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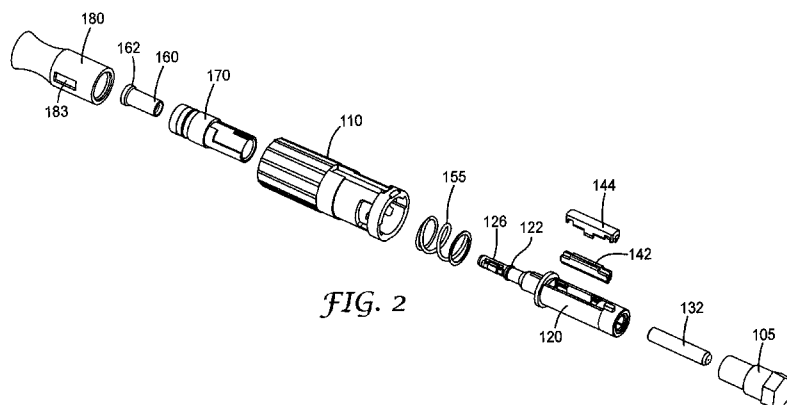
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(54) Title: FIELD TERMINABLE ST FORMAT OPTICAL FIBER CONNECTOR



(57) Abstract: An ST format optical connector for terminating an optical fiber comprises a housing configured to mate with an ST receptacle or coupling, the housing having an ST bayonet-style format. The ST format optical connector also includes a collar body and a retainer disposed in the housing, where the collar body is retained between the housing and the retainer. The housing is prevented from fully rotating about the collar body and retainer. In addition, the connector can be deactivated for fiber repositioning or reuse. The ST format optical connector can be configured either as a stub fiber or remote grip type connector.

FIELD TERMINABLE ST FORMAT OPTICAL FIBER CONNECTOR**CROSS-REFERENCE TO RELATED APPLICATION**

This application claims the benefit of U.S. Provisional Patent Application No. 61/701180, filed September 14, 2012, the disclosure of which is incorporated by reference herein in its entirety.

BACKGROUND OF THE INVENTION**Field of the Invention**

The present invention is directed to an optical connector.

Related Art

Mechanical optical fiber connectors for the telecommunications industry are known. For example, LC, ST, FC, and SC optical connectors are widely used.

ST (straight tip) connectors were developed by AT&T for fiber network implementations. These connectors have a bayonet-style mechanism that allows for connection/disconnection to a coupling or receptacle with a twist-on/twist-off motion.

Many ST connectors were made by inserting a bare fiber into a hollow ferrule and bonding the fiber into the ferrule with, typically, an epoxy-based adhesive.

Also known are hybrid optical splice connectors, as described in JP Patent No. 3445479, JP Application No. 2004-210251 (WO 2006/019516) and JP Application No. 2004-210357 (WO 2006/019515). However, these hybrid splice connectors are not compatible with standard connector formats and require significant piecewise assembly of the connector in the field. The handling and orientation of multiple small pieces of the connector can result in incorrect connector assembly that may either result in decreased performance or increase the chance of damaging the fiber.

More recently, US Patent Nos. 7,369,738 and 8,070,367 describe optical fiber connectors that include a pre-polished fiber stub disposed in the ferrule that is spliced to a field fiber with a mechanical splice.

SUMMARY OF THE INVENTION

According to a first aspect of the present invention, an ST format optical connector for terminating an optical fiber is provided. The ST format connector includes a housing configured to mate with an ST receptacle or coupling. The housing has an ST bayonet-style format. The ST format optical connector further includes a collar body disposed in the housing and a retainer disposed in the housing, wherein the collar body is retained between the housing and the retainer. The housing is prevented from fully rotating about the collar body and retainer.

In another aspect, the collar body includes a fiber stub disposed in a first portion of the collar body, the fiber stub being mounted in a ferrule and having a first end proximate to an end face of the ferrule and a second end. The collar body further includes a mechanical splice disposed in a second portion of the collar body, the mechanical splice configured to splice the second end of the fiber stub to the optical fiber.

In another aspect, the collar body further includes a buffer clamp configured within a third portion of the collar body, the buffer clamp configured to clamp at least a portion of a buffer cladding of the optical fiber upon actuation; and a buffer clamp actuation sleeve configured to be received on an outer surface of the third portion of the collar body and configured to slidably actuate the buffer clamp, the buffer clamp actuation sleeve including a flange portion formed on one end thereof.

In another aspect, the optical connector further comprises a fiber boot to restrict a lateral motion of the optical fiber, the fiber boot mountable to a portion of the retainer.

In another aspect, the fiber boot further includes one or more access slots formed through the outer surface thereof configured to permit access to the flange portion of the sleeve when the sleeve is mounted on the buffer clamp.

In another aspect, the housing includes a housing slot positionable over the mechanical splice.

In another aspect, the housing includes an inner tab receivable within a retention slot formed on an outer surface of the retainer when the connector is in an unconnected state.

In another aspect, during a connection with an ST coupling, when the housing is moved toward the ST coupling, the inner tab is released from the retention slot.

In another aspect, the collar body further includes a key structure formed on an outer surface configured to be received by a slot formed in the ST coupling.

In another aspect, the retainer further includes a ledge formed on an outer surface thereof configured to contact the inner tab to prevent additional rotation of the housing.

In another aspect of the invention, an ST format optical connector for terminating an optical fiber of a jacketed optical fiber cable comprises a housing configured to mate with an ST receptacle or coupling, the housing having an ST bayonet-style format, a collar body disposed in the housing, and a backbone having a retainer portion. The collar body is retained between the housing and the retainer portion of the backbone. The housing is prevented from fully rotating about the collar body and retainer portion. In this aspect, the ST format optical connector can be configured as a remote grip type connector.

The above summary of the present invention is not intended to describe each illustrated embodiment or every implementation of the present invention. The figures and the detailed description that follows more particularly exemplify these embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be further described with reference to the accompanying drawings, wherein:

Fig. 1 is an isometric view of a ST format optical connector for terminating an optical fiber according to an aspect of the present invention.

Fig. 2 is an exploded view of the optical connector of Fig. 1.

Fig. 3 is an isometric view of the outer housing of the optical connector of Fig. 1.

Fig. 4 is an isometric view of the retainer element of the optical connector of Fig. 1.

Fig. 5 is an isometric cross section view of the optical connector of Fig. 1.

Fig. 6 is an isometric view of the collar body and ferrule of the optical connector of Fig. 1.

Figs. 7A – 7C show views of the optical connector of Fig. 1 connecting with an ST coupling.

Figs. 8A and 8B show end views of the optical connector of Fig. 1 at different stages of connection with an ST coupling.

Fig. 9 is an isometric view of a ST format optical connector for terminating an optical fiber according to an alternative aspect of the present invention.

Fig. 10 is an exploded view of the optical connector of Fig. 9.

Fig. 11 is a cross-section view of the optical connector of Fig. 9.

While the invention is amenable to various modifications and alternative forms, specifics thereof have been shown by way of example in the drawings and will be described in detail. It should be understood, however, that the intention is not to limit the invention to the particular embodiments described. On the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the scope of the invention as defined by the appended claims.

DETAILED DESCRIPTION OF THE EMBODIMENTS

In the following Detailed Description, reference is made to the accompanying drawings, which form a part hereof, and in which is shown by way of illustration specific embodiments in which the invention may be practiced. In this regard, directional terminology, such as “top,” “bottom,” “front,” “back,” “leading,” “forward,” “trailing,” etc., is used with reference to the orientation of the Figure(s) being described. Because components of embodiments of the present invention can be positioned in a number of different orientations, the directional terminology is used for purposes of illustration and is in no way limiting. It is to be understood that other embodiments may be utilized and structural or logical changes may be made without departing from the scope of the present invention.

The present invention is directed to an optical connector. In particular, the optical connector of the exemplary embodiments is an ST-format optical connector of compact length that is capable of straightforward field termination. The exemplary connector described herein can be readily

installed and utilized for Fiber To The Home (FTTH) and/or Fiber To The X (FTTX) network installations. The exemplary connector can be utilized in installation environments that require ease of use when handling multiple connections, especially where labor costs are more expensive.

According to an exemplary embodiment of the present invention, an optical fiber connector 100 is shown in isometric view in Fig. 1 and in exploded view in Fig. 2. Figs. 3-6 show other views of connector 100 or components thereof. Optical connector 100 is configured to mate with an ST receptacle or coupling, as is illustrated in Figs. 7A – 7C.

ST-type optical fiber connector 100 can include a connector body having a housing 110 and a fiber boot 180. In this exemplary embodiment, housing 110 includes a bayonet-style outer shell having a front face that is configured to be received by an ST receptacle (e.g., an ST coupling, an ST adapter, or an ST socket), and a retainer 170 that provides further structural support. The housing 110 also contains a ferrule 132, a collar body 120, and a spring 155.

Housing 110 has a bayonet-style outer shell. In one aspect of the invention, the bayonet-style outer shell has limited rotational ability when engaging an ST compatible receptacle, socket or coupling. Some exemplary structure for limiting the housing rotation is described further herein.

Housing 110 includes an opening 111 that receives an ST compatible coupling. Slots 112a, 112b are formed near the opening 111 and engage the posts or stubs 212 (see Figs. 7A-7C) of the ST coupling during connector engagement/disengagement with the ST coupling. Notches 114a, 114b are formed on an inner surface of the opening 111 of the outer housing to allow for passage of the coupling posts or stubs 212 into housing slots 112a, 112b.

Housing 110 also includes an opening 113a formed on a side of the outer shell of sufficient size to allow for access to a mechanical splice 140 disposed therein (see further discussion below). Also, in one aspect, one or more access slots (not shown) can be provided opposite opening 113a to allow access to the mechanical splice from the opposite side. Accordingly, the design of connector 100 allows an installer to re-terminate a field optical fiber if needed or perform additional terminations using the same connector.

As shown in Fig. 4, retainer 170 is a generally tubular structure that includes a first (e.g., front) end 171 and a second (e.g., rear) end 172. An opening 173 is provided in first end 171 and is sized to slide over a rear portion of collar body 120. The retainer 170 can be snugly or snap fit onto the collar body 120. In one aspect (see Fig. 5), the retainer can include an interference surface 176 formed within retainer 170. As shown in Fig. 5, the interference surface 176 engages a locking flange 122 formed on a rear portion of collar body 122, thereby securing the collar body 120 and retainer in place, while trapping the spring 155 against shoulder 125 of the collar body and inner ring or shoulder 116 formed inside housing 110. As mentioned in further detail herein, the retainer 170 can further include a slot 175 (see Fig. 4) formed on an outer surface of the retainer 170 to hold the rotational position of the housing prior to connection.

Retainer 170 can further include a robust mounting structure 178 disposed on a rear portion thereof. A fiber boot 180, which can be utilized to protect the optical fiber from bend related stress losses, can be mounted onto structure 178 via press, interference or screw-on fit.

According to an embodiment of the present invention, housing 110 and retainer 170 can be formed or molded from a polymer material, although metal and other suitably rigid materials can also be utilized. In one aspect, the housing 110 can be formed from a harder material than the retainer 170.

As mentioned above, connector 100 further includes a collar body 120 that is disposed within the connector housing and retained therein. The retainer 170 and collar body 120 can be keyed to one another (e.g., via collar body key 124 (Fig. 6) received by retainer slot 174 (Fig. 4)), and snapped together during assembly.

According to exemplary embodiments, the collar body 120 (a collar body element may also be referred to as a “barrel”) is a multi-purpose element that can house a fiber stub assembly, a mechanical splice 140, and a fiber buffer clamp 126. As mentioned above, the collar body 120 can include a shoulder 125 (see Fig. 5) that can be used as a flange to provide resistance against spring 155, interposed between the collar body and a rear shoulder of the housing 110, when the connector is inserted in a receptacle. According to an exemplary embodiment of the present invention, collar body 120 can be formed or molded from a polymer material, although metal and other suitable materials can also be utilized. For example, collar body 120 can comprise an injection-molded, integral material.

In particular, collar body 120 includes a first end portion 121 (See Fig. 6) having an opening to receive and house a fiber stub assembly, which includes a ferrule 132 having an optical fiber 134 secured therein. As is shown in Fig. 5, collar body 120 also includes a fiber guide channel that guides a field fiber (e.g., fiber 184 from Fig. 7A) towards the ferrule. Collar body 120 can further include a key 127 formed on a front portion thereof to ensure proper alignment within a mating coupling (see an example mating shown in Figs. 7A-7C).

In addition, the collar body 120 further includes a key structure 124, as shown in Fig. 6, that helps align the position of the retainer 170 during assembly. The key structure 124 can be a raised structure configured to engage with a corresponding slot 174, formed on a front surface of retainer 170 (see e.g., Fig. 4).

Ferrule 132 can be formed from a ceramic, glass, plastic, or metal material to support the optical fiber 134 inserted and secured therein. In a preferred aspect, ferrule 132 is a ceramic ferrule. An optical fiber 134 is inserted through the ferrule 132, such that a first fiber stub end slightly protrudes from or is coincident or coplanar with the end face of ferrule 132. Preferably, this first fiber stub end is polished in the factory (e.g., flat, with or without bevels). A second end of the fiber 134 extends part-way into the interior of the connector 100 and is utilized to splice a second optical

fiber, such as field fiber 184. Preferably, the second end of fiber 134 can be cleaved (flat, with or without bevels). In one aspect, the second end of fiber 134 can be polished in the factory to reduce the sharpness of the edge of the fiber, which can create scrapings (debris) as it is installed in the splice element. For example, an electrical arc, such as one provided by a conventional fusion splicer machine, can be utilized to melt the tip of the fiber and form a rounded end, thereby removing the sharp edges. This electrical arc technique can be used in conjunction with polishing by an abrasive material to better control end face shape while reducing possible distortion of the core. An alternative non-contact method utilizes laser energy to ablate/melt the tip of the fiber.

The stub and field fibers can comprise standard single mode or multimode optical fiber, such as SMF 28 (available from Corning Inc.). In one aspect, the field fiber can comprise a 250 or 900 μm buffer coated fiber.

In an alternative embodiment, fiber 134 additionally includes a carbon coating disposed on the outer clad of the fiber to further protect the glass-based fiber. In an exemplary aspect, fiber 134 is pre-installed and secured (e.g., by epoxy or other adhesive) in the ferrule 132, which is disposed in the first end portion 121 of collar body 120. Ferrule 132 is preferably secured within collar body portion 121 via an epoxy or other suitable adhesive. Preferably, pre-installation of the fiber stub can be performed in the factory.

As shown in Fig. 2, an end cap 105 can also be provided to protect the stub fiber end prior to installation and use.

As shown in Fig. 6, collar body 120 further includes a splice element housing portion 123. In this exemplary aspect, splice element housing portion 123 provides an opening in which a mechanical splice 140 can be inserted and secured in the central cavity of collar body 120. In an exemplary embodiment, mechanical splice 140 comprises a mechanical splice device (also referred to herein as a splice device or splice) that is similar in structure to a 3M™ FIBRLOK™ mechanical fiber optic splice device, available from 3M Company, of Saint Paul, Minnesota.

For example, splice element 142 is formed from a sheet of ductile material having a focus hinge that couples two legs about a fiber axis, where each of the legs includes a fiber gripping channel (e.g., a V-type (or similar) groove) to optimize clamping forces for conventional glass optical fibers received therein. The ductile material, for example, can be aluminum or anodized aluminum. In one aspect, a conventional index matching fluid can be preloaded into the V-groove region of the splice element for improved optical connectivity within the splice element. In another aspect, no index matching fluid is utilized. For example, the element 142 can have a length of about 0.3 inches to about 0.5 inches (preferably about 0.4 in.), a height of about 0.08 to about 0.12 inches (preferably about 0.105 in.), and a width (when compressed) of about 0.045 to about 0.055 inches (preferably about 0.05 in.).

Splice element 142 is mountable in a mounting device or cradle located in portion 123 of collar body 120. In an exemplary embodiment, the cradle is integrally formed in collar body 120, e.g., by molding. The internal cradle can secure (through e.g., snug or snap-fit) the axial and lateral position of the splice device 140. In one alternative aspect, one or more retainer elements, such as overhang tabs, can be used to secure the element 142 in axial and/or height position prior to actuation of the cap. In this manner, the splice device 140 cannot be rocked or easily moved forward or backward once installed.

In an exemplary embodiment, in operation, as the cap 144 is moved from an open position to a closed position, one or more cam bars located on an interior portion of the cap 144 can slide over splice element legs, urging them toward one another. Two fiber ends, (e.g., one end of fiber 134 and one end of the field fiber 184) are held in place in grooves formed in the splice element and butted against each other and are spliced together in a channel to provide sufficient optical connection, as the element legs are moved toward one another.

Similar splice elements are described in U.S. Patent No. 5,159,653, incorporated herein by reference in its entirety. Other conventional mechanical splice devices can also be utilized in accordance with alternative aspects of the present invention and are described in U.S. Patent Nos. 4,824,197; 5,102,212; 5,138,681; and 5,155,787, each of which is incorporated by reference herein, in their entirety. In alternative aspects, connector 100 can be configured to operate with other types of conventional mechanical splice devices.

Mechanical splice 140 allows a field technician to splice the second end of fiber stub 134 to a field optical fiber 184 at a field installation location. The term “splice,” as utilized herein, should not be construed in a limiting sense since splice 140 can allow removal of a fiber. For example, the element can be “re-opened” after initial actuation, as slots may be formed in the collar body 120 and housing 110 to permit entry of a tool that moves cap 144 from an actuated position within the cradle to a non-actuated position. This configuration permits repositioning of the spliced fibers, followed by replacement of the cap to the actuating position.

In one aspect, the rotational position of the housing 110 is held in place prior to field termination so that the cap 144 is easily accessible via housing slot 113a. When a field fiber is terminated, the cap 144 is depressed beneath the inner surface of housing 110, thus permitting limited rotation of the housing 110 during a connection/coupling.

Further, collar body 120 includes a buffer clamping portion 126 that can be configured to clamp the buffer portion of the field fiber 184 being spliced. In an exemplary aspect, the buffer clamping portion 126 is disposed within the interior of the retainer 170 in the fully assembled connector. In a preferred aspect, buffer clamping portion 126 is an integral part of the connector structure. For example, Fig. 6 shows buffer clamping portion 126 including one or more longitudinally formed slots, resulting in a collet-like shape. This configuration creates clamping

fingers 128 to depress and engage the buffer portion of a field fiber 184 when a sleeve 160 is slidingly fitted over buffer clamp 126 by moving sleeve 160 in an axial direction towards the connector housing. In this aspect, sleeve 160 is a tube-like structure configured to snugly fit over clamping portion 126. In one aspect, sleeve 160 can further include a flange portion 162 formed on an outer surface of at least one end of the sleeve 160. This flange 162 can allow a field technician to more easily grip sleeve 160 in the event that the sleeve needs to be disengaged (e.g., pulled off) from the clamping portion (e.g., when using pliers or a similar tool). Other alternative buffer clamps structures can also be utilized, such as described in US Publication No. 2007/0104425 A1, incorporated by reference herein.

In a further alternative aspect, connector 100 can include a collar body having a flexible mounting portion for the ferrule, such as is described in U.S. Patent Publication No. 2012/0027360, incorporated by reference herein in its entirety.

To prevent sharp fiber bends at the connector/fiber interface, a boot 180 can be utilized. The boot 180 is coupled to the back end of connector 100 and includes a front face portion 181 configured to engage the rear portion 178 of the retainer 170. In an exemplary aspect, boot 180 includes a flare-shaped tail 182 to provide sufficient performance when using a variety of fiber types for field fiber 184 (e.g., 250 μm or 900 μm fibers). This type of boot can be pre-installed in the factory (i.e., fitted onto the connector prior to the field fiber termination). Optionally, boot 180 can further include slots 183 that provide the user access to the flange 162 of sleeve 160, for example, if there is a need for deactivation of the connector.

Alternatively, another boot shape can be utilized. Other boot configurations are described in US Publication No. 2007/0104425 A1, incorporated by reference herein.

Figs. 7A-7C show an example connection between ST connector 100 and an exemplary ST coupling 200, the twist bayonet-shaped outer housing 110 can be rotated to one of two workable positions, pushed forward, further rotated $\frac{1}{8}$ of a turn, and released. In more detail, connector 100 can be inserted axially into ST coupling 200 (ferrule end first), with key feature 127 aligned to a keyway 211 formed in a first end portion 210 of ST coupling 200. Fig. 7A shows connector 100 prior to connection, where access slot 113a is positioned over mechanical splice 140. Fig. 7B shows connector 100 during the connection process. Fig. 7C shows connector 100 connected to coupling 200.

In this exemplary aspect, the outer housing 110 is keyed to the rest of the connector. By keying the bayonet cap to the rest of the connector, the opening provided in it for accessing the element actuation cap is kept in the correct position from the time of factory assembly. This keeps from having to manually reposition the bayonet cap during the installation process. In contrast, for conventional ST connectors, the twist bayonet cap is free to rotate about the major axis of the connector without restraint.

While the connector 100 is in an unconnected state, as shown in end view (from the ferrule end) in Fig. 8A, an inner tab 115 of the outer housing 110 is disposed in a retention slot 175 formed on an outer surface of the retainer 170 (see Fig. 4). During a connection, as is shown in Fig. 7B, the outer housing 110 is pushed (e.g., via simple hand force) forward toward the coupling 200 in the direction of arrow 103. This motion releases tab 115 from the retention slot 175, thus permitting some rotation. In addition, the collar body key 127 slides into slot 211 to maintain alignment between the connector 100 and the housing 200 and to help prevent rotation of the connector sub-components as the outer housing 110 is twisted. Also, coupling post 212 (and one formed on the opposite side of coupling portion 210) slides past notch 114a, 114b (see Fig. 3) formed on an inner surface of the opening 111 of the outer housing.

In this aspect, rotation is limited to about 1/8 to about 1/4 turn in one direction, as the retainer further includes a ledge 177 (see Fig. 4) that can stop tab 115 from further rotation when the tab 115 is released from retention slot 175. For example, in Fig. 7C, the outer housing 110 is rotated (e.g., about 1/8 turn) in the direction of arrow 109. An end view showing the position of the rotated tab 115 relative to the retainer 170 is provided in Fig. 8B. In the connected position, posts 212 are captured in slots 112a, 112b.

Since the retainer 170 is keyed to the collar body, rotation of the outer housing about the axis of the connector is limited. This arrangement not only places the element cap access opening 113a in a preferential position, it also pre-aligns the retention feature lead-ins readying it for engagement with a coupling.

In addition, as mentioned above, connector 100 can allow for the deactivation of the buffer clamp 126. In one aspect, boot 180 can optionally include access slots 183 (e.g., formed on opposite sides of boot 180). For example, a user can employ a simple field tool that extends into slots 183 and engages the flange portion 162 of the sleeve 160. The sleeve can be pulled back to deactivate the buffer clamp. As the mechanical splice 140 can also be deactivated, the field fiber can be removed from the connector without damage.

Field termination can be accomplished using a field termination platform or tool, such as is described in US 7,369,738, incorporated by reference herein, in its entirety. Such a tool can provide for repeatable, accurate fiber insertion in the optical connector. This tool or platform can be provided to allow field termination of an optical fiber in an ST connector without the need to perform field polishing or use epoxies.

According to another embodiment of the present invention, an alternative ST-type optical fiber connector 300 is shown in isometric view in Fig. 9, in exploded view in Fig. 10, and in cross section view in Fig. 11. Optical connector 300 is configured as a remote grip ST-type connector for jacketed cables that avoids the need for a fiber stub mounted within the connector ferrule. A

straightforward field termination can be accomplished with or without the use of a connector termination platform or separate crimping tool.

Figs. 9 - 11 show an optical connector 300 configured to mate with an ST receptacle. ST-type optical fiber connector 300 can include a connector housing 310 and a fiber boot 380. An end cap 390 can be placed at the front end of the connector to protect the connector ferrule 332 when not in use. As described in more detail below, end cap 390 further provides a protrusion setting mechanism for use during the field termination process. Connector 300 may also provide an opening (not shown) that allows the field installer to monitor the termination process during fiber insertion.

Connector 300 includes a housing 310 having a bayonet-style outer shell. In an aspect of the invention, the bayonet-style outer shell can have limited rotational ability when engaging an ST compatible receptacle, socket or coupling, such as described above.

Housing 310 includes an opening 311 that receives an ST compatible coupling. Slots 312a, 312b are formed near the opening 311 and engage the posts or stubs of the ST coupling (see coupling 200 in Fig. 7a) during connector engagement/disengagement with the ST coupling. Notches 314a, 314b are formed on an inner surface of the opening 311 of the outer housing to allow for passage of the coupling posts or stubs 212 into housing slots 312a, 312b.

Housing 310 also includes an opening 313a formed on a side of the outer shell of sufficient size to allow for access to a gripping device 340 disposed therein (see further discussion below). Also, in one aspect, one or more access slots (not shown) can be provided opposite opening 313a to allow access to the gripping device from the opposite side. Accordingly, the design of connector 300 allows an installer to disengage and re-grip a field optical fiber if needed or perform additional terminations using the same connector.

As shown in Fig. 10, connector 300 also includes a collar body 320 (which can also be referred to as a barrel) to house a ferrule 332 and a gripping device 340, a multi-purpose backbone 316 that includes a retainer portion 370, and a boot 380.

In this exemplary embodiment, connector 300 can be utilized to terminate a field optical fiber cable 335. Optical fiber cable 335 can be of any conventional cable jacket construction. In some aspects, optical fiber cable 335 is a jacketed cable that includes an outer jacket, a coated (e.g., with a buffer coating or the like) portion, and a fiber (e.g., bare glass) portion. In some aspects, cable 335 comprises a rectangular-shaped cable 336, such as an FRP cable, commercially available from a variety of vendors. In one example, FRP cable 336 includes an FRP (rectangular-shaped in cross section) jacket, a 250 μm cladding, and a 125 μm bare fiber portion. In alternative aspects, the optical fiber cable further comprises a standard cylindrically shaped cable structure. In some aspects, the optical fiber cable can further include aramid, Kevlar, or polyester strands/yarn strength members disposed between an inner surface of the fiber jacket and an outer surface of coated portion.

In one aspect, a backbone 316 is an elongated structure (having a length of from about 40 mm to about 60 mm, such as about 50 mm) that provides a retainer portion 370, similar to retainer 170 described above, and a clamping portion 319 that provides clamping for the outer jacket of the optical fiber cable being terminated in the field. The retainer portion 370 and collar body 320 can be
5 keyed to one another in a manner similar to that described above, for example via a collar body key 324 being received by a retainer portion slot 374, and snapped together during assembly. In an alternative aspect, for optical fiber cables with strength members, the backbone 316 can provide further axial strain relief by providing a clamping surface for the strength members of the optical fiber being terminated.

Backbone 316 includes an opening 312 at a front end (where the retainer portion 370 is located) to allow for coupling to the collar body 320. The backbone 316 has an axial bore throughout to permit passage of the optical fiber being terminated. Backbone 316 can further include a mounting structure 318 that provides for coupling to the fiber boot 380. In an exemplary aspect, the mounting structure comprises a threaded surface formed on an outer portion of backbone 316 that
15 is configured to engage a corresponding threaded inner surface of the boot 380. While this embodiment shows mounting of the boot 380 to the backbone 316 via threaded mounting, other mounting structures can be utilized, such as mounting clips or snap features, to name a few. Also, for terminating fiber cables having loose strength members, the mounting structure 318 can provide a retention area for securing the strength members of the optical fiber cable being terminated.

In addition, the backbone can include a fiber guide 313 formed in an interior portion therein to provide axial alignment support for the optical fiber cable being terminated. In an exemplary aspect, the fiber guide portion 313 is a funnel-shaped channel or groove that aligns a buffered portion of the optical fiber and guides the fiber toward the mechanical gripping device 340 housed in the collar body 320.

In a preferred aspect, backbone 316 includes an axial bore formed therethrough. The axial bore can be of appropriate size to receive and engage raised end structure 328 of collar body 320 (see Fig. 11). In addition, a collar step can be formed on an inner surface of the retainer portion that forms a shoulder that can be used as a flange to provide resistance against spring 355 that is positioned over the second end portion 326 of the collar body 320. The spring 355 provides and
30 maintains an adequate contact force when two connectors are joined together.

Backbone 316 can further include one or more stops 315 formed on an interior portion thereof to provide a boundary for the insertion of the jacketed portion of the optical fiber cable 335 being terminated. In addition, backbone 316 includes a clamping portion 319 formed at one end of the backbone opposite the retainer portion end. The clamping portion 319 is configured to clamp
35 onto the jacket portion of the optical fiber cable 335 being terminated in connector 300. In a preferred aspect, clamping portion 319 comprises a collet-type, split body shape that is actuated

when the boot 380 is secured to mounting structure 318. The clamping portion 319 can include raised inner surfaces to permit ready clamping of the cable jacket portion. In an alternative aspect, the connector can also include an adapter tube to be placed over the cable jacket portion of the optical fiber cable, for example, when the optical fiber cable being clamped is of a smaller diameter.

5 In addition, the clamping portion 319 also can provide a guide structure when inserting fiber cable 335 during the termination process.

The retainer portion 370 functions similarly to separate retainer element 170 described above. Opening 312 is sized to slide over a rear portion of collar body 320. The retainer portion 370 can be snugly or snap fit onto the collar body 320. Similar to the description above, the retainer portion 370
10 can couple to collar body 320 via an interference surface/locking flange mechanism, whereby spring 355 is trapped against a shoulder 325 of the collar body or a shoulder formed inside housing 310. The retainer portion 370 can further include a slot formed on an outer surface to hold the rotational position of the housing 310 prior to connection. The retainer portion 370 and collar body 320 can be keyed to one another as described above and snapped together during assembly. As a result, the
15 housing is prevented from fully rotating about the collar body and retainer portion during operation.

In one aspect, boot 380 can include a tapered body (see Fig. 11) having an axial bore throughout. The boot 380 includes threaded grooves 384 formed on an inner surface at the boot opening, where the grooves are configured to engage with the correspondingly threaded mounting structure 318 of the backbone 316. In addition, the axial length of boot 380 is configured such that a
20 rear section 383 of the boot, which has a smaller opening than at front opening 385, engages the jacket clamp portion 319 of the backbone. For example, as the boot 380 is secured onto the mounting structure 318 of the backbone, the axial movement of the boot relative to the backbone forces the legs of clamp portion 319 to move radially inwards so that the fiber jacket is tightly gripped. In alternative aspects, for certain types of fiber cables, the strength members of the optical
25 fiber cable can be disposed between the boot and the threaded mounting structure 318 to secure the strength members as the boot is installed. This construction can also provide a connector termination capable of surviving rougher handling and greater pull forces.

According to another embodiment of the present invention, housing 310 and backbone 316 can be formed or molded from a polymer material, although metal and other suitably rigid materials
30 can also be utilized. In one aspect, the housing 310 can be formed from a harder material than the backbone 316.

In an exemplary aspect, boot 380 is formed from a rigid material. For example, one exemplary material can comprise a fiberglass reinforced polyphenylene sulfide compound material. In one aspect, the materials used to form boot 380 and backbone 316 are different materials. In
35 another aspect, the materials used to form the boot 380 and the backbone 316 can be the same.

Collar body 320 includes a first end portion 321 having an opening to receive and house a ferrule 332. Ferrule 332 has a central bore formed therethrough to allow passage of the fiber being terminated and can be formed from a ceramic, glass, plastic, or metal material to support the optical fiber being inserted and terminated. In a first exemplary aspect, ferrule 332 is a ceramic ferrule. In another exemplary aspect, ferrule 332 is a glass ferrule. The choice of suitable materials for the ferrule can be made in accordance with temperature stability parameters for the desired connector application. The fiber being terminated in the connector can comprise a standard single mode or multimode optical fiber. In one aspect, the fiber being terminated has a glass portion 338 with a diameter of about 125 μm and a buffer portion 337 with a diameter of about 250 μm .

In one aspect, the opening 321 at the first end portion of collar body 320 is over-molded onto the end of ferrule 332 to secure the ferrule to the collar body. In addition, the ferrule may optionally include a cross-groove that helps create a mechanical interference to prevent the ferrule 332 from being easily pulled away from the collar body 320. In an alternative aspect, the ferrule 332 can be secured within the collar body portion via an epoxy or other suitable adhesive.

Collar body 320 further includes a housing portion that provides an opening 322 in which the gripping device 340 can be inserted in the central cavity of collar body 320. In an exemplary embodiment, the collar body provides for a limited axial displacement of the gripping device 340 due to thermal expansion/contraction.

The gripping device 340 can include a gripping element 342, an optional element cap 341 and an actuating cap 344. Gripping element 342 is mountable in the cradle of housing portion of collar body 320 such that it is substantially secured therein. When the gripping element 342 is placed in the cradle or nest, a portion of the element can be registered against a wall or clip disposed in the housing portion of the collar body 320. When used, the element cap 341 can be configured to secure the gripping element 342 in the cradle. A suitable cradle structure is fully described in PCT Application No. PCT/CN2012/074814, incorporated by reference herein in its entirety.

The gripping element 342 of the gripping device 340 is mountable in a mounting device or cradle located within collar body 320. In an exemplary embodiment, a cradle is integrally formed in collar body 320, e.g., by molding. The cradle can be used to help secure (through e.g., snug or snap-fit) the axial and lateral position of the gripping element 342 in conjunction with an optional element cap 341, described in further detail below.

Depending on the size of the gripping element, one or more clips can be disposed into the housing portion of the collar body to provide positioning structures to limit movement of the element 342. For example, in one aspect, a clip can be positioned at an end of the housing portion closest to the ferrule 332. The clip can be designed to have an over-hanging portion that is configured to fit over an end portion of the gripping element 342 when the gripping element is seated on the cradle. The clip can be formed having a flexing piece or hinge to allow insertion of the element into the

housing portion of the collar body. The clip can prevent the gripping element end from lifting during a connection to or disconnection from a receptacle, which reduces the likelihood of fiber damage or breakage.

The collar body 320 can also include an outer collar or shoulder 325 that can be used as a flange to provide resistance against spring 355.

The collar body also includes a second end portion 326 that can engage with the retainer portion 370 of backbone 316. In a preferred aspect, second end portion 326 has a raised structure portion 328 that has a sloping shape that is insertable through the bore of the retainer portion 370 of backbone 316. Raised structure 328 can be inserted into the bore and engage against a backbone mount structure due to the bias of the spring 355.

Gripping element 342 includes a front portion, a rear portion, and a central portion formed between, where the front portion is disposed closer to the ferrule than the rear portion. In a one aspect, the gripping element 342 comprises a sheet of ductile material having a focus hinge that couples two arms, where one or both of the arms includes a fiber gripping channel (e.g., a V-type, channel type or U-type groove or a mixture of groove shapes) to optimize clamping forces for a conventional glass optical fiber received therein. In an aspect of the invention, the front portion of the gripping element includes a fiber gripping channel configured to grip the bare glass portion of the fiber when actuated. The rear portion of the gripping element can include a larger channel formed therein that helps guide the fiber through the element 342 during the field fiber insertion process.

In an alternative aspect, the element cap 341 is omitted and the actuating cap 344 can comprise a two piece cap structure, with a front cap part and a rear cap part, where the rear cap part fixes the element 342 within the collar body and the front part actuates the gripping element.

In operation, when a prepared fiber is inserted into connector 300 for field termination, the fiber end is stripped of the cable jacket, exposing only the bare glass portion and fiber tip. This portion of the fiber is gripped by the front portion of the gripping element when this element portion is actuated by actuation cap 344. The fiber is guided through the rear portion of the connector, where a stopper or shoulder (see e.g. Fig. 10, stops 315) prevents the cable jacket from moving forward inside the connector, thus preventing too great of a fiber bow during the termination process. In this aspect, the central portion is not configured to provide any additional fiber gripping, but rather provide a structure to be engaged by element cap 341.

In one embodiment, the element 342 can include a V-groove in one arm and a channel groove in the second arm to yield a three line contact region in at least one of the front and rear portions. The ductile material, for example, can be aluminum or anodized aluminum. Gripping device 340 allows a field technician to grip different portions of the optical fiber being terminated remotely from the ferrule. Alternatively, gripping device 340 can be designed to have a shape similar to that of a conventional mechanical splice device, as would be apparent to one of ordinary

skill in the art. For example, in one alternative aspect, the gripping device can include a wedge actuated mechanical gripping element.

Actuating cap 344 is preferably configured to engage the gripping element 342 such that the element 342 grips a fiber inserted therein. The actuating cap can be formed or molded from a polymer material, although metal and other suitable materials can also be utilized. In one aspect, the actuating cap 344 can be formed from a material being the same as the material forming the gripping element 342.

In more detail, actuating cap 344 includes four retention legs to retain the position of the actuating cap within the collar body 320 and to fit over element cap 341. For example, each of the retention legs can include detents formed on an outer surface thereof. A first detent(s) can be used to place the cap securely within the cradle of the collar body 320 prior to actuation. As the cap 344 is fully actuated onto the element 342, a second detent(s) can engage with the collar body to further secure the cap 344 in place. The front legs can be configured to actuate the element arms of the front portion of gripping element 342.

Further, in this exemplary aspect, cap 344 can include reinforcing walls at both ends of the camming surfaces on the underside of the cap. These walls can provide structural strength to hold the element 342 legs in their actuated position.

In this exemplary aspect, the actuating cap 344 can be secured to a portion of the collar body 320 and thus has controlled axial movement due to thermal expansion. As mentioned previously, the element cap 341 can secure the gripping element 342 so that the element and collar body are registered to the same datum.

In operation, the cap 344 can be moved from an open position to a closed position by placing a pressing force onto the cap structure via end cap lever 392 (see Figs. 10 and 11) of end cap 390. As the cap lever is moved onto the element 342, the interior surfaces of front cap legs can slide over the element arms, urging them toward one another. As mentioned above, the glass portion of the fiber being terminated is placed in a groove formed in the front portion of the element and is gripped as the element arms are moved toward one another by the cap 344.

In an alternative aspect, an actuating cap with a material having at least a similar coefficient of thermal expansion (CTE) as the element can be utilized.

In another aspect of the invention, connector 300 further includes an end cap 390 that provides protection for the fiber tip and ferrule end when not in use. In addition, end cap 390 also provides a protrusion setting mechanism for setting the fiber protrusion during field termination. End cap 390 can include a tube-like structure having a bore 391 formed therein. A disk-shaped insert 395 can be provided within the bore 391 and can be positioned against an end of the bore. The insert 395 can include a depression of a controlled depth that can be used as a stop against the end of the fiber being terminated in the field. In one aspect, the cap structure is formed from plastic and the

insert can be formed from a metal, which can provide a more controllable depth. For example, end cap 390 can be utilized to provide for a fiber protrusion of about 30 μm . In another aspect, different inserts can be utilized to provide different protrusion amounts, depending on the application.

After the field fiber 338 is secured by the gripping element, the boot 380 can be secured onto the backbone 316, thereby tightly gripping the jacket portion of fiber cable 335.

With the fiber secured by the gripping element, in a preferred aspect, the fiber tip/ferrule end face is polished using a conventional field polishing procedure such that the fiber tip is flush with the ferrule end face. Alternatively, a field polish to produce a slight fiber protrusion can be performed.

As mentioned above, the optical connector of the exemplary embodiments is of compact length and is capable of straightforward field termination with reduced assembly times. Such exemplary connectors can be readily installed and utilized for FTTP and/or FTTX network installations.

In addition to the structure described above, the optical connector of the present invention can be thermally balanced so as to effectively operate over a wide temperature range. In one aspect, the materials used to form components of the connector 300 are selected such that the thermal behavior of the gripping element 342 and glass fiber 338 gripped therein substantially matches the thermal behavior of the collar body 320 and ferrule 332.

For example, in one aspect of the invention, optical connector 300 can include a collar body 320 and an actuation cap 344 made from the same material, but each having a different CTE in the direction of the fiber axis. In particular, the actuation cap can have a CTE in the direction of the fiber axis that is substantially different from the CTE of the collar body in this same direction. As a result, the optical fiber connector can be thermally balanced over a substantial (i.e., greater than 100°C) temperature range (e.g., from -40°C to 80°C).

According to an aspect of this embodiment, the materials forming caps 341 and 344 can also be selected to help ensure thermal balancing over a large temperature range. For example, the collar body and both caps 341, 344 can be formed or molded from the same polymer material. For example, caps 341, 344 and collar body 320 can be formed from a liquid crystal polymer (LCP). A LCP such as VECTRA LCP A130, available from companies such as Polyplastics Ltd. and Ticona Company, can be utilized. However, in this exemplary aspect, the caps 341 and 344 have a CTE, in the direction of the fiber axis, which is substantially different from the CTE of the collar body 320 in this same direction. As such, the distance between the element 342 and the ferrule 332 decreases in a controlled fashion with increasing temperature. With this structure, the element 342 is constrained along its primary axis within the connector by the cap, as opposed to the collar body.

The LCP material exhibits a first CTE in the direction of flow during the molding process and a second CTE (different from the first CTE) in an orthogonal direction to the flow direction. In

this exemplary aspect, the first CTE is less than the second CTE. In this aspect, the caps 341, 344 can have a CTE in the axial direction similar to the CTE of a metal gripping element 342.

In this exemplary aspect, the CTE of the caps and element, along their major axis, is selected to be greater than that of the collar body. As such the front end of the element (closest to the ferrule) can move closer to the back end of the ferrule with increasing temperature. In this manner, the fiber position with respect to the ferrule end can be maintained over a large temperature range.

The ST connector described above can be used in many conventional optical connector applications. The optical connectors described above can also be utilized for termination (connectorization) of optical fibers for interconnection and cross connection in optical fiber networks inside a fiber distribution unit at an equipment room or a wall mount patch panel, inside pedestals, cross connect cabinets or closures or inside outlets in premises for optical fiber structured cabling applications. The optical connectors described above can also be used in termination of optical fiber in optical equipment. In addition, one or more of the optical connectors described above can be utilized in alternative applications.

As mentioned above, the ST connector of the exemplary embodiments is of compact length and is capable of straightforward field termination with reduced assembly times. Such exemplary connectors can be readily installed and utilized for FTTP and/or FTTX network installations, such as part of a fiber distribution unit.

Various modifications, equivalent processes, as well as numerous structures to which the present invention may be applicable will be readily apparent to those of skill in the art to which the present invention is directed upon review of the present specification.

We Claim:

1. An ST format optical connector for terminating an optical fiber, comprising:
a housing configured to mate with an ST receptacle or coupling, the housing having an ST bayonet-style format;
5 a collar body disposed in the housing; and
a retainer disposed in the housing, wherein the collar body is retained between the housing and the retainer and wherein the housing is prevented from fully rotating about the collar body and retainer.
2. The ST format optical connector of claim 1, wherein the collar body includes a fiber stub
10 disposed in a first portion of the collar body, the fiber stub being mounted in a ferrule and having a first end proximate to an end face of the ferrule and a second end, wherein the collar body further includes a mechanical splice disposed in a second portion of the collar body, the mechanical splice configured to splice the second end of the fiber stub to the optical fiber.
3. The ST format optical connector of claim 2, wherein the collar body further includes a buffer
15 clamp configured within a third portion of the collar body, the buffer clamp configured to clamp at least a portion of a buffer cladding of the optical fiber upon actuation; and a buffer clamp actuation sleeve configured to be received on an outer surface of the third portion of the collar body and configured to slidably actuate the buffer clamp, the buffer clamp actuation sleeve including a flange portion formed on one end thereof.
- 20 4. The ST format optical connector of claim 2, further comprising:
a fiber boot to restrict a lateral motion of the optical fiber, the fiber boot mountable to a portion of the retainer.
5. The ST format optical connector of claim 4, wherein the fiber boot further includes one or
more access slots formed through the outer surface thereof configured to permit access to the flange
25 portion of the sleeve when the sleeve is mounted on the buffer clamp.
6. The ST format optical connector of claim 2, wherein the housing includes a housing slot positionable over the mechanical splice.
7. The ST format optical connector of claim 1, wherein the housing includes an inner tab
receivable within a retention slot formed on an outer surface of the retainer when the connector is in
30 an unconnected state.

8. The ST format optical connector of claim 7, wherein, during a connection with an ST coupling, when the housing is moved toward the ST coupling, the inner tab is released from the retention slot.

9. The ST format optical connector of claim 8, therein the collar body further includes a key structure formed on an outer surface configured to be received by a slot formed in the ST coupling.

10. The ST format optical connector of claim 8, wherein the retainer further includes a ledge formed on an outer surface thereof configured to contact the inner tab to prevent additional rotation of the housing.

11. An ST format optical connector for terminating an optical fiber of a jacketed optical fiber cable, comprising:

a housing configured to mate with an ST receptacle or coupling, the housing having an ST bayonet-style format;

a collar body disposed in the housing; and

a backbone having a retainer portion, wherein the collar body is retained between the housing and the retainer portion of the backbone, and wherein the housing is prevented from fully rotating about the collar body and retainer portion.

12. The ST format optical connector of claim 11, wherein the connector is configured as a remote grip type connector, wherein the collar body is configured to secure a ferrule and house a fiber gripping element, wherein the gripping element comprises a ductile material having a focus hinge that couples first and second element arms and wherein a first portion of the gripping element includes a fiber gripping channel to clamp an optical fiber received therein upon actuation by an actuating cap.

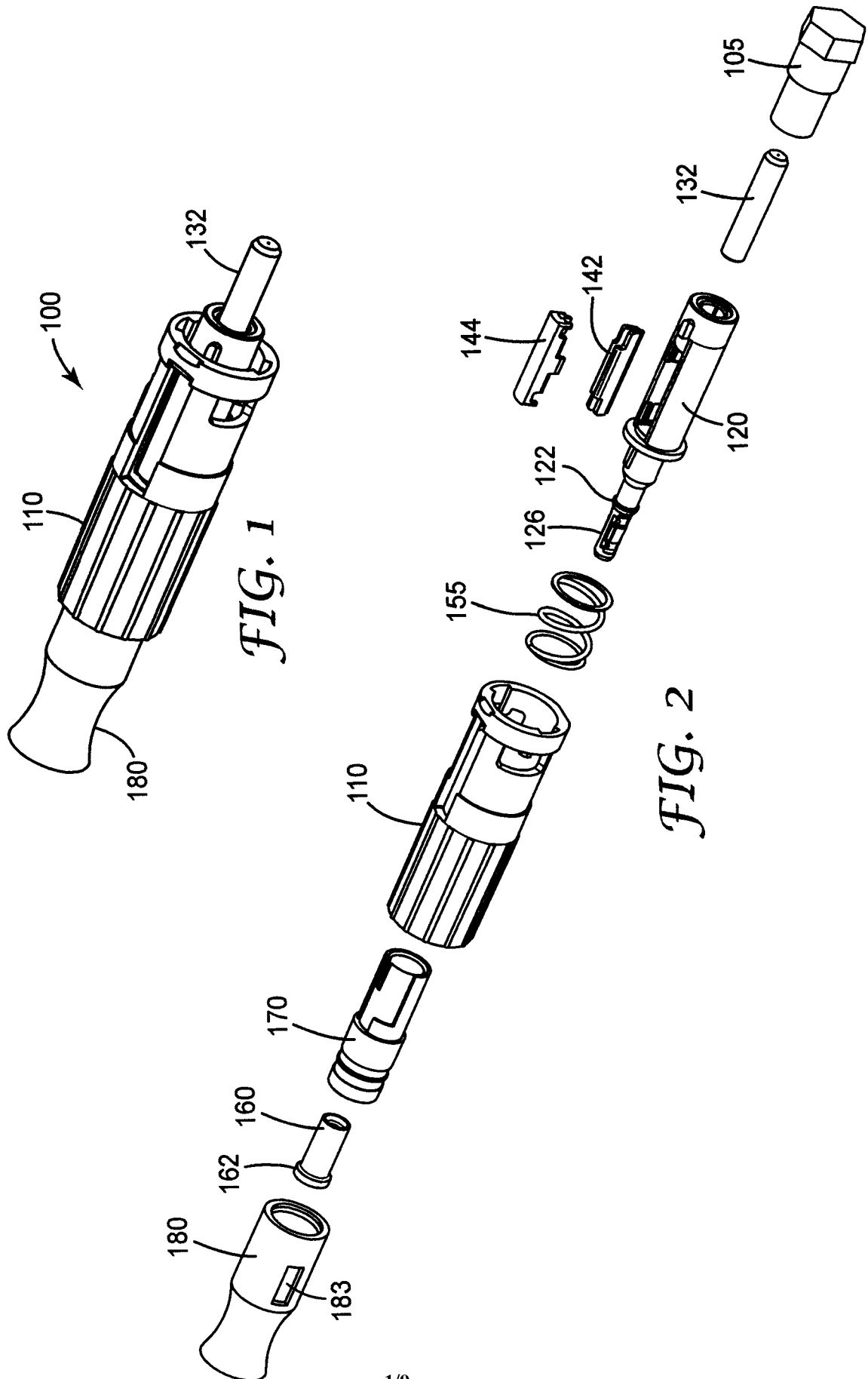
13. The ST format optical connector of claim 12, wherein the backbone further includes a fiber jacket clamping portion disposed on an opposite end of the backbone from the retainer portion and configured to clamp a jacket portion of the optical fiber cable.

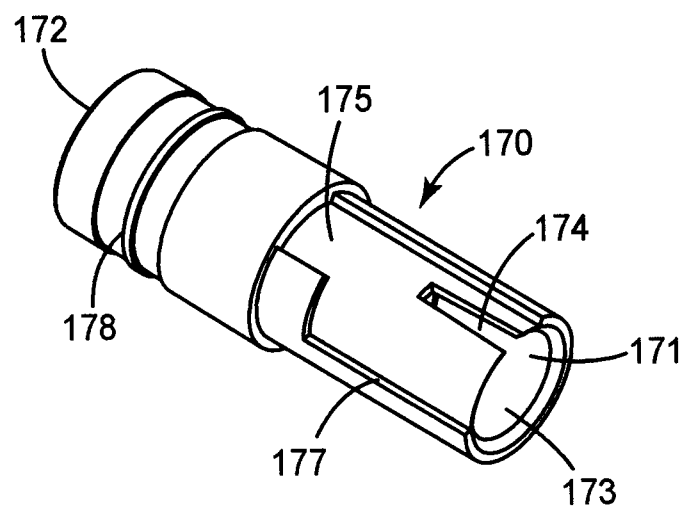
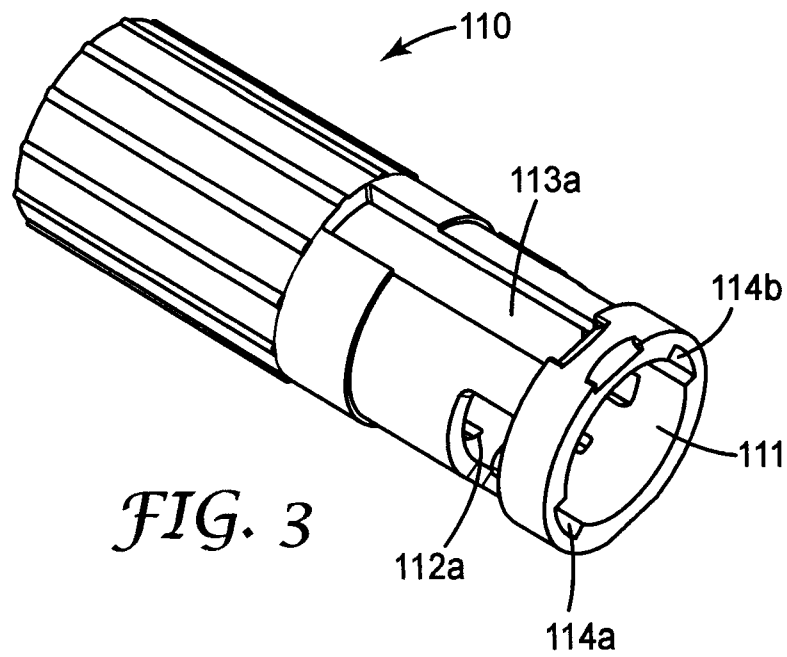
14. The ST format optical connector of claim 13, further comprising a boot attachable to a portion of the backbone, wherein the boot actuates the fiber jacket clamping portion of the backbone upon attachment to the backbone.

15. The ST format optical connector of claim 14, wherein the boot attaches to the backbone via a screw-type mechanism.

16. The ST format optical connector of claim 12, further comprising an end cap disposable at a front end of the connector to protect the connector ferrule when not in use, wherein the end cap further includes a protrusion setting mechanism for use during a field termination process.

17. The ST format optical connector of claim 16, wherein the end cap further includes a lever
5 arm that, when mounted, extends over the actuating cap and actuates the actuating cap when pressed.





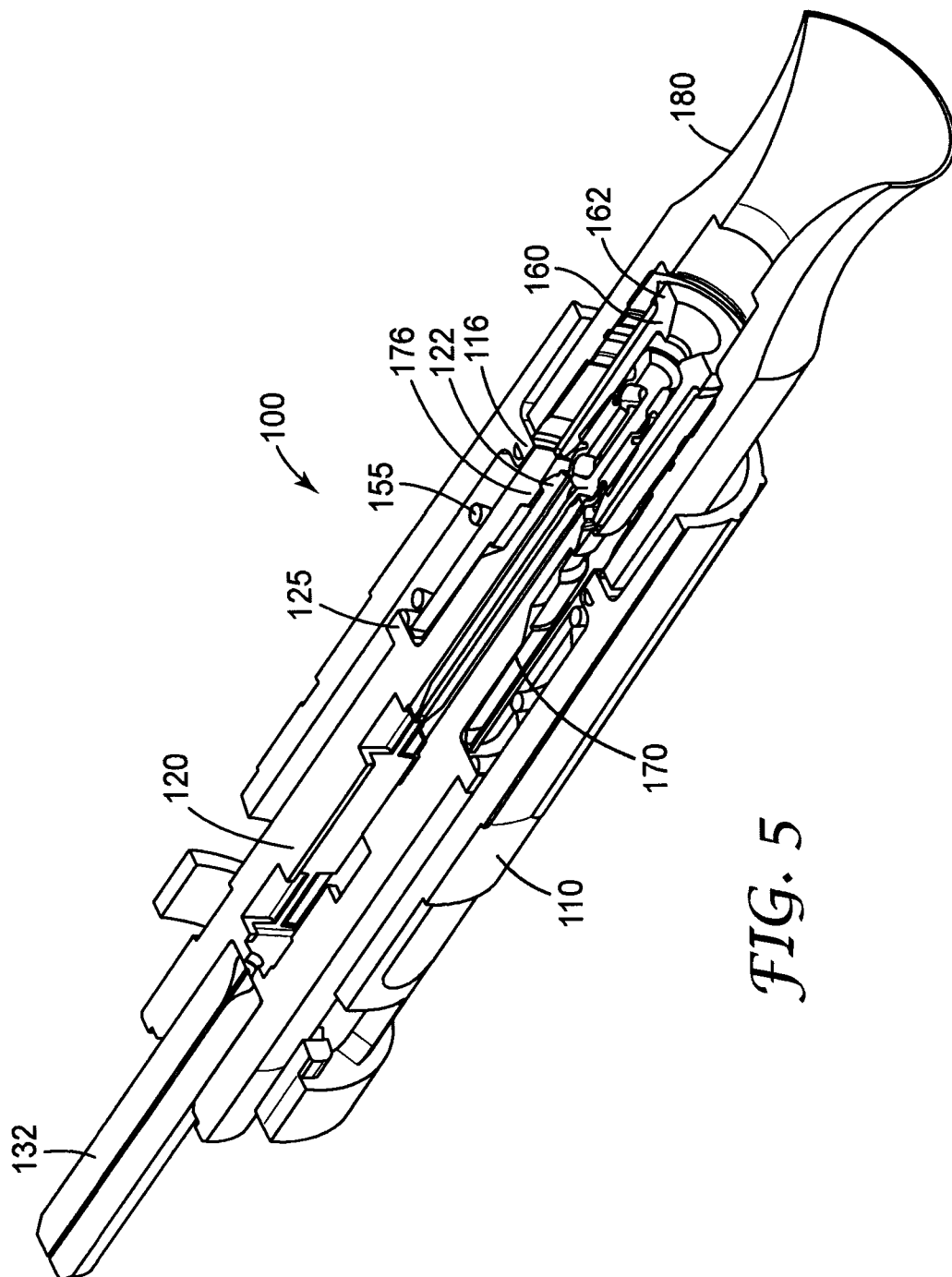
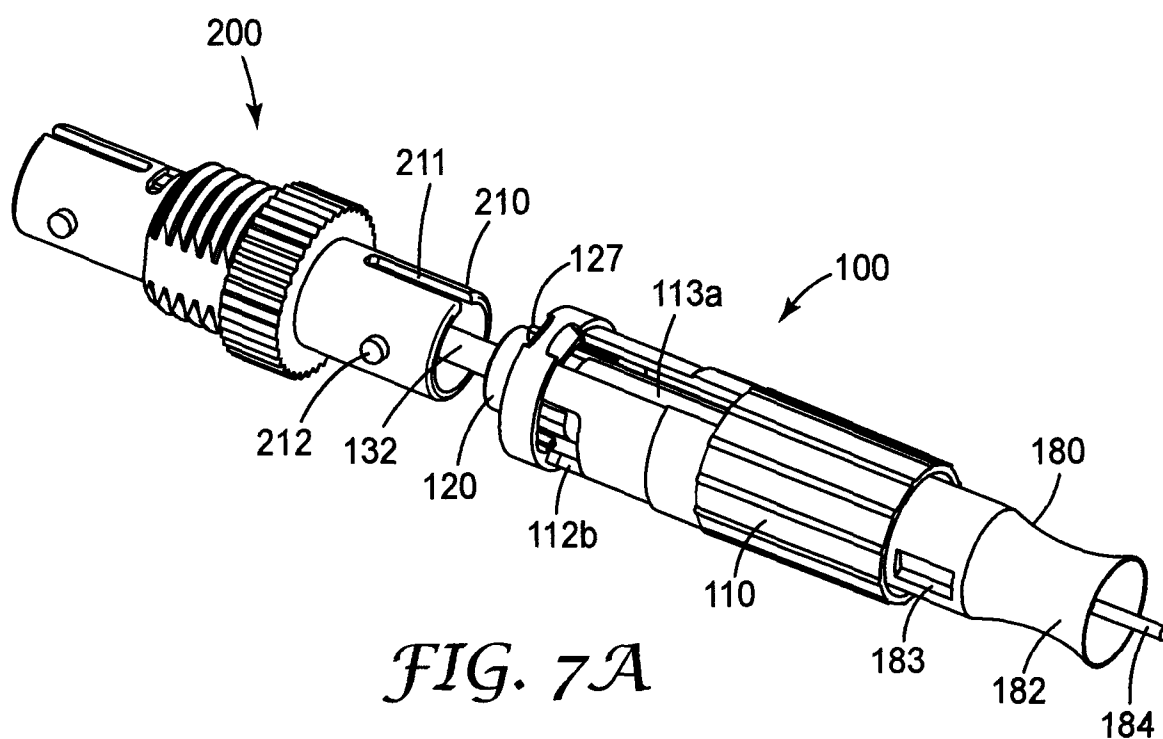
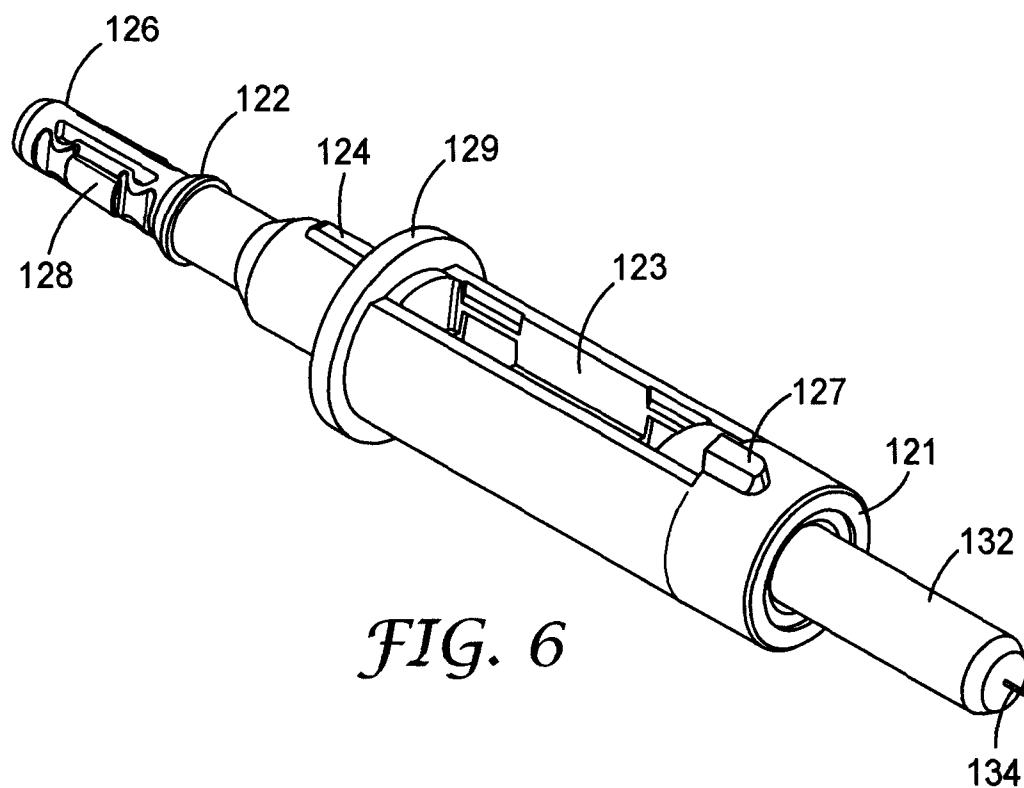
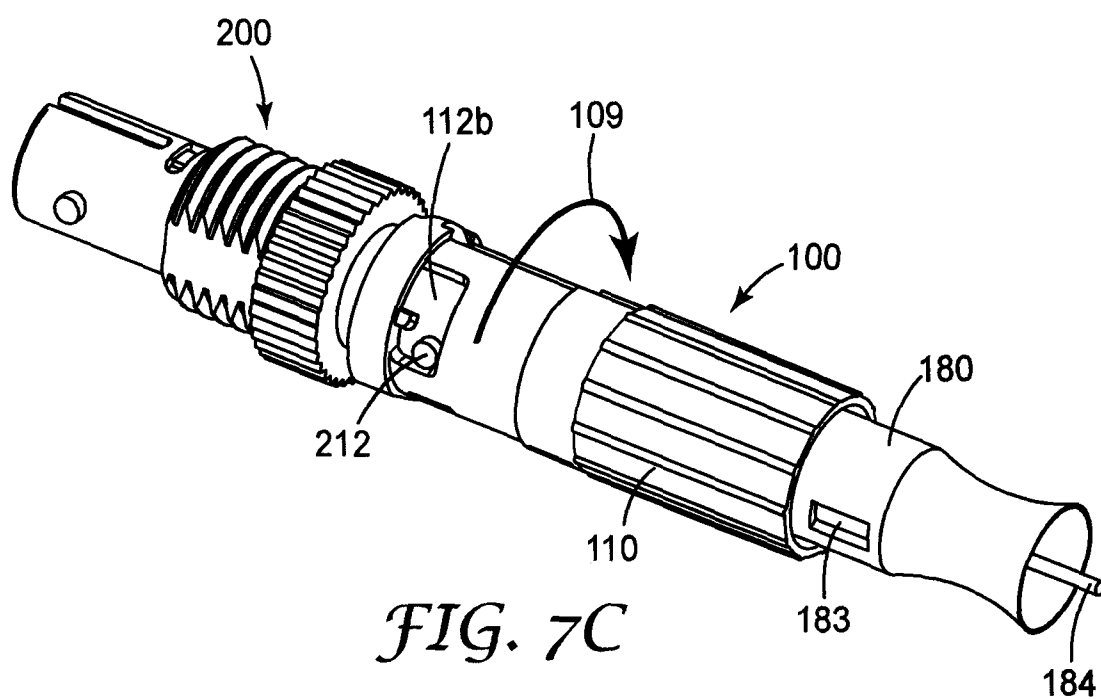
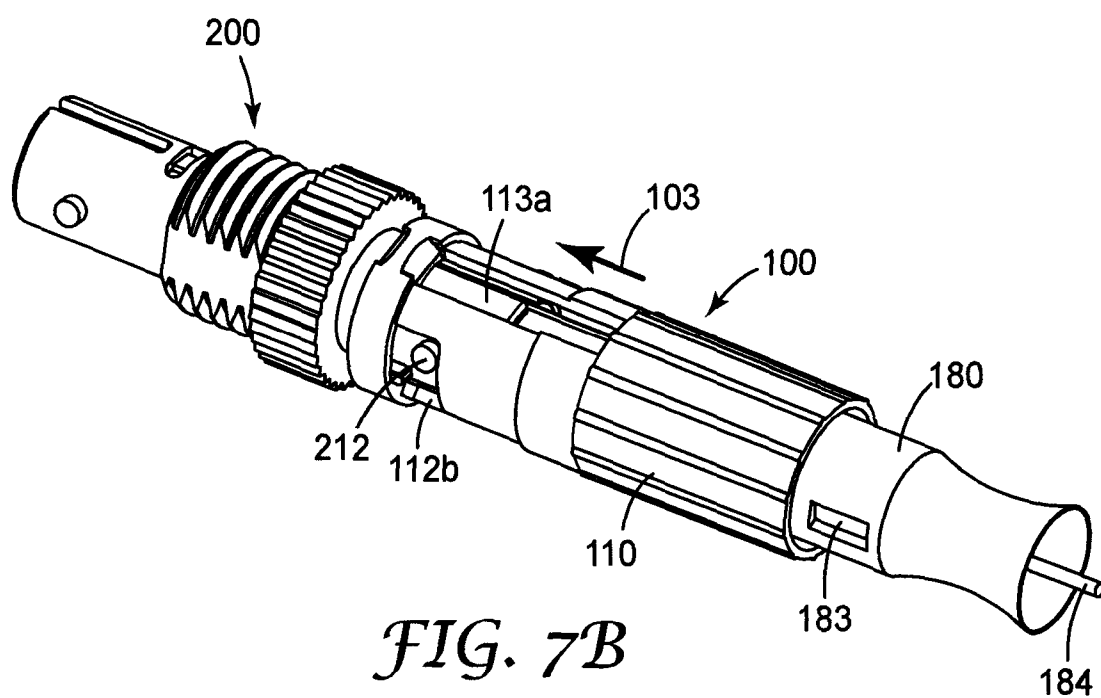


FIG. 5





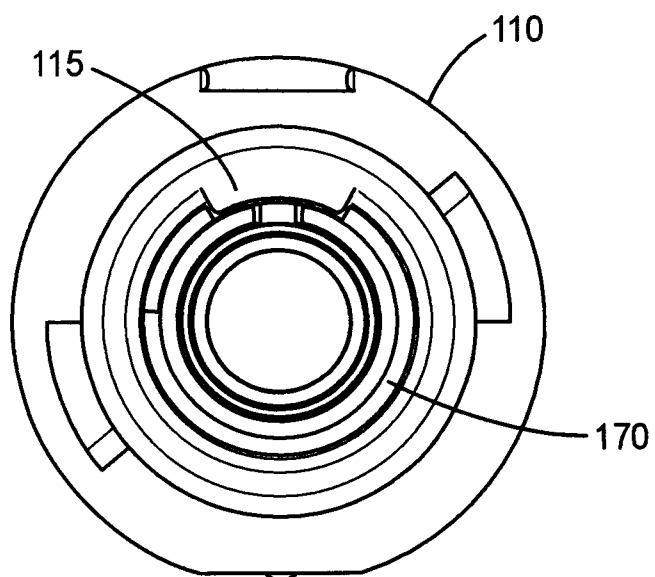


FIG. 8A

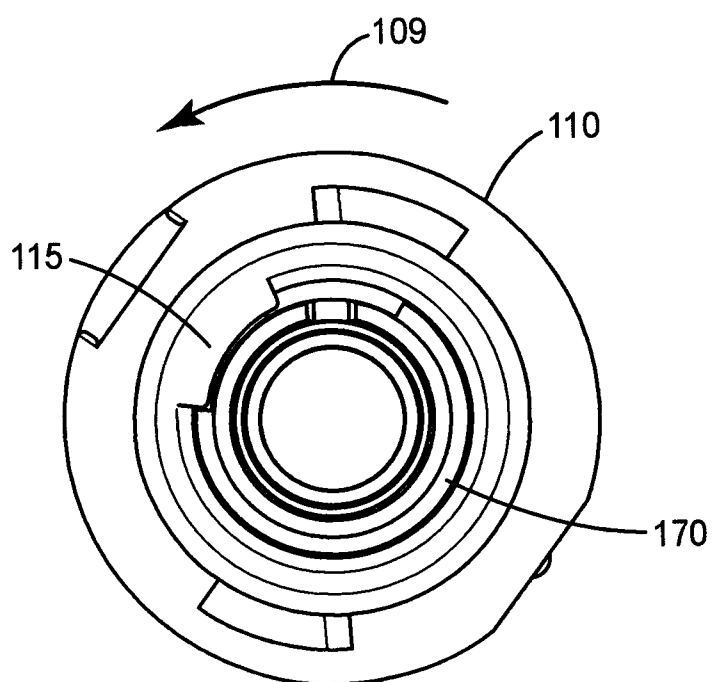
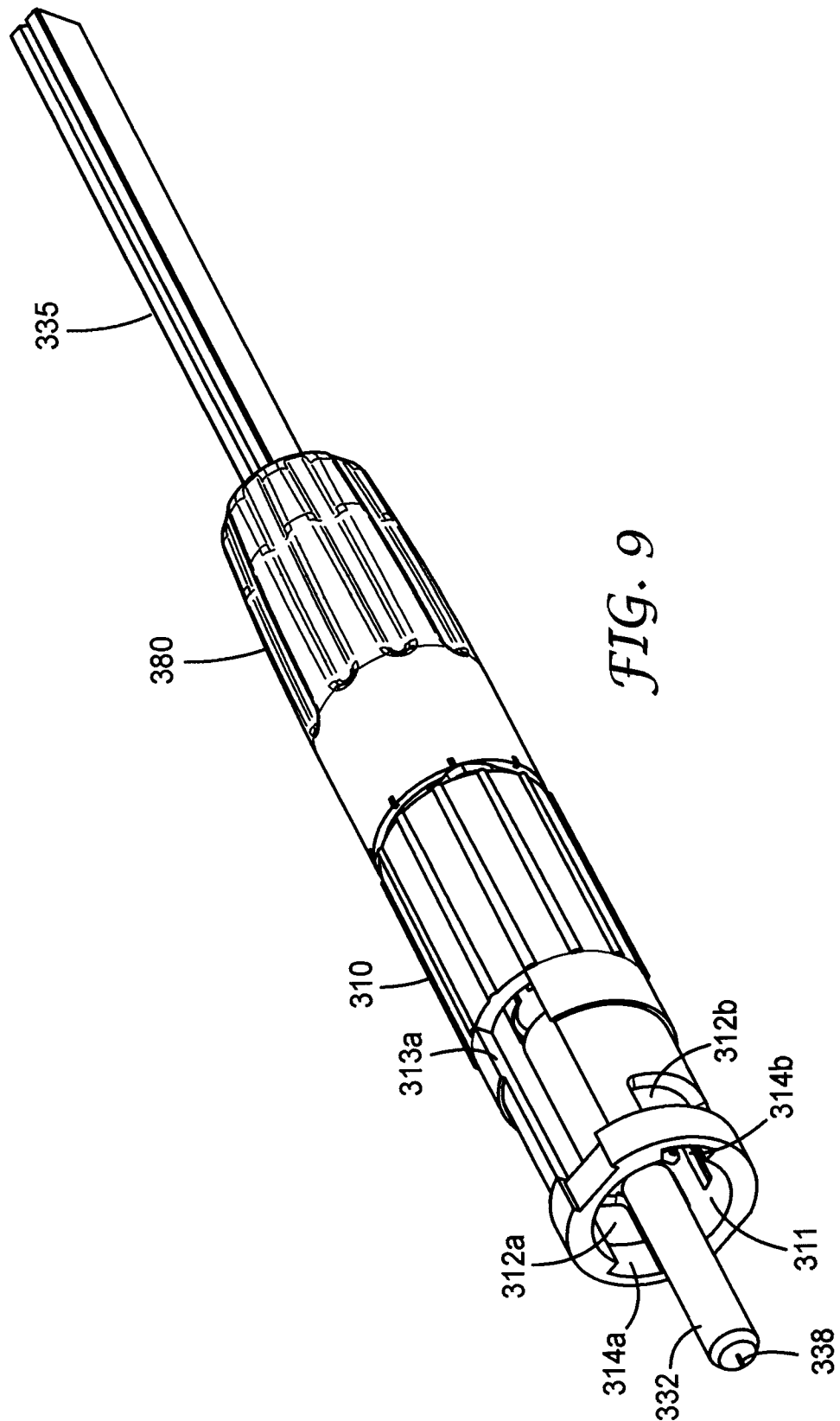


FIG. 8B



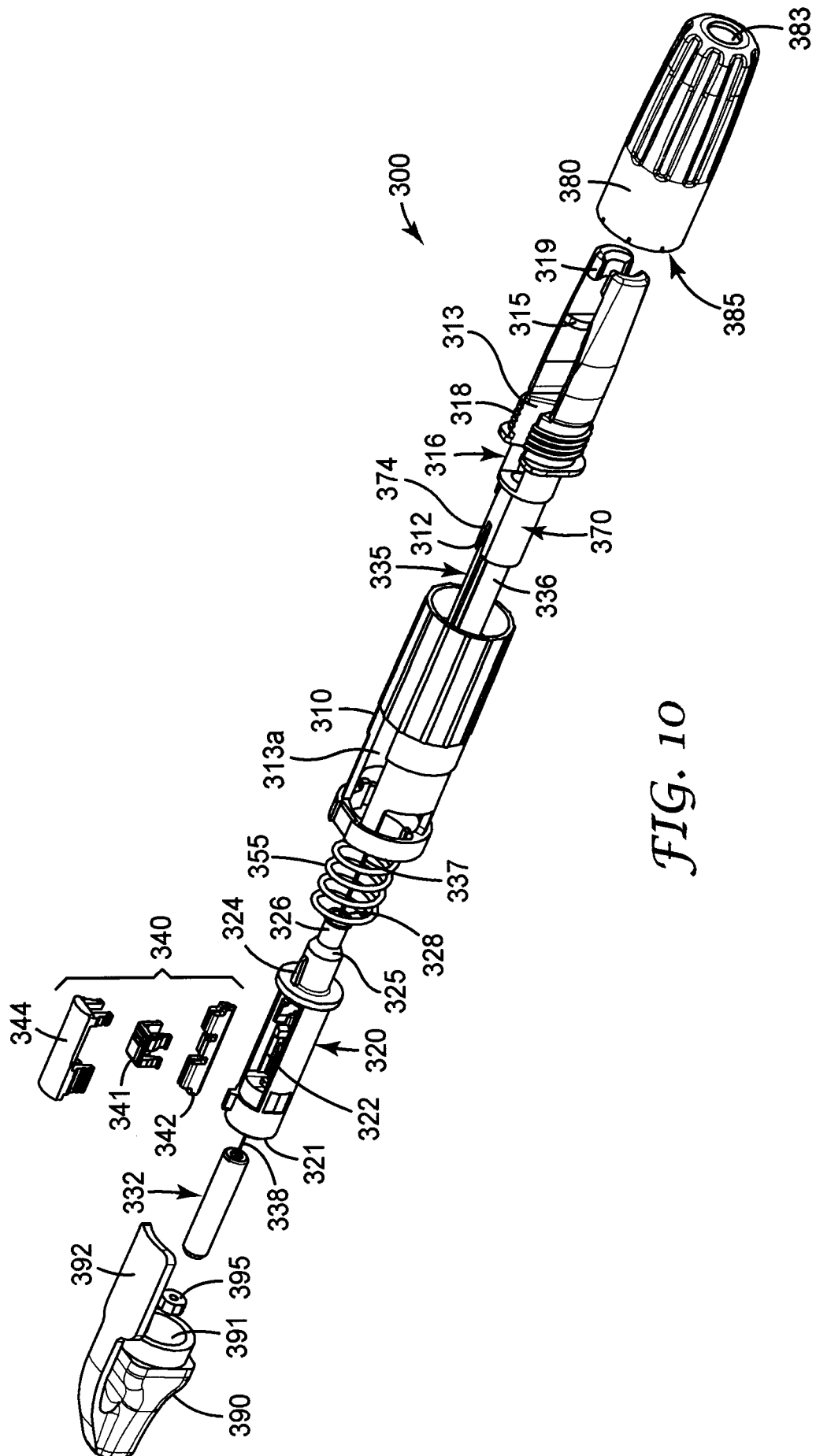


FIG. 10

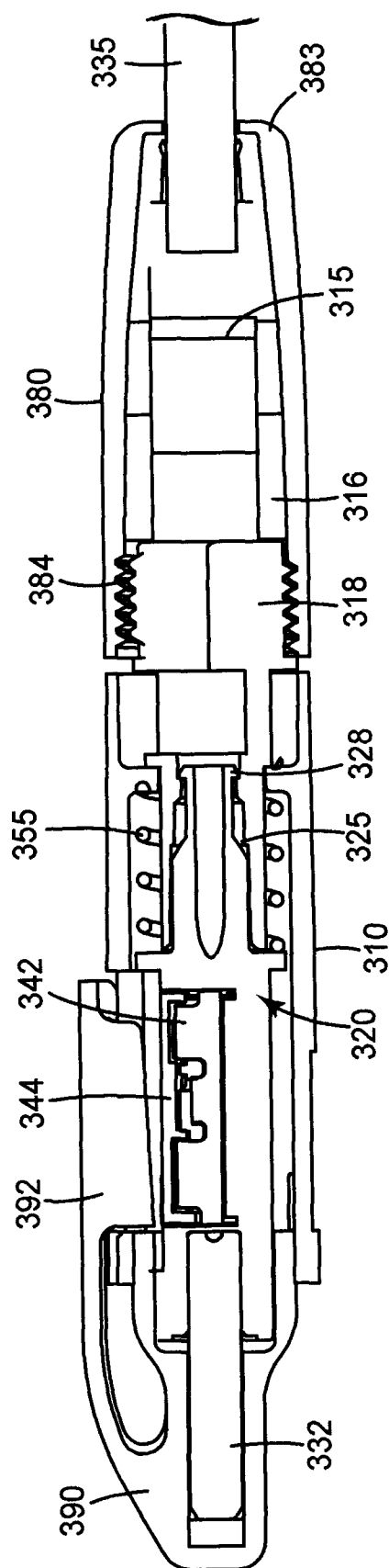


FIG. 11

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2013/083389

A. CLASSIFICATION OF SUBJECT MATTER

G02B 6/36 (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)

IPC: H04B, H04L, H04M, H04W, G02B

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

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

WPI, EPODOC, CNKI, CNPAT, IEEE, GOOGLE: fiber, optical, connector, ST, hybrid, house, housing, collar, retainer, slot, rotate, stub, splice, ferrule, limit, spacing, position, stop, assemble, dispose

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	CN 102414593 A (3M INNOVATIVE PROPERTIES COMPANY) 11 April 2012 (11.04.2012) description, paragraphs [0032]-[0039], fig 1	1-17
Y	CN 201628781 U (YINGTAN KEHAI OPTIC COMPONENT CO., LTD.) 10 November 2010(10.11.2010) description, paragraphs [0002]-[0014], fig 3	1-17
A	CN 102057308 A (3M INNOVATIVE PROPERTIES COMPANY) 11 May 2011 (11.05.2011) The whole document	1-17

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:	“T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
“A” document defining the general state of the art which is not considered to be of particular relevance	“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
“E” earlier application or patent but published on or after the international filing date	“Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
“L” document which may throw doubts on priority claim (S) or which is cited to establish the publication date of another citation or other special reason (as specified)	“&” document member of the same patent family
“O” document referring to an oral disclosure, use, exhibition or other means	
“P” document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search 26 November 2013 (26.11.2013)	Date of mailing of the international search report 19 Dec. 2013 (19.12.2013)
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Name and mailing address of the ISA/CN The State Intellectual Property Office, the P.R.China 6 Xitucheng Rd., Jimen Bridge, Haidian District, Beijing, China 100088 Facsimile No. 86-10-62019451	Authorized officer XU, Quan Telephone No. (86-10)62413312
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2013/083389

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		INCHENP 201007902 E	19.08.2011