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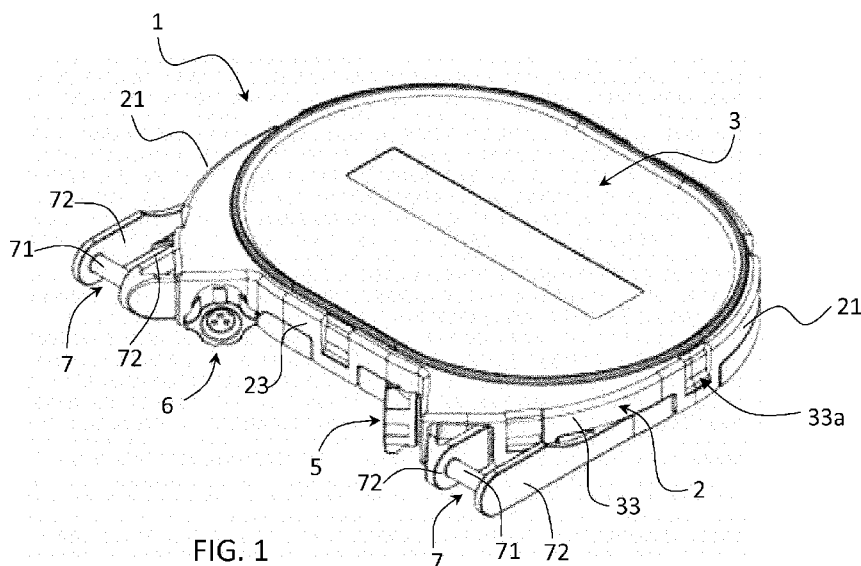


FIG. 1

(57) Abstract: It is disclose a splice tray (1) for use in a box (100) of an optical access network comprising a base portion (2) with a sidewall (22) upwardly projecting from the perimeter of said base portion (2) and a first (5) and a second passageway (6) configured to allow at least one optical fiber (130) to enter and exit the splice tray; a cover portion (3) configured to be removably coupled to the base portion (2); a sealing gasket (40) disposed between the base portion (2) and the cover portion (3), and sealing elements (50, 60), each mounted respectively on a free end of the first (5) and second passageway (6). The sealing gasket (40) and the sealing elements (50, 60) are configured to provide the splice tray (1) with a level of protection against the ingress of foreign objects.



Splice tray for optical fibers

* * * * *

DESCRIPTION

5 The present invention relates to a splice tray for optical fibers. This tray can be used, for example, in the area of the installation of optical access networks.

A so-called FTTP (Fiber-to-the-Premises") or FTTH ("Fiber-to-the-Home") network is an optical access network providing a number of end users with broadband communication services from operators, i.e. with services requiring data transmission at a very high rate, for example of some hundreds of Mbit/s or even higher.

Typically, a FTTP or FTTH optical network comprises a central unit which is connected with one or more optical distribution boxes which are typically located in the basement or cellar of the building where the end users reside.

15 The connection between the central unit and the optical distribution box is performed with a network cable. From the optical distribution box, each end user can be directly reached by an optical cable, hereinafter referred to as "drop cable".

Alternatively, when the optical distribution box is located in a building having multi dwelling units, for example arranged in a plurality of floors, intermediate optical modules are installed at each floor for receiving an optical cable, hereinafter referred to as "riser cable", which comes out of the distribution box and runs vertically through the building from the basement or cellar up to all the building floors. The connection between the intermediate optical modules and each user's apartment is then performed with other drop cables.

25 More specifically, at each floor of the building it is possible to cut an access window in the sheath of the riser cable and extract one or more optical fibers from this. Each optical fiber extracted can be routed to the premises of a user on this floor. At any intermediate point between the access window and the user's premises, the optical fiber extracted can be spliced to an optical fiber or split in a plurality of optical fibers of a drop cable. The splices/splitters between the optical fibers extracted from the riser cable at a floor of a building and the optical fibers of the drop cables installed on this floor are typically housed in suitable transition boxes.

The free end of each drop cable is typically located at the user's premises in a suitable termination box, so that the user can connect devices for using communication services (PC, set-top box, etc.) directly to this.

5 The central unit, the distribution boxes, the transition boxes and the termination boxes typically comprise one or more trays for housing the mechanical or fusion splices/splitters between optical fibers and/or any excess length of the optical fibers. In the case when the cabinet, joint or box comprises several trays, these are typically stacked in order to minimize their overall dimensions.

10 Throughout this description and in the following claims, a box is intended to be any enclosure of an optical access network configured to house at least one splice tray, for example a distribution box, a transition box, a termination box and/or a junction box.

15 Throughout this description and in the following claims, by "optical fiber" we mean an elongated optical element comprising an optical waveguide, constituted by an optically transmissive core, surrounded by a cladding. The optical waveguide is generally covered by at least one protective coating layer ("coating"). Two protective coating layers are preferably provided: a first coating layer (primary coating) is in direct contact with the optical waveguide, while a second coating layer (second coating) covers the primary coating. In addition, a
20 buffer layer may cover the optical fiber. The buffer layer may be substantially in contact with the secondary coating (tight buffer) or it may consist of a small tube housing one or more optical fibers (loose buffer). The buffer can be also protected by a jacket.

25 According to IEC 60529, based on their potential exposure to foreign objects, electrical devices and equipment must belong to a specific type of protection, also called IP (Ingress Protection) code. The IP code comprises two characteristic numerals, i.e. a first characteristic numeral and a second characteristic numeral. The first characteristic numeral of the IP code determines how the electrical equipment is protected against the ingress of
30 solid foreign objects, including dust, and, on the other hand, states the level of protection of person against access of hazardous parts. The second characteristic numeral of the IP code determines protection of the electrical equipment against damaging effects caused by the ingress of water.

35 With specific reference to a FTTP or FTTH optical network, when the box should be placed in an impervious environment, such as a manhole, or

attached to a pole and similar places, a high level of protection is required. More specifically, a level of protection IP 68 is necessary, where the first characteristic numeral (6) indicates a complete protection against dust and the second characteristic numeral (8) indicates a complete protection against a continuous immersion in water, beyond 1 meter.

Typically, in order to provide the above specified level of protection to cables, connectors (splices, splitters and other connector devices), and optical fibers of the optical network, the whole box and the input/output optical cables are suitably sealed against the ingress of foreign objects.

This solution is disadvantageous in that it is complex and the costs for sealing the entire box are extremely high.

WO 2014/035611 discloses a sealed splice tray configured for use in aerial telecommunication enclosures to protect optical connection interfaces. The tray comprises a base portion, a cover portion and sealing members disposed in a respective sidewall of the base portion to provide an environmental seal around communication cables entering and exiting the tray. The sealed splice tray is also configured to be inserted into an enclosure comprising slots provided with glands or grommets to enhance the environmental protection of the enclosure as a whole.

Also this latter known solution is complex and expensive, in that both the splice tray and the housing box are sealed for enhancing the overall environmental protection of the splice tray.

The Applicant observed that cables, connectors and optical fibers arranged inside boxes needs different levels of ingress protection (IP) compared to the level of ingress protection requested to protect fiber splices and fibers.

More specifically, in case of installation in an impervious environment, such as a manhole or a pole, the Applicant observed that only fiber splices and optical fibers require a high level of ingress protection, i.e. protection against dust and water.

Therefore, the Applicant has found that a considerable simplification of the product design, as well as a reduction of the installation costs, can be suitably achieved, still meeting required level of ingress protection, by sealing the portion of the optical access network which needs protection, i.e. the splice tray, at a high level of ingress protection, whilst maintaining the box wherein the

splice tray is housed at a level of ingress protection independent of that of the splice tray.

Therefore, the present invention relates to a splice tray for use in a box of an optical access network comprising a base portion including a sidewall upwardly projecting from a perimeter of the base portion, and a first and a second passageway configured to allow at least one optical fiber to enter and exit the splice tray; a cover portion configured to be removably coupled to the base portion; a sealing gasket disposed between the base portion and the cover portion and sealing elements, each mounted respectively on a free end of the first and second passageway, wherein the sealing gasket and the sealing elements are configured to provide the tray with a level of protection against the ingress of foreign objects.

The splice tray of the invention can advantageously provide the splices and/or fibers housed therein with the required level of ingress protection, in particular IP 68, meanwhile reducing the design complexity and the installation costs of the optical access network.

In fact, by sealing the splice tray with a high level of protection, the box into which the splice tray is housed can be maintained at a level of ingress protection independent of that of the splice tray.

Preferably, the sealing gasket is housed in a groove formed along a top surface of the sidewall of the base portion or along a bottom surface of a sidewall of the cover portion.

Preferably, the sealing elements are sealing glands, each comprising a sealing body, a pressing plate, and a nut.

Preferably, the sealing body is substantially cylindrical in shape and comprises at least one longitudinal opening for the passage of a respective optical fiber.

Preferably, the pressing plate comprises at least one opening for the passage of a respective optical fiber, said at least one opening being coaxial with the at least one opening of the sealing body.

Preferably, the nut is screwed on a corresponding thread formed on an outer surface of the first or second passageway.

According to a preferred embodiment, the splice tray further comprises a pair of hinges configured to rotatably couple the splice tray to a support element of the

box of the optical access network.

Preferably, each hinge of said pair of hinges comprises a pin fixed to opposite flaps extending from the sidewall of the base portion, externally to the splice tray, and configured to cooperate with the support element of the box.

- 5 According to a preferred embodiment, the splice tray has a level of protection against the ingress of foreign objects of IP 68, according to IEC standard 60529.

- 10 Preferably, the base portion has rounded corners having a radius of curvature greater than or equal to a minimum bending radius to which an optical fiber to be housed in the splice tray can be bent.

Preferably, the minimum bending radius to which an optical fiber can be bent is comprised in the range of 20-40 mm.

- 15 Preferably, the splice tray comprises a fiber storage area having a mandrel and guiding elements configured to cooperate with the mandrel to collect optical fiber extra-length portions in said fiber storage area.

In a particularly advantageous embodiment, the mandrel and the guiding elements comprise curved walls having a radius of curvature greater than or equal to a minimum bending radius to which an optical fiber to be housed in the splice tray can be bent.

- 20 Preferably, the fiber storage area further comprises one or more fins projecting cantilevered from the guiding elements to retain the optical fibers in position within the tray.

Preferably, the tray further comprises a splice housing area provided in the base portion.

- 25 Preferably, the splice housing area comprises a number of side-by-side splice-carrying elements.

In a preferred embodiment, the splice tray has a width between 10-20 cm and a length between 5-15 cm.

- 30 According to a second aspect of the invention, the present invention relates to a box of an optical access network comprising a splice tray as defined above, wherein the box has a level of protection against the ingress of foreign objects which is different from the level of protection of the tray.

In a preferred embodiment, the box has a level of protection against the ingress of foreign objects lower than the level of protection of the tray.

Preferably, the box further comprises a base body including a bottom wall and edges upwardly extending from the bottom wall.

- 5 Preferably, the edges comprise a front edge, a rear edge and a pair of lateral edges connecting the front edge and the rear edge.

In a preferred embodiment, the box further comprises a support element for the splice tray which extends from the bottom wall of the base body.

- 10 In another preferred embodiment, the box further comprises coaxial openings formed in each of the lateral edges and configured to house an optical cable.

Preferably, the box further comprises at least one passage formed in the edges of the base body for the passage of at least one pre-connectorized optical fiber exiting the box.

- 15 Further features and advantages of the present invention will appear more clearly from the following detailed description of a preferred embodiment thereof, such description being provided merely by way of non-limiting example and being made with reference to the annexed drawings. In such drawings:

- Figure 1 is an axonometric view of a splice tray for optical fibers, according to a preferred embodiment of the present invention;
- 20 - Figure 2 is an axonometric view of the splice tray in Figure 1, with the cover removed to show the interior of the tray; and
- Figure 3 is a top view of the splice tray in Figure 2;
- Figures 3A and 3B are exploded views of portions of the splice tray in Figure 3;
- 25 - Figure 4 is an axonometric partial view of a box of an optical access network housing a splice tray of Figures 1-3;
- Figure 5 is an axonometric section view of the splice tray in Figure 2; and
- Figure 5A is an exploded view of a section portion of the splice tray in Figure 5.
- 30 Figures 1-3 show a splice tray for optical fibers 1 according to a preferred embodiment of the present invention. The splice tray 1 can be housed in a box, for example a distribution box, a transition box, a drop box or a termination box

of a FTTP or FTTH network.

The splice tray 1 is preferably configured for housing a number of splices (for example, fusion splices) between optical fibers and any excess length of the spliced optical fibers.

- 5 The splice tray 1 comprises a base portion 2 and a cover portion 3 configured to be removably coupled to the base portion 2.

In particular, the base portion 2 has a substantially rectangular shape with rounded corners 21 and comprises a working or upper surface 22 and a sidewall 23 projecting from the perimeter of base portion 2 in a direction
10 substantially perpendicular thereto on the same side of the upper surface 22. This is only an example, as the base portion 2 can have any other shape, for example square with rounded corners, elliptical, etc.

The cover portion 3 has a shape which matches the shape of the base portion 2 and comprises a sidewall 33 coupling, in use, with the sidewall 23 of the base
15 portion 2.

The corners 21 of the base portion 2 preferably have a radius of curvature greater than or equal to a minimum bending radius, which depends on the type of optical fiber to be housed in the tray 1. For example, for optical fibers of the type defined by the Recommendation ITU-T G. 652D, the maximum bending
20 radius to which the optical fibers can be bent with acceptable losses is comprised in the range of 20-40 mm.

As shown in figure 2, the upper surface 22 of base portion 2 comprises a splice housing area 24 for housing the mechanical or fusion splices between optical fibers and a fiber storage area 25 for parking extra-length portions of the optical
25 fibers.

The splice housing area 24 preferably comprises a number of side by side splice-carrying elements 26, each of which is able to house one or more splices between optical fibers.

The fiber storage area 25 comprises a mandrel 27 in the shape of a cylinder with axis substantially perpendicular to the upper surface 22 of base portion 2 and, on the opposite sides with respect to the mandrel 27, guiding elements 28, configured to cooperate with the mandrel 27 to collect the abovementioned
30 extra-length portions of optical fibers in the fiber storage area 25.

The guiding elements 28 and the mandrel 27 are defined by curved walls having a radius of curvature at least greater than or equal to the minimum bending radius of the optical fibers. The value of the minimum bending radius depends on the type of the optical fibers. Typically, it is comprised in the range of 20-40 mm.

Preferably, the fiber storage area 25 also comprises one or more fins 29 that project cantilevered from the top surface of the curved walls of the guiding elements 28 toward the axis of the mandrel 27, to retain the optical fibers in position within the splice tray 1.

With reference to figures 2 and 5, the splice tray 1 further comprises a sealing member, preferably in the form of a sealing gasket or ring 40, which is housed in a groove 30 formed along a top surface of the sidewall 23 of the base portion 2.

The cover portion 3 and the base portion 2 are coupled together, preferably, by means of snap-fit fastening systems. In particular, the sidewall 23 comprises a plurality of male protruding elements 23a extending laterally from the sidewall 23 and matching with respective female elements 33a formed on the sidewall 33 of the cover portion 3. Preferably, the splice tray 1 comprises five male protruding elements 23a substantially equidistant one together and respectively five female elements 33a.

With reference to figures 1, 2 and 5, each female element 33a has a tilting structure provided with a hole and is adapted to flex outwardly when the cover portion 3 is initially fitted on the base portion 2. Each protruding element 23a comprises an upper sliding portion to guide the engagement of the female element 33a over the male protruding element 23a.

With reference to figure 5a, when each female element 33a has overcome each respective male protruding element 23a, the cover portion 3 is firmly coupled on the base portion 2, thus pressing the sealing gasket 40 and maintaining the latter squeezed against the groove 30 in order to seal any voids or air passages between the cover portion 3 and the base portion 2.

In an alternative embodiment of the invention, the sealing gasket 40 can be housed in a groove (not shown) formed along a bottom surface of sidewall 33 of the cover portion 3.

The splice tray 1 further comprises, preferably at a side thereof opposite to that

where the splice housing area 24 is provided, a first and a second passageways 5, 6, projecting from the sidewall 23 of base portion 2, externally to the splice tray 1. More specifically, the first passageway 5 is configured to allow an optical fiber unit of an optical cable to enter the splice tray 1, while the
5 second passageway 6 is configured to allow pre-connectorized optical fiber unit to exit the splice tray 1.

A further sealing element, specifically a compression sealing fitting or sealing gland 50, 60, is mounted on a free end of the first and second passageway 5, 6.

More specifically, and with reference to figures 3A and 3B, each sealing gland
10 50, 60 comprises a sealing body 51, 61 substantially cylindrical in shape and partially pressure inserted in the respective passageway 5, 6. The sealing body 51, 61, preferably made of rubber, includes a plurality of openings 52, 62 for the passage or one or more optical cables and/or optical fibers. The openings 52, 62 extend longitudinally through the sealing body 51, 52 of the sealing gland
15 51, 61. A pressing plate 53, 63 is pressure fitted on the free end of the sealing body 51, 61 of the sealing gland 50, 60. The pressure plate 53, 63 comprises a plurality of openings 54, 64 for the passage of optical cables and/or optical fibers. The openings 54, 64 formed in the pressure plate 53, 63 are coaxial with the openings 52, 62 formed in the sealing body 51, 61. A nut 55, 65 is
20 preferably threaded mounted on the respective passageway 5, 6 thereby housing therein the sealing body 51, 61 and the pressure plate 53, 63. To this end a female thread (not shown) is formed in an inner wall 56, 66 of the nut 55, 65 suitable for coupling with a male thread 57, 67 formed on an outer wall of the passageway 5, 6.

25 Advantageously, when the nut 55, 65 is screwed on the threaded end 57, 67, the edge of the nut 55, 65 pushes the pressure plate 53, 63 against the sealing body 51, 61 so that the latter is squeezed on the optical cables and/or optical fibers to seal possible voids between the openings 52, 62 and optical cables and/or optical fibers.

30 The splice tray 1 preferably also comprises a pair of hinges 7 able to rotatably couple the tray 1 to a support element, e.g. of a distribution box, a transition or and a termination box, so as to facilitate the operations of the operator on the underlying structure, such as for example the insertion in the box of the fibers extracted from the riser cable of the user network, as well as the insertion of the
35 splices in an underlying tray.

The hinges 7 are preferably arranged along one edge of base 2, in particular the edge opposite to that at which the splice-carrying elements 23 are provided.

More particularly, each hinge 7 comprises a pin 71 fixed to opposite flaps 72 extending from the sidewall 22 of base 2, externally to the tray 1.

- 5 The splice tray 1 preferably has a width between 10 cm and 20 cm and a length between 5 cm and 15 cm.

The base portion 2 and the cover portion 3 of the splice tray 1 are preferably made in one piece by moulding a plastic. The plastic used can for example be ABS (acrylonitrile-butadiene-styrene).

- 10 The sealing body 51, 61 of the sealing glands 50, 60 and the sealing gasket 40 are preferably made of elastomeric and polymeric materials, such as thermoplastic elastomers, vulcanite rubbers, polyurethane foams, soft plastics, soft rubber, flexible rubber.

- 15 In figure 4, numeral reference 100 indicates a box of an optical access network according to a preferred embodiment of the present invention.

As shown in figure 4, the box 100 comprises a base body 110 provided with a cover (not shown), preferably hinged to the base body 110, so as to close a compartment for housing optical access network components, e.g. a splice tray 1 as described above.

- 20 More specifically, the base body 110 comprises a bottom wall 111, and edges 112-114 upwardly extending from the bottom wall 111. More specifically, the edges comprise a front edge 112, a rear edge 113 and a pair of lateral edges 114.

- 25 A support element 116 for the tray 1 preferably extends from the bottom wall 111 of the base body 110, so as to allow to hinge the tray 1. More particularly, the tray 1 is hinged to the support element 116 by means of the pins 71 and the flaps 72.

- 30 Openings 115 are formed in each of the lateral edges 114 for housing an optical cable 120 passing through the box 100 and comprising a jacket 121 enclosing a plurality of optical fibers 130.

By cutting the optical cable 120, an access window 122 is created in the jacket 121 to extract one or more optical fibers from it. The extracted optical fibers 130 enter the tray 1 by passing through the first passage 5.

A portion of the above mentioned optical fibers 130 or the optical fibers 130 which are not used are parked in the fiber storage area 25 of the splice tray 1. The optical fibers 130 which are used reach the splice housing area 24, where each of them is spliced to a respective pre-connectorized optical fiber 131 or
5 alternatively splitted in a plurality of optical fibers.

Each optical fiber 131 so spliced or splitted exits the tray 1 by passing through the second passage 6 and then exits the box 100 by passing through passages 117 preferably formed in the lateral edges 114 of the base body 110 of the box 100.

10 Preferably, sealing elements (not shown) are provided in the box 100, specifically at the passages 117, the openings 115 and at an upper surface 118 of the edges 112-114 configured to mate with the cover in order to sealingly close the box 100. The sealing elements are configured to protect the box 100 from the ingress of foreign objects with a level of protection independent of that
15 of the splice tray 1. More specifically, the level of protection of the box 100 is lower than that of the tray 1, for example lower than a level of protection IP 68.

According to the present invention, with the simplification of the design of the box, as well as the splice tray, the level of ingress protection of the splice tray can be maintained independent from the level of ingress protection of the box,
20 thereby reaching a reduction of the installation costs.

Preferably, the box may have a null level of protection against the ingress of foreign objects or a level of protection against the ingress of foreign objects lower than the level of protection of the tray in order to reduce even more the design and installation costs.

CLAIMS

1. A splice tray (1) for use in a box (100) of an optical access network comprising:
- a base portion (2) comprising a sidewall (22) upwardly projecting from a perimeter of said base portion (2) and a first (5) and a second passageway (6) configured to allow at least one optical fiber (130) to enter and exit the splice tray (1),
 - a cover portion (3) configured to be removably coupled to the base portion (2);
 - a sealing gasket (40) disposed between the base portion (2) and the cover portion (3), and
 - sealing elements (50, 60), each mounted respectively on a free end of the first (5) and second passageway (6),
- wherein the sealing gasket (40) and the sealing elements (50, 60) are configured to provide the splice tray (1) with a level of protection against the ingress of foreign objects.
2. The splice tray (1) according to claim 1, wherein the sealing gasket (40) is housed in a groove (30) formed along a top surface of the sidewall (22) of the base portion (2) or along a bottom surface of a sidewall (33) of the cover portion (3).
3. The splice tray (1) according to claim 1 or 2, wherein the sealing elements (50, 60) are sealing glands, each comprising a sealing body (51, 61), a pressing plate (53, 63), and a nut (55, 65).
4. The splice tray (1) according to claim 3, wherein said sealing body (51, 61) is substantially cylindrical in shape and comprises at least one longitudinal opening (52, 62) for the passage of a respective optical fiber (130, 131).
5. The splice tray (1) according to claim 4, wherein said pressing plate (53, 63) comprises at least one opening (54, 64) for the passage of a respective optical fiber (130, 131), said at least one opening (54, 64) being coaxial with the at least one opening (52, 62) of the sealing body (51, 61).
6. The splice tray (1) according to any claim 3 to 5, wherein the nut (55, 65) is screwed on a corresponding thread (57, 67) formed on an outer surface of the first (50) or second passageway (60).

7. The splice tray (1) according to any previous claim, further comprising a pair of hinges (7) configured to rotatably couple the splice tray (1) to a support element (116) of the box (100) of the optical access network.
8. The splice tray (1) according to claim 7, wherein each hinge (7) of said pair of hinges (7) comprises a pin (71) fixed to opposite flaps (72) extending from the sidewall (22) of the base portion (2), externally to the splice tray (1), and configured to cooperate with the support element (116) of the box (100).
9. The splice tray (1) according to any previous claim, wherein it has a level of protection against the ingress of foreign objects of IP 68, according to IEC standard 60529.
10. The splice tray (1) according to any previous claim, wherein the base portion (2) has rounded corners (21) having a radius of curvature greater than or equal to a minimum bending radius to which an optical fiber (130) to be housed in the splice tray (1) can be bent.
11. The splice tray (1) according to claim 10, wherein the minimum bending radius to which the optical fiber (130) can be bent is comprised in the range of 20-40 mm.
12. The splice tray (1) according to any previous claim, further comprising a storage area (25) having a mandrel (27) and guiding elements (28) configured to cooperate with the mandrel (27) to collect optical fiber extra-length portions in said fiber storage area (24).
13. The splice tray (1) according to claim 12, wherein the mandrel (27) and the guiding elements (28) comprise curved walls having a radius of curvature greater than or equal to a minimum bending radius to which the optical fiber (130) to be housed in the splice tray (1) can be bent.
14. The splice tray (1) according to claim 12 or 13, wherein the fiber storage area (25) further comprises one or more fins (29) projecting cantilevered from the guiding elements (28) to retain the optical fibers in position within the tray (1).
15. The splice tray (1) according to any previous claim, further comprising a splice housing area (24) provided in the base portion (2).
16. The splice tray (1) according to claim 15, wherein said splice housing area (24) comprises a number of side-by-side splice-carrying elements (26).

17. The splice tray (1) according to any previous claim, wherein it has a width between 10-20 cm and a length between 5-15 cm.
18. A box (100) of an optical access network comprising a splice tray (1) according to any previous claim housed therein, wherein said box has a level of protection against the ingress of foreign objects which is different than the level of protection of the tray (1) housed therein.
19. The box (100) according to claim 18, having a level of protection against the ingress of foreign objects lower than the level of protection of the tray (1).
20. The box (100) according to claim 18 or 19, wherein it further comprises a base body (110) including a bottom wall (111), and edges (112-114) upwardly extending from the bottom wall (111).
21. The box (100) according to claim 20, wherein said edges (112-114) comprise a front edge (112), a rear edge (113) and a pair of lateral edges (114) connecting the front edge (112) and the rear edge (113).
22. The box (100) according to claim 20 or 21, wherein it further comprises a support element (116) for the tray (1) which extends from the bottom wall (111) of the base body (110).
23. The box (100) according to any claim 20 to 22, wherein it further comprises coaxial openings (115) formed in each of the lateral edges (114) and configured to house an optical cable (120).
24. The box (100) according to any claim 20 to 23, wherein it further comprises at least one passage (117) formed in the edges (111-114) of the base body (110) for the passage of at least one pre-connectorized optical fiber (131) exiting the box (100).

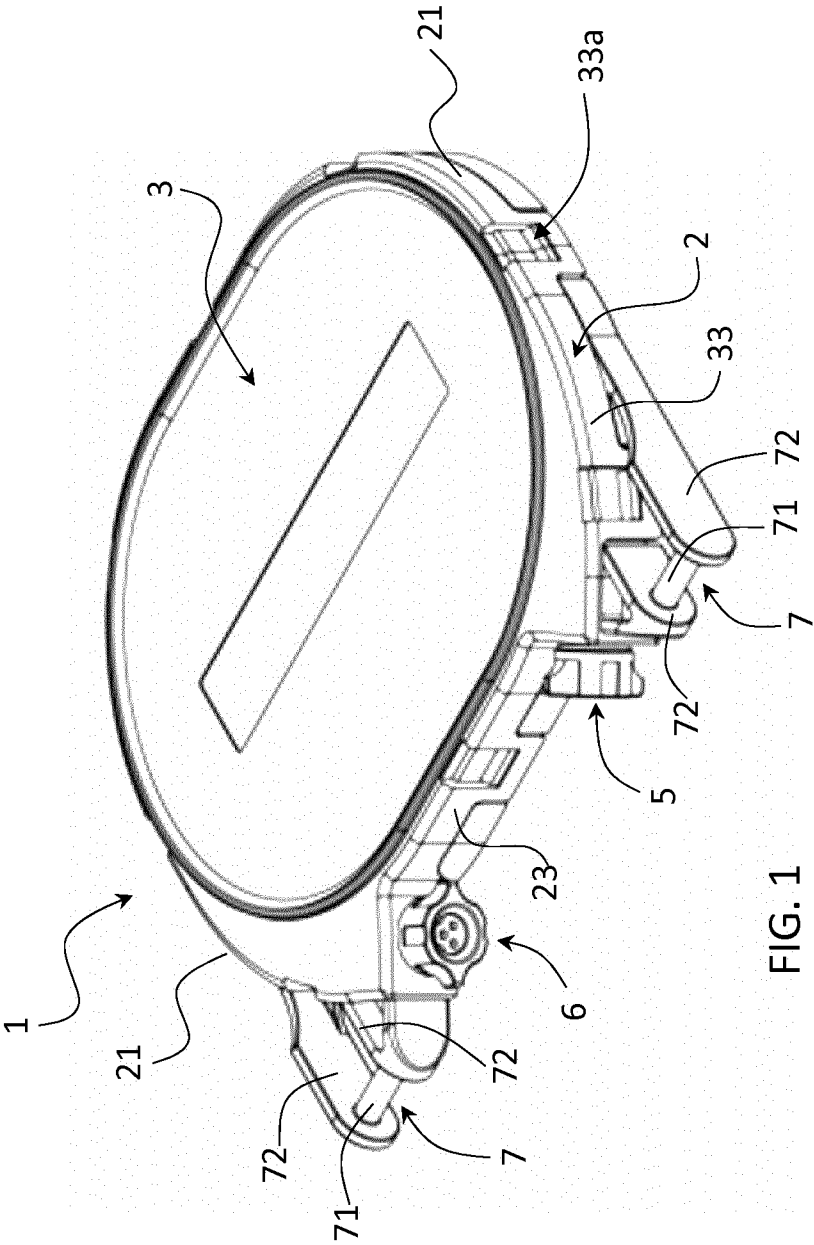


FIG. 1

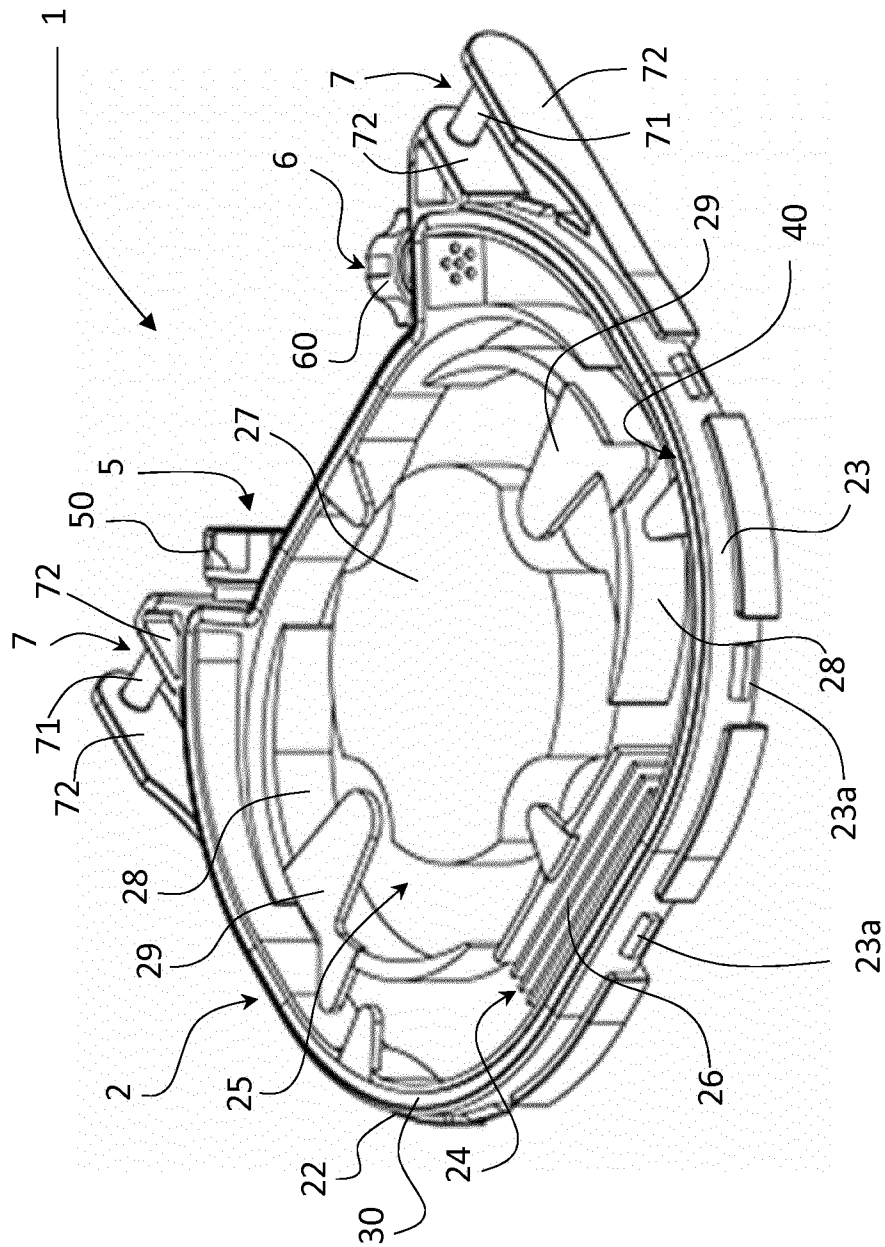


FIG. 2

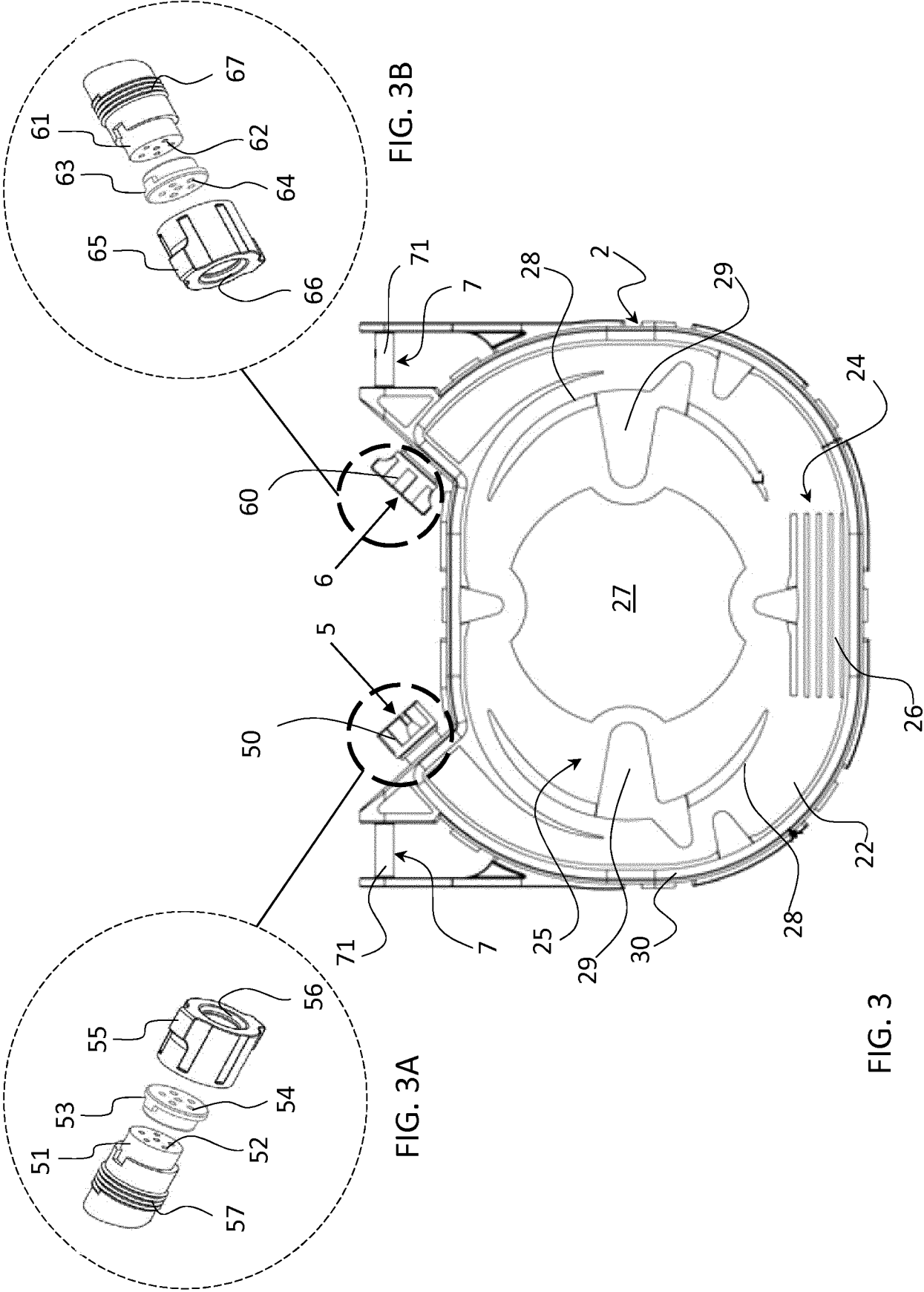


FIG. 3

FIG. 3A

FIG. 3B

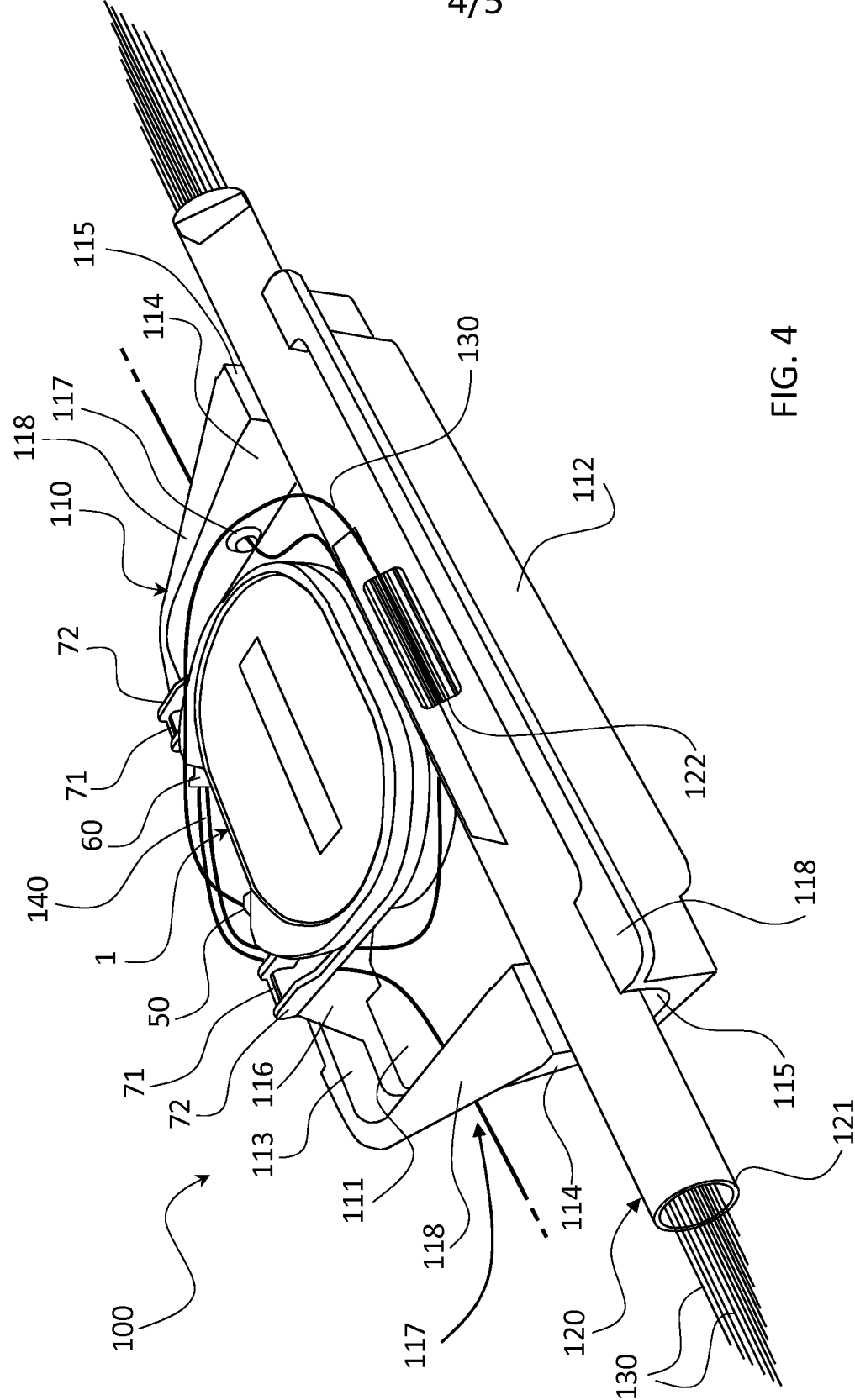
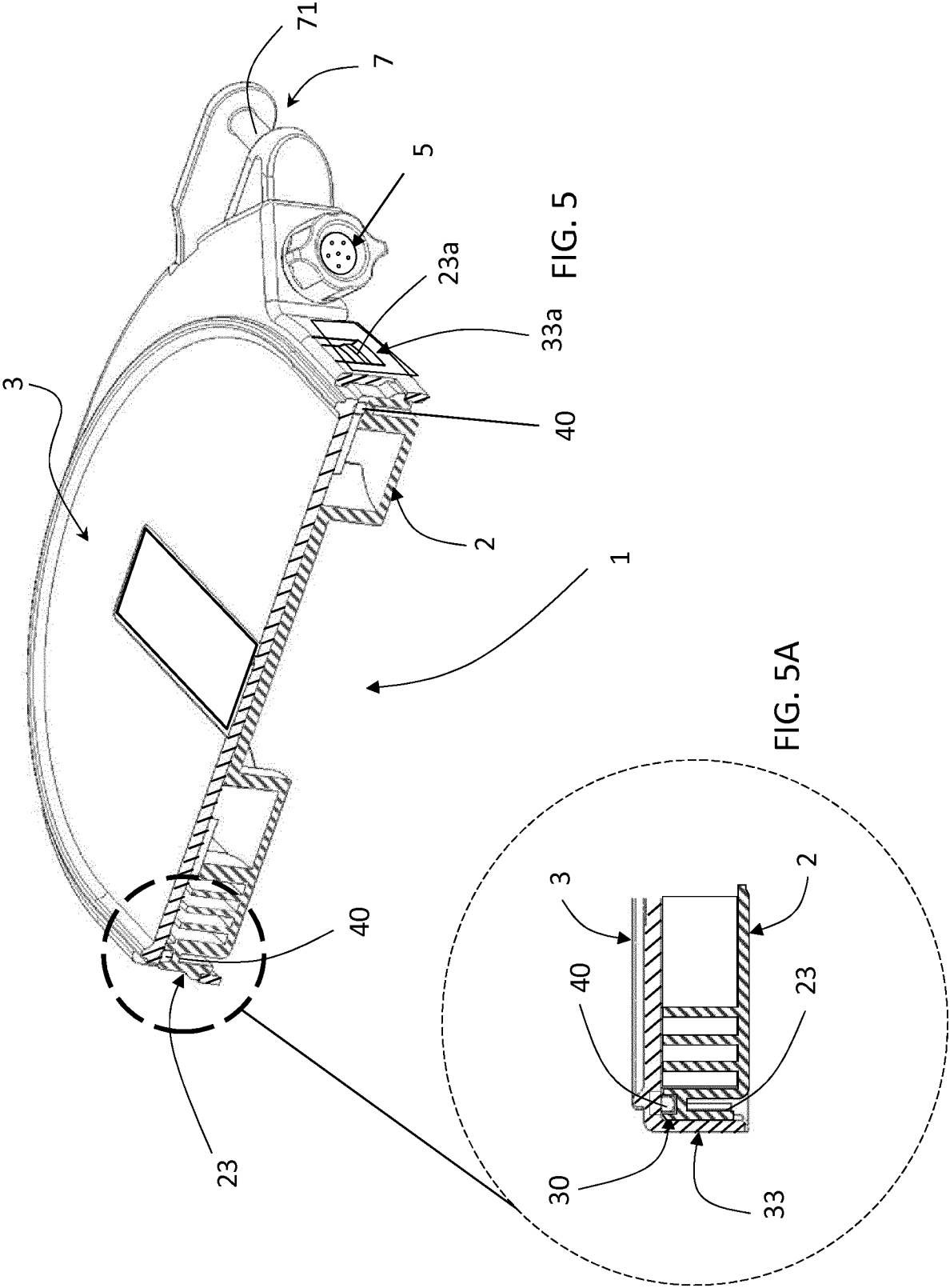


FIG. 4



INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2016/052249

A. CLASSIFICATION OF SUBJECT MATTER
INV. G02B6/44
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G02B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2014/035611 A1 (3M INNOVATIVE PROPERTIES CO [US]) 6 March 2014 (2014-03-06) cited in the application	1,2,7-9, 15,16, 18-24
Y	figures 1A, 1B,3A,2,6A,6B,1C -----	11,17
X	EP 2 182 601 A1 (3M INNOVATIVE PROPERTIES CO [US]) 5 May 2010 (2010-05-05)	1,3-6, 10,12-14
Y	paragraph [0055]; figures 2,8,6 -----	11,17
X	WO 2007/011754 A2 (AFL TELECOMMUNICATIONS LLC [US]; DOBBINS PATRICK E [US]; NIEVES ANTHON) 25 January 2007 (2007-01-25) figures 4,8 -----	1
X	US 2009/290844 A1 (MULLANEY JULIAN [US] ET AL) 26 November 2009 (2009-11-26) figure 2 -----	1



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

11 October 2016

Date of mailing of the international search report

19/10/2016

Name and mailing address of the ISA/

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2016/052249

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2014035611	A1	06-03-2014	NONE

EP 2182601	A1	05-05-2010	AT 541349 T 15-01-2012
		CN 102204049 A	28-09-2011
		EP 2182601 A1	05-05-2010
		RU 2011112014 A	10-10-2012
		US 2011217017 A1	08-09-2011
		WO 2010051160 A1	06-05-2010

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		WO 2007011754 A2	25-01-2007

US 2009290844	A1	26-11-2009	NONE
