zone of the view.

Background of the invention

The irradiation equipment is often a plug-in feature of CCTV cameras. For common irradiation equipment, sources of luminous flow are located on a ring or one or multiple plane panels that can be rotated to adjust the irradiation angle to camera's field of view. Main disadvantage of these solutions is that the luminous output for individual areas of the scene can not independently and continuously be distributed according to current nature of the scene. Due to poor light conditions, the image quality is not optimal with respect to resolution of objects.

The European patent EP 1273962 B1 for BOSH (published 8 January 2003) describes an illuminator device commonly used for image capturing device (CCTV camera). This device consists of printed circuit board of ring shape and of higher count of LED diodes. In each case, the LED diodes have two electrodes with ring-like pattern arrangement on the printed circuit, whereas each LED diode has at least one radiation direction that differs from optical axis of the device by beta angle. In addition, the diodes are arranged so that the direction in which they reflect their light is not parallel. Each diode has four legs, two of them are bent end and projecting outside and soldered to the printed circuit as built-up components, and where spaces and tilt of the diodes depend on bending and size of remaining legs. Favourably, the beta angle between the direction of irradiation with maximum intensity and optical axis is 15-45 degrees and in average, it is about 30 degrees. The LED diodes are regularly spaced on the substrate of the illuminator device. The diodes are placed in ring-like pattern along the optical axis of the device. The diodes used in this embodiment have four legs, whereas at least one is connected as cathode and one as anode. Favourably, the device contains 4 - 16 diodes, most favourably 8 diodes. At least some of the diodes used must be of HPWT-DH00 type. Favourably, the device is used in motor vehicles. In addition, there is patent application US 2005168625 A1 for Airbus (published 4 August 2005), which describes similar solution of the problem. The difference exists in the possibility of turning the diodes in multiple directions.
and in the possibility of multiple ring levels of the diodes. Contrary to the solution brought by Bosh, the diodes do not have to strictly be located in a circle around the camera lenses that are located also in the centre of the optical area. The invention according to the patent application US 2005168625 A1 for Airbus permits placement of the diodes into different parts of the board. The illuminator according to Airbus (patent application US 2005168625 A1) is adapted according to diodes adjustment in production of the board with LED diodes and it is not possible to change the illuminator otherwise than by turning on/off voltage for power supply of the diodes.

The patent US 7593056 B2 for Honeywell (published 27 April 2006) also uses turning of the diodes for adjustment of field of vision of the illuminator device. Contrary to the solution provided by Bosh EP 1273962 B1 and Airbus US 2005168625 A1, the diodes in this embodiment do not have to be placed in a ring pattern around the camera lenses and placement of the illuminator panels and the diodes is still around the camera lenses but in two strips, each on the lens side. The feature of the illuminator section as provided by Honeywell US 7593056 B2 is higher number of the illuminator panels (usually two), whereas each of them consists of multiple irradiation sources (e.g. LED diodes). These sources do neither have the optical axis parallel to the camera optical axis nor optical axis of the other irradiation sources. At the same time, however, all irradiation sources produce single light direction through optically transparent window in the cover of this embodiment. The irradiation sources are again located on a single plane despite the optical axes themselves are not parallel. Turning of the optical axes of the LED diodes is designed so that each diode has placed in the printed circuit as slope so that the turning angle complies to the requirements. The irradiation produced by the LED diodes may be visible or infrared.

The solution described in the US patent application US 2009196593 A1 for CHENG YI-JEN [TW] (published 6 August 2009) as well as previous solutions by Honeywell US 7593056 B2 has no LED diodes placed around the camera but in two panels on sides of the camera lens. The innovative feature in this case is placement of the diodes into a "stair-like" structure containing three stairs on each case and the invention thereby improves irradiation compared to placement of the same on a single plane. All irradiation sources have optical axis parallel to all other sources as well as internal optical axis of the tracking camera. The irradiation produced by the LED diodes may be visible and infrared.
The patent application **WO 2011/024193 A2** for KANNAN NATARAJAN (published 3 March 2011) describes an electronic variable IR illuminator for a camera with multiple IR LED diodes of different irradiating angles, where the full view of vision is controlled by a central unit that adapts the irradiation based on the camera needs. The present microchip checks image taken by the camera and adjusts its intensity and field of vision of the illuminator based on the analysis. The benefit of this embodiment is possibility of manual illuminator adjustment using a remote keyboard. The microchip automatically adjusts the field of vision depending on adjustment of the camera zoom. The microchip also checks the output image and adjusts the illuminator to avoid excessive image irradiation. In this embodiment, the LED diodes are connected in series. Each LED diode series has its internal control unit for power voltage control. In favourable embodiment, there may be multiple illuminator panels and all are governed by identical parameters as if there is just one panel only.

The patent application **US 2008151052 A1** for VIDEOLARM INC (published 26 June 2008) describes the first light source and the second light source that is set to position in relation to the first light source and contains position control mechanism for different positions of the second light source in relation to the first light source so that the light beams of the first and second light source may be adjusted depending on the input signal from a camera (it may either be input signal from the internal camera or input signal from external photo camera).

**Summary of the invention**

The imperfections described above are removed by this invention to a large extent. The irradiation device intended for imaging device containing the irradiation sources provides the irradiation sources on a carrier and the sources are divided into at least two sub-groups. The first sub-group has \( n_1 \) irradiation sources and the second sub-group has \( n_2 \) irradiation sources. The centroid of the effective irradiating area of the irradiation sources of each sub-group is on the plane of circular ring shape.

The number of circular rings on which individual sub-groups of the irradiation sources are located is at least two, more favourably the number of circular rings is from to five inclusive. The circular ring surfaces on which the irradiation sources are located have radius of
curvature RX1 from 8mm to 75mm inclusive and radius of curvature RX2 is either 0mm or from 9mm to 350mm. X in identification of each RX1 and RX2 refers to relevant circular ring.

The irradiation source may be any irradiation source such as LED diode, a bulb, luminescent tube, discharge lamp, IR emitting diode, laser diode, halogen lamp, fluorescent tube or any other source of optical irradiation etc. The term "irradiation source" as used in this application refers to any source emitting optical irradiation and the list of the irradiation sources mentioned above is indicative only and not exhaustive.

Each irradiation source has an independent current control. Each irradiation source is independently adjustable, either mechanically or automatically. Total number of irradiation sources may be from 10 to 101. Total irradiation angle of individual irradiation sources is 5 degrees up to 50 degrees. Individual sub-groups of the irradiation sources may be shifted as in stairs pattern each other. According to favourable embodiment, the irradiating device may be used either individually or connected to body of a CCTV camera.

The invention can be used particularly for the purposes of optical monitoring and surveillance under poor light conditions. The invention improves resolution of details of monitored objects in CCTV camera image on the understanding that based on image information, it changes irradiation of individual scene areas so that the image of the objects produced in CCTV camera is contrast, balanced and free of any unwanted high brightness levels caused by reflections from very close and/or reflective and/or unsuitably turned objects in the scene being monitored.

Radiance of individual irradiation sources may be controlled by a control unit. The control unit is favourably fitted with a device for capturing of input information from external sensors and cameras. However, it is also possible that the irradiation device in question operates without the control unit as well. In this case, the irradiation can be controlled manually. The distributed irradiation of the scene areas is carried out by current control for independently current-controlled and fixed irradiation sources. The irradiation sources are light sources irradiating in visible and/or infrared spectrum area. Each irradiation source may be fitted with an integrated lens.
A group of N irradiation sources may be divided into at least two sub-groups with the number of \( n_1 \) and \( n_2 \) of irradiation sources, where \( n \) is the sum of \( n_1 \) and \( n_2 \). Each sub-group is placed in the space right on one circular ring so that the centroid of the effective irradiating area of the irradiation source of each sub-group is located on the surface of circular ring-like shape. Individual sub-groups of the irradiation sources may be shifted as in stairs pattern each other. Total number of the irradiation sources is usually 12, from at least 10 to 101 maximum.

The device according to this invention may be independent or placed e.g. on CCTV camera body. The CCTV camera may work in day-night mode (however, not exclusively). For traditional illuminators, emphasis is put on balanced irradiation of the scene and current position is not taken into account as well as rotation and nature of the objects on the scene. Contrary to that, the invention dynamically optimizes quality of images of objects being monitored by separated control of irradiation of individual scene areas. The basic function of the invention is optimization of the image quality of the objects being monitored by distributed scene irradiation.

The control unit may be a computer, current controller and interface between the control unit computer and surrounding devices that supply input information. The control unit receives input information from surrounding sensors and the camera. The sensors include surrounding light or irradiation sensor, temperature sensor, gate open, air and fog sensor. The control unit computer continuously evaluates input information and the main criterion for assessment is quality of the CCTV camera image. Based on this evaluation of information, the control unit distributes intensity of electric current to individual irradiation sources.

The art provides known stair-like arrangement of groups with LED diodes according to the patent application US 2009196593 A1, however, this embodiment has all irradiation sources parallel with the optical axis of all other sources as well as its optical axis of monitoring camera and in this way, the invention differs from this invention. Said invention differs especially in that each sub-group with the LED diodes has circular ring-like shape.

As far as patent EP 1273962 B1 for Bosh is concerned, the diodes are placed in a single plane, whereas according to this invention they are placed on a plane of circular ring-like shape and
the illuminator can be adjusted depending on nature of the scene, which are the new features of this invention in question.

The optical axis of the irradiation source of said irradiating device is defined as a line intersecting the centroid of the effective irradiating area of the irradiation source and the point called centroid of irradiation, hereinafter referred to as centroid only. The centroid is a point located in the space inside a spherical volume illuminated by this one irradiation source. The spherical volume has a centre in the centroid of the effective irradiating area and the radius of curvature of at least twentyfold of maximum dimension of the effective irradiating area of this irradiation source.

The following relationships apply for calculation of the centroid coordinates:

\[ x_c = \frac{\int E(x,y)z(x,y) \sqrt{1 + \left(\frac{\partial z}{\partial x}\right)^2 + \left(\frac{\partial z}{\partial y}\right)^2} \, dx \, dy}{\int E(x,y) \, dx \, dy}, \]

\[ y_c = \frac{\int E(x,y)z(x,y) \sqrt{1 + \left(\frac{\partial z}{\partial x}\right)^2 + \left(\frac{\partial z}{\partial y}\right)^2} \, dx \, dy}{\int E(x,y) \, dx \, dy}, \]

\[ z_c = \frac{\int E(x,y) \, dx \, dy}{\int E(x,y) \, dx \, dy}, \]

where \( x_c, y_c, z_c \) are the coordinates of the centroid in the orthogonal system of coordinates, where is still applicable

\[ S_{xy} = \int E(x,y)z(x,y) \sqrt{1 + \left(\frac{\partial z}{\partial x}\right)^2 + \left(\frac{\partial z}{\partial y}\right)^2} \, dx \, dy, \]

\[ S_{yz} = \int E(x,y)x \sqrt{1 + \left(\frac{\partial z}{\partial x}\right)^2 + \left(\frac{\partial z}{\partial y}\right)^2} \, dx \, dy, \]

\[ S_{xz} = \int E(x,y)y \sqrt{1 + \left(\frac{\partial z}{\partial x}\right)^2 + \left(\frac{\partial z}{\partial y}\right)^2} \, dx \, dy, \]

where \( x, y, z(x,y) \) are the coordinates in the orthogonal system of coordinates, \( E(x,y) \) is irradiation of said spherical volume by relevant irradiation source, where \( z(x,y) \)
and $E(x,y)$ are functions $x$ and $y$, whereas $[x,y] \in \mathcal{M}$ and where $P$ is total luminous flow of the irradiation source on the spherical volume. Total luminous flow $P$ is defined by equation

$$P = \iint_{\mathcal{M}} E(x,y) \sqrt{1 + \left(\frac{\partial z}{\partial x}\right)^2 + \left(\frac{\partial z}{\partial y}\right)^2} \, dx \, dy.$$ 

The whole group of the irradiation sources is divided into sub-groups and each sub-group is located on the area of one circular ring, which is defined by the radius of curvature $RX_1$, $RX_2$, curvature centres $CX_1$, $CX_2$, rotation axis intersecting the $CX_2$ curvature centre. The rotation axis is orthogonal to the line crossing the $CX_1$ and $CX_2$ curvature centre. For $RX_1$ and $RX_2$ it is true either $RX_2 > RX_1$ or $RX_2$ equals to 0, then, if $RX_2 = 0$, $RX_1$ may be of any value from the scope of values applicable for $RX_1$. $RX_2$ is the distance between the $CX_2$ and $CX_1$ curvature centres.

**Summary of figures on the drawings**

The figures are attached for better understanding of the invention.

Figure 1 shows a device according to one of the embodiments of this invention in combination with a CCTV camera and the control unit in isometric view.

Figure 2 shows a device together with CCTV camera and the control unit in the profile drawing.

Figure 3 shows a device together with CCTV camera and the control unit in the front view.

Figure 4 shows production of circular ring by rotating a circle around the rotation axis.

Figure 5 shows an irradiation source with the centroid of the effective irradiating area and optical mechanical axis of the radiation source.

Figure 6 shows a sub-group of the radiation sources on relevant circular ring.

Figure 7 shows the second sub-group of irradiation sources and their placement on relevant circular ring area.
Figures 8a and 8b show the irradiation sources on relevant circular rings in the sub-group in the profile drawing.

Figure 9 shows the irradiation sources on relevant circular rings in the sub-groups in the ground plan.

Figure 10 shows the circular ring of the second sub-group with six placed and oriented irradiation sources, where two of the irradiation sources are in partial section view.

Figure 11 shows cones of 50% irradiation levels of individual irradiation sources in the space.

Figures 12 to 16 show angular deployment of irradiation levels achieved by the distributed luminous flow from the irradiation sources according to this invention. The curve on Figure 12 reflects distribution of the irradiation intensity for full scene irradiation. The curve on Figure 13 reflects distribution of the irradiation level in directional scene irradiation. The curve on Figure 14 reflects distribution of the irradiation level in directional scene irradiation. The curve on Figure 15 reflects distribution of the irradiation level in directional scene irradiation. The curve on Figure 16 reflects distribution of the irradiation level in directional scene irradiation.

**Examples of the invention embodiment**

Further, there are specific embodiments of the invention, which, however, do not limit the scope of protection in any way as described in the patent claims.

**Example 1**

Figure shows a device according to one of the embodiments of this invention in combination with a CCTV camera 5 and the control unit in isometric view 3. A carrier 1 of the irradiation sources is attached to the camera and the camera lens 4. The device contains the carrier 1 of the LED diodes where two sub-groups are located. Each sub-group is located on the area of circular ring shape 9. In the first group of this example embodiment, there are six light emitting diodes and the second group contains twelve light emitting diodes. Each sub-group is located just on one circular ring 9 so that the optical axis 12 of each light emitting diode of
said sub-group is orthogonal to the area of relevant circular ring 9 and the centroid 10 of the effective irradiating area 8 of each LED diode of this sub-group touch the relevant circular ring 9. In this way, the first group has assigned the circular ring 9 with the radii of curvature \( R11 = 27.2 \) mm and \( R12 = 250.0 \) mm and the second group has assigned the circular ring 9 with the radii of curvature \( R21 = 14.9 \) mm and \( R22 = 18.1 \) mm.

Figure 12 to 16 shows angular deployment of the irradiation level in the spatial section view being achieved according to this invention. The numbers in semi-circles correspond to the spatial direction. The narrower the curve is, the smaller area of the scene is covered by the luminous flow according to this invention. Selectively, the scenes not directly adjacent each other may be irradiated as well, whereas irradiation of adjacent areas may be suppressed. This results in the distributed irradiation of the space in front of the irradiation source that may change over individual camera images.

Example 2

The invention consists of the carrier 1 of suitable irradiation source and of the control unit 3. The irradiation sources are spatially deployed over the carrier 1 into three sub-groups. The first sub-group of this example embodiment has twelve irradiation sources, the second sub-group has ten irradiation sources and the third sub-group has eight irradiation sources. The centroid of the effective irradiation surface of the irradiation sources of each sub-group is on the plane of circular ring shape. A unit vector is assigned to each optical axis of the irradiation source. Orientation of the unit vector is identical to the direction as prevailing direction of effective irradiation of the irradiation sources in close infrared spectral area. Three selected unit vectors of one sub-group are coplanar. Any plane parallel to all vectors of said sub-group is the plane of the sub-group. The plane of the first sub-group contains \( 9^\circ \) angle with the plane of the second sub-group and the plane of the third sub-group contains \( 15.5^\circ \) angle with the first sub-group plane. The control unit 3 consists of a computer, current controller and interface between the control unit computer 3 and surrounding devices that supply input information. The control unit 3 receives input information from surrounding sensors and the camera 5. The sensors include surrounding light or irradiation sensor, temperature sensor, gate open, air and fog sensor. The control unit computer 3 continuously evaluates input information and the main criterion for assessment is quality of the CCTV camera 5 image.
Based on this evaluation of information, the control unit 3 distributes intensity of electric current to individual irradiation sources.
List of reference marks

1 carrier of irradiation source
2 irradiation source
3 control unit
4 CCTV camera lens
5 CCTV camera
6 rotation axis with RX2 rotation radius
7 CXI centre of curvature
8 CX2 centre of curvature
9 circular ring
10 centroid of the effective irradiating area of the irradiation source
11 centroid of irradiation
12 optical axis of the irradiation source
13 mechanical axis of the irradiation source
14 section view of LED diode
15 second group circular ring
16 irradiation device
17 cones with 50% irradiation level of individual irradiation sources
18 base
PATENT CLAIMS

1. The irradiating device intended for imaging device, containing the irradiation sources, characterized by that the carrier (1) holds the irradiation sources (2) being divided into at least two sub-groups, whereas the first sub-group has \( n_1 \) irradiation sources and the second sub-group has \( n_2 \) irradiation sources, and where the centroid of the effective irradiating area of the irradiation sources of each sub-group is on the plane of circular ring shape (9).

2. The irradiating device according to claim 1, characterized by that the number of circular rings (9), on which the individual sub-groups of the irradiation sources (2) are located, is at least two.

3. The irradiating device according to claim 2, characterized by that the number of circular rings, on which the individual sub-groups of the irradiation sources (2) are located, is favourably from two to five inclusive.

4. The irradiating device according to any of the previous claims, characterized by that the areas of circular rings (9), on which the individual sub-groups of the irradiation sources (2) are located, have their radius of curvature \( R_{X1} \) ranging from 8mm to 75mm inclusive and the radius of curvature \( R_{X2} \) is either 0mm or range from 9mm to 350mm.

5. The irradiating device according to any of the previous claims, characterized by that the irradiation source (2) may be any irradiation source such as LED diode, a bulb, luminescent tube, discharge lamp, IR emitting diode, laser diode, halogen lamp, fluorescent tube or any other source of optical irradiation etc.

6. The irradiating device according to claim 5, characterized by that each irradiation source (2) has independent current control.
7. The irradiating device according to claim 5 and/or 6, characterized by that each irradiation source (2) is independently adjustable either mechanically or automatically.

8. The irradiating device according to any of the claims 5 to 7, characterized by that the total number of irradiation sources (2) may be from 10 to 101.

9. The irradiating device according to any of the claims 5 to 8, characterized by that the total irradiation angle of individual irradiation sources (2) ranges from angle of 5° to 50°.

10. The irradiating device according to any of the previous claims, characterized by that the individual sub-groups of the irradiation resources (2) are shifted in stairs-like pattern against each other.

11. The irradiating device according to any of the previous claims, characterized by that the irradiating device is used either independently or on body of a CCTV camera.
Figure 11

Figure 12
A. CLASSIFICATION OF SUBJECT MATTER

INV. H04N5/225 G03B15/03

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)

H04N G03B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic database consulted during the international search (name of database and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
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<td>W0 94/106022 A2 (WURZER HARALD [AT]; NAGYPAL TIBOR [AT]) 11 May 1994 (1994-05-11) pages 3-5, 9-11; figure 1</td>
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<td>CN 202 469 553 U (SUZHOU JINGPIN PHOTOREOPTICAL TECHNOLOGY CO LTD) 3 October 2012 (2012-10-03) figure 2</td>
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Further documents are listed in the continuation of Box C. See patent family annex.

*: Special categories of cited documents:

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Date of the actual completion of the international search: 14 July 2014

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Name and mailing address of the ISA:
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