(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
5 February 2015 (05.02.2015)

WIPO | PCT

(10) International Publication Number
WO 2015/016892 A1

(51) International Patent Classification: *G02B 6/38* (2006.01)

(21) International Application Number: PCT/US2013/052968

(22) International Filing Date: 31 July 2013 (31.07.2013)

(25) Filing Language: English

(26) Publication Language: English

(71) Applicant: CORNING CABLE SYSTEMS LLC [US/US]; 800 17th Street NW, Hickory, North Carolina 28601 (US).

(72) Inventors; and
(71) Applicants : **DEAN, JR., David Lee** [US/US]; 2520 17th Street NE, Hickory, North Carolina 28601 (US). **DE JONG, Michael** [US/US]; 605 Beverly Drive, Colleyville, Texas 76034 (US). **HANFORD, Keith Ernest** [US/US]; 1160 Victor Road, Macedon, New York 14502-8834 (US). **HENKE, Charles Todd** [US/US]; 246 County Road 4678, Boyd, Texas 76023 (US). **JONES, Roger** [US/US]; 927 Old Forester Ln., Charlotte, North Carolina 28214 (US). **PARKMAN, III, Louis Edward** [US/US]; 3231 Mimosa Park Drive, Richland Hills, Texas 76118 (US). **THEUERKORN, Thomas** [US/US]; 420 32nd Ave. Drive NW, Hickory, North Carolina 28601 (US).

(74) Agent: **WEEKS, Adam R.**; Corning Cable Systems LLC, Intellectual Property Department, SP-TI-03-1, Corning, New York 14831 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report (Art. 21(3))*

(54) Title: FIBER OPTIC CONNECTOR SUB-ASSEMBLIES HAVING A FRONT-LOADING LOCKING FERRULE HOLDER AND RELATED FIBER OPTIC COMPONENTS, DEVICES AND METHODS

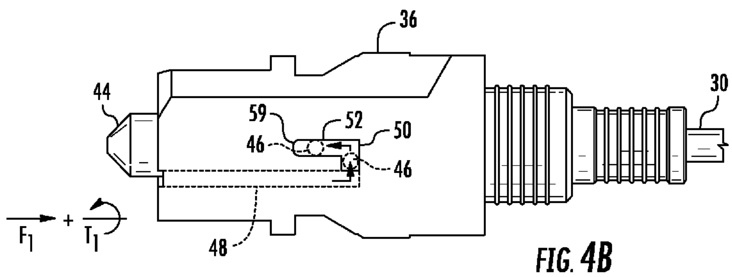

FIG. 4B

(57) Abstract: A fiber optic connector inner housing (38) employing a front-loading retention feature for receiving and retaining a ferrule holder (34), and related fiber optic connectors, cables, and methods are disclosed. In one example, the inner housing (38) has an opening extending therethrough and at least one bayonet locking mechanism that includes an insertion slot (48), a rotation slot (50), and a retention slot (52) disposed in an interior surface of the opening. A ferrule holder (34) having a key portion (46) is inserted into the opening such that the key portion is received by the insertion slot. The ferrule holder is next rotated in the rotation slot and released such that a bias member within the inner housing moves the key portion of the ferrule holder into the retention slot, thereby retaining the ferrule holder in the inner housing and preventing accidental removal of the ferrule holder from the inner housing.

WO 2015/016892 A1

FIBER OPTIC CONNECTOR SUB-ASSEMBLIES HAVING A FRONT-LOADING LOCKING FERRULE HOLDER AND RELATED FIBER OPTIC COMPONENTS, DEVICES AND METHODS

BACKGROUND

[0001] The disclosure relates generally to fiber optic connector sub-assemblies, and more particularly to a fiber optic connector sub-assembly that includes a front-loading locking ferrule holder, which may be used in assembly of fiber optic connectors. Related components, devices and methods are also disclosed.

[0002] Benefits of utilizing optical fiber include extremely wide bandwidth and low noise operation. Because of these advantages, optical fiber is increasingly being used for a variety of applications, including but not limited to broadband voice, video, and data transmission in communications networks. As a result, communications networks include a number of optical interconnection points in fiber optic equipment and between fiber optic cables in which optical fibers must be interconnected via fiber optic connections. To conveniently provide these fiber optic connections, fiber optic connectors are provided. A fiber optic connector includes a housing that provides internal components for receiving, supporting, protecting, and aligning one or more end portions of optical fibers exposed from a fiber optic cable(s) when mated with other fiber optic connectors or adapters provided in fiber optic equipment or fiber optic cables. Fiber optic connectors may be installed on fiber optic cables in the field. Alternatively, fiber optic cables may be "pre-connectorized" during the manufacturing of the fiber optic cables.

[0003] In this regard, a fiber optic connector typically employs a fiber optic connector sub-assembly having a plurality of components. For example, **FIG. 1** shows a view of an exemplary fiber optic connector sub-assembly **10** for a conventional SC-type connector. The connector sub-assembly **10** is assembled by inserting a ferrule holder **12** having a ferrule **14** mounted thereon into a rear opening **16** of an inner housing **18**. The ferrule **14** extends through the inner housing **18** to a front opening (not shown) of the inner housing **18**. A spring **20** is then disposed around the end of the ferrule holder **12** and a crimp body **22** is inserted into the rear opening **16** of the inner housing **18** around the ferrule holder **12** and spring **20**. The crimp body **22** has a plurality of radial teeth **24** that align with grooves **26** within the rear opening **16** of the inner housing **18**, and a snap fit flange **28** that securely mates with a complementary snap fit feature (not shown) within the inner housing **18**. An unterminated fiber optic cable **30** can then be passed through the crimp body **22** to be mated with the ferrule holder **12** for final assembly of the connectorized optical cable.

[0004] These and other methods of assembling fiber optic cable connectors include a number of mechanical steps and typically may include manual labor. The influence of manual labor in the assembly process provides cost, affects consistency, and can decrease throughput in processing fiber optic connector terminations. Automated fiber optic connector termination processes for fiber optic cable preparations have been employed to reduce manual labor influence, but at significant capital costs. Even so, these automated fiber optic connector termination processes may not be flexible with respect to terminating varieties of fiber optic connectors or fiber optic cable types. Further, with these fiber optic connector termination processes, if one fiber optic connector termination fails, it must be reworked or the entire fiber optic cable must scrapped. In either case, the fiber optic cable assembly can be delayed, thereby disrupting fiber optic cable assembly throughput and increasing scrapped fiber optic cables, increasing costs as a result.

[0005] No admission is made that any reference cited herein constitutes prior art. Applicant expressly reserves the right to challenge the accuracy and pertinency of any cited documents.

SUMMARY

[0006] Embodiments disclosed herein include fiber optic connector inner housing employing a front-loading retention feature for receiving and retaining a ferrule holder. Related fiber optic connectors, cables, and methods are also disclosed. In one embodiment, inner housing includes an inner housing having an opening extending therethrough. An interior surface of the opening includes a bayonet locking mechanism having an insertion slot, a rotation slot, and a retention slot, and a bias member mounting portion for mounting a bias member. A ferrule holder having a key portion is inserted into the opening such that the key portion is received by the insertion slot and the bias member is disposed between the ferrule holder and the bias member mounting portion. The ferrule holder is next rotated such that the key portion rotates within the rotation slot. The ferrule holder is then released such that the bias member moves the key portion of the ferrule holder into the retention slot, thereby retaining the ferrule holder in the inner housing and preventing accidental removal of the ferrule holder from the inner housing. This arrangement simplifies assembly of a fiber optic connector sub-assembly and provides secure retention of the ferrule holder within the inner housing.

[0007] One embodiment of the disclosure relates to a fiber optic connector inner housing for mounting and retaining a ferrule holder as part of a fiber optic connector sub-assembly. The inner housing includes an inner housing having an opening extending therethrough, wherein the opening comprises a front end, a rear end, and an interior surface. The inner housing further includes at least one bayonet locking mechanism. Each bayonet locking mechanism comprises an insertion slot disposed in the interior surface of the opening configured to receive a respective key portion of a ferrule holder when the ferrule holder is inserted into the front end of the opening. Each bayonet locking mechanism further comprises a rotation slot disposed in the interior surface of the opening for rotating the key portion of the ferrule holder away from the insertion slot. Each bayonet locking mechanism further comprises a retention slot disposed in the interior surface of the opening for retaining the ferrule holder in the inner housing.

[0008] An additional embodiment of the disclosure relates to a fiber optic connector sub-assembly. The fiber optic connector sub-assembly includes an inner housing comprising an inner housing having an opening extending therethrough, wherein the opening comprises a front end, a rear end, and an interior surface. The inner housing also includes at least one bayonet locking mechanism comprising an insertion slot disposed in the interior surface of the opening, a rotation slot disposed in the interior surface of the opening, and a retention slot disposed in the interior surface of the opening. The fiber optic connector sub-assembly further includes a bias member mounting portion disposed at the rear end of the opening, a ferrule holder having a key portion disposed in the inner housing, and a bias member disposed in the inner housing between the ferrule holder and the bias member mounting portion. The insertion slot is configured to receive the key portion of the ferrule holder when the ferrule holder is inserted into the opening. The rotation slot is configured to allow the ferrule holder to be rotated away from the insertion slot. The bias member is configured to move the key portion of the ferrule holder into the retention slot when the ferrule holder is released, thereby retaining the ferrule holder in the inner housing.

[0009] An additional embodiment of the disclosure relates to a method of assembling a fiber optic connector sub-assembly. The method comprises providing an inner housing comprising an inner housing having an opening extending therethrough, wherein the opening comprises a front end, a rear end, and an interior surface. The inner housing further includes at least one bayonet locking mechanism comprising an insertion slot disposed in the interior surface of the opening, a rotation slot disposed in the interior surface of the opening, and a retention slot disposed in the interior surface of the opening. The inner housing further includes a bias member mounting portion disposed at the rear end of the opening. The method further includes providing a bias member in the inner housing adjacent the bias member mounting portion. The method further includes inserting the ferrule holder into the front end of the opening of the inner housing such that the key portion is received by the insertion slot and the bias member is disposed between the ferrule holder and the bias member mounting portion. The method further includes rotating the ferrule holder about a longitudinal axis of the opening such that the key portion rotates within the rotation slot. The method further includes releasing the ferrule holder such that the bias member moves the key portion of the ferrule holder into the retention slot, thereby retaining the ferrule holder in the inner housing.

[0010] Additional features and advantages will be set forth in the detailed description which follows, and in part will be readily apparent to those skilled in the art from the description or recognized by practicing the embodiments as described in the written description and claims hereof, as well as the appended drawings.

[0011] It is to be understood that both the foregoing general description and the following detailed description are merely exemplary, and are intended to provide an overview or framework to understand the nature and character of the claims.

[0012] The accompanying drawings are included to provide a further understanding, and are incorporated in and constitute a part of this specification. The drawings illustrate one or more embodiment(s), and together with the description serve to explain principles and operation of the various embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] **FIG. 1** is an exploded isometric view of a fiber optic connector sub-assembly having a rear loading ferrule holder according to the prior art;

[0014] **FIG. 2** is an exploded isometric view of an exemplary fiber optic connector sub-assembly having a front-loading ferrule holder according to an embodiment;

[0015] **FIG. 3** is a cross-sectional side view of the inner housing sub-assembly of **FIG. 2** showing a bayonet locking mechanism for receiving and retaining the front-loading ferrule holder;

[0016] **FIG. 4A-4C** are side views of the inner housing sub-assembly of **FIG. 2** showing insertion and retention of a ferrule holder within the inner housing sub-assembly;

[0017] **FIG. 5A** and **5B** are respective front and top cutaway views of an exemplary assembled fiber optic connector sub-assembly showing a locking mechanism for the fiber optic connector sub-assembly according to an alternative embodiment;

[0018] **FIG. 6A-6D**are side views of an inner housing sub-assembly according to an alternative embodiment showing insertion and retention of a ferrule holder within the inner housing sub-assembly employing a ramp feature for automatically rotating and retaining the ferrule holder in the inner housing, including detail views of the bayonet mechanism of the inner housing sub-assembly illustrating a prescribed displacement assembly system;

[0019] **FIG. 7A-7C** are side views of an inner housing sub-assembly according to an alternative embodiment showing insertion and retention of a ferrule holder within the inner housing sub-assembly employing a latch feature for automatically locking and retaining the ferrule holder in the inner housing;

[0020] **FIG. 8A-8C** are side views of an inner housing sub-assembly according to an alternative embodiment showing insertion and retention of a ferrule holder within the inner housing sub-assembly employing an alternative latch feature for automatically locking and retaining the ferrule holder in the inner housing;

[0021] **FIG. 9A-9C** are side views of an inner housing sub-assembly according to an alternative embodiment showing insertion and retention of a ferrule holder within the inner housing sub-assembly employing an alternative latch feature for automatically locking and retaining the ferrule holder in the inner housing;

[0022] **FIG. 10A-10C** are side views of an inner housing sub-assembly according to an alternative embodiment showing insertion and retention of a ferrule holder within the inner housing sub-assembly employing an alternative latch feature for automatically locking and retaining the ferrule holder in the inner housing; and

[0023] **FIG. 11A-11C** are side views of an inner housing sub-assembly according to an alternative embodiment showing insertion and retention of a ferrule holder within the inner housing sub-assembly employing an alternative latch feature for automatically locking and retaining the ferrule holder in the inner housing.

DETAILED DESCRIPTION

[0024] Various embodiments will be further clarified by the following examples. In this regard, **FIG. 2** is an exploded isometric view of an exemplary fiber optic connector sub-assembly **32** having a front-loading ferrule holder **34** according to an embodiment. An inner housing sub-assembly **36** includes an inner housing **38** and crimp body **40** assembled and/or integrally formed as one piece. A spring **42** or other bias member is inserted into a front opening **43** of the inner housing sub-assembly **36** and a ferrule holder **34** having a ferrule **44** mounted thereon is inserted into the front opening **43** of the inner housing sub-assembly **36** through the spring **42**. In this example, the ferrule holder **34** has a pair of key portions **46** that align with complementary insertion slots **48** in an interior surface of the inner housing **38** to permit insertion of the ferrule holder **34** into the front opening of the inner housing **38**. As will be shown in greater detail in **FIGS. 3A** and **3B**, each insertion slot **48** is part of a bayonet locking mechanism that allows the complementary key portion **46** of the ferrule holder **34** to be inserted into the insertion slot **48**, rotated in a rotation slot **50** and retained in a retention slot **52**. After the key portions **46** are locked into their complementary retention slots the key portions **46** are retained in the retention slots **52** by the bias force of the spring **42** pressing against the ferrule holder **34**. In addition, as will be discussed below with respect to **FIGS. 5A** and **5B**, the key portions **46** can be further retained the retention slots **52** in this embodiment by complementary locking flanges (not shown) on an interior surface of a shroud **54** that mate with respective locking slots **56** on an outer surface of the inner housing **38**. In this manner, a number of retention mechanisms can be employed to permanently secure and retain the key portions **46** within their respective retention slots **52**, thereby securely retaining the ferrule holder **34** within the inner housing **38**. An optical fiber **57** extending from fiber optic cable 30 may be passed through the rear end of the ferrule holder **34** and connected to the ferrule **44** using conventional techniques.

[0025] In this regard, **FIG. 3** is a cross-sectional side view of the inner housing sub-assembly **36** including a detailed view of the bayonet locking mechanism of the inner housing sub-assembly **36**. As described above with regard to **FIG. 2**, the spring **42** is inserted into the front opening **43** of inner housing **38**. The crimp body **40** is connected to the inner housing **38** at the rear end of opening **43**, and a stepped surface of the crimp body **40** forms a bias member mounting portion **58** in this embodiment, which is abutted by the inserted spring **42**. In another embodiment, an alternative bias member mounting portion (not shown) can be formed in the inner housing **38** instead of on the crimp body **40**.

[0026] **FIG. 3** also illustrates how structural integrity and bend resistance of the inner housing can be maintained when including a bayonet mechanism according to different embodiments disclosed herein. For example, fiber optic inner housings are commonly formed from a moldable material such as thermoplastic. Accordingly, the limitations of molding techniques may determine the types of unitary shapes that can be produced. It is possible to form the straight insertion slot **48** as a groove along the longitudinal axis of the inner housing **38** that does not completely pass through the wall of the inner housing **38** because a mold pin configured to produce such a groove can be removed from the inner housing sub-assembly **36** in a longitudinal direction without damaging the inner housing **38**. However, conventional molding techniques do not permit forming the rotation channel **50** and retention slot **52** in this manner, because the mold pin could not then be removed from the inner housing **38** without damaging the inner housing **38**. Instead, conventional molding techniques require either a flange in an inner surface of the mold to contact the mold pin, thereby creating an aperture through the inner housing **38**, or a subsequent coring out of an aperture to form the rotation slot **50** and retention slot **52** after the molding process. Thus, at least a portion of the rotation slot **50** and a portion of the retention slot **52** extends from the interior surface of the inner housing **38** through an outer surface of the inner housing **38** in this embodiment. As can be seen from **FIG. 3**, the rotation slot **50** and retention slot **52** are comparatively small in relation to the overall inner housing **38**. Accordingly, it can be seen in this and other embodiments that the relative size of the rotation slot **50** and retention slot **52** can be designed so as to optimize the structural integrity and bend resistance of the inner housing **38**.

[0027] To illustrate insertion and retention of the ferrule holder **34** within the inner housing sub-assembly **36**, **FIG. 4A-4C** illustrate exemplary steps for inserting and retaining the ferrule holder **34**. After the spring **42** is disposed in the inner housing **38** to abut the bias member mounting portion **58**, **FIG. 4A** shows the ferrule holder **34** being inserted into the front opening **43** of the inner housing **38** using an insertion force F_1 parallel to a longitudinal axis of the fiber optic inner housing sub-assembly **36**. In this embodiment, the key portions **46** of the ferrule holder **34** are protrusions that slidably engage the insertion slot **48** of the inner housing **38** during insertion.

[0028] After the ferrule holder **34** has been fully inserted, as shown in **FIG. 4B**, the rotation slot **50** permits each key portion **46** to rotate with respect to a longitudinal axis of the fiber optic connector, thereby permitting the entire ferrule holder **34** to be rotated about the longitudinal axis. In this embodiment, the initial rotation of the key portion 46 into the rotation slot **50** requires application of a rotational force T_1 in combination with maintaining the original insertion force F_1, to counteract the compression of the spring 42 (not shown). After the ferrule holder **34** has been rotated, the retention slot **52** permits the ferrule holder **34**

to move back toward the front opening **43** of the inner housing **38** by the spring **42**. In this manner, a ferrule holder **34** can be inserted and retained in the inner housing sub-assembly **36** by a simple, two-step motion.

[0029] As can be seen from **FIGS. 4A-4C**, the insertion slots **48**, rotation slots **50**, and retention slots **52** are configured to slidably accommodate the key portions **46**. The retention slots **52** permit the key portions **46** to freely move longitudinally forward and backward, while providing a stop **59** at the front end of the retention slots **52** to prevent removal of the ferrule holder **34** and to properly align the ferrule **44** within predetermined tolerances with respect to the connector assembly. In addition, the key portions 46 are located away from the longitudinal axis of the ferule holder **34**. This arrangement creates a longer moment arm for the key portions **46**, such that rotation of the ferule holder **34** about the longitudinal axis permits greater control of the rotation of the key portions **46** and/or permits greater manufacturing tolerances for the key portions **46** and rotations slots **50**.

[0030] To prevent accidental removal of the ferrule holder **34** via the rotation slots **50**, spring **42** also keeps the ferrule holder **34** biased forward toward the opening **43** such that the ferrule holder **34** cannot be removed from the inner housing **38** without simultaneously applying an insertion and rotation force to the ferrule holder. In this manner, the ferrule holder **34** is thus also prevented from being accidentally or unintentionally removed from the inner housing sub-assembly **36**.

[0031] Additional features may also be included to prevent removal of the ferrule holder **34** from the inner housing **38** after the key portions **46** have been retained by the retention slots **52**. For example, a locking mechanism may be employed to physically obstruct the rotation slots **50** after the key portions **46** have been retained by the retention slots **52**. In this regard, **FIGS. 5A** and **5B** are respective front and top cutaway views of an exemplary assembled fiber optic connector sub-assembly of **FIG. 2**. As discussed above with respect to **FIG. 2**, the inner housing may include retention slots **52** on an outer surface of the inner housing **38**. As shown in **FIGS. 5A** and **5B**, complementary locking flanges **60** disposed on the interior surface of the shroud **54** are configured to slidably mate with the locking slots **56** when the inner housing sub-assembly **36** is inserted into the shroud **54**. As shown in **FIG. 5B**, each locking slot **56** is adjacent to the retention slot **52** and passes through the rotation slot **50**. Thus, when the locking flanges **60** are mated with the locking slots **56**, each locking flange **60** physically blocks a portion of the rotation slot **50**, thereby preventing the key portion **46** disposed in the retention slot **52** from being rotated out of the retention slot **52**. In many embodiments, the shroud **54** may be configured to be permanently attached to the inner housing sub-assembly **36**, for example through a one-way snap-fit or other conventional attachment mechanism. Thus, in this embodiment, the locking flange **60** of the shroud **54** effectively forms a permanent side wall for the retention slot **52** when the inner housing sub-assembly **36** is permanently mounted within the shroud **54**.

[0032] Additional features for retaining the key portion **46** in the retention slot **52** of a bayonet locking mechanism may also be employed. In this regard, **FIGS. 6A** and **6B** are side views of an exemplary inner housing sub-assembly **62** for a fiber optic connector sub-assembly showing a ramp feature for automatically rotating and retaining a ferrule holder having key portions **46** in the inner housing sub-assembly **62**. In this example, an alternative bayonet locking mechanism includes an insertion slot **64**, a rotation slot **66**, and a retention slot **68**. However, the rotation slot **66** in this example has a trapezoidal profile including a first ramp surface **70** for guiding a key portion **46** away from insertion slot **64** during insertion of the ferrule holder **34** (not shown), and a second ramp surface **72** for blocking and guiding the key portion **46** away from the insertion slot **64** and toward the retention slot **68** when the ferrule holder **34** is released. One advantage of this arrangement is that insertion and rotation of the ferrule holder **34** can be accomplished by a single longitudinal insertion force F_1 that does not include an external torque component. **FIG. 6A** illustrates how continued application of insertion force F_1 causes the key portion **46** to engage the first ramp surface **70** of the rotation slot **66** and automatically rotate as the key portion **46** travels further in the longitudinal direction. As shown by **FIG. 6B**, the second ramp surface **72** causes a similar rotation toward the retention slot **68** as the spring **42** applies a bias force (i.e., counterforce) in the opposite longitudinal direction when the insertion force is released. One advantage of this arrangement is that it simplifies both manual and automated assembly by requiring a simple, one dimensional force to be applied to the ferrule holder **34**.

[0033] In addition, the precision of the insertion force F_1 can be varied in this arrangement, because the key portion **46** does not need to be fully rotated in the rotation slot **66** prior to releasing the insertion force. For example, so long as the key portion **46** is rotated out of the insertion slot **64**, the second ramp surface **72** will prevent the counterforce from the spring **42** (not shown) from moving the key portion back into the insertion slot **64**. Instead, the counterforce from the spring **42** will cause the key portion **46** to be rotated toward and into the retention slot **68** automatically by the second ramp surface **72**. Thus, in an automated process, the precise amount of insertion force to be applied to the ferrule holder **34** can have a relatively large tolerance (i.e., manufacturing window). Likewise, in a manual process, the small amount of time saved by a simplified, one-action insertion assembly process may produce substantial savings in aggregate time and labor costs.

[0034] This arrangement also permits a "prescribed displacement" system to be used, for example, to design assembly tools having appropriate tolerances. In this regard, **FIG. 6C** and **6D** are simplified detail views of the bayonet mechanism of **FIGS. 6A** and **6B** with additional dimensions that may be used for determining acceptable tolerances for assembly tools. **FIG. 6C** illustrates a first length A representative of a minimum allowable insertion distance for key feature 46, i.e., the distance beyond which the key feature 46 will contact the second ramp surface when the insertion tool is released, thereby biasing the key feature toward and into the retention slot. **FIG. 6C** also illustrates a second length B representative of a maximum allowable insertion distance for key feature 46, i.e., the vertex between the first ramp surface 70 and the wall of retention slot 68. Thus, an appropriate insertion tool for this design should have a length L_T equal to the average of A and B plus or minus an acceptable tolerance of half the difference of B and A. This relationship is represented by Equation 1 below:

Equation 1:

$$L_T = \frac{(B + A)}{2} \pm \frac{(B - A)}{2}$$

[0035] To aid in designing for specific values of A and B, **FIG. 6D** illustrates a number od dimensions of the bayonet mechanism. In this regard, the three illustrated lengths L_1-L_3 correspond to the length of the insertion slot **64** measured from different points in the bayonet mechanism. L_1 corresponds to the length of the insertion slot **64** measured from the vertex of the insertion slot **64** and second ramp surface **72**. L_2 corresponds to the length of the insertion slot **64** measured from the vertex of the insertion slot **64** and first ramp surface **72**. L_3 corresponds to the length of the insertion slot **64** and rotation slot **66** measured from the vertex of the rotation slot **66** and second ramp surface **72**. **FIG. 6D** also illustrates angle θ corresponding to the angle of the first ramp surface **70**, and angle α corresponding to the angle of second ramp surface **72**. Finally, **FIG 6D** illustrates a width I of insertion slot **64**, width R of retention slot **68** (equal to width I in this embodiment), and intermediate width W therebetween. These dimensions permit an appropriate prescribed displacement design calculation to be performed.

[0036] For example, to determine an appropriate manufacturing tool length tolerance to form the first ramp surface **70** for the bayonet mechanism of **FIGS. 6A-6D**, the threshold longitudinal distance T_y traveled by the key portion within the rotation slot **66** must be determined. This distance T_y is equal to (B-A), which corresponds the longitudinal translation of the center of the key feature **46** from the point at which the center of the key feature rotates out of the insertion slot **64** (at distance A) to the point at which the key feature **46** abuts the far wall of the rotation slot **66** and the first ramp surface **70** (at distance B). Because the diameter of the key feature **46** is equal to width R in this embodiment, the distance (B-A) can be also be represented by equation 2 below.

Equation 2:

$$T_y = (B - A) = \left(\frac{1}{2}R + W\right) tan\theta$$

[0037] Combining Equation 2 with Equation 1 yields the following calculation for determining L_T may be represented by equation 2 below.

Equation 3:

$$L_T = \frac{(B + A)}{2} \pm \left(\frac{1}{2}R + W\right) tan\theta$$

[0038] Thus, as shown above, a prescribed displacement system can be used with this and other embodiments to design assembly tools that achieve reliable assembly during manufacturing while allowing for maximum allowable tolerances to keep overall manufacturing costs down.

[0039] The bayonet locking mechanism may include additional structures for preventing removal of the ferrule holder **34** as well. In this regard, **FIGS. 7A-7C** are side views of an exemplary inner housing sub-assembly **74** for a fiber optic connector sub-assembly showing a latch feature for automatically locking and retaining the ferrule holder in the inner housing. As shown in **FIG. 7A**, the rotation slot **78** includes a one-way flexible latch structure **82** that extends towards and partially obstructs the retention slot **80**. **FIG. 7B** illustrates that the latch structure **82** is bendable about the first ramp surface **84** such that the latch structure **82** is pushed aside by the key portion **46** when the key portion **46** is being guided into the retention slot **80**. However, once the key portion **46** is retained in the retention slot **80**, the latch structure **82** blocks and obstructs the key portion **46**. If an attempt is made to move the key portion **46** back into the rotation slot **78**, as shown in **FIG. 7C**, the key portion **46** will engage a free end **86** of the latch structure **82** such that the latch structure **82** impedes movement of the key portion **46** and may also resiliently deform to further block the rotation slot **78**.

[0040] Advantageously, and as shown in FIGS. 7A-7C, the latch structure 82 may designed as with first and second substantially straight sections separated by a bend. This configuration allows for a latch structure with a longer length, which helps distribute loads.

[0041] Another alternative fiber optic inner housing sub-assembly **88** is disclosed in **FIGS. 8A-8C**. In this embodiment, as shown by **FIG. 8A**, the fiber optic inner housing sub-assembly **88** includes a bayonet locking mechanism including an insertion slot **90**, a rotation slot **92**, and a retention slot **94** for accommodating a ferrule holder, such as ferrule holder **34** having key portions **46** and carrying ferrule **44**. The rotation slot **92** has an irregular curved profile to facilitate movement of key portion **46** into the retention slot **94**. A latch structure **96** also includes a ramped flange **98** in this embodiment. As shown by **FIG. 8B**, the ramped flange **98** has a first ramp surface **100** facing the rotation slot **92** that facilitates movement of the key portion **46** from the rotation slot **92** by moving the latch feature away from the rotation slot **92** when the key portion **46** engages the first ramp surface **100**. The ramped flange **98** also has a second ramp surface **102** facing the retention slot **94.** As shown by **FIG. 8C**, the second ramp surface **102** prevents removal of the key portion **46** from the retention slot **94** by moving the latch feature further into the rotation slot **92** when the key portion **46** engages the second ramp surface **102**, thereby preventing removal of the key portion **46** from the retention slot **94**.

[0042] **FIGS. 9A-9C** show another fiber optic inner housing sub-assembly **104** that includes a bayonet locking mechanism including an insertion slot **106**, a rotation slot **108**, and a retention slot **110** for accommodating a ferrule holder, such as ferrule holder **34** having key portions **46** and carrying ferrule **44**. As shown in **FIG. 9A**, a latch structure **112** disposed in the rotation slot **108** comprises a leaf spring (e.g., has a leaf spring profile). As shown in **FIG. 9B**, insertion of the key portion **46** causes the latch structure **112** to flatten out within the rotation slot **108** when the key portion **46** is moved through the rotation slot **108** toward the retention slot **110**. However, after the key portion **46** moves past the latch structure **112**, the leaf spring profile of the latch structure **112** causes the latch structure **112** to spring back into place. Thus, as shown in **FIG. 9C**, if an attempt to remove the key portion **46** from the retention slot **110** is made, the key portion **46** engages the free end **114** of the latch structure **112**, thereby causing the leaf spring profile to bow out toward the opposite wall of the rotation slot **108** and obstruct the rotation slot **108**.

[0043] In some embodiments, the latch structure can obstruct the interface between the rotation slot and insertion slot. In this regard, **FIGS. 10A-10C** show another fiber optic inner housing sub-assembly **116** that includes a bayonet locking mechanism including an insertion slot **118**, a rotation slot **120**, and a retention slot **122** for accommodating a ferrule holder, such as ferrule holder **34** having key portions **46** and carrying ferrule **44**. The fiber optic inner housing sub-assembly **116** also includes a latch structure **124** that extends along a portion of the insertion slot **118** into the rotation slot **120**. As shown by **FIGS. 10A** and **10B**, a ramped surface **126** of the latch structure **124** causes the latch structure **124** to press away from the key portion **46** during insertion into the rotation slot **120**. As shown by **FIG. 10C**, the ramped surface **126** then obstructs the rotation slot **120** to impede movement of the key portion **46** out of the rotation slot **120** back into the insertion slot **118**.

[0044] **FIGS. 11A-11C** show another fiber optic inner housing sub-assembly **128** that includes a bayonet locking mechanism including an insertion slot **130**, a rotation slot **132**, and a retention slot **134** for accommodating a ferrule holder, such as ferrule holder **34** having key portions **46** and carrying ferrule **44**. In this embodiment, a latch structure **136** on the inner housing sub-assembly **128** extends within the rotation slot **132** to obstruct the key portion **46** from being moved from the rotation slot **132** to the insertion slot **130**. As shown by **FIGS. 11A** and **11B**, when the key portion **46** is inserted into the insertion slot **130**, the key portion **46** engages a ramp surface **140** of a flange **138** disposed on the end of the latch structure **136**. The latch structure **136** is pressed toward a rear of the rotation slot **132** while the ramp surface **140** guides and rotates the key portion **46** into the rotation slot **132**, where it can then be rotated toward the retention slot **134** and released. However, as shown by **FIG. 11C**, when the key portion **46** is rotated back toward the insertion slot **130**, the key portion **46** engages a side surface **142** of flange **138** and is prevented from rotating further. Thus, the flange **138** of the latch structure **136** permits movement of the key portion **46** into the rotation slot **132** for assembly while preventing removal of the key portion **46** from the rotation slot **132** into the insertion slot **130**, thereby preventing accidental disassembly.

[0045] Unless otherwise expressly stated, it is in no way intended that any method set forth herein be construed as requiring that its steps be performed in a specific order. Accordingly, where a method claim does not actually recite an order to be followed by its steps or it is not otherwise specifically stated in the claims or descriptions that the steps are to be limited to a specific order, it is no way intended that any particular order be inferred.

[0046] It will be apparent to those skilled in the art that various modifications and variations can be made without departing from the spirit or scope of the invention. Since modifications combinations, sub-combinations and variations of the disclosed embodiments incorporating the spirit and substance of the invention may occur to persons skilled in the art, the invention should be construed to include everything within the scope of the appended claims and their equivalents.

What is claimed is:

1. A fiber optic connector inner housing sub-assembly for mounting and retaining a ferrule holder as part of a fiber optic connector sub-assembly, comprising:

an inner housing having an opening extending therethrough, wherein the opening comprises a front end, a rear end, and an interior surface; and

at least one bayonet locking mechanism comprising:

an insertion slot disposed in the interior surface of the opening and configured to receive a respective key portion of a ferrule holder when the ferrule holder is inserted into the front end of the opening;

a rotation slot disposed in the interior surface of the opening for rotating the key portion of the ferrule holder away from the insertion slot; and

a retention slot disposed in the interior surface of the opening for retaining the ferrule holder in the inner housing.

2. The fiber optic connector inner housing sub-assembly of claim 1, wherein the inner housing comprises a stop disposed at a front end of the retention slot to provide a stop surface for retaining the ferrule holder in the inner housing.

3. The fiber optic connector inner housing sub-assembly of claim 1 or 2, wherein the insertion slot is a groove extending substantially parallel to a longitudinal axis of the fiber optic connector inner housing.

4. The fiber optic connector inner housing sub-assembly of claim 3, wherein one of a portion of the rotation slot and a portion of the retention slot extends from the interior surface of the opening through an outer surface of the fiber optic connector inner housing.

5. The fiber optic connector inner housing sub-assembly of any of claims 1-4, wherein the retention slot extends substantially parallel to a longitudinal axis of the fiber optic connector inner housing.

6. The fiber optic connector inner housing sub-assembly of any of claims 1-5, wherein the rotation slot extends substantially perpendicular to a longitudinal axis of the fiber optic connector inner housing.

7. The fiber optic connector inner housing sub-assembly of any of claims 1-5, wherein the rotation slot includes a ramp surface configured to cause the key portion of the ferrule holder to rotate away from the insertion slot with respect to a longitudinal axis of the fiber optic connector inner housing when an insertion force parallel to the longitudinal axis is applied to the ferrule holder.

8. The fiber optic connector inner housing sub-assembly of any of claims 1-7, wherein the rotation slot includes a ramp surface configured to cause the key portion of the ferrule holder to rotate the key portion toward the retention slot with respect to a longitudinal axis of the inner housing toward the retention slot when a bias force parallel to the longitudinal axis is applied to the ferrule holder.

9. The fiber optic connector inner housing sub-assembly of any of claims 1-6, further comprising a latch configured to permit movement of the key portion of the ferrule holder from the rotation slot into the retention slot, and to impede movement of the key portion of the ferrule holder from the retention slot into the rotation slot.

10. The fiber optic connector inner housing sub-assembly of claim 9, wheren the latch includes first and second substantially straight sections separated by a bend.

11. The fiber optic connector inner housing sub-assembly of claim 9, wheren the latch comprises a leaf-spring.

12. The fiber optic connector inner housing sub-assembly of any of claims 1-11, further comprising a crimp body connected to the inner housing at the rear end of the opening, wherein the inner housing is integarlly formed with a crimp body at the rear end of the opening.

13. A fiber optic connector sub-assembly comprising:

a fiber optic connector inner housing sub-assembly according to any of claims 1-12, wherein the fiber optic connector inner housing sub-assembly includes a bias member mounting portion disposed at the rear end of the opening of the inner housing;

a ferrule holder disposed in the inner housing and having a key portion, the front end of the opening being configured to accommodate the ferrule holder; and a bias member disposed in the inner housing between the ferrule holder and the bias member mounting portion;

wherein the insertion slot is configured to receive the key portion of the ferrule holder when the ferrule holder is inserted into the opening;

wherein the rotation slot is configured to allow the ferrule holder to be rotated away from the insertion slot; and

wherein the bias member is configured to move the key portion of the ferrule holder into the retention slot when the ferrule holder is released, thereby retaining the ferrule holder in the inner housing.

14. The fiber optic connector sub-assembly of claim 13, further comprising a crimp body connected to the inner housing at the rear end of the opening, wherein the inner housing is integrally formed with a crimp body at the rear end of the opening.

15. The fiber optic connector sub-assembly of claim 13 or 14, further comprising a shroud mounted to the fiber optic connector inner housing.

16. The fiber optic connector sub-assembly of any of claims 13-15, further comprising an optical fiber extending through a rear end of the ferrule holder and connected to a fiber optic ferrule mounted in the ferrule holder.

17. The fiber optic connector sub-assembly of any of claims 13-16, wherein the key portion of the ferrule holder is a protrusion such that the insertion slot, rotation slot and retention slot of the inner housing are configured to slidably accommodate the protrusion.

18. A method of assembling a fiber optic connector sub-assembly comprising:

providing a fiber optic connector inner housing sub-assembly according to any of claims 1-13, wherein the fiber optic connector inner housing sub-assembly includes a bias member mounting portion disposed at the rear end of the opening of the inner housing;

providing a bias member in the inner housing adjacent the bias member mounting portion;

inserting the ferrule holder into the front end of the opening of the inner housing such that the key portion is received by the insertion slot and the bias member is disposed between the ferrule holder and the bias member mounting portion;

rotating the ferrule holder about a longitudinal axis of the opening such that the key portion rotates within the rotation slot; and

releasing the ferrule holder such that the bias member moves the key portion of the ferrule holder into the retention slot, thereby retaining the ferrule holder in the inner housing.

19. The method of claim 18, wherein:

inserting the ferrule holder into the front end of the opening comprises applying an insertion force to the ferrule holder in a first direction substantially parallel to the longitudinal axis of the inner housing; and

rotating the ferrule holder about the longitudinal axis comprises continuing to apply the insertion force in the first direction.

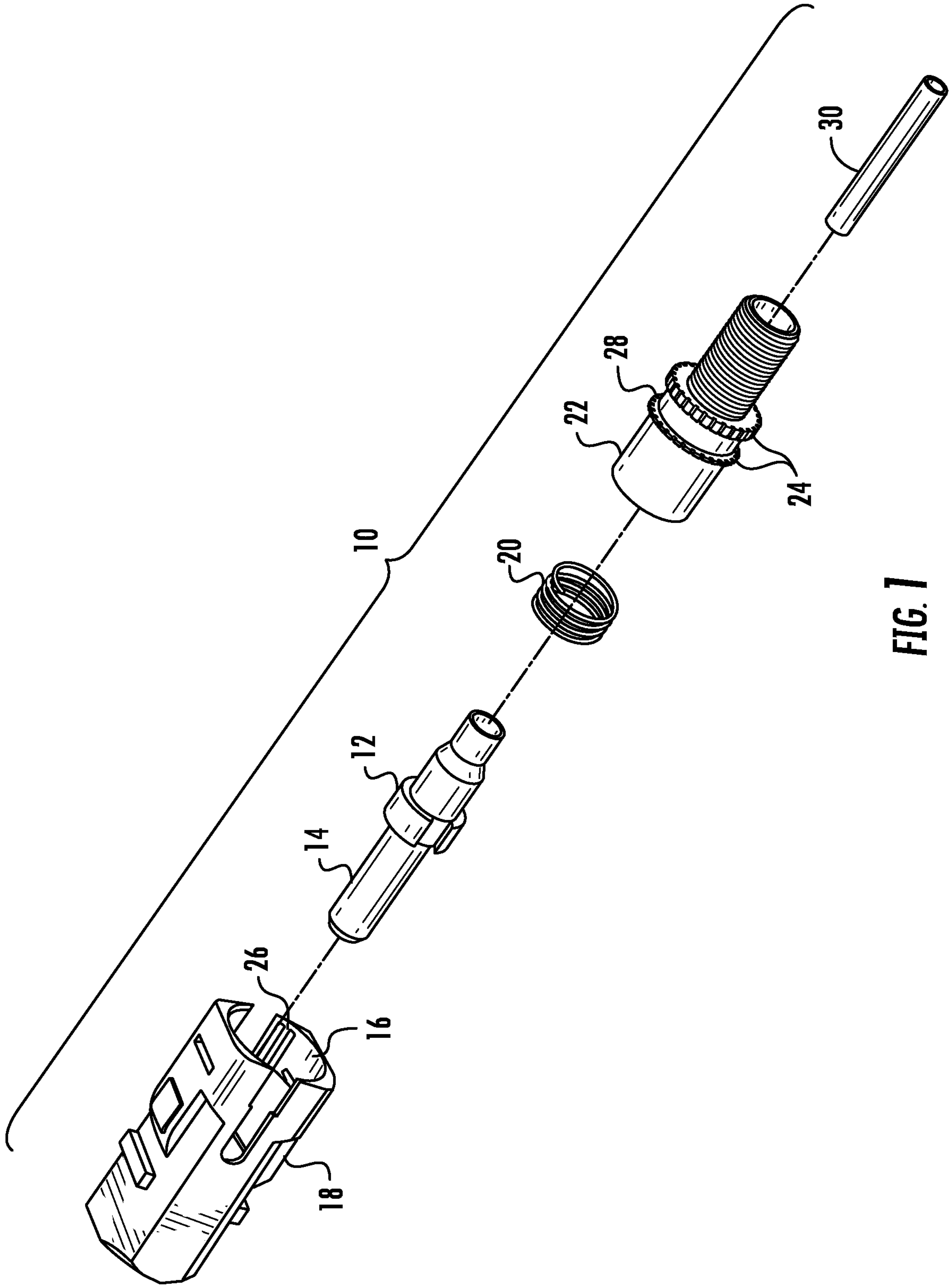

FIG. 1
(PRIOR ART)

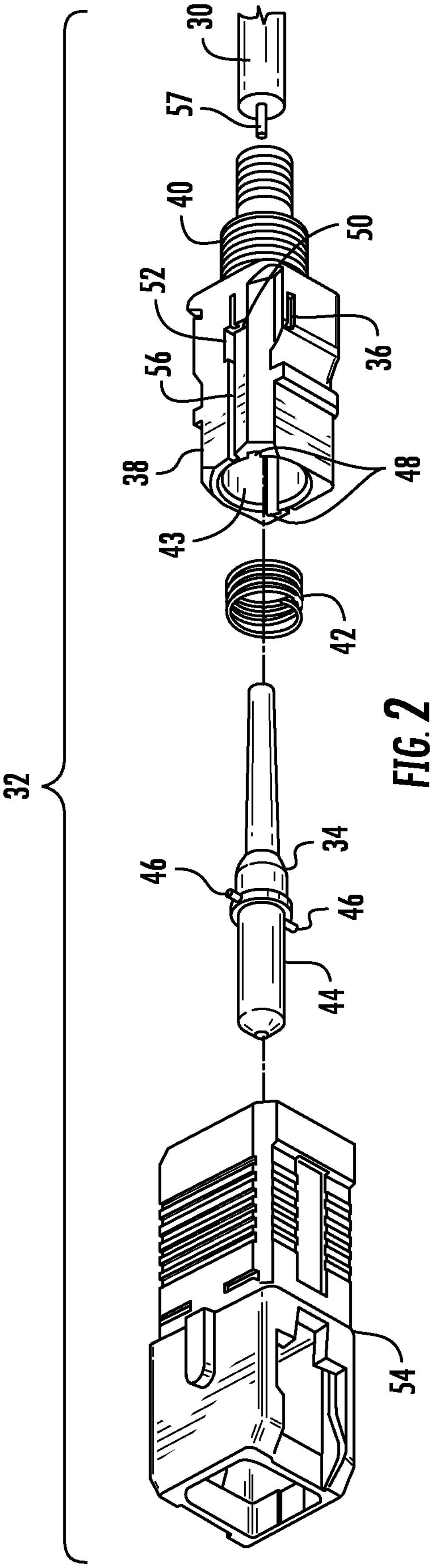

FIG. 2

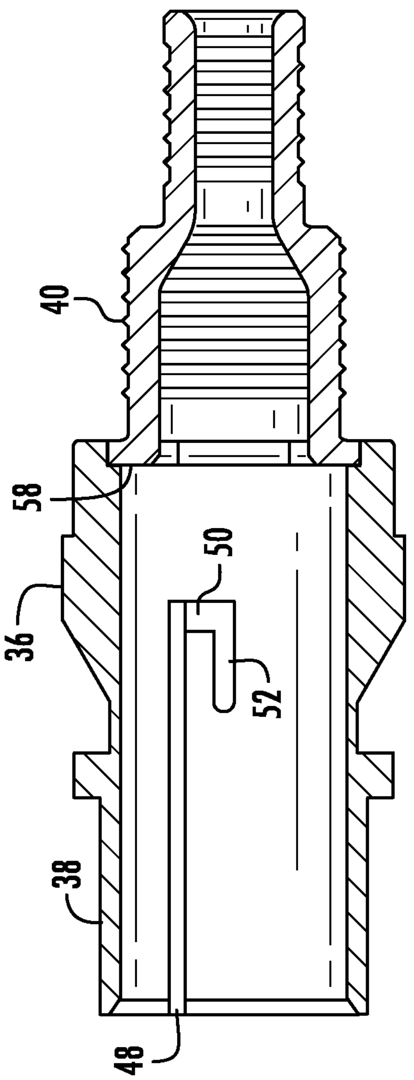

FIG. 3

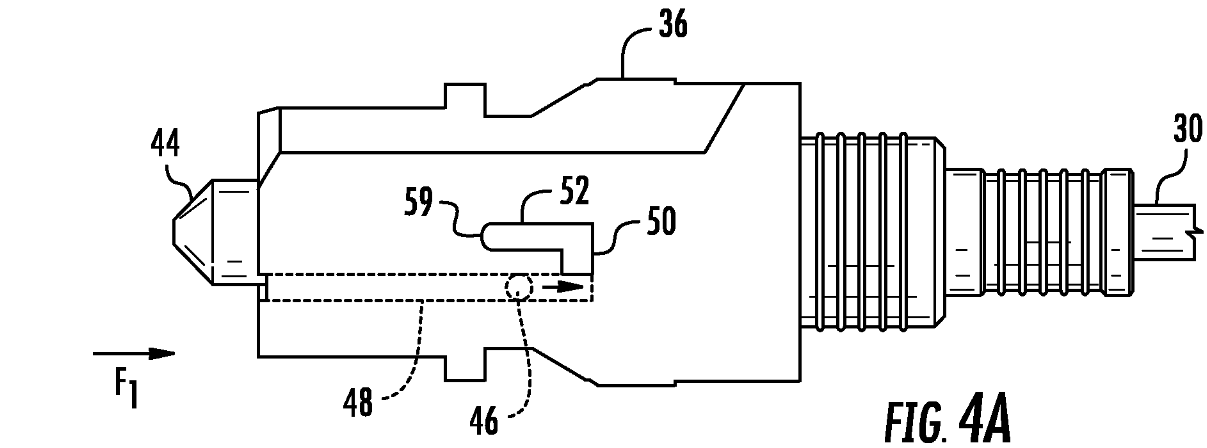

FIG. 4A

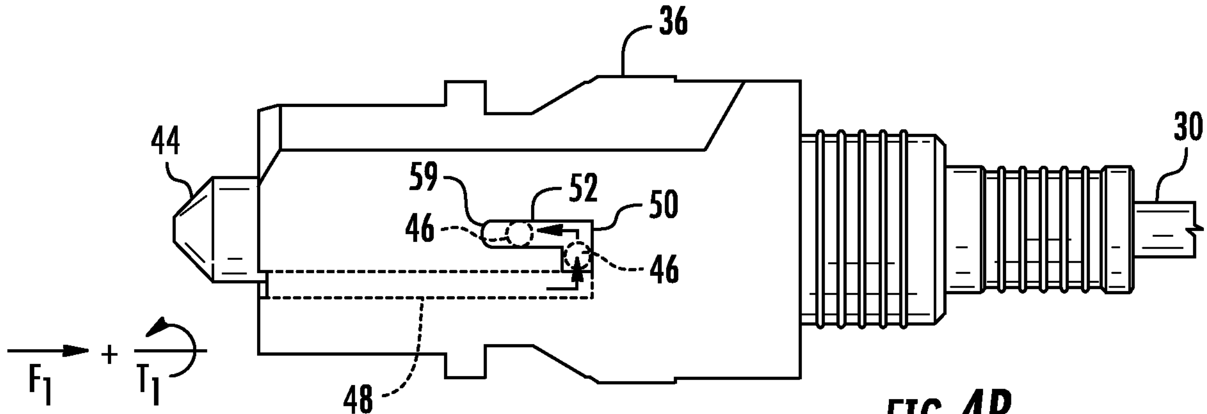

FIG. 4B

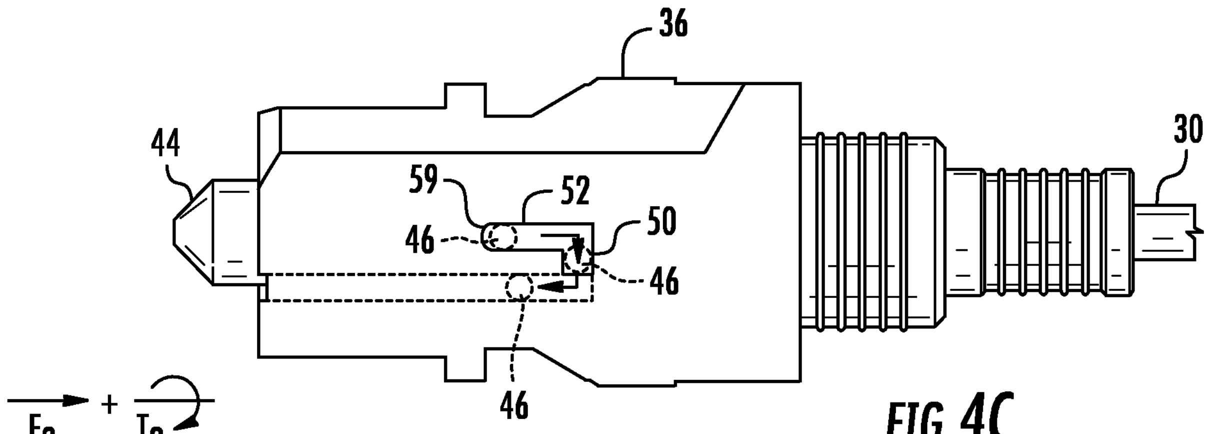

FIG. 4C

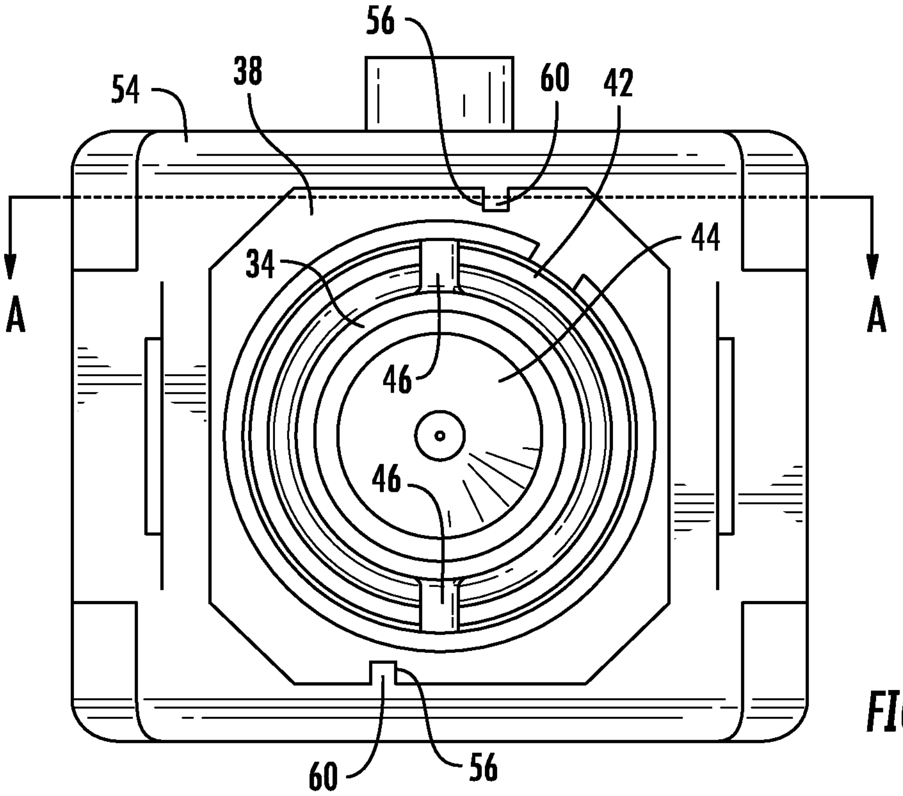

FIG. 5A

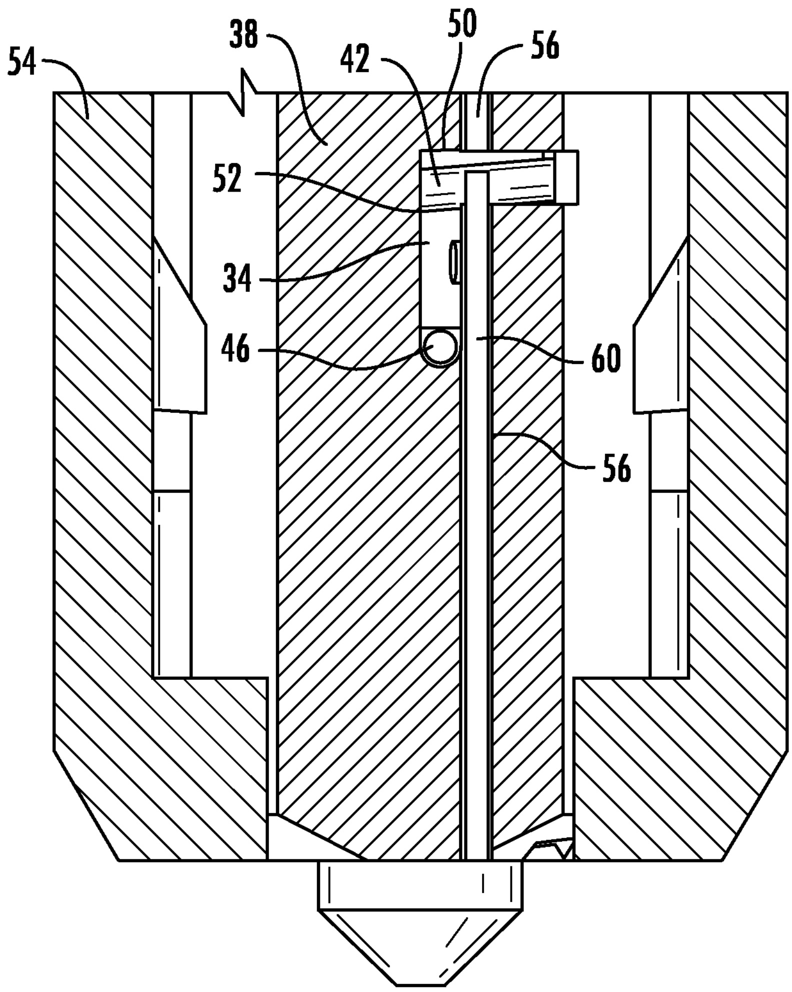

FIG. 5B

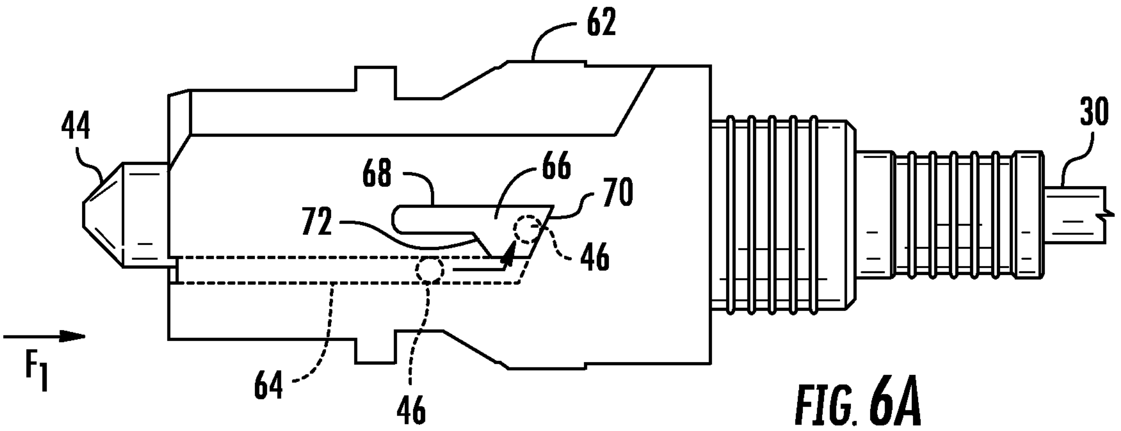

FIG. 6A

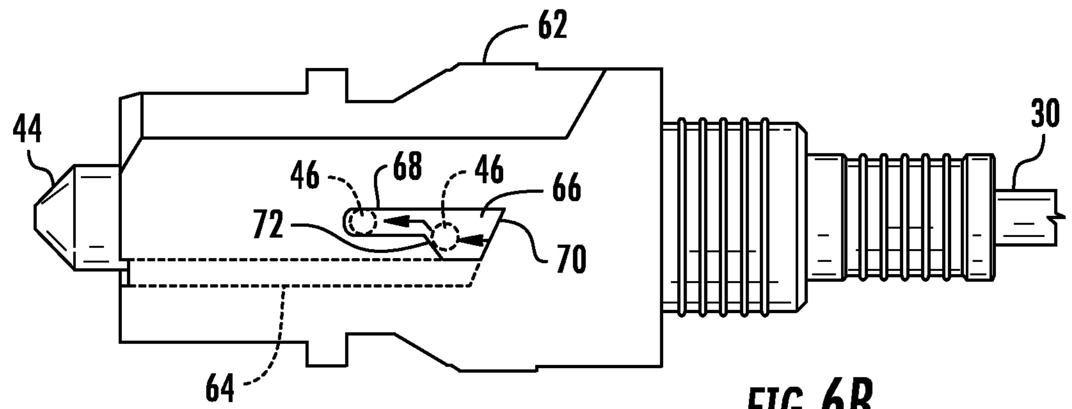

FIG. 6B

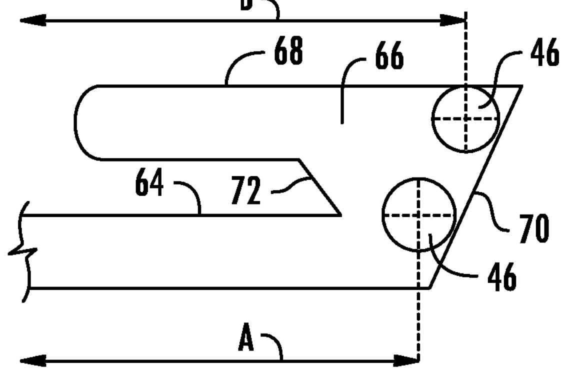

FIG. 6C

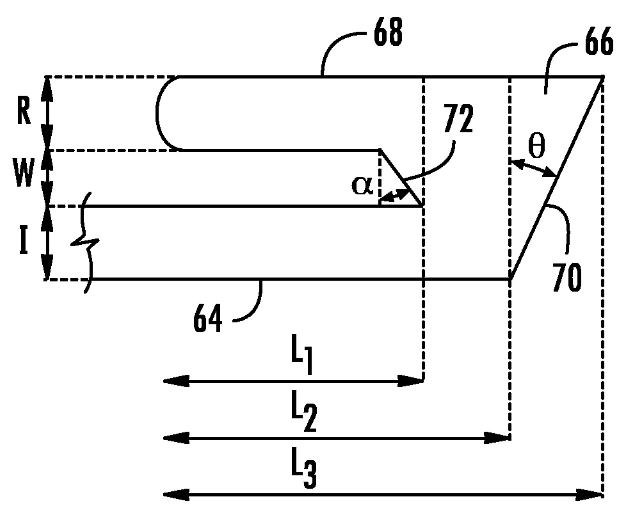

FIG. 6D

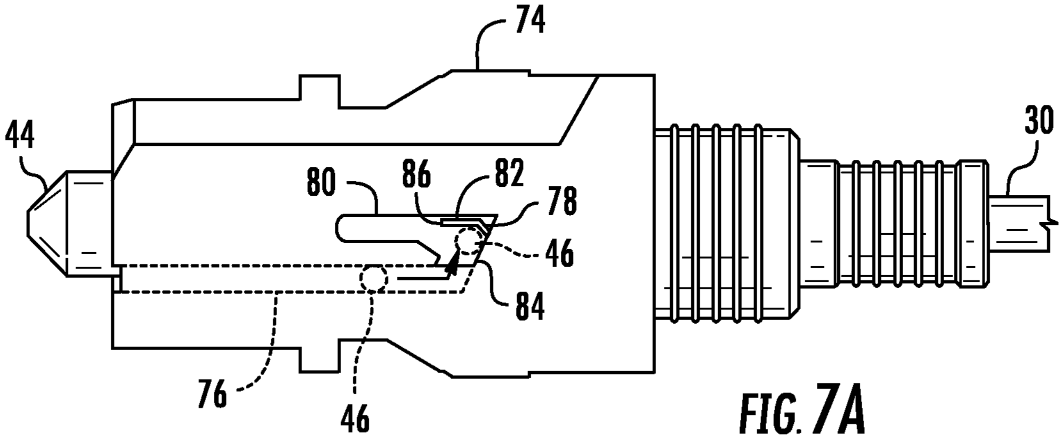

FIG. 7A

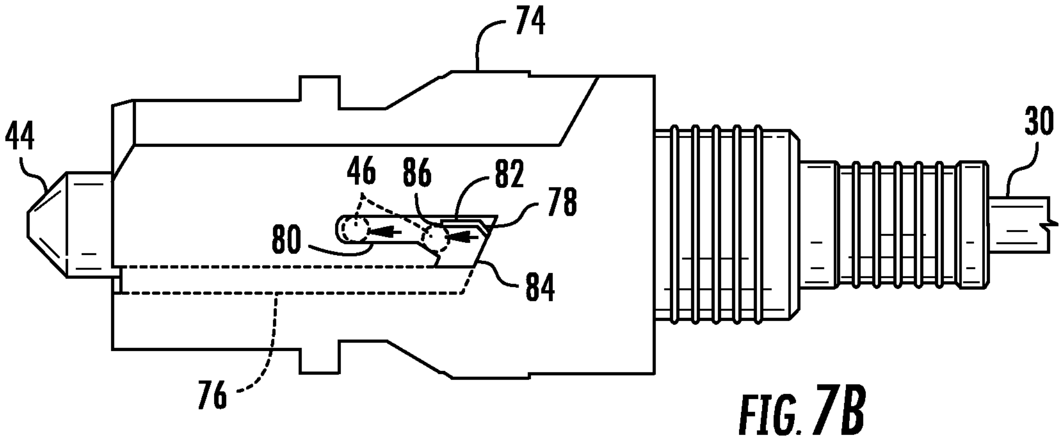

FIG. 7B

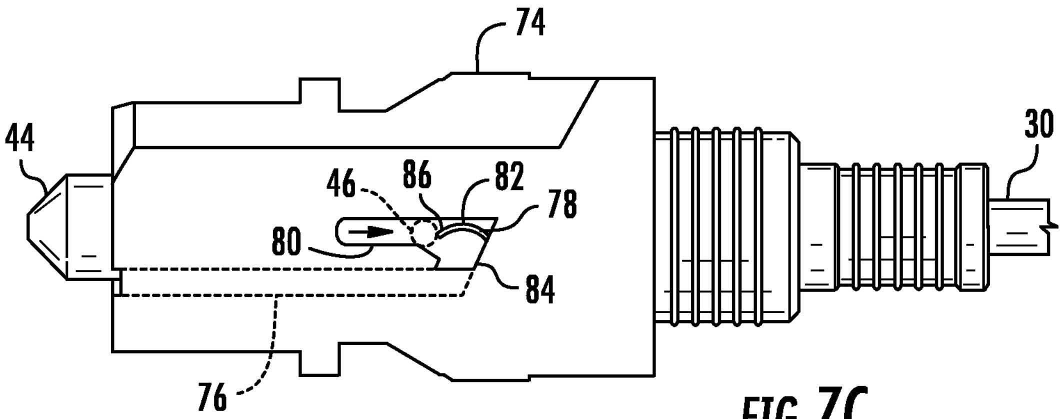

FIG. 7C

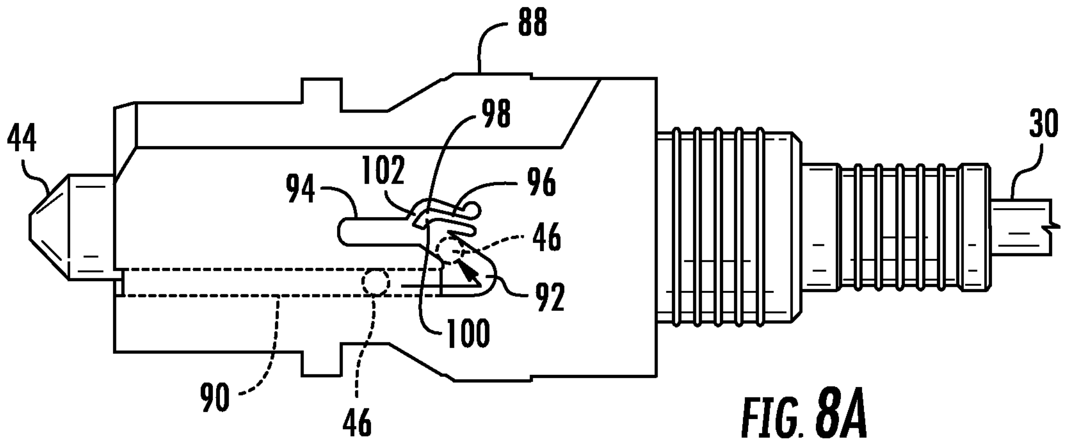

FIG. 8A

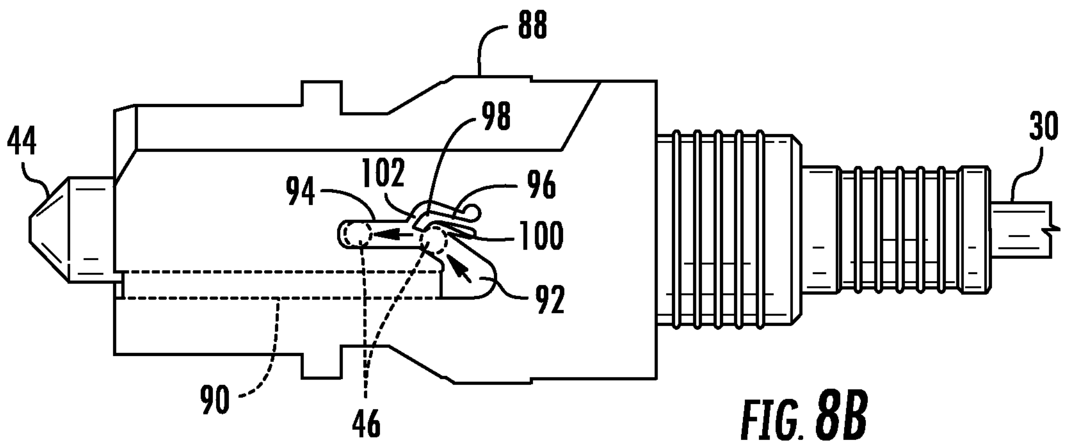

FIG. 8B

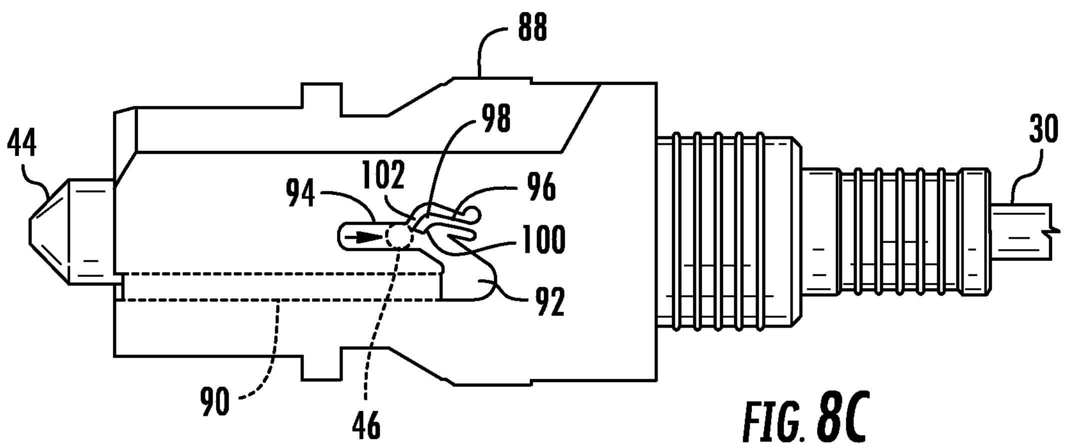

FIG. 8C

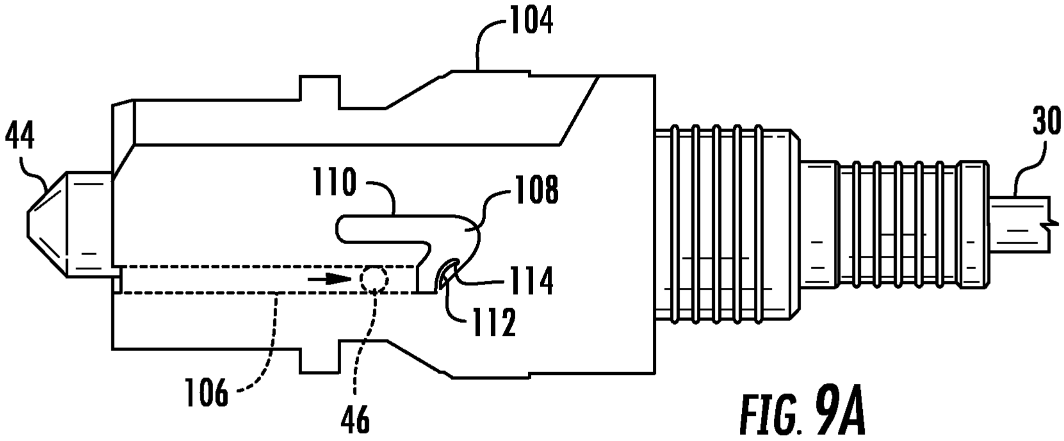

FIG. 9A

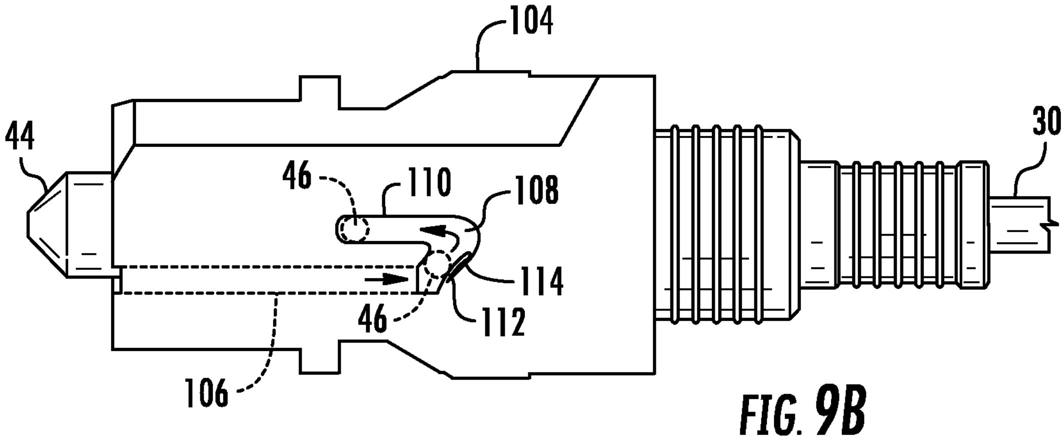

FIG. 9B

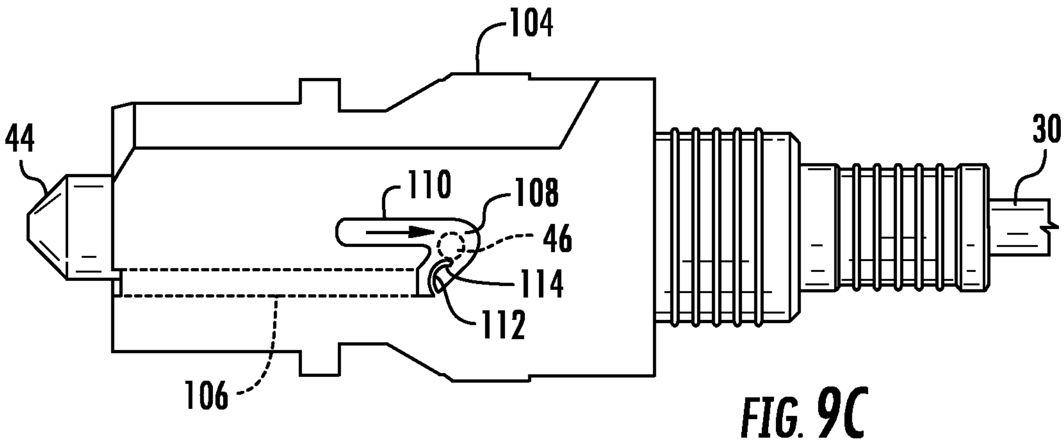

FIG. 9C

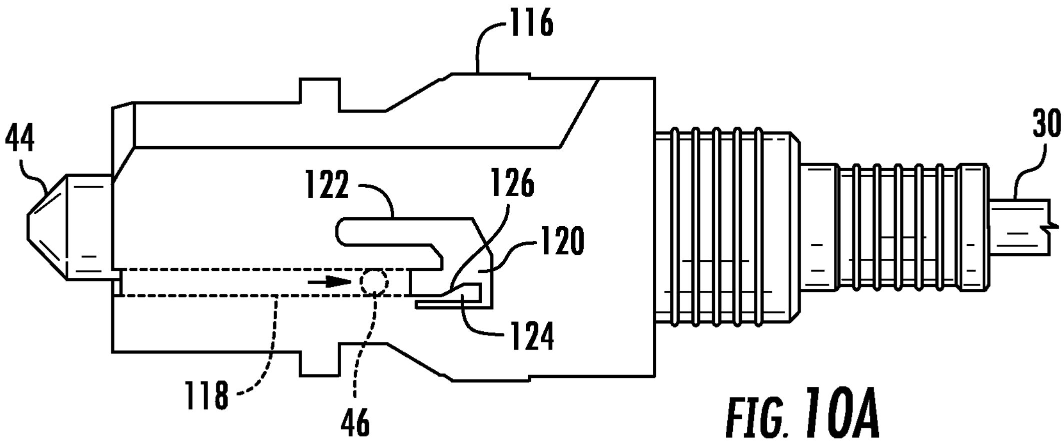

FIG. 10A

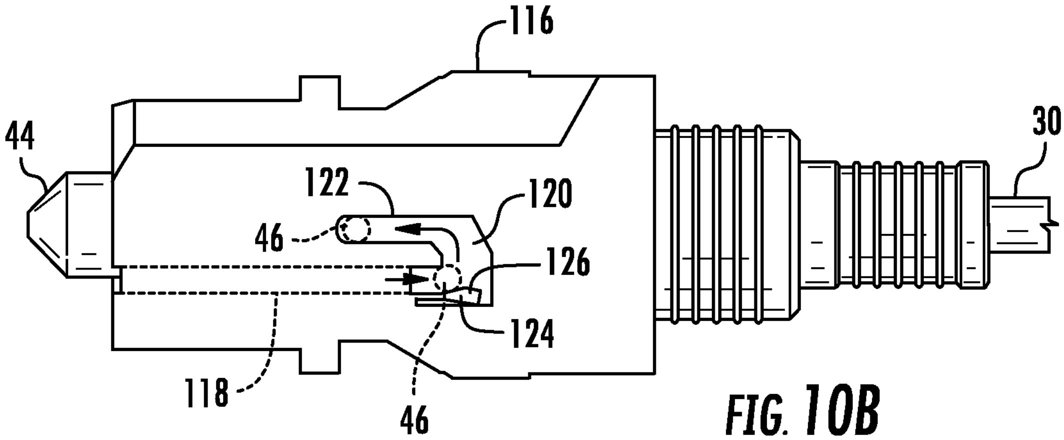

FIG. 10B

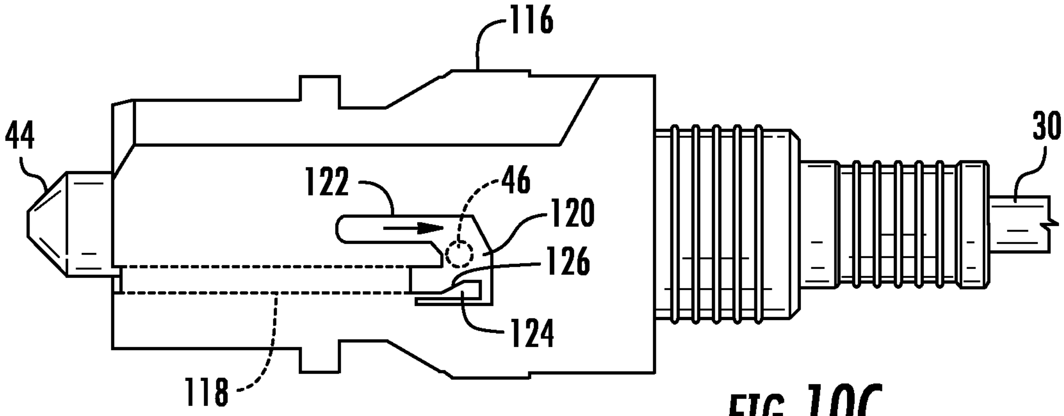

FIG. 10C

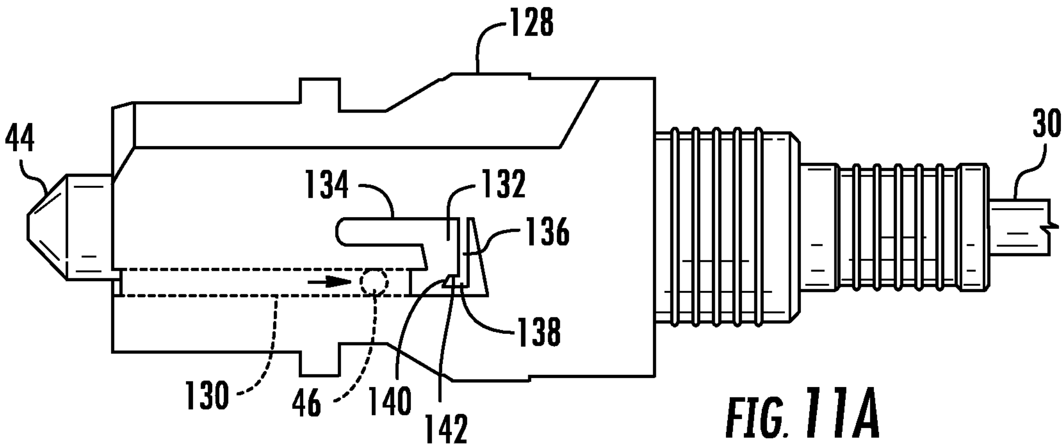

FIG. 11A

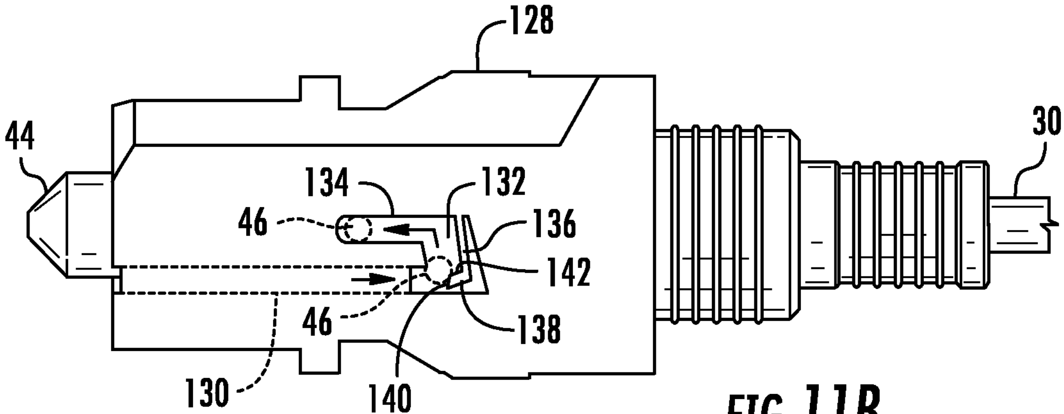

FIG. 11B

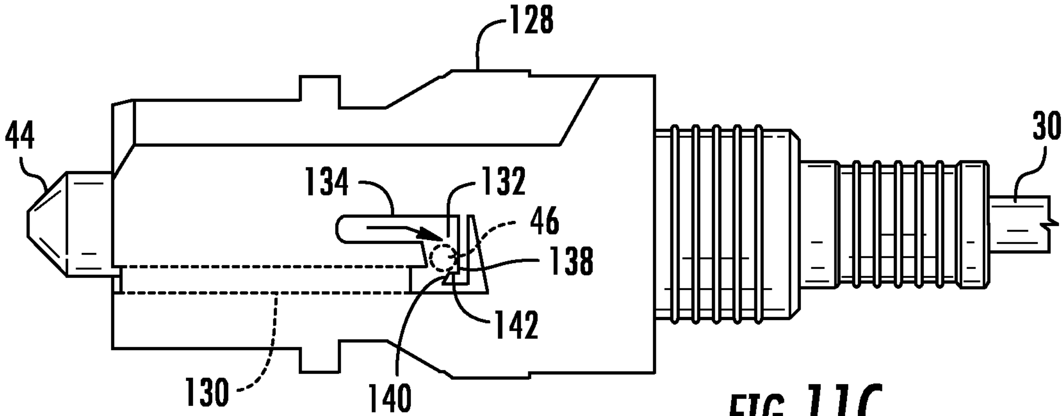

FIG. 11C

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2013/052968

A. CLASSIFICATION OF SUBJECT MATTER
INV. G02B6/38
ADD.

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

B. FIELDS SEARCHED

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

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

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

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	WO 2006/069093 A1 (MOLEX INC [US]) 29 June 2006 (2006-06-29) page 9, line 29 - page 11, line 7; figures 8a-8d -----	1-8,13, 16-19 9-11
Y A	US 2003/138217 A1 (LECOMTE FABRICE [FR] ET AL) 24 July 2003 (2003-07-24) paragraph [0025] - paragraph [0044]; figures 1-4 -----	1-8,13, 16-19 9-11
Y A	US 5 074 637 A (RINK DAN L [US]) 24 December 1991 (1991-12-24) column 4, line 16 - line 45; figures 3-10 -----	7 9-11
Y A	US 2012/020618 A1 (ERDMAN DAVID DONALD [US] ET AL) 26 January 2012 (2012-01-26) paragraph [0051] - paragraph [0056]; figure 7 -----	4,7 9-11
	-/--	

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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

"E" earlier application or patent but published on or after the international filing date

"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)

"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

"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

"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

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 February 2014	09/05/2014

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Frisch, Anna Maria

1

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2013/052968

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	EP 2 290 416 A1 (TERUMO CORP [JP]) 2 March 2011 (2011-03-02) paragraph [0068] - paragraph [0071]; figures 14,15	4,7 9-11
Y A	US 2008/050070 A1 (GURRERI MICHAEL LAWRENCE [US] ET AL) 28 February 2008 (2008-02-28) paragraph [0047]; figure 3	4,7 9-11
Y A	WO 90/15350 A1 (COMMISSARIAT ENERGIE ATOMIQUE [FR]) 13 December 1990 (1990-12-13) page 5, line 7 - line 13 page 10, line 17 - page 11, line 7; figures 1,3,6	4,7 9-11
Y A	JP S61 262709 A (SEIKO GIKEN KK) 20 November 1986 (1986-11-20) abstract; figure 1	1-8,13, 16-19 9-11

1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/052968

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-11, 13, 16-19

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-11, 13, 16-19

   Subject 1 relates to a fibre connector sub-assembly with a ferrule held in an inner housing with a bayonet locking mechanism, to details of the bayonet locking mechanism, and to a corresponding method of mounting a ferrule in an inner housing.

   ---

2. claims: 12, 14

   Subject 2 also relates to a fibre connector sub-assembly with a ferrule held in an inner housing with a bayonet locking mechanism, and to details of a crimp body for the strain relief on an optical cable mounted to the inner housing.

   ---

3. claim: 15

   Subject 3 also relates to a fibre connector sub-assembly with a ferrule held in an inner housing with a bayonet locking mechanism, and to a protection shroud mounted to the inner housing.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2013/052968

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2006069093 A1	29-06-2006	CN 101084460 A	05-12-2007
		CN 101124500 A	13-02-2008
		EP 1828827 A1	05-09-2007
		EP 1842090 A2	10-10-2007
		JP 4722943 B2	13-07-2011
		JP 4727674 B2	20-07-2011
		JP 2008524658 A	10-07-2008
		JP 2008524660 A	10-07-2008
		KR 20070089238 A	30-08-2007
		KR 20070089239 A	30-08-2007
		US 2006171638 A1	03-08-2006
		US 2006171640 A1	03-08-2006
		WO 2006069045 A2	29-06-2006
		WO 2006069093 A1	29-06-2006
US 2003138217 A1	24-07-2003	NONE	
US 5074637 A	24-12-1991	NONE	
US 2012020618 A1	26-01-2012	US 2012020618 A1	26-01-2012
		WO 2012011950 A1	26-01-2012
EP 2290416 A1	02-03-2011	CN 102066998 A	18-05-2011
		EP 2290416 A1	02-03-2011
		JP 5150725 B2	27-02-2013
		US 2012002928 A1	05-01-2012
		WO 2009154103 A1	23-12-2009
US 2008050070 A1	28-02-2008	NONE	
WO 9015350 A1	13-12-1990	EP 0476024 A1	25-03-1992
		FR 2648240 A1	14-12-1990
		JP H04505813 A	08-10-1992
		WO 9015350 A1	13-12-1990
JP S61262709 A	20-11-1986	NONE	