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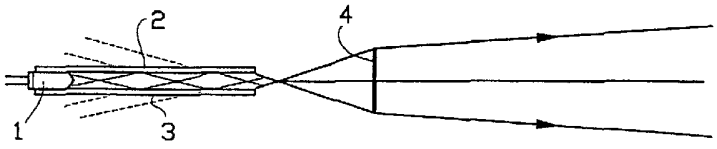
(54) Title: ILLUMINATION DEVICE



(57) Abstract: The invention relates to a device for illuminating an object comprising a row of several lamps, a mirror cavity comprising two plane-parallel mirrors placed above each other and a positive cylindrical lens, wherein the row of lamps is placed at the rear edge of the mirrors between the mirrors and the lens is placed parallel to the front edge of mirror cavity, such that the light of the lamps reflected by the mirror cavity is directed with an equalised intensity distribution on the object to be illuminated.

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Illumination device

The present invention relates to a device for illuminating a (three dimensional) object in a measuring device.

Several measuring devices are known in which an object is illuminated and the radiation reflected by the object is analysed or the reflected image is examined. Analysis of the reflected radiation means in particular that it is determined which wavelengths are absorbed by the object. An example of a device in which the radiation reflected by an object is analysed is an imaging spectrograph.

It is known to use halogen lamps for illuminating the object in imaging spectrographs, often in combination with glass fibres and line arrays (glass fibre bundle in which all glass fibres are positioned adjacently). Halogen lamps, however, have the drawback of the spectral emission in the range between 400 and 450 nm being very low. For various uses, for instance the measuring of flowers (ornamental plants), it is desirable to measure the reflection in this spectral range.

LEDs (Light Emitting Diodes) emitting these wavelengths are available. The intensity of LEDs is very low, however. One LED can only evenly illuminate a very small object. The use of a row of LEDs does not result in an even illumination. Sometimes frosted glass is placed in front of a row of LEDs, however this has the drawback of light being absorbed.

Therefore there is a need for a device providing an illumination having an equalised intensity of an object having a surface area of up to for instance

10 x 2 cm.

According to the invention that need is met by means of a device for illuminating a (three-dimensional) object in a measuring device, comprising

a row of several lamps,

a mirror cavity comprising two plane-parallel mirrors, the one mirror being placed above the other and the reflecting surfaces of the mirrors facing each other, and

a cylindrical lens,

wherein the row of lamps is placed at the rear edge of the mirrors between the mirrors and the lens is placed parallel near the front edge of mirrors, such that the light of the lamps reflected by the plane-parallel mirrors is directed by the lens as a virtually parallel beam of light on the object to be illuminated.

By using the device according to the invention an illumination having an equalised intensity is achieved. The achieved illumination has an evenly running intensity distribution in the three dimensions x, y and z, the z-direction being the direction of the beam coming from the device and the x- and the y-direction being perpendicular to each other and in a plane perpendicular to the direction of the light beam. The y-direction is perpendicular to a plane parallel to the parallel mirrors.

The device according to the invention enables to combine a number of relatively weak lamps such that an illumination having sufficient intensity is achieved.

The term lamp refers to a device serving to illuminate. In the device according to the invention preferably light emitting diodes (LEDs) are used. Based on his knowledge a person skilled in the art will know or realise which types of lamps are suitable for use in the invention.

The cylindrical lens to be used in the device according to the invention is a positive lens, that means a lens which converges the incident rays. In the present description and claims, cylindrical lens does not only refer to single-axis spherical lenses but also to single-axis a-spherical lenses. The lens used in the device according to the invention can also be a part of a cylinder. In other words, the cylindrical lens of the device according to the invention is a positive lens having at least one refracting surface that is a part of a cylindrical surface wherein a cylindrical surface refers to a surface described by straight lines that each are parallel to a straight line and pass through a certain curve. Said curve is not limited to circular curves.

When using a cylindrical lens in general the distance between the end of the mirror cavity and the axis of the cylindrical lens will be a little larger than the focal distance of the lens. The optimal position of the lens, that means the position providing a beam which is as parallel as possible, can very easily be established by experiments.

Figure 1 schematically shows a cross-section of an embodiment of a device according to the invention. In figure 1, 1 refers to a LED of a row of LEDs clamped in between an upper mirror 2 and a lower mirror 3, which have been provided at the lower and upper side, respectively, with a reflecting surface and which together form a mirror cavity. After a number of reflections in the mirror cavity the intensity distribution of the light coming from the lamps has been equalised in the x- and y-direction. The light leaving the mirror cavity is guided by a rod lens (cylindrical lens) 4, the focus of which is situated outside the mirror cavity, to form a parallel beam so that an even intensity distribution is also achieved in the z-direction.

The mirrors form the upper and lower walls of the mirror cavity. The front side of the mirror cavity is open. The rear side of the cavity is closed off by the row of lamps. The side walls of the mirror cavity preferably are closed.

The surface of the side walls preferably is not reflecting. Most preferably the side walls are frosted black. The mirrors generally have a rectangular shape. The length of the mirror, the distance between lamps and front side, is considerably larger than the height of the mirror cavity, the distance between the mirrors.

The width of the mirror depends on the wanted width that has to be illuminated. When a larger illumination surface is wanted, the number of LEDs in the row can be increased.

The height of the mirror cavity is determined by the diameter of the LEDs. It is possible to use several rows of LEDs placed above one another. However, when the height is doubled, the effect of the mirror cavity is halved. In general it is desirable then to make the mirror cavity twice as long. Increasing the height of the mirror cavity also has consequences for the lens diameter, object distance and degree of parallelism of the beam. High-intensity LEDs having a very small diameter therefore are preferred.

By combining the device according to the invention with halogen illumination, an equalised intensity distribution over a broad wavelength range can be achieved. A number of devices having LEDs with a contiguous emission spectrum can also be combined.

The nature of the object is in fact unlimited. Due to the equalised intensity distribution of the light beam obtained with the device according to the invention, it is not necessary that the object is flat.

The present invention can for instance be used for illuminating fruits, plants, flowers or seeds, for instance in an industrial sorting device.

Based on his general knowledge the person skilled in the art will realise for which other illumination purposes the device according to the invention can

be used.

Example

Between a mirror cavity consisting of two plane-parallel mirrors placed at a distance of 5 mm from each other and having a width of 125 mm made of 1 mm thick material, 50 bright blue light emitting LEDs (by Agilent, type HLMP-DB25-P0000) having an intensity of 100 mcd and an opening angle of 25° and a length of 8.71 mm cm were placed, wherein the centres of the LEDs were situated at a distance of 50 mm from the front edge of the mirrors. At a distance of 20 mm from the front edge of the mirrors a rod lens in the shape of a plastic (perspex) cylinder having a diameter of 50 mm and a length of 130 mm was mounted, such that the axis of the cylinder ran parallel to the front edge of the mirror cavity and was situated in a plane parallel to the mirrors. The mirrors and the lens were mounted in a plastic box.

Figure 2 shows the intensity distribution obtained with the above-mentioned example of a device according to the invention. The reflection values on a white background were measured by means of a digital camera. The reflection pattern obtained with the device according to the invention is shown at the bottom. For comparison purposes the reflection pattern of a single row of LEDs is shown at the top.

Figure 3 shows a graphical depiction of the intensity distribution obtained with the above example of a device according to the invention measured by means of a digital camera. The x- and y-axis are spatial axes in a plane placed perpendicular in the beam and show pixels (image dots). The image has not been calibrated, but 1 pixel approximately corresponds to 1 mm^2. The z-axis represents the intensity in grey values. The intensity distribution obtained with the device according to the example is indicated by a, whereas b refers to the intensity distribution of a single row of LEDs.

Figure 4 shows the intensity distribution of figure 3 in contour lines. The intensity has not been calibrated, but has been shown in grey values, 40 grey values per step.

Claims

1. A device for illuminating a (three-dimensional) object in a measuring device, comprising

a row of several lamps,

a mirror cavity comprising two plane-parallel mirrors, the one mirror being placed above the other and the reflecting surfaces of the mirrors facing each other, and

a cylindrical lens,

wherein the row of lamps is placed at the rear edge of the mirrors between the mirrors and the lens is placed parallel to the front edge of mirrors, such that the light of the lamps reflected by the plane-parallel mirrors is directed by the lens as a virtually parallel beam on the object to be illuminated.

2. A device according to claim 1, wherein the lens is a cylindrical lens.

3. A device according to claim 1, wherein the lamps are LEDs.

4. A device according to claim 3, wherein the LEDs are bright blue LEDs.

5. A measuring device comprising a device according to any one of the claims 1-4.

6. A measuring device comprising a device according to any one of the claims 1-4 and a halogen illumination.

7. A measuring device comprising several devices according to any one of the claims 1-4 wherein the LEDs of the various devices have different

emission spectra.

8. A measuring device according to any one of the claims 5-7 which is an imaging spectrograph.

9. A method for illuminating an object in a measuring device, wherein the object is illuminated using a device according to any one of the claims 1-4.

10. A method according to claim 9, wherein the object comprises plants or plant material, such as seeds, fruits and flowers.

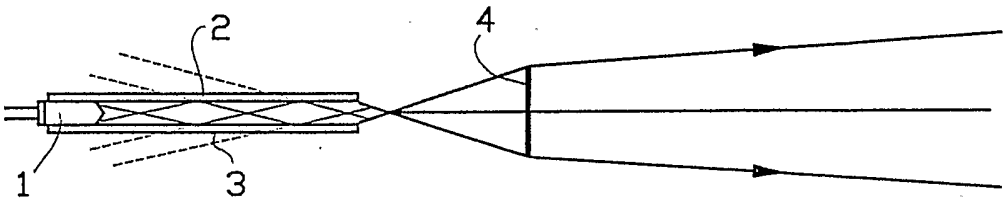

FIG. 1

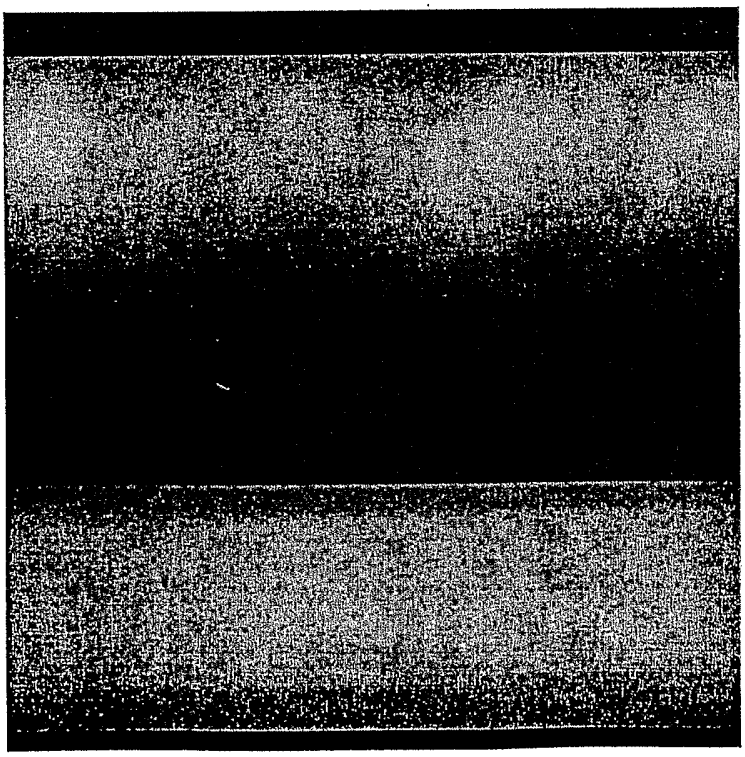

FIG. 2

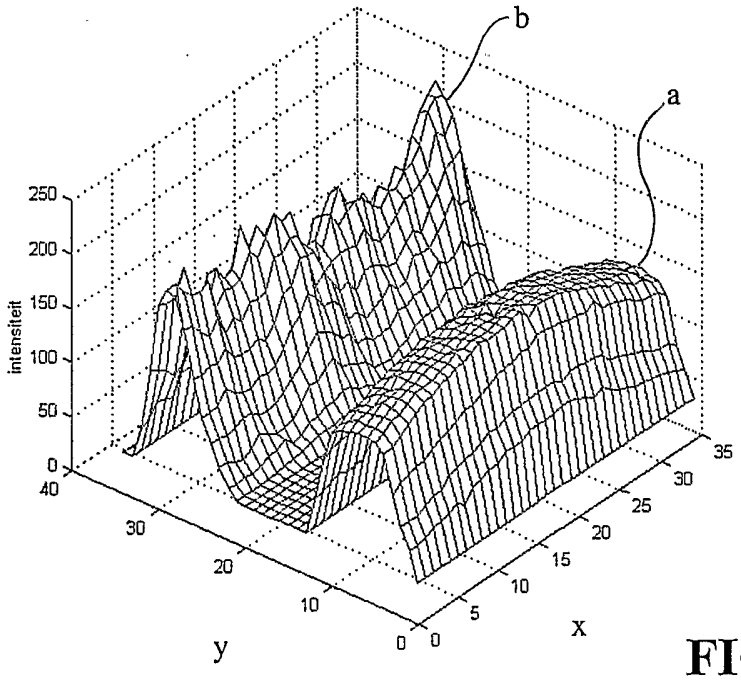
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FIG. 3

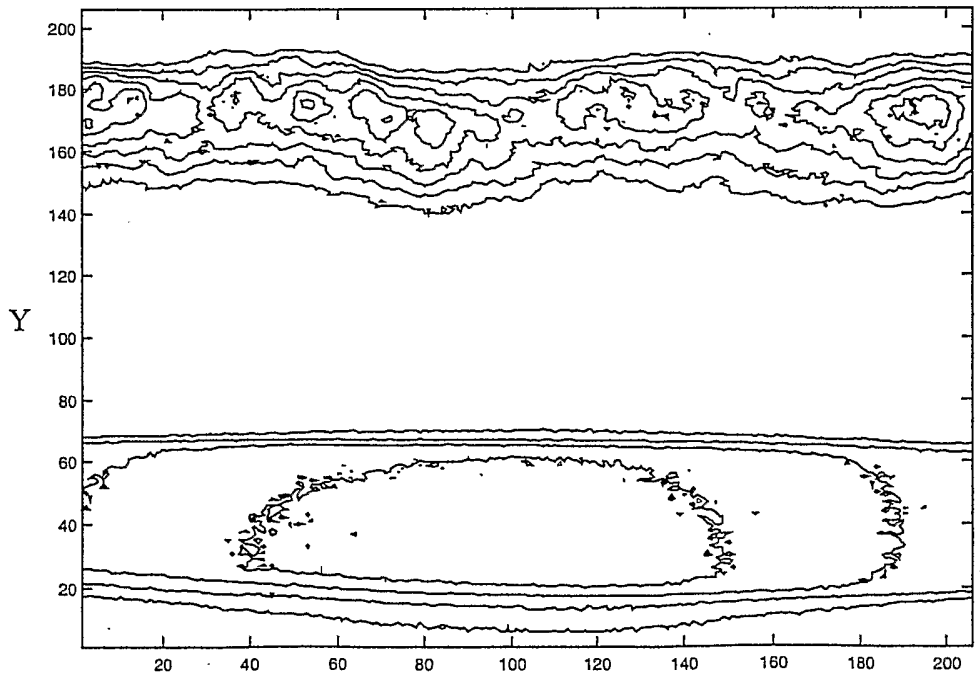
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FIG. 4

INTERNATIONAL SEARCH REPORT

Interne Application No
PCT/NL 03/00042

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G01D11/28

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G01D 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)

WPI Data, EPO-Internal, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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A	EP 0 691 552 A (CORNING INC) 10 January 1996 (1996-01-10) abstract	1

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° *Special categories of cited documents :*

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Date of the actual completion of the international search	Date of mailing of the international search report
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Name and mailing address of the ISA	Authorized officer
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INTERNATIONAL SEARCH REPORT

Interna pplication No
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