(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 869 921 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
25.08.2021 Bulletin 2021/34

(21) Application number: **21158442.0**

(22) Date of filing: **22.02.2021**

(51) Int Cl.:
H05B 45/46 *(2020.01)* ***H05B 45/10*** *(2020.01)*
F21V 5/00 *(2018.01)* *F21V 5/08 (2006.01)*

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(30) Priority: **20.02.2020 IT 202000003566**

(71) Applicant: **Arianna S.p.A.**
35020 Brugine (PD) (IT)

(72) Inventor: **TREVISANELLO, Lorenzo**
35020 Brugine (PD) (IT)

(74) Representative: **Feltrinelli, Secondo Andrea**
APTA S.r.l.
Patent Department
Via Ca' di Cozzi, 41
37124 Verona (IT)

(54) LED LIGHTING DEVICE

(57) A LED light apparatus (1), comprising a carrier element (2), a plurality of strings (3; 3a-3e) of LEDs (4), fixed to the carrier element (2), a plurality of groups (5; 5a-5e) of primitive optics (6; 6a-6e), each associated with a respective LED (4), and each configured for concentrating and conveying the light emitted by the respective LED (4); a power supply unit (8), provided with a plurality of independent outputs (9), each connected to a respective string (3; 3a-3e) of LEDs (4), and a control unit (10) for the current that powers the single strings (3; 3a-3e) of LEDs (4), to which the power supply unit (8) is operatively connected. The control unit (10) is configured for powering each of the strings (3; 3a-3e) of LEDs (4), by means of the power supply unit (8), all simultaneously and in a differentiated manner for each string (3; 3a-3e), so as to modulate the absorbed power thereof, and so as to obtain an overall photometric distribution of the apparatus (1) that derives from the combination of the light intensities emitted by the strings (3; 3a-3e), each modulated in an autonomous manner; the control unit (10) is also configured for carrying out, by means of the power supply unit (8), a dimming of the current that powers the single channels of the strings (3; 3a-3e) of LEDs (4), with values comprised between 0 and 1.

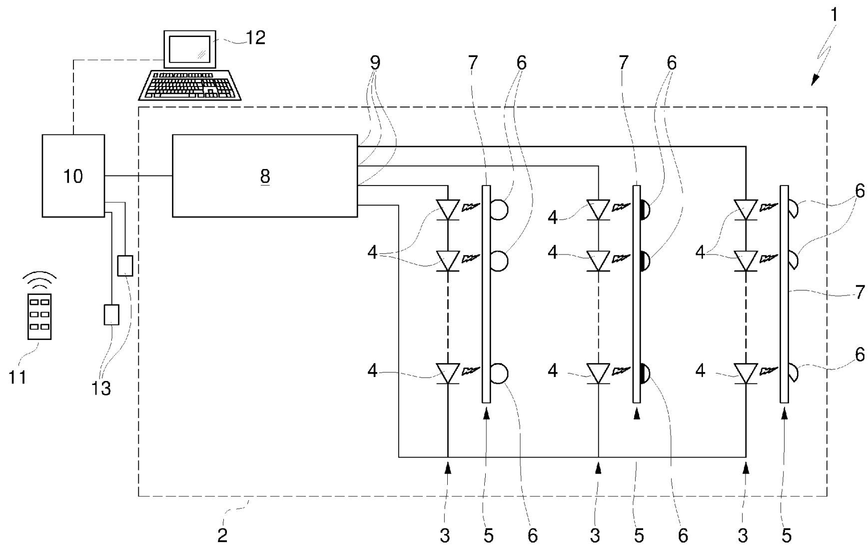

FIG. 1

EP 3 869 921 A1

Printed by Jouve, 75001 PARIS (FR)

Description

TECHNICAL FIELD OF THE INVENTION

[0001] The present invention relates to a LED light apparatus.

[0002] More in detail, the present invention relates to a LED light apparatus comprising a device for the dynamic adjustment of the photometric distribution of the apparatus itself.

BACKGROUND ART

[0003] One of the most important factors affecting road safety is lighting at night.

[0004] There are several standards that define the minimum requirements for street lighting in relation to certain parameters, such as uniformity and average luminance, capable of ensuring an adequate safety level.

[0005] It should also be considered that the conditions of the road surface, which depend on both the type of surface finish and the climatic situation (possible rain, snow, ice, etc.), have a significant influence on the safety parameters.

[0006] In addition, there is, however, growing attention to additional parameters that relate to the visual comfort of the user, such as discomfort glare.

[0007] In order to be able to meet all the lighting requirements, which can also be very different from one another, street lighting fixtures must be able to offer as general photometric distributions as possible.

[0008] More in detail, street lighting fixtures must achieve lighting conditions that comply with regulations even under different installation conditions due to height above the ground, reciprocal distance between poles and road width.

[0009] Some manufacturers provide lighting devices with different photometric distributions, suitable for different scenarios and different needs.

[0010] In light apparatuses with generic photometric distribution, of known type, the emission is never optimized for a specific scenario, and therefore there is always a considerable scattering of unused light.

[0011] Photometric features of this type have, on average, a rather low effectiveness, where by effectiveness we mean the ratio between the so-called "lumen output" and the average luminance in the area to be illuminated.

[0012] On the other hand, in the case of apparatuses with different photometric features, the effectiveness is better, since the distribution is optimized for the various scenarios. However, this latter approach requires prior knowledge of the geometric features of the installation, and this makes the post-design logistics process more difficult. Furthermore, the use of this technology makes any post-installation changes impossible, which may be required, for example, in the event of a change in climatic conditions and in road finish, or in the event of a change in road safety classification, due to a decrease or increase in the volume of vehicle traffic.

OBJECTS OF THE INVENTION

[0013] The technical aim of the present invention is to improve the state of the art in the field of LED light apparatuses.

[0014] Within such technical aim, it is an object of the present invention to provide a LED light apparatus to overcome the above-mentioned drawbacks.

[0015] Another object of the present invention is to provide a LED light apparatus, particularly for street lighting applications, which allows to optimize the photometric distribution in any application and installation condition.

[0016] It is a further object of the present invention to provide a LED light apparatus which allows to not resort to different photometric features for different application and installation conditions.

[0017] Yet another object of the present invention is to provide a LED light apparatus that allows to optimize the photometric distribution also *in situ*, without having to know the geometric features of the installation *a priori.*

[0018] Another object of the present invention is to provide a LED light apparatus that allows the optimum management of situations of even very sudden climatic changes.

[0019] Another object of the present invention is to provide a LED light apparatus that allows to adapt the photometric distribution thereof in the case of events, of limited duration, that change the operating scenario of the apparatus itself.

[0020] A further object of the present invention is to provide a LED light apparatus that allows to adapt the photometric distribution thereof to situations with changing traffic volumes. This aim and these objects are all achieved by a LED light apparatus according to the attached claim 1.

[0021] The apparatus comprises a carrier element, a plurality of LED strings, fixed to the carrier element, and a plurality of groups of primitive optics, each associated with a respective LED, and each configured for concentrating and conveying the light emitted by the respective LED.

[0022] The apparatus further comprises a power supply unit, provided with a plurality of independent outputs, each connected to a respective LED string; the apparatus also comprises a control unit for the current that powers the single LED strings, to which the power supply unit is operatively connected.

[0023] According to an aspect of the invention, the control unit is configured for powering each of the LED strings, by means of the power supply unit, all at the same time and in a differentiated manner for each string, so as to modulate the absorbed power thereof, and so as to obtain an overall photometric distribution of the apparatus that derives from the combination of the light intensities emitted by the strings, each modulated in an autonomous manner.

[0024] According to another aspect of the invention, the control unit of the apparatus is configured for carrying out, by means of the power supply unit, a dimming of the current which powers the single channels of the LED strings.

[0025] In particular, the aforesaid dimming is carried out using, for each LED string, values comprised between 0 and 1.

[0026] This allows to modulate, very accurately, the light intensity of each of the LED strings; consequently, it is possible to modify, as desired, the photometric distribution of the entire apparatus in relation to adjustment parameters chosen by the user, based on the result to be obtained (for example, in relation to certain environmental conditions in the area to be illuminated).

[0027] The dependent claims refer to preferred and advantageous embodiments of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0028] These and other advantages will be better understood by those skilled in the art from the description below and from the accompanying drawings, given as a non-limiting example, in which:

- Figure 1 is a schematic representation of the LED light apparatus according to the invention;
- Figure 2 shows an example of basic photometric curves generated by four LED strings of the apparatus, and two resulting photometric curves thereof below;
- Figure 3 is an axonometric view of the LED light apparatus;
- Figure 4 is an exploded axonometric view of the same LED light apparatus;
- Figures 5 and 6 are respective axonometric views of first primitive optics installed in an embodiment of the apparatus according to the invention;
- Figure 7 is an axonometric view of second, third primitive optics installed in an embodiment of the apparatus according to the invention;
- Figure 8 is an axonometric view of fourth primitive optics installed in an embodiment of the apparatus according to the invention;
- Figures 9 and 10 are respective axonometric views of fifth primitive optics installed in an embodiment of the apparatus according to the invention;
- Figure 11 is a three-dimensional diagram showing the emission angles of a primitive optic installed in the apparatus according to the invention.

EMBODIMENTS OF THE INVENTION

[0029] With particular reference to Figure 1, a LED light apparatus according to the present invention is indicated as a whole with the reference number 1.

[0030] The apparatus 1 is illustrated, in Figure 1, in a completely schematic manner, and not limited to particular geometric conformations or configurations, which are not referred to in the present description.

[0031] In fact, the solution of the present invention can be applied to LED light apparatuses of any type, without particular limitations.

[0032] An application of the present invention of particular practical interest is that of street lighting.

[0033] The apparatus 1 comprises a carrier element 2, or support structure, which may be of any type, and may have any shape and size (the carrier element 2 is depicted discontinuously in Figure 1).

[0034] The apparatus 1 comprises a plurality of strings 3 of LEDs 4.

[0035] More in detail, the apparatus comprises a predetermined number N of strings 3 of LEDs 4.

[0036] The strings 3 of LEDs 4 are fixed to the carrier element 2.

[0037] In more detail, the strings 3 of LEDs 4 are fixed, to the carrier element 2, in any manner and according to any configuration, suitable for the specific application.

[0038] In each of the strings 3, the LEDs 4 are connected to each other in series, and they are drivable independently of one another.

[0039] The LEDs 4 of each of the strings 3 can have any specific features, without any particular limitations.

[0040] According to an aspect of the invention, the apparatus 1 further comprises a plurality of groups 5 of primitive optics 6.

[0041] In particular, the apparatus 1 comprises a number of groups 5 of primitive optics 6 equal to N, i.e., equal to the number of strings 3 of LEDs 4.

[0042] Each group 5 comprises a specific type of primitive optics 6, each associated with a respective LED 4.

[0043] The primitive optics 6, which can be of different types and/or geometries and/or configurations, have the function of concentrating and conveying the light emitted by the respective LED 4, according to the desired ways, chosen in the design step.

[0044] The primitive optics 6 of each group 5 are preferably all identical, but it is not excluded that they may differ from each other, for certain design or application reasons. Furthermore, the primitive optics 6 of each group 5 have different geometric features from the primitive optics 6 of the other groups 5.

[0045] The primitive optics 6 of each group 5 can be mounted on a respective support 7; the support 7 is, in turn, fixed/connected to the respective string 3 of LEDs 4.

[0046] According to another aspect of the invention, the apparatus 1 comprises a power supply unit 8.

[0047] The power supply unit 8 in turn comprises a plurality of independent outputs 9; more specifically, the power supply unit 8 comprises a number of independent outputs 9 equal to the aforementioned predetermined number N.

[0048] The strings 3 of LEDs 4 are each connected to a respective output 9 of the power supply unit 8.

[0049] The power supply unit 8 is configured for driving, in current, each of the strings 3 of LEDs 4, connected to the outputs 9, in an autonomous manner from one another. According to a further aspect of the invention, the apparatus 1 comprises a control unit 10 for the current that powers the channels of the single strings 3 of LEDs 4.

[0050] The power supply unit 8 is operatively connected to the aforesaid control unit 10, which, therefore, is configured for managing the currents that, by means of the power supply unit 8, is supplied to the single strings 3 of LEDs 4.

[0051] According to another aspect of the invention, the control unit 10 is provided with a remote control interface.

[0052] The control unit 10 is configured for powering each of the strings 3 of LEDs 4, through the aforesaid power supply unit 8, all at the same time and in a differentiated manner for each string 3, so as to modulate the power absorbed by each of the strings 3.

[0053] As better explained below, this allows to obtain a photometric distribution of the apparatus 1, which derives from the combination of the light intensities emitted by the single strings 3, each modulated in an autonomous manner.

[0054] Furthermore, the control unit 10 is configured for carrying out, by means of the power supply unit 8, a dimming of the single channels of the strings 3 of LEDs 4, with values comprised between 0 and 1, as better explained below.

[0055] The remote control interface can be, for example, of the type with wireless technology, or of the powerline type, or other suitable type for this application.

[0056] Pi is defined as the two-dimensional matrix "1 x m" which represents the light intensity values obtained with the i-th primitive optic 6 (i.e., with the i-th group 5 of primitive optics 6).

[0057] The dimensions of the matrix Pi - with reference to Figure 11 - are given by the sampling interval of the emission angles considered, with reference to any given i-th primitive optic 6, installed in the apparatus 1 according to the invention.

[0058] In particular, in the diagram of Figure 11, "1" is the number of angles γ between 0° and 180°, while "m" is the number of planes C1, C2, C3, C4 (which in this case are four, i.e., four semi-planes perpendicular to each other, respectively at 0°, 90°, 180°, 270°). The diagram of Figure 11 also shows the directions X, Y on the pavement, or ground, of the illuminated environment.

[0059] There are therefore a number N of matrices Pi, one for each group 5 of primitive optics 6 (and then one for each string 3 of LEDs 4).

[0060] B, on the other hand, is defined as the one-dimensional matrix, or vector, of dimension N, which represents the N dimming values (or of adjustment of the absorbed power) of the single channels of the strings 3 of LEDs 4, with values comprised between 0 and 1; the i-th value of B is indicated with bi.

[0061] In addition, F is defined as the matrix that represents the light intensity values of the combination of all the strings 3 of LEDs 4 of the apparatus 1.

[0062] According to the invention, said matrix F is obtained as follows:

$$F = \sum_{i=1}^{n} b_i \cdot P_i$$

[0063] As shown in Figure 2, merely by way of non-limiting example, each string 3 of LEDs 4 of the apparatus 1, with the respective primitive optics 6, emits a certain light beam in the surrounding space, which, as is known, can be represented by a respective photometric curve.

[0064] In the aforesaid Figure 2, the photometric curves K, L, M, R (which we can define primitive) of four different strings 3 of LEDs 4, associated with the respective groups 5 of primitive optics 6, are shown.

[0065] In the same Figure 2, two examples of resulting photometric curves V, W, obtained from the combination of the different primitive photometric curves K, L, M, R, are also shown.

[0066] The matrices Pi (with i from 1 to N) of the light intensities of the different strings 3 of LEDs 4 are constant, and they are essentially linked to the geometry of the corresponding primitive optics 6.

[0067] In a use mode according to the invention, the matrix B can also be kept constant, so as to obtain a certain photometric distribution that does not change over time.

[0068] In this use mode, a dimming of the luminous flux is carried out, maintaining a constant photometric distribution of the apparatus 1.

[0069] In another use mode according to the invention, the matrix B can instead be varied in a dynamic manner.

[0070] In this other use mode, it is possible to perform a punctual dimming of the current that powers the single strings 3 of LEDs 4, allowing to obtain numerous possible photometric distributions, capable of working effectively in different installation scenarios.

[0071] In general, the control unit 10 is configured for allowing the modulation of the luminous flux or light distribution, in an active manner, using different approaches, and distinguishing the installation step from the subsequent operational management step. More in detail, and according to another aspect of the invention, the apparatus 1 can comprise a remote control device 11 (for example, a remote control, radio control, or the like), configured for being connected to the control unit 10 with a wireless connection.

[0072] The remote control device 11 is configured for modifying the dimming of the single channels of the strings 3 of LEDs 4, both in the installation step and in the subsequent management of the operating conditions of the apparatus 1, and at any moment. According to a further aspect of the invention, the apparatus 1 may comprise a web application, to which the control unit 10 is connectable, configured for allowing, at any moment, the remote management of the operating conditions of the apparatus 1 itself, for example by means of a terminal 12, a tablet, a smartphone, or the like.

[0073] According to yet another aspect of the invention, the apparatus 1 comprises one or more sensors 13 for detecting the environmental conditions in the area of installation of the apparatus 1 itself.

[0074] The sensors 13 are integrated in the apparatus 1 and are operatively connected to the control unit 10.

[0075] For example, the sensors 13 may be luminance sensors, or rain sensors, or another type suitable for this type of application.

[0076] Different methods can be used for installing and setting the apparatus 1.

[0077] A first method includes a spot control by means of the aforesaid remote control device 11; a second method includes an automatic spot control, remotely, by entering design data into the aforesaid web application.

[0078] Post-installation operational management can also be carried out in different manners. A first method of operational management involves a manual spot control, remotely, through the aforesaid web application.

[0079] A second method of operational management includes an automatic spot control, by means of the aforesaid sensors 13 integrated in the apparatus 1.

[0080] Figures 3-10 refer to a specific, non-limiting embodiment of the apparatus 1 according to the invention, particularly intended for street lighting.

[0081] In this embodiment, the apparatus 1 comprises, merely by way of example, a number N=5 of strings 3 of LEDs 4, and in particular a first string 3a, a second string 3b, a third string 3c, a fourth string 3d and a fifth string 3e.

[0082] Figures 3,4 show the arrangement of such five strings 3a-3e of LEDs 4 on the carrier element 2.

[0083] Each string 3a-3e of LEDs 4 is associated with a respective group 5a-5e of primitive optics 6a-6e.

[0084] The first string 3a of LEDs 4 is positioned substantially in the centre of the carrier element 2, and it comprises four LEDs 4, arranged according to a 2x2 matrix.

[0085] The LEDs 4 of the first string 3a are associated with a first group 5a of first primitive optics 6a.

[0086] The first primitive optics 6a (left and right versions) are respectively shown, in detail, in Figures 5,6.

[0087] Each of the first primitive optics 6a comprises a base 14, a concentrating surface 15, inclined for longitudinal illumination, and a lateral stop surface 16 of the marginal rays, which are thus reflected in the centre.

[0088] With respect to the base 14, the concentrating surface 15 has an appropriate lateral orientation, to direct the beam longitudinally.

[0089] The second string 3b of LEDs 4 is positioned along one side of the carrier element 2, and it comprises four LEDs 4, arranged in a row.

[0090] The LEDs 4 of the second string 3b are associated with a second group 5b of second primitive optics 6b.

[0091] The second primitive optics 6b are shown, in detail, in figure 7.

[0092] The third string 3c of LEDs 4 is positioned along another side of the carrier element 2 (opposite the second string 3b), and it comprises four LEDs 4, arranged in a row.

[0093] The LEDs 4 of the third string 3c are associated with a third group 5c of third primitive optics 6c.

[0094] The third primitive optics 6c are identical to the second primitive optics 6b (Figure 7). Each of the second, third primitive optics 6b, 6c comprises a base 14, a double-ray surface 17, for distributing light along the entire lane, and a full-reflection rear surface 18.

[0095] The fourth string 3d of LEDs 4 is positioned along another side of the carrier element 2, and it comprises four LEDs 4, arranged in a row.

[0096] The fourth string 3d is arranged orthogonal to the second string 3b and to the third string 3c.

[0097] The LEDs 4 of the fourth string 3d are associated with a fourth group 5d of fourth primitive optics 6d.

[0098] Each of the fourth primitive optics 6d is shown, in detail, in Figure 8.

[0099] Each of the fourth primitive optics 6d comprises a base 14, a double-belly surface 19, for dividing the light into two beams, which dose the illumination at the edges of the central area, and backs 20 for the total forward reflection and recovery of the scattered light.

[0100] The fifth string 3e of LEDs 4 is positioned substantially in the centre of the carrier element 2 (near the first string 3a), and it comprises four LEDs 4, arranged according to a 2x2 matrix.

[0101] The LEDs 4 of the fifth string 3e are associated with a fifth group 5e of fifth primitive optics 6e.

[0102] The fifth primitive optics 6e (left and right versions) are shown in Figures 9,10, respectively.

[0103] Each of the fifth primitive optics 6e comprises concentrating surfaces 21, for tilting and directing the light beam in the outermost zones, longitudinally to the road, and a stop and control surface 22 of the beam.

[0104] The fifth primitive optics 6e are installed with an appropriate orientation, to orient the light beam longitudinally.

[0105] The photometric curves K, L, M, R shown in Figure 2 refer, respectively, to the first primitive optics 6a, the second, third primitive optics 6b, 6c, the fourth primitive optics 6d and the fifth primitive optics 6e.

[0106] It should be noted that, in other embodiments, the shapes of the primitive optics 6a-6e may be different, in relation to certain application needs.

[0107] The object of the present invention is also a control method of the light apparatus 1 described above.

[0108] The control method comprises a step of providing a plurality of matrices Pi each of which representing the light intensity values obtained with the i-th primitive optic 6 (i.e., with the i-th group 5 of primitive optics 6).

[0109] The method then comprises a step of providing a one-dimensional matrix B, or vector, (of dimension N) which represents the dimming (or absorbed power adjustment) values of the single channels of the strings 3 of LEDs 4, with values comprised between 0 and 1; the i-th value of B is indicated with bi.

[0110] This is followed by a step of determining a matrix F, which represents the light intensity values of the combination of all the strings 3 of LEDs 4 of the apparatus 1, as follows:

$$F = \sum_{i=1}^{n} b_i \cdot P_i$$

[0111] The method finally comprises a step of carrying out, by means of the control unit 10, the dimming of the current that powers the single channels of the strings 3 of LEDs 4, by means of the aforesaid matrix F.

[0112] The invention thus conceived allows to achieve important technical advantages.

[0113] First, it becomes possible to regulate installations where the photometric distribution used is incorrect, due to incorrect lighting design.

[0114] Furthermore, it is possible to install lighting fixtures in situations where the geometries of the lighting scenario are unknown, so that they can be subsequently regularized.

[0115] In addition, it is possible to quickly and effectively manage changes in weather conditions, keeping lighting parameters within the limits of safety and visual comfort.

[0116] Last but not least, it becomes possible to adapt the photometric distribution of the apparatus in case of events of limited duration, or in case of changes in traffic volumes (for example, in the transition from a certain situation in the early hours of the night, to a different situation in later hours of the same night).

[0117] In fact, thanks to the analogue, and therefore continuous, dimming of all the simultaneously powered LED strings, and to the overlapping of the primitive photometric features, it is possible to create infinite photometric features within a predefined range.

[0118] A further advantage in the use of the light apparatus 1 according to the present invention is given by the considerable reduction in the number of different models available, since, by virtue of the proposed solution, the photometric distribution is no longer a variable.

[0119] This allows to speed up the entire logistics process, from the manufacturing of the apparatus to installation.

[0120] Furthermore, the maintenance process of the apparatus is also sped up.

[0121] In fact, in the event of a fault, it will no longer be necessary to wait for the replacement of a particular product code, which can often take a long time, but the replacement can be carried out with a completely generic and universal model, stored in the maintenance warehouse.

[0122] It has thus been seen how the invention achieves the intended purposes.

[0123] The invention thus conceived is susceptible to numerous modifications and variations, all falling within the inventive concept.

[0124] In addition, all the details can be replaced by other technically equivalent elements.

[0125] In practice, the materials employed, as well as the shapes and the dimensions, may be any according to requirements without thereby departing from the scope of protection of the following claims.

Claims

1. LED light apparatus (1), comprising
a carrier element (2);
a plurality of strings (3; 3a-3e) of LEDs (4), fixed to said carrier element (2);
a plurality of groups (5; 5a-5e) of primitive optics (6; 6a-6e), each of said primitive optics (6; 6a-6e) being associated with a respective LED (4), and configured for concentrating and conveying the light emitted by the respective LED (4);
a power supply unit (8), provided with a plurality of independent outputs (9), each connected to a respective string (3; 3a-3e) of LEDs (4), and
a control unit (10) for the current that powers the single strings (3; 3a-3e) of LEDs (4), which is operatively connected to said power supply unit (8), **characterized in that** said control unit (10) is configured for powering each of said strings (3; 3a-3e) of LEDs (4), by means of said power supply unit (8), all at the same time and in a differentiated manner for each string (3; 3a-3e), so as to modulate the absorbed power thereof, and so as to obtain an overall photometric distribution of the apparatus (1) that derives from the combination of the light intensities emitted by said strings (3; 3a-3e), each modulated in an autonomous manner, **and in that** said control unit (10) is configured for carrying out, by means of said power supply unit (8), a dimming of the current that powers the single channels of said strings (3; 3a-3e) of LEDs (4), with values comprised between 0 and 1.

2. Apparatus (1) according to claim 1, wherein the primitive optics (6; 6a-6e) of each group (5; 5a-5e) have geometric features different from the primitive optics (6; 6a-6e) of the other groups (5; 5a-5e).

3. Apparatus (1) according to one of the preceding claims, wherein the primitive optics (6; 6a-6e) within each group (5; 5a-5e) are identical to each other.

4. Apparatus (1) according to one of the preceding claims, comprising a remote control device (11), configured for being connected to said control unit (10) with a wireless connection, and configured for modifying the dimming of the single channels of said strings (3; 3a-3e) of LEDs (4), both in installation step and in the subsequent management of the operating conditions of the apparatus (1), and at any moment.

5. Apparatus (1) according to one of the preceding claims, comprising a web application, which is connected to said control unit (10), configured for allowing, at any moment, the remote management of the operating conditions of the apparatus (1), for example by means of a terminal (12), a tablet, a smartphone, or the like.

6. Apparatus (1) according to one of the preceding claims, comprising one or more sensors (13) for detecting the environmental conditions of the area of installation of the apparatus (1), said sensors (13) being integrated in the apparatus (1) and operatively connected to said control unit (10).

7. Method for controlling the apparatus (1) according to one of claims 1-6, comprising the steps of:

providing a plurality of matrices (Pi), each of which representing the light intensity values obtained with the i-th group (5; 5a-5e) of primitive optics (6; 6a-6e);
providing a one-dimensional matrix (B) which represents the dimming values of the single channels of said strings (3; 3a-3e) of LEDs (4), with values comprised between 0 and 1, wherein the i-th value of (B) is indicated with (bi);
determining a matrix (F), which represents the light intensity values of the combination of all said strings (3; 3a-3e) of LEDs (4) of the apparatus (1), in the following manner:

$$F = \sum_{i=1}^{n} b_i \cdot P_i$$

carrying out, by means of said control unit (10), the dimming of the current that powers the single channels of the strings (3; 3a-3e) of LEDs (4), by means of said matrix (F).

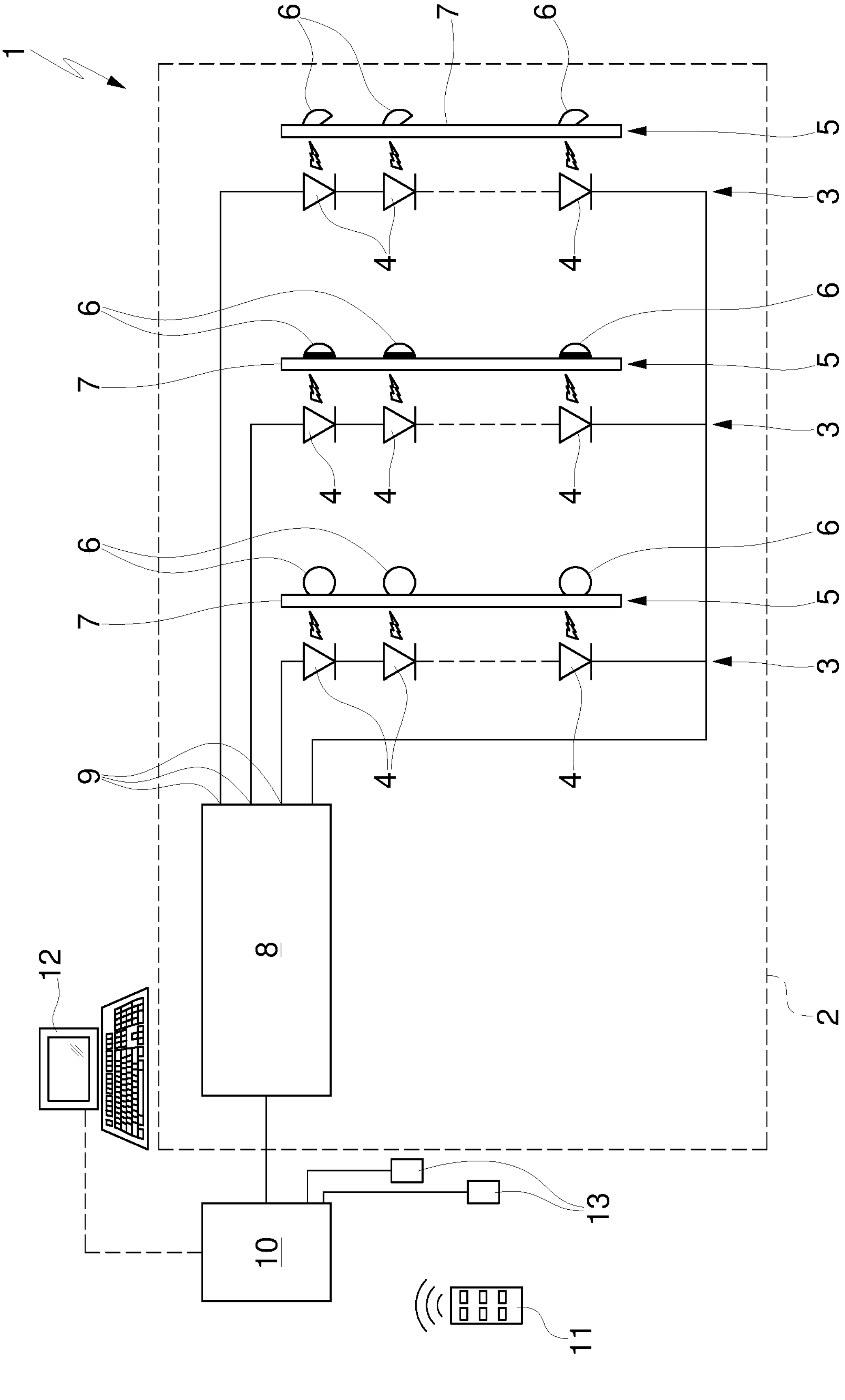

FIG. 1

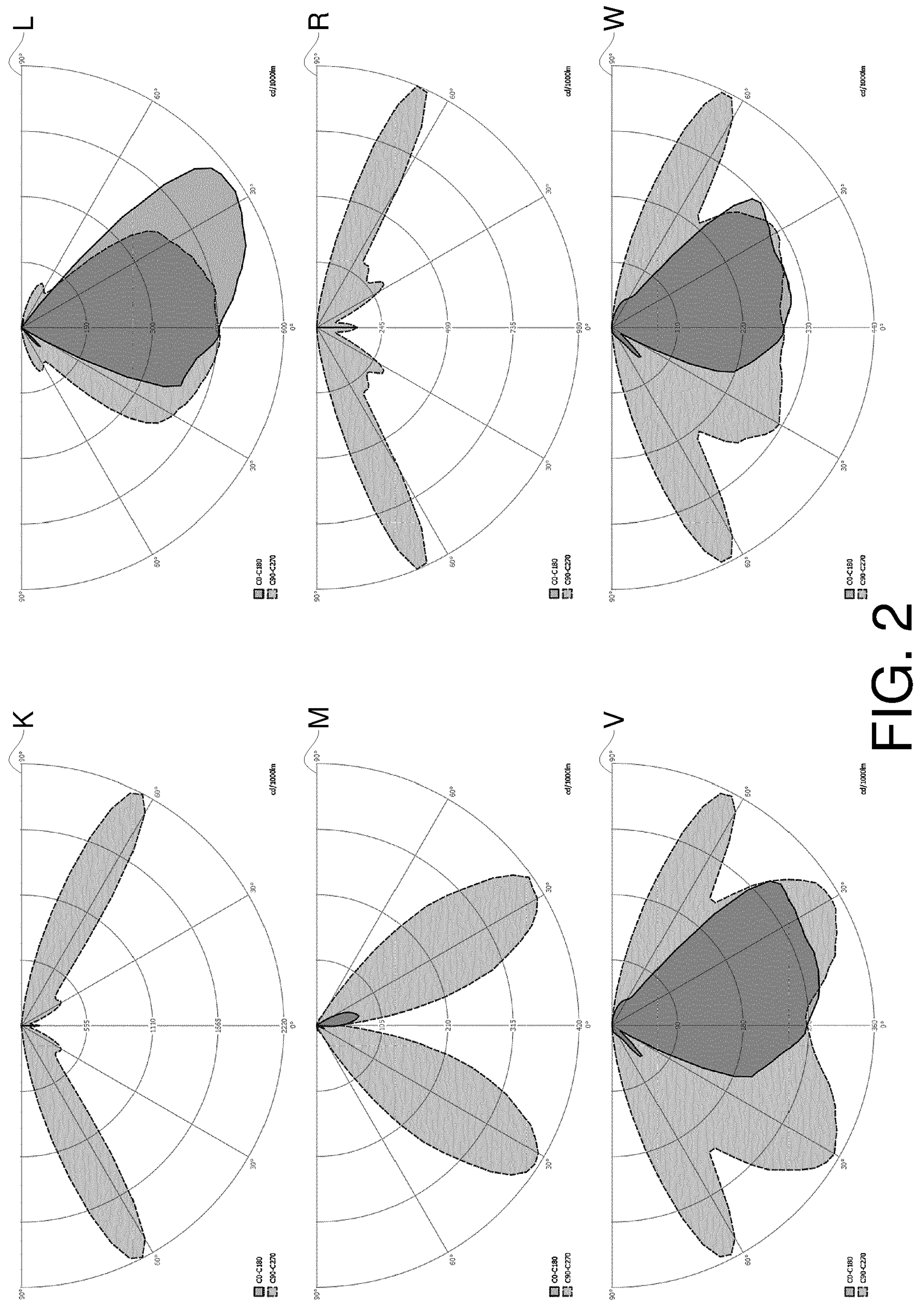

FIG. 2

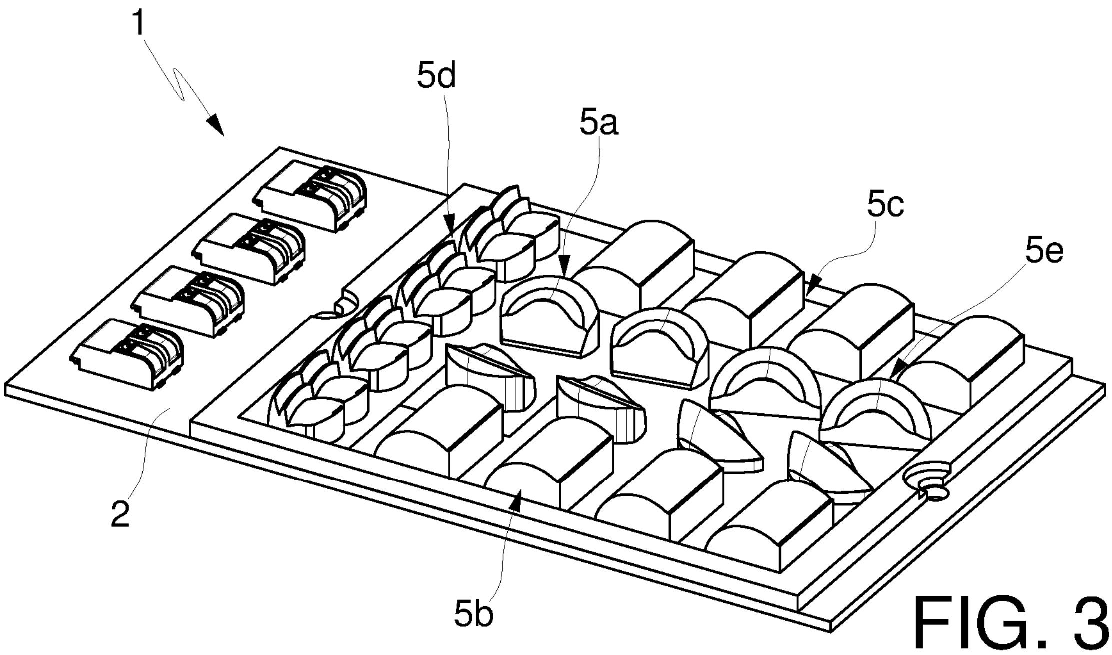

FIG. 3

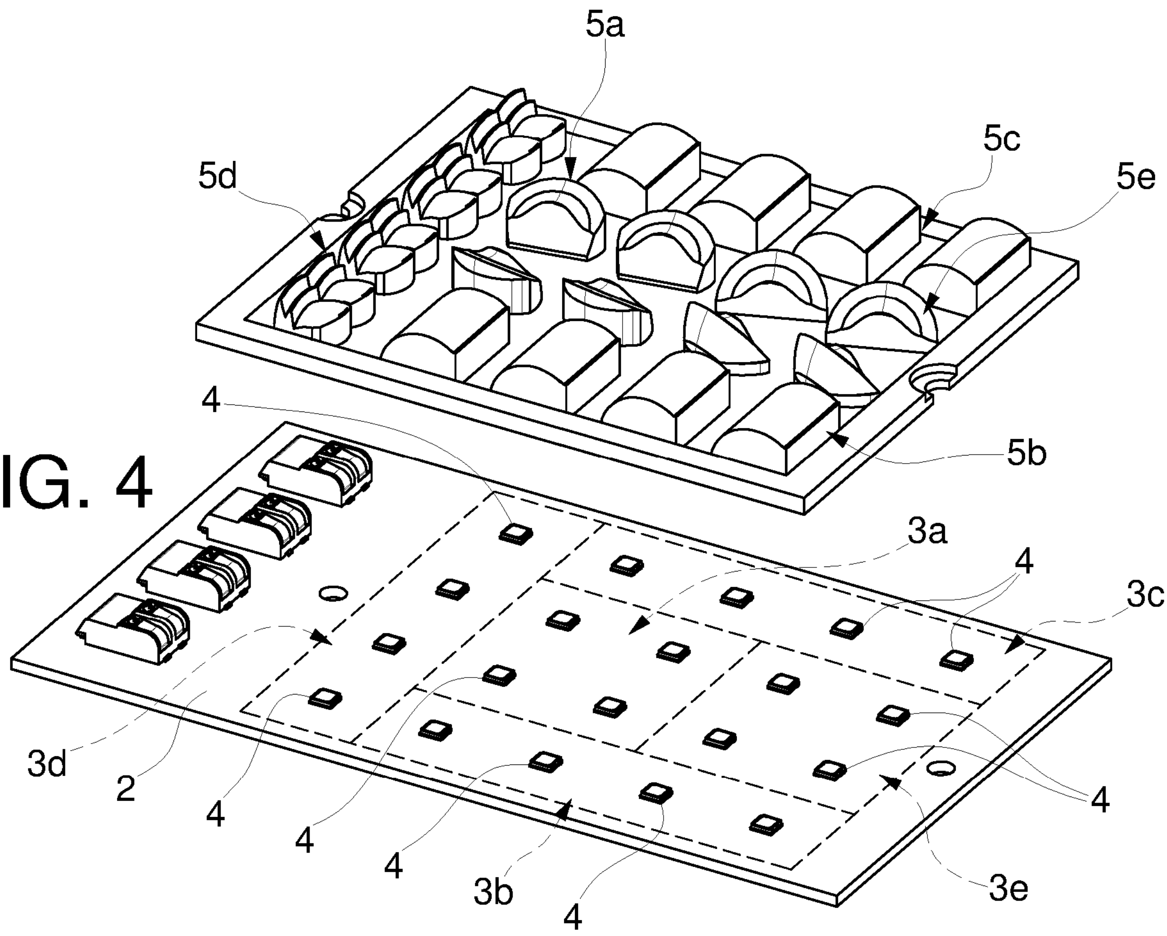

FIG. 4

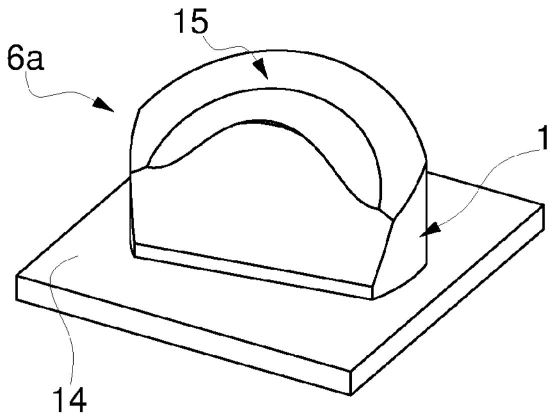

FIG. 5

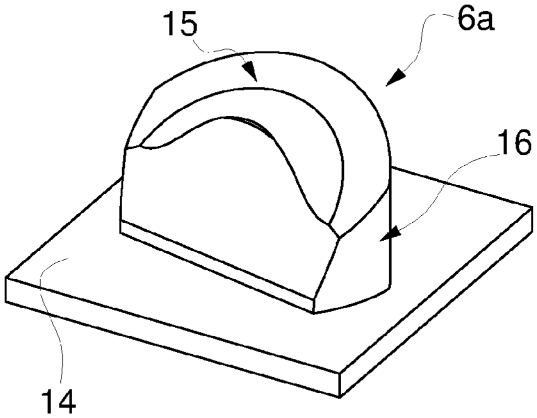

FIG. 6

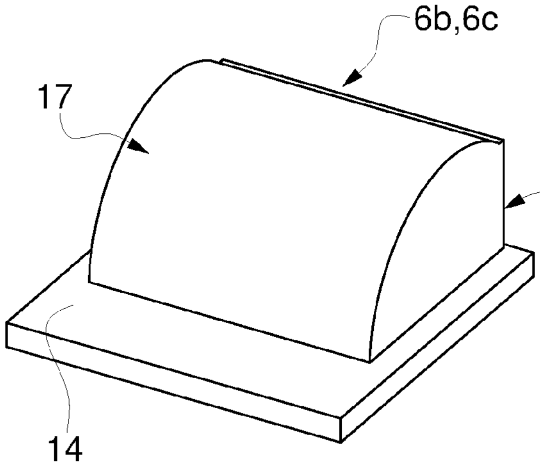

FIG. 7

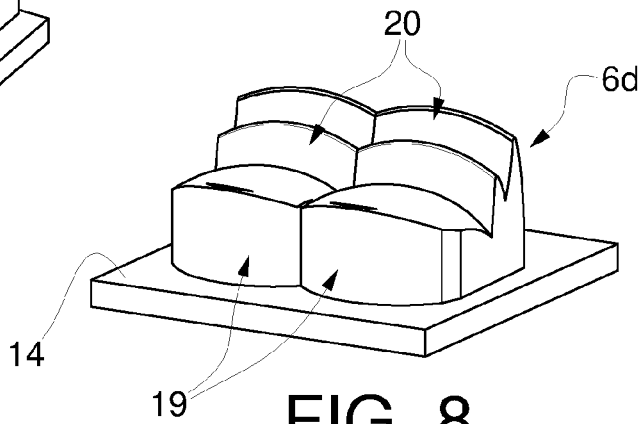

FIG. 8

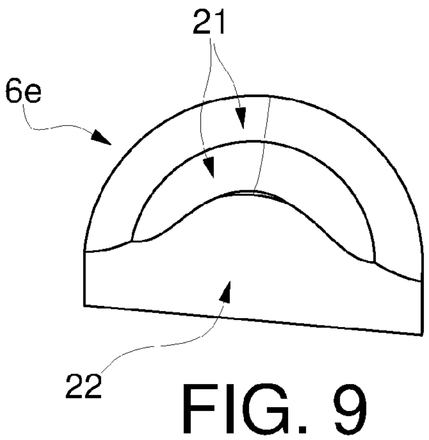

FIG. 9

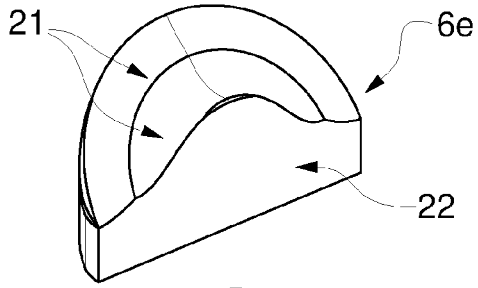

FIG. 10

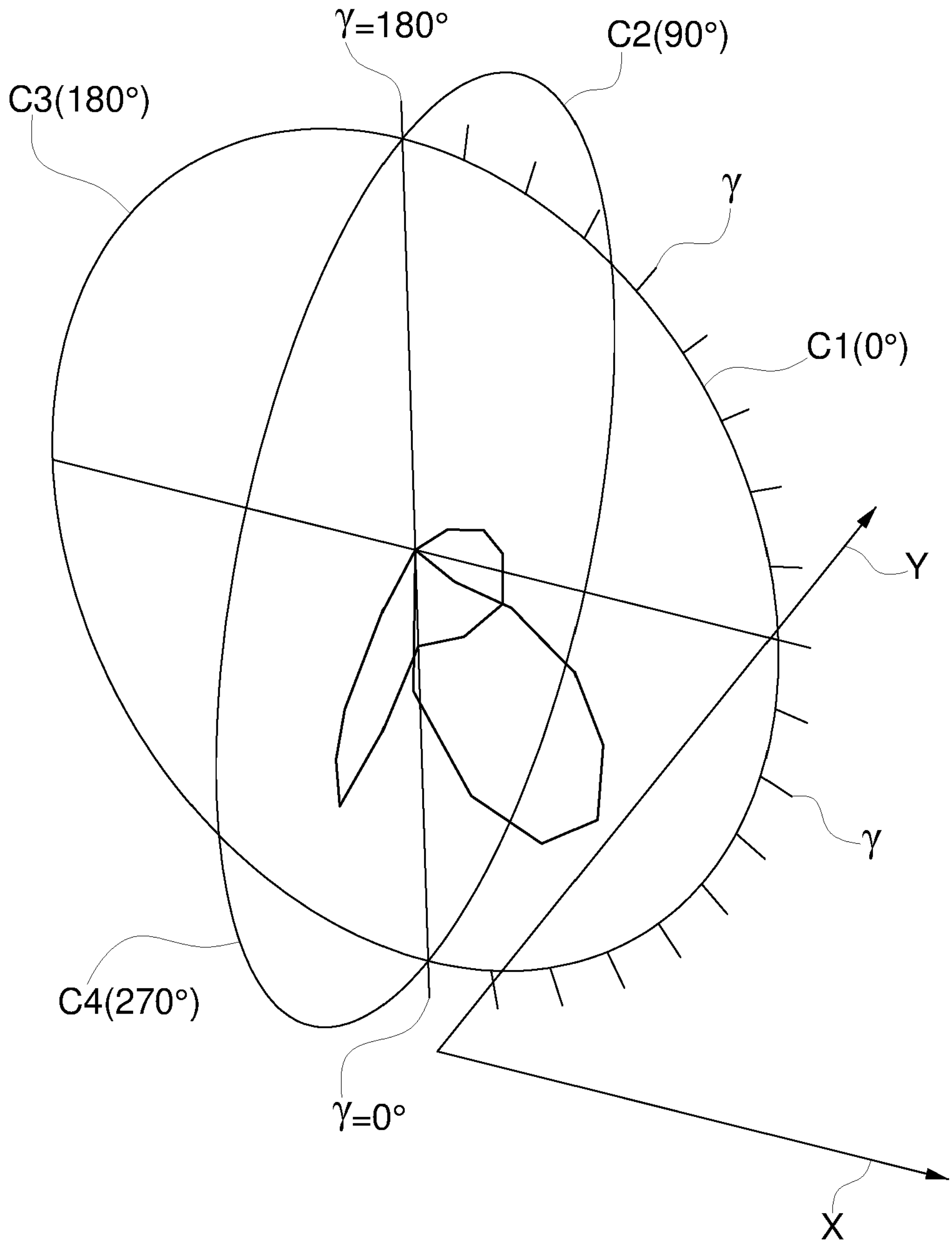

FIG. 11

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 21 15 8442

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 A	US 2007/091602 A1 (VAN VOORST VADER PIETER J Q [NL] ET AL) 26 April 2007 (2007-04-26) * paragraphs [0019] - [0040]; figures 3-12 *	1-6 7	INV. H05B45/46 H05B45/10 F21V5/00
X	US 2012/212138 A1 (JUNGWIRTH PAUL [CA] ET AL) 23 August 2012 (2012-08-23) * paragraphs [0038] - [0053]; figures 3,4 *	1-6	ADD. F21V5/08
A	US 2010/060185 A1 (VAN DUIJNEVELDT WIDO [NL]) 11 March 2010 (2010-03-11) * paragraphs [0041] - [0067]; figures 1,2 *	7	

TECHNICAL FIELDS SEARCHED (IPC)

H05B
F21V
F21K

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	2 July 2021	Waters, Duncan

1

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

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 21 15 8442

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

02-07-2021

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2007091602 A1	26-04-2007	CN 101297238 A	29-10-2008
		EP 1943560 A1	16-07-2008
		JP 2007180520 A	12-07-2007
		TW 200728885 A	01-08-2007
		US 2007091602 A1	26-04-2007
		WO 2007049176 A1	03-05-2007
US 2012212138 A1	23-08-2012	NONE	
US 2010060185 A1	11-03-2010	CN 101568952 A	28-10-2009
		EP 2095353 A1	02-09-2009
		JP 5324466 B2	23-10-2013
		JP 2010514131 A	30-04-2010
		KR 20090096525 A	10-09-2009
		RU 2009127701 A	27-01-2011
		TW 200901815 A	01-01-2009
		US 2010060185 A1	11-03-2010
		WO 2008078274 A1	03-07-2008

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82