

**NARROW WIDTH ADAPTERS AND CONNECTORS
WITH MODULAR LATCHING ARM**

BACKGROUND

[0001] The present disclosure relates generally to connectors having remote release, and more specifically to narrow width adapters and connectors, such as narrow pitch distance Lucent Connector (LC) duplex adapters and narrow width multi-fiber connectors.

[0002] The prevalence of the Internet has led to unprecedented growth in communication networks. Consumer demand for service and increased competition has caused network providers to continuously find ways to improve quality of service while reducing cost.

[0003] Certain solutions have included deployment of high-density interconnect panels. High-density interconnect panels may be designed to consolidate the increasing volume of interconnections necessary to support the fast-growing networks into a compacted form factor, thereby increasing quality of service and decreasing costs such as floor space and support overhead. However, the deployment of high-density interconnect panels have not been fully realized.

[0004] In communication networks, such as data centers and switching networks, numerous interconnections between mating connectors may be compacted into high-density panels. Panel and connector producers may optimize for such high densities by shrinking the connector size and/or the spacing between adjacent connectors on the panel. While both approaches may be effective to increase the panel connector density, shrinking the connector size and/or spacing may also increase the support cost and diminish the quality of service.

[0005] In a high-density panel configuration, adjacent connectors and cable assemblies may obstruct access to the individual release mechanisms. Such physical obstructions may

impede the ability of an operator to minimize the stresses applied to the cables and the connectors. For example, these stresses may be applied when the user reaches into a dense group of connectors and pushes aside surrounding optical fibers and connectors to access an individual connector release mechanism with his/her thumb and forefinger. Overstressing the cables and connectors may produce latent defects, compromise the integrity and/or reliability of the terminations, and potentially cause serious disruptions to network performance.

[0006] While an operator may attempt to use a tool, such as a screwdriver, to reach into a dense group of connectors and activate a release mechanism, adjacent cables and connectors may obstruct the operator's line of sight, making it difficult to guide the tool to the release mechanism without pushing aside the adjacent cables. Moreover, even when the operator has a clear line of sight, guiding the tool to the release mechanism may be a time-consuming process. Thus, using a tool may not be effective at reducing support time and increasing the quality of service.

[0007] Small Form Factor Pluggable Transceivers (SFP) are used presently in telecommunication infrastructures within rack mounted copper-to-fiber media converters, and are also known as Ethernet switches and/or patching hubs. These infrastructure Ethernet and fiber optic connections are evolving quickly to increase connection density due to limited space for such equipment. Although fiber optic connectors have become smaller over the years, they have not been designed to be any smaller than necessary to plug into commonly sized and readily available SFPs. However, as transceiver technologies develop, smaller SFPs will be used to create higher density switches and/or patching hub equipment. Accordingly, there is a need for fiber optic connectors that will meet the needs of future developments in smaller SFPs.

SUMMARY

[0008] In summary, one aspect provides a narrow pitch fiber optic connector including at least one lucent ferrule housed within a plug frame. The plug frame has a top and a bottom. The plug frame is mechanically coupled to a rear body, having a top and bottom. The rear body secures the at least one lucent ferrule within the plug frame. The narrow pitch fiber optic connector may also have a pull tab located adjacent to the top of the plug frame rear body. The pull tab may include at least one recess.

[0009] Another aspect provides a system including a transceiver and at least one flexing latch. The transceiver includes at least one receptacle comprising a top wall, a bottom wall, a first side wall, and a second side wall. The first side wall comprises a first track with a first recess. The second side wall comprises a second track with a second recess. The at least one flexing latch may include: a front comprising a lip, a back, a first side having a first tension member, and a second side having a second tension member. The first tension member interlocks with the first recess and the second tension member interlocks with the second recess when the at least one flexing latch is inserted into the transceiver.

[0010] A further aspect provides a system including a narrow pitch fiber optic connector and a corresponding transceiver. The narrow pitch fiber optic connector has at least one lucent ferrule housed within a plug frame. The plug frame is connected to a rear body, which secures the at least one lucent ferrule within the plug frame. The narrow pitch fiber optic connector further includes a pull tab with at least one recess. The transceiver includes at least one receptacle and at least one flexing latch within the at least one receptacle. The flexing latch has a front edge with a lip and a first and second tension member. The first tension member interlocks with a first recess of the transceiver, and the second tension member interlocks with the second recess of the transceiver.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] FIG. 1A is a perspective view of a prior art standard 6.25mm pitch LC connector SFP;

[0012] FIG. 1B is a perspective view of a prior art standard 6.25mm pitch LC adapter;

[0013] FIG. 1C is a top view of the prior art adapter of FIG. 1B;

[0014] FIG. 1D is a front view of the prior art adapter of FIG. 1B, showing the 6.25mm pitch;

[0015] FIG. 2A is a perspective view of a prior art LC duplex connector;

[0016] FIG. 2B is a perspective view of a prior art LC duplex connector with a remote release pull tab;

[0017] FIG. 2C is a top view of a prior art LC connector used in the embodiments shown in FIGS. 2A and 2B;

[0018] FIG. 2D is a side view of the prior art LC connector of FIG. 2C;

[0019] FIG. 3 is a perspective view of a future narrow pitch LC SFP for receiving connectors disclosed herein according to aspects of the present disclosure;

[0020] FIG. 4A is a perspective view of one embodiment of a narrow pitch LC adapter according to aspects of the present disclosure;

[0021] FIG. 4B is a top view of the narrow pitch LC adapter of FIG. 4A;

[0022] FIG. 4C is a front view of the narrow pitch LC adapter of FIG. 4A, showing a 4.8mm pitch;

[0023] FIG. 5 is a perspective view of one embodiment of a narrow pitch LC duplex connector with remote release according to aspects of the present disclosure;

[0024] FIG. 6A is a top view of an LC connector used in the embodiment of FIG. 5 according to aspects of the present disclosure;

[0025] FIG. 6B is a side view of the LC connector of FIG. 6A according to aspects of the present disclosure;

[0026] FIG. 7 is a perspective view of narrow pitch LC duplex connector of FIG. 5, with the release mechanism being removed according to aspects of the present disclosure;

[0027] FIG. 8 is a perspective disassembled view of the narrow pitch LC duplex connector of FIG. 5 according to aspects of the present disclosure;

[0028] FIG. 9 is a perspective view of a prior art standard multiple-fiber push-on/pull-off (MPO) SFP;

[0029] FIG. 10A is a perspective view of a prior art standard MPO connector;

[0030] FIG. 10B is a top view of the prior art MPO connector of FIG. 10A, having a width of 12.4mm;

[0031] FIG. 10C is a front view of the prior art MPO connector of FIG. 10A;

[0032] FIG. 11 is a perspective view of a future narrow width multi-fiber SFP for receiving connectors disclosed herein according to aspects of the present disclosure;

[0033] FIG. 12A is a perspective view of one embodiment of a narrow width multi-fiber connector with remote release according to aspects of the present disclosure;

[0034] FIG. 12B is a top view of the narrow width multi-fiber connector of FIG. 12A, having a width of 9.6mm according to aspects of the present disclosure;

[0035] FIG. 12C is a front view of the narrow width multi-fiber connector of FIG. 12A according to aspects of the present disclosure;

[0036] FIG. 13A is a perspective view of a narrow width multi-fiber connector inserted into a narrow width SFP having an SFP latch according to aspects of the present disclosure;

[0037] FIG. 13B is a perspective view of a narrow width multi-fiber connector inserted into a narrow width adapter having an adapter latch according to aspects of the present disclosure;

[0038] FIG. 14 is a side view of a narrow width multi-fiber connector of FIG. 13A having a recess engaged with an SFP latch in a normal pull tab position according to aspects of the present disclosure; and

[0039] FIG. 15 is a side view of the narrow width multi-fiber connector of FIG. 13A, being disengaged from the SFP latch by retracting the pull tab according to aspects of the present disclosure.

[0040] FIG. 16A is a perspective view of a narrow width multi-fiber connector having an adapter latch according to aspects of the present disclosure;

[0041] FIG. 16B is a perspective disassembled view of a narrow width multi-fiber connector having an adapter latch according to aspects of the present disclosure;

[0042] FIG. 17A is a front view of the narrow pitch adapter of FIG. 16A, showing a 3.80mm pitch;

[0043] FIG. 17B is a side view of the narrow width connector of FIG. 16A;

[0044] FIG. 17C is a side view of a plug frame fitting inside a SFP according to aspects of the present disclosure;

[0045] FIG. 17D is a perspective view of the narrow width connector of FIG. 16A with the push/pull tab in a normal position in the SFP latching recess according to aspects of the present disclosure;

[0046] FIG. 17E is a perspective view of the narrow width connector of FIG. 16A with the push/pull tab in a pulled back position with respect to the SFP latching recess according to aspects of the present disclosure;

[0047] FIG. 18A is a perspective view of a small form factor transceiver according to aspects of the present disclosure;

[0048] FIG. 18B and FIG. 18C are respective side views of the transceiver of FIG. 18A according to aspects of the present disclosure;

[0049] FIG. 19 is a perspective view of a SFP having one connector inserted;

[0050] FIG 20A and FIG. 20B are side views of a SFP holding a connector according to aspects of the present disclosure;

[0051] FIG. 21 is a perspective view of the SFP having one connector inserted and with the push/pull tab retracted according to aspects of the present disclosure;

[0052] FIG. 22A and FIG. 22B are side views of the SFP latch in a lifted position to unlatch the connector according to aspects of the disclosure;

[0053] FIG. 23 represents a latch to be used in a SFP according to aspects of the present disclosure;

[0054] FIG. 24 is a perspective view of a connector inserted into an adapter according to aspect of the present disclosure;

[0055] FIG. 25A and FIG. 25B are side views of the connector and the adapter of FIG. 24 with the latch in the normal position;

[0056] FIG. 26 is a perspective view of a connector inserted into an adapter with the push/pull tab retracted according to aspects of the present disclosure;

[0057] FIG. 27A and FIG. 27B are side views of the connector and adapter of FIG. 26 having the adapter latch in an unlatching position according to aspects of the present disclosure;

[0058] FIGS. 28A-D are various embodiments of the adapter and snap hooks used to engage a connector according to various aspects of the present disclosure;

[0059] FIG. 29 is a perspective view of one embodiment of a narrow pitch LC duplex connector with latching arm according to aspects of the present disclosure;

[0060] FIG. 30 is a perspective view of one embodiment of a narrow pitch LC duplex connector with modular latching arm according to aspects of the present disclosure;

[0061] FIG. 31 is a perspective view of one embodiment of a narrow pitch LC duplex connector with modular latching arm according to aspects of the present disclosure, wherein the modular latching arm is detached;

[0062] FIG. 32 is a perspective view of one embodiment of a narrow pitch LC duplex connector with latching arm and corresponding transceiver according to aspects of the present disclosure;

[0063] FIG. 33 is a perspective view of one embodiment of a narrow pitch LC duplex connector with latching arm and corresponding pull tab according to aspects of the present disclosure;

[0064] FIG. 34 is a detailed front view of a duplex adapter according to aspects of the present disclosure;

[0065] FIG. 35A is a detailed top view of a duplex adapter according to aspects of the present disclosure;

[0066] FIG. 35B is another detailed top view of a duplex adapter according to aspects of the present disclosure;

[0067] FIG. 36A is a detailed side view of an adapter according to aspects of the present disclosure;

[0068] FIG. 36B is another detailed side view of an adapter according to aspects of the present disclosure;

[0069] FIG. 37 is an exploded view of a connector according to aspects of the present disclosure;

[0070] FIG. 38A is an exploded view of an connector according to aspects of the present disclosure;

[0071] FIG. 38B is a perspective view of a fully assembled connector according to aspects of the present disclosure;

[0072] FIG. 39 is an exploded view of another connector according to aspects of the present disclosure;

[0073] FIG. 40A is an exploded view of another connector according to aspects of the present disclosure;

[0074] FIG. 40B is a perspective view of a fully assembled connector according to aspects of the present disclosure;

[0075] FIG. 41A is a perspective view of an adapter for a latch style with no hook according to aspects of the present disclosure;

[0076] FIG. 41B is a perspective view of an adapter latch style with a connector plugged in according to aspects of the present disclosure;

[0077] FIG. 41C is a perspective view of an adapter latch style where the connector is released according to aspects of the present disclosure;

[0078] FIG. 42A is a perspective view an adapter with pull release style according to aspects of the present disclosure;

[0079] FIG. 42B is a perspective view an adapter with pull release style according to aspects of the present disclosure;

[0080] FIG. 43A is a cross-sectional view of an adapter with a connector according to aspects of the present disclosure;

[0081] FIG. 43B is a cross-sectional view of a connector being released from an adapter in according to aspects of the present disclosure;

[0082] FIG. 43C is a cross-sectional view of an adapter latch style where the connector is removed from the adapter according to aspects of the present disclosure;

[0083] FIG. 44A is a perspective view of a connector being plugged into an adapter according to aspects of the present disclosure;

[0084] FIG. 44B is another perspective view of a connector being plugged into an adapter according to aspects of the present disclosure;

[0085] FIG. 45 is an illustrative example of a connector being plugged into an adapter according to aspects of the present disclosure;

[0086] FIG. 46A is an illustrative example of a connection device according to aspects of the present disclosure; and

[0087] FIG. 46B is another illustrative example of a connection device according to aspects of the present disclosure.

DETAILED DESCRIPTION

[0088] This disclosure is not limited to the particular systems, devices and methods described, as these may vary. The terminology used in the description is for the purpose of describing the particular versions or embodiments only, and is not intended to limit the scope.

[0089] As used in this document, the singular forms “a,” “an,” and “the” include plural references unless the context clearly dictates otherwise. Unless defined otherwise, all technical and scientific terms used herein have the same meanings as commonly understood by one of ordinary skill in the art. Nothing in this disclosure is to be construed as an admission that the embodiments described in this disclosure are not entitled to antedate such disclosure by virtue of prior invention. As used in this document, the term “comprising” means “including, but not limited to.”

[0090] The following terms shall have, for the purposes of this application, the respective meanings set forth below.

[0091] A connector, as used herein, refers to a device and/or components thereof that connects a first module or cable to a second module or cable. The connector may be configured for fiber optic transmission or electrical signal transmission. The connector may be any suitable type now known or later developed, such as, for example, a ferrule connector (FC), a fiber distributed data interface (FDDI) connector, an LC connector, a mechanical transfer (MT) connector, a square connector (SC) connector, an SC duplex connector, or a straight tip (ST) connector. The connector may generally be defined by a connector housing body. In some embodiments, the housing body may incorporate any or all of the components described herein.

[0092] A “fiber optic cable” or an “optical cable” refers to a cable containing one or more optical fibers for conducting optical signals in beams of light. The optical fibers can be

constructed from any suitable transparent material, including glass, fiberglass, and plastic. The cable can include a jacket or sheathing material surrounding the optical fibers. In addition, the cable can be connected to a connector on one end or on both ends of the cable.

[0093] Various embodiments described herein generally provide a remote release mechanism such that a user can remove cable assembly connectors that are closely spaced together on a high density panel without damaging surrounding connectors, accidentally disconnecting surrounding connectors, disrupting transmissions through surrounding connectors, and/or the like. Various embodiments also provide narrow pitch LC duplex connectors and narrow width multi-fiber connectors, for use, for example, with future narrow pitch LC SFPs and future narrow width SFPs. The remote release mechanisms allow use of the narrow pitch LC duplex connectors and narrow width multi-fiber connectors in dense arrays of narrow pitch LC SFPs and narrow width multi-fiber SFPs.

[0094] FIG. 1A shows a perspective view of a prior art standard 6.25mm pitch LC connector SFP 100. The SFP 100 is configured to receive a duplex connector and provides two receptacles 102, each for receiving a respective LC connector. The pitch 104 is defined as the axis-to-axis distance between the central longitudinal axes of each of the two receptacles 102. FIG. 1B shows a perspective view of a prior art standard 6.25 mm pitch LC adapter 106. The adapter 106 is also configured to receive a duplex connector, and provides two receptacles 108, each for receiving a respective LC connector. FIG. 1C is a top view of the adapter 106 of FIG. 1B. The pitch of the adapter 106 is defined similarly to that of the SFP 100, as the axis-to-axis distance between the central longitudinal axes of each of the two receptacles 108, as illustrated in FIG. 1D, which shows a front view of the adapter 106.

[0095] FIG. 2A shows a prior art LC duplex connector 200 that may be used with the conventional SFP 100 and the conventional adapter 106. The LC duplex connector 200 includes two conventional LC connectors 202. FIG. 2B shows another prior art LC duplex connector 204 having a remote release pull tab 206, and including two conventional LC connectors 208. As shown, the remote release pull tab includes two prongs 210, each configured to couple to the extending member 212 of a respective LC connector 208. FIGS. 2C and 2D show top and side views, respectively, of the conventional LC connector 208, having a width of 5.6 mm, and further showing the extending member 212.

[0096] Various embodiments disclosed herein are configured for use with a future SFP, such as the narrow pitch LC SFP 300 shown in FIG. 3, having a pitch less than that of conventional 6.25 mm and 5.25 mm pitches. Various embodiments utilize LC type fiber optic connectors in duplex arrangements (having transmitting and receiving fibers) but with a connector axis-to-axis distance that is less than the conventional 6.25 mm and 5.25 mm pitches, as described further below.

[0097] According to another aspect, embodiments of narrow pitch duplex LC adapters are disclosed. FIGS. 4A to 4C show one embodiment of a narrow pitch adapter 400. The narrow pitch adapter 400 has receptacles 402 on opposite ends thereof, configured for mating two narrow pitch LC duplex connectors according to aspects disclosed herein. FIG. 4B shows a top view of the adapter 400. FIG. 4C shows a front view, further illustrating that the adapter 400 has a pitch of 4.8 mm. The adapter 400 is configured to receive a duplex LC connector, with a pitch of the adapter corresponding to the axis-to-axis distance between the LC connectors of the LC duplex connector. Although the adapter 400 has a pitch of 4.8 mm, various embodiments of narrow pitch adapters disclosed herein may have a different pitch that is less than that of the

pitch of conventional adapters, for example less than 6.25 mm and less than about 5.25 mm. In some embodiments, the pitch may be about 4.8 mm or less.

[0098] In addition to the need for narrow connectors, there is a need for remote unlatching of the narrow connectors used in dense narrow SFP arrays. This is because finger access to connectors is nearly impossible without disruption to the service of adjacent optical fibers. Although there are current designs of remotely unlatching fiber optic connectors, as shown for example in FIG. 2B, they have proven to be difficult to function as desired when plugged into the die cast construction that is typical of all SFP's. The die cast SFP is not one that is ever free of sharp edges and internal flashing (burrs) that can interfere with the normal flexing motion of the plastic latches of the fiber optic connectors. The interference between metal edges and burrs may prevent the fiber optic connector's plastic latch from either becoming fully engaged or easily disengaged, especially with latches that are remotely triggered by pull tabs that project a distance behind the connector so as to keep fingers from disturbing adjacent optical fibers.

[0099] To make the latching/unlatching of the connectors from the SFP more reliable, various embodiments disclosed herein add a spring force to the remote latching component (pull tab), for example as shown and described in relation to FIGS. 5, 7, 8 and 12 below, to ensure that the connector latches are allowed to return to the undisplaced position and thereby become fully engaged inside the SFP's recess.

[0100] FIG. 5 shows one embodiment of a narrow pitch connector 500 according to aspects disclosed herein. The narrow pitch connector 500 is a duplex LC connector including two LC connectors 502. Each of the LC connectors 502 includes a respective ferrule 503 and a respective extending member or latching arm 504. The connector 500 has a pitch of 4.8 mm,

defined as the axis-to-axis distance between the central axes of the LC connectors 502. In other embodiments, the connector pitch may be less than that of the pitch of conventional connectors, for example less than 6.25 mm and less than about 5.25 mm. In some embodiments, the pitch may be about 4.8 mm or less.

[0101] The connector 500 further includes a housing 506 having a bottom housing 508 and a top housing 510. The bottom housing 508 includes side walls 512. In various embodiments, the housing of the connector may be a switchable housing. The side walls may be configured to open so as to facilitate opening of the housing, for example to change polarity of the connector. The side walls 512 may be raised towards the rear of the connector, as shown in FIG. 5. One advantage of raising the side walls towards the rear of the connector is easier access. In other embodiments, the side walls may be raised at another location.

[0102] The connector 500 further includes a pull tab 514 having a distal end 516 and a proximal end 518. The pull tab 514 further includes a spring 520 configured to provide a force such that the connector latching arms 504 return to the undisplaced position and thereby become fully engaged inside the SFP's recess. The distal end 516 of the pull tab 514 may be pulled to remotely release the connector 500 from an SFP or adapter. The proximal end 518 of the pull tab 514 is uniquely shaped so as to engage with the unique profile of the latching arms 504 of the narrow pitch LC connector 500. The proximal end 518 engages both latching arms 504 of the duplex LC connector 500. That is, the proximal end 518 includes a single prong configured to engage the latching arms of both connectors 502. At the proximal end 518 of the pull tab 514 there are outwardly pointing pins 522 configured to rest directly above and slide along the semi-circular surface of latching arms 504 of the duplex LC connectors 502. The horizontal and rearward path direction of the pins 522 causes the semi-circular profile of the connector latching

arms 504 to flex downward. Because the pins 522 are not contained inside ramped grooves of the connector latching arms 504, the pull tab 514 can also be pushed down at a location directly behind the LC connectors 502 rather than pulling the tab in a rearward motion from a remote distance behind the connectors, such as from the distal end 516. The action of pushing down the connectors' integral levers or latching arms 504 unlatches the connector 500. In some cases, the horizontal motion of the pull tab 514 may not be desirable. Thus, the connector latching arms 504 may be pushed down without resulting in a horizontal motion of the pull tab 514.

[0103] FIGS. 6A and 6B show top and side views, respectively, of the LC connector 502 of the narrow pitch connector 500. FIG. 6A further shows that the LC connector 502 has a width of 4.6mm. FIG. 6B shows the semi-circular profile of the latching arm 504.

[0104] FIG. 7 shows a partially disassembled view of the narrow pitch connector 500 of FIG. 5. The top housing 510 is separated from the bottom housing 508. The pull tab 514 is coupled to the top housing 510 and configured to slide longitudinally along the length of the connector. The top housing 510 also includes a restraint 524 configured to receive the pull tab 514.

[0105] FIG. 8 shows a further disassembled view of the narrow pitch connector 500. Specifically, the pull tab 514 is shown to be separated from the top housing 510, and the spring 520 is removed from the pull tab. The pull tab 514 includes a longitudinal recess 526 configured to receive the spring 520, and at least one restraint 528 configured to retain the spring. The top housing 510 also includes a recess 530 configured to accommodate at least a portion of the pull tab 514, such as the spring 520 and the proximal end 518. In various embodiments, the pull tab may be removably coupled to the connector via the top housing.

[0106] FIG. 9 shows a perspective view of a prior art standard MPO SFP 900. The SFP 900 is configured to receive a standard MPO connector and provides a receptacle 902 for receiving an MPO connector having a conventional width, as shown for example in FIGS. 10A to 10C.

[0107] FIG. 10A shows a perspective view of a conventional MPO connector 1000. As shown in FIG. 10B, the conventional MPO connector 1000 has a width of 12.4mm. FIG. 10C shows a front view of the MPO connector 1000.

[0108] FIG. 11 shows an embodiment of a future narrow width multi-fiber SFP 1100 according to aspects of the present disclosure. Various embodiments disclosed herein are configured for use with the narrow width multi-fiber SFP 1100, having a width less than that of conventional MPO connectors, that is less than about 12.4 mm. The narrow width multi-fiber SFP has a receptacle 1102 configured to receive a narrow width multi-fiber connector, such as a narrow width connector having an MT ferrule.

[0109] FIG. 12A shows one embodiment of a narrow width connector 1200 according to aspects disclosed herein. The narrow width connector 1200 is a multi-fiber connector including a multi-fiber MT/MPO ferrule 1202. The connector 1200 includes two extending members or latching arms 1204. In other embodiments, the connector may include at least one latching arm. The connector 1200 has a width of 9.6 mm, as shown in the top view of the connector 1200 in FIG. 12B. In other embodiments, the connector width may be less than that of the width of conventional multi-fiber connectors, for example less than the 12.4 mm of the conventional MPO connector shown in FIG. 10B. In some embodiments, the width may be about 9.6 mm or less.

[0110] The connector 1200 further includes a housing 1206 having a bottom housing 1208 and a top housing 1210. The bottom housing 1208 includes side walls 1212. In various embodiments, the housing of the connector may be a switchable housing. The side walls may be configured to open so as to facilitate opening of the housing, for example to change polarity of the connector. The side walls 1212 may be raised towards the rear of the connector. One advantage of raising the side walls towards the rear of the connector is easier access. The side walls may also be raised at another location.

[0111] The connector 1200 further includes a pull tab 1214 having a distal end 1216 and a proximal end 1218. The pull tab 1214 further includes a spring 1220 configured to provide a force such that the connector latching arms 1204 return to the undisplaced position and thereby become fully engaged inside the SFP's recess. The distal end 1216 of the pull tab 1214 may be pulled to remotely release the connector 1200 from an SFP or adapter. The proximal end 1218 of the pull tab 1214 is uniquely shaped so as to engage with the unique profile of the latching arms 1204 of the narrow width multi-fiber connector 1200. The proximal end 1218 engages both latching arms 1204 of the multi-fiber connector 1200. That is, the proximal end 1218 includes a single prong configured to engage the latching arms 1204. At the proximal end 1218 of the pull tab 1214 there are outwardly pointing pins 1222 configured to rest directly above and slide along the semi-circular surface of latching arms 1204. The horizontal and rearward path direction of the pins 1222 causes the semi-circular profile of the connector latching arms 1204 to flex downward. Because the pins 1222 are not contained inside ramped grooves of the connector latching arms 1204, the pull tab 1214 can also be pushed down at a location directly behind the latching arms 1204 rather than pulling the tab in a rearward motion from a remote distance behind the connector, such as from the distal end 1216. The action of pushing down the

connector's integral levers or latching arms 1204 unlatches the connector 1200. In some cases, the horizontal motion of the pull tab 1214 may not be desirable. Thus, the connector latching arms 1204 may be pushed down without resulting in a horizontal motion of the pull tab 1214.

[0112] FIGS. 12B and 12C show top and front views, respectively, of the narrow width multi-fiber connector 1200. FIG. 12B further shows that the connector 1200 has a width of 9.6 mm.

[0113] In various embodiments described above, the narrow width connectors have latching arms configured to engage with a fixed or immovable recess within a narrow width SFP or a narrow width adapter. In these embodiments, the pull tab of the connector displaces the flexible latching arm of the connector so as to disengage the latching arm from the recess of the SFP or the adapter. For example, the latching arms bend down as the pull tab is pulled back, so as to disengage the connector from the SFP or the adapter.

[0114] In other embodiments, as further described for example in relation with FIGS. 13A, 13B, 14, and 15 below, the remote latch release pull tab may be configured to couple with a latch or a hook within the adapter or the SFP. In these embodiments, the flexible latching arm of the connector is moved into the main cavity of the SFP or the adapter, and the latch of the SFP or the adapter engages a recess of the connector when the pull tab is in a normal location that is pushed forward by a spring. The pull tab may be configured to have a ramp area such that when the pull tab is pulled back, the latch of the SFP or the adapter is lifted by the retracted pull tab, thereby disengaging the latch of the SFP or the adapter from the connector.

[0115] FIG. 13A shows a narrow pitch multi-fiber connector 1300 inserted into a narrow pitch SFP 1302 such that a recess of the connector engages an SFP latch. FIG. 13B

shows the narrow pitch connector 1300 inserted into a narrow pitch adapter 1304 such that a recess of the connector engages a latch of the adapter.

[0116] FIG. 14 shows a side view of the narrow width connector 1300 of FIG. 13A coupled to the narrow width SFP 1302. Details of the coupling are shown within the circle 1400. Specifically, the SFP 1302 includes an SFP latch 1402. The connector 1300 includes a recess 1404. For example, the connector housing may comprise a recess 1404. The pull tab 1406 may be spring loaded as described in relation to various embodiments. This allows the pull tab 1406 to return to a position that will allow the SFP latch 1402 to engage with the connector recess 1404. When the pull tab 1406 is in the normal pull tab location, that is pushed forward by a spring, as shown in FIG. 14, the SFP latch 1402 is engaged with the connector recess 1404 as illustrated within the circle 1400.

[0117] FIG. 15 shows a side view of the narrow width connector 1300 of FIG. 13A as it is disengaged from the narrow width SFP 1302. Details of the decoupling are shown within the circle 1500. The pull tab 1406 includes a taper or a ramp area 1502. As the pull tab 1406 is pulled back in the direction of the arrow 1504 as shown, the SFP latch 1402 is lifted by the ramp area of the retracted pull tab, thereby disengaging the SFP latch 1402 from the connector as illustrated within the circle 1500. The same effect described herein in conjunction with FIG. 15 also occurs in other embodiments of connectors coupled to a narrow width adapter as shown for example in FIG. 13A.

[0118] Although FIGS. 14 and 15 illustrate coupling of the connector to a narrow width SFP, in other embodiments of the connector may be coupled to a narrow width adapter having an adapter latch, similar to that of the SFP latch. Further, although the embodiments shown in

FIGS. 13A, 13B, 14, and 15 include a narrow width multi-fiber connector, embodiments also work with narrow pitch LC connectors.

[0119] FIGS. 16A – 23 are various views and details that show a narrow pitch multi-fiber connector, a SFP and the latching mechanisms associated therewith according to various aspects of the invention.

[0120] FIGS. 24 – 28D illustrate various views and details that show a narrow pitch multi-fiber connector both engaged and disengaged with an adapter. The connector and the adapter include latching mechanisms designed and arranged to be latched and unlatched, for example, with the use of a push/pull tab that is positioned on the connector body.

[0121] FIG. 29 shows another example embodiment of a narrow pitch connector 2900 according to aspects disclosed herein. The narrow pitch connector 2900 is a duplex LC connector including two LC connections 2902. In some embodiments, such as that shown, the two LC connectors 2902 may comprise a single combined unit. In alternative embodiments, the LC connectors 2902 may be separate members, wherein an air gap exists between the two members, or wherein the two separate members are located adjacent and flush to each other (i.e., no air gap exists). In some embodiments, each of the LC connectors 2902 includes a respective ferrule 2903 and a respective extending member or latching arm 2904. The connector 2900 may have a pitch of 4.8 mm, defined as the axis-to-axis distance between the central axes of the LC connectors 2902. In other embodiments, the connector pitch may be less than that of the pitch of conventional connectors, for example less than 6.25 mm and less than about 5.25 mm. In some embodiments, the pitch may be about 4.8 mm or less.

[0122] The connector 2900 further includes a housing 2906 having a bottom housing 2908 and a top housing 2910. The bottom housing 2908 includes side walls 2912. In various

embodiments, the housing of the connector may be a disassembled into the various parts disclosed herein. In one non-limiting example, a fastening mechanism 2913 may be depressed allowing the housing 2906 to detach from the rear member 2909. The low profile of the latching arm 2904 and compact design of the housing 2906 allows for the LC duplex adapter/connector 2900 to be used in a compact array of small form factor pluggable transceivers (SFPs).

[0123] In other embodiments, such as that shown in FIG. 30, an LC connector 3000 (e.g., duplex connector) may have a modular latching arm 3004. The modular latching arm 3004 may interlock with the LC connector 3000 to ensure the security of the LC adaptor when inserted into a SFP. In one non-limiting example, and as shown in FIG. 30, the modular latching arm 3004 may have a base member 3005, wherein the base member has two edges 3007 that are slanted upward at an angle toward the center of the latching arm. The LC adaptor 3000 may also have a recess for receiving the modular latching arm. In some embodiments, the recesses may have angled walls that correspond to the angles 3007 of the base of the modular latching arm 3005.

[0124] Referring now to FIG. 31, an illustrated embodiment is shown wherein the latching arm 3104 has been removed from the LC connector 3100. As discussed herein, the latching arm 3104 is modular, and thus, the latching arm base 3105 may be removed from the recess 3107 of the LC connector 3100. In some embodiments, as shown, the LC connector 3100 may have multiple recesses 3107. This allows the latching arm 3104 to be moved from the top of the LC connector to the bottom of the LC connector as indicted by the additional recess 3109 on the bottom of the LC connector.

[0125] It should be understood by those skilled in the art, that the interlocking of the modular latching arm as shown in FIG. 31, is a non-limiting example of interconnection.

Additional embodiments may also be utilized, for example, an embodiment may involve an interlock system wherein the modular latching are is inserted into a recess in the LC connector and twisted (e.g., 90°, 108°, etc.) to interlock secure the base with the recess. Additional embodiments, may comprise a more complex shape than that shown in FIG. 31. For example, a u-shaped recess wherein the modular connector based is cooperatively shaped and is inserted and fed through the u-shape until secure. It should thus be understood, that any system or method of interlocking may be used to attach the latching arm to the LC connector, including various locations (e.g., sliding from the front, sides, back, bottom, top, etc.).

[0126] In current designs, if an LC connector, particularly a duplex LC adaptor, needs to have the ferrules rotated or swapped, it can be a time consuming and difficult process. Generally, if a duplex connector needs to be rotated, current systems require twisting the individual LC connector tips 180 degrees. However, this process also twists the fibers that enter the connector tip. Twisting the fiber at any stage of the connection can cause wear and/or damage to the delicate fibers. Thus, most systems involve an alternative solution, wherein the LC adaptor is partially or completely disassembled in order to access the ferrules or fibers and manually relocate them within the LC connector. However, swapping connectors side to side is a delicate operation. In order to prevent damage to the internal fibers, great care must be taken. Thus, this operation usually requires specialized tools and preparation time to perform safely and accurately.

[0127] Therefore, embodiments as described herein, allow for easy, quick, and safe swapping of the left and right side connectors in a LC duplex connector. Thus, some embodiments discussed herein, may allow for a change in polarity of the LC duplex connector without twisting the fibers or performing any complex disassembly of the LC duplex connector.

For example, removing a modular latching arm and relocating the modular latching arm to the bottom of the LC connector may enable for easy transposition of two or more ferrules housed within the LC connector.

[0128] In further embodiments, other advantages may be realized. For example, in typical embodiments, the modular latching arm 3104 is required to be flexible in order to properly interact with transceiver housing (e.g., those discussed herein). This is because the interlocking mechanism relies on the latching arm moving slightly up and down to traverse the interlocking mechanism on the transceiver (e.g., groove, recess, hole, etc.). Thus, when a latching mechanism and an LC connector (e.g., duplex connector) are built as one unified member (as is currently done), the LC connector is built of a similar flexible or less rigid material.

[0129] Building the LC connector housing out of a plastic or polymeric material, limits the amount of rigidity that it can have. As discussed herein, LC connectors are getting smaller and smaller in size in order to accommodate larger arrays of LC connectors in a smaller space allowing for increased bandwidth. Thus, as LC connectors continue to reduce in size, the strength of the housing has been reduced. Therefore, it would be advantageous to build the LC connectors out of a more robust material while still allowing the latching arm to remain flexible. In order to accomplish this, in some embodiments, the LC connector 3100 may be manufactured out of a very rigid or strong material (e.g., steel, graphene, carbon, metal alloys, or any material of suitable properties). Because the LC connector 3100 and the latching arm 3104 need only interlock with each other, the modular latching arm may still be made out of a more flexible material. Thus, the modular nature of the embodiments disclosed herein allow for a more robust and secure overall design when dealing with the shrinking footprint of LC connectors.

[0130] Referring now to FIG. 32, an example embodiment involving a LC duplex connector 3200A and a duplex transceiver 3200B (e.g., small form factor pluggable transceiver (SFP)) is shown. As discussed herein, the LC connector 3200A may comprise a latching arm 3204A. The latching arm 3204A is configured to interlock with a corresponding latching mechanism 3204B on the transceiver 3200B. Although the latching mechanism 3204B is shown as a cutout, it should be understood that this is a non-limiting example, and that the latching mechanism may comprise a groove, recess, cutout, cavity, bump, or the like. Moreover, as discussed herein, the latching arm 3204A may be fixed or modular depending on the design and/or needs of the system.

[0131] In further embodiments, as illustrated in FIG. 33, a pull tab 3310 may be connected to a LC connector 3300. In some embodiments, the pull tab 3310 may be configured to couple to the latching arm 3304 as shown. When the pull tab 3310 is pulled (e.g., by a user) in a direction away from the front of the LC connector 3300, as illustrated by dashed arrow 3311, the incline ramps 3313 may be impacted by a portion of the LC connector 3312. This impact may cause a raised portion 3315 of the pull tab 3310 to be lowered. As the raised portion 3315 lowers, it impacts the latching arm 3304 causing the latching arm to also be lowered. As discussed herein, as and shown in FIG. 32, the latching arm 3304 interlocks with a latching mechanism (e.g., 3204B of FIG. 32). However, when the latching arm 3304 is lowered (e.g., due to impacting the raised portion 3315 of the pull tab 3310), the latching arm disengages the connection with the interlocking mechanism, thereby releasing the LC connector 3300 from any transceiver it was previously connected to. This allows for easier access and removal of LC connectors that utilize the designs discussed herein.

[0132] In the above detailed description, reference is made to the accompanying drawings, which form a part hereof. In the drawings, similar symbols typically identify similar components, unless context dictates otherwise. The illustrative embodiments described in the detailed description, drawings, and claims are not meant to be limiting. Other embodiments may be used, and other changes may be made, without departing from the spirit or scope of the subject matter presented herein. It will be readily understood that the aspects of the present disclosure, as generally described herein, and illustrated in the Figures, can be arranged, substituted, combined, separated, and designed in a wide variety of different configurations, all of which are explicitly contemplated herein.

[0133] The present disclosure is not to be limited in terms of the particular embodiments described in this application, which are intended as illustrations of various aspects. Many modifications and variations can be made without departing from its spirit and scope, as will be apparent to those skilled in the art. Functionally equivalent methods and apparatuses within the scope of the disclosure, in addition to those enumerated herein, will be apparent to those skilled in the art from the foregoing descriptions. Such modifications and variations are intended to fall within the scope of the appended claims. The present disclosure is to be limited only by the terms of the appended claims, along with the full scope of equivalents to which such claims are entitled. It is to be understood that this disclosure is not limited to particular methods, reagents, compounds, compositions or biological systems, which can, of course, vary. It is also to be understood that the terminology used herein is for the purpose of describing particular embodiments only, and is not intended to be limiting.

[0134] With respect to the use of substantially any plural and/or singular terms herein, those having skill in the art can translate from the plural to the singular and/or from the singular

to the plural as is appropriate to the context and/or application. The various singular/plural permutations may be expressly set forth herein for sake of clarity.

[0135] It will be understood by those within the art that, in general, terms used herein, and especially in the appended claims (for example, bodies of the appended claims) are generally intended as “open” terms (for example, the term “including” should be interpreted as “including but not limited to,” the term “having” should be interpreted as “having at least,” the term “includes” should be interpreted as “includes but is not limited to,” et cetera). While various compositions, methods, and devices are described in terms of “comprising” various components or steps (interpreted as meaning “including, but not limited to”), the compositions, methods, and devices can also “consist essentially of” or “consist of” the various components and steps, and such terminology should be interpreted as defining essentially closed-member groups. It will be further understood by those within the art that if a specific number of an introduced claim recitation is intended, such an intent will be explicitly recited in the claim, and in the absence of such recitation no such intent is present. For example, as an aid to understanding, the following appended claims may contain usage of the introductory phrases “at least one” and “one or more” to introduce claim recitations. However, the use of such phrases should not be construed to imply that the introduction of a claim recitation by the indefinite articles “a” or “an” limits any particular claim containing such introduced claim recitation to embodiments containing only one such recitation, even when the same claim includes the introductory phrases “one or more” or “at least one” and indefinite articles such as “a” or “an” (for example, “a” and/or “an” should be interpreted to mean “at least one” or “one or more”); the same holds true for the use of definite articles used to introduce claim recitations. In addition, even if a specific number of an introduced claim recitation is explicitly recited, those skilled in the art will recognize that such

recitation should be interpreted to mean at least the recited number (for example, the bare recitation of "two recitations," without other modifiers, means at least two recitations, or two or more recitations). Furthermore, in those instances where a convention analogous to "at least one of A, B, and C, et cetera" is used, in general such a construction is intended in the sense one having skill in the art would understand the convention (for example, "a system having at least one of A, B, and C" would include but not be limited to systems that have A alone, B alone, C alone, A and B together, A and C together, B and C together, and/or A, B, and C together, et cetera). In those instances where a convention analogous to "at least one of A, B, or C, et cetera" is used, in general such a construction is intended in the sense one having skill in the art would understand the convention (for example, "a system having at least one of A, B, or C" would include but not be limited to systems that have A alone, B alone, C alone, A and B together, A and C together, B and C together, and/or A, B, and C together, et cetera). It will be further understood by those within the art that virtually any disjunctive word and/or phrase presenting two or more alternative terms, whether in the description, claims, or drawings, should be understood to contemplate the possibilities of including one of the terms, either of the terms, or both terms. For example, the phrase "A or B" will be understood to include the possibilities of "A" or "B" or "A and B."

[0136] In addition, where features or aspects of the disclosure are described in terms of Markush groups, those skilled in the art will recognize that the disclosure is also thereby described in terms of any individual member or subgroup of members of the Markush group.

[0137] As will be understood by one skilled in the art, for any and all purposes, such as in terms of providing a written description, all ranges disclosed herein also encompass any and all possible subranges and combinations of subranges thereof. Any listed range can be easily

recognized as sufficiently describing and enabling the same range being broken down into at least equal halves, thirds, quarters, fifths, tenths, et cetera. As a non-limiting example, each range discussed herein can be readily broken down into a lower third, middle third and upper third, et cetera. As will also be understood by one skilled in the art all language such as “up to,” “at least,” and the like include the number recited and refer to ranges which can be subsequently broken down into subranges as discussed above. Finally, as will be understood by one skilled in the art, a range includes each individual member. Thus, for example, a group having 1-3 cells refers to groups having 1, 2, or 3 cells. Similarly, a group having 1-5 cells refers to groups having 1, 2, 3, 4, or 5 cells, and so forth.

[0138] Various of the above-disclosed and other features and functions, or alternatives thereof, may be combined into many other different systems or applications. Various presently unforeseen or unanticipated alternatives, modifications, variations or improvements therein may be subsequently made by those skilled in the art, each of which is also intended to be encompassed by the disclosed embodiments.

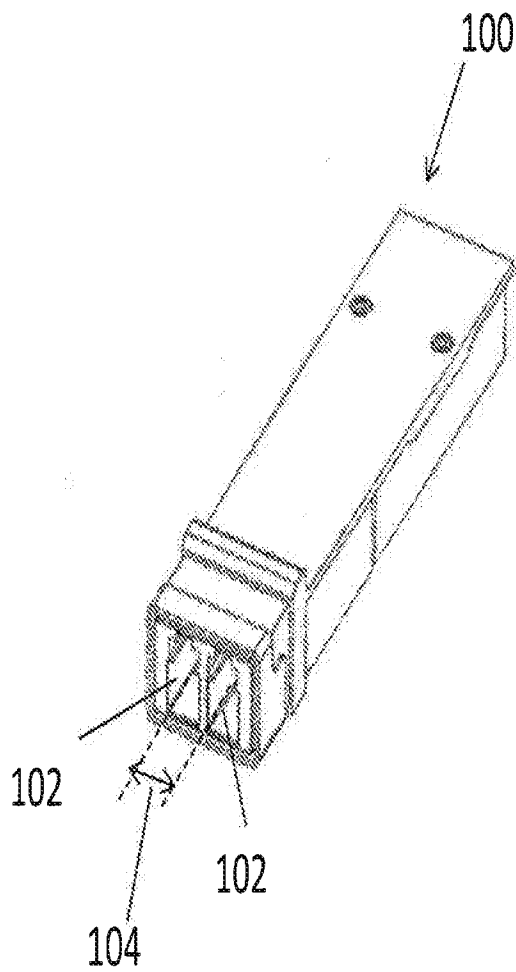


FIG. 1A
(Prior Art)

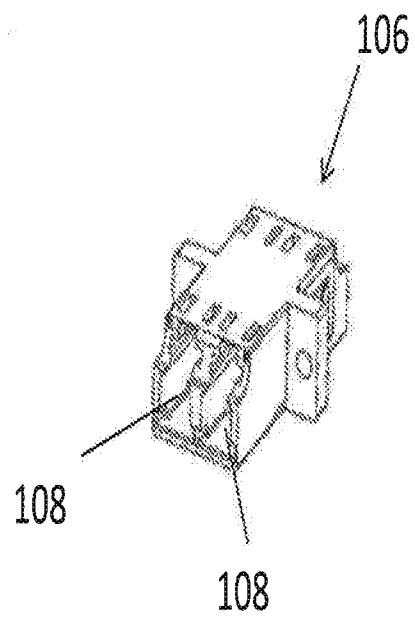


FIG. 1B
(Prior Art)

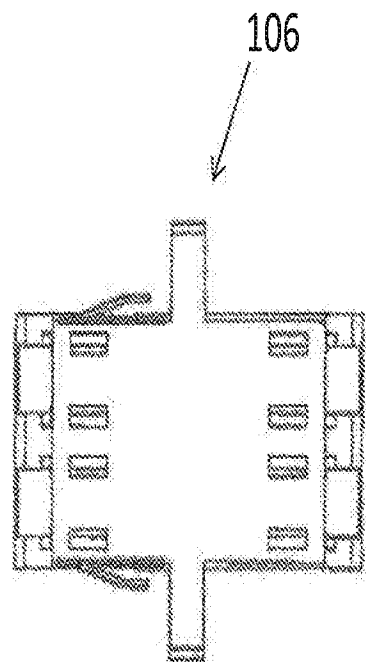


FIG. 1C
(Prior Art)

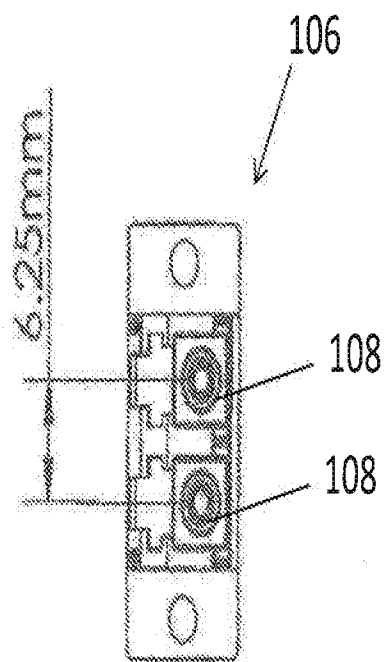


FIG. 1D
(Prior Art)

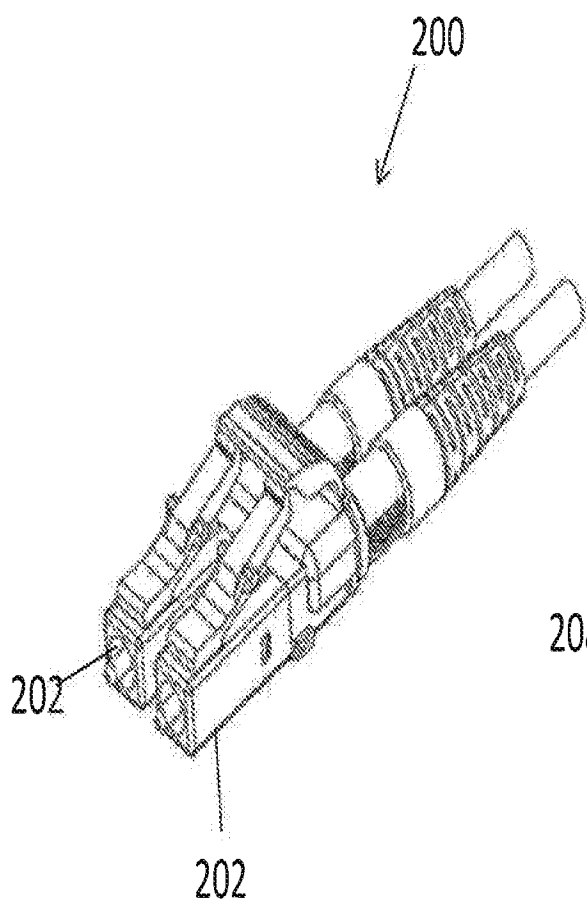


FIG. 2A
(Prior Art)

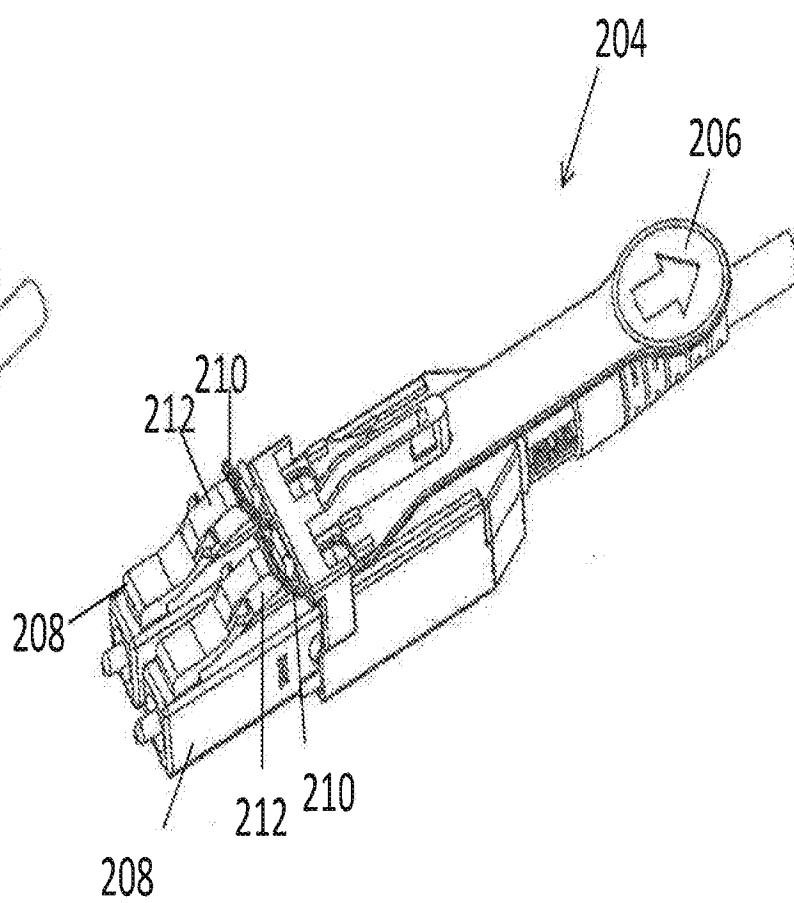


FIG. 2B
(Prior Art)

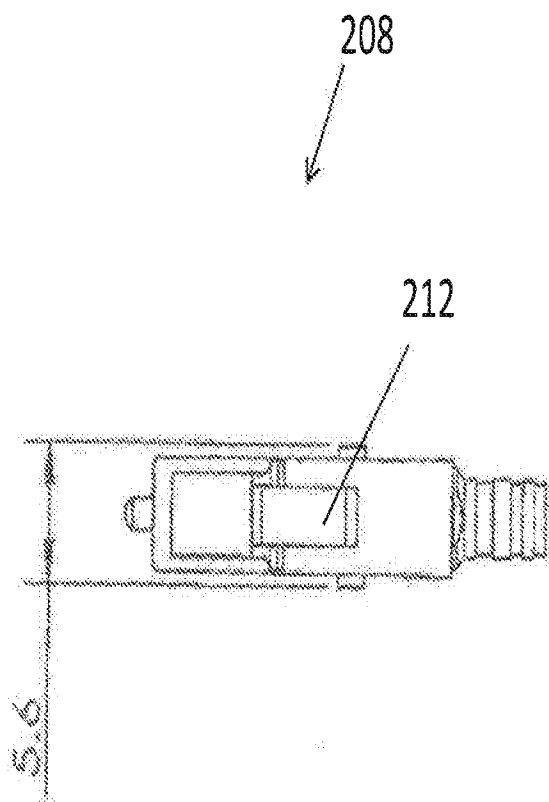


FIG. 2C
(Prior Art)

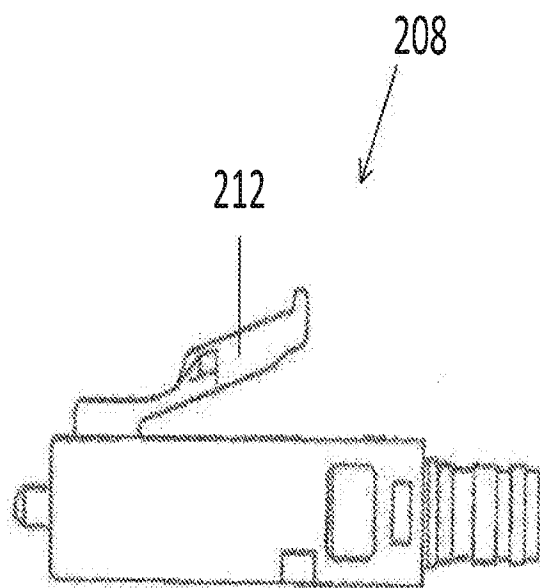


FIG. 2D
(Prior Art)

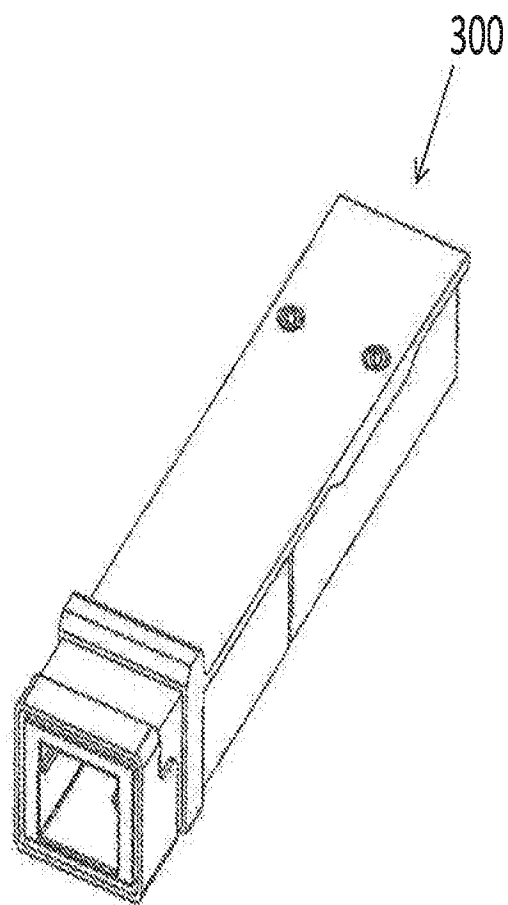


FIG. 3

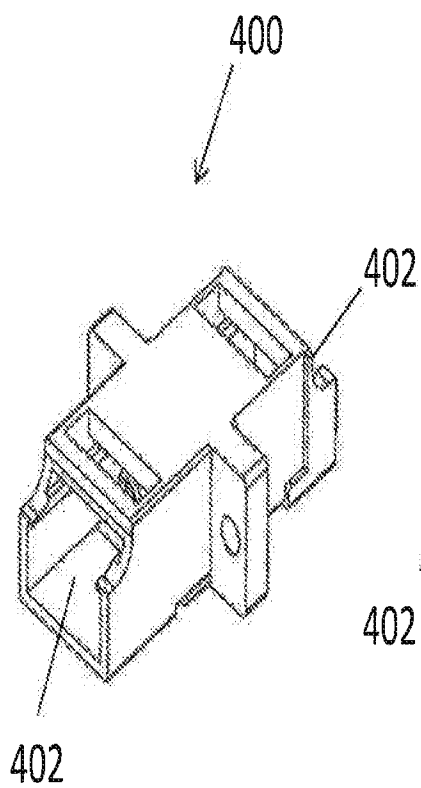


FIG. 4A

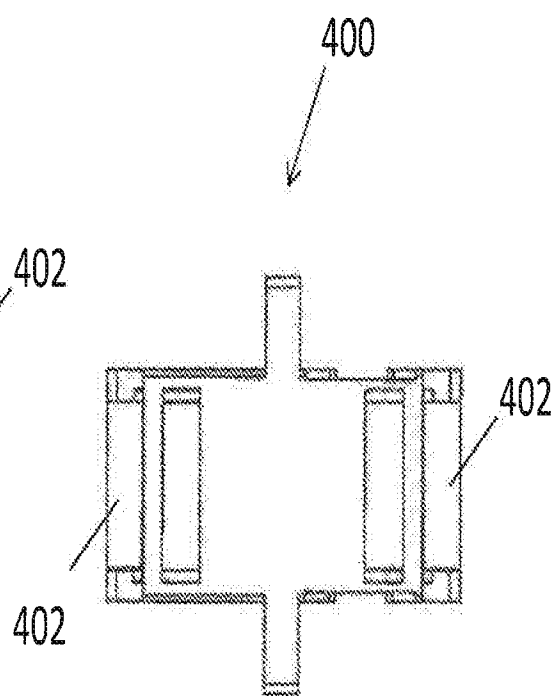


FIG. 4B

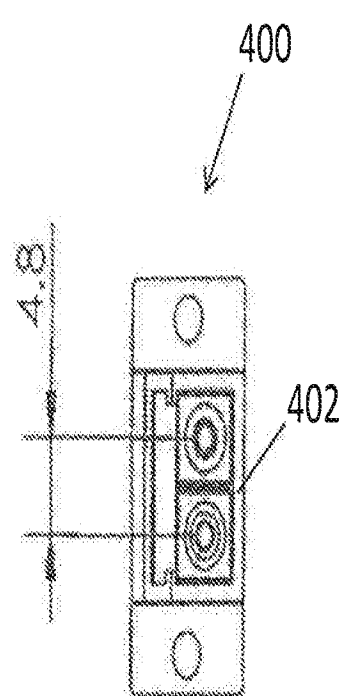
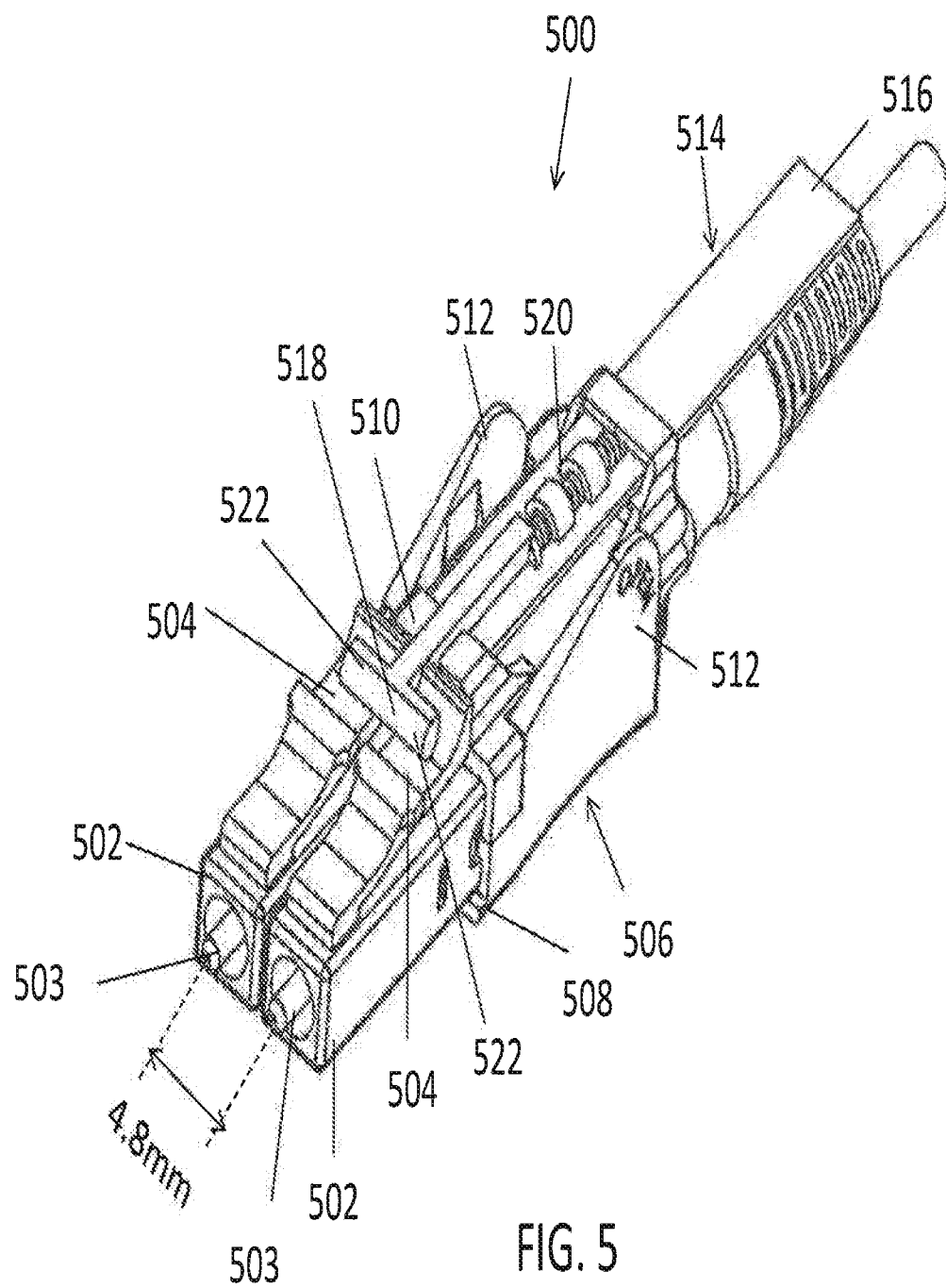


FIG. 4C



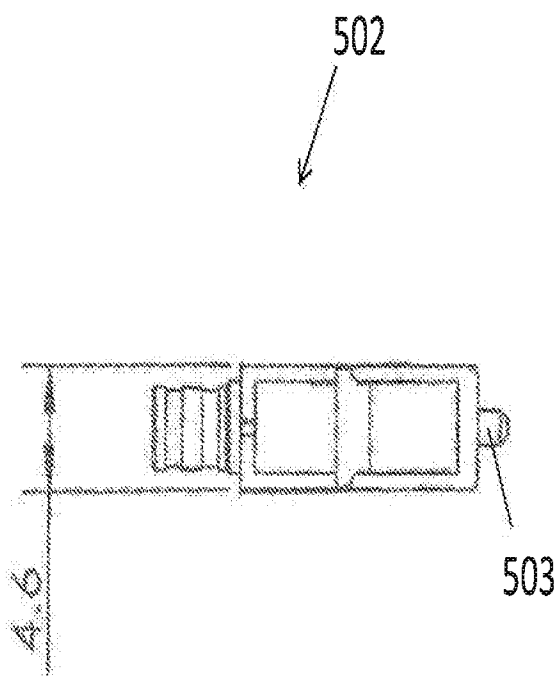


FIG. 6A

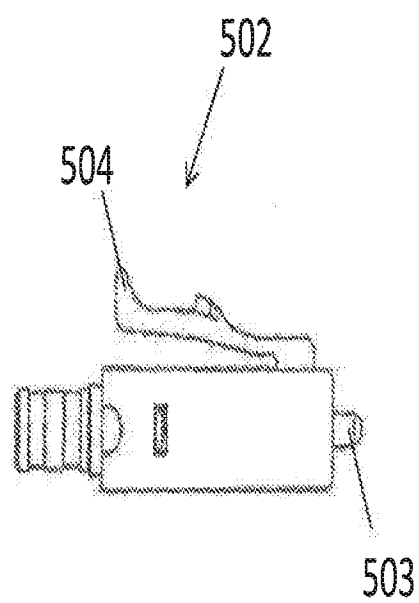


FIG. 6B

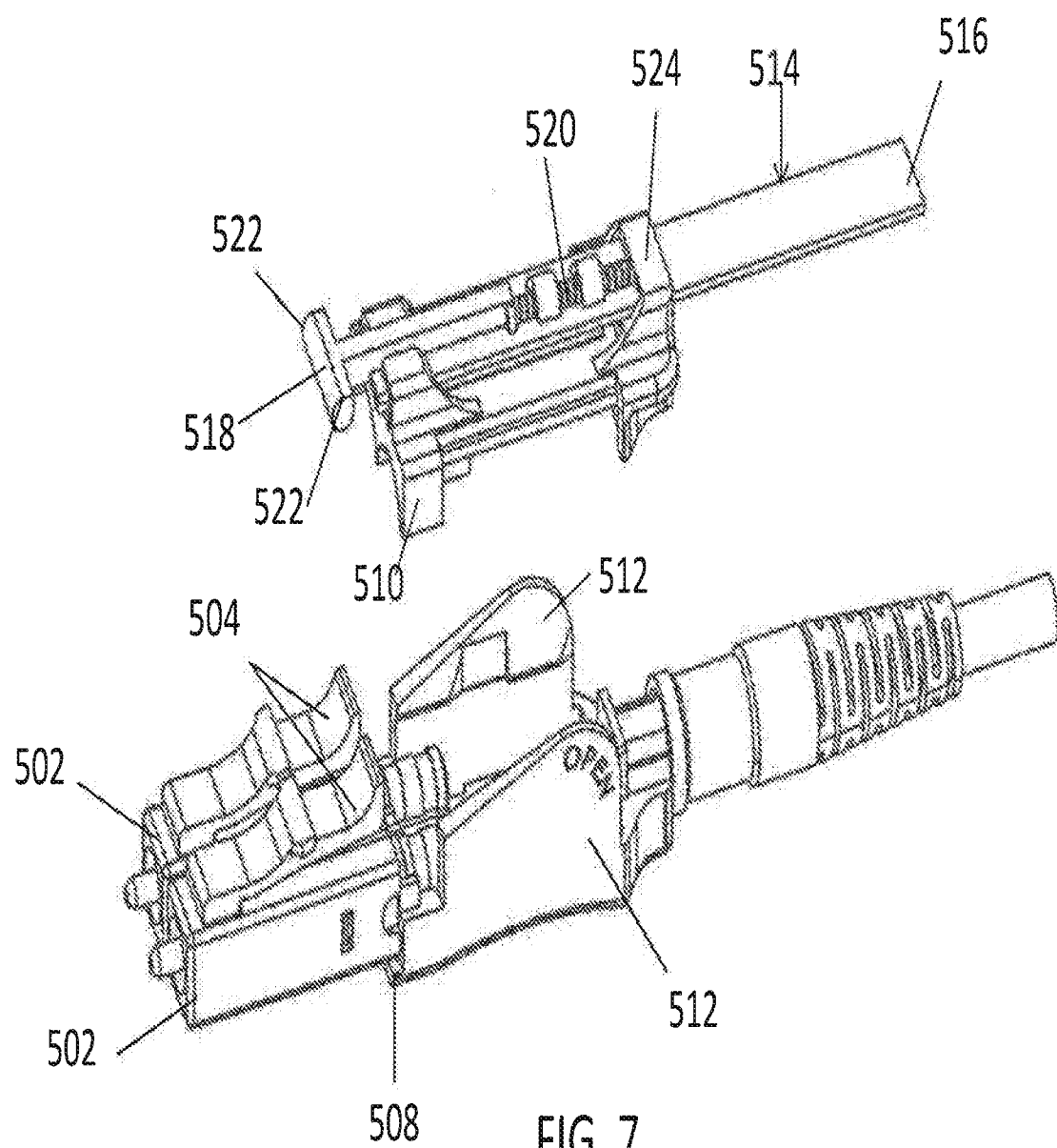


FIG. 7

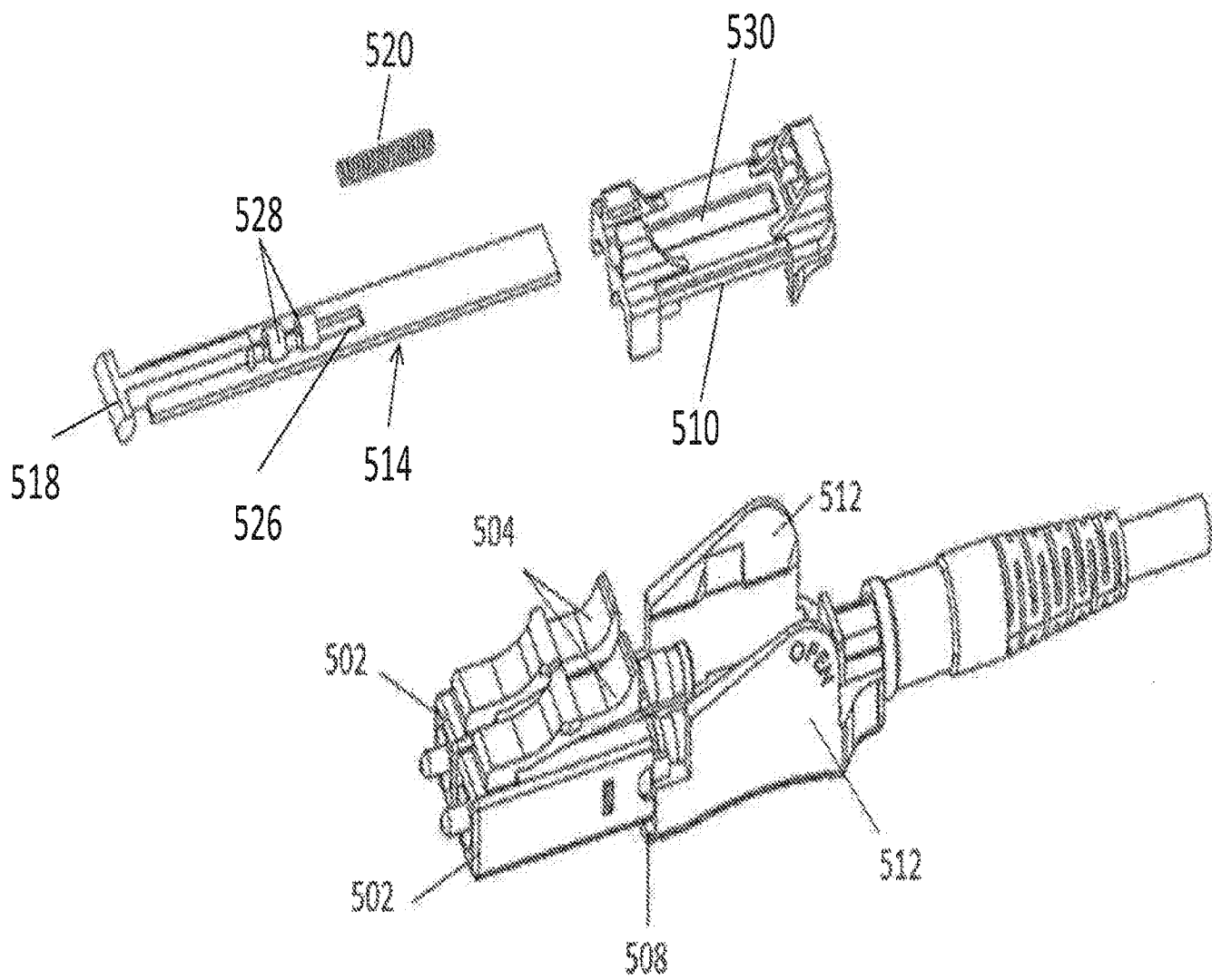


FIG. 8

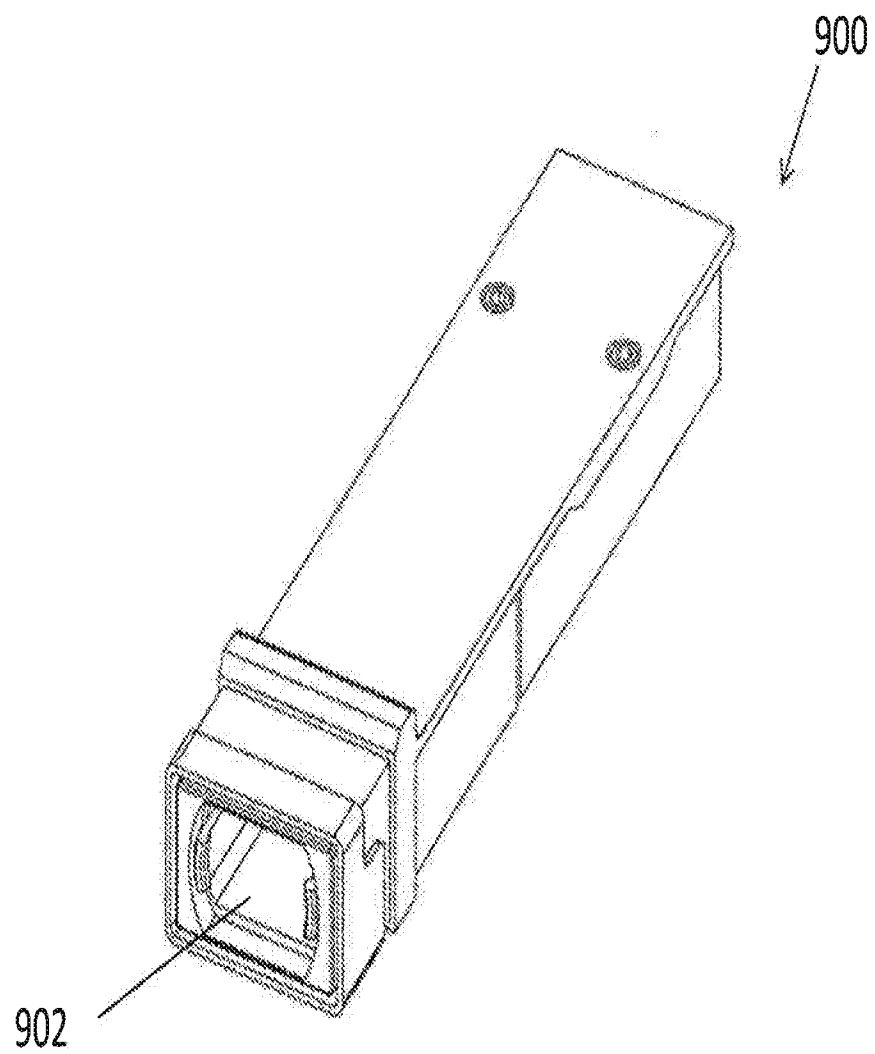


FIG. 9
(Prior Art)

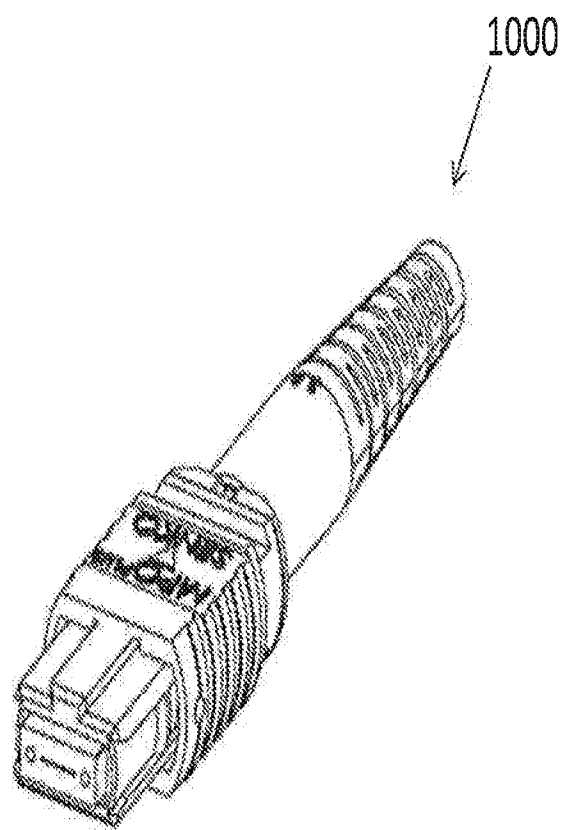


FIG. 10A
(Prior Art)

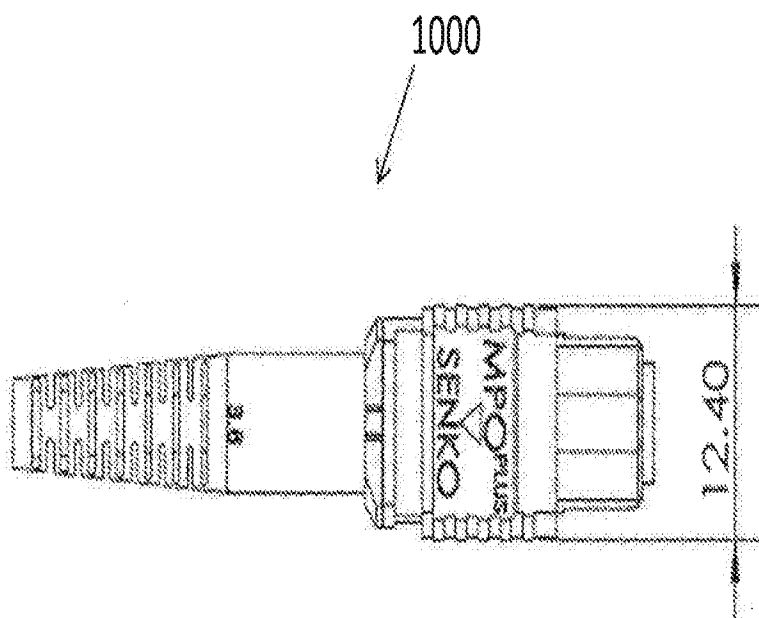


FIG. 10B
(Prior Art)



FIG. 10C
(Prior Art)

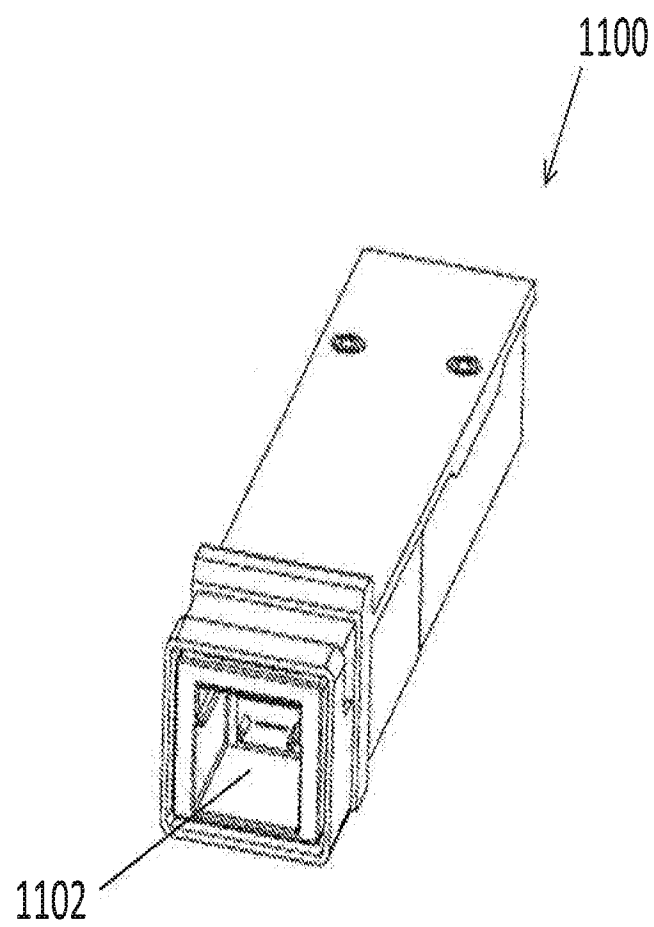


FIG. 11

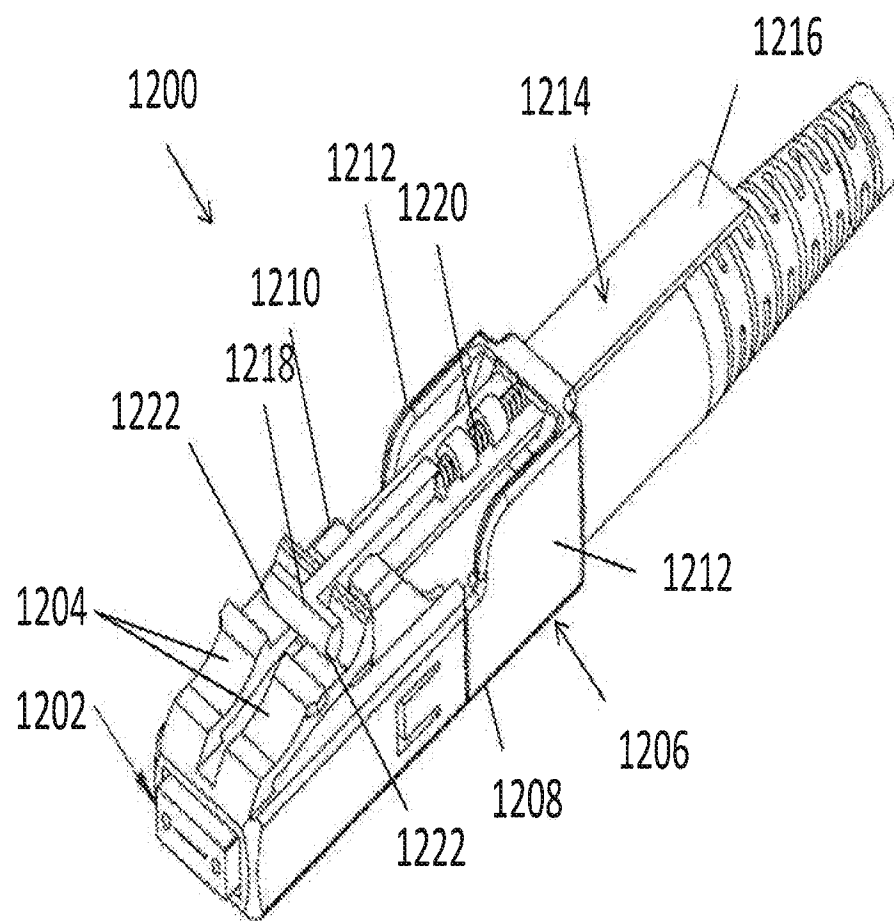


FIG. 12A

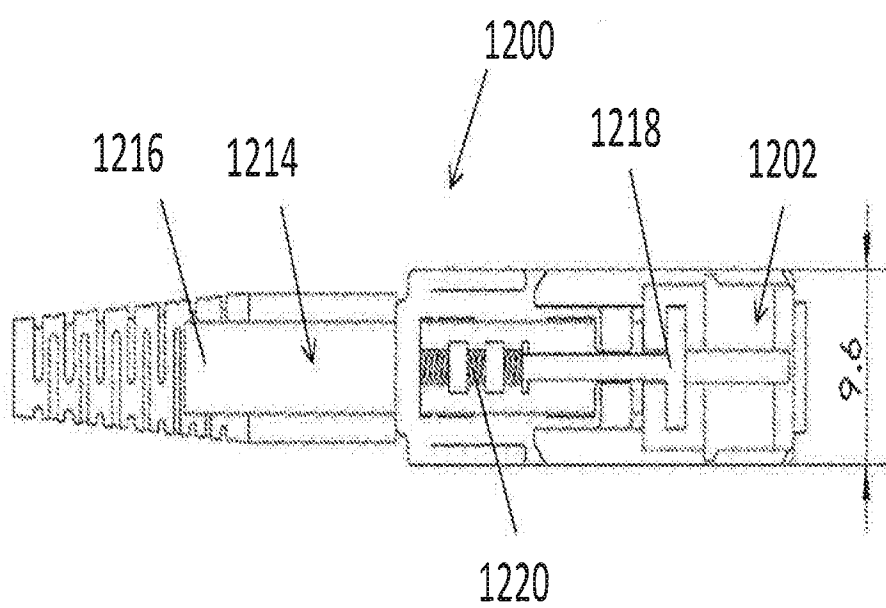


FIG. 12B

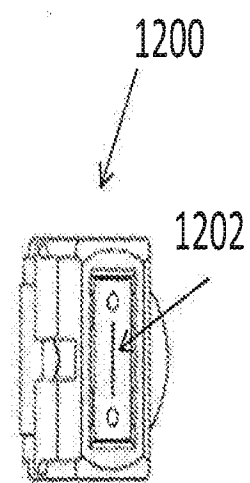


FIG. 12C

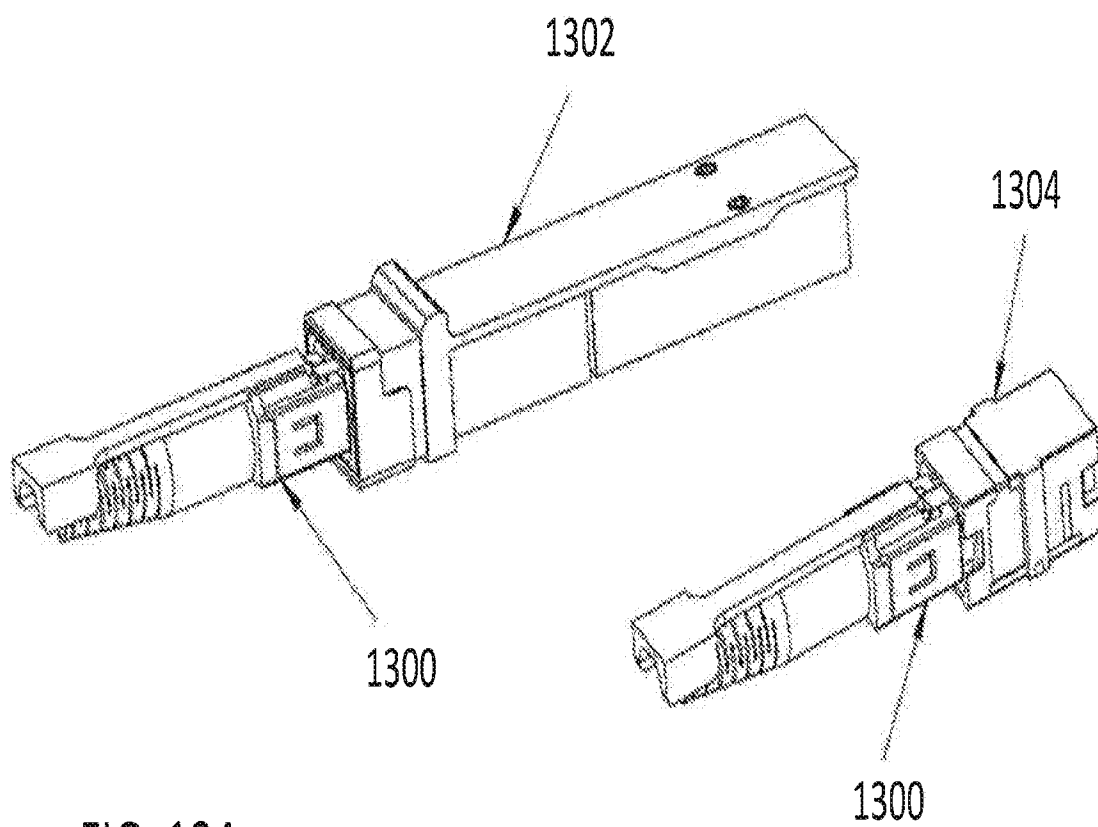


FIG. 13A

FIG. 13B

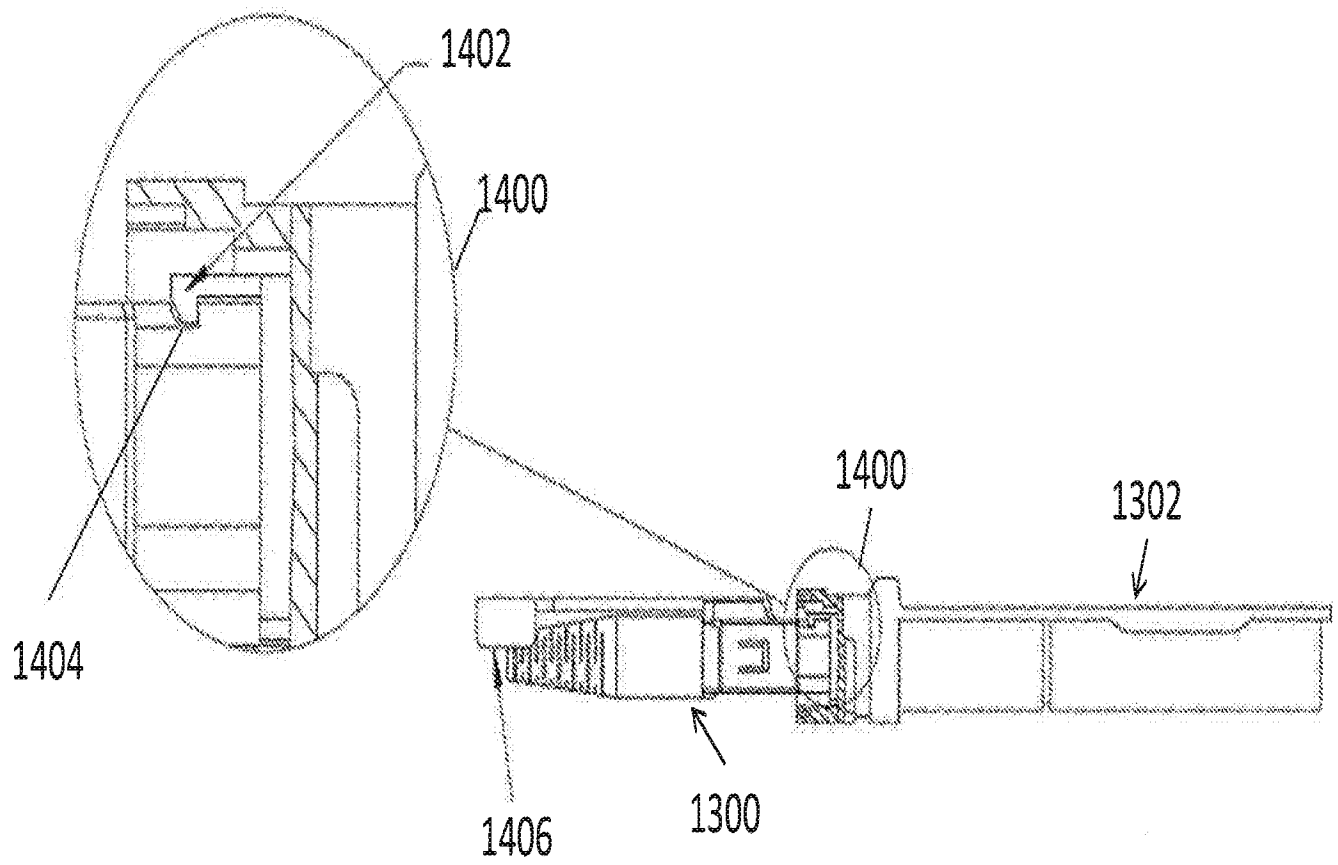


FIG. 14

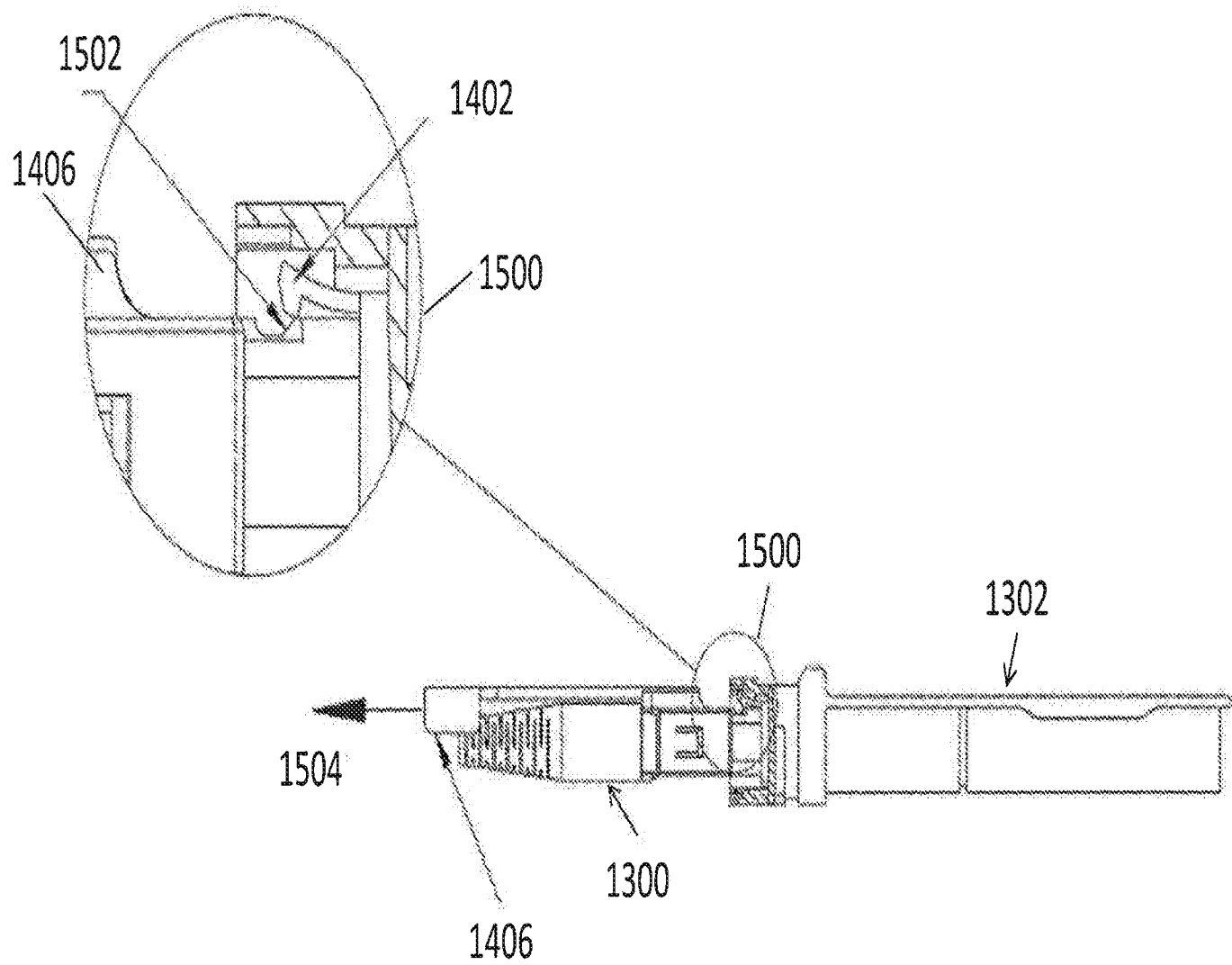


FIG. 15

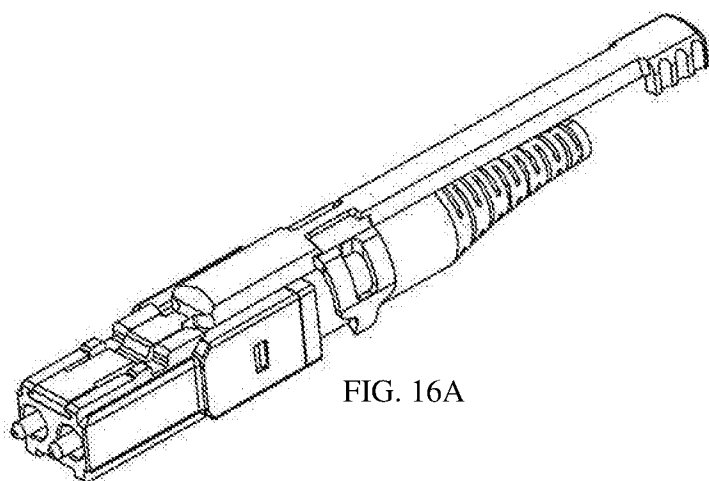


FIG. 16A

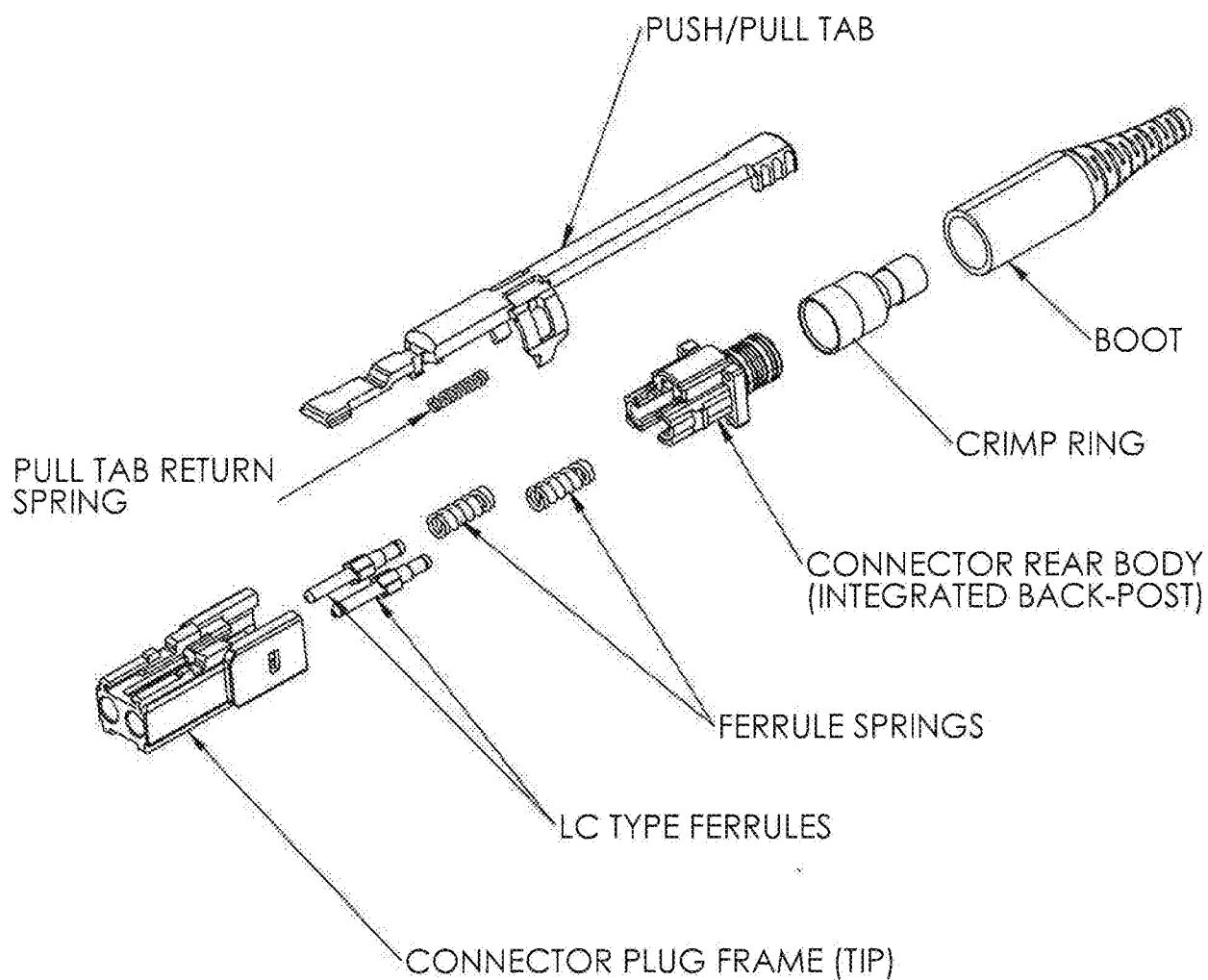


FIG. 16B

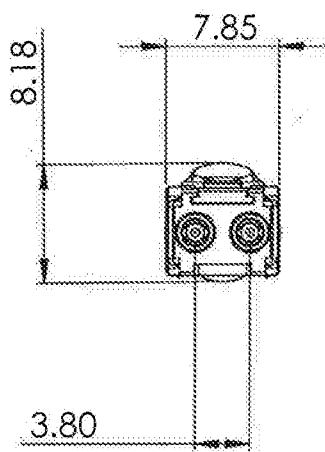


FIG. 17A

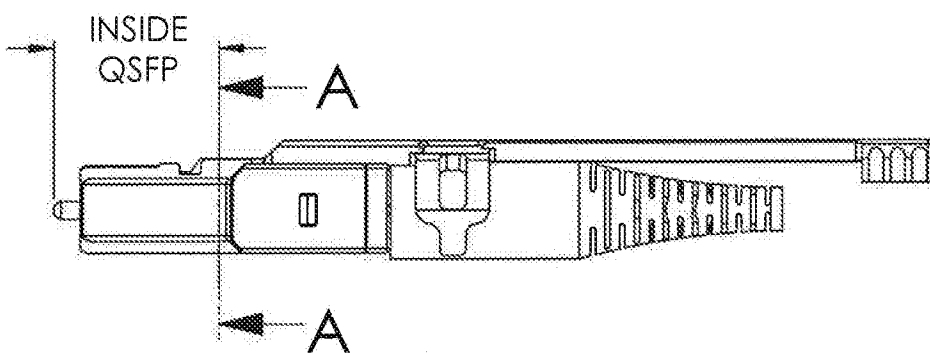


FIG. 17B

A-A
 SIZE OF PLUG FRAME FITTING
 INSIDE THE QSFP

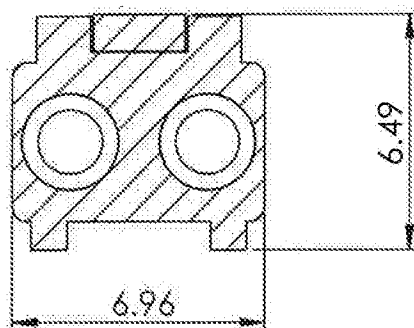


FIG. 17C

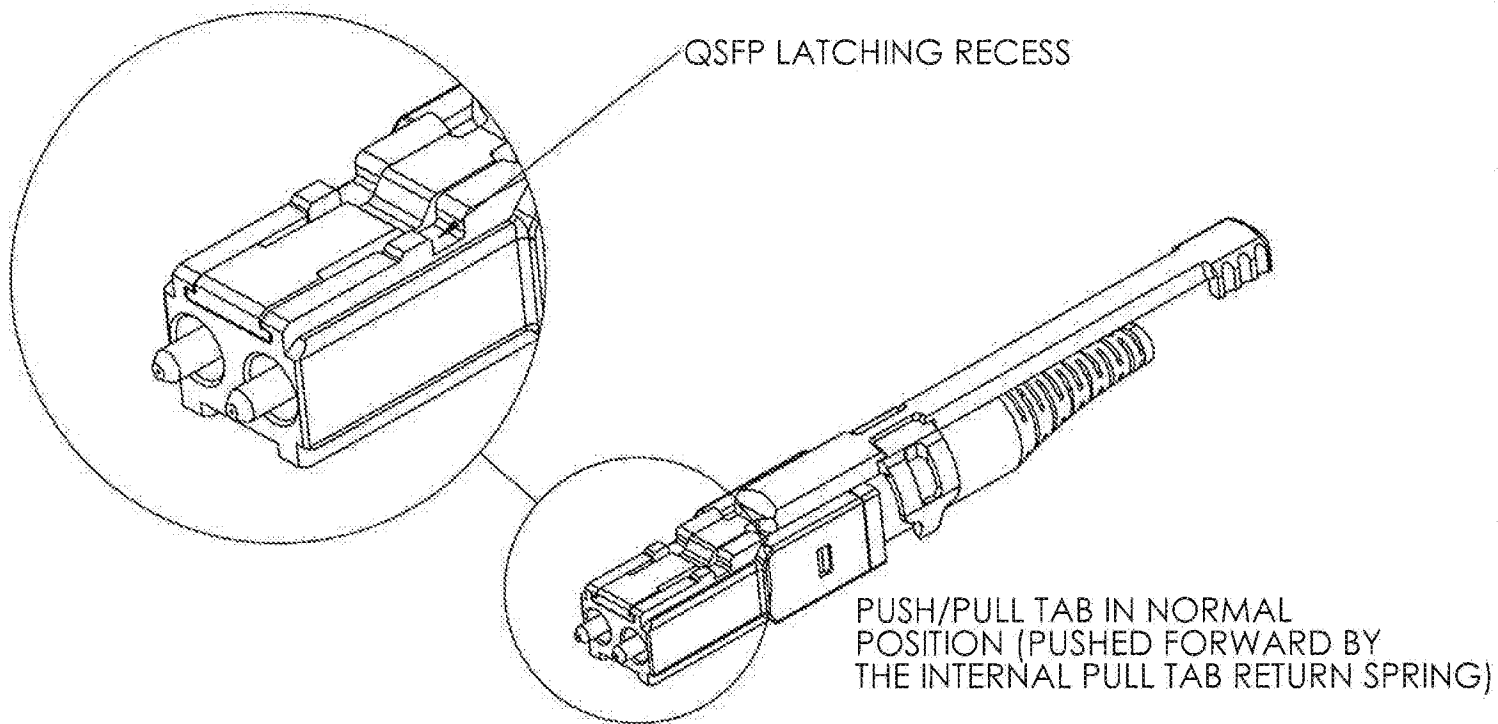


FIG. 17D

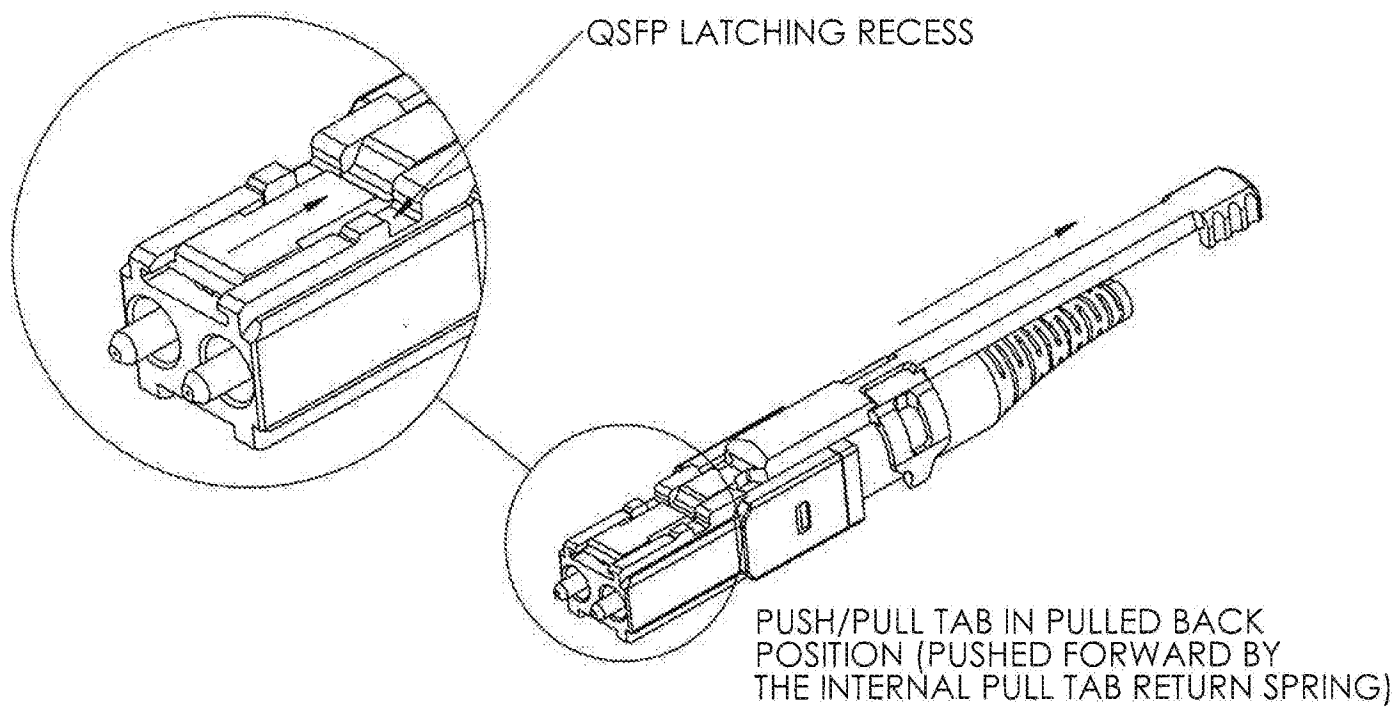


FIG. 17E

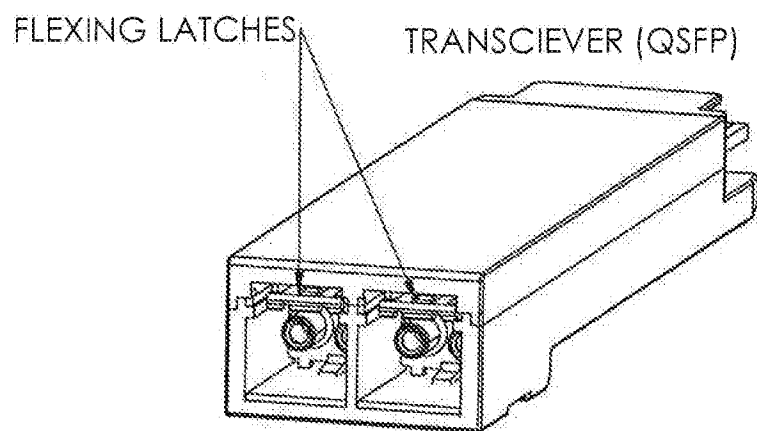


FIG. 18A

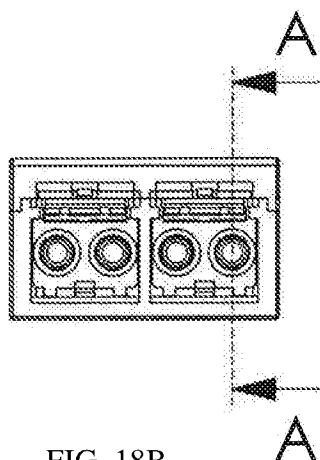


FIG. 18B

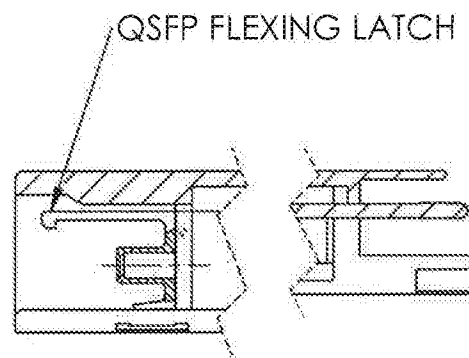


FIG. 18C

QSFP WITH ONE DUAL FERRULE CONNECTOR INSERTED

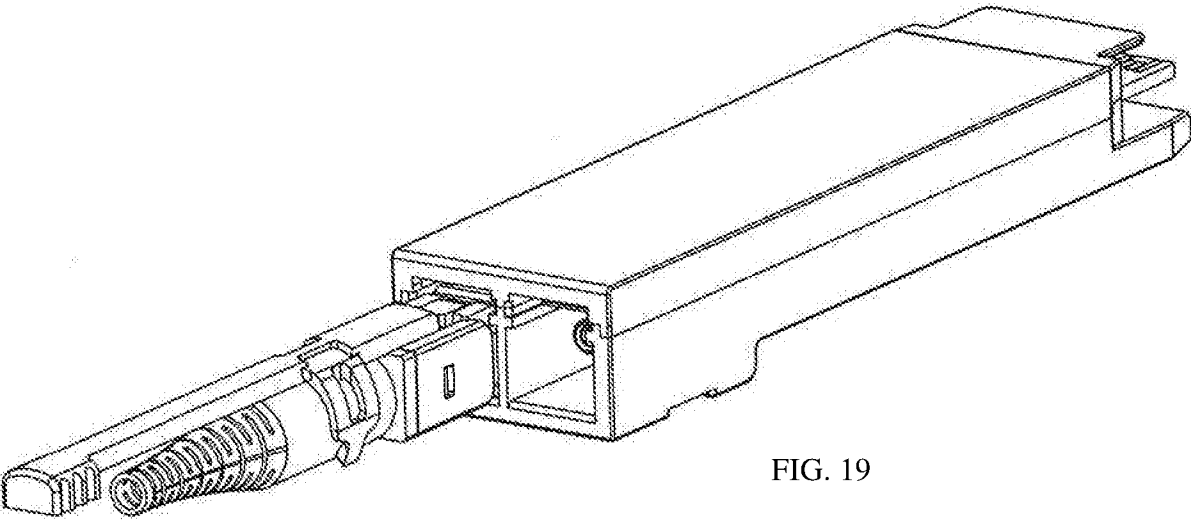


FIG. 19

QSFP LATCH HOLDS THE CONNECTOR
PUSH/PULL TAB IN NORMAL POSITION
(PUSHED FORWARD BY RETURN SPRING)

CONNECTOR
LATCH RECESS

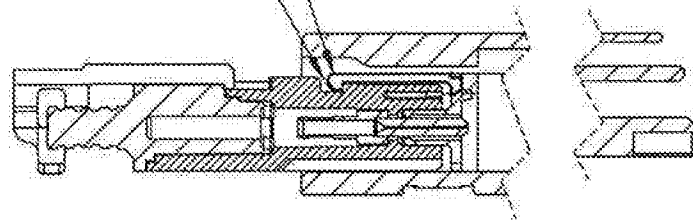


FIG. 20A

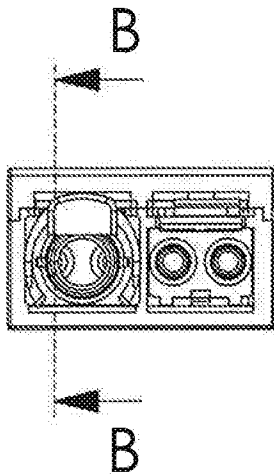
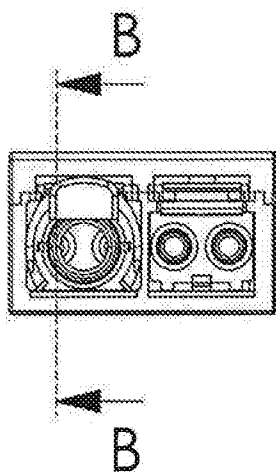
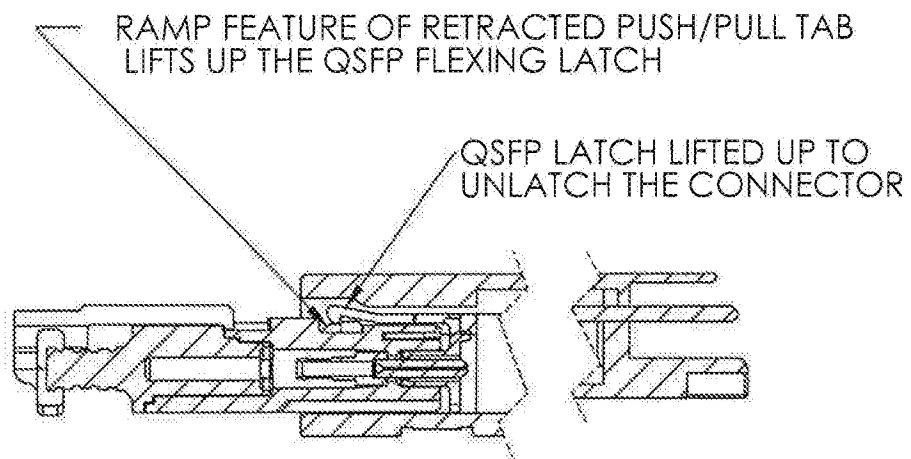
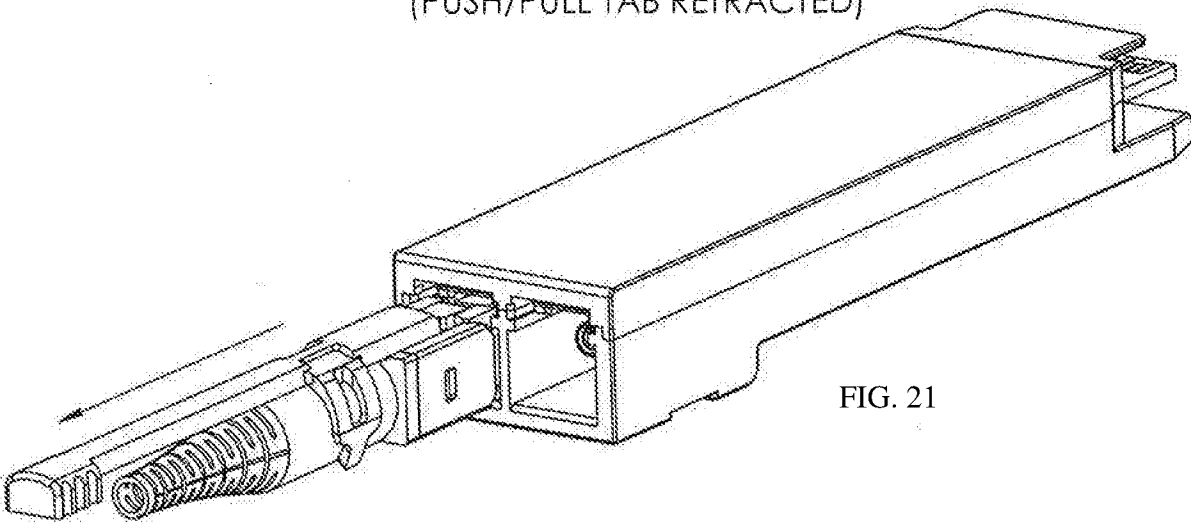
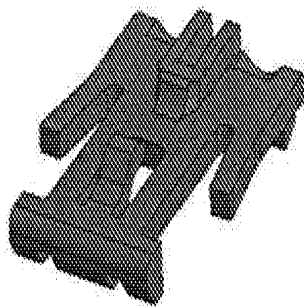


FIG. 20B

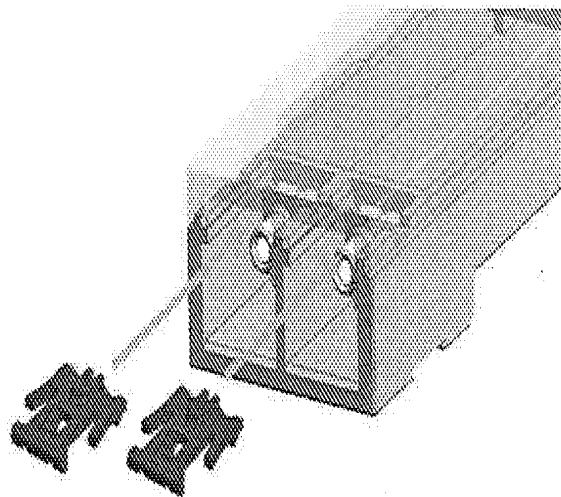
QSFP WITH ONE DUAL FERRULE CONNECTOR INSERTED
(PUSH/PULL TAB RETRACTED)



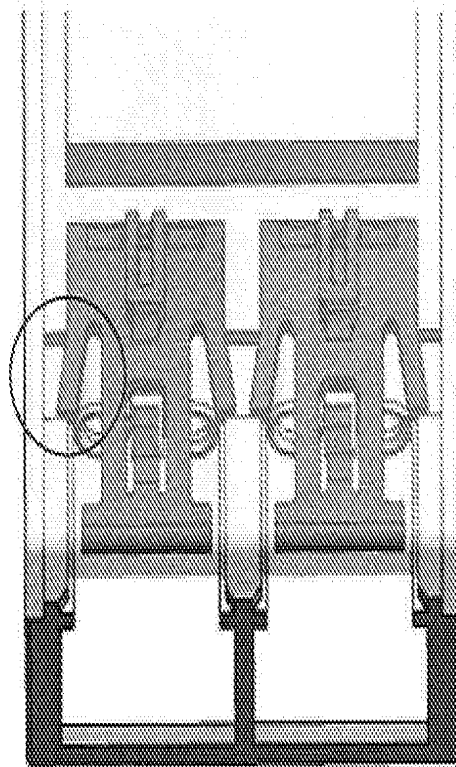
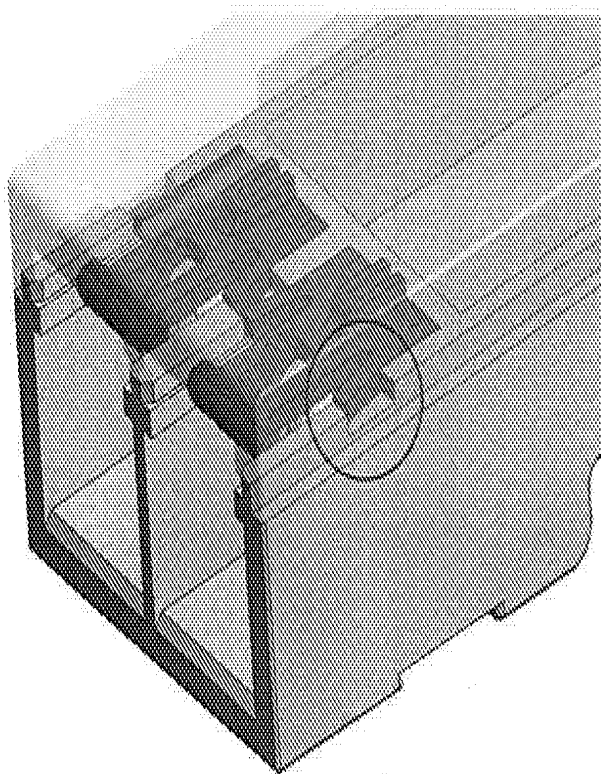
Details on latch part



Plastic molded part



Slide in the parts



Mechanically locked by the latches

ADAPTER WITH ONE DUAL FERRULE CONNECTOR II

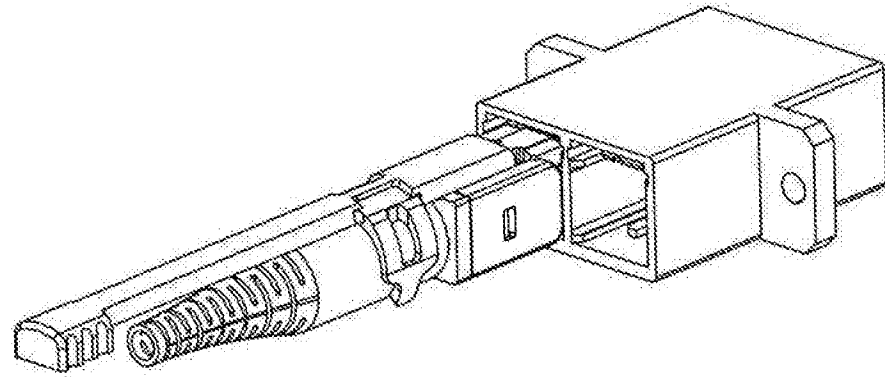


FIG. 24

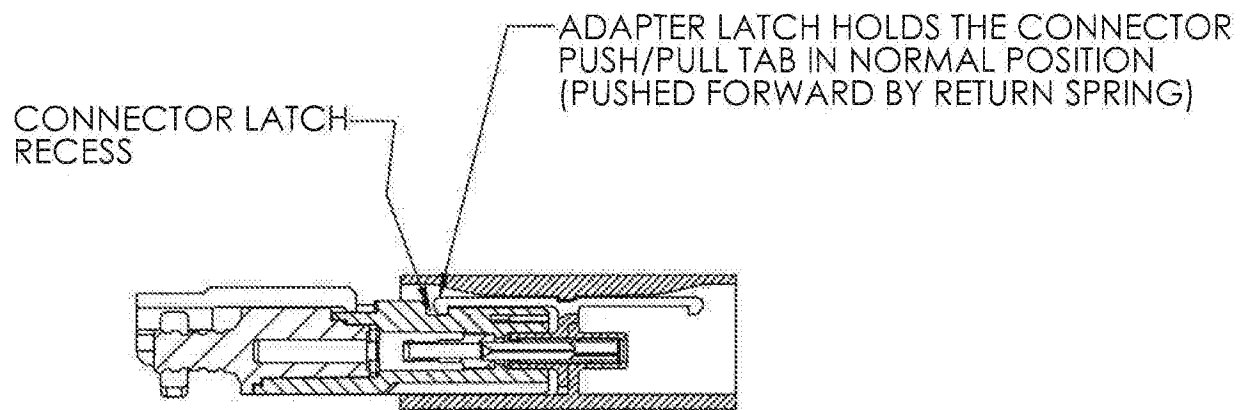


FIG. 25A

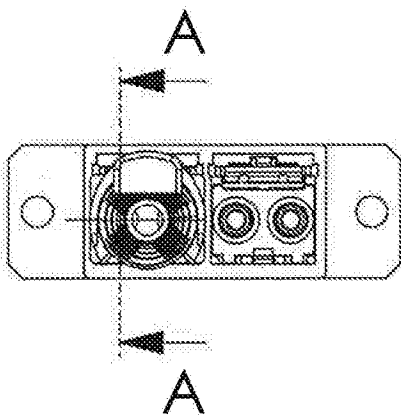


FIG. 25B

ADAPTER WITH ONE DUAL FERRULE CONNECTOR INSERTED
(PUSH/PULL TAB RETRACTED)

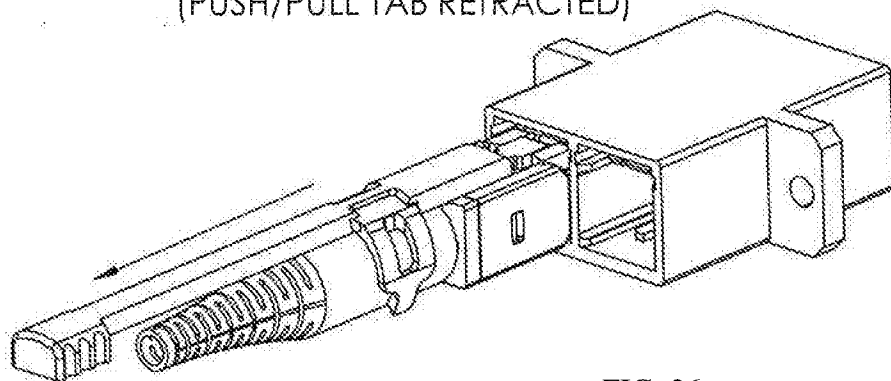


FIG. 26

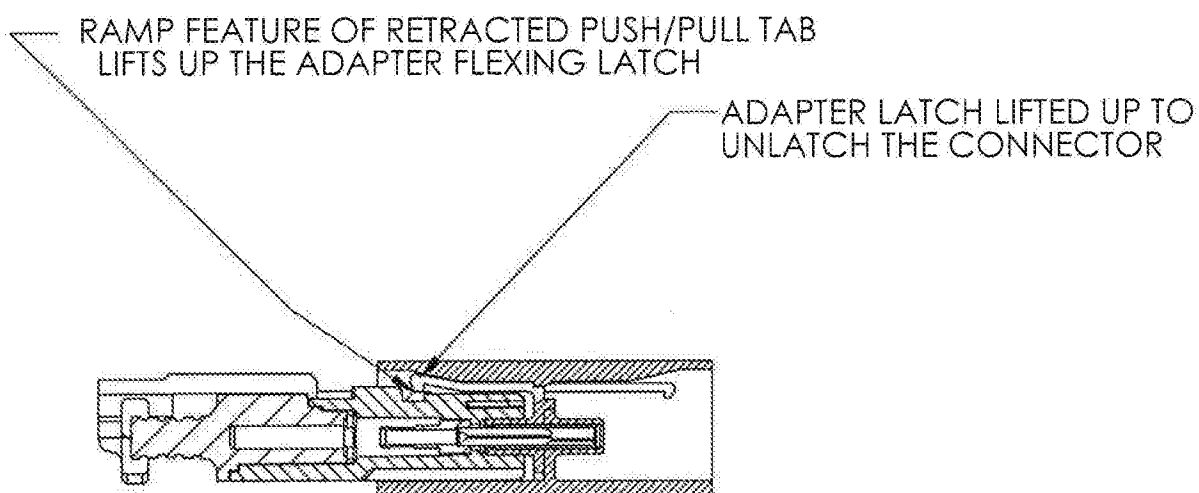


FIG. 27A

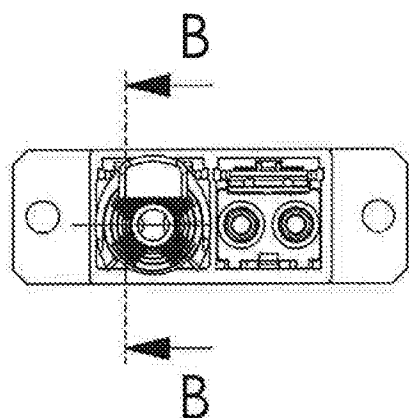


FIG. 27B

LATCH HOOKS SLIDE INTO AND SNAP INTO PLACE DURING ADAPTER ASSEMBLY

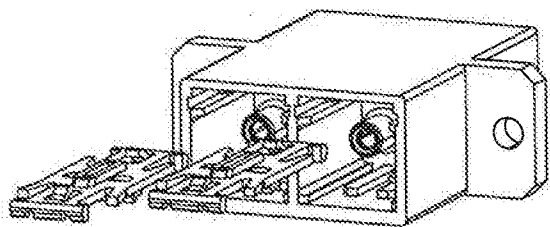


FIG. 28A

ASSEMBLED ADAPTER

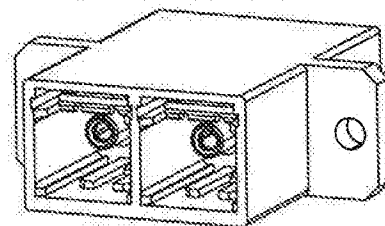
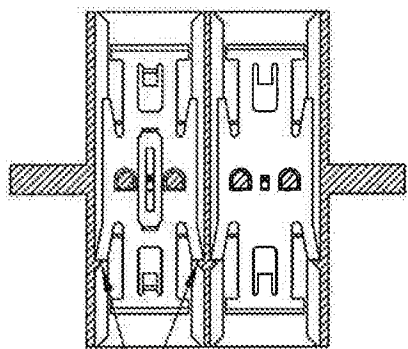


FIG. 28B



A-A HOOK SNAPS INTO ADAPTER BODY DURING ADAPTER ASSEMBLY

FIG. 28C

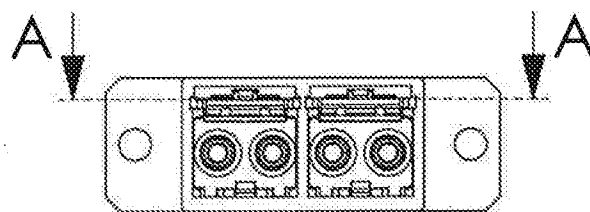


FIG. 28D

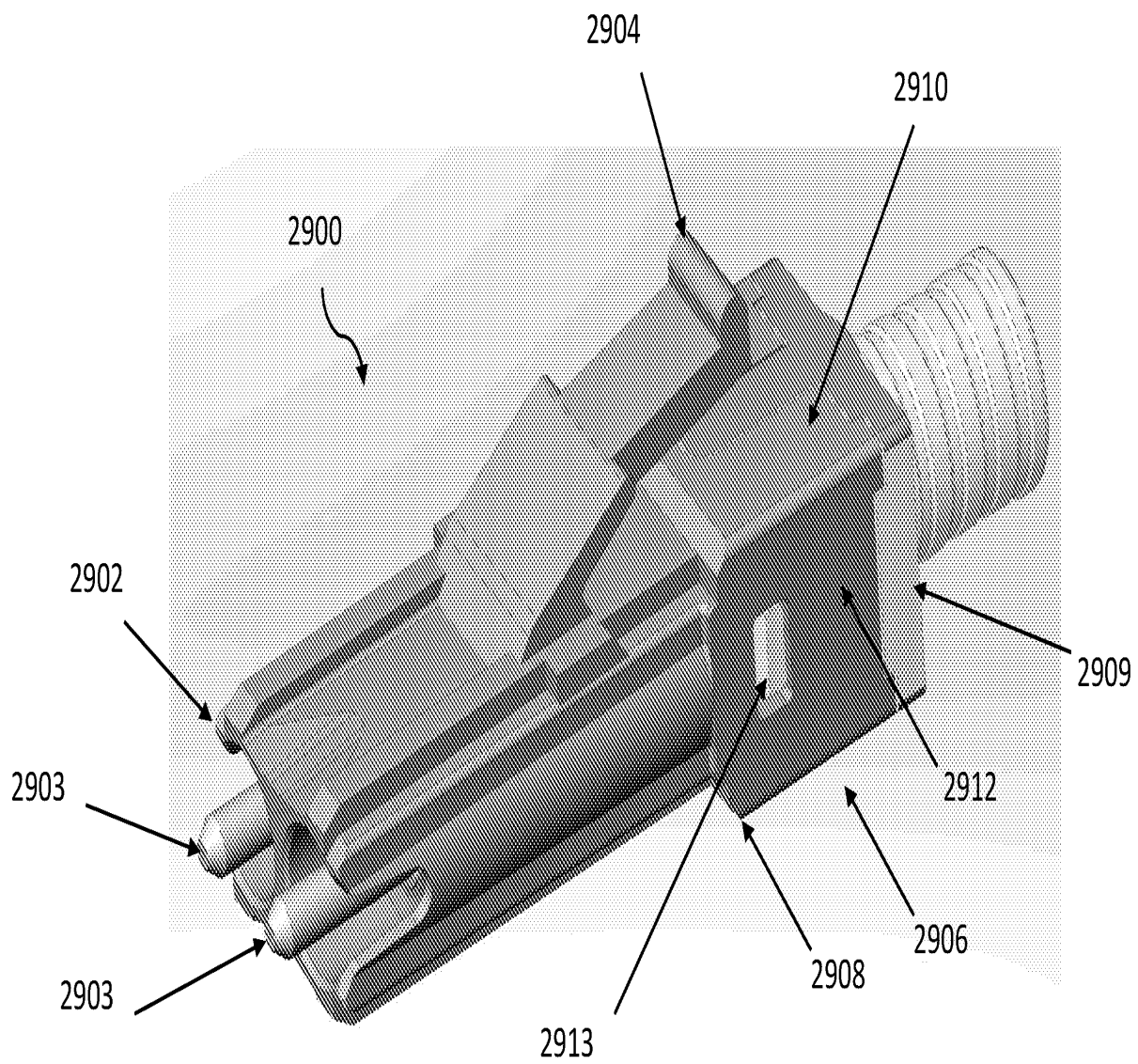


FIG. 29

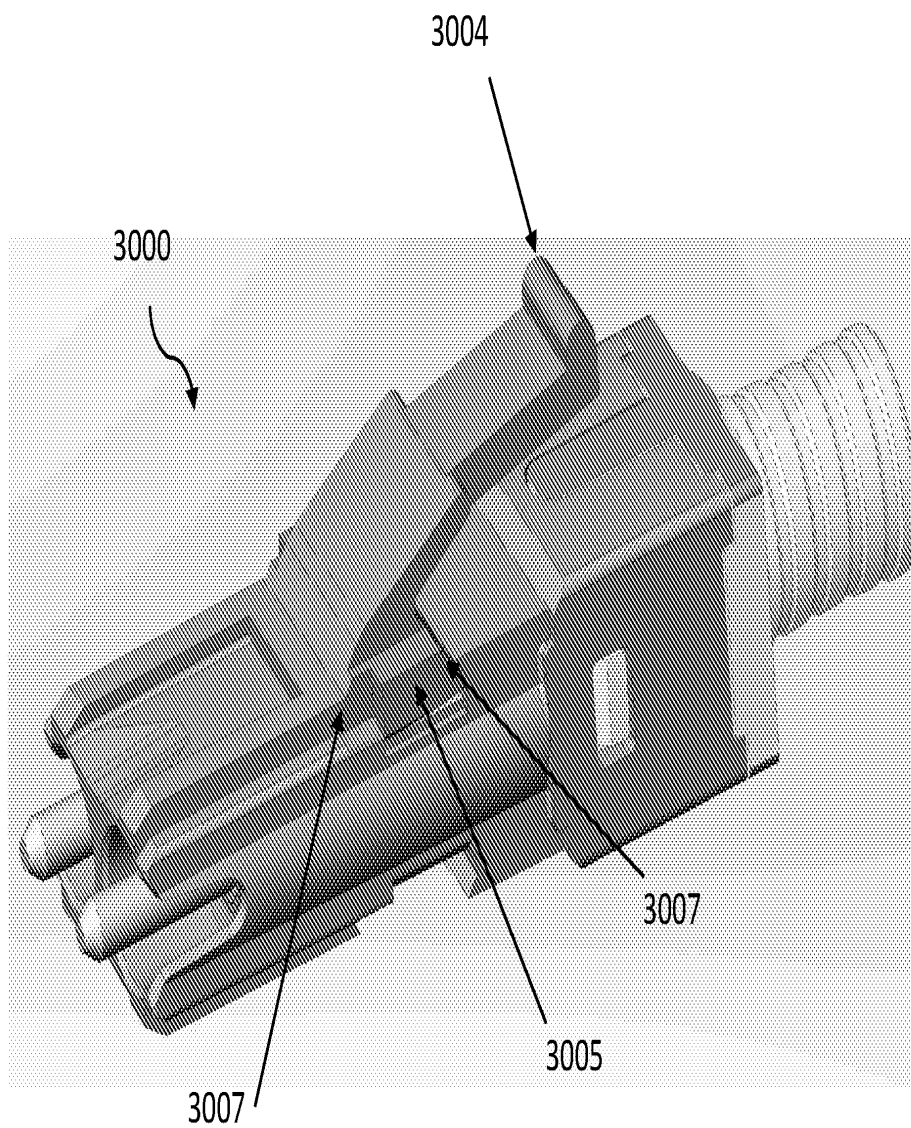


FIG. 30

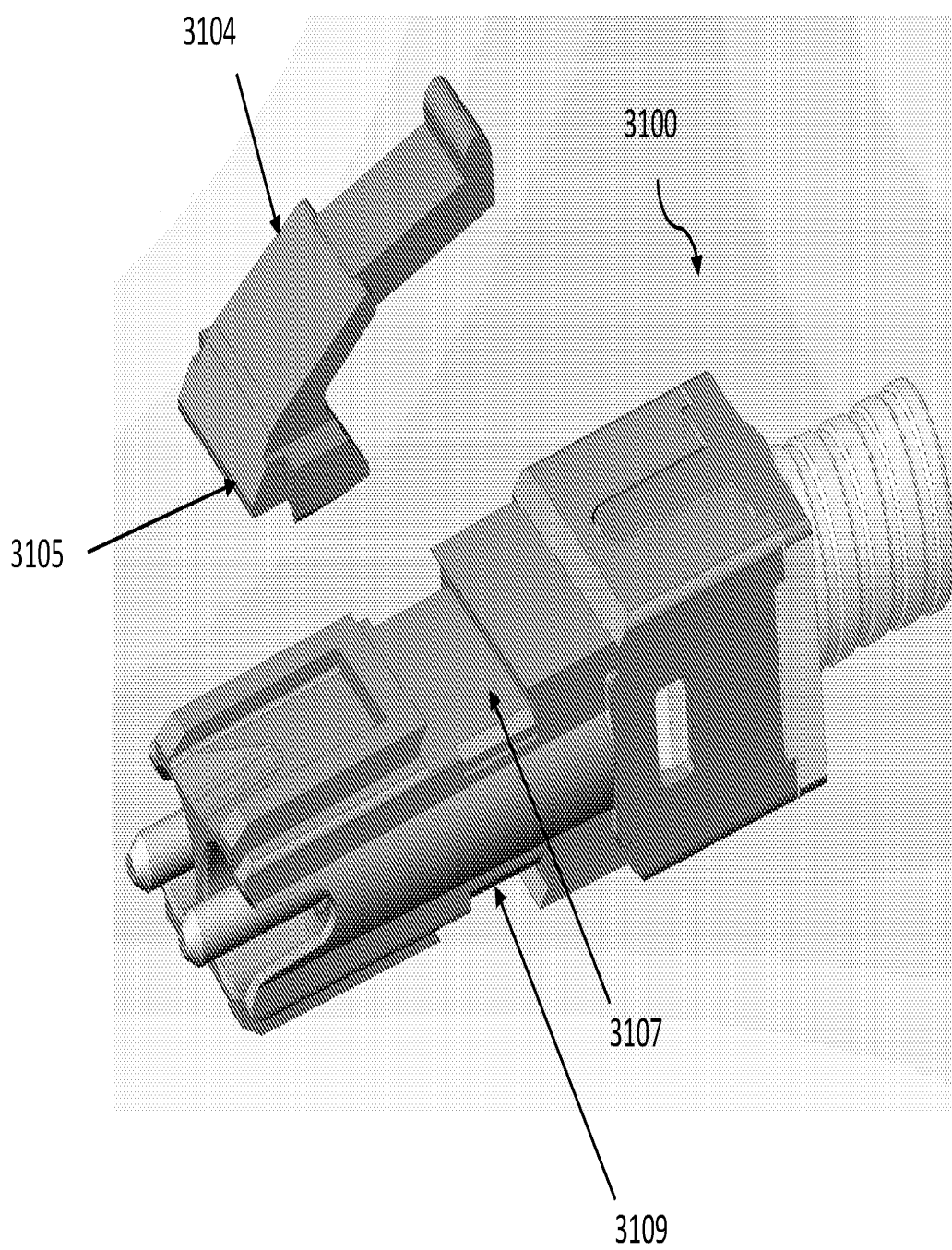


FIG. 31

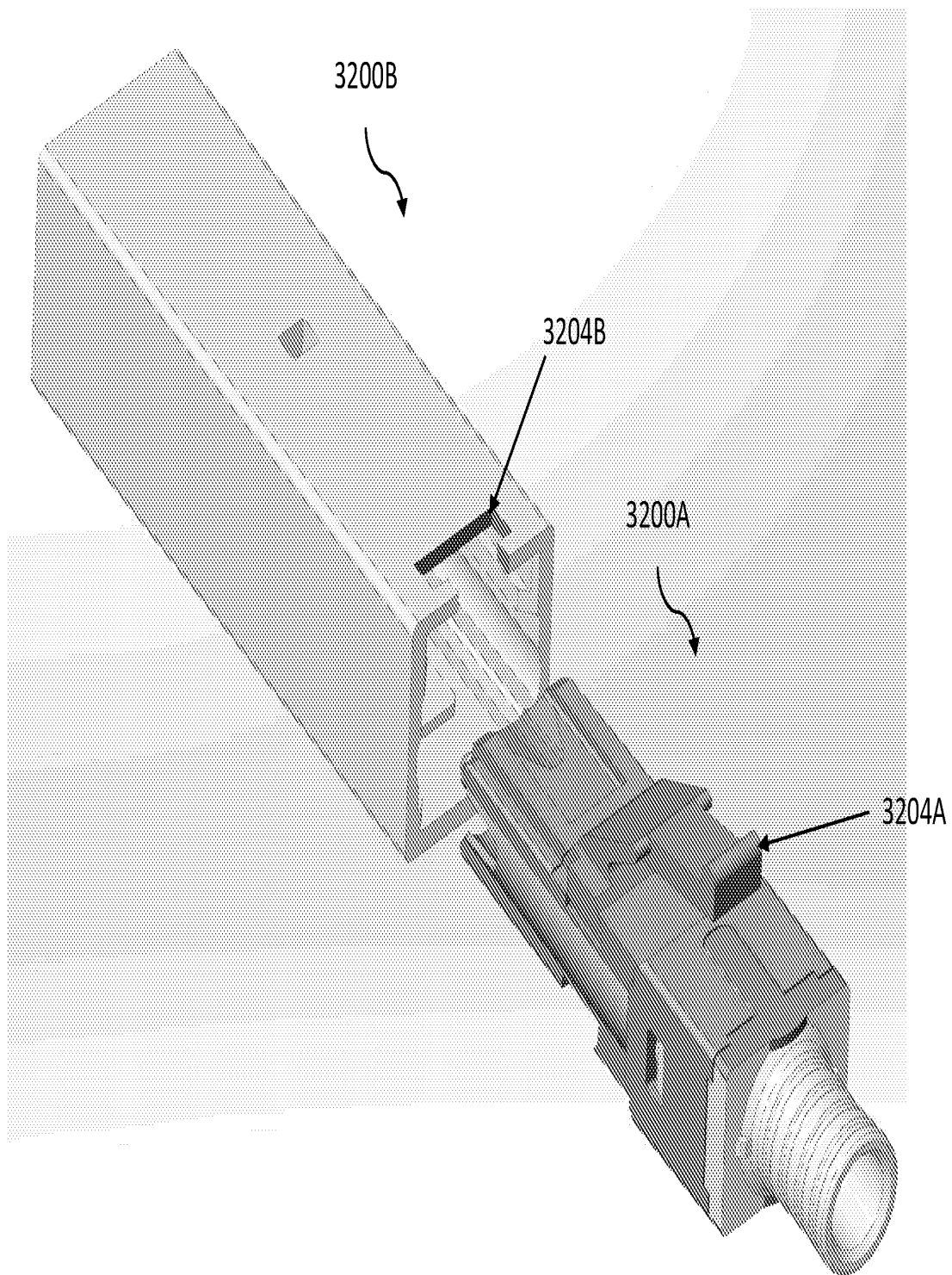


FIG. 32

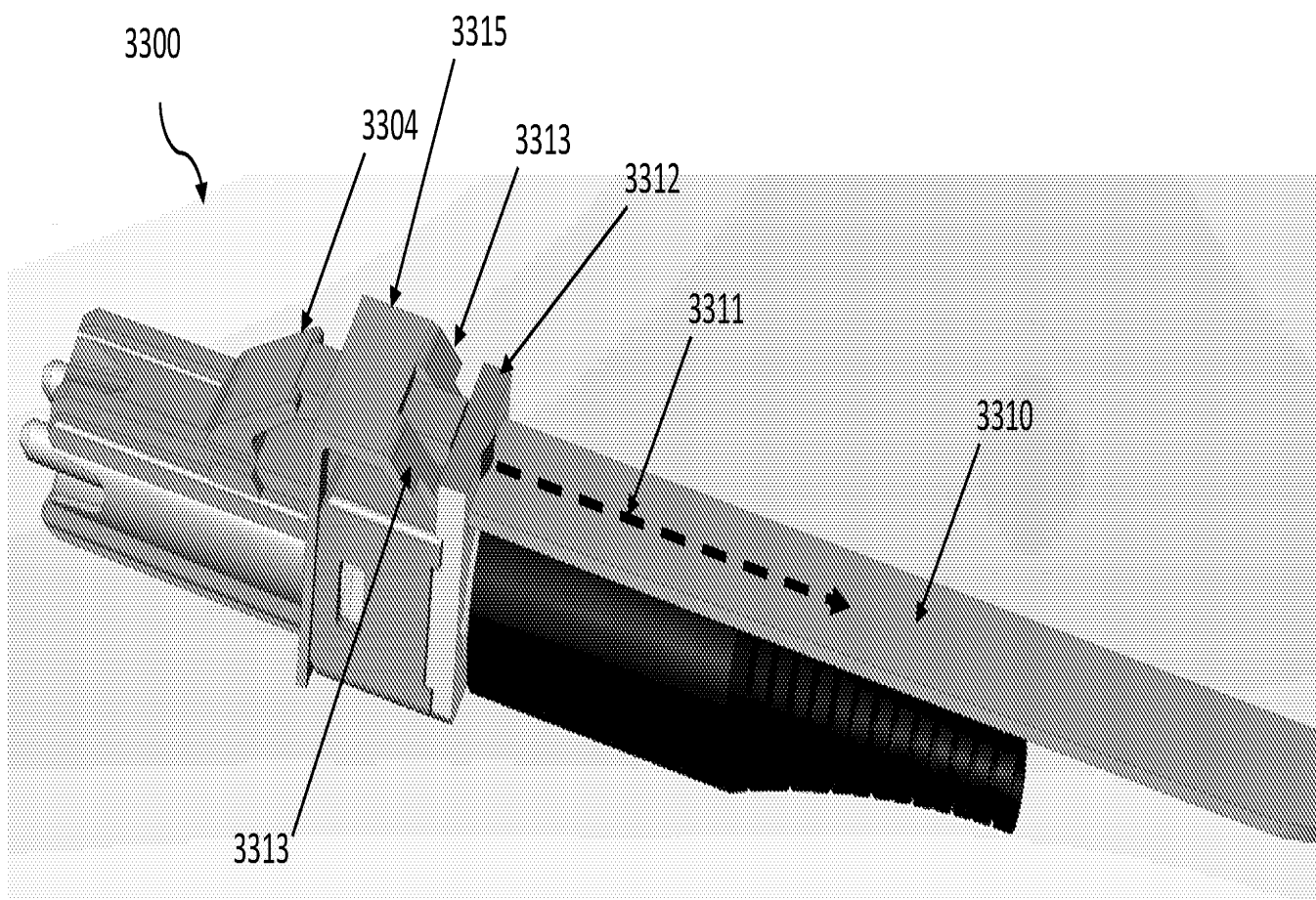


FIG. 33

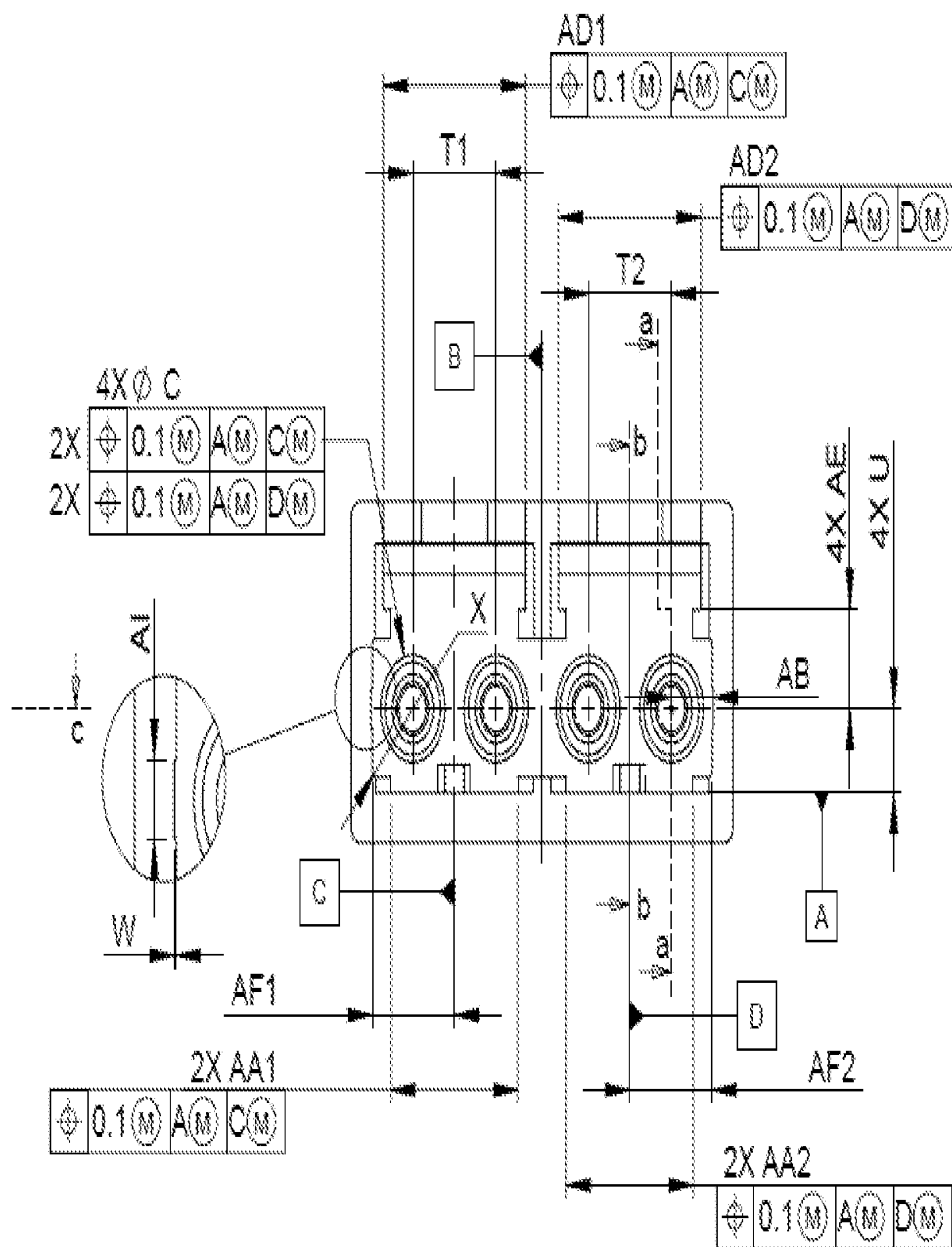


FIG. 34

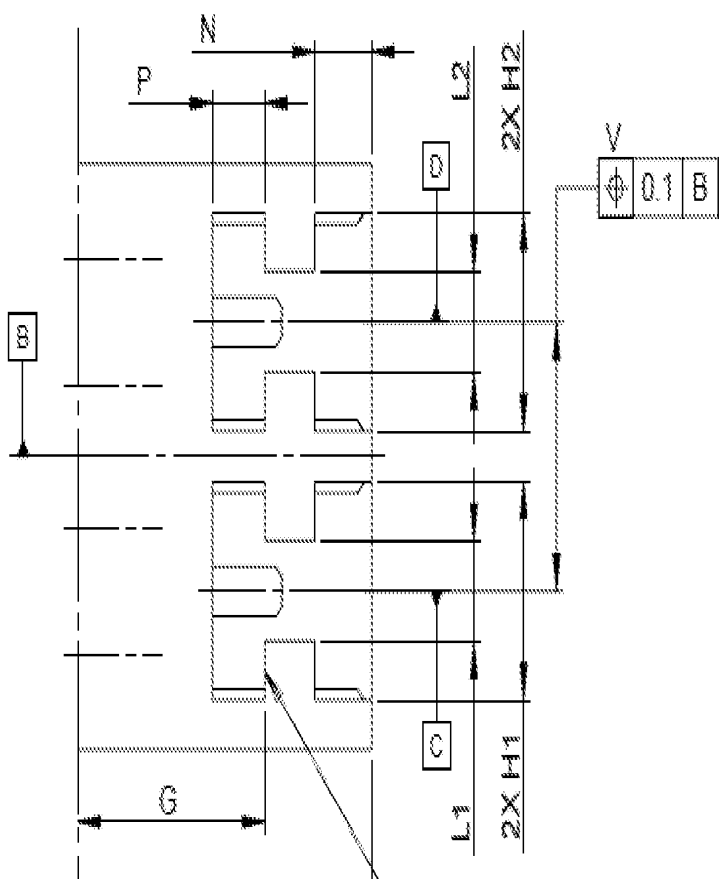


FIG. 35A

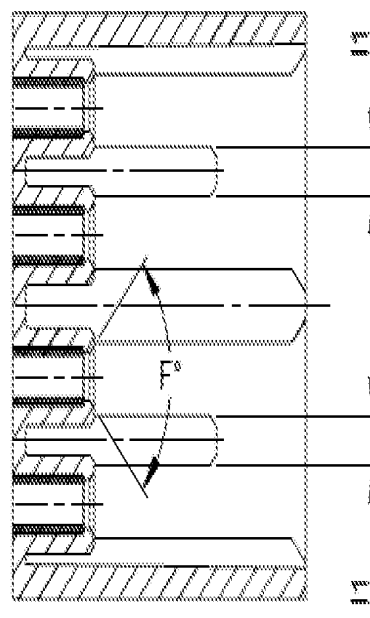


FIG. 35B

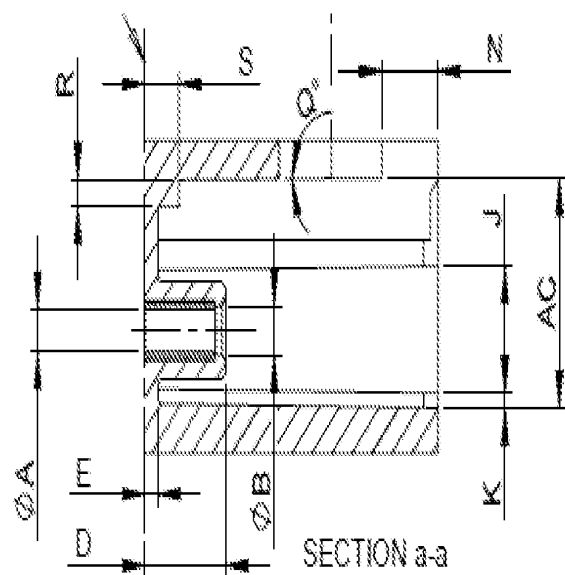


FIG. 36A

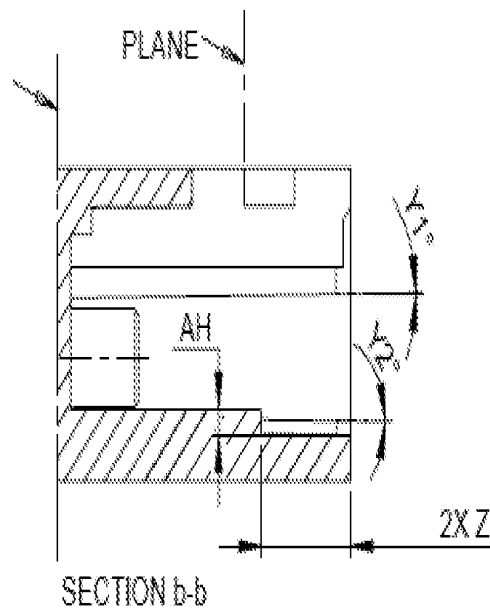


FIG. 36B

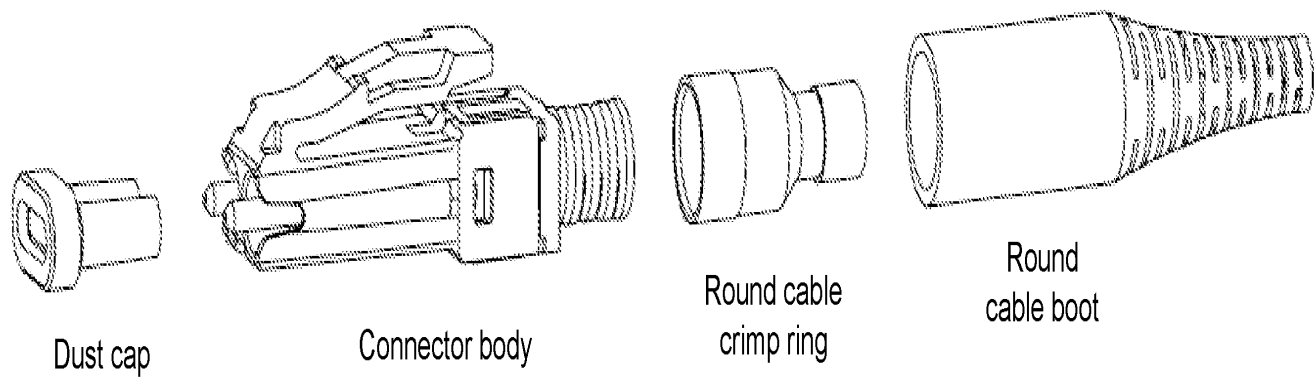
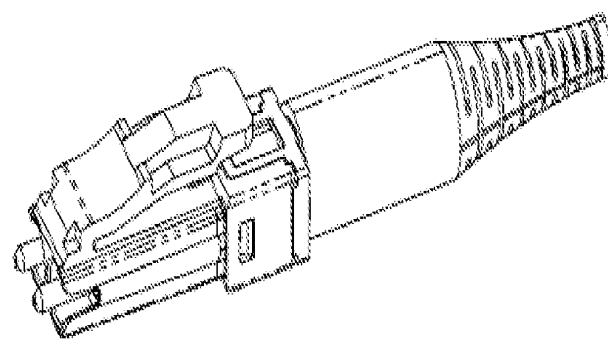
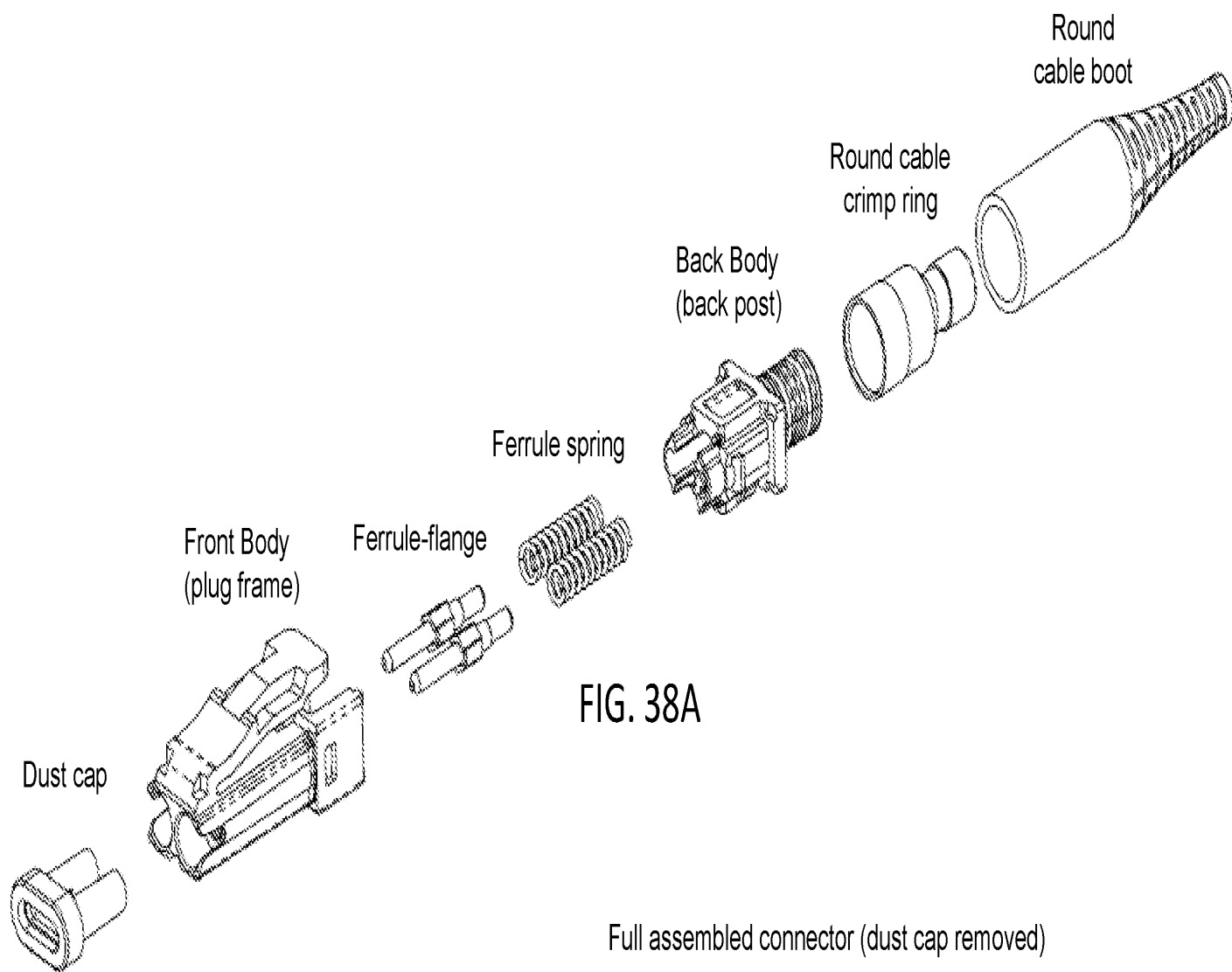


FIG. 37



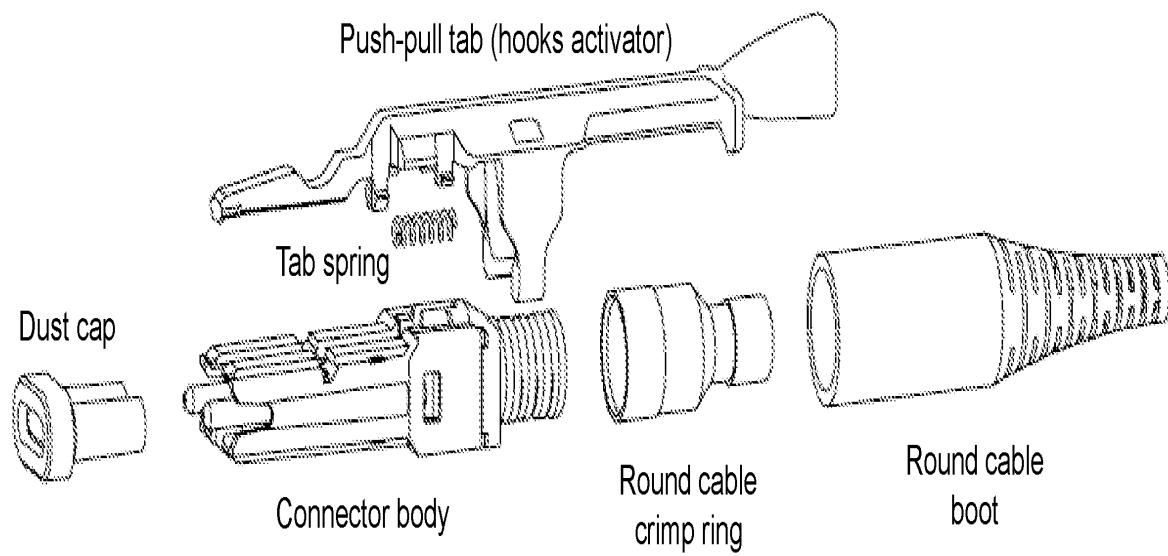


FIG. 39

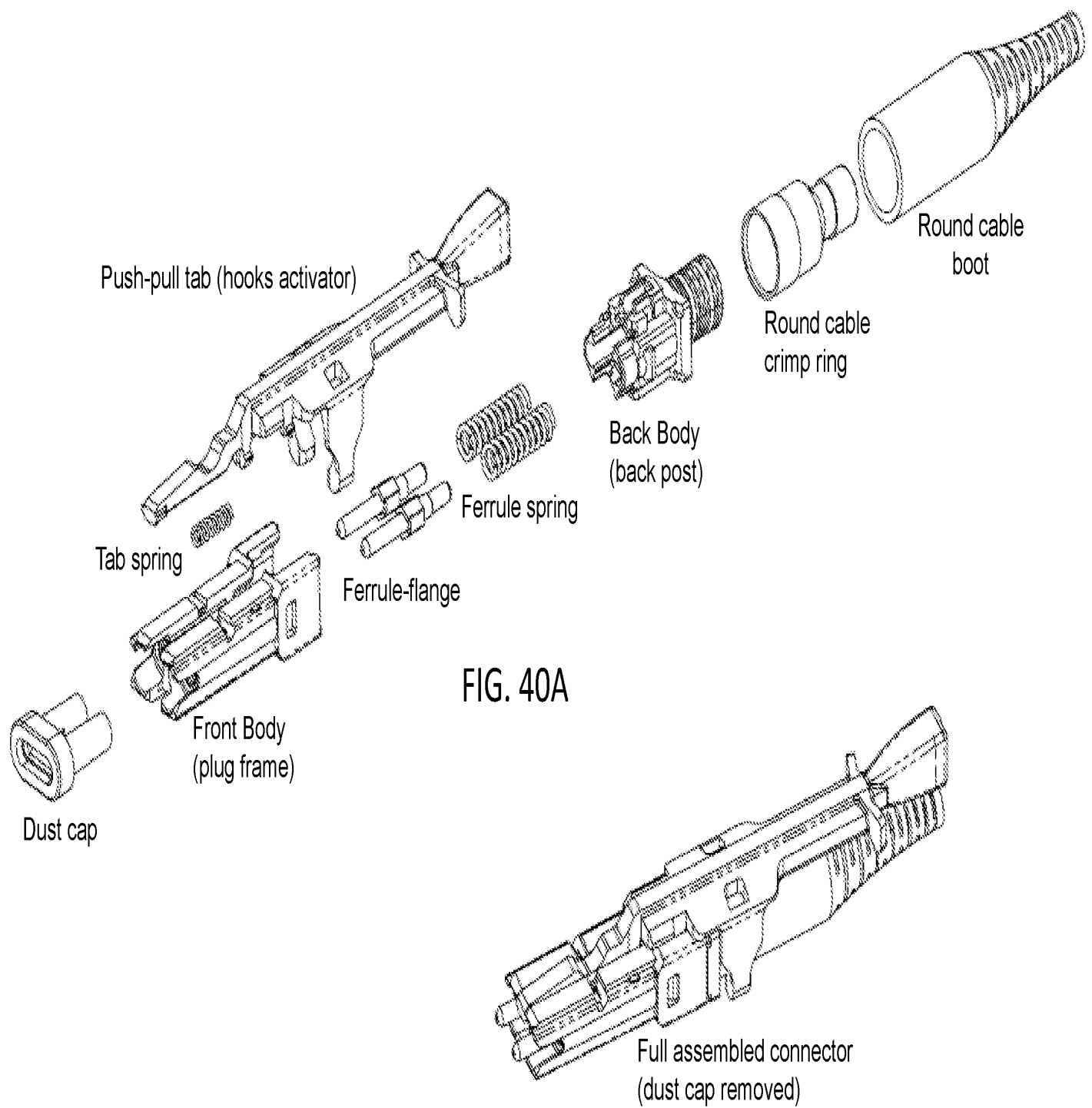


FIG. 40B

Adapter for Latch style (no hook)

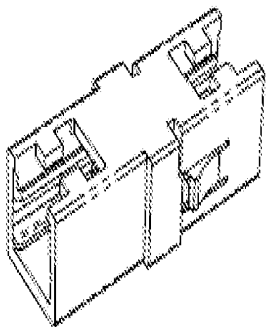


FIG. 41A

Connector plugged into Adapter

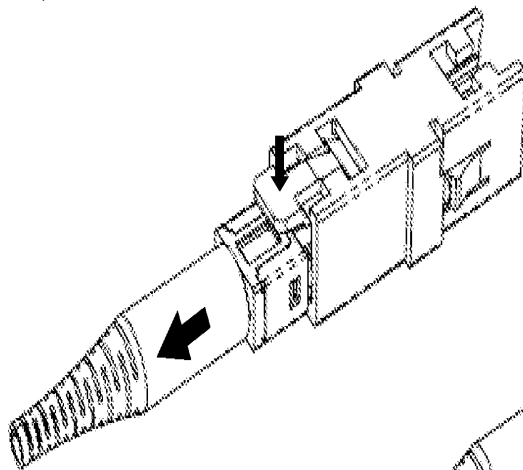


FIG. 41B

Connector latch pressed downwards,
release from Adapter unit

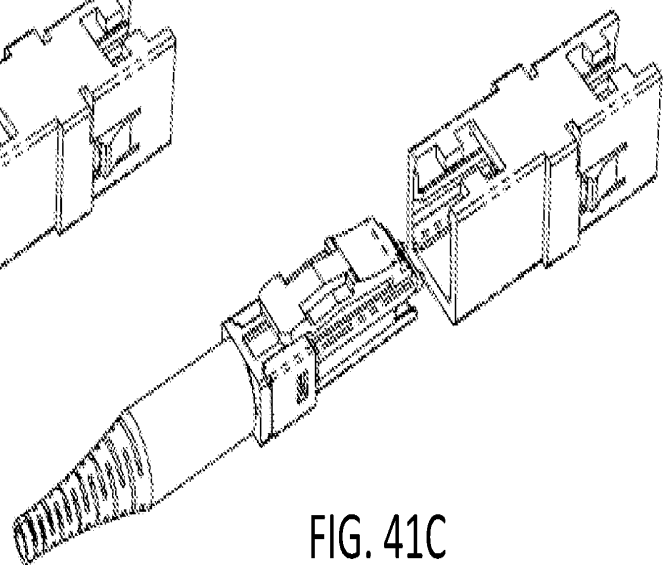


FIG. 41C

Adapter for Pull-release
style (with hooks)

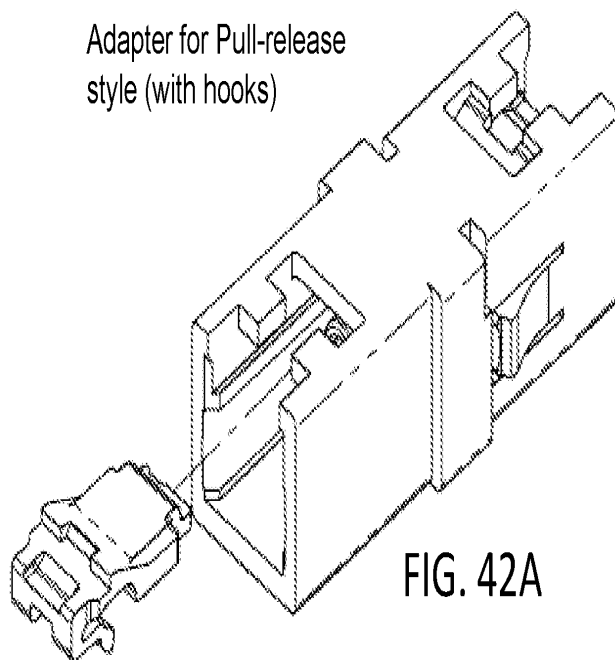


FIG. 42A

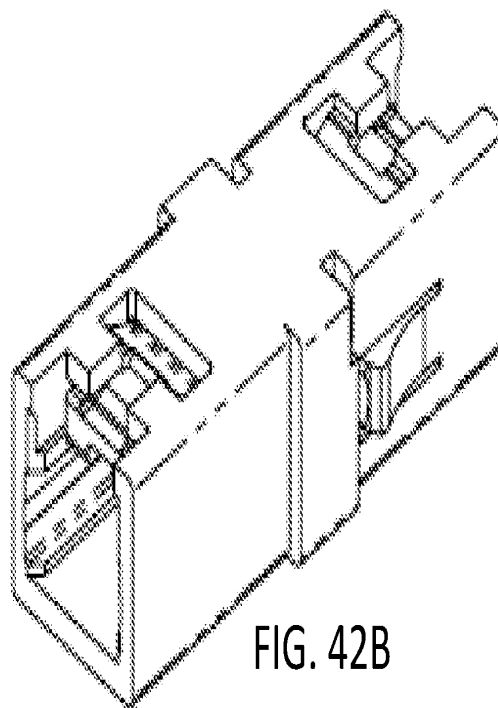


FIG. 42B

Cross-section shows unlatching process

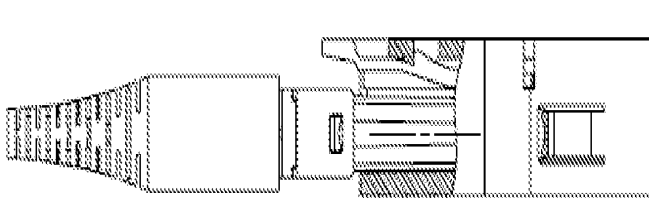


FIG. 43A

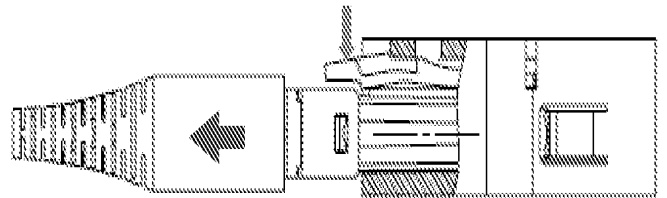


FIG. 43B

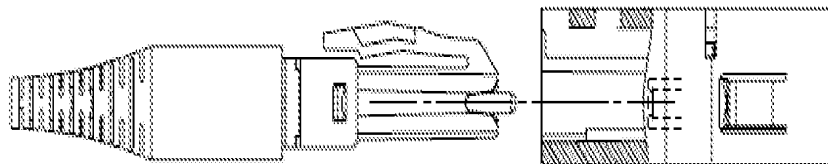


FIG. 43C

Connector being plugged into Adapter

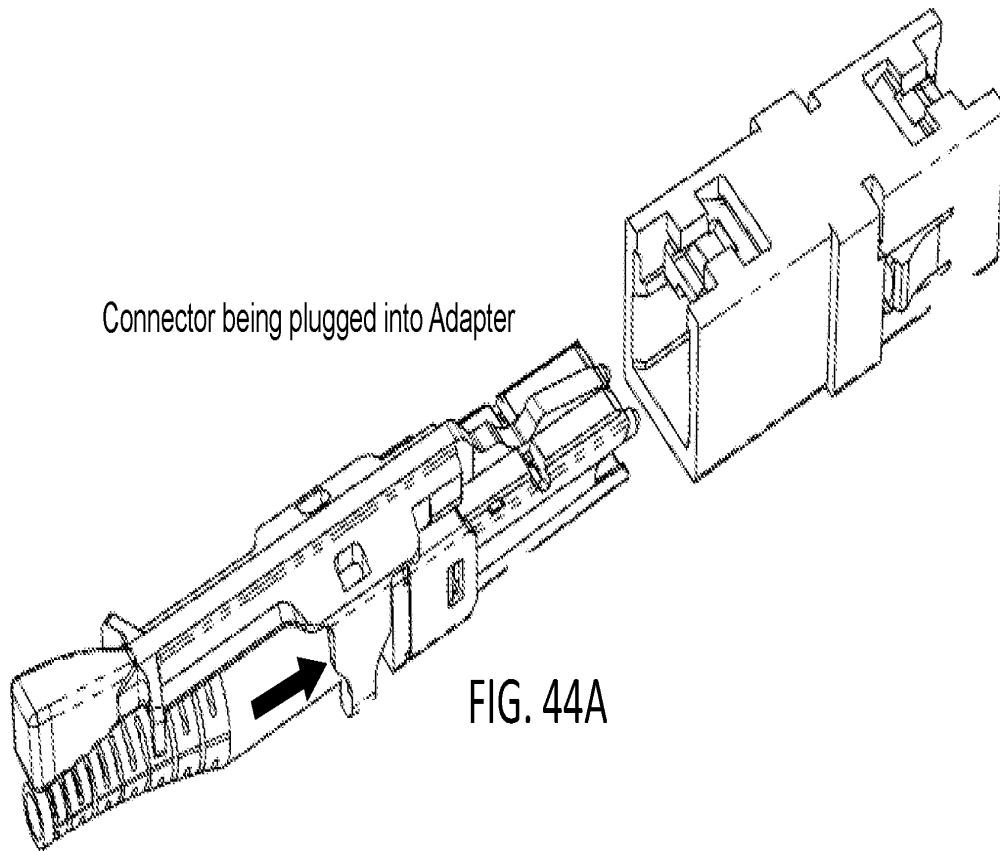


FIG. 44A

Connector plugged into Adapter

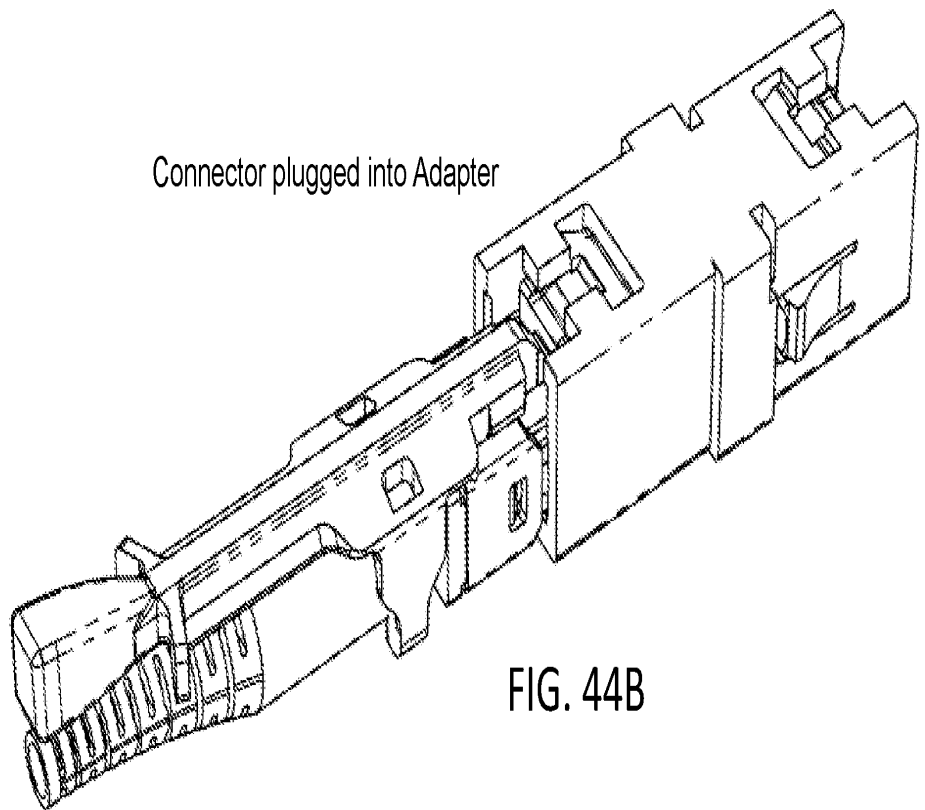


FIG. 44B

Cross-section shows plugging in process

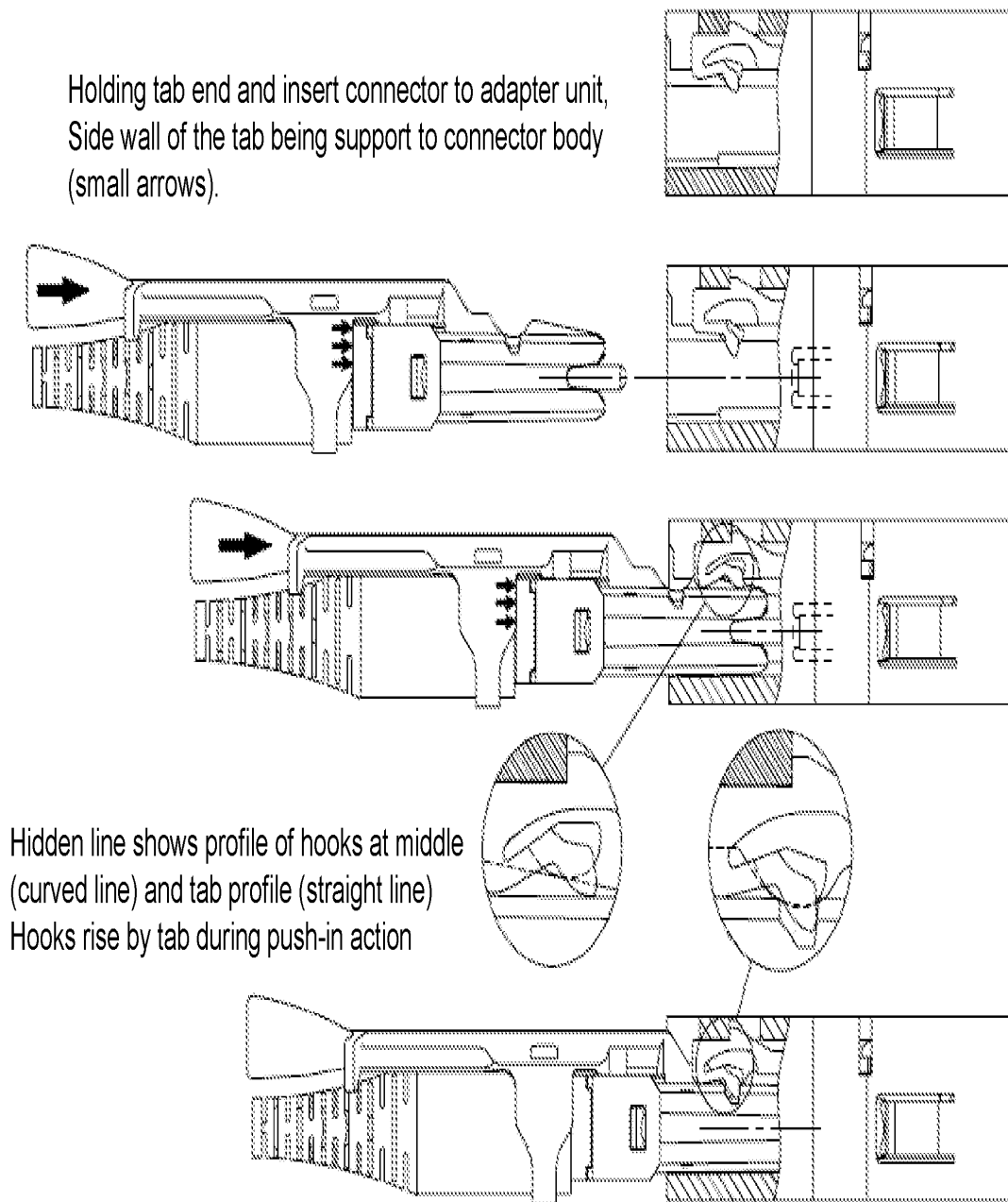


FIG. 45

Push-pull tab and Hook
(profile for activation of
mechanism)

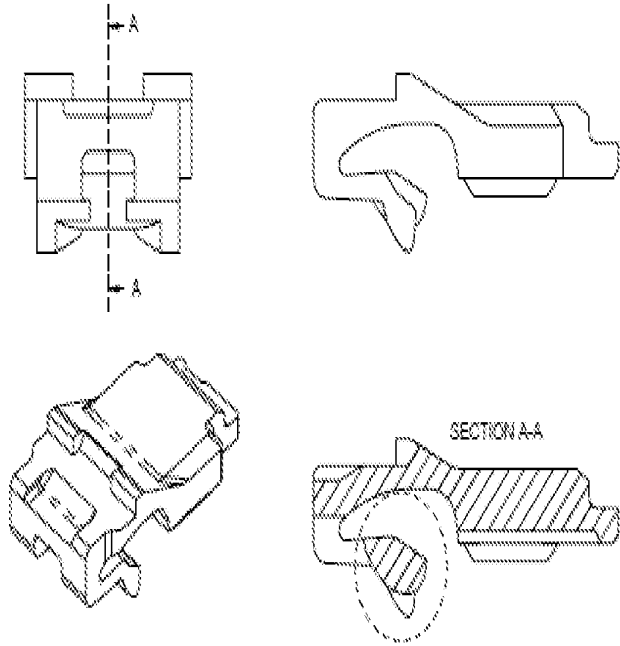


FIG. 46A

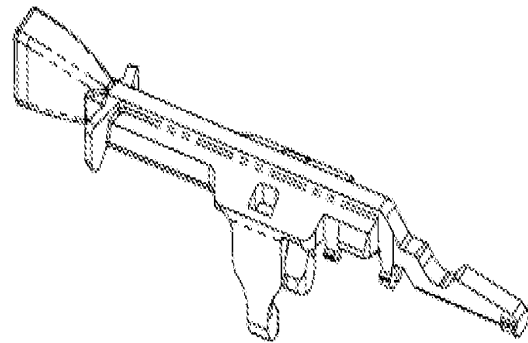


FIG. 46B