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(72) Inventors:
• **Block, Steffen**
6850 Dornbirn (AT)
• **Daniel, Christian**
6850 Dornbirn (AT)
• **Kreilhuber, Ronald**
6850 Dornbirn (AT)

(71) Applicant: **Zumtobel Lighting GmbH**
6850 Dornbirn (AT)

(74) Representative: **Beder, Jens**
Mitscherlich PartmbB
Patent- und Rechtsanwälte
Karlstraße 7
80333 München (DE)

(54) **PENDANT LUMINAIRE WITH INTEGRATED SLOT ANTENNA**

(57) The present invention relates to an installation frame for a pendant luminaire comprising fastening means (9, 10) for fixing the installation frame (1) in a recess (2a) of a ceiling (2), mounting means (13a, 13b)

for mounting the pendant luminaire to the installation frame (1), and at least one slot antenna (12, 15..19) formed into the installation frame.

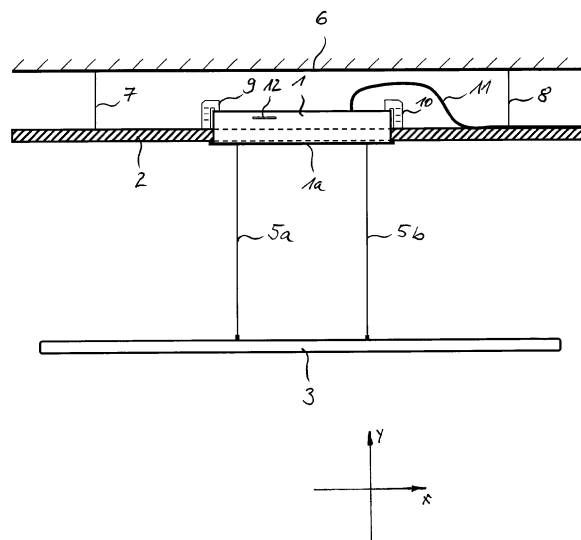


Fig. 1

Description

[0001] The present invention relates generally to luminaires having a wireless data transmission function and, more particularly, to pendant luminaires.

[0002] In lighting systems, radio communication can be used not only to control luminaires (or luminaries), but also for other services.

[0003] DE 10 2011 007416 A1 discloses a pendant luminaire equipped with a wireless network module to receive control signals and to provide Internet access for WLAN devices, wherein the wireless network module is located in the luminaire housing suspended from the ceiling.

[0004] In some applications, the wireless module and operating device (ballast) that powers the light source are located outside the luminaire housing in a separate enclosure (installation frame) mounted in or on the ceiling for design or safety reasons. However, the quality of the radio connection (propagation distance and package error rate) depends on the environment of the antenna of the wireless module (transceiver) and the installation frame usually consists of metal parts that negatively affect the radio connection.

[0005] It is an object of the present invention to provide an apparatus and a method, which reduce the above problems. In particular, an object of the present invention is to provide an installation frame and a pendant luminaire, with which radio propagation conditions for a transceiver housed in the installation frame can be improved.

[0006] This object is achieved by the installation frame and the pendant luminaire according to the enclosed independent claims. Advantageous features of the present invention are defined in the corresponding subclaims.

[0007] According to the present invention, the installation frame for a pendant luminaire comprises fastening means for fastening/fixing the installation frame in a recess of a ceiling, mounting means for mounting the pendant luminaire to the installation frame and at least one slot antenna formed into the installation frame.

[0008] The slot antenna can consist of one or more openings, in particular slots, which are formed in a metallic part of the installation frame. The metallic part can form a waveguide, into which a portion of the radiated electromagnetic waves of the radio signal emitted by an antenna located inside the installation frame is coupled, wherein the opening(s) in the metallic part, which is fed by the propagation modes of electromagnetic waves inside the waveguide, acts as slot antenna radiating wireless signals to an external device.

[0009] In this way, transmitting and receiving conditions for a transceiver housed in the installation frame can be improved.

[0010] The techniques for recessed mounting are well known and the fastening means can include one or more attachment springs attached to the outer peripheral surface of the installation frame and biased outward, so that the attachment spring acts on the surface of the recess

to fix the installation frame in the recess. However, other techniques for the recessed mounting, such as those used to install recessed light fixtures in ceilings, can be used.

[0011] The mounting means for mounting the pendant luminaire to the installation frame can comprise one or more chains, cables, cords or rods for suspending the pendant luminaire and/or screws or hooks for fixing the chains, cables, cords or rods to the pendant luminaire and the installation frame.

[0012] The installation frame can have a cup shape. Alternatively, the installation frame can be substantially a (rectangular) parallelepiped, which has an upper side to be inserted into the recess of the ceiling, an underside facing the pendant luminaire and permanent sidewalls to at least the left, right, front and rear.

[0013] At least one slot antenna can be formed into at least one of the permanent sidewalls so that the signal can be radiated laterally into the space above a suspended ceiling. A (removable) cover plate can close the underside. In addition, at least one slot antenna can be formed into the cover plate so that the signal can be radiated into the space below the (dropped) ceiling.

[0014] Alternatively or in addition, at least one slot antenna can be formed by the cover plate and one of the permanent sidewalls so that the slot antenna radiates the signal laterally below the (dropped) ceiling.

[0015] A flange can be formed on the underside, the flange abutting an outer surface of the ceiling when the installation frame is inserted into the recess. At least one slot antenna can be arranged between the cover plate and the flange so that the slot antenna is covered up by the cover plate and is therefore not visible. The at least one slot antenna can be formed in an edge/bar of the flange, on which the cover plate 1a rests. Alternatively, at least one slot antenna can be formed by the cover plate (1a) and a section of the permanent side wall, on which no flange is arranged, i.e., the slot of the slot antenna is formed by the cover plate (1a) and a flange-free section of one of the permanent side walls.

[0016] At least one slot antenna can be formed into a sidewall of the upper side so that the signal can be radiated upward into the space above a suspended ceiling.

[0017] The installation frame can comprise at least two slot antennas having different radiation and/or polarization directions.

[0018] The installation frame can comprise a device having an antenna for transmitting and/or receiving a radio signal to/from the at least one slot antenna or a mounting case for mounting the device in the installation frame.

[0019] The device can be a control gear (ballast) that powers the light source or a radio module.

[0020] The mounting case can comprise a slot antenna facing the at least one slot antenna formed into the installation frame, i.e., the slot (antenna) of the mounting case and the slot (antenna) of the installation frame are located opposite to each other. Alternatively, the device can comprise a housing having a slot antenna facing the

at least one slot antenna formed into the installation frame.

[0021] The fastening means can be configured to fasten the installation frame in a recess of a suspended ceiling.

[0022] According to the present invention, the pendant luminaire comprises the described installation frame, a luminaire housing for a light source, an operating device arranged in the installation frame and configured to provide a supply voltage to the light source and an electric line for connecting the operating device and the light source.

[0023] The operating device or a radio module can comprise the (internal) antenna located inside the installation frame, wherein the electric line acts as an (external) antenna and is coupled to the internal antenna by inductive, capacitive or radiation coupling.

[0024] Embodiments of the invention are discussed in detail with reference to the enclosed figures, in which

FIG. 1 shows a pendant luminaire according to a first embodiment of the present invention in side view,

FIG. 2 shows a perspective view of the pendant luminaire shown in FIG. 1,

FIG. 3 shows the installation frame of the pendant luminaire shown in FIG. 1 before installation in a suspended ceiling,

FIG. 4 shows the pendant luminaire shown in FIG. 2 with cover plate open,

FIG. 5 shows a cross sectional view of an installation frame according to a second embodiment of the present invention,

FIG. 6 shows a cross sectional view of an installation frame according to a third embodiment of the present invention,

FIG. 7 shows a cross sectional view of an installation frame 1 according to a fourth embodiment of the present invention,

FIG. 8 shows a cross sectional view of an installation frame 1 according to a fifth embodiment of the present invention, and

FIG. 9 shows an installation frame 1 according to a sixth embodiment of the present invention in a top view.

[0025] In the figures, same reference numbers denote same or equivalent structures. The explanation of structures with same reference numbers in different figures is avoided where deemed possible for sake of conciseness.

[0026] FIG. 1 and FIG. 2 show a pendant luminaire

according to a first embodiment of the present invention in side view and perspective view, respectively. The pendant luminaire comprises an installation frame 1, which is installed in a recess of a suspended ceiling 2, a luminaire housing 3 including a light source (not shown) and a reflector 4 for reflecting the light generated by the light source and two cables 5a, 5b, with which the luminaire housing 3 is suspended from the dropped (false) ceiling 2 and the light source is supplied with energy.

[0027] The dropped (false) ceiling 2 is attached to a concrete ceiling 6 with steel strips 7, 8 and the installation frame 1 is fixed in the recess by brackets 9, 10.

[0028] The installation frame 1 is of metal and can be made by bending a sheet metal part with an opening at the bottom. FIG. 3 shows the installation frame 1 before installation in the suspended ceiling 2. As shown in FIG. 3, a flange 1b is formed around the opening, which rests against the surface of the suspended ceiling 2 when the installation frame 1 is inserted into the recess 2a (as indicated by the arrows). The brackets 9, 10 are foldable for inserting the frame into the recess 2a.

[0029] In FIG. 1 and FIG. 2, the installation frame 1 is closed with a cover plate 1a through which the cables 5a, 5b pass. FIG. 4 shows the pendant luminaire with the cover plate 1a open and, in a separate window A, a section of the installation frame 1 including a cable clamp 13a (strain relief) for cable 5a. Such a cable clamp 13b is also provided for cable 5b, wherein the cable clamps 13a, 13b are used to fix the luminaire housing 3 in a desired vertical position.

[0030] The operating voltage/current for the light source (e.g., LED module) is generated by an operating device arranged in the installation frame 1 and generated based on a control signal. The operating device (not shown) is connected to mains cable 11, the cables 4, 5 and a radio module (transmitter) that receives the control signal and outputs the received control signal to the operating device. In addition, the received control signal or a status signal indicating the operating status (on/off) can be forwarded to another pendant luminaire.

[0031] The pendant luminaire is configured to send or receive signals to/from other pendant luminaires. For this purpose, the installation frame 1 comprises a slot antenna 12 that is fed by the signal send from the radio module, wherein a portion of the radiated electromagnetic waves of the signal emitted by the antenna of the radio module is coupled into the installation frame 1 forming a waveguide and the slot antenna 12 fed by the propagation modes of electromagnetic waves inside the waveguide radiates the (control) signal to the other pendant luminaire which is constructed in the same way and receives the control signal via its slot antenna. The slot antenna 12 is directed towards to the other pendant luminaire and radiates the control/status signal into the space between the suspended ceiling 2 and the concrete ceiling 6.

[0032] The radio module or the antenna of the radio module is positioned within the installation frame 1 in

such a way that a good coupling to the slot antenna 12 is achieved, e.g., centered on the slot with a distance to the slot that is greater than $\lambda/2$.

[0033] The installation frame 1 is cuboidal and the slot for the slot antenna 12 can be formed on any side (including the cover plate 1a) or edge. The slot measures at least one dimension $\lambda/2$, wherein λ is the wavelength corresponding to a transmission frequency f_c of the radio signal used by the radio module. The other dimension may correspond to the material thickness of the installation frame 1 (or the respective side), for example one to two millimeters.

[0034] FIG. 5 shows a cross sectional view of an installation frame 1 according to a second embodiment of the present invention. The installation frame 1 of FIG. 5 comprises the radio module 14 and four slot antennas 12, 15, 16, 17, one on each of the longitudinal sides of the installation frame 1 (including the cover plate 1a). The slot antennas 12, 15 and 16 radiate the control/status signal into the space between the suspended ceiling 2 and the concrete ceiling 6, and the slot antenna 17 formed in the cover plate 1a radiates the control/status signal below the suspended ceiling 2 in the direction of the luminaire housing 3 (not shown).

[0035] FIG. 6 shows a cross sectional view of an installation frame 1 according to a third embodiment of the present invention, in which two slot antennas 18 and 19 are arranged in the flange 1b instead of the slot antenna 17 arranged in the cover plate 1a. The outer edge of the flange 1b is bent in the direction of the cover plate 1a to form a bar 1c on which the cover plate 1a rests and in which the slot antennas 18 and 19 are formed. The slot antennas 18 and 19 radiate the signal laterally below the suspended ceiling 2. Since the cover plate 1a covers the slot antennas 18 and 19 in the vertical direction, they are hardly visible. Alternatively, the bar 1c having the slot antennas 18 and 19 can be formed on the cover plate 1a.

[0036] The devices installed in the installation frame 1 can differ depending on the application, and the respective device can be fixed in the installation frame 1 by means of an adapter mounting frame (housing). FIG. 7 shows a cross sectional view of an installation frame 1 according to a fourth embodiment of the present invention, in which the installation frame 1 comprises a housing 20 for the radio module 14 and the operating device (not shown). The housing 20 having a similar cuboid shape to the installation frame 1 is made of metal and is fixed into the installation frame 1 by means of screws (not shown). For transmitting the control/status signal, the housing 20 comprise a slot antenna 21 facing the slot antenna 12 formed into the installation frame 1, a slot antenna 22 facing the slot antenna 15 formed into the installation frame 1 and a slot antenna 23 facing the slot antenna 16 formed into the installation frame 1. The housing 20 is open at the bottom so that there is a direct coupling between the slot antennas 18, 19 and the radio module 14.

[0037] In FIG. 6 und FIG. 7, the slot antennas 18 and

19 radiating the signal laterally below the suspended ceiling 2 are formed in the bar 1c of the flange 1b (or a bar of the cover plate 1a). Alternatively or in addition, slot antennas can be formed through recesses in the flange 1b to radiate the signal laterally below the suspended ceiling 2. FIG. 8 shows a cross sectional view of an installation frame 1 according to a fifth embodiment of the present invention, in which a slot antenna 24 radiating the signal below the suspended ceiling 2 in direction Z is formed by a recess/gap in the flange 1b, i.e., by a flange-free section with a length $\lambda/2$ in direction X and a width in direction Y corresponding to the material thickness of the flange 1b (the installation frame 1).

[0038] In the described embodiments, the signal is radiated by means of at least one slot antenna 12, 15..19 formed in the installation frame 1, wherein a slot in the installation frame 1 is preferably sized so as to resonate in a desired frequency band, thereby forming a slot antenna radiating element. In addition, the signal can also be emitted via at least one of the cables 5a and 5b. FIG. 8 shows an installation frame 1 according to a sixth embodiment of the present invention in a top view. As shown in FIG. 8, the cables 5a and 5b passing through the cover plate 1a are fixed with the cable clamps 13a, 13b and are connected to an operating device 25. The part of the cable 5b extending outwardly from the installation frame 1 serves as an antenna, the cable 5b being wrapped around the radio module 14, i.e., around the antenna thereof, to enable coupling between the cable 5a and the antenna of the radio module 14.

[0039] The cover plate 1a can be a part of the installation frame 1. Alternatively or in addition, the operating device 25 and/or the radio module 14 can be mounted on the cover plate 1a so that they are inserted and positioned in the installation frame 1 when the installation frame 1 is closed with the cover plate 1a.

Claims

1. An installation frame for a pendant luminaire, comprising
 - fastening means (9, 10) for fastening the installation frame (1) in a recess (2a) of a ceiling (2);
 - mounting means (13a, 13b) for mounting the pendant luminaire to the installation frame (1);
 - and
 - at least one slot antenna (12, 15..19) formed into the installation frame.
2. The installation frame according to claim 1, wherein the installation frame (1) is substantially a parallelepiped, which has an upper side to be inserted into the recess (2a) of the ceiling (2), a underside facing the pendant luminaire and permanent side wall to at least the left, right, front and rear.

3. The installation frame according to claim 2, wherein the at least one slot antenna (12, 15..19) is formed into at least one of the permanent side walls.
4. The installation frame according to claim 2 or 3, further comprising a cover plate (1a) for closing the underside.
5. The installation frame according to claim 4, wherein the at least one slot antenna (12, 15..19) is formed into the cover plate (1a).
6. The installation frame according to claim 4 or 5, wherein the at least one slot antenna (12, 15..19) is formed by the cover plate (1a) and one of the permanent side walls.
7. The installation frame according to claim 4, 5 or 6, wherein
a flange (1b) is formed on the underside; and the at least one slot antenna (12, 15..19) is arranged between by the cover plate (1a) and the flange (1b) or between by the cover plate (1a) and one of the permanent side walls.
8. The installation frame according to any one of claims 2 to 7, wherein the at least one slot antenna (12, 15..19) is formed into permanent side wall of the upper side.
9. The installation frame according to any one of the preceding claims, wherein the installation frame (1) comprises at least two slot antennas (12, 15..19) having different radiation and/or polarization directions.
10. The installation frame according to any one of the preceding claims, further comprising
a device (14) having an antenna for transmitting and/or receiving a radio signal to/from the at least one slot antenna (12, 15..19); or
a mounting case (20) for mounting the device (14) in the installation frame (1).
11. The installation frame according to claim 10, wherein the mounting case (20) comprises a slot antenna (21..23) facing the at least one slot antenna (12, 15..19) formed into the installation frame (1).
12. The installation frame according to claim 10, wherein
the device (14) comprises a housing; and
the housing comprises a slot antenna facing the at least one slot antenna formed into the installation frame.
13. The installation frame according to any one of the preceding claims, wherein the fastening means (9, 10) is configured to fasten the installation frame (1) in a recess (2a) of a suspended ceiling.
14. A pendant luminaire, comprising
the installation frame (1) according to any one of the preceding claims;
luminaire housing (3) for a light source;
operating device (24) arranged in the installation frame (1) and configured to provide a supply voltage to the light source; and
electric line (5a, 5b) for connecting the operating device (24) and the light source.
15. The pendant luminaire according to claim 14, if dependent on claim 10, 11 or 12, wherein
the device is the operating device (24) or a radio module (14); and
the electric line (5a, 5b) acts as an antenna and is coupled to the antenna of the device by inductive, capacitive or radiation coupling.

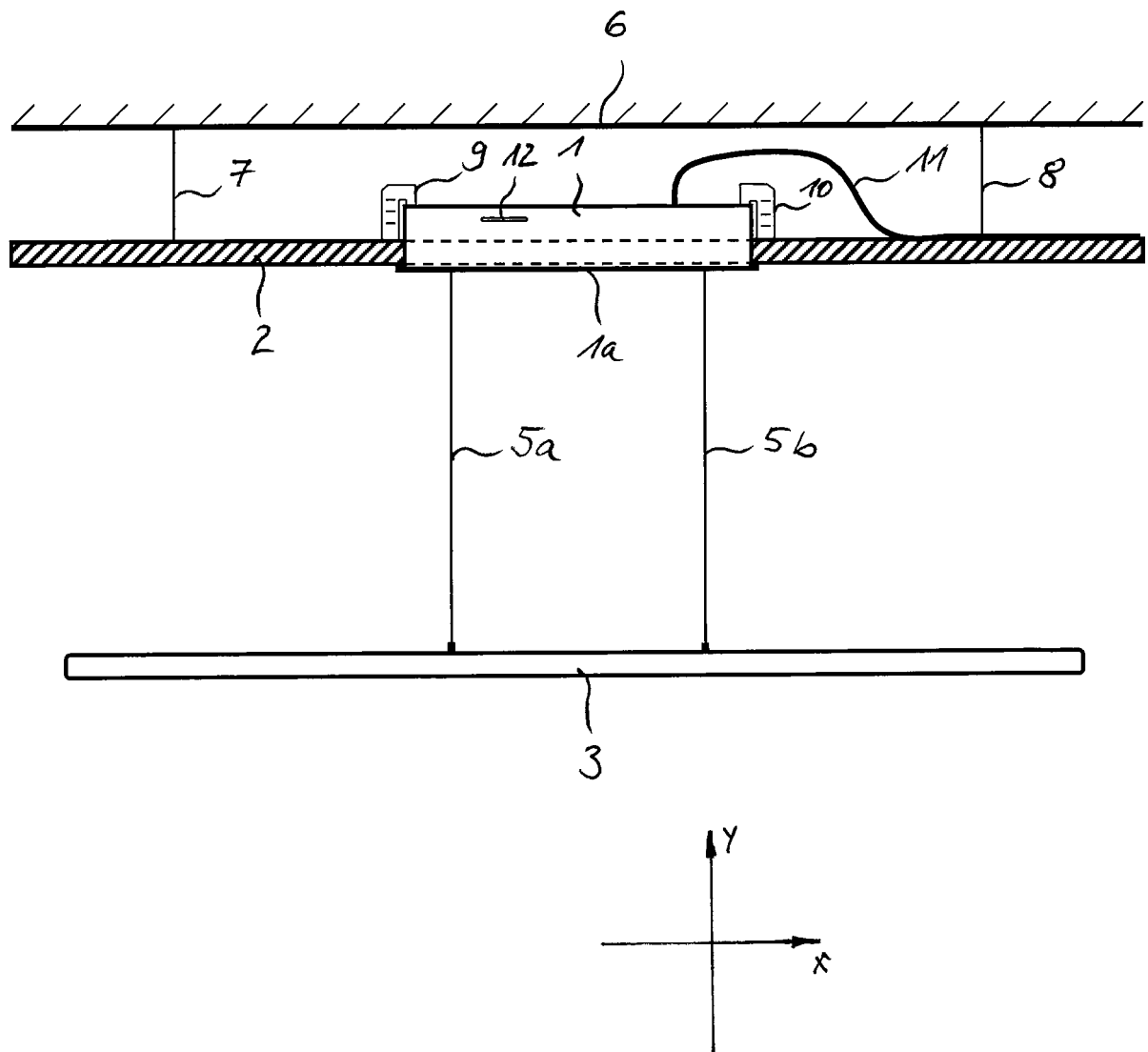


Fig. 1

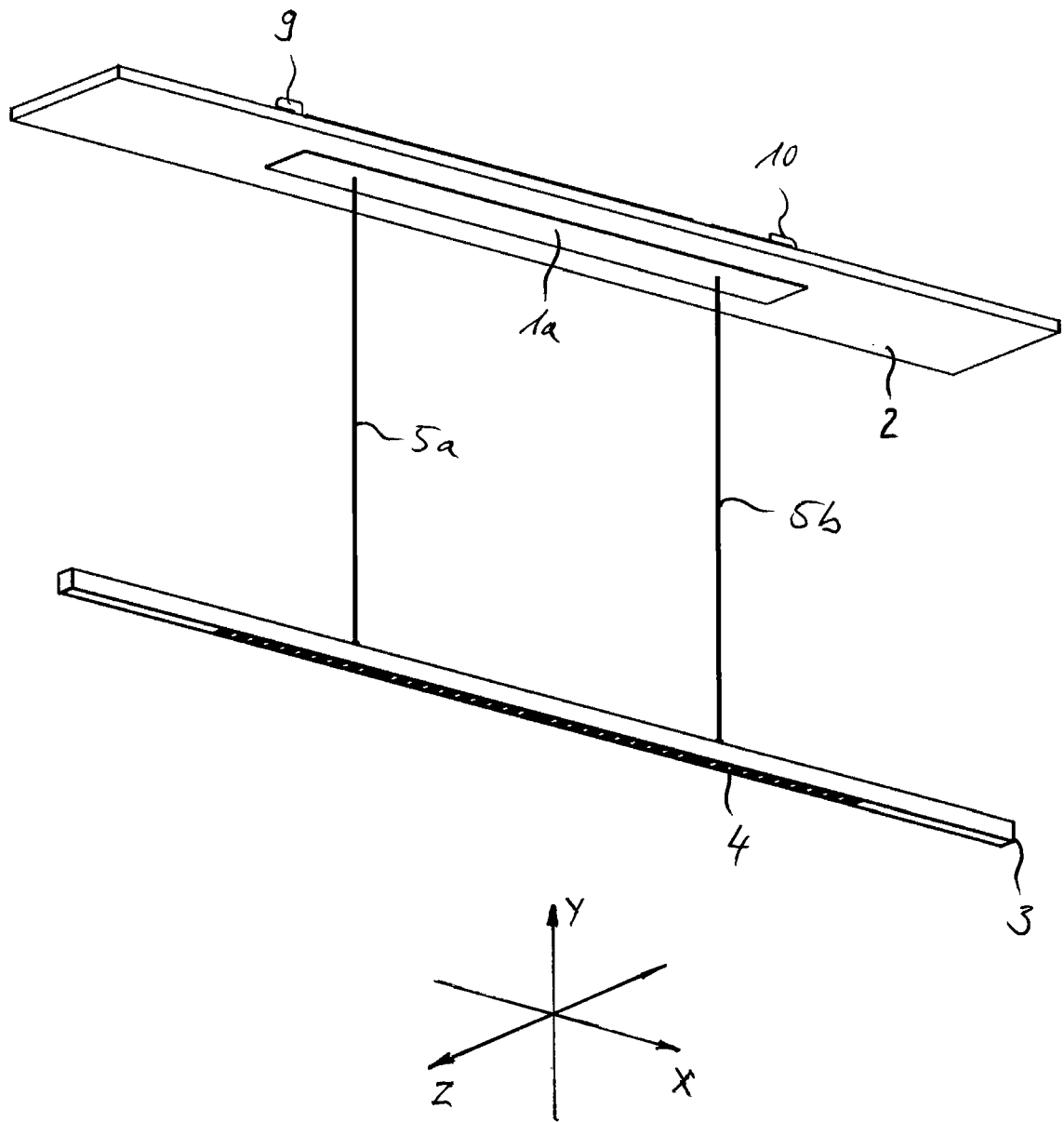


Fig. 2

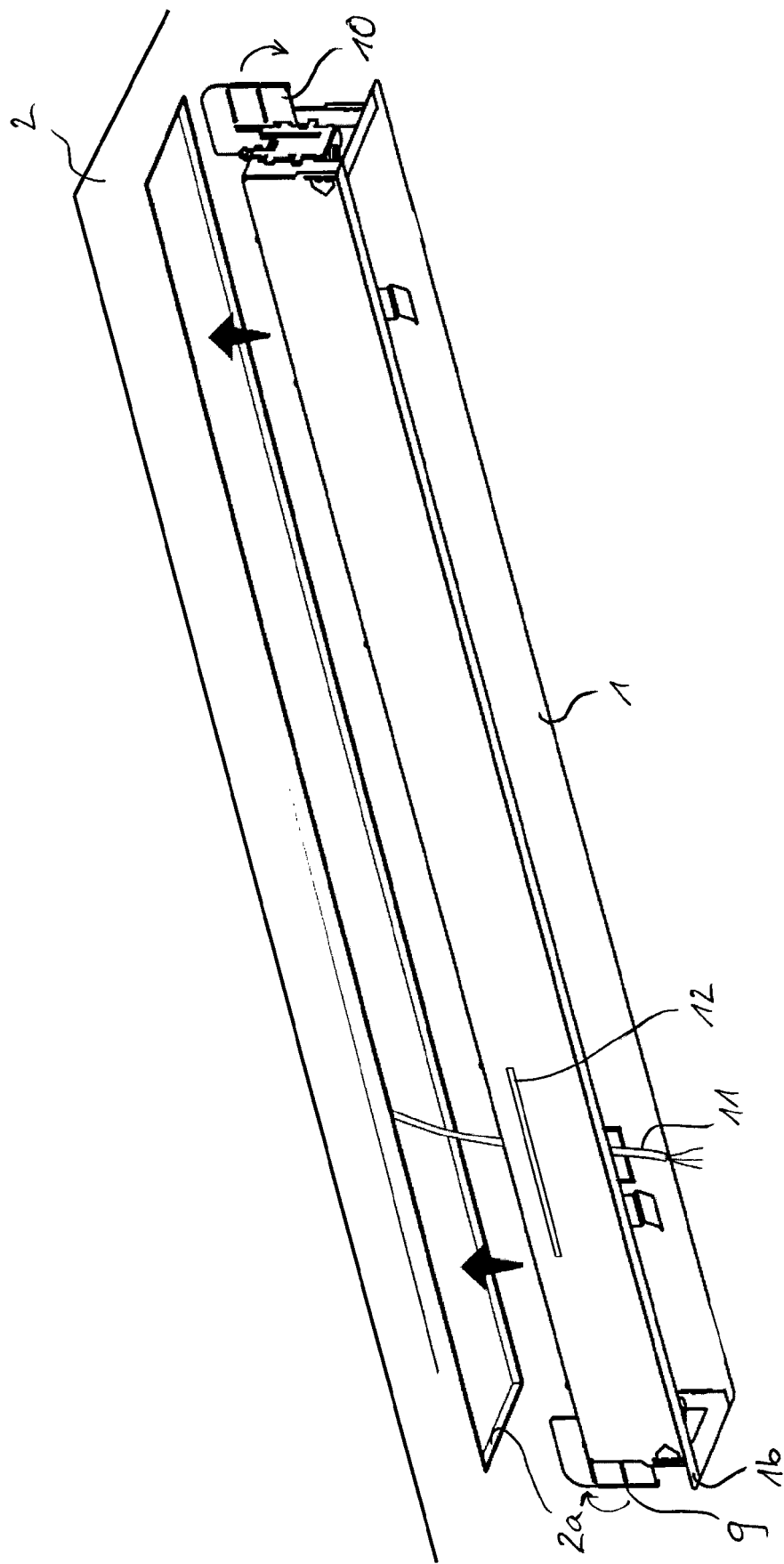


Fig. 3

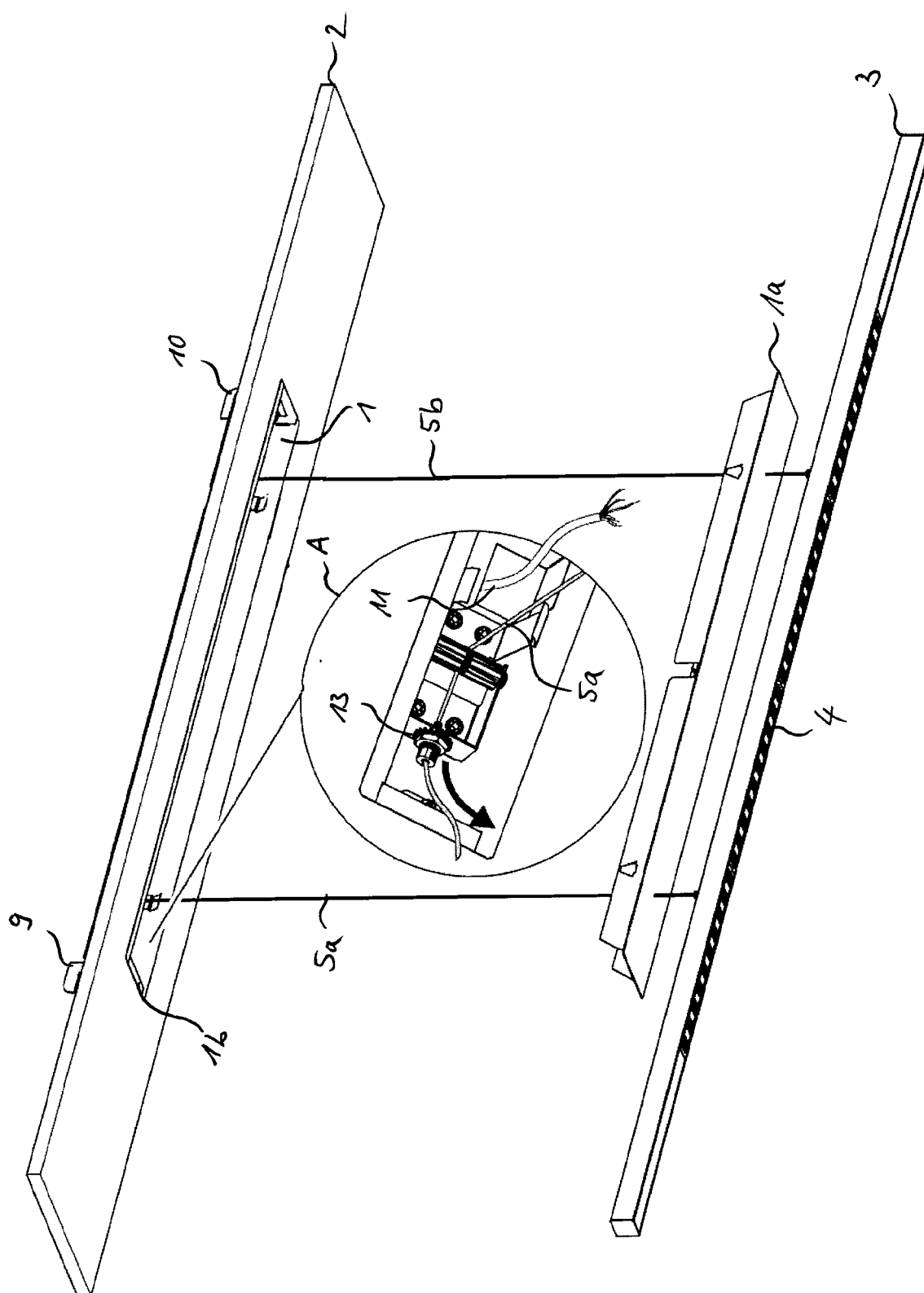


Fig. 4

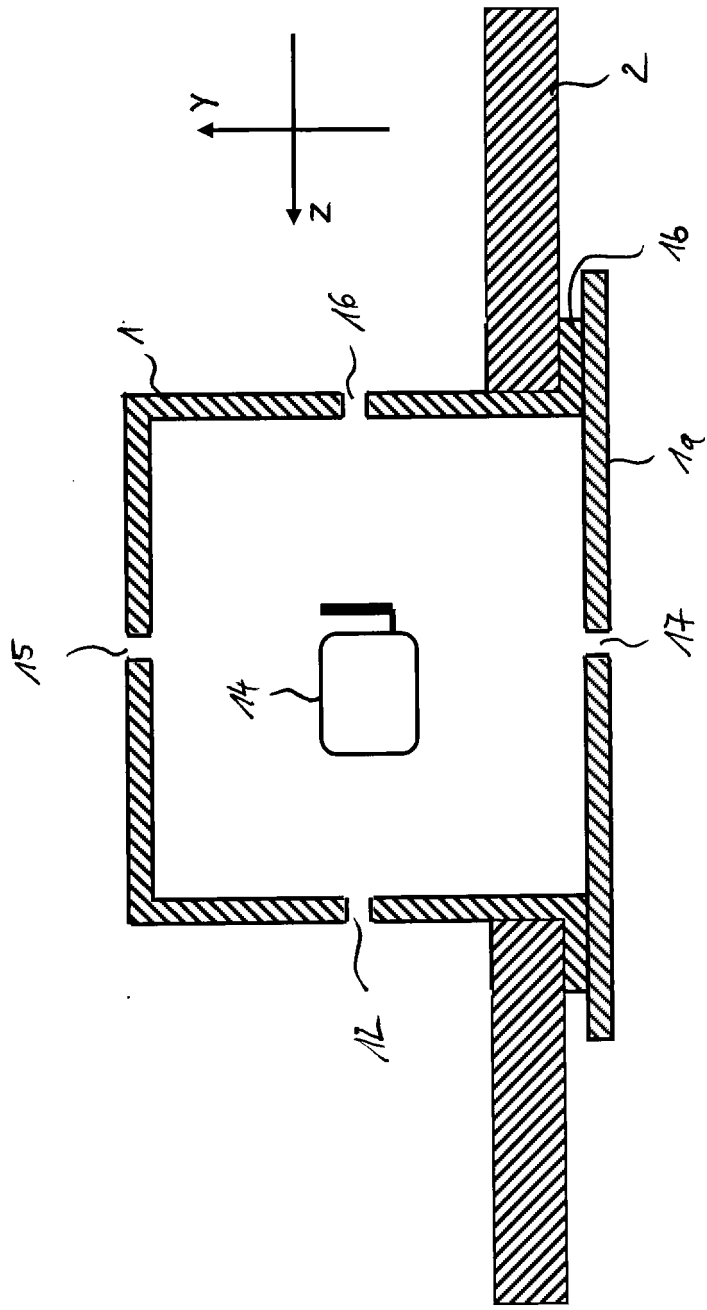


Fig. 5

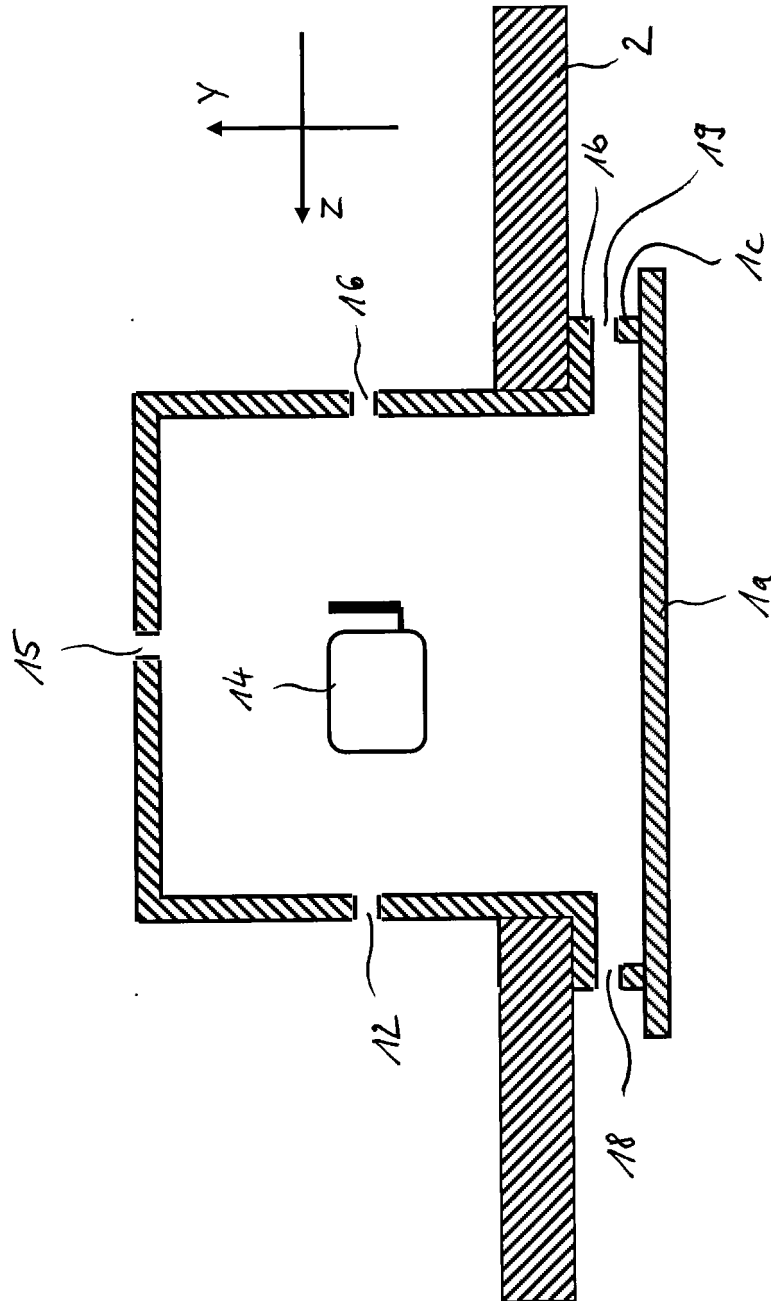


Fig. 6

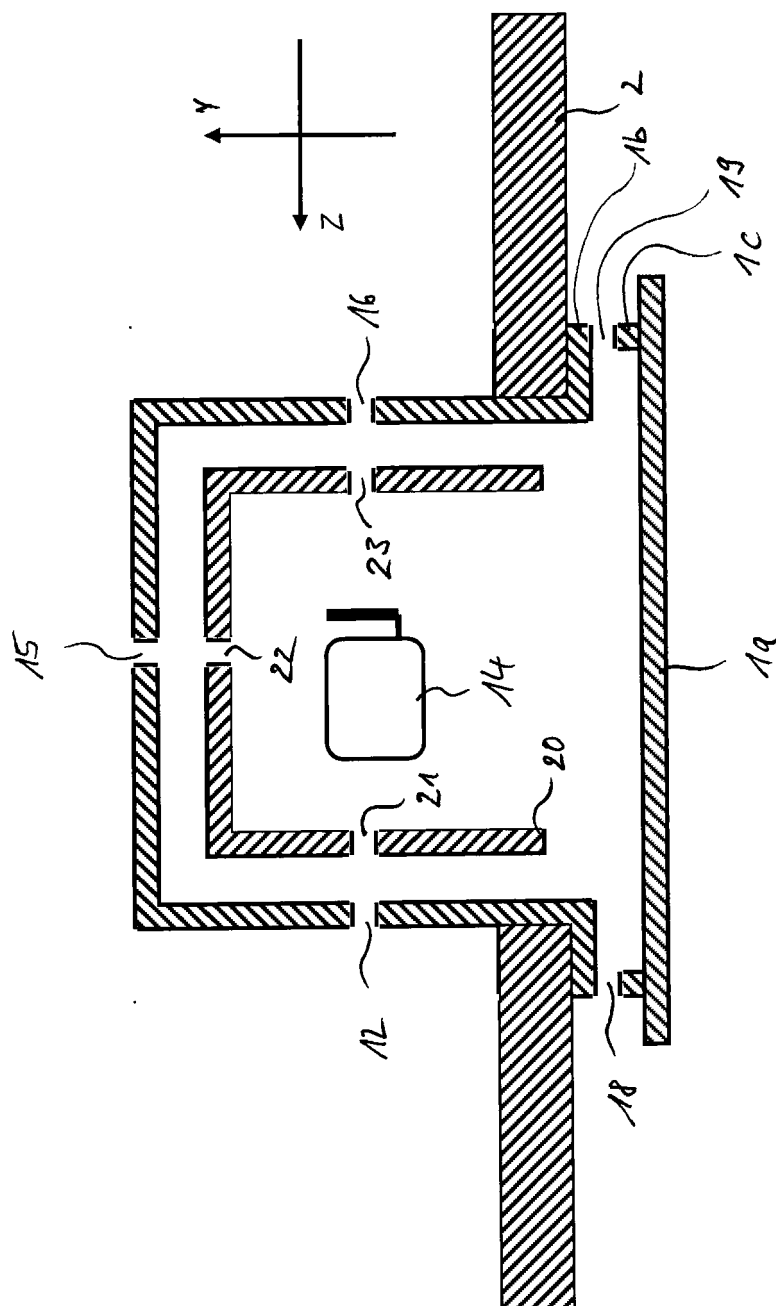


Fig. 7

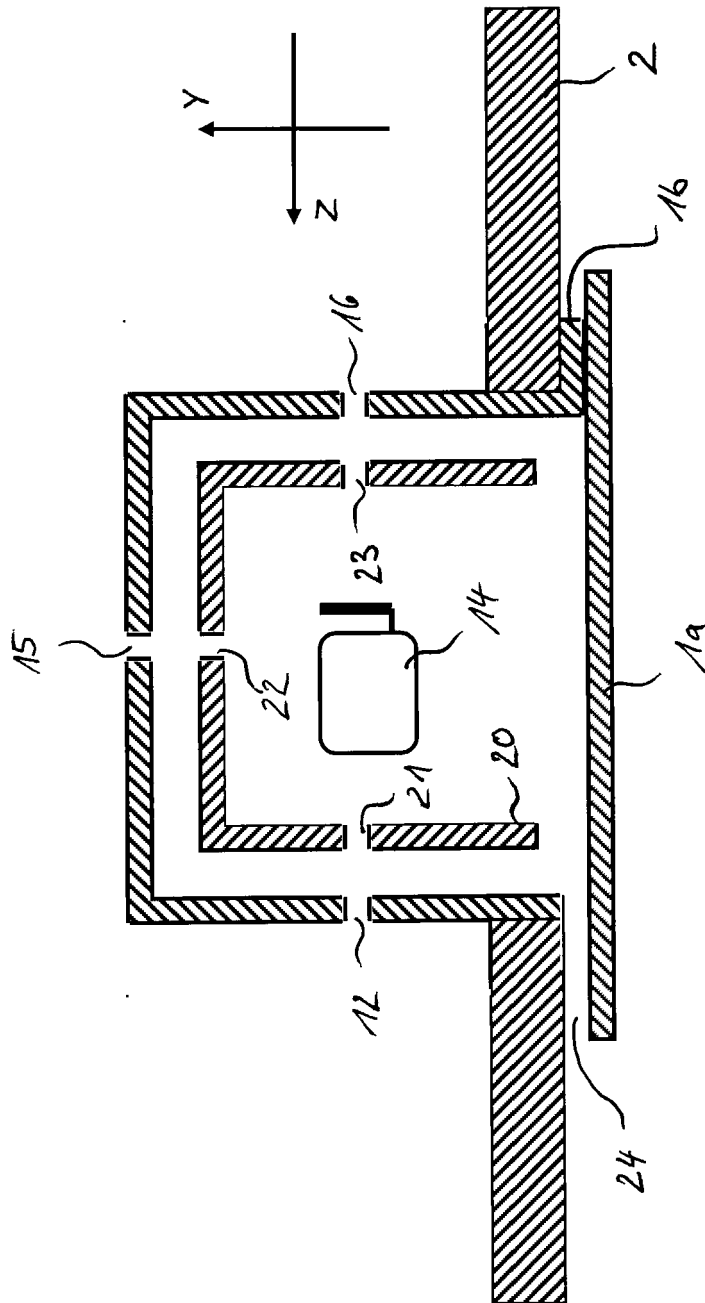


Fig. 8

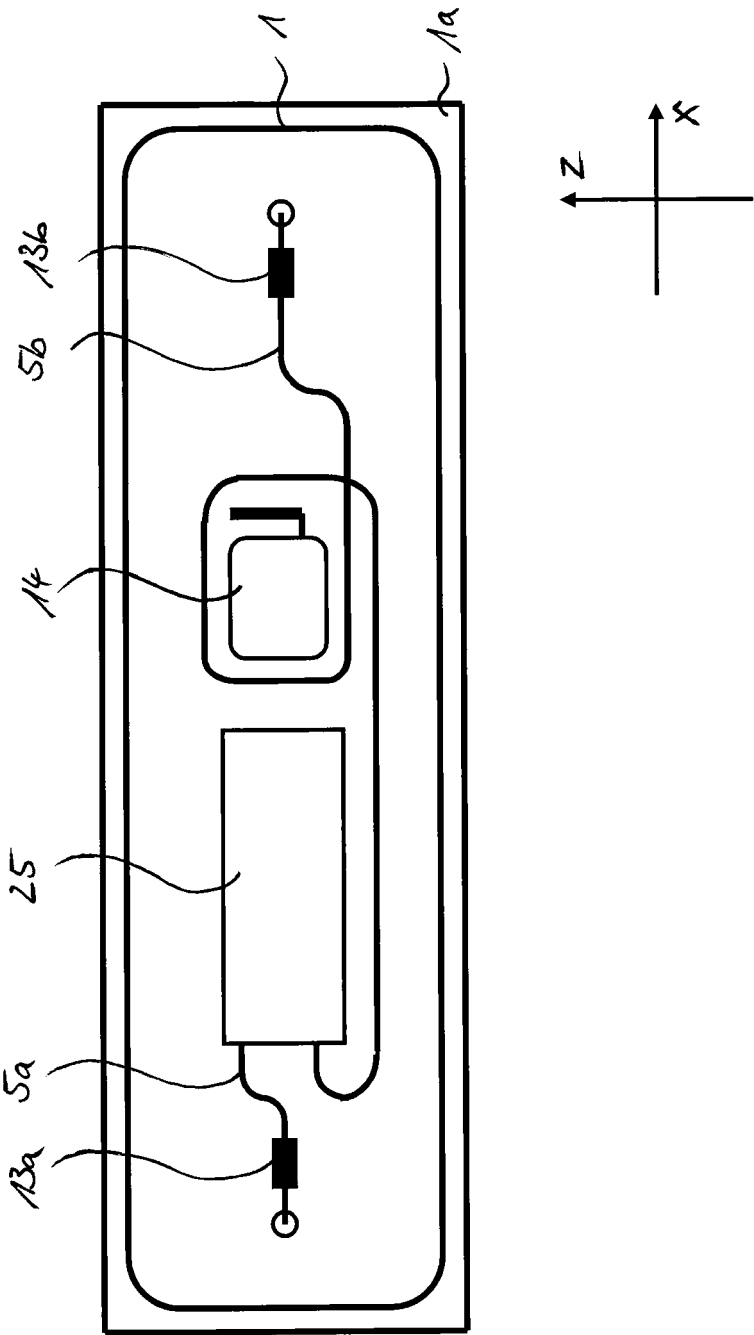


Fig. 9



EUROPEAN SEARCH REPORT

Application Number

EP 22 20 1843

DOCUMENTS CONSIDERED TO BE RELEVANT

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	WO 2020/124145 A1 (SMALL DAVID FREDERICK [AU]) 25 June 2020 (2020-06-25)	1, 2, 4-6	INV.
A	* figures 9-13 * -----	10-12, 15	F21S8/02 F21S8/06 F21V23/04
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	* figure 3 * -----		
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EPO FORM 1503 03.82 (P04C01)

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

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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 The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

30-03-2023

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