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(54) **A LIGHTING MODULE**

(57) The invention relates to a lighting module (100), comprising: a housing (101); a radio module (103) inside the housing (101), wherein the radio module (103) comprises a first antenna (104) extending along a first direction (d1); and a slot antenna (102) inside the housing (101)

extending along a second direction (d2), wherein the slot antenna (102) is electromagnetically coupled to the first antenna (104), and wherein an angle (α) between the first direction (d1) and the second direction (d2) is adjustable.

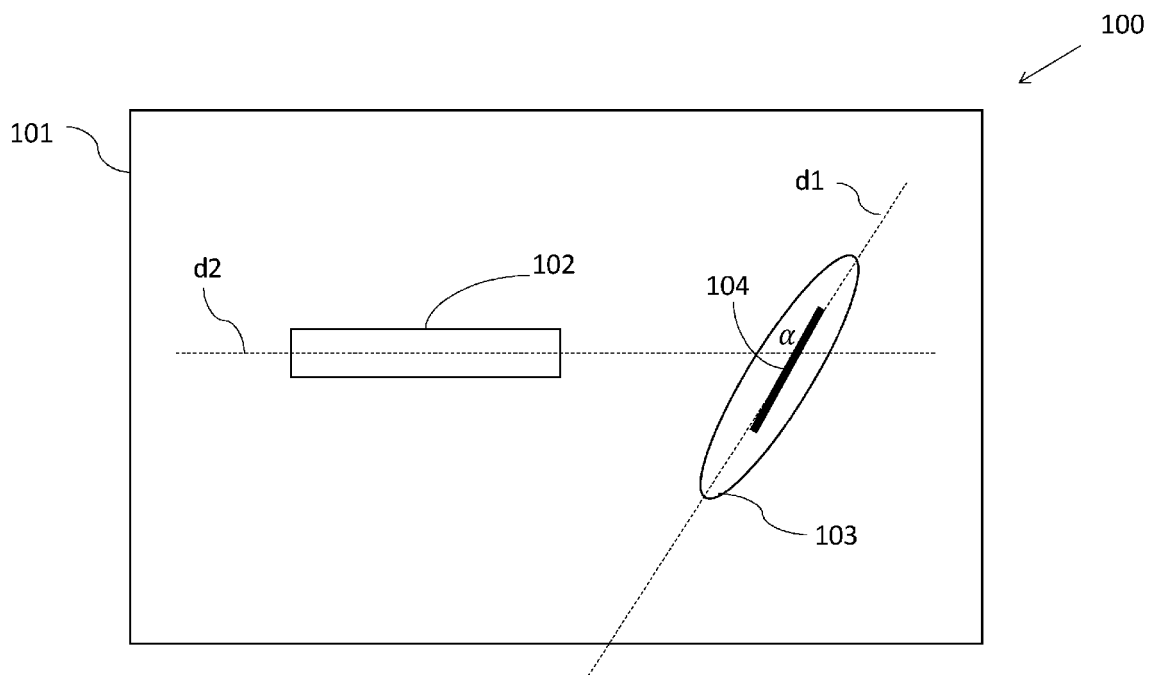


Fig. 1

Description

TECHNICAL FIELD OF THE INVENTION

[0001] The invention relates to a lighting module comprising a radio module.

BACKGROUND OF THE INVENTION

[0002] Many lighting modules or luminaires comprise radio modules and LED drivers whose mounting positions are fixed after the production of the lighting module or luminaire. However, this often means that a radiation performance of the radio module is fixed and cannot be optimized in the actual application of the lighting module or luminaire.

[0003] For instance, in metal luminaires, it is known to position a radio module in a metal housing which comprises an opening such that a signal of the radio module can exit from the housing. It is further known to use slot antennas in the housing to facilitate the signal to exit the housing. The slot antennas are excited by the radio module and act as an antenna to the outside.

[0004] However, these slot antennas are arranged rigidly in the housing and, due to different arrangements of antennas of different types, there may be fluctuations in how well the radio signal primarily generated by the radio module can be decoupled. The relative orientation of the radio module to the slit is a crucial parameter which cannot be changed to optimize performance in most known luminaires.

[0005] Thus, it is an objective to provide for an improved lighting module which avoids the above disadvantages. In particular, it is an objective to optimize the radiation performance of a radio module in a lighting module.

SUMMARY OF THE INVENTION

[0006] The object of the present invention is achieved by the solution provided in the enclosed independent claims. Advantageous implementations of the present invention are further defined in the dependent claims.

[0007] According to a first aspect of the invention, a lighting module is provided. The lighting module comprises a housing, a radio module inside the housing, wherein the radio module comprises a first antenna extending along a first direction and a slot antenna inside the housing extending along a second direction, wherein the slot antenna is electromagnetically coupled to the first antenna, and wherein an angle between the first direction and the second direction is adjustable.

[0008] The angle can be adjusted by changing the orientation of the slot antenna relative to the radio module.

[0009] This provides the advantage that the performance of the radiation emitted by the radio module can be optimized with respect to the outside according to the specific application by changing the relative orientation

of the first antenna with respect to the slot antenna.

[0010] In a preferred embodiment, the first antenna is in a fixed position with respect to the housing, and the housing further comprises a rotational element and the slot antenna is arranged on the rotational element.

[0011] This provides the advantage that the position of the slot antenna relative to the first antenna or radio module can easily be changed or adjusted even in case that the relative position of the entire module to the housing cannot be changed. This is particularly advantageous for cases where a fixing structure of the housing and the radio module allow only one specific position.

[0012] In a preferred embodiment, the rotational element is a disk. Such a disk that is arranged in a wall of the housing can easily be rotated so that any relative orientation between the first and 10 and the second antenna can be achieved.

[0013] In a preferred embodiment, the first antenna is configured to be rotated with respect to the slot antenna arranged fixedly in the housing.

[0014] This provides the advantage that the position of the first antenna relative to the slot antenna can easily be adjusted e.g. by changing the orientation of the first antenna with respect to the housing and keeping the slot antenna in a fixed position with respect to the housing. This is specifically advantageous because the structure of the housing become simpler because movable components can be avoided. The number of parts regarding the housing is reduced and thus manufacturing costs may also be reduced. In this case, the radio module is configured to allow a rotation of the first antenna with respect to the orientation of the second antenna. This can be achieved by positioning the entire module such that the desired orientation between the first antenna and the second antenna is achieved and then affixing the radio module to the housing in this position.

[0015] In a preferred embodiment, the housing further comprises one or more positioning elements cooperating with one or more corresponding elements of the radio module such that the radio module can be positioned in a plurality of orientations relative to the slot antenna.

[0016] This provides the advantage that the position of the radio module relative to the slot antenna can easily be changed and, therefore, the performance of the radiation emitted by the radio module relative to the outside world can be optimized according to the application case. Using such a predefined position additionally has the advantage that an unintended change of the relative orientation between the first and 10 and the second antenna can be avoided.

[0017] In a preferred embodiment, the housing is a metal housing. Having a metal housing has the advantage that the characteristics of the emitted radiation are precisely defined by the second antenna in cooperation with the first antenna. The metal housing functions as a shield for undesired emission of radio signals by the first and 10 are.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] The invention will be explained in the followings together with the figures.

Fig. 1 shows an embodiment of a lighting module;

Fig. 2 shows an embodiment of a lighting module;

Fig. 3 shows an embodiment of a lighting module;

Fig. 4 shows an embodiment of a lighting module; and

Fig. 5 shows an embodiment of a lighting module;

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0019] For describing the present invention in greater detail, the expression 'LED luminaire' shall mean a luminaire with a light source comprising one or more LEDs or OLEDs. LEDs are well-known in the art, and therefore, will only briefly be discussed to provide a complete description of the invention.

[0020] Now referring to Fig. 1, a lighting module 100 according to the invention is shown according to an embodiment.

[0021] The lighting module 100 comprises a metal housing 101, a radio module 103 inside the housing 101, wherein the radio module 103 comprises a first antenna 104 extending along a first direction d_1 . Moreover, the housing 101 comprises a slot antenna 102 defined by a recess in one of the walls of the housing 101, extending along a second direction d_2 , wherein the slot antenna 102 is electromagnetically coupled to the first antenna 104, and wherein an angle α is defined the first direction d_1 and the second direction d_2 . The lighting module 100 is configured such that this angle can be adjusted by changing the directions d_1 and d_2 relative to each other.

[0022] This provides the advantage that the slot antenna 102 or its position or at least its orientation d_2 relative to the first antenna 104 of the radio module 103 is adjustable to ensure an optimized emission of radio signals without the need of providing an antenna projecting from the outer surface of the metal housing..

[0023] The lighting module 100 can be a luminaire, in particular an LED luminaire. The lighting module 100 can comprise a plurality of LEDs and an LED driver for providing electrical energy to the LEDs. The LED driver can be arranged in the housing 101. It is to be noted that the radio module 103 may be integrated in the LED driver.

[0024] The slot antenna 102 can be a dipole antenna, in particular a $\lambda/2$ dipole antenna.

[0025] The radio module 103, schematically represented by an ellipse in the figures, can be an RF module which is configured to transmit and/or receive RF (radio frequency) signals. For example, the RF signals can be control signals or status signals.

[0026] As indicated above, the housing 101 can be a metal housing, which prevents radio emission of the first antenna 104 to be radiated at other positions and towards other directions apart from the second antenna 102.

5 Thus, the overall emission characteristics can be designed by adjusting the size of the second antenna 102 together with the orientation of the first antenna 104 and the second antenna 102 relative to each other.

[0027] It is to be noted that in the top view of the sidewall of the housing 101 in the figures, the radio module 103 and the second antenna 102 are shown to be arranged in a non-overlapping manner only in order to facilitate the understanding of the drawing. However, the position of the radio module 103 is usually chosen such that the first antenna 104 and the second antenna 100 and to overlap at least partially.

[0028] Fig. 2 shows an embodiment of the lighting module 100.

[0029] In this embodiment, a rotational element 201 is provided in the housing 101, in which element the actual slot antenna 102 is arranged. Usually, the element, in which the rotational element 201 is provided, is a sidewall of the metallic housing 101. By rotating the rotational element 201, the orientation d_2 of the slot antenna 102 (second antenna) is adjusted relative to the housing 101 and, ultimately, to the radio module 103 fixedly arranged in the housing 101 by means of the fixing elements 103a and 103b. In this embodiment, the position and the orientation of the first and second antenna 104 relative to the entire radio module 103 are fixed. Thus, the relative orientation between the first direction and the second direction is adjusted by rotating the rotation element 201. In the advantageous embodiment shown in figure 2, the rotational element 201 has a disc shape with a circular circumference. However, different shapes of the circumference may be thought of as long as they allow different rotational positions. This could for example be achieved by using a regular hexagon. Of course, the recess in the sidewall of the housing 101 must have a corresponding shape so that the rotational element 201 can be inserted at different rotational positions.

[0030] Preferably and as shown in the drawing, the rotational element 201 is a disk rotatably mounted in the sidewall of the housing. Such a disk can be formed with an outer edge that secures the disk-shaped rotational element 201 to an annular recess in the sidewall of the housing 101 such that the rotation element 201 may be rotated but is permanently arranged in the recess. Contrary, in case of for example the regular hexagon mentioned above, the rotational element 201 must be detached, rotated and attached again in order to change its orientation.

[0031] The slot antenna 102 is arranged in the disk. In order to ensure that the orientation of the rotational element 201 is not changed unintentionally, it is preferred that friction between the rotational element 201 and the sidewall in which the rotational element 201 is arranged large enough so that a change of the orientation of the

rotational element 201 can only be achieved by using a tool such as a screwdriver.

[0032] Fig. 3 shows a further embodiment of the lighting module 100.

[0033] In this embodiment, the slot antenna 102 in the housing 101 cannot be adjusted with respect to its orientation. The slot antenna 102 is established by a recess that is arranged in a sidewall of the housing 101. In order to be able to set the relative orientation of the two elements (slot antenna 102 and first antenna 104 of the radio module 103), the radio module 103 or at least its antenna 104 can variably be mounted in the housing 104. For this purpose, several positioning elements 301 (e.g. positioning holes or pins) are arranged in the area of the slot antenna 102, so that the first antenna 104 of the radio module 103 can be rotated in this area by positioning the entire radio module 103 such that the desired orientation of the first direction and the second direction relative to each other is achieved. On the radio module 103 there are provided corresponding elements that interact with the positioning elements 301. For example, in case that positioning holes are formed in the sidewall of the housing 101 as positioning elements 301, the radio module 103 is provided with projections that can protrude into the holes of the housing 101. By rotating the entire radio module 103 and then inserting its projections into the respective positioning holes, the desired orientation of the radio module 103 relative to the slot antenna 102 can be set. Having achieved this desired relative orientation, the radio module 103 is then fixed to the housing 101, preferably using conventional fixing technology like, for example, screws clamping a flange of the radio module 103 to the housing 101. Alternatively, in case that the positioning elements 301 are realized as pins that project from an inner side of the sidewall of the housing 101, the radio module 103 provides recesses into which the positioning elements 301 of the housing 101 can be inserted.

[0034] Further, it is also possible that the radio unit 103 provides projections that can interact with the spaces between such projections as positioning elements 301 in order to avoid undesired rotation of the radio module 103. Again, once the desired orientation of the first antenna 104 and the second antenna 102 is adjusted, the radio module 103 is fixed to the housing 101 such that the radio module 103 is securely attached to the side wall of the housing 101 by means of screws, for example. It must be ensured that the overall design of the luminaire or rather the lighting module 100 allows the radio module 103 to be rotated in order to freely adjust the orientation of the first antenna 104 and the second antenna 102 relative to each other. Thus, there should be enough space in the housing 101 of the lighting module 101 in order to rotate the radio module 103.

[0035] In particular, in the embodiment shown in Fig. 3, the positioning elements 301 are arranged along a circle around a portion of the slot antenna 102. This allows to arrange the radio module 103 at different angles rel-

ative to the slot antenna 102 by means of the fixing element indicated as 103c in the drawing and representing the corresponding structure of the radio module 103 interacting with the positioning elements 301.

[0036] A different solution is shown in the embodiment illustrated in figure 4. Instead of arranging the positional elements 301 along a circle around a portion of the slot antenna 102, the positioning elements 301 are arranged along a straight line crossing the direction of the slot antenna 102, which means that the straight line and the direction of the slot antenna 100 into include an angle different from 0°. The radio module 103 may then be pivoted around a pivot bearing that may simultaneously serve as a fixing structure. For example, the pivot bearing may be realized by a through-hole provided in a mounting flange of the radio module 103 through which a bolt is inserted clamping the radio module 103 to the housing 101 once the desired orientation of the antennas relative to each other is achieved. The interaction of the positioning elements 301 and the corresponding elements on the radio module 103 then inhibit an undesired change of the relative orientation. The angle between the first antenna and second antenna is adjusted by the fixing element 103c establishing a connection between the radio module 103 and one of the respective positioning elements 301.

[0037] An advantage of the structure shown in figure 4 is that the positioning elements 103 can be provided along a straight line which maybe beneficial to the desired manufacturing technique. Further, contrary to the circular arrangement of the positioning elements 301, only a reduced number of positioning elements 301 needs to be provided. However, the downside of this arrangement is that there is a limitation in the angles that may be achieved between the orientations of the two antennas.

[0038] In this embodiment, the slot antenna 102 is again in a fixed position with respect to the housing 101. The angle α between the first direction d_1 and the second direction d_2 can be adjusted by changing the position of the radio module 103 relative to the slot antenna 102. The radio module 103 can be mounted through the fixing element 103c such as a stay on these positioning elements 301 such that the relative position of the radio module 103 with respect to the slot antenna 102 can be adjusted according to the case.

[0039] Fig. 5 shows a further embodiment of a lighting module 100. In this embodiment, the slot antenna 102 is in a fixed position with respect to the housing 101. The angle α between the first direction d_1 and the second direction d_2 can be adjusted by changing the position of the radio module 103 relative to the slot antenna 102.

[0040] The position of the radio module 103 can be changed by moving the radio module 103 on the rails 103d and 103e, wherein the rails 103d and 103e are arranged in a fixed position with respect to the housing 101 or with respect to the radio module 103 and are designed to interact with corresponding guide rails on the respectively other side. Again, once the orientation of the two

antennas relative to each other is adjusted, a commonly known fixing structure can be used to secure the first and 10 are 104 and respectively the radio module 103 in this orientation to the sidewall of the housing 101.

[0041] All features of all embodiments described, shown and/or claimed herein can be combined with each other.

[0042] While various embodiments of the present invention have been described above, it should be understood that they have been presented by way of example only and not limitation. Numerous changes to the disclosed embodiments can be made in accordance with the disclosure herein without departing from the spirit of scope of the invention. Thus, the breadth and scope of the present invention should not be limited by any of the above-described embodiments. Rather, the scope of the invention should be defined in accordance with the following claims and their equivalence.

[0043] Although the invention has been illustrated and described with respect to one or more implementations, equivalent alternations and modifications will occur to those skilled in the art upon the reading of the understanding of the specification and the annexed drawings. In addition, while a particular feature of the invention may have been disclosed with respect to only of the several implementations, such features may be combined with one or more other features of the other implementations as may be desired and advantage for any given or particular application.

Claims

1. A lighting module (100), comprising:

- a housing (101);
- a radio module (103) inside the housing (101), wherein the radio module (103) comprises a first antenna (104) extending along a first direction (d1); and
- a slot antenna (102) inside the housing (101) extending along a second direction (d2),
- wherein the slot antenna (102) is electromagnetically coupled to the first antenna (104), and
- wherein an angle (α) between the first direction (d1) and the second direction (d2) is adjustable.

2. The lighting module (100) of claim 1, wherein the first antenna (104) is in a fixed position with respect to the housing (101), and the housing (101) further comprises a rotational element (201) and the slot antenna (102) is arranged on the rotational element (201).

3. The lighting module (100) of claim 2, wherein the rotational element (201) is a disk.

4. The lighting module (100) of claim 1, wherein the

radio module (103) is configured to allow first antenna (104) to be rotated with respect to the slot antenna (102) arranged fixedly in the housing (101).

5. The lighting module (100) of claim 4, wherein the housing (101) further comprises one or more positioning elements (301) cooperating with one or more corresponding elements (103c) of the radio module (103) such that the radio module (103) can be positioned in a plurality of orientations relative to the slot antenna (102).

6. The lighting module (100) of any one of the preceding claims, wherein the housing (101) is a metal housing.

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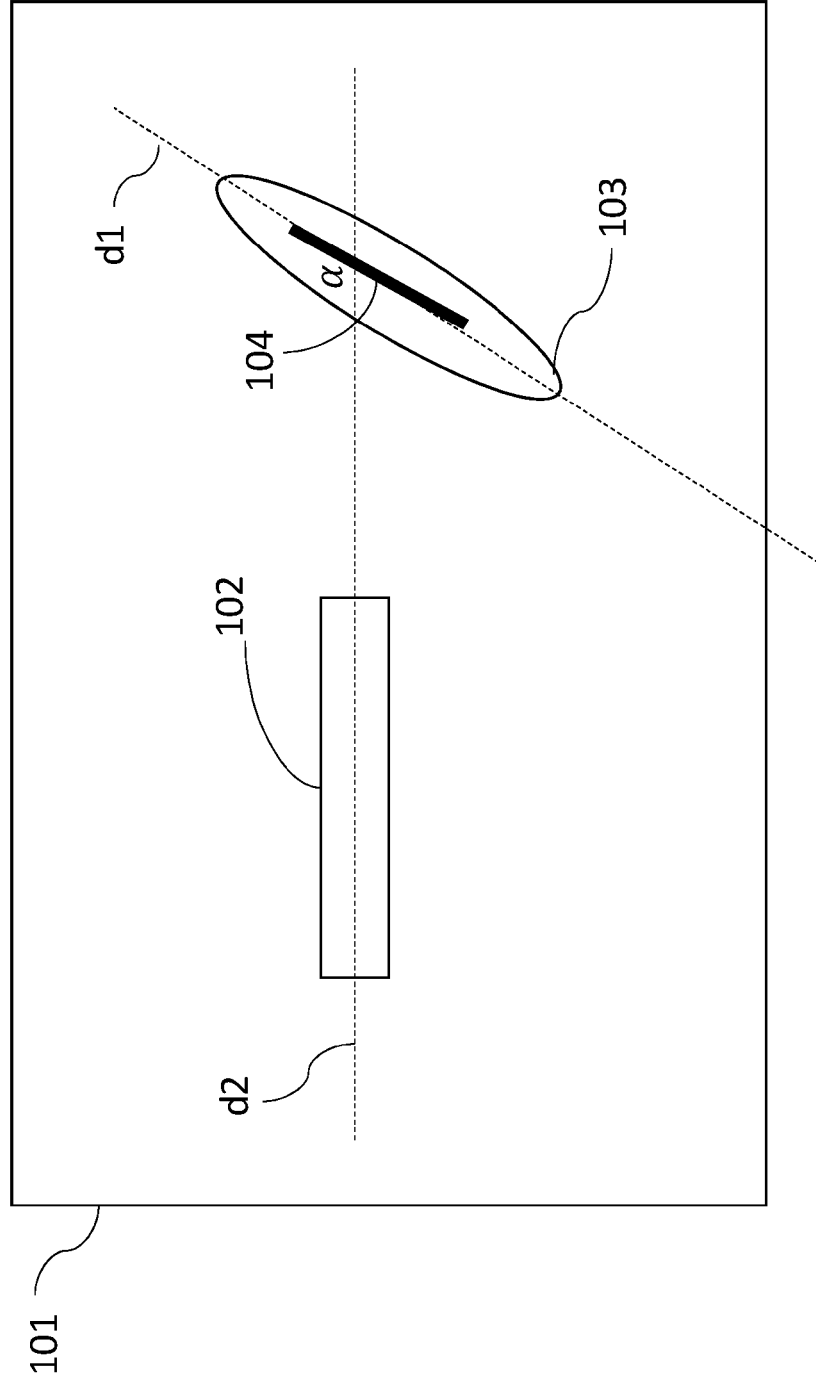


Fig. 1

100

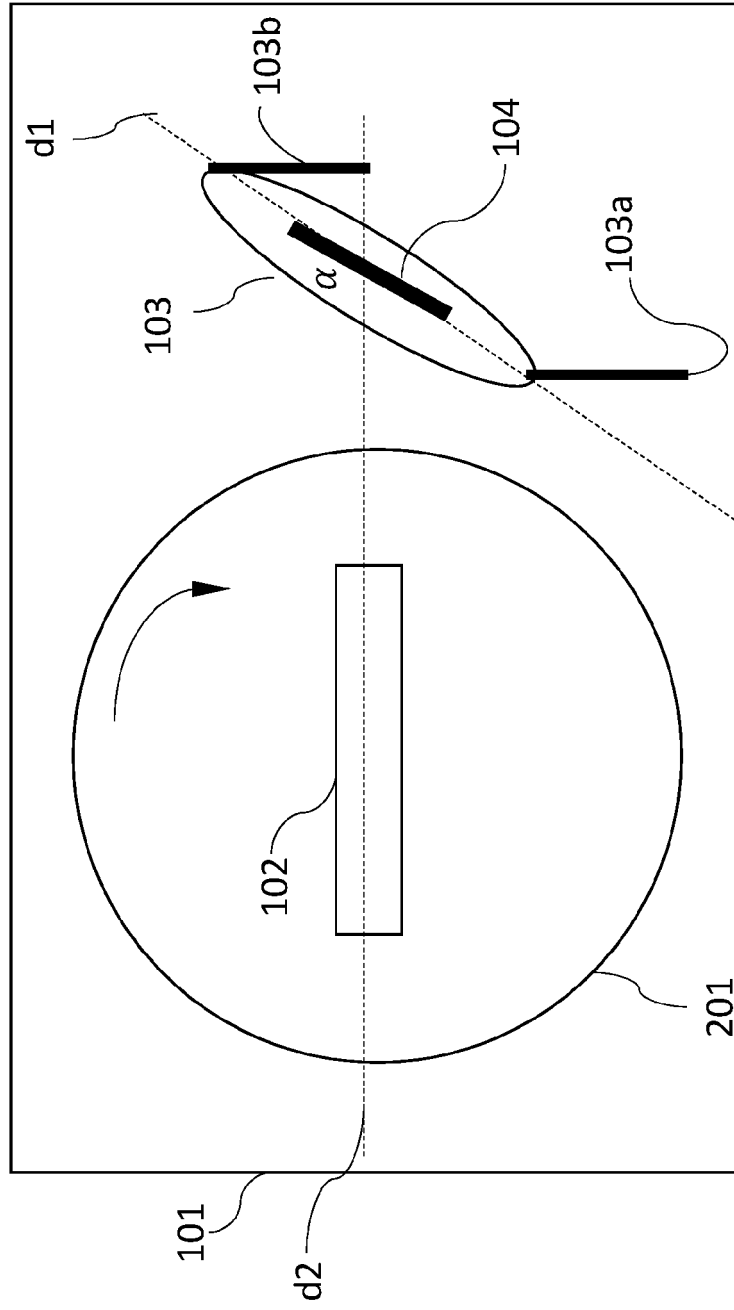


Fig. 2

100

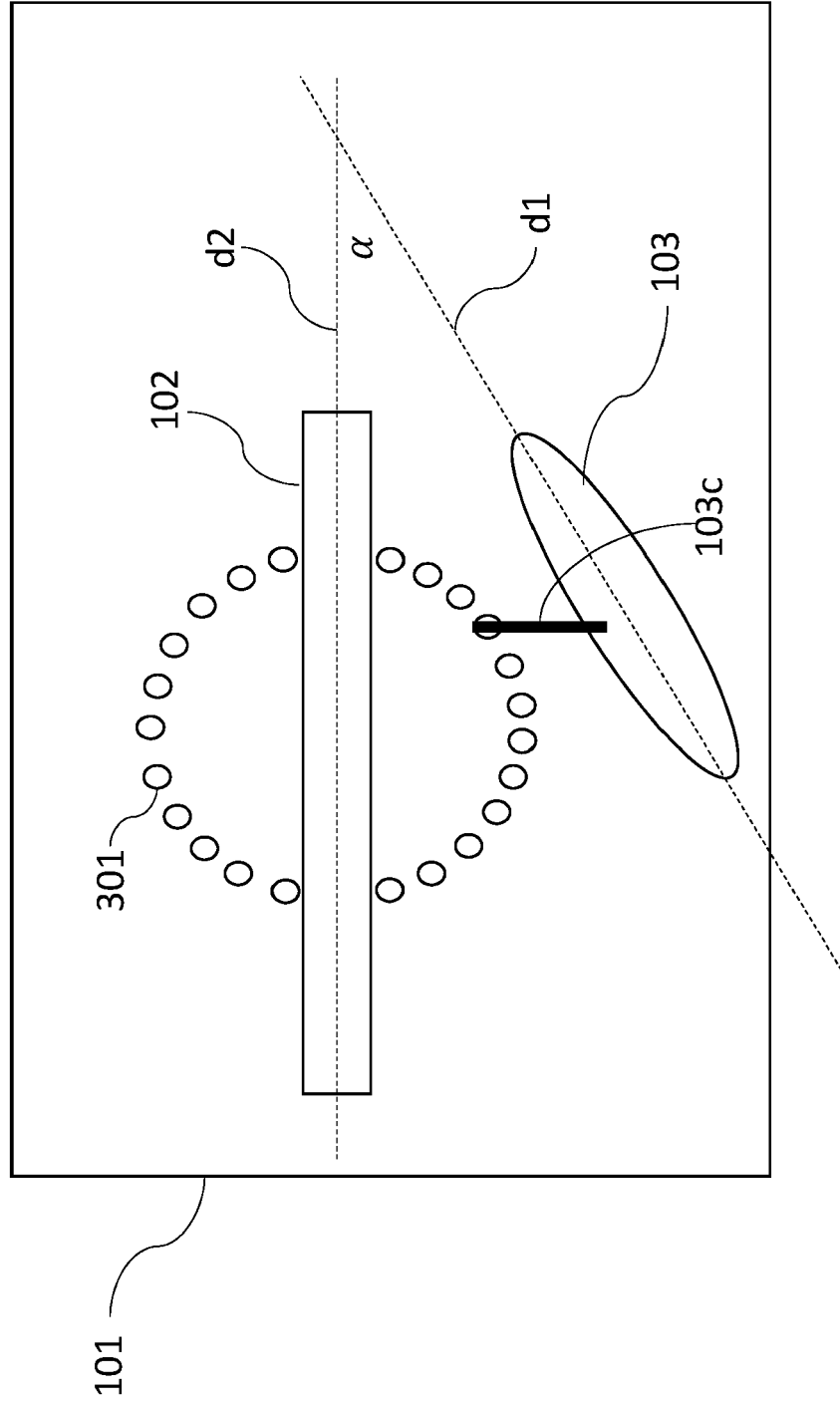


Fig. 3

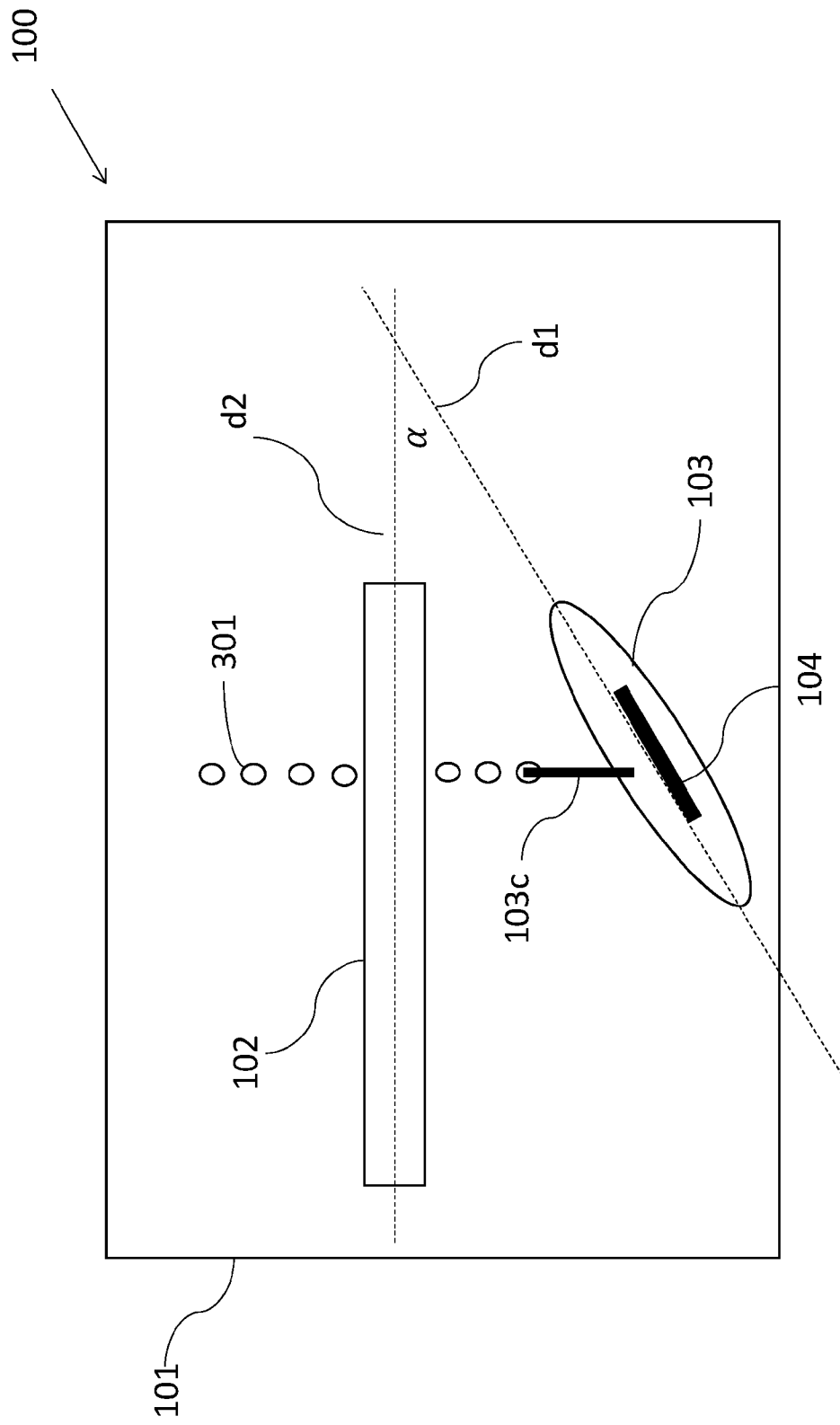


Fig. 4

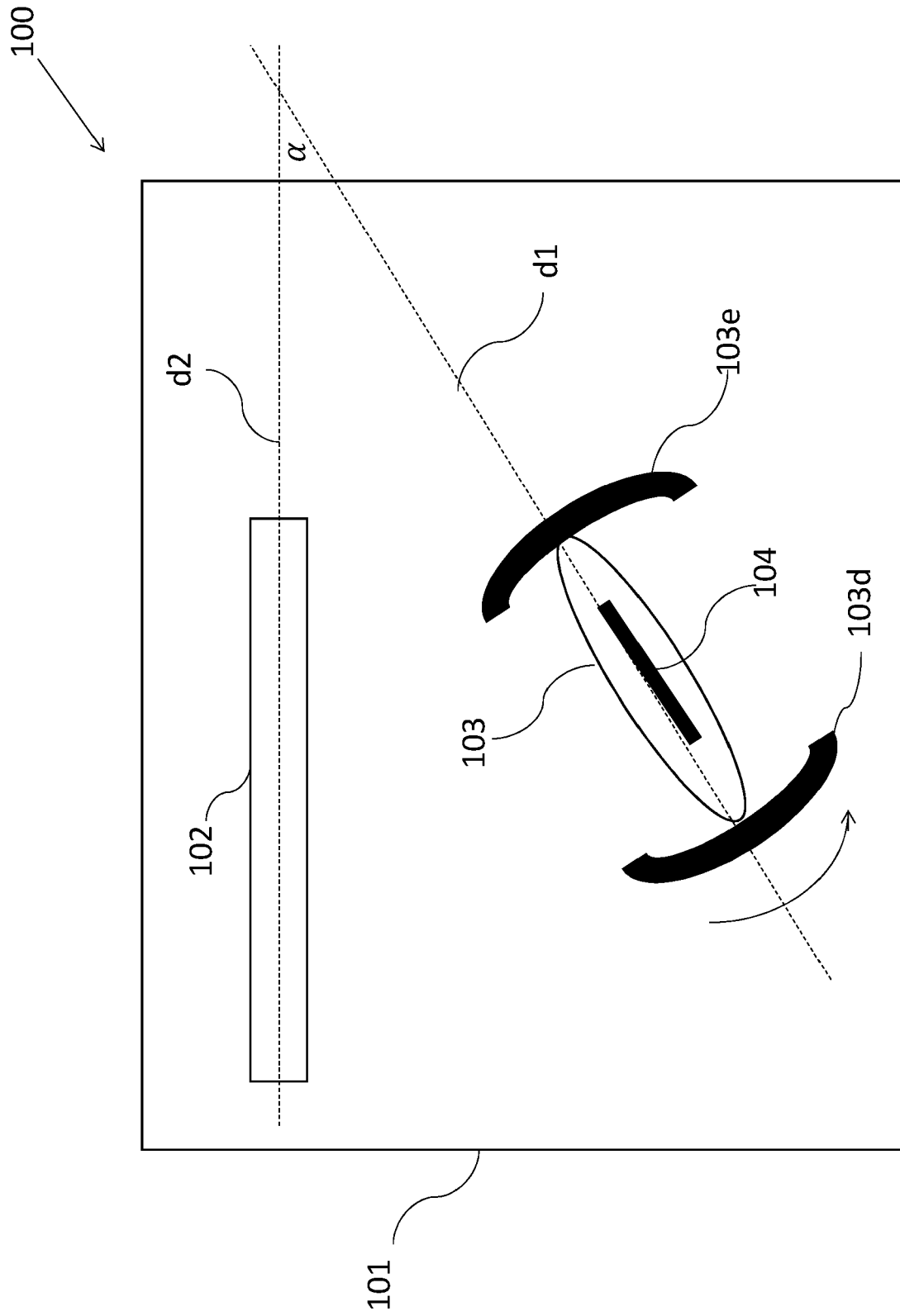


Fig. 5



EUROPEAN SEARCH REPORT

Application Number

EP 22 16 9399

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EPO FORM 1503 03.82 (P04C01)

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 2016/069551 A1 (ANDO TAMOTSU [JP] ET AL) 10 March 2016 (2016-03-10) * figure 3 * * figure 4 * * figure 7 * * paragraph [0063] * * paragraph [0079] * * paragraph [0095] * * paragraph [0104] * * paragraph [0089] * -----	1-6	INV. H01Q3/12 H01Q13/18 H01Q1/44 H05B47/19
X	CN 108 966 443 A (PANASONIC IP MAN CO LTD) 7 December 2018 (2018-12-07) * figure 2 * * figure 4 * * paragraph [0040] - paragraph [0041] * * paragraph [0058] * * paragraph [0062] - paragraph [0063] * -----	1-6	TECHNICAL FIELDS SEARCHED (IPC) H01Q
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 3 October 2022	Examiner Kalialakis, Christos
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	

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

EP 22 16 9399

5 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
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03-10-2022

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