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

(11) **EP 4 560 187 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
28.05.2025 Bulletin 2025/22

(21) Application number: **23212323.2**

(22) Date of filing: **27.11.2023**

(51) International Patent Classification (IPC):
F21S 43/13 *(2018.01)* ***F21S 43/14*** *(2018.01)*
F21S 43/237 *(2018.01)* ***F21S 43/239*** *(2018.01)*
F21S 43/243 *(2018.01)* ***F21S 43/245*** *(2018.01)*
F21S 43/247 *(2018.01)* ***F21S 43/251*** *(2018.01)*
F21S 43/30 *(2018.01)* ***F21S 43/50*** *(2018.01)*

(52) Cooperative Patent Classification (CPC):
F21S 43/245; F21S 43/13; F21S 43/14; F21S 43/237; F21S 43/239; F21S 43/243; F21S 43/247; F21S 43/251; F21S 43/252; F21S 43/253; F21S 43/30; F21S 43/50

(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 ME MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
KH MA MD TN

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(54) **LIGHTING SYSTEM**

(57) A lighting system for generating a light strip effect, for example for a light of an automotive lamp, comprises at least one thread-like lighting source (10) suitable for emitting a light beam in a lateral direction, and at least one light guide (14) optically coupled to the thread-like lighting source. The light guide (14) comprises a proximal light guide portion (142) and a distal light guide portion (144). The proximal light guide portion (142) is suitable for reflecting at least one portion of the light beam generated by the thread-like lighting source so as to channel said light beam portion into the distal light guide portion (144). The distal light guide portion (144) is configured to reflect the light beam portion so as to direct the light beam portion towards a distal emitting end (148) of light guide which provides the desired light strip effect when illuminated.

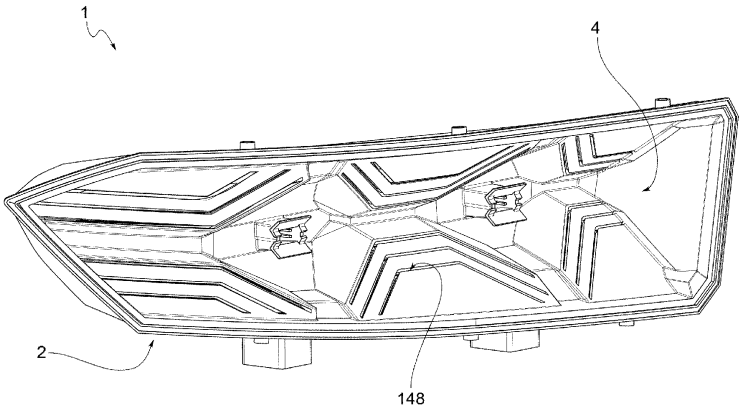

FIG.1

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Description

[0001] The present invention relates to a lighting system for generating a light strip effect, for example for a light of an automotive lamp.

[0002] The trend to create lighting effects as a light strip, i.e., in which the light beam has a thin and elongated shape, is increasingly widespread, even in the automotive lamp industry.

[0003] Such lighting effects as a light strip can be obtained by using a LED strip, i.e., a band or an electronic board in the form of a bar, on which a row of LEDs is mounted and powered.

[0004] However, this solution is not without drawbacks and limitations.

[0005] For example, LEDs are point sources which, although being close together, make the resulting light beam not perfectly uniform. In order to mitigate this inconvenience, a plate with optical features of diffusing the light produced by the point sources is often applied to the LED strip.

[0006] However, over the last few years, car manufacturers have chosen to equip their new models of rear lamps with lighting sources consisting of optical fibers emitting lateral or radial light, hereinafter referred to as "laterally emitting fiber". Indeed, these allow obtaining a more homogeneous light emission and consuming less energy as compared to the solutions with bar-shaped electronic boards.

[0007] As known, the laterally emitting fiber is a device made of polymers which convey therein the light emitted by a LED or Laser light source, and which is provided with a semi-transparent sheath, in the cladding of which microfractures are obtained, which allow laterally or radially adjusting the dispersion of the light along the fiber. However, the profile of the light strip is conditioned by the curvature and flexibility limit of the laterally emitting fiber, which, if exceeded, would lead to a breakage of the fiber itself. In fact, although the laterally emitting fibers are flexible, they are not capable of being bent at sharp edge, particularly on the plane orthogonal to the direction in which the light beam should mainly be directed. As a result, the style requirements of car manufacturers are not fully met.

[0008] It is the object of the present invention to suggest a lighting system capable of generating a light strip effect which can extend along a broken line, and in particular for automotive lamps, while obviating the limitations or drawbacks complained above.

[0009] It is a further object of the invention to provide a lighting system of the type mentioned above, which uses a smaller number of lighting sources, for example of the LED type, than that provided for conventional lighting systems.

[0010] Such objects are achieved by a lighting system in accordance with claim 1 and by an automotive lamp in accordance with claim 13.

[0011] The dependent claims describe preferred or advantageous embodiments of the lighting system.

[0012] The features and advantages of the lighting system according to the invention will however become apparent from the following description of preferred embodiments thereof, given by way of indication and not by way of limitation, with reference to the accompanying drawings, in which:

- Figures 1 and 1a schematically show a perspective view and an exploded perspective view of an example of an automotive lamp provided with a lighting system according to the present invention;
- Figures 2 and 2a are two perspective views, a rear and a front view, of only the lighting system of the lamp in Figure 1;
- Figure 3 is a rear view of the lighting system;
- Figure 4 is an exploded view of a part of the lighting system;
- Figure 4a is an enlarged view of a part of the lighting system;
- Figures 5 and 5a are two views, a rear and a front view, of the lighting system without light guides, so as to highlight the rear covers;
- Figure 6 is an axial section of a lighting source and respective light guide;
- Figure 7 is a view similar to the preceding one, with the addition of a rear cover;
- Figure 8 shows some examples of light guides of the lighting system; and
- Figure 9 is an enlarged rear view of a curved stretch of the lighting system.

[0013] The following description relates to a lighting system used to create lights for an automotive lamp. The lighting system of the present invention can however be advantageously used in various applications, possibly with appropriate adaptations, where obtaining light effects in the form of polylines or strips, in particular having curved stretches, with sharp edges or corners, is desired.

[0014] In the present disclosure, all directional references (such as upper, lower, upwards, downwards, left, right, to the left, to the right, at the top, at the bottom, above, below, vertical, horizontal, clockwise, and counterclockwise) are exclusively used for identification purposes to help the reader understand the described embodiments, and do not create limitations, in particular regarding the position, orientation or use of the embodiments described.

[0015] Connection references (such as fixed, coupled, connected, and the like) should be interpreted broadly and can include intermediate elements between a connection of elements and a relative movement between elements. Therefore, connection references do not necessarily imply that two elements are directly connected and in a fixed relationship with each other.

[0016] In said drawings, reference numeral 1 indicates an automotive lamp.

[0017] The automotive lamp 1 comprises a lamp body

2 defining a lamp compartment 4. A front cover 6 (seen in the exploded view in Figure 1a), at least partially made of a transparent or semi-transparent material, is placed to close the lamp compartment 4.

[0018] The lamp body 2 supports a lighting system 5 suitable for generating, in the lamp compartment 4, the effect of a light strip or line.

[0019] In a general embodiment, the lighting system 5 comprises at least one thread-like lighting source 10. In the example of lamp 1 shown in the drawings, the lighting system is provided with five thread-like lighting sources 10.

[0020] The term "thread-like" means a lighting source having a long and thin shape, i.e., having a cross section the maximum diameter of which has a much shorter length than the longitudinal extension of the lighting source. For example, the term "thread-like" includes a cable shape or a bar shape. Moreover, preferably, the thread-like lighting source is flexible, i.e., it can be bent, at least up to a certain radius of curvature, so as to follow a predetermined path, as will be described below.

[0021] An example of a thread-like lighting source 10 consists of an optical fiber (or an optical fiber cable), to at least one end of which a lighting element, for example a LED or a laser source, is optically coupled.

[0022] In the example shown in the drawings, each thread-like lighting source 10 consists of an optical fiber at the ends of which a LED or laser source 12 is optically coupled.

[0023] At least one active longitudinal portion 10' of the thread-like lighting source 10 is suitable for emitting a light beam in a lateral or radial direction. In other words, the light beam is mainly emitted in a direction orthogonal to the longitudinal direction along which the active longitudinal portion 10' of the thread-like lighting source 10 extends.

[0024] For example, in the case of the optical fiber, the light beam introduced and conveyed into the fiber by the LED or laser source(s) is laterally or radially transmitted through the cladding. In other words, the optical fiber used is of the laterally or radially emitting type. Each reference below regarding the optical fiber relates to the type of optical fiber mentioned above, i.e., the laterally or radially emitting optical fiber.

[0025] Therefore, the thread-like lighting source 10 is suitable for emitting a light beam laterally or radially over the entire length thereof. As it will be described below, active longitudinal portion 10' means the portion of the lighting source used to generate the desired light effect. In fact, the desired light effect does not necessarily have a pattern or shape corresponding to the entire extension of the thread-like lighting source 10, in the direction of the longitudinal extension thereof. As shown in the drawings, for example, the thread-like lighting source 10 has several active longitudinal portions 10' spaced from one another so that the light effect obtained is the effect of a broken light strip or line.

[0026] A respective light guide 14 is optically coupled to each active longitudinal portion 10'.

[0027] As mentioned above, in the case of lighting the entire thread-like source 10 over the entire longitudinal extension thereof, a single light guide 14 can be used to generate a continuous light effect, or a plurality of light guides 14 can be used to generate a light effect in broken lines.

[0028] In some embodiments, the longitudinal portions of a fully illuminated thread-like lighting source 10 not coupled to any light guide 14 can be obscured with an opaque element. In the example of automotive lamp 1 shown in the Figures, it is the lamp body 2 that forms the opaque element. In fact, in the lamp body 2, slits 2' are obtained, through which the luminous flux produced by the lighting system 5 placed behind the lamp body, in particular by the light guides 14, is emitted.

[0029] Each light guide 14 comprises a proximal light guide portion 142 and a distal light guide portion 144.

[0030] The proximal light guide portion 142 forms a source seat 146, for example in the shape of a channel, in which at least the active longitudinal portion 10' of the thread-like lighting source 10 is accommodated.

[0031] Such a proximal light guide portion 142 is suitable for reflecting at least one portion of the light beam generated by the active longitudinal portion 10' so as to channel the light beam portion into the distal light guide portion 144 (see Figures 6 and 7).

[0032] In turn, the distal light guide portion 144 is configured to reflect, preferably so as to meet the condition of total internal reflection, the light beam portion received by the proximal light guide portion 142, or directly by the active longitudinal portion 10', so as to direct the light beam portion towards a distal emitting end of the light guide 148 from which the light beam portion is emitted.

[0033] Such a distal emitting end 148, when illuminated, provides the desired effect of a light strip or line (depending on the thickness of the distal emitting end).

[0034] In other words, the light effect perceived by the observer is produced by the distal emitting end 148 of the light guide and is thus determined in height by the height or thickness of the distal emitting end 148 and in the longitudinal direction by the direction along which the light guide longitudinally extends.

[0035] In the example of lamp 1 shown in the drawings, the lighting system 5 is fixed behind the lamp body 2. The distal emitting end 142 engages or is placed immediately behind the slots 2' obtained in the lamp body 2 so as to project the luminous flux into the lamp compartment 4.

[0036] In one embodiment, each light guide 14 is made in one piece as a single body, for example of plastic material by injection molding. In other words, the distal light guide portion 144 is an extension (in the radial direction with respect to the longitudinal direction of the thread-like lighting source) of the proximal light guide portion 142.

[0037] In one embodiment, the light guide 14 has an extension in length substantially corresponding to the active longitudinal portion 10'. As mentioned above,

the light guide 14 has a transverse extension chosen so as to place the distal emitting end 148 at a predetermined distance from the active longitudinal portion 10'. In other words, the transverse extension of the light guide 14, i.e., in the direction orthogonal to the main extension direction of the thread-like lighting source 10, determines the distance between the luminous flux source 10 and the point where the luminous flux is emitted so as to produce the desired light effect.

[0038] In one embodiment shown, in particular, in the sectional views in Figures 6 and 7, the proximal light guide portion 142 is "C"-shaped. Therefore, the proximal light guide portion 142 forms a source seat 146 open on the rear side so as to allow easily inserting the thread-like lighting source 10 into the source seat 142.

[0039] For example, the source seat 146 can have a rectangular section (as shown in the drawings) or an oval section.

[0040] In one embodiment, the distal light guide portion 144 is in the shape of a plate with parallel or distally converging flat faces 144'.

[0041] The distal emitting end 148 also forms a surface or edge for the connection of such parallel or converging flat faces 144'.

[0042] The distal light guide portion 144 can extend longitudinally along a polyline, which can comprise sharp edges or corners, the radius of curvature of which is less than the characteristic breaking radius of the thread-like lighting source 10.

[0043] In some embodiments, the distal emitting end 148 has an optical element suitable for influencing the emission of the light beam portion, or an embossing, or it can be made of an opal diffusing material.

[0044] In one embodiment, the distal emitting end 148 forms an emitting surface having an extension in height substantially equal to the diameter of the cross section of the thread-like lighting source 10. In the embodiment in which the distal portion 144 is in the form of a plate with parallel flat faces, the proximal light guide portion 142 and the distal light guide portion 144 can be connected by at least one inclined intermediate surface 149 which also has the function of reflecting the light rays diverging with respect to the transverse or radial direction, as shown for example in Figure 7.

[0045] In one embodiment, the source seat 146, for example in the shape of a channel, is closed, on the opposite side with respect to the distal emitting end 148, by a reflective rear cover 16 suitable for reflecting a portion of the light beam towards the distal light guide portion 144.

[0046] In the example shown in the drawings, the lighting system 5 comprises two beams of thread-like lighting sources 10, consisting of two and three lighting sources, respectively. In each of the beams, the lighting sources 10 extend parallel to each other. Each of the beams of thread-like lighting sources is associated with several groups of light guides 14, separated from one another. In the example shown, three mutually spaced apart groups of light guides 14a, 14b, 14c are associated with the beam having two lighting sources; three other mutually spaced apart groups of light guides 14d, 14e, 14f are associated with the beam having three lighting sources.

[0047] Each group of light guides 14a-14f consists of two or three light guides 14, respectively, one for each respective thread-like lighting source 10. In one embodiment, the light guides 14 of each group are connected together so as to form a single body, for example made in one piece by injection molding.

[0048] Each group of light guides 14a-14f is associated with a respective reflective rear cover 16a-16f. For example, once the lighting sources 10 have been inserted into the respective light guides, the rear covers 16 and the respective light guides 14 can be press- or snap-coupled together.

[0049] The rear reflective covers 16 can be provided with respective holes 16' for fixing the cover-lighting source-light guide assembly to the lamp body 2, for example by screwing.

[0050] In one embodiment, as in the example shown in the drawings, the thread-like lighting sources 10 and the respective light guides 14 form at least one curve or corner.

[0051] In one embodiment, if the desired light effect to be obtained from the light guides 14 requires that the light guides 14 form curves or corners with smaller radii of curvature than a minimum radius of curvature that the thread-like lighting source 10 can withstand, or sharp edges, at the curve or corner of the light guide, the source seat 146 has a section with a greater width than the maximum diameter of the thread-like lighting source 10 so as to compensate for the difference between the respective radii of curvature (see Figure 9).

[0052] In other words, the optical coupling between the light guide 14 and the thread-like lighting source 10 allows creating polyline-shaped light effects. In fact, the profile of the distal light guide portion 144 can include sharp edges, from which light emitted by the thread-like lighting source accommodated inside the source seat 146 of the light guide comes out.

[0053] Advantageously, the profile of the distal light guide portion 144, which can extend along a polyline, is powered by the thread-like lighting source, which seamlessly extends into its source seat 146.

[0054] As a result, the distal light guide portion 144 can also form a discontinuous lighting surface, without the need to use a light source, for example a LED light source, close to each segment of the distal light guide portion 144 forming the polyline.

[0055] In one embodiment, the distal light guide portion 144 extends from the proximal light guide portion 142 towards the distal emitting end 148 along a distal portion axis passing through the center of the cross section of the thread-like lighting source 10, as shown in particular in the enlarged sections in Figures 6 and 7.

[0056] In other embodiments, as shown in Figure 8, the

distal light guide portion 144 extends from the proximal light guide portion 142 towards the distal emitting end 148 along a distal portion axis which is offset with respect to the center of the cross section of the thread-like lighting source 10. This contrivance can also allow the thread-like lighting source to compensate for the different radius of curvature between the light guides 14 and the thread-like lighting sources 10.

[0057] Therefore, the lighting system described above allows generating light effects in the shape of a strip or line, even with curves or corners and/or interruptions, by virtue of the optical coupling between a radially emitting thread-like lighting source, for example a radial optical fiber, and one or more light guides.

[0058] The light guides allow both obtaining the desired light effect and emitting the light beam at a distance from the lighting source. The latter can thus be installed in the most appropriate position, according to the application.

[0059] The use of a radially emitting thread-like lighting source, for example instead of a LED strip, allows the light line or strip to be smooth, without the need for optical elements usually used to mix the light generated by point sources.

[0060] Those skilled in the art may make changes and adaptations to the embodiments of the lighting system according to the invention or may replace elements with others which are functionally equivalent in order to meet contingent needs, without departing from the scope of the following claims. Each of the features described as belonging to a possible embodiment can be achieved irrespective of the other embodiments described.

Claims

1. A lighting system for generating a light strip effect, for example for a light of an automotive lamp, comprising:

   - at least one thread-like lighting source (10), at least one active longitudinal portion (10') of said thread-like lighting source being suitable for emitting a light beam in a lateral or radial direction;
   - at least one light guide (14) optically coupled at least to said active longitudinal portion (10'), wherein the light guide (14) comprises a proximal light guide portion (142) and a distal light guide portion (144), and wherein:
   - the proximal light guide portion (142) forms a source seat (146) in which at least the active longitudinal portion (10') is accommodated, said proximal light guide portion (142) being suitable for reflecting at least one portion of the light beam generated by the active longitudinal portion so as to channel said light beam portion into the distal light guide portion (144);
   - the distal light guide portion (144) is configured to reflect the light beam portion so as to direct the light beam portion towards a distal emitting end (148) of light guide from which the light beam portion is emitted, so that said distal emitting end (148), when illuminated, provides said light strip effect.

2. A lighting system according to claim 1, wherein the light guide (14) has an extension in length substantially corresponding to the active longitudinal portion (10') and a transverse extension selected so as to arrange the distal emitting end (148) at a predetermined distance from the active longitudinal portion (10').

3. A lighting system according to claim 1 or 2, wherein the proximal light guide portion (142) is "C"-shaped.

4. A lighting system according to any one of the preceding claims, wherein the distal light guide portion (144) is in the shape of a plate with parallel or distally converging flat faces (144'), the distal emitting end (148) forming a side or edge for the connection of said parallel or converging flat faces (144').

5. A lighting system according to any one of the preceding claims, wherein the distal emitting end (148) forms an emitting surface having an extension in height substantially equal to the diameter of the cross section of the thread-like lighting source (10).

6. A lighting system according to any one of the preceding claims, wherein the source seat (146) is closed, on the opposite side with respect to the distal emitting end, by a reflective rear cover (16) suitable for reflecting a portion of the light beam towards the distal light guide portion (144).

7. A lighting system according to any one of the preceding claims, wherein the active longitudinal portion (10') and the light guide (14) form at least one curve.

8. A lighting system according to the preceding claim, wherein the light guide (14) forms a curve with a smaller radius of curvature than a minimum radius of curvature that the thread-like lighting source (10) can withstand, and wherein, at said curve of the light guide, the source seat (146) has a section with a greater width than the maximum diameter of the thread-like lighting source so as to compensate for the difference between the respective radii of curvature.

9. A lighting system according to any one of the preceding claims, wherein the distal light guide portion (144) extends from the proximal light guide portion

(142) towards the distal emitting end along a distal portion axis passing through the center of the cross section of the thread-like lighting source (10).

10. A lighting system according to any one of claims 1-8, wherein, in at least one longitudinal portion of the light guide (14), the distal light guide portion (144) extends from the proximal light guide portion (142) towards the distal emitting end (148) along a distal portion axis which is offset with respect to the center of the cross section of the thread-like lighting source (10) .

11. A lighting system according to any one of the preceding claims, wherein the thread-like lighting source (10) comprises at least one laterally or radially emitting optical fiber and at least one light source (12) optically coupled to a respective end of the optical fiber to generate a light beam which illuminates the optical fiber and is transmitted through the cladding of the optical fiber.

12. A lighting system according to any one of the preceding claims, wherein the distal emitting end (148) has an optical element suitable for influencing the emission of the light beam portion, or an embossing, or it can be made of an opal diffusing material.

13. A lighting system according to any one of the preceding claims, wherein the distal light guide portion (144) extends longitudinally along a polyline forming sharp edges or corners, the radius of curvature of which is less than the characteristic breaking radius of the thread-like lighting source (10).

14. An automotive lamp (1) comprising a lamp body (2) defining a lamp compartment (4), a front cover (6) placed to close the lamp compartment and at least partially made of a transparent or semi-transparent material, and a lighting system (5) according to any one of the preceding claims supported by the light body (2) and suitable for generating, in the light compartment (4), the effect of a light strip or line.

15. An automotive lamp according to claim 14, wherein the lighting system (5) is placed behind the lamp body (2), and wherein slots (2') are obtained in the lamp body (2), through which the luminous flux produced by the light guides (14) is emitted.

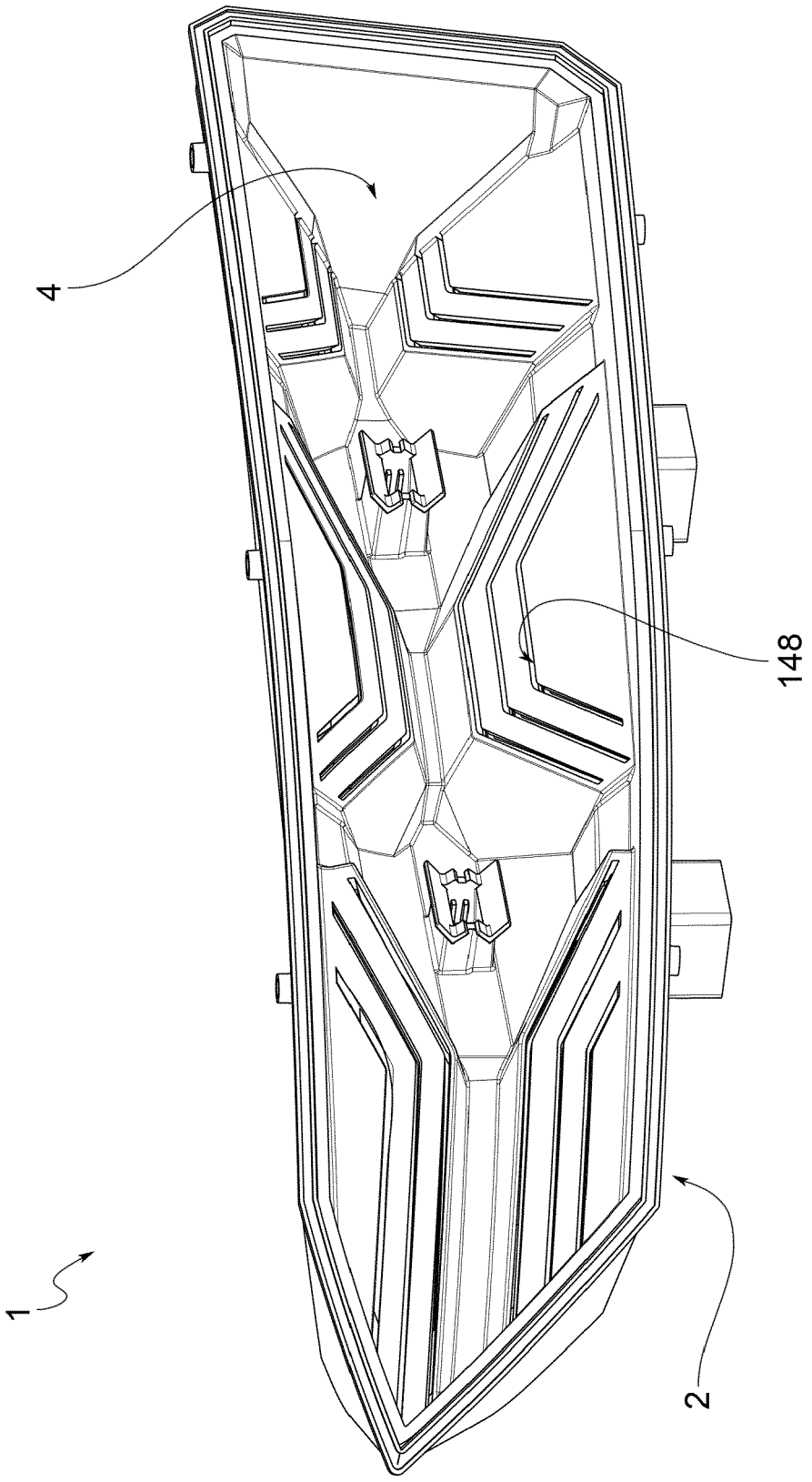

FIG.1

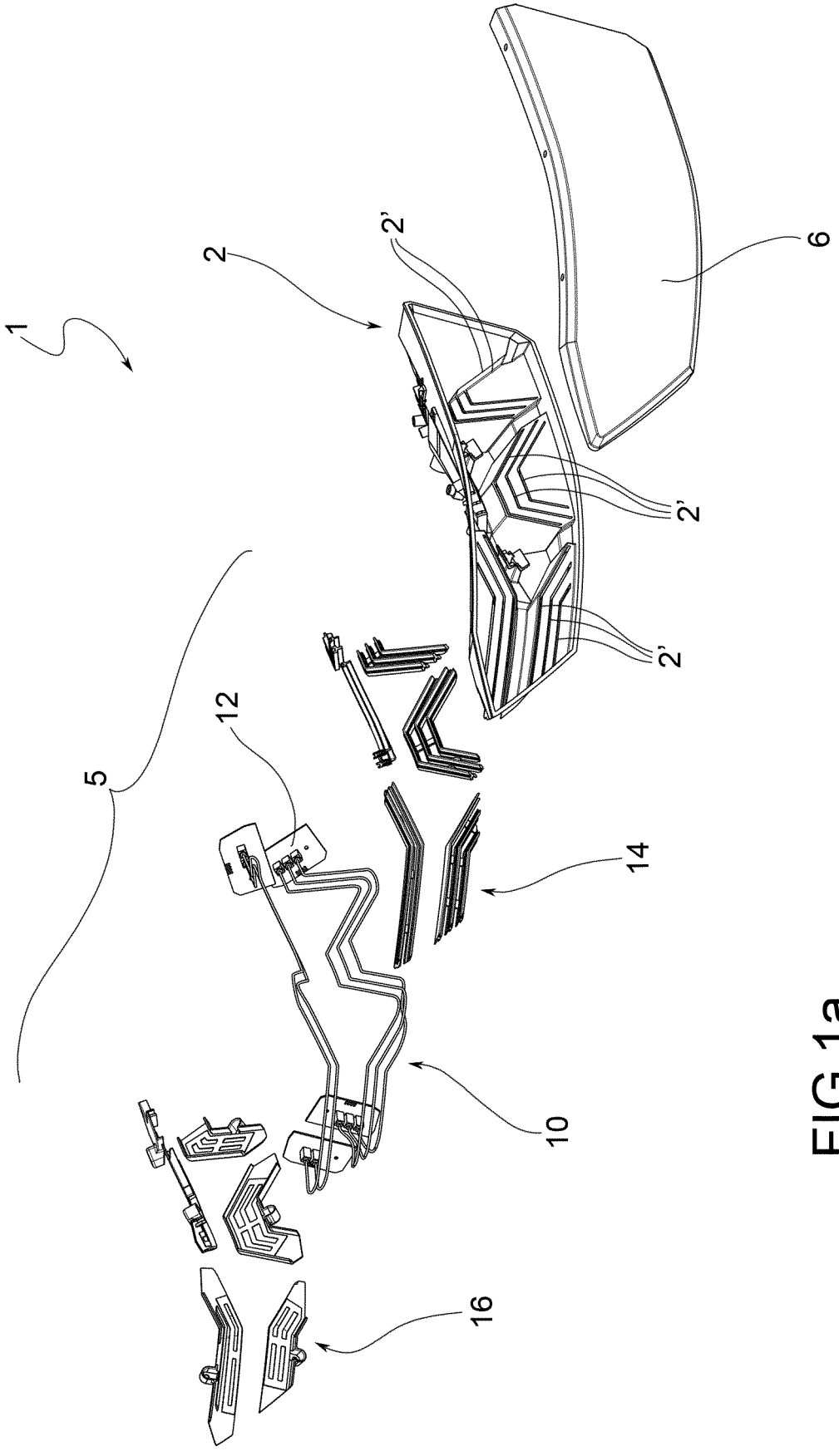

FIG.1a

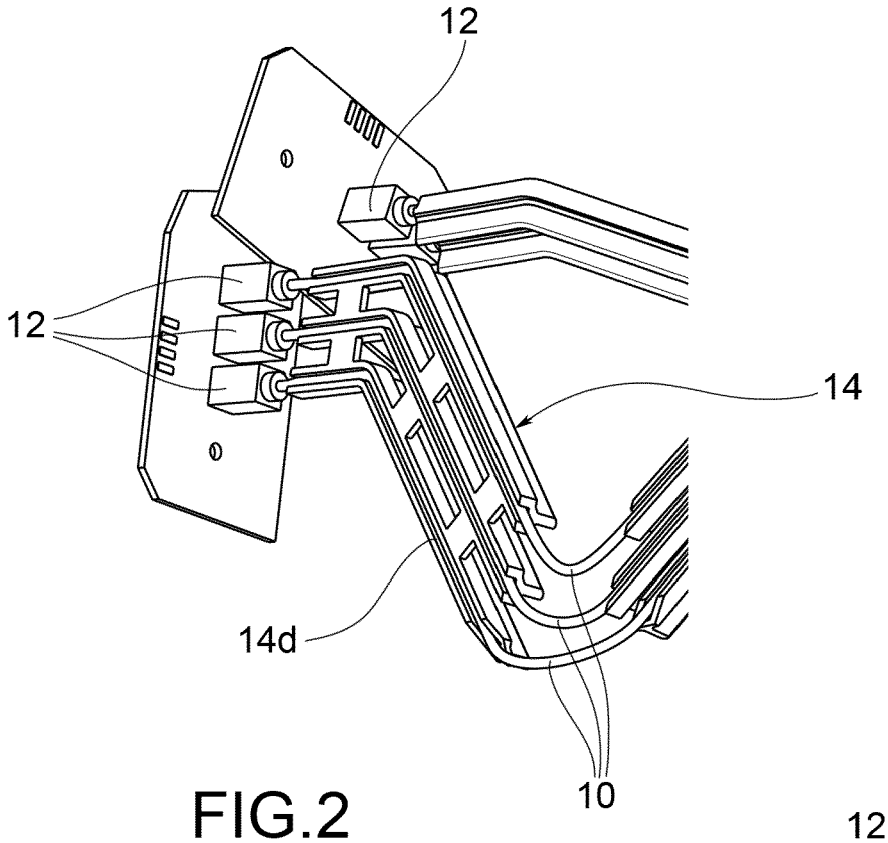

FIG.2

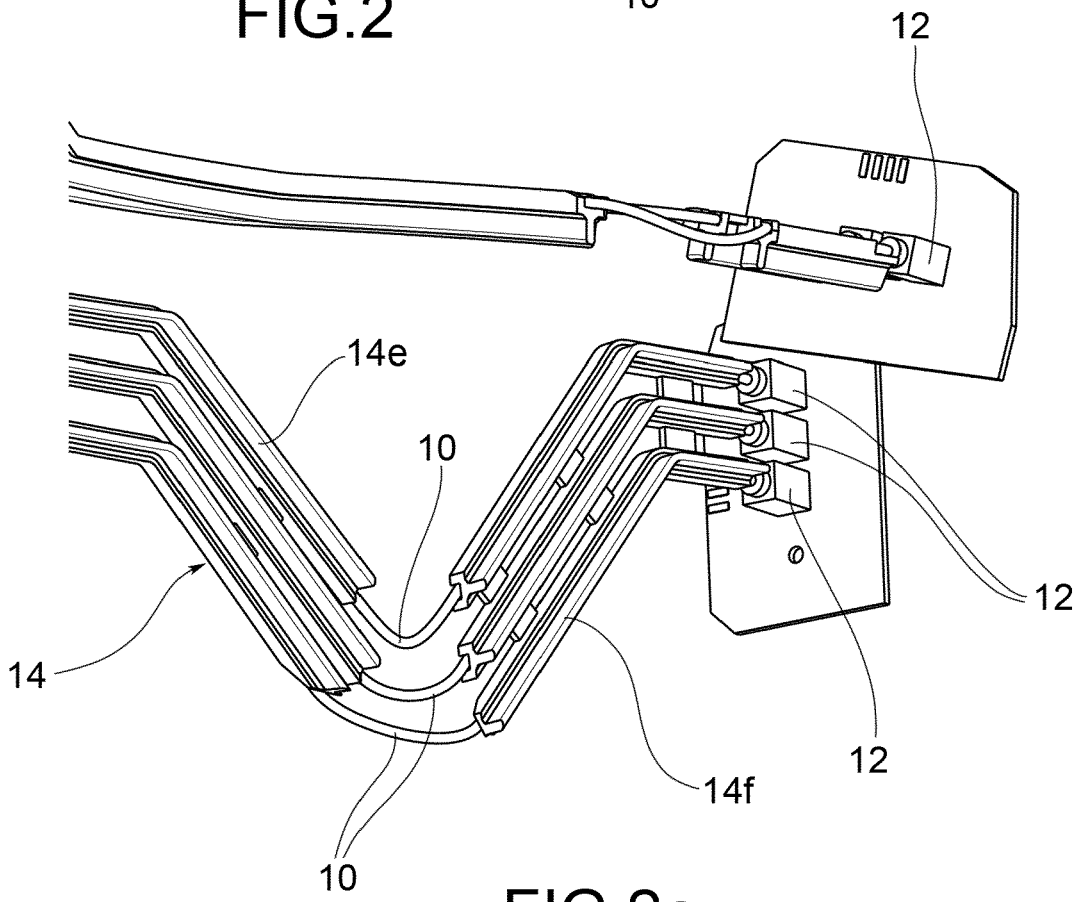

FIG.2a

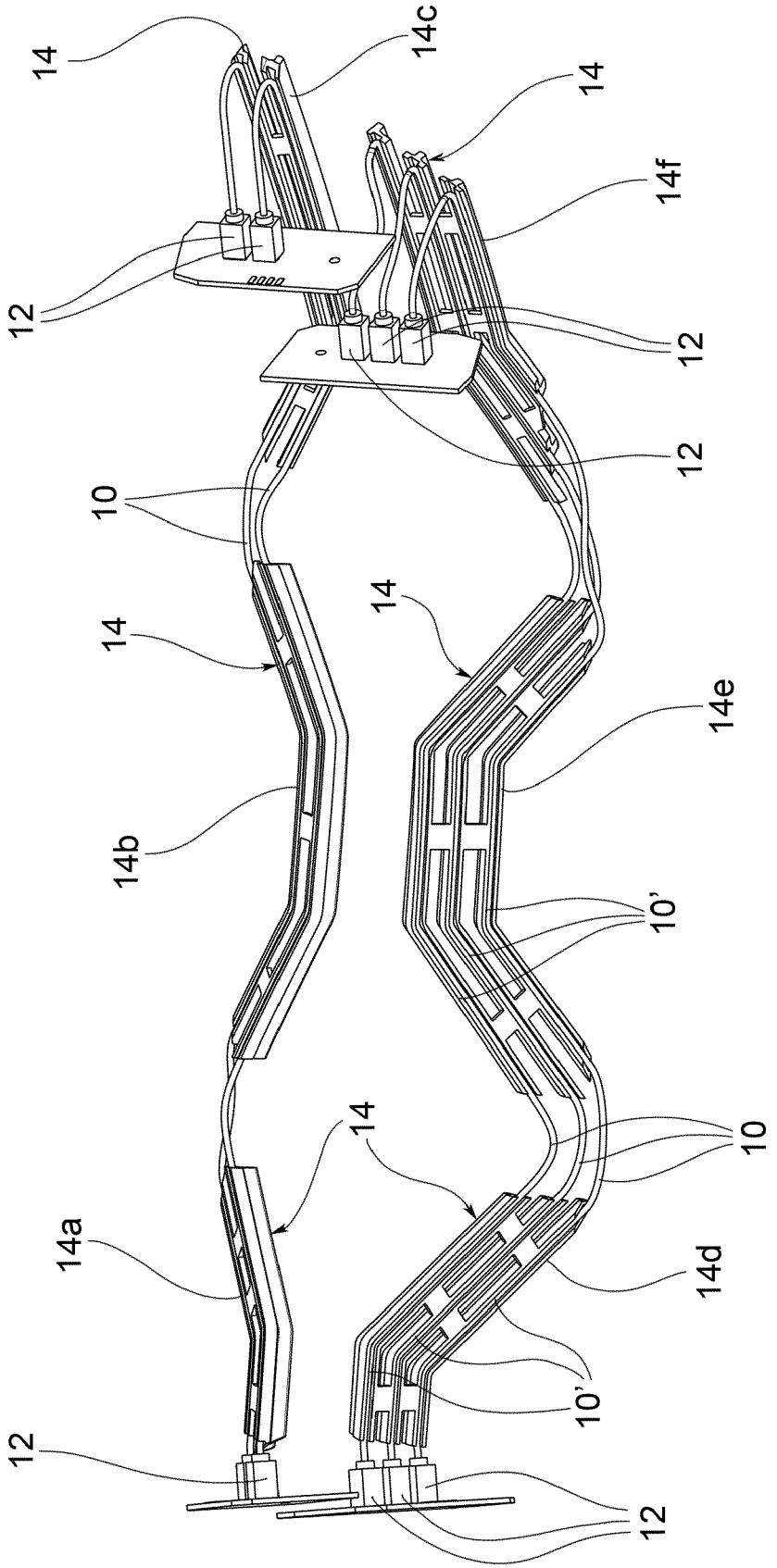

FIG.3

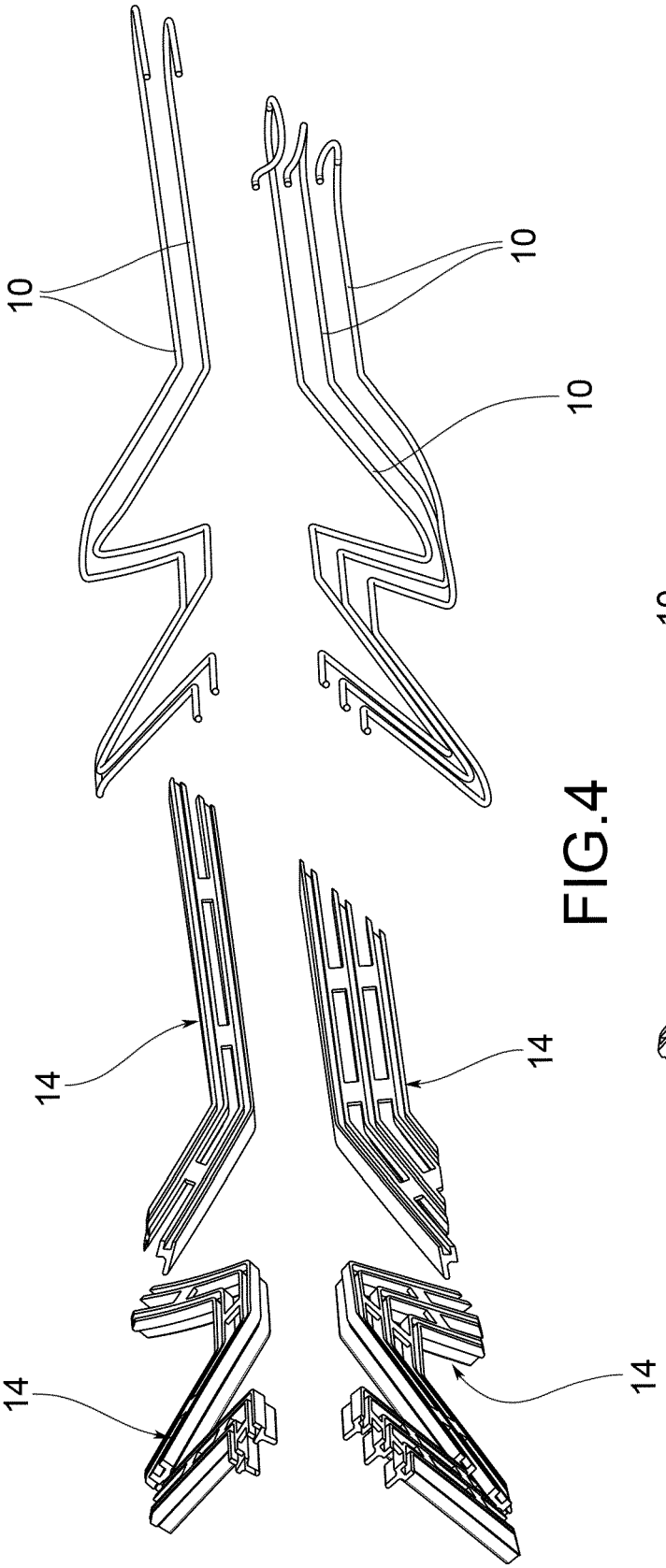

FIG.4

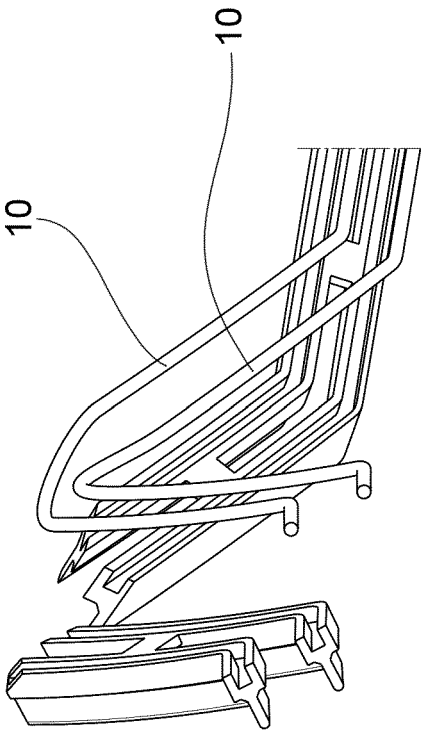

FIG.4a

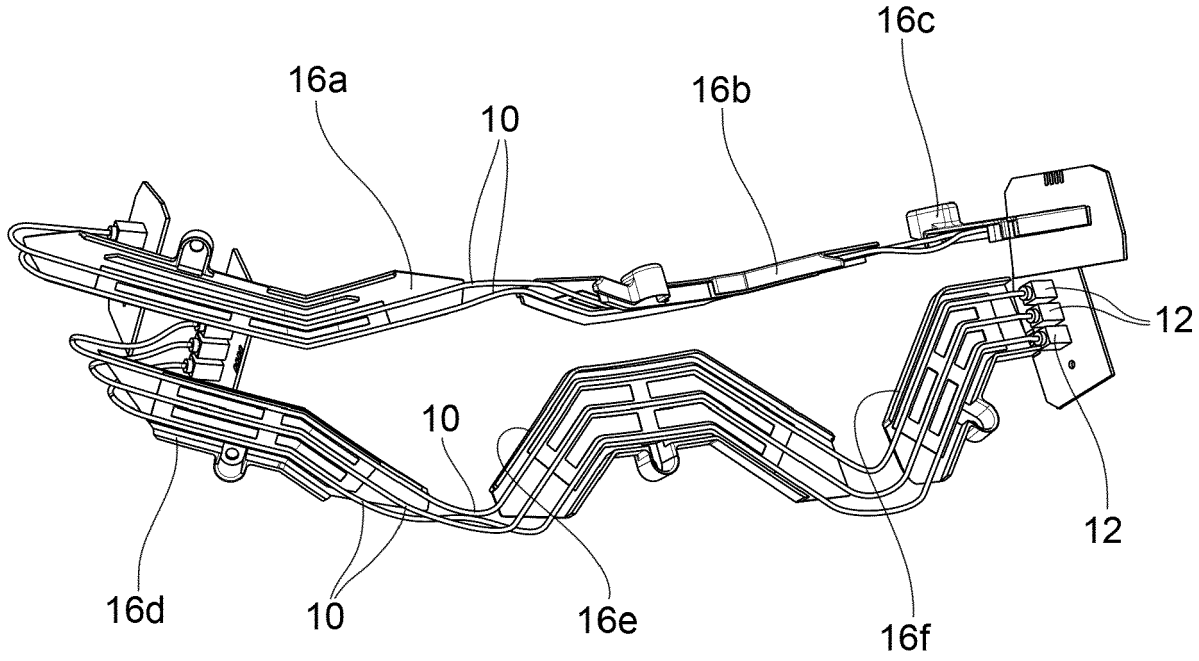

FIG.5

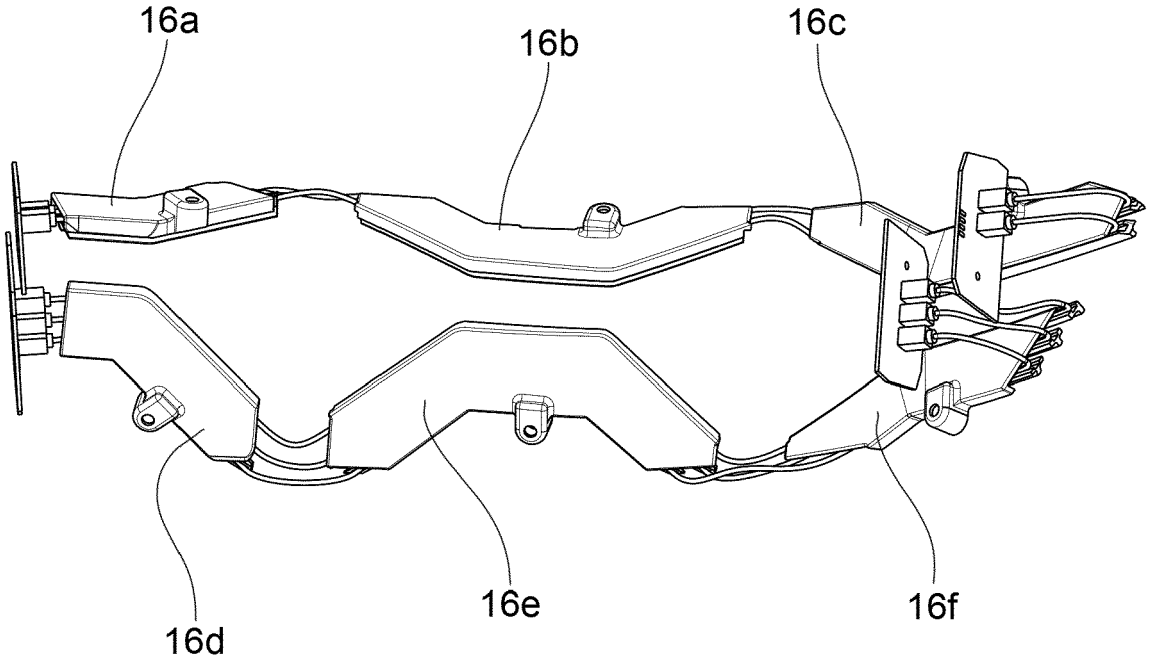

FIG.5a

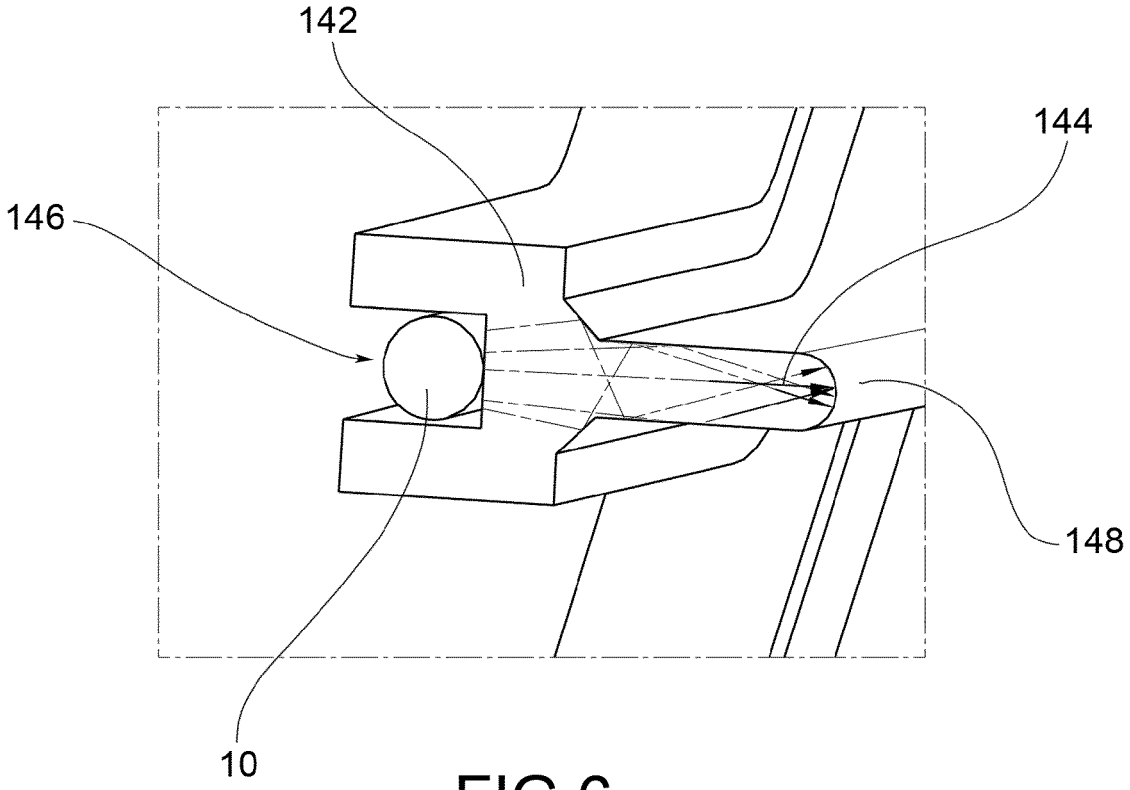

FIG.6

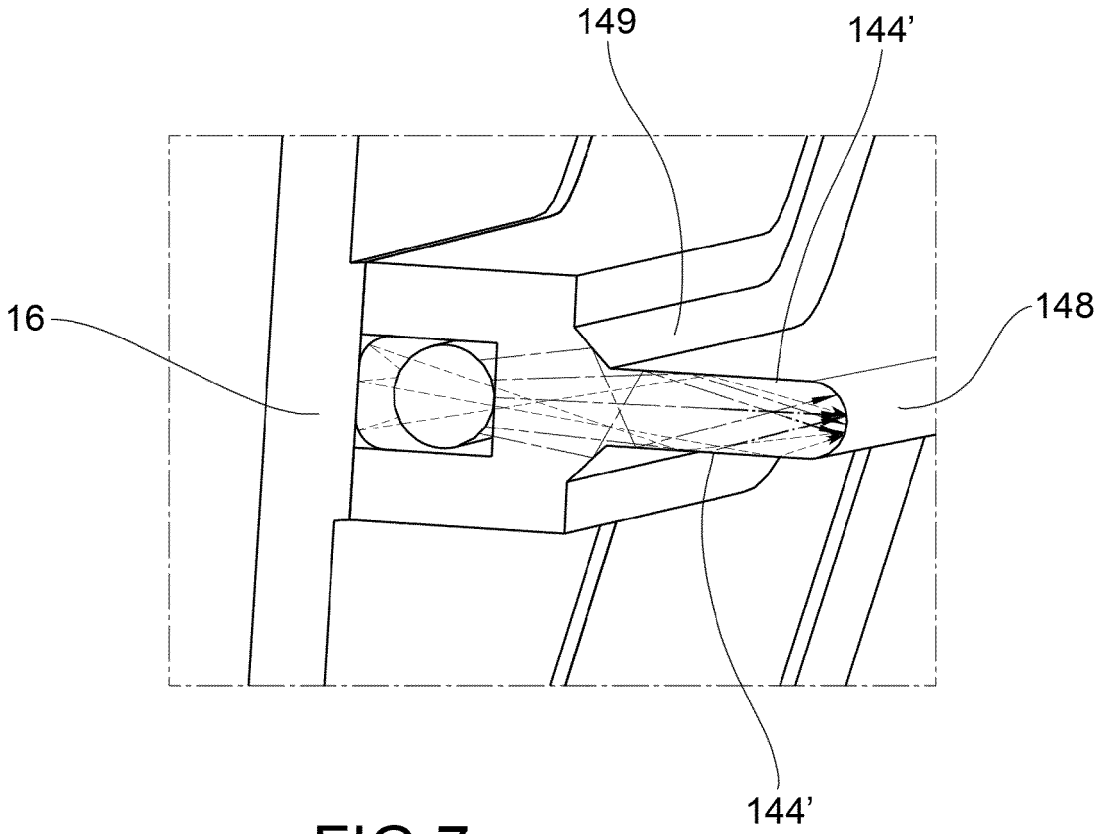

FIG.7

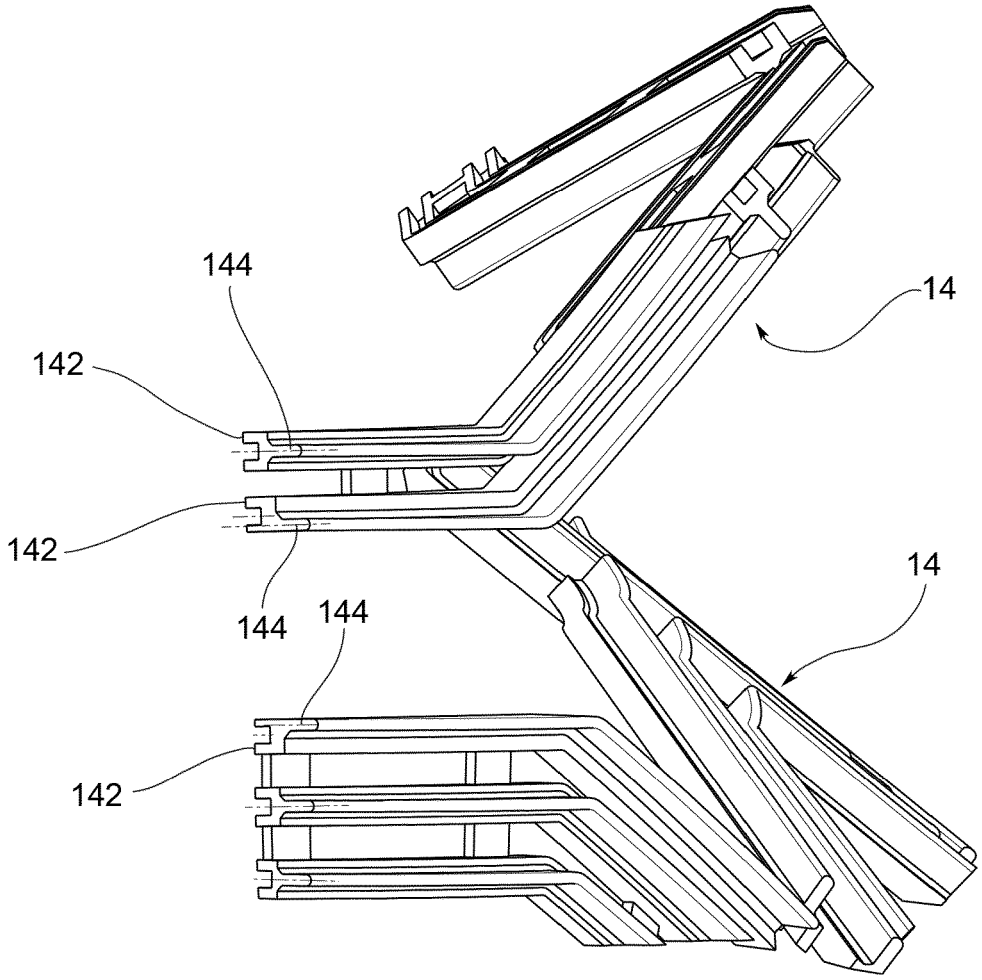

FIG.8

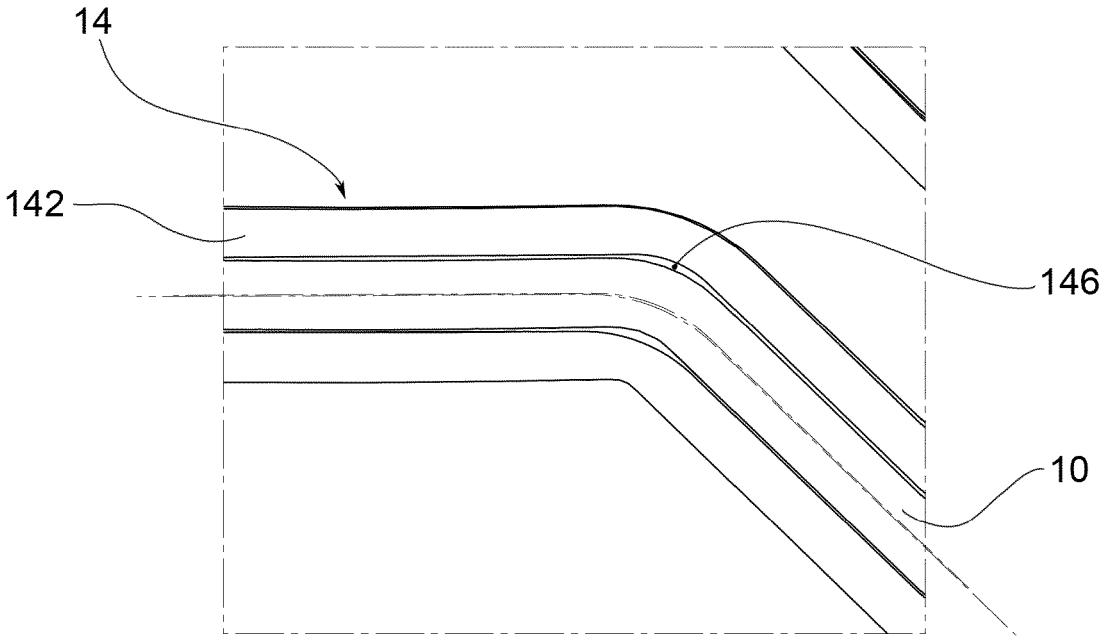

FIG.9

Europäisches Patentamt
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EUROPEAN SEARCH REPORT

Application Number
EP 23 21 2323

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	JP 2020 095782 A (KOITO MFG CO LTD) 18 June 2020 (2020-06-18)	1-5,10, 14	INV. F21S43/13
Y	* see attached machine translation; paragraphs [0001], [0005], [0018], [0020], [0026], [0030], [0036], [0062] - [0080], [0082]; figures 10-15 *	6-9, 11-13,15	F21S43/14 F21S43/237 F21S43/239 F21S43/243 F21S43/245
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	12 March 2024	Goltes, Matjaz

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