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(54) FERRULE ASSEMBLIES EMPLOYING MECHANICAL INTERFACES FOR OPTICAL FIBERS, AND RELATED COMPONENTS AND METHODS

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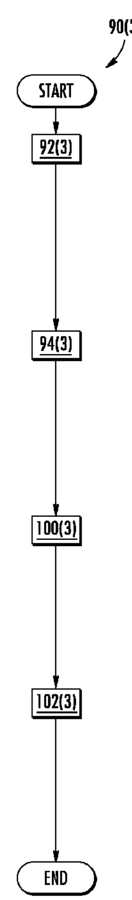
CPC ***G02B 6/36*** (2013.01); ***B23P 11/025*** (2013.01)
USPC **385/81**; 29/428; 29/447

(57) **ABSTRACT**

Embodiments disclosed herein include ferrule assemblies employing mechanical interfaces for optical fibers and related component and methods. The ferrule assemblies may be used in fiber optic connectors to precisely position the optical fiber relative to the ferrule to facilitate an optical connection with another optical device. In certain embodiments disclosed herein, the ferrule assemblies include a ferrule that includes an inner surface forming a ferrule bore. Each of the ferrules may also include an end portion of an optical fiber disposed in the ferrule bore. The inner surface of the ferrule bore abuts against an outer surface of the optical fiber to form a mechanical interface. In this manner, the mechanical interface secures the optical fiber within the ferrule bore and precisely positioned relative to the ferrule. This mechanical interface may eliminate the need for epoxy or other means to secure the optical fiber within the ferrule bore.



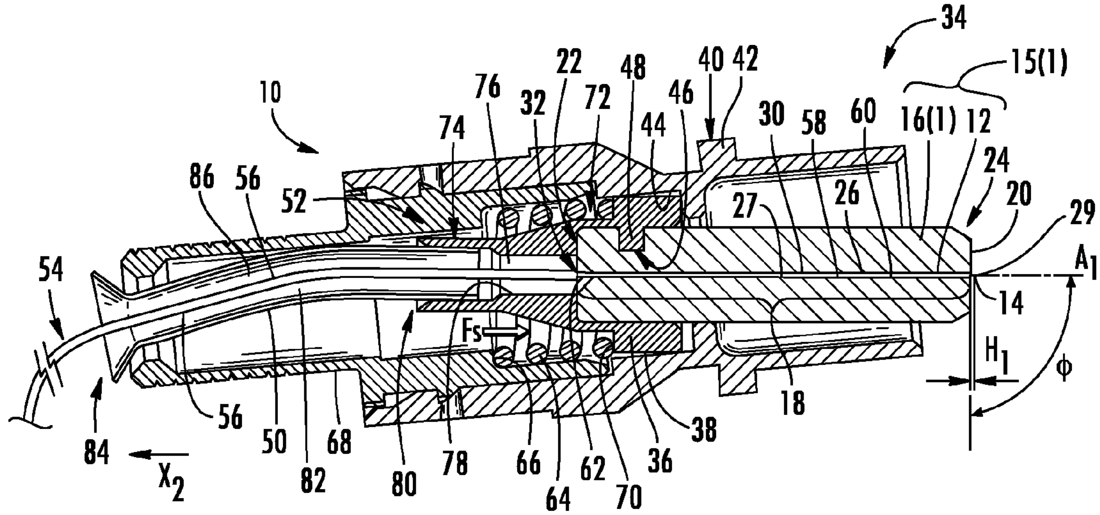


FIG. 1

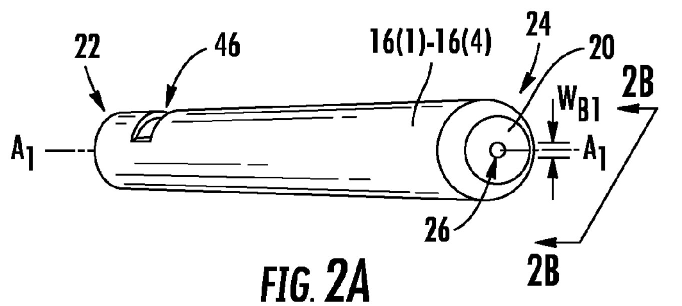


FIG. 2A

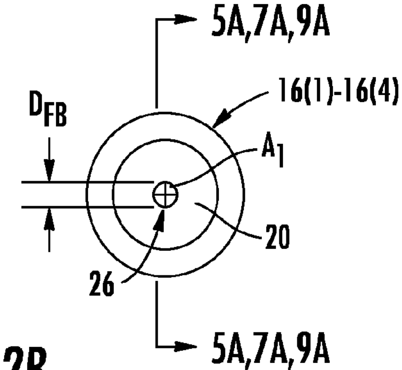


FIG. 2B

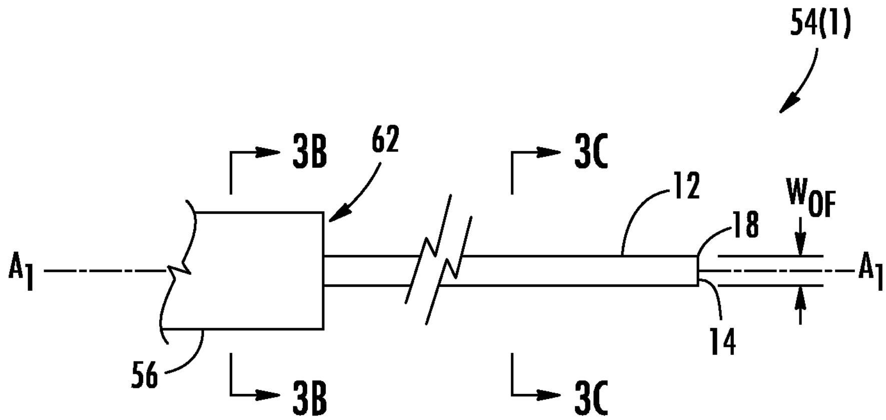


FIG. 3A

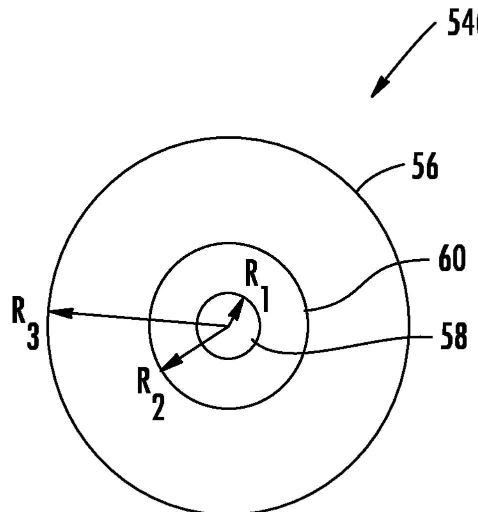


FIG. 3B

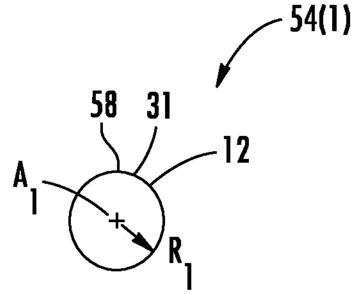
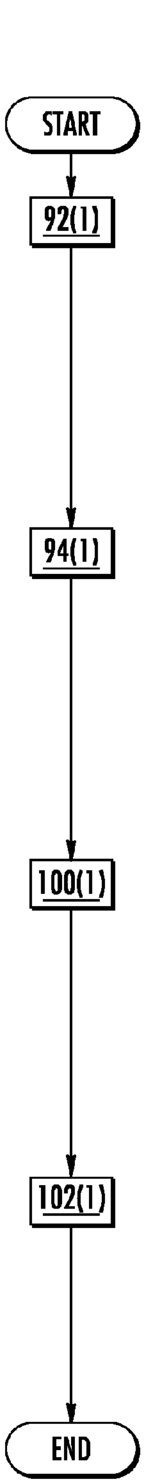


FIG. 3C



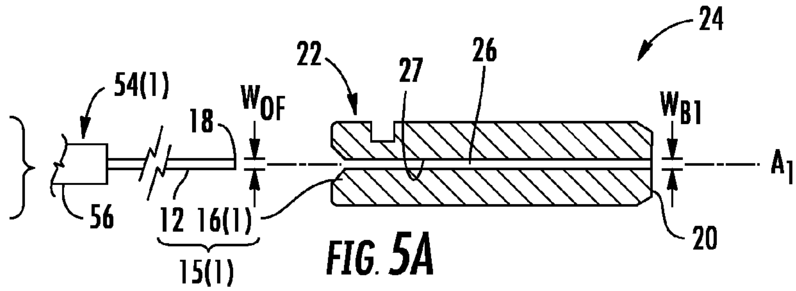


FIG. 5A

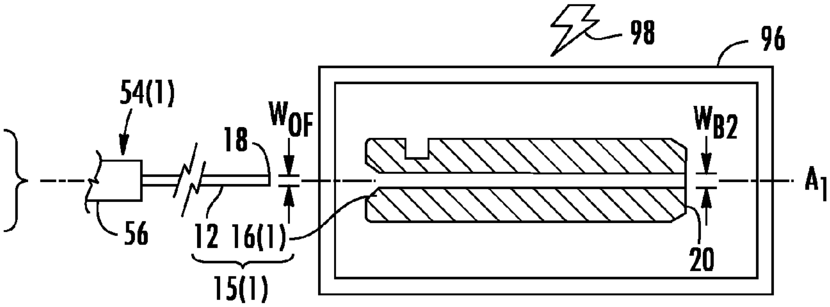


FIG. 5B

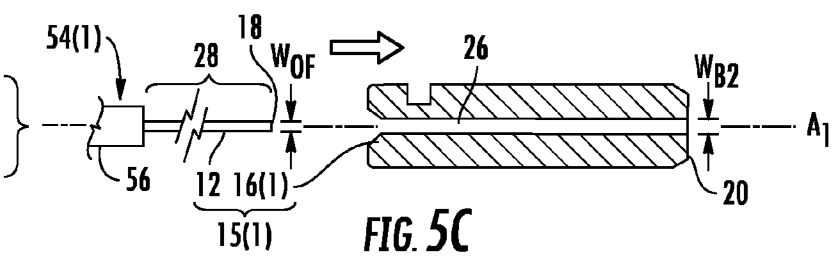


FIG. 5C

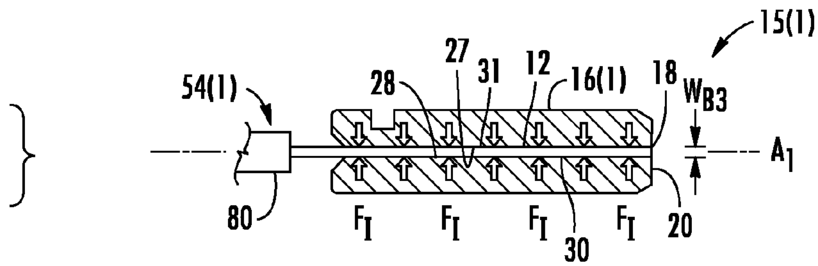


FIG. 5D

FIG. 4

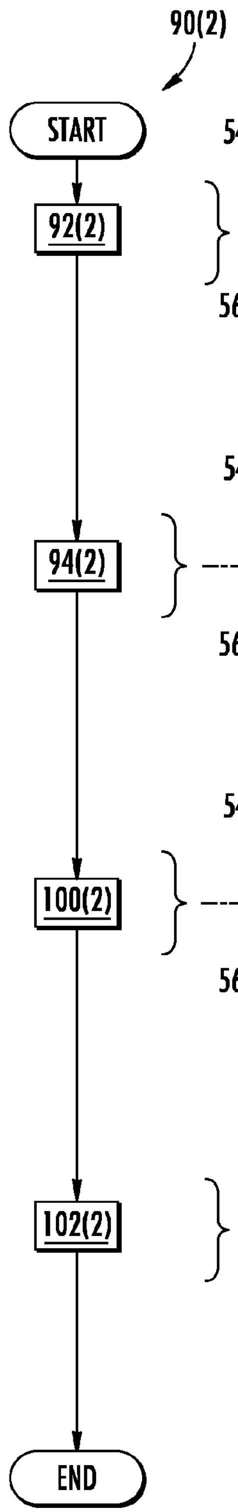


FIG. 6

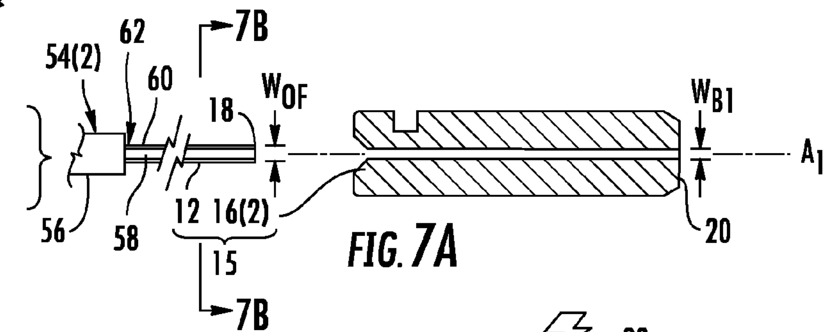


FIG. 7A

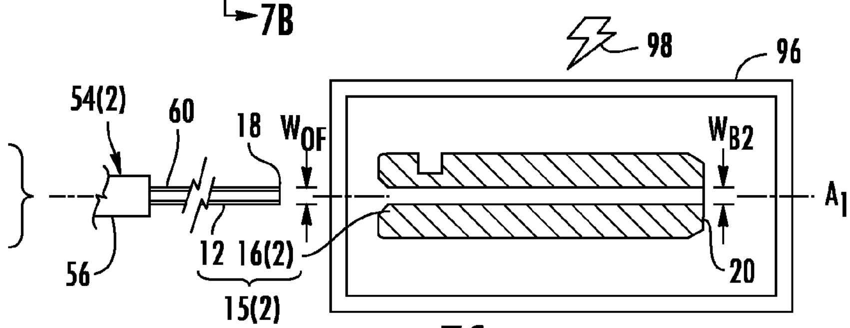


FIG. 7C

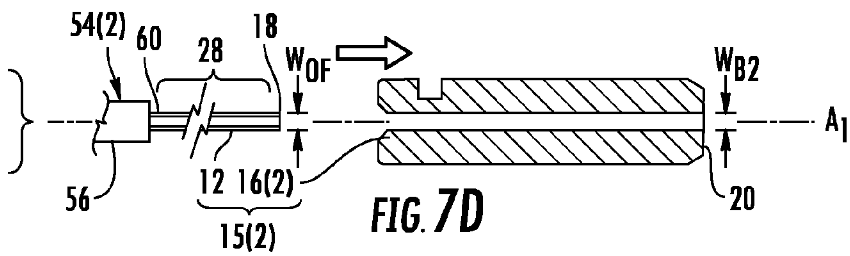


FIG. 7D

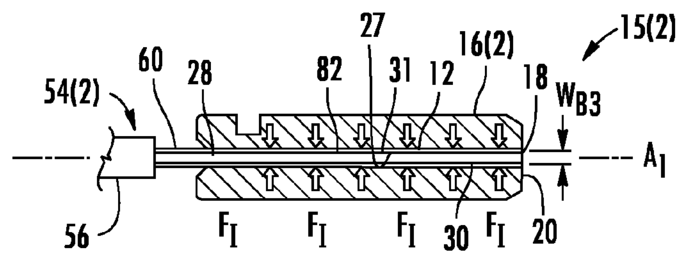


FIG. 7E

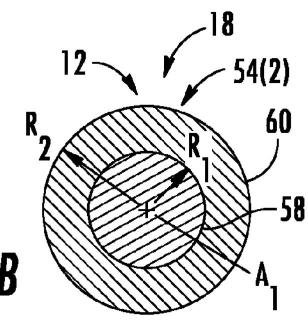


FIG. 7B

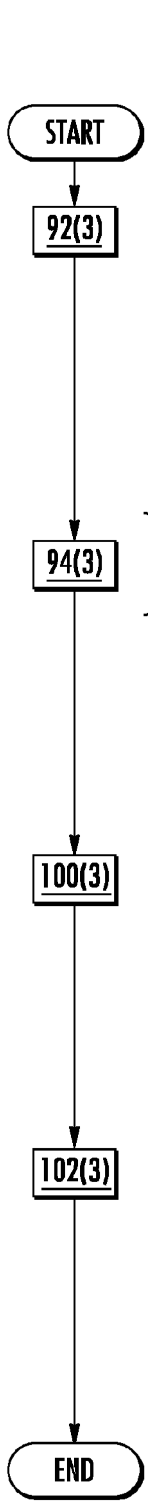


FIG. 8

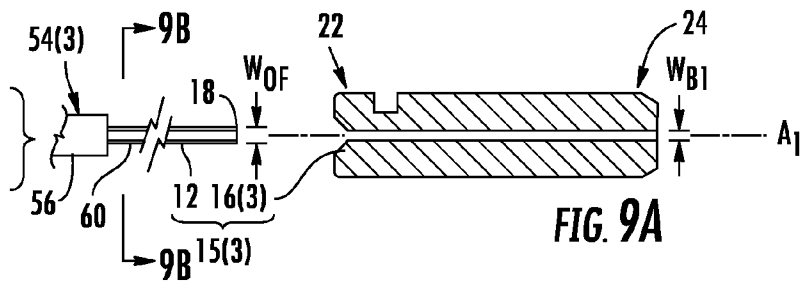


FIG. 9A

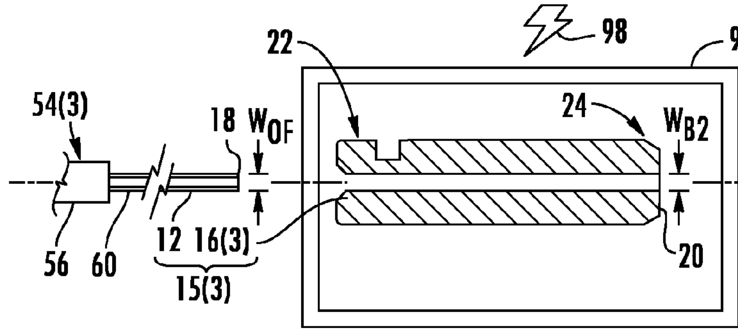


FIG. 9C

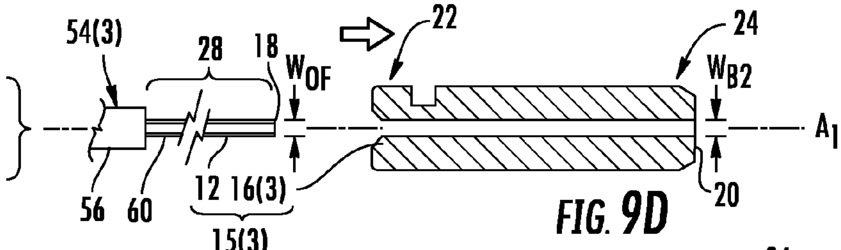


FIG. 9D

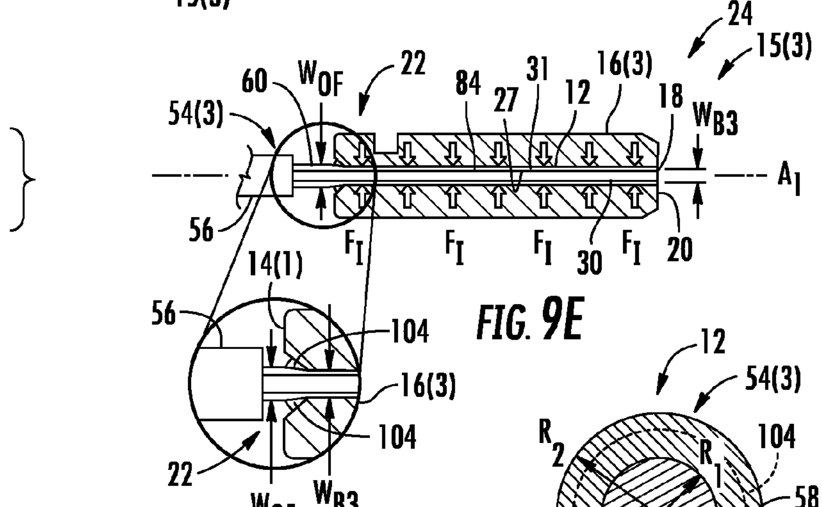


FIG. 9E

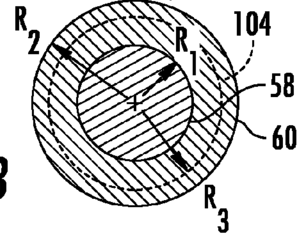


FIG. 9B

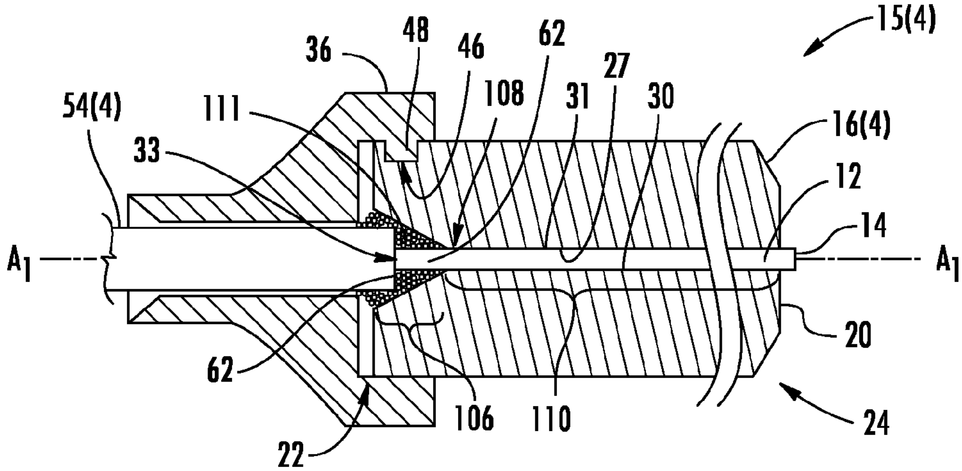


FIG. 10A

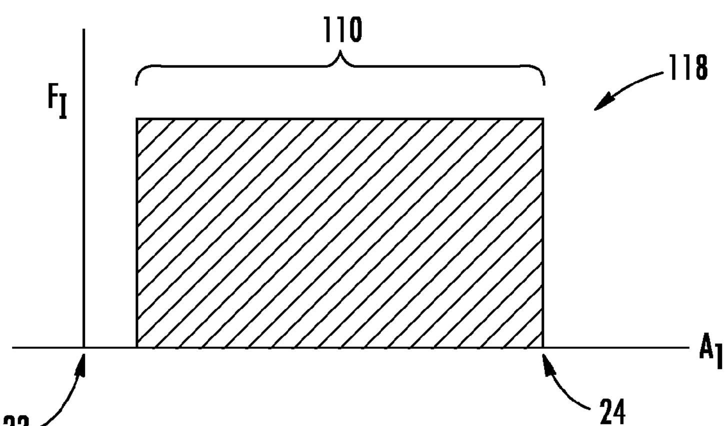


FIG. 10B

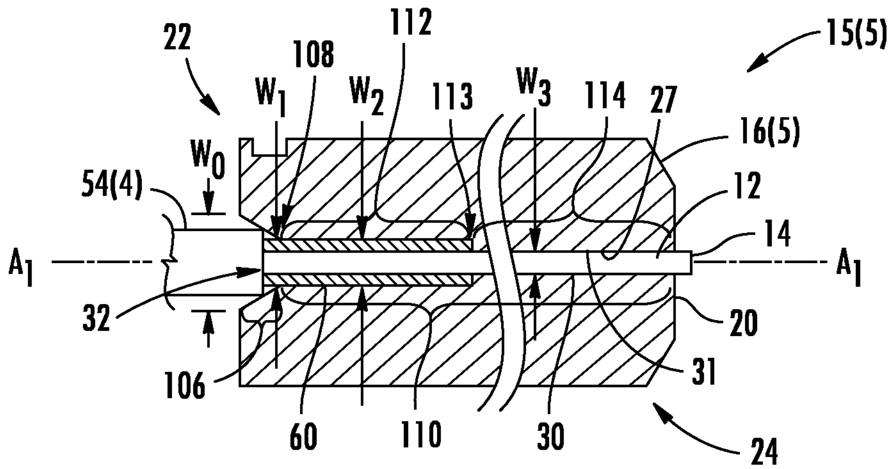


FIG. 11A

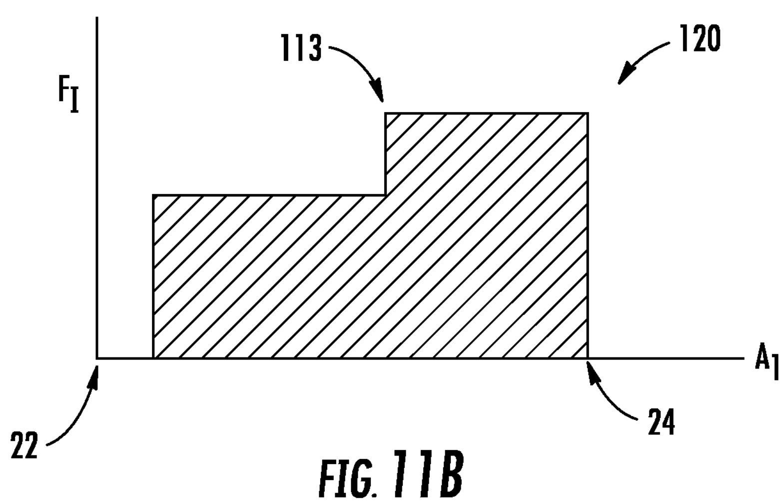


FIG. 11B

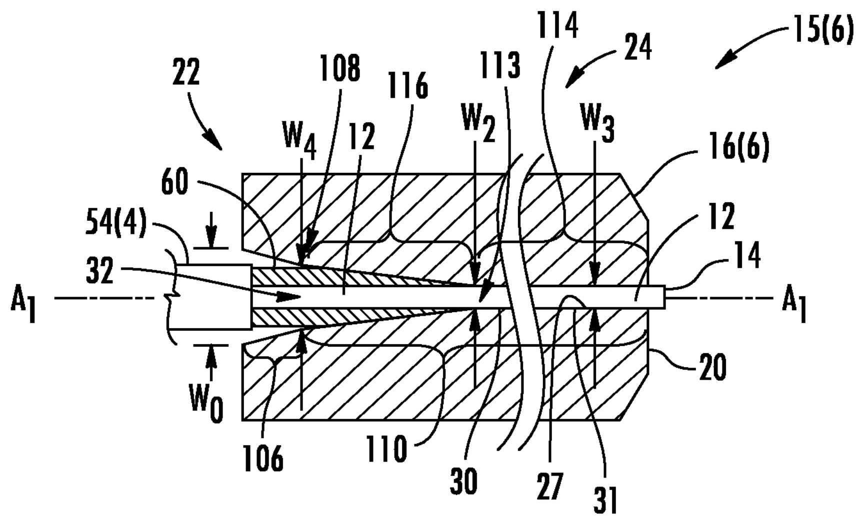


FIG. 12A

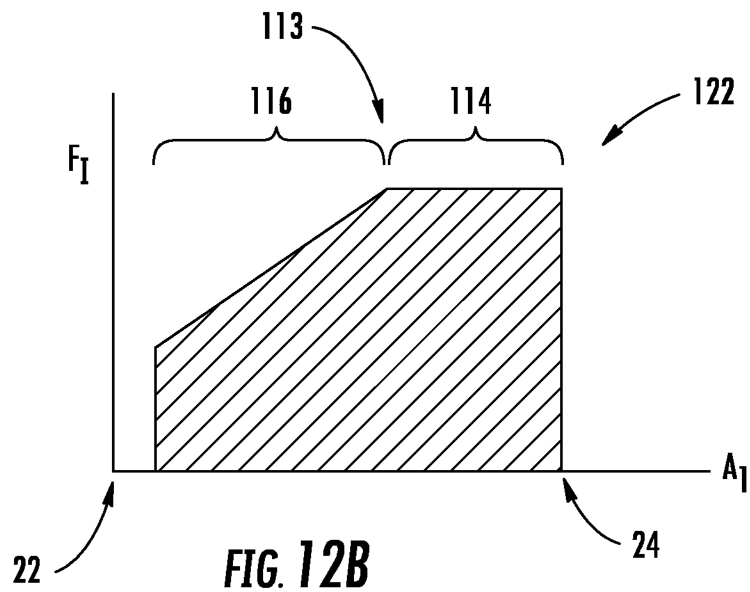


FIG. 12B

FERRULE ASSEMBLIES EMPLOYING MECHANICAL INTERFACES FOR OPTICAL FIBERS, AND RELATED COMPONENTS AND METHODS

RELATED APPLICATIONS

[0001] This application claims the benefit of priority under 35 U.S.C. §119 of U.S. Provisional Application Ser. No. 61/663,199 filed on Jun. 22, 2012, the content of which is relied upon and incorporated herein by reference in its entirety.

BACKGROUND

[0002] 1. Field of the Disclosure

[0003] The technology of the disclosure relates to securing optical fibers in ferrules as part of fiber optic connector assemblies used to establish fiber optic connections.

[0004] 2. Technical Background

[0005] Benefits of optical fibers include extremely wide bandwidth and low noise operation. In cases where high bandwidth is required between two interconnection locations, fiber optic cables having fiber optic connectors may be used to communicate information between these locations. The fiber optic connectors also may be used to conveniently connect and disconnect the fiber optic cables from the interconnect locations when maintenance and upgrades occur.

[0006] Each of the fiber optic connectors may include a ferrule assembly having a ferrule. The ferrule has several purposes. The ferrule includes an internal pathway, called a ferrule bore, through which an optical fiber is supported and protected. The ferrule bore also includes an opening at an end face of the ferrule. The opening is where an optical surface of an end portion of the optical fiber may be located to be aligned to an end portion of another optical fiber of a complementary connector. The end portions need to be aligned to establish an optical connection.

[0007] The optical surface of the optical fiber is designed for a fixed spatial relationship to the end face of the ferrule. The optical surface facilitates light transmission and/or reception to and from the fiber optic cable. Efficient and accurate transmitting and receiving light between the optical surfaces of adjacent optical fibers of the fiber optic connector and the complementary fiber optic connector, respectively, is critical to minimize signal attenuation. In this regard, the optical fiber should not move relative to the ferrule or the spatial relationship of the optical surface of the optical fiber from the end face of the ferrule would not be precisely located. Precision is required, because the optical fiber extends from the end face of the ferrule towards another optical surface of the optical fiber of the complementary optical connector. When the spatial relationship is precisely achieved, the optical surface of the optical fiber will exactly press against the optical surface of the other optical fiber of the complementary fiber optic connector to minimize the air gap therebetween, for example, consistent with International Standard CEI/IEC 61755-3-2. Air gaps between the optical surfaces can increase attenuation.

[0008] In this regard, a thermosetting epoxy ("epoxy") is typically utilized to bond the optical fiber to the ferrule bore, so the optical fiber is secured within the ferrule bore. Epoxy may be less desirable because of fundamental mechanical properties, an inefficient and difficult application process, and significant manufacturing waste. The fundamental mechanical properties of epoxy cause problems for fiber optic connector performance. The ferrule and the optical fiber bond may be required to function consistently over tens of thousands of cycles of optical connections and disconnections with complementary optical connectors as networks are upgraded and maintained over the life of the optical connector. The mechanical properties of epoxy are plastic wherein the optical fiber generally increasingly moves over time when subjected to mechanical and thermal loading. The spatial relationship of the optical fiber within the ferrule is difficult to predict with certainty, because epoxy is difficult to apply uniformly to all ferrule assemblies.

[0009] Applying epoxy during manufacturing can be inefficient and difficult. The epoxy may be incorrectly applied to the ferrule and optical fiber during manufacturing. Specifically, epoxy is typically applied within the ferrule manually through a syringe. The epoxy flows from the syringe and is difficult to direct to the designated location between the ferrule and the optical fiber. An incomplete bond may be formed between the optical fiber and the ferrule when not enough epoxy flows to the designated location. The incomplete bond may allow movement to occur and thereby change the spatial relationship between the optical fiber and the ferrule and cause attenuation. Epoxy may also inadvertently flow from the syringe to other areas of the fiber optic connector causing defects. For example, the epoxy may flow to a spring connected to a ferrule holder body which needs to move within an inner housing unfettered by epoxy. A relatively expensive epoxy-resistant part, for example, a Teflon lead-in tube, is added to the fiber optic connectors to contain the epoxy and prevent epoxy flow to other areas of the fiber optic connector. Epoxy may also develop air bubbles or voids and so the ferrule and optical fiber may need to be placed in a time-consuming vacuum environment to remove these voids or air bubbles. To detect defects related from epoxy, labor-intensive inspection procedures can be conducted as part of the manufacturing process. The numerous additional manufacturing steps needed to support the application of epoxy to the ferrule make the manufacture of a ferrule assembly inefficient.

[0010] Also, applying epoxy as part of assembling a ferrule assembly may create significant manufacturing waste. Epoxy is made up of an epoxide resin ("resin") and a polyamine hardener ("hardener"). The resin and hardener are mixed together before being introduced into the ferrule. Shipments of resin and hardener often arrive at the assembly area at irregular frequencies and may have a shelf life of six (6) months to a year. As an example, characteristics of the epoxy change during the six (6) months and so unused epoxy is discarded after a six (6) month period has elapsed, causing in some cases significant manufacturing waste. Further, once mixed, the epoxy must be used within a time window or discarded causing even further waste. The time window may be generally only extended to, for example, up to eight (8) hours when the mixed epoxy is chilled.

[0011] A process and assembly are desired to secure the optical fiber from moving with respect to the ferrule that is more efficient to manufacture and creates less waste.

SUMMARY OF THE DETAILED DESCRIPTION

[0012] Embodiments disclosed herein include ferrule assemblies employing mechanical interfaces for optical fibers and related component and methods. The ferrule assemblies may be used in fiber optic connectors to precisely position the optical fiber relative to the ferrule to facilitate an optical connection with another optical device. In certain embodiments disclosed herein, the ferrule assemblies include a ferrule that includes an inner surface forming a ferrule bore. Each of the ferrules also includes an end portion of an optical fiber disposed in the ferrule bore. The inner surface of the ferrule bore abuts against an outer surface of the optical fiber to form a mechanical interface. In this manner, the mechanical interface secures the optical fiber within the ferrule bore and precisely positions the optical fiber relative to the ferrule. This mechanical interface may eliminate the need for epoxy or other means to secure the optical fiber within the ferrule bore.

[0013] In another embodiment, a method of assembling a ferrule assembly for a fiber optic connector is provided. The method includes providing a ferrule including an inner surface forming a ferrule bore. The method also includes disposing an end portion of the optical fiber in the ferrule bore. The method also includes forming a mechanical interface by abutting the inner surface of the ferrule bore against an outer surface of the optical fiber. The mechanical interface secures the end portion of the optical fiber within the ferrule bore. In this manner, the optical fiber is secured within the ferrule bore and thereby precisely positioned relative to the ferrule.

[0014] 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 that description or recognized by practicing the embodiments as described herein, including the detailed description that follows, the claims, as well as the appended drawings.

[0015] It is to be understood that both the foregoing general description and the following detailed description present embodiments, and are intended to provide an overview or framework for understanding the nature and character of the disclosure. The accompanying drawings are included to provide a further understanding, and are incorporated into and constitute a part of this specification. The drawings illustrate various embodiments, and together with the description serve to explain the principles and operation of the concepts disclosed.

BRIEF DESCRIPTION OF THE FIGURES

[0016] FIG. **1** is a side cross-sectional view of an exemplary fiber optic connector that includes a ferrule assembly including an optical fiber of a fiber optic cable secured within a ferrule by a mechanical interface provided within a ferrule bore;

[0017] FIGS. **2**A and **2**B are perspective and front views, respectively, of the ferrule of FIG. **1**;

[0018] FIG. **3**A is a side view of the fiber optic cable of FIG. **1**, including an optical fiber disposed within an outer jacket of the fiber optic cable and an end portion of the optical fiber, stripped, and extending from a transition interface and prepared to be disposed in the ferrule bore;

[0019] FIGS. **3**B and **3**C are cross-sectional views of the fiber optic cable of FIG. **3**A through a stripped and unstripped portion of the fiber optic cable, respectively;

[0020] FIG. **4** is a flowchart diagram of an exemplary process of inserting an optical fiber into the ferrule bore as part of assembling a first exemplary ferrule assembly of the fiber optic connector of FIG. **1**;

[0021] FIG. **5**A is a cutaway view along an optical axis A_1 of the ferrule of FIG. **2**A adjacent to the optical fiber of FIG. **3**A, and according to the exemplary process of FIG. **4**;

[0022] FIG. **5**B is a cutaway view along the optical axis A_1 of the ferrule of FIG. **5**A adjacent to the optical fiber of FIG. **3**A, with the ferrule being heated according to the exemplary process of FIG. **4**;

[0023] FIG. **5**C is a cutaway view along the optical axis A_1 of the ferrule of FIG. **5**B adjacent to the optical fiber of FIG. **5**B, with the optical fiber being disposed within the ferrule and the ferrule at a threshold temperature according to the exemplary process of FIG. **4**;

[0024] FIG. **5**D is a cutaway view along the optical axis A_1 of the ferrule of FIG. **5**B with the optical fiber of FIG. **5**B secured by a mechanical interface within the ferrule according to the exemplary process of FIG. **4**;

[0025] FIG. **6** is a flowchart diagram of another exemplary process of inserting an optical fiber into the ferrule bore as part of assembling a second exemplary ferrule assembly of the fiber optic connector of FIG. **1**;

[0026] FIG. **7**A is a cutaway view along an optical axis A_1 of the ferrule of FIG. **2**A adjacent to an optical fiber including a primary coating according to the exemplary process of FIG. **6**;

[0027] FIG. **7**B is a cross-sectional view orthogonal to the optical axis A_1 of the optical fiber of FIG. **7**A including the primary coating according to the exemplary process of FIG. **6**;

[0028] FIG. **7**C is a cutaway view along the optical axis A_1 of the ferrule of FIG. **7**A adjacent to the optical fiber of FIG. **7**A, with the ferrule being heated according to the exemplary process of FIG. **6**;

[0029] FIG. **7**D is a cutaway view along the optical axis A_1 of the ferrule of FIG. **7**C adjacent to the optical fiber of FIG. **7**C, with the optical fiber being disposed within the ferrule and the ferrule at a threshold temperature according to the exemplary process of FIG. **6**;

[0030] FIG. **7**E is a cutaway view along the optical axis A_1 of the ferrule of FIG. **7**D with the optical fiber of FIG. **7**D secured by a mechanical interface within the ferrule according to the exemplary process of FIG. **6**;

[0031] FIG. **8** is a flowchart diagram of another exemplary process of inserting an optical fiber into the ferrule bore as part of assembling a third exemplary ferrule assembly of the fiber optic connector of FIG. **1**;

[0032] FIG. **9**A is a cutaway view along an optical axis A_1 of the ferrule of FIG. **2**A adjacent to an optical fiber having a primary coating, according to the exemplary process of FIG. **8**;

[0033] FIG. **9**B is a cross-sectional view orthogonal to the optical axis A_1 of the optical fiber of FIG. **9**A including the primary coating;

[0034] FIG. **9**C is a cutaway view along the optical axis A_1 of the ferrule of FIG. **9**A adjacent to the optical fiber of FIG. **9**A, wherein the ferrule may be heated according to the exemplary process of FIG. **8**;

[0035] FIG. **9**D is a cutaway view along the optical axis A_1 of the ferrule of FIG. **9**C adjacent to the optical fiber of FIG. **9**C, with the optical fiber being disposed within the ferrule and the ferrule at a threshold temperature according to the exemplary process of FIG. **8**;

[0036] FIG. **9**E is a cutaway view along the optical axis A_1 of the ferrule of FIG. **9**D with the optical fiber of FIG. **9**D secured by a mechanical interface within the ferrule according to the exemplary process of FIG. **8**;

[0037] FIG. **10**A is a fourth exemplary ferrule assembly including the optical fiber of FIG. **3**A and the ferrule of FIG. **2**A; with silicone disposed between the ferrule and optical fiber;

[0038] FIG. **10**B is a graph showing a force F_I of the mechanical interface versus position along the optical axis of the ferrule assembly of FIG. **10**A;

[0039] FIG. **11**A is a fifth exemplary ferrule assembly including the optical fiber of FIG. **3**A and a second exemplary ferrule;

[0040] FIG. **11**B is a graph showing a force F_I of the mechanical interface versus position along the optical axis of the ferrule assembly of FIG. **11**A;

[0041] FIG. **12**A is a sixth exemplary ferrule assembly including the optical fiber of FIG. **3**A and a third exemplary ferrule; and

[0042] FIG. **12**B is a graph showing a force F_I of the mechanical interface versus position along the optical axis of the ferrule assembly of FIG. **12**A.

DETAILED DESCRIPTION

[0043] Reference will now be made in detail to the embodiments, examples of which are illustrated in the accompanying drawings, in which some, but not all embodiments are shown. Indeed, the concepts may be embodied in many different forms and should not be construed as limiting herein; rather, these embodiments are provided so that this disclosure will satisfy applicable legal requirements. Whenever possible, like reference numbers will be used to refer to like components or parts.

[0044] Embodiments disclosed herein include ferrule assemblies employing mechanical interfaces for optical fibers and related component and methods. The ferrule assemblies may be used in fiber optic connectors to precisely position the optical fiber relative to the ferrule to facilitate an optical connection with another optical device. In certain embodiments disclosed herein, the ferrule assemblies include a ferrule that includes an inner surface forming a ferrule bore. Each of the ferrules also includes an end portion of an optical fiber disposed in the ferrule bore. The inner surface of the ferrule bore abuts against an outer surface of the optical fiber to form a mechanical interface. In this manner, the mechanical interface secures the optical fiber within the ferrule bore and precisely positioned relative to the ferrule. This mechanical interface may eliminate the need for epoxy or other means to secure the optical fiber within the ferrule bore.

[0045] In this regard, FIG. **1** illustrates a fiber optic connector **10** that includes a ferrule assembly employing a mechanical interface for an optical fiber. As illustrated in FIG. **1**, the fiber optic connector **10** has an optical fiber **12** that includes an optical surface **14** for mating to another optical fiber (not shown) in a mated fiber optic connector or adapter. The fiber optic connector **10** includes a ferrule assembly **15** including the optical fiber **12** and a ferrule **16**(**1**). The ferrule **16**(**1**) laterally and angularly aligns an end portion **18** of the optical fiber **12** at an end face **20** of the ferrule **16**(**1**). The ferrule **16**(**1**) includes a first end **22**, a second end **24**, and a ferrule bore **26** ("microbore") extending between the first end **22** and the second end **24**.

[0046] The ferrule **16**(**1**) includes an inner surface **27** forming the ferrule bore **26** and connecting the first end **22** of the ferrule **16**(**1**) to the second end **24**. The end portion **18** of the optical fiber **12** is disposed in the ferrule bore **26** and extends to the end face **20** on the second end **24** of the ferrule **16**(**1**). An opening **29** of the end face **20** of the ferrule **16**(**1**) may enable the optical fiber **12** to exit the ferrule bore **26** and extend through the end face **20** so that the end portion **18** of the optical fiber **12** may be located at the end face **20** of the ferrule **16**(**1**) for convenient optical coupling with the complementary receptacle. An optical axis A_1 may be disposed through a center of the ferrule bore **26**.

[0047] The optical axis A_1 extends from the first end **22** to the second end **24** of the ferrule **16**(**1**). The optical axis A_1 may coincide with the ferrule bore **26**, because the optical fiber **12** may be received through the ferrule bore **26**.

[0048] The optical fiber **12** is secured within the ferrule bore **26** with a mechanical interface **30** in this embodiment as opposed to use of epoxy as a non-limiting embodiment. The inner surface **27** of the ferrule bore **26** may abut against an outer surface **31** of the optical fiber **12** to form the mechanical interface **30**. The mechanical interface **30** secures the optical fiber **12** within the ferrule bore **26**. The mechanical interface **30** may be free from a bonding agent, for example, epoxy. In this manner, no epoxy may be disposed between the inner surface **27** of the ferrule bore **26** and the outer surface **31** of the optical fiber **12**. The mechanical interface **30** may prevent movement of the optical fiber **12** within the ferrule bore **26** to minimize signal attenuation between the optical fiber **12** and the complementary receptacle (not shown), which may include an opposing optical fiber.

[0049] As will be discussed by example in more detail below, the mechanical interface **30** may be configured to allow the optical fiber **12** to enter or depart the ferrule bore **26** when a temperature of the ferrule **16**(**1**) is at least a threshold temperature, for example, one-hundred (100) degrees Celsius. The mechanical interface **30** may be a thermal clamp operated by changes in temperature of the ferrule **16**(**1**) which changes dimensions of the inner surface **27** of the ferrule bore **26** relative to the outer surface **31** of the optical fiber **12**. A thermal expansion coefficient of the ferrule **16**(**1**) may be at least fifteen (15) times as large as a thermal expansion coefficient of the optical fiber **12**. In this manner, a minimum bore width W_{B1} (FIG. 2A) of the ferrule bore **26** may increase at least fifteen (15) times as fast as a maximum fiber width W_{OF} of the outer surface **31** of the optical fiber **12** as the ferrule **16**(**1**) is heated. When the temperature of the ferrule **16**(**1**) reaches the threshold temperature, then the optical fiber **12** may be inserted into the ferrule bore **26** of the ferrule **16**(**1**). When the temperature of the ferrule **16**(**1**) is reduced to ninety-five (95) degrees Celsius or below, then the mechanical interface **30** is configured to secure the end portion **18** of the optical fiber **12** within the ferrule bore **26**. The ninety-five (95) degrees Celsius temperature may provide sufficient margin above an expected temperature operating range of the fiber optic connector **10**. It is noted that the maximum fiber width W_{OF} of the optical fiber **12** may be greater than the minimum bore width W_{B1} of the ferrule bore **26** when the ferrule **16**(**1**) and the optical fiber **12** are detached and less than or equal to ninety-five (95) degrees Celsius.

[0050] With continuing reference to FIG. **1**, the end face **20** of the ferrule **16**(**1**) may be butted against a complementary receptacle (not shown), which may include, for example, another ferrule, under pressure to provide the lowest attenuation of light passing between the end portion **18** of the optical fiber **12** and the complementary receptacle. The ferrule **16**(**1**) may be made of a rigid material that may be manufactured to tight tolerances. One example of such rigid material is a ceramic material, for example, zirconium dioxide (ZrO_2). As discussed above, the ferrule **16**(**1**) may receive, support, and position the end portion **18** of the optical fiber **12**.

[0051] With continuing reference to FIG. **1**, the end face **20** may be orthogonal to the optical axis A_1 or may be angled at angle ϕ (phi) with respect to the optical axis A_1. The angle ϕ (phi) may be, for example, within ten (10) degrees of orthogonal with respect to the optical axis as depicted in FIG. **1**. The angle ϕ (phi) may be angled to be non-orthogonal to suppress optical reflection at the optical surface **14**.

[0052] An entry opening **32** may be disposed at the first end **22** of the ferrule **16**(**1**). The entry opening **32** may provide the passageway by which the optical fiber **12** enters the ferrule bore **26** of the ferrule **16**(**1**). The entry opening **32** may be cone-shaped to provide easy entry of the optical fiber **12** into the ferrule bore **26**.

[0053] With continuing reference to FIG. **1**, the ferrule **16**(**1**) may be disposed at a front end **34** of the fiber optic connector **10**. The first end **22** of the ferrule **16**(**1**) may be at least partially disposed within a ferrule holder body **36**. The ferrule holder body **36** supports the ferrule **16**(**1**) within the fiber optic connector **10**. The ferrule holder body **36** may include a body alignment surface **38** which may be disposed to allow easy insertion of the ferrule holder body **36** within a housing **40** of the fiber optic connector **10**. In the non-limiting examples used herein, the housing **40** may be, for example, an inner housing **42** including a housing alignment surface **44**. The second end **24** of the ferrule **16**(**1**) may be at least partially disposed within the inner housing **42**. In this regard, the ferrule **16**(**1**) may be better protected from random perturbation forces ("side loads") orthogonal to the optical axis A_1 when unmated to the complementary receptacle (not shown).

[0054] It is noted that the ferrule holder body **36** in FIG. **1** may also be used in other fiber optic connectors, including but not limited to a spring-loaded ferrule holder body **36** without the inner housing **42**, for example, non-SC type fiber optic connectors. In these other fiber optic connectors, the housing may be an enclosure (not shown) around the ferrule holder body **36**. It is also noted that the ferrule **16**(**1**) may include a ferrule notch **46**. A portion **48** of the ferrule holder body **36** may be disposed within the ferrule notch **46** to prevent the ferrule **16**(**1**) from disengaging from the ferrule holder body **36**. The ferrule holder body **36** may comprise, for example, molded plastic.

[0055] The ferrule **16**(**1**) includes more features than can be observed in FIG. **1**. In this regard, FIGS. **2**A and **2**B depict the ferrule **16**(**1**) shown in FIG. **1** in a perspective and front view, respectively. The ferrule notch **46** may be a recess in the ferrule **16**(**1**). The ferrule notch **46** may be separated from the ferrule bore **26** which is shown with the maximum fiber width W_{B1} in FIG. **2**B. In this manner, the portion **48** may not obstruct the ferrule bore **26** and thereby prevent passage of the optical fiber **12** during assembly of the ferrule assembly **15**.

[0056] With reference back to FIG. **1**, the fiber optic connector **10** may also include a lead-in tube **50** engaged to a rear end **52** of the ferrule holder body **36** to align the optical fiber **12**. Specifically, the lead-in tube **50** facilitates guiding the end portion **18** of the optical fiber **12** into the ferrule holder body **36**, where the optical fiber **12** can then be guided to the ferrule **16**(**1**). The lead-in tube **50** may also prevent sharp bends from occurring in the optical fiber **12** during insertion that could damage the optical fiber **12** as the optical fiber **12** is disposed in the ferrule holder body **36** and into the ferrule **16**(**1**).

[0057] The optical fiber **12** includes more features than can be observed in FIG. **1**. In this regard, FIGS. **3**A through **3**C illustrate a side view and two cross-sectional views, respectively, of a fiber optic cable **54**(**1**). The optical fiber **12** may be part of a fiber optic cable **54**(**1**) which may be used in the fiber optic connector **10** of FIG. **1**. The fiber optic cable **54**(**1**) and optical fiber **12** include broken lines in FIG. **3**A to show indeterminate length. The fiber optic cable **54**(**1**) may be a single fiber drop cable, and the ferrule **16**(**1**) may be a single fiber ferrule, although the use of other types of drop cables, optical fibers connector types, and/or ferrules are possible. The fiber optic cable **54**(**1**) may include an outer jacket **56** to surround and protect the outer surface **31** of the optical fiber **12**. The optical fiber **12** may comprise, for example, a silicon dioxide (SiO_2) material. The outer jacket **56** may comprise a strong flexible material, for example, a polyurethane acrylate resin commercially available from DSM Desotech Inc. of Elgin, Ill.

[0058] The optical fiber **12** may include a bare optical fiber **58** and a primary coating **60**. The primary coating **60** may surround the bare optical fiber **58** and may prevent surface abrasions from forming on the bare optical fiber **58** during manufacturing and while in the fiber optic connector **10**. Surface abrasions may be created when the bare optical fiber **58** contacts other objects. The surface abrasions may weaken the bare optical fibers **58** and thereby damage or break the bare optical fibers **58**. The primary coating **60** prevents surface abrasions from being created and thereby protect the bare optical fiber **58**. The primary coating **60** may comprise a strong flexible material, for example, ultra-violet (UV) curable acrylate.

[0059] The outer jacket **56** of the fiber optic cable **54** may be partially stripped from the end portion **18** up to a transition interface **62**, as shown in FIG. **3**A, to expose the optical fiber **12** before insertion of the end portion **18** into the ferrule **16**(**1**). In some embodiments none, some, or an entire amount of the primary coating **60** may be removed from the end portion **18** up to the transition interface **62**. FIG. **3**C depicts the optical fiber **12** comprising the bare optical fiber **58** where the primary coating **60** may be removed up to the transition interface **62**. When the optical fiber **12** is fully inserted and secured by the mechanical interface **30**, the transition interface **62** may be disposed just outside the first end **22** of the ferrule **16**(**1**) (FIG. **1**) so that the optical fiber **12** may be protected by the outer jacket **56** outside the ferrule **16**(**1**).

[0060] With reference back to FIG. **1**, there are also features to press the optical fiber **12** forward to facilitate the formation of an optical connection with a complimentary receptacle. A spring **64** may be disposed between a spring seat base **66** of a crimp body **68** attached to the inner housing **42** and a spring seating surface **70** of the ferrule holder body **36**. The spring **64** may be biased to apply a spring force F_S to the spring seating surface **70** to push the ferrule holder body **36** and thereby push the end face **20** of the ferrule **16**(**1**) against the complementary receptacle. With contact between the end face **20** and the complementary receptacle, the ferrule holder body **36** may translate in the rear direction X_2 and the spring force F_S will press the end face **20**, including the end portion **18** of the optical fiber **12**, against the complementary receptacle to minimize attenuation.

[0061] Details of the fiber optic connector **10** have been introduced employing the ferrule **16**(**1**) having the end portion **18** of the optical fiber extending through the end face **20** of the ferrule **16**(**1**). The relationship of the ferrule **16**(**1**) to the insertion of the optical fiber **12** into the ferrule **16**(**1**) and ferrule holder body **36** will now be discussed in relation to a fiber optic connector **10**. In this regard, the fiber optic connector **10** may form the final critical passageway travelled by the end portion **18** of the optical fiber **12** to the end face **20**. The ferrule holder body **36** may comprise a front end **72** opposite a rear end **74** along the optical axis A_1. The ferrule holder body **36** may include an internal passage **76** formed by an inner body surface **78** extending from the front end **72** to the rear end **74** along the optical axis A_1 to thereby align the end portion **18** of the optical fiber **12** to the ferrule bore **26**. The lead-in tube **50** may include a front end **80** integrated with the rear end **74** of the ferrule holder body **36**. The lead-in tube **50** may include a lead-in bore **82** extending in the optical axis A_1 from a rear end **84** of the lead-in tube **50** to the front end **80** of the lead-in tube **50**. An inner lead-in surface **86** may form the lead-in bore **82** of the lead-in tube **50**. The inner lead-in surface **86** may guide the optical fiber **12** thorough the lead-in bore **82** and into the internal passage **76** of the ferrule holder body **36**.

[0062] The lead-in tube **50** may be made of a flexible and resilient material with high surface lubricity, for example, polyethylene, silicone, or thermoplastic elastomer. This material may also include additives, for example, mineral fill or silica-based lubricant or graphite. In this manner, the optical fiber **12** may smoothly travel the lead-in bore **82** without being caught during insertion.

[0063] The ferrule holder body **36** may be made of a relatively strong material, for example, metal or plastic. The ferrule holder body **36** may be made with all junctions and edges of the internal passage **76** chamfered or otherwise smoothly transitioned from one inside diameter to the next to provide surfaces to the optical fiber **12** without sharp edges for the optical fiber **12** to catch or be damaged during insertion.

[0064] The front end **80** of the lead-in tube **50** may be configured to receive and guide the end portion **18** of the optical fiber **12** along the optical axis A_1 through the rear end **74** of the ferrule holder body **36** and into the internal passage **76** of the ferrule holder body **36**. The lead-in bore **82** of the lead-in tube **50** and the internal passage **76** of the ferrule holder body **36** enables the end portion **18** of the optical fiber **12** to reach the first end **22** of the ferrule **16(1)** with a protected and aligned position before continuing through the ferrule bore **26** to the end face **20**. The end portion **18** of the optical fiber **12** may exit the ferrule bore **26** through the opening **29** after traveling from the first end **22** to the second end **24** of the ferrule **16(1)**. After exiting the opening **29**, the end portion **18** may extend a height H_1 past the end face **20** of the ferrule **16(1)**. The optical fiber **12** may then be secured by the mechanical interface **30**. The height H_1 may be, for example, more than five-hundred (500) nanometers (nm) and may be further reduced with material removal operations, for example polishing, to form the optical surface **14** of the end portion **18** of the optical fiber **12**.

[0065] The optical surface **14** of the optical fiber **12** is disposed at a position relative to the end face **20** of the ferrule **16(1)** to provide a pathway for optical transmission and/or reception. Efficient and accurate transmitting and receiving of light between the optical surfaces **14** of the adjacent optical fibers **12** of the fiber optic connector **10** and the complementary receptacle, respectively, may be critical to minimize signal attenuation. In this regard, the optical surface **14** of the optical fiber **12** should be created to be free of optical defects. Secondly, the position of the optical surface **14** of the optical fiber **12** relative to the end face **20** of the ferrule **16(1)** may be accurately achieved and secured by the mechanical interface **30**. Accuracy of the position is required, because the optical fiber **12** extends from the ferrule bore **26** of the ferrule **16(1)** to exactly press against the optical surface **14'** of the other optical fiber **12'** of the complementary receptacle during an optical connection to minimize the air gap therebetween, for example, consistent with International Standard CEI/IEC 61755-3-2. Air gaps between the optical surfaces causes attenuation and should be avoided; thus keeping the optical fiber **12** secure within the ferrule **16(1)** with the mechanical interface **30** may reduce air gaps.

[0066] Now that the ferrule assembly **15** has been introduced, exemplary processes **90(1)-90(3)** will be introduced in succession for inserting the optical fiber **12** within the ferrule bore **26** as part of assembling the ferrule assembly **15**. The ferrule assembly **15** employs the mechanical interface **30** for the optical fiber **12**. In this regard, FIG. **4** is a flowchart diagram of the exemplary process **90(1)** of assembling the ferrule assembly **15** for the fiber optic connector **10**. The process **90(1)** in FIG. **4** will be described using terminology and information provided above. FIGS. **5**A-**5**D correspond with steps **92(1)**, **94(1)**, **100(1)**, and **102(1)**, respectively in FIG. **4**, and will be discussed together.

[0067] As shown in FIG. **5**A, the process **90(1)** includes providing the ferrule **16(1)** and the optical fiber **12** of the ferrule assembly **15(1)** (step **92(1)** in FIG. **4**). The ferrule **16(1)** includes the inner surface **27** forming the ferrule bore **26**. The ferrule **16(1)** and the optical fiber **12** may be detached and have temperatures less than or equal to ninety-five (95) degrees Celsius where the minimum bore width W_{in} of the ferrule bore **26** may be less than the maximum fiber width W_{OF} of the optical fiber **12**.

[0068] As depicted in FIG. **5**B, the process **90(1)** may include heating the ferrule **16(1)** above the threshold temperature (step **94(1)** in FIG. **4**). The ferrule **16(1)** may be heated, for example, in an oven **96** powered by electricity **98**. As a temperature of the ferrule **16(1)** increases to the threshold temperature, the minimum bore width W_{B1} may increase to a minimum bore width W_{B2} which is greater than the maximum fiber width W_{OF} of the optical fiber **12**. It is noted that the optical fiber **12** may also be heated to reduce the risk of thermal shock to the ferrule **16(1)** or optical fiber **12** when they are later placed in contact. The thermal expansion coefficient of the ferrule **16(1)** may be at least fifteen (15) times as large as the thermal expansion coefficient of the optical fiber **12**. In this regard, as both the optical fiber **12** and the ferrule **16(1)** may be heated, the minimum bore width W_{B2} of the ferrule bore **26** may increase in size faster than the maximum fiber width W_{OF} of the optical fiber **12**. It is noted that FIG. **5**B depicts only the ferrule **16(1)** being heated according to the process **90(1)**.

[0069] FIG. **5**C depicts the process **90(1)** may include disposing the end portion **18** of the optical fiber **12** in the ferrule bore **26** of the ferrule **16(1)** (step **100(1)** in FIG. **4**). The minimum bore width W_{B2} of the ferrule bore **26** may be greater than the maximum fiber width W_{OF} of the optical fiber **12**, so that the optical fiber **12** may be inserted without damage. The end portion **18** of the optical fiber **12** may be disposed adjacent to the end face **20** of the ferrule **16(1)**.

[0070] FIG. **5**D depicts the process **90(1)** including forming the mechanical interface **30** between the inner surface **27** of the ferrule **16(1)** and the outer surface **31** of the optical fiber **12** to secure the end portion **18** of the optical fiber **12** within the ferrule bore **26** (step **102(1)** in FIG. **4**). The ferrule **16(1)**

and the optical fiber **12** may be cooled to less than or equal to ninety-five (95) degrees Celsius. While cooling, a minimum bore width W_{B3} may be reached by the ferrule **16(1)** as the ferrule **16(1)** constricts around the end portion **18** of the optical fiber **12** causing a force F_I to be applied by the ferrule **16(1)** upon the optical fiber **12**. The force F_I may form the mechanical interface **30** to secure the end portion **18** of the optical fiber **12** within the ferrule **16(1)** by friction or by an interference fit. The resulting minimum bore width W_{B3} may be greater than the minimum bore width W_{B1} and less than the minimum bore width W_{B2}.

[0071] FIG. **6** is a flowchart diagram of an exemplary process **90(2)** of assembling a ferrule assembly **15(2)** which may be used instead of the ferrule assembly **15(1)** in the fiber optic connector **10**. The process **90(2)** will be described using the terminology and information provided above. Specifically, process **90(2)** is similar to the process **90(1)** and only the differences between the processes **90(1)-90(2)** will be discussed to enhance conciseness and clarity. In this regard, the process **90(2)** may include steps **92(2)**, **94(2)**, **100(2)**, and **102(2)** of FIG. **6**, corresponding with FIGS. 7A, 7C, 7D, and 7E, respectively.

[0072] FIG. 7B shows a cross-section view of the optical fiber **12** of FIG. 7A. Unlike the process **90(1)**, the fiber optic cable **54(2)** may be stripped back to the transition interface **62** so that the primary coating **60** may be disposed upon the bare optical fiber **58** of the end portion **18** of the optical fiber **12**. In this manner, twice a radius R_2, including a radius R_1 of the bare optical fiber **58**, determines the maximum fiber width W_{OF} to form a portion of the mechanical interface **30** with the inner surface **27** of the ferrule bore **26**. In this manner, the primary coating **60** may provide additional friction to secure the bare optical fiber **58** to the ferrule **16(2)**. The primary coating **60** may also provide protection from discontinuities in a material of the ferrule **16(2)** and from mechanical damage between the bare optical fiber **58** and the ferrule bore **26**.

[0073] FIG. **8** is a flowchart diagram of an exemplary process **90(3)** of assembling a ferrule assembly **15(3)** which may be used instead of the ferrule assembly **15(1)** in the fiber optic connector **10**. The process **90(3)** will be described using the terminology and information provided above. Specifically, process **90(3)** is similar to process **90(1)** and accordingly only the differences between the processes **90(1)-90(3)** will be discussed to enhance conciseness and clarity. The process **90(3)** may include steps **92(3)**, **94(3)**, **100(3)** and **102(3)** of FIG. **8** and correspond with FIGS. **9**A and **9**C-**9**E, respectively.

[0074] In this regard, FIG. **9**B shows a cross-section of the optical fiber **12** of FIG. **9**A. Unlike the process **90(1)**, but similar to the process **90(2)**, the fiber optic cable **54(3)** may be provided stripped back to the transition interface **62** so that the primary coating **60** may be disposed upon the bare optical fiber **58** of the end portion **18** of the optical fiber **12**. In this manner, twice the radius R_2, which includes the radius R_1 of the bare optical fiber **58**, may be utilized to determine the maximum fiber width W_{OF} of the optical fiber **12** outside the ferrule **16(3)**. In process **90(3)**, twice the radius R_2 is greater than the minimum bore width W_{B2} of the ferrule **16(3)** when the ferrule **16(3)** is at the threshold temperature. A portion **104** of the primary coating **60** may be outside a radius R_3 of the optical fiber **12** wherein twice the radius R_3 may be equivalent to the minimum bore width W_{B2} of the ferrule **16(3)**. Accordingly, in FIG. **9**D when the end portion **18** of the optical fiber **12** is being disposed in the ferrule bore **26**, the portion **104** may be stripped away to accumulate the portion **104** of the primary coating **60** at the first end **22** of the ferrule **16(3)** as shown in FIG. **9**E. The stripping and accumulation of the portion **104** may be facilitated by the ferrule **16(3)** which may be at least the threshold temperature. The accumulation of the portion **104** of the primary coating **60** at the first end **22** of the ferrule **16(3)** may protect the optical fiber **12** from forming a sharp bend, which may cause damage to the optical fiber **12** or signal attenuation.

[0075] Now that the processes **90(1)-90(3)** have been discussed to assemble the ferrule assemblies **15(1)-15(3)** for the fiber optic connector **10**, ferrule assemblies **15(4)-15(6)** are now introduced including ferrules **16(4)-16(5)**, respectively. The ferrule assemblies **15(4)-15(6)** are compatible with the processes **90(1)-90(3)** and the mechanical interface **30** to secure the end portion **18** of the optical fiber **12** within the ferrule bore **26**. The details of the ferrule bore **26** facilitating the mechanical interface **30** will now be discussed.

[0076] In this regard, FIG. **10**A depicts a ferrule assembly **15(4)** which may replace the ferrule assembly **15(1)** in the fiber optic connector **10** of FIG. **1**. The inner surface **27** of the ferrule **16(4)** may include a first bore transition interface **108** between the first end **22** and the second end **24** of the ferrule **16(4)**. The inner surface **27** may also include an entry cone **106** extending from the first end **22** to the first bore transition interface **108**. The first bore transition interface **108** may connect the entry cone **106** to a first portion **110** of the inner surface **27**. The entry cone **106** may have a tapered shape to facilitate the entry of the end portion **18** of the optical fiber **12** into the ferrule bore **26** during assembly. The first portion **110** of the inner surface **27** may include a uniform or substantially uniform width (measured orthogonal to the optical axis A_1) from the second end **24** of the ferrule **16(4)** to the first bore transition interface **108**. The uniform or substantially uniform width allows for a uniform or substantially uniform force F_I to secure the optical fiber **12** with the first portion **110** of the inner surface **27** as shown in a graph **118** in FIG. **10**B of force F_I versus position along the optical axis A_1 of the ferrule **16(4)**.

[0077] Moreover, the tapered shape of the entry cone **106** may also provide space for the silicone **111** to be disposed in the first end **22** of the ferrule **16(4)** between the ferrule **16(4)** and the optical fiber **12**. The silicone **111** may protect the optical fiber **12** from sharp bends which may damage the optical fiber **12**. The mechanical interface **30** may still provide sufficient force F_I to secure the optical fiber **12** within the ferrule **16(4)** in the presence of the silicone **111**.

[0078] In a different example, FIG. **11**A depicts a ferrule assembly **15(5)** having a ferrule **16(5)** which may replace the ferrule assembly **15(1)** of FIG. **1**. The inner surface **27** of the ferrule **16(5)** may include a first bore transition interface **108** between the first end **22** and the second end **24** of the ferrule **16**. The inner surface **27** may also include an entry cone **106** extending from the first end **22** to the first bore transition interface **108**. The first bore transition interface **108** may connect the entry cone **106** to a first portion **110** of the inner surface **27**. The entry cone **106** may have a tapered shape to facilitate the entry of the end portion **18** of the optical fiber **12** into the ferrule bore **26** during assembly.

[0079] Moreover, the ferrule **16(5)** may further include a second bore transition interface **113** between the second end **24** of the ferrule **16(5)** and the first bore transition interface **108**. The first portion **110** of the inner surface **27** may include an exit portion **114** and a second portion **112**. The second bore transition interface **113** may attach the exit portion **114** to the second portion **112**. The exit portion **114** comprises a uniform or substantially uniform width from the second end **24** of the ferrule **16(5)** to the second bore transition interface **113**. The second portion **112** may comprise a uniform or substantially uniform width from the second bore transition interface **113** to the entry cone **106**. The uniform or substantially uniform width W_2 of the second portion **112** may be greater than the uniform or substantially uniform width W_3 of the exit portion **114** to thereby increase the force F_I closer to the end face **20** of the ferrule **16(5)**. The increased force F_I may thereby better secure the optical fiber **12** adjacent to the end face **20**. FIG. **11**B depicts the increased force F_I in a graph **120** showing force F_I versus position along the optical axis A_1 of the ferrule **16(5)** of FIG. **11**A. It is noted that the primary coating **60** of the outer surface **31** of the optical fiber **12** may abut against the inner surface **27** and create the force F_I in the second portion **112**.

[0080] In a different example, FIG. **12**A depicts a ferrule assembly **15(6)** having a ferrule **16(6)** which may replace the ferrule assembly **15(1)** of FIG. **1**. The inner surface **27** of the ferrule **16(6)** may include a first bore transition interface **108** between the first end **22** and the second end **24** of the ferrule **16(6)**. The inner surface **27** may also include an entry cone **106** extending from the first end **22** to the first bore transition interface **108**. The first bore transition interface **108** may connect the entry cone **106** to a first portion **110** of the inner surface **27**. The entry cone **106** may have a tapered shape to facilitate the entry of the end portion **18** of the optical fiber **12** into the ferrule bore **26** during assembly.

[0081] Moreover, the ferrule **16(6)** may further include the second bore transition interface **113** between the second end **24** of the ferrule **16(6)** and the first bore transition interface **108**. The first portion **110** of the inner surface **27** may include the exit portion **114** and a third portion **116**. The second bore transition interface **113** may attach the exit portion **114** to the third portion **116**. The exit portion **114** may comprise the uniform or substantially uniform width from the second end **24** of the ferrule **16(6)** to the second bore transition interface **113**. The third portion **116** may comprise a second tapered shape from the second bore transition interface **113** to the entry cone **106**. The second tapered shape includes a smaller width change than the first tapered shape. The second tapered shape of the third portion **116** allows a gradual increase in the force F_I to provide gradual support for the optical fiber **12** along the optical axis A_1 towards the end face **20** of the ferrule **16(6)**. In this regard, FIG. **12**B is a graph **122** showing force F_I versus position along the optical axis A_1 of the ferrule **16(6)** in FIG. **12**A. It is noted that the primary coating **60** of the outer surface **31** of the optical fiber **12** may abut against the inner surface **27** and create the gradual increase in the force F_I in the third portion **116**.

[0082] As used herein, it is intended that terms "fiber optic cables" and/or "optical fibers" include all types of single mode and multi-mode light waveguides, including one or more optical fibers that may be upcoated, colored, buffered, ribbonized and/or have other organizing or protective structure in a cable such as one or more tubes, strength members, jackets or the like. The optical fibers disclosed herein can be single mode or multi-mode optical fibers. Likewise, other types of suitable optical fibers include bend-insensitive optical fibers, or any other expedient of a medium for transmitting light signals. Non-limiting examples of bend-insensitive, or bend resistant, optical fibers are ClearCurve® Multimode or single-mode fibers commercially available from Corning Incorporated. Suitable fibers of these types are disclosed, for example, in U.S. Patent Application Publication Nos. 2008/0166094 and 2009/0169163, the disclosures of which are incorporated herein by reference in their entireties.

[0083] Many modifications and other embodiments of the embodiments set forth herein will come to mind to one skilled in the art to which the embodiments pertain having the benefit of the teachings presented in the foregoing descriptions and the associated drawings. For example, the optical fiber **12** may be cooled or heated while the ferrule **16** is heated to the threshold temperature. Also, for simplicity the processes **90(1)**-**90(3)** and associated FIGS. **5**A-**5**D, **7**A-**7**E, and **9**A-**9**E do not depict components of the fiber optic connector **10**, for example, the ferrule holder body **36**, the lead-in tube **50**, the spring **64**, and the inner housing **42**. However, some or all these components may be assembled to the ferrule **16** prior to the disposing of the optical fiber **12** in the ferrule **16**.

[0084] Therefore, it is to be understood that the description and claims are not to be limited to the specific embodiments disclosed and that modifications and other embodiments are intended to be included within the scope of the appended claims. It is intended that the embodiments cover the modifications and variations of the embodiments provided they come within the scope of the appended claims and their equivalents. Although specific terms are employed herein, they are used in a generic and descriptive sense only and not for purposes of limitation.

1. A ferrule assembly for a fiber optic connector, comprising:

a ferrule including an inner surface forming a ferrule bore; and

an end portion of an optical fiber disposed in the ferrule bore, the inner surface of the ferrule bore abuts against an outer surface of the optical fiber to form a mechanical interface, and the mechanical interface secures the optical fiber within the ferrule bore.

2. The ferrule assembly of claim **1**, wherein no epoxy is disposed between the inner surface of the ferrule bore and the outer surface of the optical fiber.

3. The ferrule assembly of claim **1**, wherein a coefficient of thermal expansion of the ferrule is larger than a coefficient of thermal expansion of the optical fiber.

4. The ferrule assembly of claim **1**, wherein a coefficient of thermal expansion of the ferrule is at least fifteen (15) times as large as a coefficient of thermal expansion of the optical fiber.

5. The ferrule assembly of claim **1**, wherein the mechanical interface is configured to secure the optical fiber within the ferrule bore while a temperature of the ferrule and the optical fiber are less than or equal to ninety-five (95) degrees Celsius.

6. The ferrule assembly of claim **1**, wherein the mechanical interface is configured to allow the optical fiber to enter or depart the ferrule bore when a temperature difference between the ferrule and the optical fiber is greater than a threshold temperature, wherein the threshold temperature of the ferrule is at least one-hundred (100) degrees Celsius.

7. (canceled)

8. The ferrule assembly of claim **1**, wherein a maximum fiber width of the optical fiber is greater than a minimum bore width of the ferrule bore when the ferrule and the optical fiber are detached and less than or equal to ninety-five (95) degrees Celsius.

9. The ferrule assembly of claim **8**, wherein the optical fiber further comprises a primary coating, wherein the primary coating of the end portion of the optical fiber abutting the inner surface of the ferrule is thinner than the primary coating outside the ferrule.

10. (canceled)

11. The ferrule assembly of claim **1**, wherein the inner surface of the ferrule comprises a first bore transition interface between a first end and a second end of the ferrule, the inner surface of the ferrule also includes an entry cone extending from the first end to the first bore transition interface, the first bore transition interface connects the entry cone to a first portion of the inner surface, the entry cone includes a first tapered shape.

12. The ferrule assembly of claim **11**, wherein the first portion of the inner surface comprises a uniform or substantially uniform width from the second end of the ferrule to the first bore transition interface.

13. The ferrule assembly of claim **11**, wherein the ferrule further comprises a second bore transition interface between the second end of the ferrule and the first bore transition interface, the first portion of the inner surface includes an exit portion and a second portion, the second bore transition interface attaches the exit portion to the second portion, the exit portion comprises a uniform or substantially uniform width from the second end of the ferrule to the second bore transition interface, and the second portion comprises a second uniform or substantially uniform width from the second bore transition interface to the entry cone, and the second uniform or substantially uniform width of the second portion is greater than the uniform or substantially uniform width of the exit portion.

14. The ferrule assembly of claim **11**, wherein the ferrule further comprises a second bore transition interface between the second end of the ferrule and the first bore transition interface, the first portion of the inner surface includes an exit portion and a third portion, the second bore transition interface attaches the exit portion to the second portion, the exit portion comprises a uniform or substantially uniform width from the second end of the ferrule to the second bore transition interface, and the third portion comprises a second tapered shape from the second bore transition interface to the entry cone, and the second tapered shape includes a smaller width change than the first tapered shape.

15. The ferrule assembly of claim **11**, further comprising silicone disposed between the ferrule and the optical fiber.

16. A method of assembling a ferrule assembly for a fiber optic connector, comprising:

providing a ferrule of a ferrule assembly including an inner surface forming a ferrule bore;

disposing an end portion of an optical fiber in the ferrule bore; and

forming a mechanical interface by abutting the inner surface of the ferrule bore against an outer surface of the optical fiber, and the mechanical interface secures the end portion of the optical fiber within the ferrule bore.

17. The method of claim **16**, wherein the forming the mechanical interface comprises forming an epoxy-free interface.

18. The method of claim **16**, wherein the providing the ferrule comprises the ferrule including a coefficient of thermal expansion at least fifteen (15) times as large as a coefficient of thermal expansion of the optical fiber.

19. The method of claim **16**, wherein the forming the mechanical interface comprises changing a temperature of the ferrule and a temperature of the optical fiber to less than or equal to ninety-five (95) degrees Celsius.

20. The method of claim **16**, further comprising heating the ferrule above a threshold temperature to expand a minimum bore width of the ferrule bore to be larger than a maximum fiber width of the optical fiber, wherein the disposing the end portion of the optical fiber comprises a threshold temperature of at least one-hundred (100) degrees Celsius.

21. (canceled)

22. The method of claim **16**, wherein the providing the ferrule comprises a minimum bore width of the ferrule bore less than a maximum fiber width of the optical fiber when the ferrule and the optical fiber are detached and at a temperature less than or equal to ninety-five (95) degrees Celsius.

23. The method of claim **22**, wherein the disposing the end portion of the optical fiber in the ferrule bore comprises the end portion of the optical fiber including a primary coating disposed upon a bare optical fiber, wherein the disposing the end portion of the optical fiber in the ferrule bore comprises stripping a portion of the primary coating of the end portion of the optical fiber entering a first end of the ferrule, wherein the stripping the portion of the primary coating includes of the primary mar coating at the first end of the ferrule.

24-26. (canceled)

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