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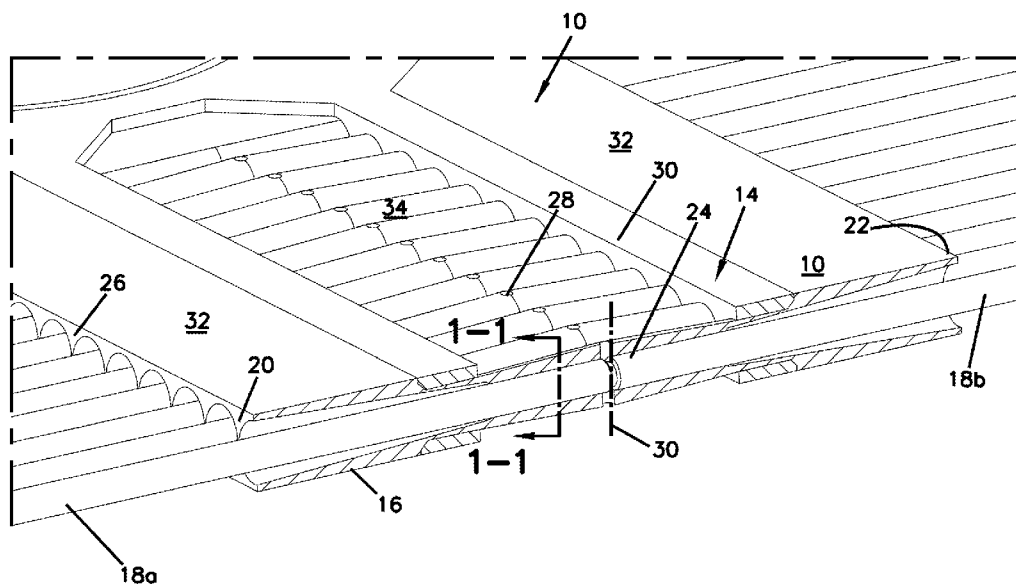
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(54) Title: ELASTOMERIC OPTICAL FIBER ALIGNMENT AND COUPLING DEVICE

FIG. 1A



(57) Abstract: A fiber optic coupling device comprises an elastomeric body. The elastomeric body includes first and second sides with a deformable alignment passage extending there between. The deformable alignment passage is configured to elastically center opposing first and second optical fibers. The deformable alignment passage includes a first portion that is configured to receive the first optical fiber having a first core. The deformable alignment passage also includes an opposing second portion that is configured to receive the second optical fiber having a second core. The first portion and the opposing second portion of the alignment passage are defined by a common encompassing periphery, and meet at a common location within the alignment passage to present the core of the received first optical fiber in coaxial alignment with the core of the received second optical fiber.

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ELASTOMERIC OPTICAL FIBER ALIGNMENT AND COUPLING DEVICECross-Reference to Related Application

This application is being filed on June 23, 2017 as a PCT International Patent Application and claims the benefit of U.S. Patent Application Serial No. 62/354,480, filed
5 on June 24, 2016, the disclosure of which is incorporated herein by reference in its entirety.

Technical Field

The present disclosure is directed to the coupling of optical fibers and, more particularly, to the coaxial alignment of optical fibers with an elastomeric coupling device.

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Background

Communication systems utilizing fiber optic cables are in wide spread use. Each fiber optic cable includes one or more optical fibers, each of which comprises a waveguide configured to transmit optical signals containing various types of information and/or power. The optical signals comprise light that enters one end of the fiber and exits the
15 opposite end of the fiber. Transmission of an optical signal over a single length of fiber subjects the optical signal to minimal loss. However, to transmit optical signals over long distances, periodic coupling of fibers is necessary. Each instance of coupling can introduce loss into the optical signal through various factors including misalignment of the cores of the fibers. Accordingly, fiber alignment and the minimization of loss in the
20 coupling of fibers is a concern.

Various methods and devices have been developed to assist with alignment and minimization of loss. For example, fusion splicing, e.g., fusing the ends of two fibers together with a heat treatment, can be used for couplings that are intended to be permanent

and stable. Fusion splicing is performed using an automated precision alignment tool and produces a fiber coupling with extremely low loss. For couplings that are non-permanent, a ferrule is provided about the interfacing ends of the optical fibers to which is secured interfacing connectors, e.g., SC, LC and ST connectors. Care is taken to correctly position the cores of the optical fibers such that when interfacing connectors are coupled the fibers held within the ferrules of the interfacing connectors are coaxially aligned such that loss is kept to a minimum. In high density fiber applications coupling devices comprising v-groove array assemblies, wherein the v-grooves help to position fibers for alignment, are used. Fusion splicing of optical fibers, equipping optical fibers with ferrule connectors, and the use of v-groove array assemblies can introduce significant time and financial costs to fiber optic systems as well as undesired signal transmission losses.

Summary

One aspect of the present disclosure is directed to a fiber optic coupling device comprising an elastomeric body. The elastomeric body includes first and second sides with a deformable alignment passage extending there between. The deformable alignment passage includes a first portion that is configured to receive a first optical fiber having a first core. The deformable alignment passage also includes an opposing second portion that is configured to receive a second optical fiber having a second core. The first portion and the opposing second portion of the alignment passage are defined by a common encompassing periphery, and meet at a common location within the alignment passage to present the core of the received first optical fiber in coaxial alignment with the second core of the received second optical fiber.

Another aspect of the present disclosure is directed to a fiber optic coupling device comprising a frame and an elastomeric body contained by the frame. The elastomeric body includes first and second sides with a deformable alignment passage extending there

between. The deformable alignment passage is configured to elastically center opposing first and second optical fibers. The deformable alignment passage includes a first portion that is configured to receive a first optical fiber having a first tip portion and a first core. The deformable alignment passage also includes an opposing second portion that is

5 configured to receive a second optical fiber having a second tip portion and a second core. The first portion and the opposing second portion are configured to have a common periphery that provides 360 degree support about the first and second tip portions of the received first and second optical fibers, respectively. The first portion and the opposing second portion of the alignment passage meet at a common location within the alignment

10 passage to present the core of the received first optical fiber in coaxial alignment with the core of the received second optical fiber.

Still another aspect of the present disclosure is directed to a method for aligning cores of first and second optical fibers. The method comprises receiving the first optical fiber into a first opening of a deformable alignment passage of an elastomeric body

15 through a common periphery to a common location and receiving the second optical fiber into a second opening of the deformable alignment passage of the elastomeric body through the common periphery to the common location. The method further comprises elastically aligning the received first and second optical fibers within an alignment passage of the elastomeric body to achieve coaxial alignment of the cores at the common location.

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Brief Description of the Drawings

FIG. 1A is a cross-sectional view of an alignment passage of a coupling device according to the present disclosure.

FIGS. 1B-1E are cross-sectional views of peripheries of the alignment passage.

FIG. 2 is a perspective view of a coupling device according to the present disclosure.

FIG. 3 is a top view of a frame of the coupling device.

FIG. 4 is a top view of a frame of the coupling device.

5 FIG. 5 is a cross-sectional view of an alignment passage of the coupling device of FIG. 1.

FIG. 6 is a cross-sectional view of an alignment passage of the coupling device of FIG. 1

10 FIG. 7 is a perspective view of the coupling device in combination with a fiber optic guide.

Detailed Description

The present disclosure is directed to devices and methods for coupling and coaxially aligning optical fibers. The coupling device generally includes a body that is
15 fabricated from an elastomer material; the body is configured to include a plurality of alignment passages. The alignment passages are defined by a periphery having a least one cross-dimension that is smaller than the diameter of the fiber which is inserted therein. The alignment passages function to couple the ends of optical fibers and, in doing so, operate to align the outer diameters of the fibers such that the true centers of the optical
20 fibers are aligned enabling transmission of optical signals over the coupled and coaxially aligned fibers. The coupling device is configured to elastically deform, rather than plastically deform, such that the coupling device can recover its shape and provide desired performance over many uses.

Referring to FIG. 1A a cross-sectional view of an example embodiment of an
25 elastomeric coupling device 10 of the present disclosure is illustrated. The elastomeric coupling device 10 functions as an alignment interface for aligning ferrule-less or ferruled

optical fibers 18a, 18b. The coupling device 10 generally comprises an elastomeric body 12 about which may be placed an optional frame 14. The elastomeric body 12 includes one or more passages 16 configured to receive a first optical fiber 18a at a first end 20 and configured to receive a second optical fiber 18b at a second end 22. Each of the passages 16 is defined by a periphery 24, see FIG. 1B, that is configured to completely encompass the outer diameter (OD) of the fibers 18a, 18b. In the instance of a circular periphery 24, a diametrical cross-dimension (CD) of at least a portion of the passage 16 is smaller than the OD of the fiber 18a, 18b. Accordingly, upon insertion of the fibers 18a and 18b, the periphery 24 of the passage 16 elastically deforms to fully surround and axially orient each of the fibers 18a, 18b. Note that prior to insertion of the fibers 18a, 18b the ends of the fibers 18a, 18b are preferably heat treated. Additional information about the heat treating of optical fibers is described in WO2012/112344 entitled "Portable Device for Attaching a Connector to an Optical Fiber", the entire disclosure of which is hereby incorporated by reference.

FIGS. 1C – 1E illustrate alternative periphery configurations of the passage 16 with a triangular periphery 24a, a square periphery 24b, and a hexagonal periphery 24c, respectively. Other periphery configurations are also possible. Regardless of the periphery configuration, at least one cross-dimension (CD) of the periphery 24 is less than the OD of the fiber 18a, 18b causing the passage 16 to elastically deform upon insertion of the fiber 18a, 18b such that encompassing contact/support is provided by the passage 16. The walls 26 between passages 16 are of sufficient thickness to enable elastic deformation of the passage 16 upon insertion of the fibers 18a, 18b without disturbing the alignment function of adjacent passages 16. The thickness of the walls 26 and/or the CD of the periphery 24 of the passage 16 can vary, e.g., taper or widen, or be uniform. One or more vent holes 28, for venting air and/or as an access point to view the coupling of the fibers

18a, 18b, are provided at the approximate center point 30 of the passage 16 where fibers 18a and 18b meet in coaxial alignment.

The periphery 24 of each of the passages 16 of the elastomeric body 12 is formed with a precisely configured molding pin that extends to either side of the center point 30 of the passage 16 ensuring a consistency in periphery 24 from one side of the passage 16 to the other side of the passage, and ensuring a resulting coaxial optical alignment of fibers 18a, 18b with little to no transmission loss between fibers.

The frame 14, if utilized, may substantially cover the outer surfaces of the elastomeric coupling device 10. Alternatively, the frame 14, if utilized, may provide support only at various locations about the coupling device 10 to limit the restrictive effect of the frame 14 on the elastic deformation of the coupling device. In the example of FIG. 1A, the frame 14 provides minimal restriction by using centralized ribs 30 that allow the sides 32 and center 34 of the coupling device 10 to deform.

Referring to FIGS. 2 and 3, a coupling device 100 of the present disclosure is illustrated. The coupling device 100 generally comprises an optional frame 110 and an elastomeric body 200.

The frame 110 includes a first side portion 112, a second side portion 114 and a central portion 116. The first side portion 112 includes an upper face 120 and an oppositely positioned lower face 122. In one example embodiment, the upper face 120 and the lower face 122 comprise two identical, symmetric parts that can be joined together with a pin and hole alignment mechanism. The upper face 120 and lower face 122 are connected by side walls 124 and 126, and by outer end wall 128 and inner end wall 129. Similarly, the second side portion 114 includes an upper face 130 and an oppositely

positioned lower face 132. The upper face 130 and lower face 132 are connected by side walls 134 and 136, and by outer end wall 138 and inner end wall 139.

The central portion 116, see FIG. 4, of the frame 110 connects the first side portion 112 to the second side portion 114. The central portion 116 includes two upper ribs 140(a), 140(b), and two lower ribs 142(a), 142(b), each of which extend between inner end walls 129, 139. The upper ribs 140(a), 140(b) each include an upper face 144 and a lower face 146 connected by proximal side wall 148 and distal side wall 150. Similarly, the lower ribs 142(a), 142(b) include an upper face 154 and a lower face 156 connected by proximal side wall 158 and distal side wall 160. A central cavity 170 extends through the central portion 116 that is bounded by inner end walls 129, 139 of the first and second side portions 112, 114, respectively. The central cavity 170 is further bounded by the lower faces 146 of the upper ribs 140(a), 140(b) and by the upper faces 154 of the lower ribs 142a, 142b. In this configuration, the ribs 140(a), 140(b), 142(a), 142(b) work in cooperation with the first and second side portions 112, 114 to define a first side chamber 171, a central chamber 172, and a second side chamber 173.

In some example embodiments, the inner walls 129, 139 present a single, elongate surface. In other example embodiments, the inner walls 129, 139 are configured to present a plurality of connected sections, e.g., sections 164(a) – 164(g), see FIG. 3, that present a planar or arcuate surface. Further, in some example embodiments, the frame 110 is provided with a continuous upper face, e.g., face 180, and/or a continuous lower face, see FIG. 4. The frame 110 is configured to provide some stiffness, or structural rigidity, to the elastomer body 200 of the coupler 100.

Referring to FIGS. 2, 5 and 6, the elastomeric body 200 of the coupler 100 may be appreciated. The elastomeric body 200 comprises a single piece element that generally

includes one or more alignment passages 250 extending there through. The alignment passages 250 are generally of a cylindrical configuration; however, in other example embodiments the alignment passages 250 are shaped in a different arcuate or walled configuration, e.g., triangular, square, hexagonal, etc. The elastomeric body 200 is

5 configured to reside within the central cavity 170 and within the chambers 171, 172, 173 that are defined by the frame 110. Within the first and second chambers 171, 173 of the frame 110, the elastomeric body 200 presents a planar upper surface 212 and a planar lower surface 214 connected by a side wall 216 and end walls 218, 220. The side wall 216 presents the opening(s) 222 to the one or more alignment passages 250; spacers 224

10 separate the alignment passages 250. The end walls 218, 220 are provided with a shape, or are capable of conforming to, the configuration of the inner walls 129, 139 of the first and second side portions 112, 114, respectively, of the frame 110.

Within the central chamber 172 of the frame 110, the elastomeric body 200 presents an upper surface 226 and a lower surface 228 each incorporating one or more

15 arcuate sections 230 in correspondence to the number of alignment passages 250. In other example embodiments, all upper and/or lower surfaces of the elastomeric body 200 incorporate arcuate sections. In still other example embodiments, all upper and/or lower surfaces of the elastomeric body 200 are substantially flat, or are various combinations of flat and arcuate sections. In still other example embodiments, the arcuate shape is

20 replaced by a non-arcuate, e.g., walled, shaped. Note that the surfaces of the ribs 140a, 140b, 142a, 142b of the frame 110 that are proximate the elastomeric body 200 are configured to accommodate the arcuate and/or flat (or planar) nature of the upper and lower surfaces 226, 228 of the elastomeric body 200 as necessary.

Referring now to FIG. 6, each of the alignment passages 250 includes a first

25 portion 252 and an opposing second portion 254, with the first and second portions 252,

254 meeting at a common location 256. In some example embodiments, the common location, or center point, 256 is at the middle of the alignment passage 250 while in other example embodiments the common location 256 is off-middle. In some example embodiments, each of the first and second portions 252, 254 includes a periphery 255 that
5 begins at opening 222 extends through a tapering, conical section 258, to a non-tapered, cylindrical section 260, to endpoint 262. The non-tapered, cylindrical section 260 of the periphery 255 within the first and second sections 252, 254 of the passages 250 is configured to provide 360 degree support about the fiber to help establish the fiber core alignment.

10 In other example embodiments, the first and second portions 252, 254 include a periphery 255 having only a tapering conical section, tapering from opening 222 to endpoint 262. In still other various alternative embodiments, the first and second portions 252, 254 include a periphery 255 having only a non-tapered, cylindrical section that extends from opening 222 to endpoint 262. In still other example embodiments, the
15 conical and cylindrical shapes are replaced by other arcuate configurations or walled configurations, e.g. triangular, square, and hexagonal, etc.

The common location, or center point, 256 is defined by an alignment passage 264, see FIG. 5, having a central axis that is perpendicular to the central axis of the alignment passages 250. The passage 264 extends through both the upper surface 226 and the lower
20 surface 228 of the elastomeric body 200 providing a vent hole 266 at each end of the passage 264. In various alternative embodiments, the passage 264 remains within the boundaries of the upper and lower surfaces, 226, 228. In still other embodiments, the passage 264 is eliminated.

The non-tapered, cylindrical section 260 of the first and second portions 252, 254 of the alignment passages 250 within the elastomeric body 200 is configured to provide the core-to-core alignment between two optical fibers. The narrow tolerances required for core-to-core alignment are established through micro-molding, or other appropriate manufacturing techniques, of the alignment passages 250 of the elastomeric body 200. In one example embodiment, each of the passages 250 of the elastomeric body 200 is formed with a precisely configured molding pin to define the periphery 255 that will be in contact and encompass the fibers inserted therein. The molding pin is used such that it extends to either side of the center point 256 of the passage 250 ensuring a consistency in periphery 255 from one side of the passage 250 to the other. The result is a passage 250 that provide all-encompassing support to inserted fibers and precise coaxial alignment of fibers with little to no transmission loss between fibers.

As the name implies, the elastomeric body 200 comprises an elastomer, or elastomeric material, that is selected for its elastic deformation properties. In various example embodiments, the elastomer comprises a thermoset, high durometer silicon rubber. In other example embodiments, the elastomer comprises a highly-cross-linked polyolefin. In still other example embodiments, other elastomer materials are used.

A combination of various parameters can be used to optimize the core-to-core alignment provided by the elastomeric body 200. In various embodiments, and as illustrated in FIG. 6, the parameters for consideration in selecting the appropriate elastomeric material for the elastomeric body 200 can include one or more of the following: (1) free fiber length (L), e.g., the length of stripped optical fiber that is unsupported by the coupling device 100; (2) the outside diameter (D) of the periphery 255 of the passage 250; (3) the outside diameter variation angle (ϕ), e.g. how much the alignment passage 250 is allowed to flex to accommodate variation in outside diameters of

optical fibers; (4) inside diameter (d) of the periphery 255 of the passage 250 (e.g., the portion of periphery 255 of the passage 250 that is in direct contact and encompasses the fiber 302(a), 302(b) inserted therein) and (5) elastomer material properties of modulus and/or durometer (P).

5 When considering all five of the parameters, the alignment quality of the coupling device 100 is defined as: Alignment Quality (Insertion Loss) $\approx f(P, D, d, \phi, L)$. By way of example, when considering 125 micron, bare glass fibers, the parameter L typically falls in a range of 3 to 10 mm, the parameter D is typically $\geq 175 \mu\text{m}$, and the parameter d is typically $\leq 125 \mu\text{m}$. In other example embodiment, other and/or additional parameters
10 are used to achieve a desired alignment quality between fibers when inserted into passages 250.

 While the above described coupling device 100 can be configured for use with a pair of single fibers, it is especially suited to high density fiber applications as illustrated in the FIGS. 2 and 5. As shown, two high density sets 300(a), 300(b) of optical fibers
15 302(a) and 302(b) are presented for coupling; the edges of the fiber tips 304(a), 304(b) having been rounded by laser, fusion arc, or another treatment. A length of each optical fiber 302(a), 302(b) is stripped to its cladding 306(a), 306(b) and then inserted into corresponding openings 222, through the passages 250 to the common location 256. The elastomer material of the elastomeric body 200 operates to elastically flex in
20 accommodating and aligning the outer diameters (OD) of the optical fibers 302(a), 302(b) such that the true centers of opposing fibers 302(a), 302(b) are aligned for minimal transmission loss of an optical signal. The ability to elastically deform, rather than plastically deform, enables the coupling device 100 to recover fully and provided identical performance over many cycles of use.

The coupling device 100 of the present disclosure provides for a single-material design that effectively combines the features of v-groove and presser spring alignment without actually requiring the v-groove or presser spring. Moreover, the coupling device 100 presents a small form factor, an important feature for high density connectors. Further, 5 the coupling device 100 provides 360 degree alignment contact, as opposed to the more standard configuration of two lines of contact, and additionally provides allowance for the slight buckling/bending of the stripped fiber length outside of the coupling device 100.

The coupling device 100 is configured to accommodate differences in fiber diameter, e.g., with the coupling device 100, the alignment passage 250 can “bulge out” 10 during the fiber alignment process, yet still provide optical fiber centering; an improvement over the inflexible nature of v-groove arrays. Thus, the coupling device 100 eliminates the effects of fiber diameter mismatch leaving only fiber core/cladding concentricity errors, surface defect absorption/dispersion (which is small in fibers finished with laser or electric arcs), and mode field mismatch (usually a small factor) to affect fiber 15 alignment.

It should be noted that while the description above describes the coupling device 100 for use with ferrule-less optical fibers, the coupling device 100 may also be configured for use with optical fibers that include ferrules.

Referring to FIG. 7, the coupling device 100 can additionally include a fiber optic 20 guide 600 positioned about the frame 110 and elastomeric body 200. The fiber optic guide 600 includes a plurality of passages 602 configured to support and guide the length of stripped fiber that extends intermediate the coupling device 100 and the unstripped fiber. In some example embodiments, the guide 600 is of an elastomeric material selected for

elastic properties in helping to align and support the various fibers 300(a), 300(b). In other example embodiments, the guide 600 comprises a non-elastic material.

Claims

What is claimed:

1. A fiber optic coupling device comprising:

an elastomeric body, wherein the elastomeric body includes:

a first side and a second side; and

a deformable alignment passage extending from the first side to the second side, wherein the alignment passage includes:

a first portion configured to receive a first optical fiber having a first core; and

an opposing second portion configured to receive a second optical fiber having a second core, wherein the first portion and the opposing second portion are defined by a common encompassing periphery and meet at a common location within the alignment passage to present the first core of the received first optical fiber in coaxial alignment with the second core of the received second optical fiber, respectively.

2. The fiber optic coupling device of claim 1, wherein the periphery of the deformable alignment passage has at least one cross-dimension that is less than an outer diameter of the first and second optical fibers.

3. The fiber optical coupling of claim 2, wherein the periphery of the alignment passage elastically deforms to receive and fully encompass the first and second optical fibers.

4. The fiber optic coupling device of claim 1, wherein the first and second portions of the deformable alignment passage include a tapered, conical portion intermediate the cylindrical portion and the corresponding first and second sides of the elastomeric body.
5. The fiber optic coupling device of claim 1, wherein the first and second portions are configured to receive first and second ferrule-less optical fibers.
6. The fiber optical coupling device of claim 1, wherein the first and second portions are configured to receive optical fibers with ferrules.
7. The fiber optic coupling device of claim 1, wherein the elastomeric body includes a plurality of deformable alignment passages.
8. The fiber optic coupling device of claim 1, wherein the deformable alignment passage is configured to accommodate first and second fibers of different diameters.
9. The fiber optic coupling device of claim 1, wherein the elastomeric body includes a vent hole at the common location.
10. The fiber optic coupling device of claim 1, wherein the common location includes a passage perpendicular to the deformable alignment passage.
11. The fiber optic coupling device of claim 1, further comprising a frame, wherein the elastomeric body is contained by the frame, and wherein the frame includes first and second sides connected by one or more ribs.
12. The fiber optic coupling device of claim 11, further comprising an optical fiber guide positioned about the frame.
13. The fiber optic coupling device of claim 1, wherein the material of the elastomeric body meets predetermined parameter values, wherein the predetermine parameter values

are for parameters selected from one or more of the following parameters: free fiber length; outside diameter of the cylindrical portion; inside diameter of the cylindrical portion, outside diameter variation angle, elastomer modulus, or elastomer durometer.

14. A fiber optic coupling device comprising:

a frame; and

an elastomeric body contained by the frame, wherein the elastomeric body includes:

a first side and a second side; and

a deformable alignment passage configured to elastically center opposing first and second optical fibers, the deformable alignment passage extending from the first side to the second side, wherein the alignment passage includes:

a first portion configured to receive the first optical fiber having a first tip portion and a first core; and

an opposing second portion configured to receive the second optical fiber having a second tip portion and a second core, wherein each of the first portion and the opposing second portion have a common periphery configured to provide 360 degree support of the first and second tip portions of the first and second received optical fibers, respectively, and wherein the first portion and the opposing second portion of the alignment passage meet at a common location to present the first core of the received first optical fiber in coaxial alignment with the second core of the received second optical fiber.

15. The fiber optic coupling device of claim 14, wherein the periphery has at least one cross-dimension that is less than an outer diameter of the first and second optical fibers.
16. The fiber optical coupling of claim 15, wherein the periphery of the alignment passage deforms to receive the first and second optical fibers.
17. The fiber optic coupling device of claim 14, wherein the first and second portions of the deformable alignment passage include a tapered, conical portion intermediate the cylindrical portion and the corresponding first and second sides of the elastomeric body.
18. The fiber optic coupling device of claim 14, wherein the elastomeric body includes a plurality of deformable alignment passages.
19. The fiber optic coupling device of claim 14, wherein the deformable alignment passage is configured to accommodate first and second fibers of different diameters.
20. The fiber optic coupling device of claim 14, wherein the elastomeric body includes a vent hole at the common location.
21. The fiber optic coupling device of claim 14, wherein the common location includes a passage perpendicular to the deformable alignment passage.
22. The fiber optic coupling device of claim 14, wherein the frame includes first and second sides connected by one or more ribs.
23. The fiber optic coupling device of claim 14, wherein the material of the elastomeric body meets predetermined parameter values, wherein the predetermine parameter values are for parameters selected from one or more of the following parameters: free fiber length; outside diameter of the cylindrical portion; inside diameter of the cylindrical portion, outside diameter variation angle, elastomer modulus, or elastomer durometer.

24. A method for aligning cores of first and second optical fibers, the method comprising:

receiving the first optical fiber into a first opening of a deformable alignment passage of an elastomeric body through a common periphery to a common location;

receiving the second optical fiber into a second opening of the deformable alignment passage of the elastomeric body through the common periphery to the common location,

elastically aligning the received first and second optical fibers within an alignment passage of the elastomeric body to achieve coaxial alignment of the cores at the common location.

25. A fiber optic coupling device comprising:

an elastomeric body, wherein the elastomeric body includes:

a first side and a second side; and

a deformable alignment passage extending from the first side to the second side, wherein the alignment passage includes:

a first portion configured to receive a first optical fiber having a first core; and

an opposing second portion configured to receive a second optical fiber having a second core, wherein the first portion and the opposing second portion are defined by a common encompassing periphery and meet at a common location within the alignment passage to present the first core of the received first optical fiber in coaxial alignment with the second core of the received second optical fiber, respectively, and wherein the common periphery is made consistent along a length of the alignment passage that

includes both the first and second portions, the consistency of the periphery providing alignment of the first and second portions, wherein the consistent periphery along the length of the alignment passage is obtained through use of a continuous molding pin of the same length during a molding fabrication process of the elastomeric body.

FIG. 1A

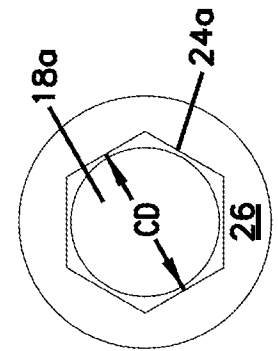
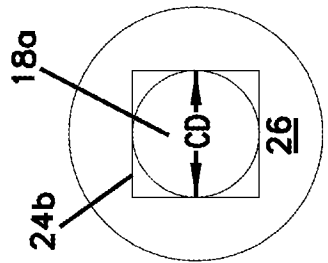
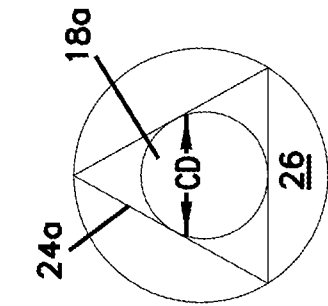
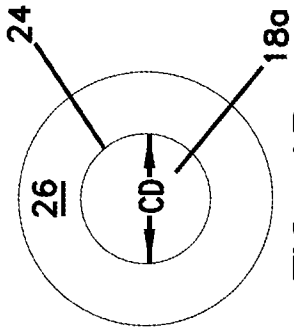
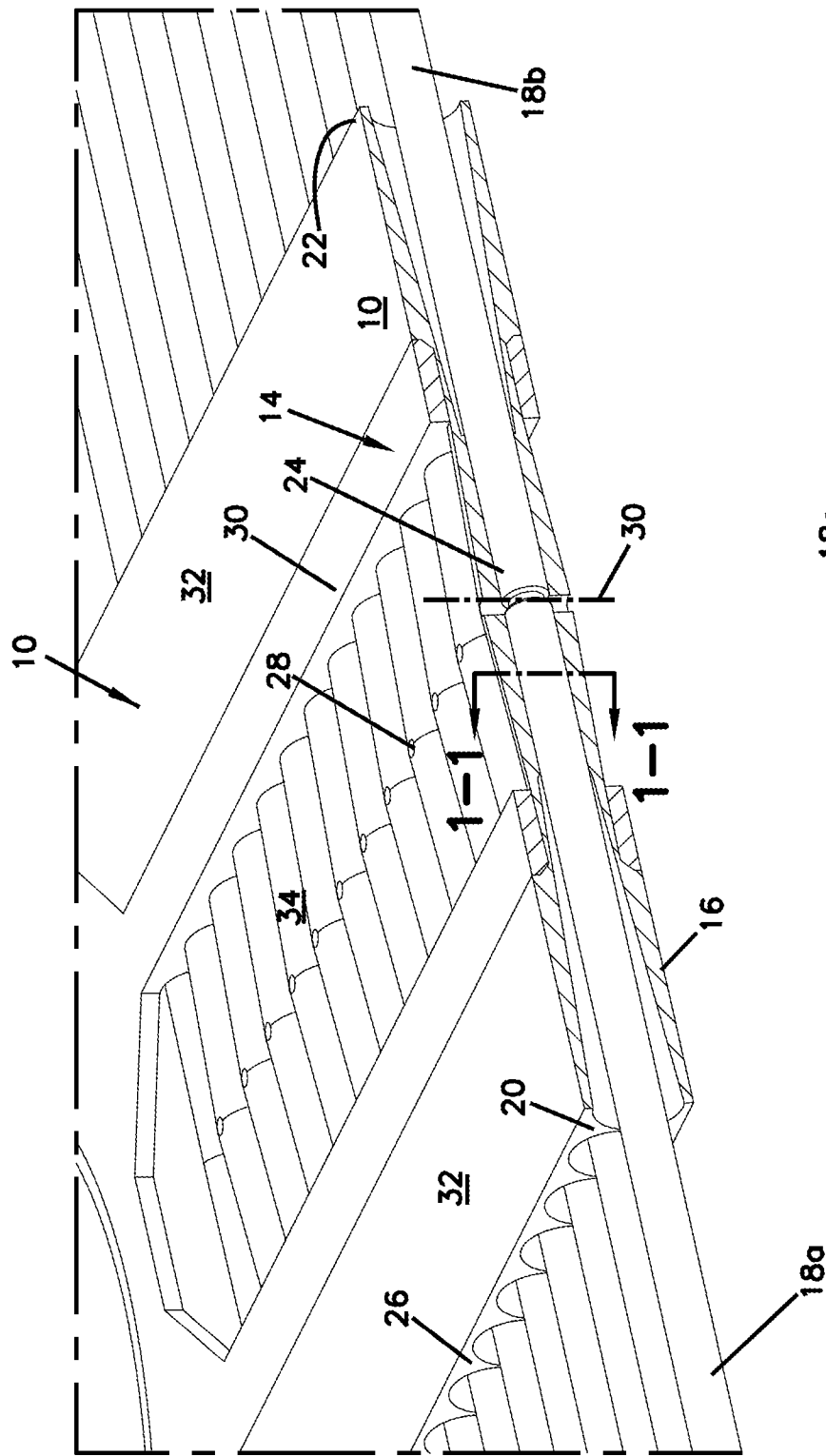


FIG. 1B

FIG. 1C

FIG. 1D

FIG. 1E

FIG. 2

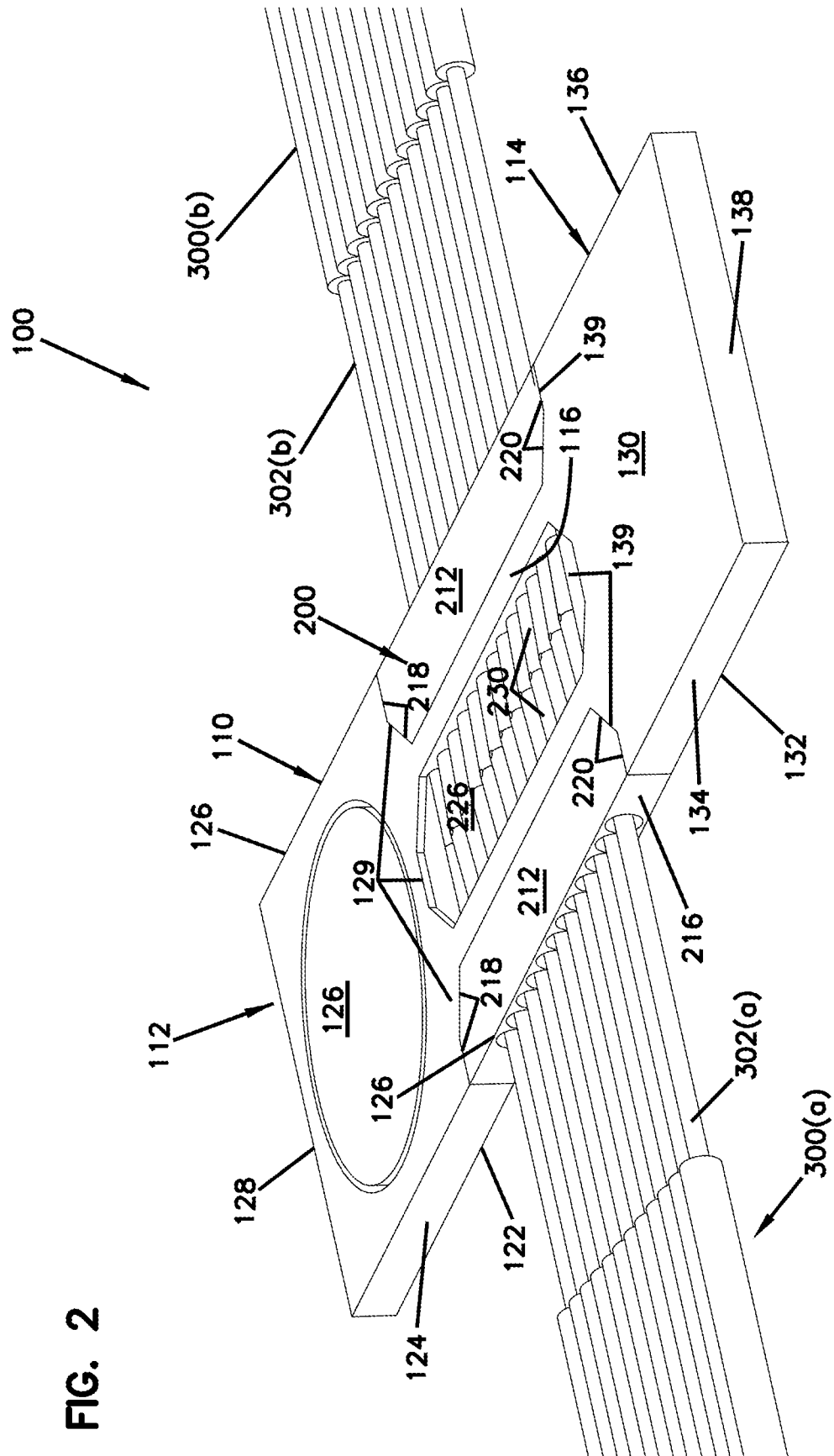


FIG. 3

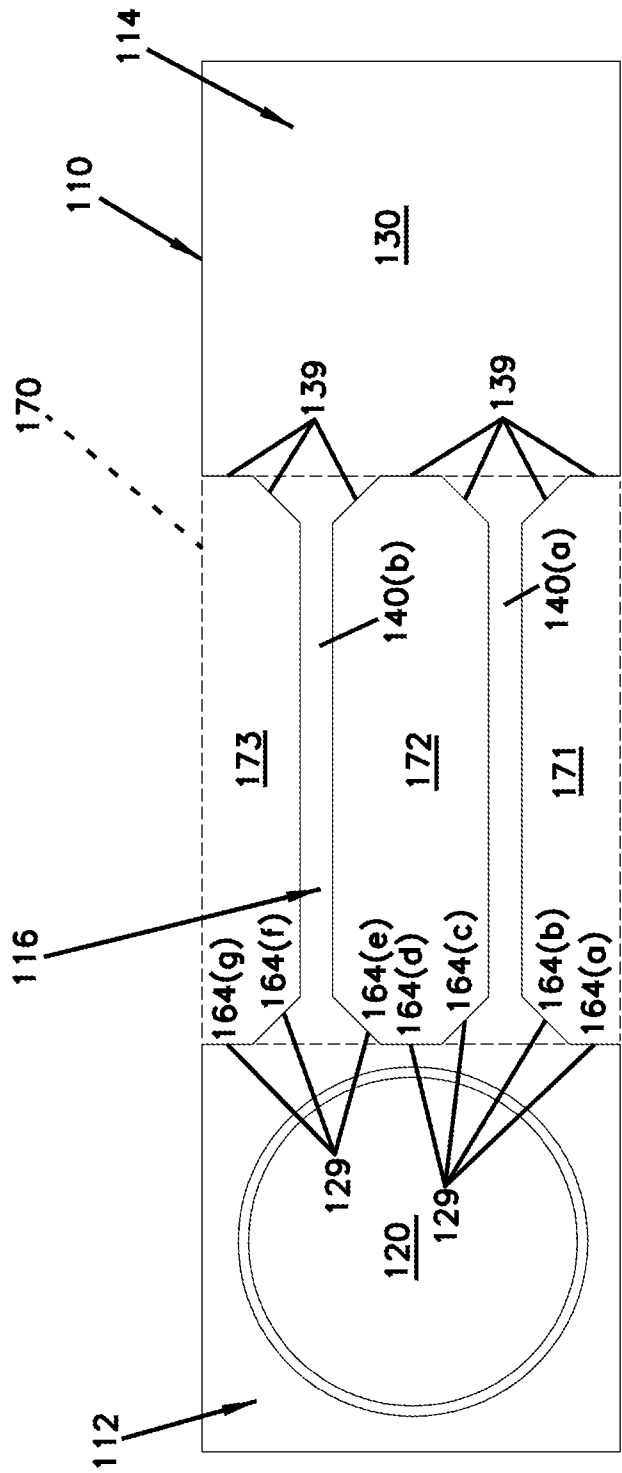


FIG. 4

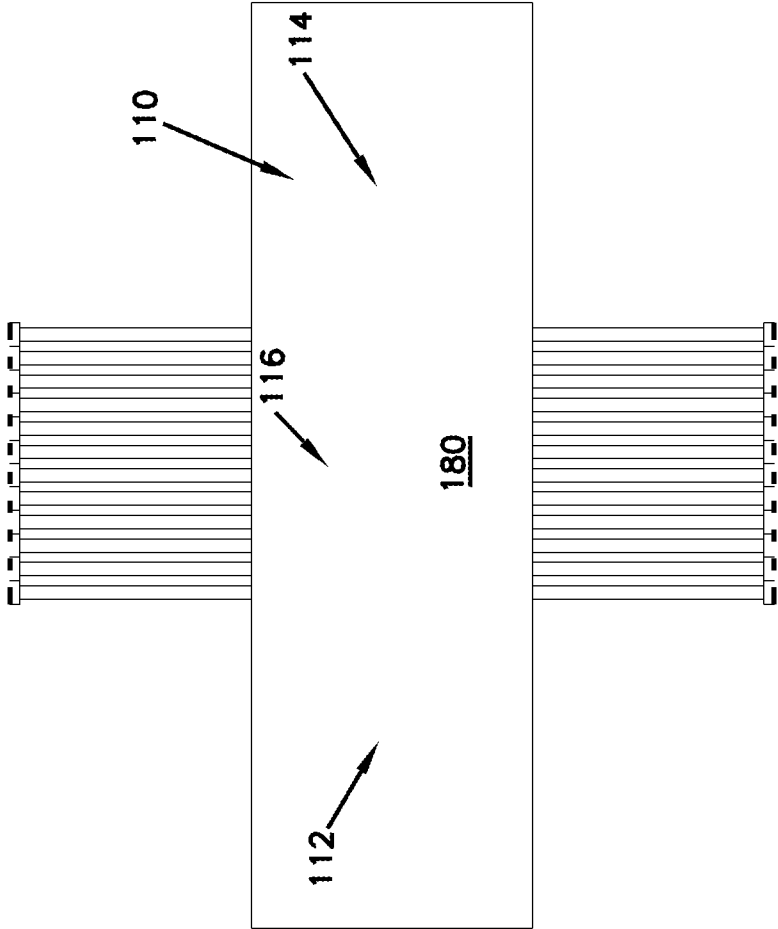


FIG. 5

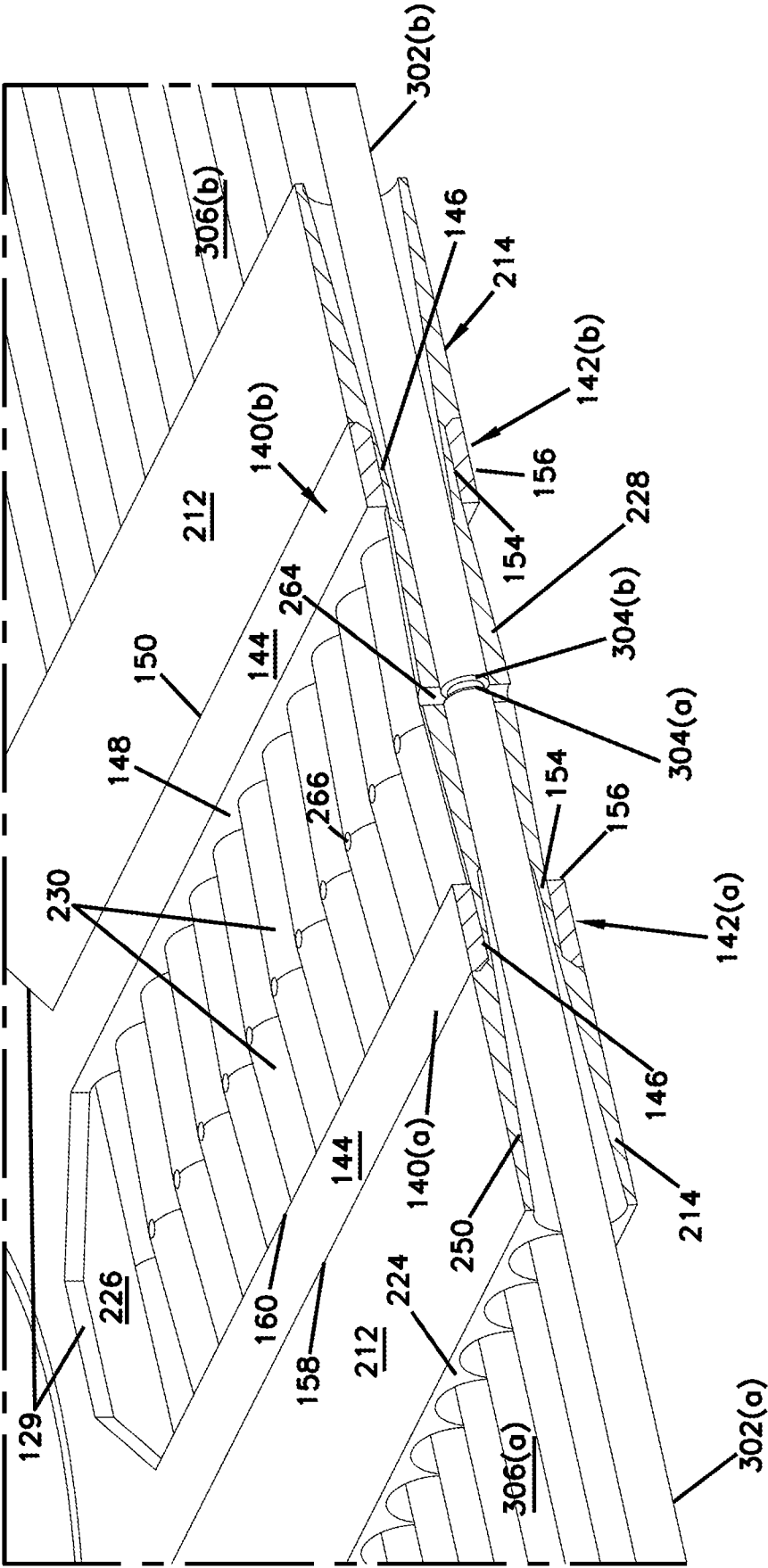


FIG. 6

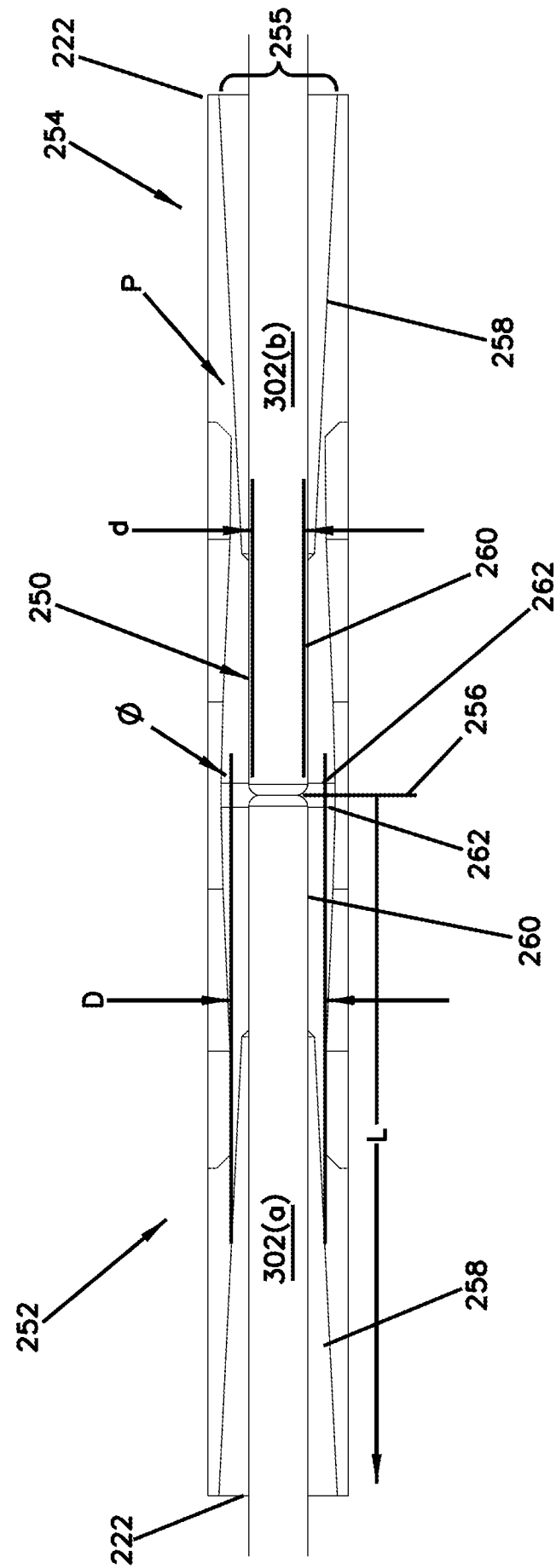
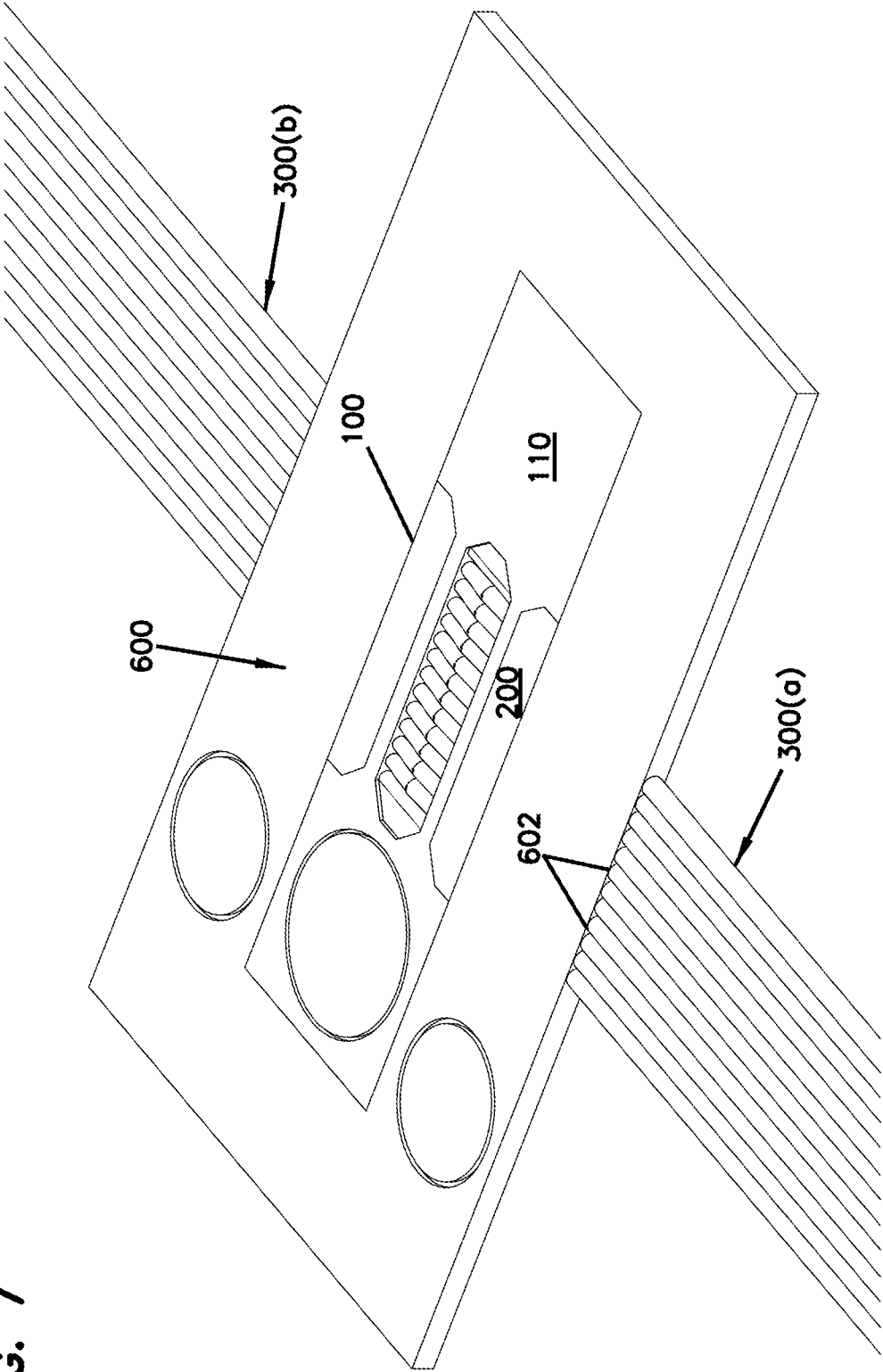


FIG. 7



A. CLASSIFICATION OF SUBJECT MATTER**G02B 6/38(2006.01)i, G02B 6/40(2006.01)i**

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 6/38; G02B 6/26; G02B 7/26; G02B 6/36; G02B 5/16; G02B 6/40

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

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

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

eKOMPASS(KIPO internal) & Keywords: fiber, couple, elastomeric body, passage, mold

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4325607 A (CARLSEN) 20 April 1982 See column 3 lines 1-3, column 4, lines 21-36, 57-62, column 5, lines 56-58, claims 1-2 and figure 2.	1-25
Y	US 5319733 A (EMMONS et al.) 07 June 1994 See column 2, lines 14-15, claims 3-4, 8, 16 and figure 1.	1-25
A	US 4080044 A (GOUSSEAU) 21 March 1978 See claim 1 and figures 1-2.	1-25
A	JP 5228037 B2 (TOMOEGAWA PAPER CO., LTD.) 03 July 2013 See paragraph [0012] and figure 1.	1-25
A	JP 3157863 B2 (SUMITOMO ELECTRIC IND. LTD. et al.) 16 April 2001 See claim 1 and figures 1, 4.	1-25



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

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27 September 2017 (27.09.2017)

Date of mailing of the international search report

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Name and mailing address of the ISA/KR

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2017/039017

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4325607 A	20/04/1982	None	
US 5319733 A	07/06/1994	EP 0619889 A1 EP 0619889 B1 WO 93-13438 A1	19/10/1994 11/12/1996 08/07/1993
US 4080044 A	21/03/1978	JP 51-072446 A JP 58-100311 U JP 60-032649 Y2	23/06/1976 08/07/1983 30/09/1985
JP 5228037 B2	03/07/2013	EP 2267499 A1 EP 2267499 A4 EP 2267499 B1 US 2011-0026881 A1 US 8611712 B2 WO 2009-122674 A1	29/12/2010 09/05/2012 12/10/2016 03/02/2011 17/12/2013 08/10/2009
JP 3157863 B2	16/04/2001	CA 2077856 C EP 0540850 A2 EP 0540850 B1 EP 0642043 A1 EP 0642043 B1 JP 05-066325 A JP 05-066326 A JP 06-067066 A KR 10-1993-0006466 A US 5339376 A US 5351328 A US 5416868 A	15/02/2000 12/05/1993 10/12/1997 08/03/1995 02/12/1998 19/03/1993 19/03/1993 11/03/1994 21/04/1993 16/08/1994 27/09/1994 16/05/1995