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Re-Spliceable Splice-On Connector and Method of Making Same

Abstract

An operational re-spliced splice-on connector produced by a process including at least five steps: (1) stripping insulation from an end portion of a first optic fiber; (2) stripping insulation from an end portion of a second optic fiber having a connector body fixed to an opposite end portion thereof. One end portion of the connector body is sized and configured to be inserted into an end portion of an elongated hollow member. The process further includes: (3) splicing together the first and second fiber optic end portions to produce either an SOC or a re-spliced splice-on connector (“RSSOC”). The SOC has a predetermined length to enable cutting at three predetermined locations spaced from the connector body. The process also includes: (4) if an operational fault is caused in a system using the SOC or RSSOC, cutting the SOC or the RSSOC at one of the three predetermined regions; and (5) repeating step (3), thus producing the operational re-spliced splice-on connector.

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Background/Summary

REFERENCE TO RELATED APPLICATIONS [0001] This application is a continuation-in-part ("CIP") of U.S. patent application Ser. No. 18/197,967 filed May 16, 2023, which in turn is a CIP of U.S. application Ser. No. 17/525,864 filed Nov. 13, 2021, both of which are hereby incorporated by reference in their entirety for priority purposes pursuant to 35 U.S. Code, § 120.

FIELD
[0002] The present subject matter, in general, is directed to an optic fiber stub portion and, more particularly, is directed to a re-spliceable splice-on connector.
[0003] An optic fiber is a flexible and transparent fiber manufactured by drawing glass or plastic to a diameter slightly more than the diameter of a strand of human hair. [See "Optical Fiber," The Fiber Optic Association.] Optic fibers, able to transmit light between end portions of optic fiber, are used in fiber-optic communications, as fibers permit data transmission over greater distances and at higher bandwidths ("higher data transfer rates") than electrical cables. ["Optical Fiber," cited above.]
[0004] Optic fibers are used instead of metal wires since signals travel along optic fibers with less flux intensity loss through them. [*Optical Fiber Communications: Principles and Practice*, by Senior, John M; and Jamro, M. Yousif (2009), Pearson education, pp. 7-9.] Also, optic fibers are immune to electromagnetic interference, a problem experienced when using metal wires. [*Optical Fiber Communications.]*
[0005] In addition, optic fibers have a core covered by a transparent cladding material which has a lower index of refraction. [*Optical Fiber Communications*.] Light is kept in the core by the phenomenon of total internal reflection, thus causing the fiber to function as a waveguide. [*Optical Fiber Communications,* pages 12-14.]
[0006] Joining optic fibers with low loss is important in optic fiber communication. [Optical Fiber Communications, page 218.] Joining optic fibers, more complex than joining electrical wires or cables, involves careful cleaving of the optic fibers, precise alignment of fiber cores, and the precise coupling of resulting-aligned cores. *[Optical Fiber Communications*.] For applications requiring permanent connections, a fusion splicer is typically used. Employing a fusion splicer technique, an electric arc is used to melt two optic fiber ends together. [*Optical Fiber Communications.]*
[0007] Certain terms which I shall use throughout this patent application shall now be noted and defined as follows. The term "connector" shall be understood to refer to an optic fiber connector having four basic components: a ferrule; a connector body; a cable; and a coupling device. The term "fiber stub" shall be understood to refer to a length or piece of optic fiber, ordinarily very short in length, that extends from the back of a connector. The term "fiber stub length" shall be understood to refer to length, which will vary and can be about 125 mm, a preferred length for the present subject matter, for optic fiber extending from the back of a connector.
[0008] The term "fusion splicer" shall be understood to refer to a machine using an electric arc to melt two optic fibers together at cleaved end faces to form fused optic fiber. A resulting fusion splice permanently joins two optic fibers end-to-end, enabling light signals to pass from one end to the other with little loss. The splicer precisely adjusts, automatically in modern devices, light-guiding cores at the ends of the fibers to be spliced. The term "cable holder" refers to a device that positions or holds optic fiber cable in a splicer. Cable holders differ based on optic fiber diameter,

with the most popular cable holders being designed for 250 μm, 900 μm, 2 mm, and 3 mm diameter cables, and 12-fiber “ribbon cable” consisting of twelve individual 250 μm diameter cables bonded together as a single cable. A “cable” consists of a core, cladding, buffer, and jacket. (See Wikipedia for such cable layers.)

[0009] The term “connector holder” shall be understood to refer to a device that holds and properly positions the connectors in a fusion splicer for splicing. The term “rubber boot” shall be understood to refer to an elongated (hollow) silicone rubber material, sized and shaped to cover and protect the splice area of the optic fiber. The rubber boot also connects to the connector, and thereby provides strain relief. The term “rubber boot length” shall be understood to refer to the total length of the rubber boot. The term “strain relief,” essential to preserve the mechanical and electrical integrity and overall performance of spliced optic fiber cables, shall be understood to refer to relief of stress and tension, in an optic fiber, that could cause damage to the fiber cable or the connection between the connector and the cable.

[0010] The term “FC” shall be understood to refer to an optic fiber cable connector using a threaded plug and socket. For bi-directional transmission, two optic fiber cables and two FC connectors are used. The term “SC,” an acronym for a standard connector and/or a subscriber connector, shall be understood to refer to an optic fiber cable connector using a push-pull latching mechanism resembling common audio and video cables. For bi-directional transmission, two optic fiber cables and two SC connectors (aka dual SC) are used. The term “LC,” an acronym for Lucent connector, shall be understood to refer to a miniature version of an optic fiber SC connector. While an LC connector resembles an SC connector, with an LC connector being half the size, an LC connector thus has a 1.25 mm ferrule instead of a 2.5 mm ferrule. The term “ST,” also referred to as a straight tip connector, the original de facto “standard” connector for commercial optic fiber cable wiring needs, shall be understood to refer to an optic fiber cable connector having a bayonet plug and a socket. Bi-directional transmission requires two fiber cables and two ST connectors.

[0011] The term “MPO” refers to an industry acronym for a “multi-fiber push on” connector, used by technicians and persons of ordinary skill in this field. The MPO connector was developed to provide multi-fiber connectivity in a single connector to support high bandwidth and high data density applications. While present fiber counts for MPO connectors are 12 and 24 optic fibers per connector, fusion splicers presently commercially available can only splice 12-fiber count MPO connectors.

[0012] The term “MTP,” also used by technicians and persons of ordinary skill in this field, shall be understood to refer to an assortment of high-performance MPO connectors with special enhancements engineered to provide MTP connectors with optical and/or mechanical performance improvements in comparison to ordinary MPO connectors. In 1996, “MTP” a federally-registered trademark owned by US Conec and used in relation to a family of advanced MPO connectors designed for 4-, 8-, and 12-fiber ribbon applications, was released to the US market. In that same year, the International Electrotechnical Commission standardized this MPO format.

[0013] As a result there are five types of optic fiber connectors: FC (single fiber); LC (single fiber); SC (single fiber); ST (single fiber); and MPO/MTP (12 or more fibers).

[0014] Current attempts to permanently join two optic fibers end-to-end, enabling optical light signals to pass from one optic fiber to another with minimal loss, will occasionally result in a “failure.” Such failure may occur when an optic fiber end portion is poorly cleaved by a cleaving mechanism; may occur when an optic fiber end portion has a crack in it; may occur when an optic fiber end portion is dirty; may occur when a fusion splicer over-arcs by accident and damages an optic fiber end portion; may occur when a given length of optic fiber is not properly arranged in the grooves of a cable splicer; or may occur when a portion of the length of optic fiber has a bend in it and a fusion splicer camera cannot focus upon the optic fiber.

[0015] However, using a fusion splicer to re-join optic fiber end portions resulting from such failure is currently impractical, based on current fiber-joining techniques.

[0016] Since I did not find a commercial product that addresses the failure problem noted and enables a fusion splicer easily to re-join optic fiber end portions resulting from such failures, I reviewed US patents and published applications for a solution.
[0017] U.S. Pat. No. 4,728,170 to Robertson discloses a process whereby a single mode optical fiber preset attenuator is made by forming a fusion splice between a length of silica fiber possessing no internal waveguiding structure to a length of single mode optical fiber, then cutting the silica fiber to a predetermined length to form a short stub that is next fusion-spliced to a second length of single mode fiber.
[0018] U.S. Pat. No. 5,993,071 to Hultermans discloses an adapter used to connect a first optical fiber connector to a second optical fiber connector. The adapter makes it possible for optical fiber connectors with perpendicular and inclined end faces to be interconnected or connected to a corresponding different optical fiber system.
[0019] U.S. Pat. Nos. 6,805,491 and 6,955,478, both to Durrant et al., are directed to a device which includes a stub and an optical fiber. The stub has an aperture and includes a first end and a second end. The optical fiber, located in the aperture, has a first end and a second end. The first end of the optical fiber is polished and made flush with the first end of the stub. The second end of the optical fiber is cleaved at a predetermined position, to provide a predetermined length for the optical fiber measured from the first end to the second (i.e., opposite) end of the optical fiber.
[0020] U.S. Pat. No. 7,178,990 to Cavey et al. is directed to a fiber optic stub fiber connector used for reversibly and nondestructively terminating an inserted field fiber having a buffer over a portion of it. The connector includes a housing and a ferrule including a stub fiber disposed within and extending from a bore through the ferrule. The ferrule is partially disposed within and supported by the housing. The connector includes a reversible actuator adapted to non-destructively and reversibly terminate a connection between the field fiber and the stub fiber. The reversible actuator has a buffer clamp to engage with the buffer to simultaneously provide a reversible and nondestructive strain relief to the terminated field fiber.
[0021] U.S. Pat. No. 7,186,035 to Dunn et al. is directed to an optical fiber connector having a receptacle or socket which includes a recessed optical fiber ferrule assembly for aligning an optical fiber within the connector. Recessed within the socket is a sleeve for receiving and bringing into optical alignment the optical fiber ferrule assembly, located at an internal end of the socket, with a similar optical fiber ferrule assembly of an optical plug which is connected to the optical socket.
[0022] U.S. Pat. No. 7,261,473 to Owen et al. discloses an optical sub assembly that provides electrical isolation between a receptacle having a nose for receiving an optical fiber and a package housing an optical device. The nose houses a ferrule containing a fiber stub optically aligned with an optical device housed in a package before securing the receptacle to the package. The electrical insulation is provided between the nose and the package by a sleeve extending along a middle portion of the ferrule and an insulating portion located between the sleeve and the nose.
[0023] U.S. Pat. No. 7,956,992 to Watt et al. is directed to a method for testing optical fiber connection quality of an optical drop fiber between a telecommunications system and a subscriber connection box in a multi-dwelling unit or other subscriber premises before connection to other subscriber equipment. An end portion of an optical fiber to-be-tested is placed in a fiber-holding device. The fiber-holding device holds the fiber end portion in alignment with a suitable reflective body. An optical signal is provided from the system direction which is reflected by the reflective body back towards the system. The reflected signal is detected by a suitable instrument, such as an optical time domain reflectometer, to confirm acceptable signal quality of the optical path between the system and the fiber end.
[0024] U.S. Pat. No. 8,556,521 to Everett et al. is directed to an optical connector for use in a fiber optic communications system, and to an expanded beam optical connector for connecting optical fibers. The connector comprises a housing, a port for receiving an optical fiber end, a cylindrical ferrule within the housing having opposite first and second ends, and an optical fiber stub held

within the ferrule and extending between the ferrule ends. A sleeve surrounding the ferrule extends towards the port away from the second ferrule end to present an open end to the sleeve for receiving a termination ferrule of an optical fiber inserted into the port.
[0025] U.S. Pat. Nos. 9,557,492 and 9,897,770, both to Park et al., are directed to a hybrid optical fiber stub device comprising a first ferrule transparent to UV light and a second ferrule. An optical fiber is disposed through the first and second ferrules. The input and output faces of the optical fiber, when properly prepared, are suitable for optical coupling. A photonic device is coupled to the first optical fiber surface. A UV-curable epoxy is disposed between the photonic device and the first optical fiber surface. The UV-curable epoxy has an index of refraction that ranges from an index of refraction of the first optical fiber to an index of refraction of the photonic device. A second optical fiber is coupled to the first optical fiber.
[0026] U.S. Pat. No. 10,345,536 to Shao et al. is directed to an optical fiber connector, comprising: a housing, a ferrule within the housing; an end sleeve connected to a rear end of the housing; and an optical cable clamp inserted within the end sleeve. The clamp is provided for the purpose of clamping an optical cable. The optical cable is secured within the optical cable clamp. The optical cable clamp is inserted and secured within the end sleeve. The optical fiber of the optical cable is inserted within the housing and butt-joined with the embedded optical fiber in the ferrule.
[0027] U.S. Pat. No. 10,473,859 to Chabot et al. is directed to fiber optic connector comprising a fusion assembly for strengthening a splice point. The fusion assembly comprises an elongate mechanical support positioned adjacent the splice point and snugly encased by a flexible tube. A meltable adhesive in the form of a hollow tube is positioned over the splice point and the flexible tube comprises a heat shrinkable material. The elongate mechanical support comprises an elongate plate having a concave surface positioned adjacent the splice point and a C-shaped cross section.
[0028] U.S. Pat. No. 10,761,277 to Durrant is directed to a vent or slot, which is provided between the ferrule and the stub body, for enabling gases generated from a low melting glass sealing process of an optical fiber to the ferrule stub to escape.
[0029] US published application 2013/0004128 to Zhang discloses a device that enables a physical contact fiber optic connector into an expanded beam connector. The device includes a fiber stub, an aspherical lens, and a housing. The fiber stub includes a stub body and a predetermined length of optical fiber retained that is by the stub body. The housing retains the fiber stub and aspherical lens so that the length of optical fiber of the fiber stub is in optical communication with the lens.
[0030] US published application 2021/0103097 to Wang is directed to a low-profile splice protection system for protecting multi-fiber fusion splice sites. The splice protection system includes coating material to package a splice site, and a housing.
[0031] U.S. Pat. No. 8,043,013 to Lichoulas et al. discloses a splice-on connector system including a connector body, and an incoming fiber spliced to the connector body. The system also includes a splice sleeve for covering a splice point at which the incoming fiber is spliced to the connector body, and an extender tube covering the splice sleeve. Also disclosed is a method of producing the splice-on connector.
[0032] U.S. Pat. No. 10,770,831 to Kralik discloses a cable connector assembly including a connector fitting having a first coupling portion and a second coupling portion, and a connector body having a connection portion coupled to the second coupling portion of the connector fitting. The connector body has a sleeve interface portion formed about an outer surface of the connector body. An elongate compliant sleeve has a connector interface portion coupled to the sleeve interface portion of the connector body to form a coupling interface having a keyed profile.
[0033] However, these US patents and published applications do not provide solutions to problems occurring when an optic fiber end portion is poorly cleaved by a cleaving mechanism, when an optic fiber end portion is cracked, when an optic fiber end portion is dirty, when a fusion splicer accidentally over-arcs and damages an optic fiber end portion, when a given length of optic fiber is not properly arranged in grooves of a cable splicer, or when a portion of the length of optic fiber is

bent and the fusion splicer camera, as a result, cannot focus upon the optic fiber.

[0034] To solve these problems, I increased optic fiber stub length extending from the connector by increasing a length of the associated rubber boot. One advantage of increasing the rubber boot length is that a longer optic fiber stub length eliminates a need for different connector holders relative to a fusion splicer. Connector holders are expensive and not universal to different types of connectors or fusion splicers. My design only requires a cable holder for an optic fiber stub, a simpler design. Another advantage is that a longer fiber stub length provides up to three opportunities to splice optic fiber ends correctly instead of the current single opportunity to splice correctly, thus saving money on “failed-splice” connections. Still another advantage of my solution to these problems is that an increased boot length better protects optic fiber within the boot, which improves fiber strain relief.

SUMMARY

[0035] A method of re-splicing a splice-on connector (“SOC”) in accordance with the present subject matter is summarized by the following five steps: (1) stripping insulation away from an end portion of a first optic fiber; (2) stripping insulation away from an end portion of a second optic fiber having a connector body fixed to an opposite end portion thereof, wherein an end portion of the connector body is dimensioned and configured to be removably insertable into an end portion of an elongated hollow member; (3) splicing together the first and second fiber optic end portions to produce a splice-on connector (“SOC”) or a re-spliced splice-on connector (“RSSOC”), wherein the SOC has a predetermined length to enable cutting at three predetermined locations spaced from the connector body; (4) if an operational fault is caused in a system using the SOC or RSSOC, cutting the SOC or the RSSOC at one of the three predetermined regions; and (5) repeating step (3).

[0036] Additional features of the present subject matter are directed to an elongated optic fiber stub portion. Such an optic fiber stub portion results from using an elongated hollow elastomeric tubular member, also known as a rubber boot, preferably made of silicone rubber, in connection with another method for fusing two end portions of optic fiber together, which includes the following steps.

[0037] A first step involves passing an end of a first optic fiber having an insulation layer through the elongated tubular member and then through a heat-meltable sleeve. A second step involves stripping away the insulation layer from an end portion of the first optic fiber. A third step involves cleaning the insulation-stripped end portion with an effective amount of cleaning fluid and then cleaving an end face of the cleaned end portion of the optic fiber. A fourth step involves positioning the cleaved end face of the cleaned end portion of the first optic fiber in a fusion splicer. A fifth step involves stripping an insulation layer from an end portion of a second optic fiber. The second optic fiber includes an optic fiber connector that is attached to an end portion opposite the insulation-stripped end portion. A sixth step involves cleaning the second optic fiber end portion stripped of insulation with an effective amount of cleaning fluid and thereafter cleaving an end face of the cleaned end portion of the second optic fiber. A seventh step involves positioning the second optic fiber cleaved end portion in the fusion splicer closely adjacent, preferably abutting, the cleaved end portion of the second optic fiber. An eighth step involves fusing together the cleaved end faces of the first and second fibers.

[0038] A ninth step involves moving the sleeve made of meltable plastic over the fused-together end portions of the first and second optic fibers and then inserting the sleeved portion of the fused first and second fibers into an oven to melt the sleeve for the purpose of protecting the fused-together portions of the fibers. The elongated tubular member has opposite end portions; and one end portion of the elongated tubular member defines a tip. A tenth step involves sliding the hollow elongated tubular member over the sleeve-protected fused ends of the first and second optic fibers and attaching the end portion of the elongated tubular member that is located opposite the tip to the optic fiber connector. The elongated tubular member has a length effective for resulting in the sleeve-protected fused optic fibers disposed therein, to be cut near the tubular member tip, for producing an elongated optic fiber stub portion of the present subject matter. When the eighth step results in a failure to fuse abutting end faces of the first and second optic fibers, the second through eighth steps are repeated, and the ninth and tenth steps performed, whenever successful fusion of end faces of the two optic fibers occurs.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0039] FIGS. **1**A, **1**B, **1**C and **1**D are screen shots of a video of step 1 of a method demonstrating the fusing of two cleaved end faces of optic fiber together, which is a noted use for the optic fiber elongated stub portion of the present subject matter.

[0040] FIGS. **2**A, **2**B, **2**C, and **2**D are video screen shots of step 2 of the method.

[0041] FIGS. **3**A and **3**B are video screen shots of step 3 of the method.

[0042] FIGS. **4**A and **4**B are video screen shots of step 4 of the method.

[0043] FIGS. **5**A and **5**B are video screen shots of step 5 of the method.

[0044] FIGS. **6**A and **6**B are video screen shots of step 6 of the method.

[0045] FIGS. **7**A and **7**B are video screen shots of step 7 of the method.

[0046] FIGS. **8**A, **8**B, **8**C, and **8**D are video screen shots of step 8 of the method.

[0047] FIGS. **9**A and **9**B are video screen shots of step 9 of the method.

[0048] FIGS. **10**A and **10**B are video screen shots of step of the method.

[0049] FIGS. **11**A, **11**B, **11**C, **11**D are video screen shots of step of the method.

[0050] FIGS. **12**A, **12**B, **12**C, **12**D are video screen shots of step of the method.

[0051] FIG. **13** depicts two examples of optic fiber stub portions, one of which depicts prior art, the other an elongated stub portion of the present subject matter.

[0052] FIG. **14** depicts two examples of optic fiber stub portions shown in FIG. **13**, but with their associated components disassembled, to clearly show select details.

[0053] FIG. **15**A depicts a splice-on connector according to the present subject matter, and three preferred splice points spaced from an end of a connector body; and FIG. **15**B depicts a hollow member having a frustoconical tip, and three sleeves.

[0054] Throughout the drawing figures and detailed description, I shall use similar reference numerals to refer to similar components of the present subject matter.

DETAILED DESCRIPTION

[0055] An operational re-spliced splice-on connector in accordance with the present subject matter is produced by a process that includes some or all of the following steps numbered (1) through (18): (1) disposing an end portion of a first optic fiber into and longitudinally through one end portion of an elongated hollow member such that the first fiber end portion extends from an opposite end portion of the hollow member; (2) stripping insulation away from the end portion of the first optic fiber; (3) cleaning the insulation-stripped end portion of the first optic fiber with a preselected cleaning fluid to provide the first fiber with a clean end face; (4) cleaving the first optic fiber clean end face to provide a cleaved end portion; (5) positioning the first optic fiber cleaved end portion within a fusion splicer; (6) stripping insulation away from an end portion of a second optic fiber having a connector body fixed to an opposite end portion thereof, wherein an end portion of the connector body is dimensioned and configured to be removably inserted into the opposite end portion of the hollow member; (7) cleaning the insulation-stripped end portion of the second optic fiber with a preselected cleaning fluid to provide the second fiber with a clean end face; (8) cleaving the second fiber clean end face to produce a cleaved end portion; (9) closely spacing the cleaved end portions of the first and second optic fibers; (10) using the splicer to splice together the closely spaced cleaved end portions of the optic fibers, to thereby produce either a splice-on connector (“SOC”) or a re-spliced splice-on connector (“RSSOC”), wherein the SOC has a predetermined length effective for cutting the SOC or the RSSOC at three predetermined locations spaced seriatim from the connector body; (11) positioning a heat-meltable sleeve relative to the spliced-together first and second optic fiber end portions such that the sleeve encloses the first and second optic fiber spliced-together end portions, wherein the sleeve is dimensioned and configured to fit within an interior region of the hollow member; (12) inserting the spliced-together fiber end portions enclosed by the sleeve into an oven having an interior heated to a predetermined temperature to cause the sleeve to melt onto the spliced-together optic fiber end portions; (13) moving the elongated hollow member relative to the spliced-together first and second optic fiber end portions such that the spliced-together optic fiber end portions are disposed within the hollow member interior region; (14) inserting the connector body end portion into the opposite end portion of the hollow member; (15) if an operational fault is caused in a system using the SOC or the RSSOC, removing the connector body end portion from the hollow member, (16) cutting the SOC or the RSSOC at one of the three predetermined regions; (17) using the fusion splicer to splice together closely-spaced other pairs of cleaned-and-cleaved end portions of the first and second optic fibers; and (18) repeating steps (11) through (14), thereby producing the operational re-spliced splice-on connector.

[0056] In the process described in the preceding paragraph, the hollow member **500** (please see FIG. **15**B) is essentially cylindrical, and one of its end portions **502** defines a frustoconical tip. Also, the second optic fiber **510** (please see FIG. **15**A) has a length ranging from about 110 millimeters (“mm”) to about 140 mm or from about 115 mm to about 127 mm or from about 120 mm to about 122 mm. A first one of the three predetermined locations is spaced from about 99 mm to about 91 mm or from about 96 mm to about 94 mm (preferably about 95 mm) from an end of connector body **520**. A second one of the three predetermined locations is spaced from about 80 mm to about 70 mm or from about 78 mm to about 72 mm or from about 76 mm to about 74 mm (preferably about 75 mm) from an end of connector body **520**. A third one of the three predetermined locations is spaced from about 58 mm to about 52 mm or from about 56 mm to about 54 mm (preferably about 55 mm) from an end of the connector body **520**. Hollow member **500** has a length, L, ranging from about 110 mm to about 150 mm or from about 120 mm to about 140 mm or from about 130 mm to about 135 mm or from about 128 mm to about 132 mm. The sleeve **530** is cylindrical with a length, LS, ranging from about 30.1 mm to about 32.1 mm or from about 31.1 mm to about 31.6 mm.

[0057] Additional features of the present subject matter are described as follows.

[0058] Step 1: Pass Optic Fiber End through an Elongated Boot and Plastic Sleeve. Please refer to FIG. **1**A which shows a technician using his/her right hand RH to hold a hollow and elongated elastomeric tubular member made of rubber, known as a rubber boot **100** by those of ordinary skill in this field. The technician, shown holding in his/her left LH an end portion **102** of an optic cable **104**, is inserting the end portion **102** of the optic cable **104** into an opening at a hollow tip **106** located at one end portion of the elongated elastomeric tubular member **100** preferably made of silicone rubber, which I refer to as a “rubber boot” throughout this patent application. FIG. **1**B shows the end portion **102** of optic cable **104** extending from an opposite end **108** of the elastomeric tubular member or rubber boot **100** after the end portion **102** of optic cable **104** was pushed through the rubber boot **100**. After the technician has pulled the end portion **102** of the optic cable **104** through the tubular member or rubber boot **100** and set the rubber boot **100** down to the left (beyond the field of view), FIG. **1**C shows how the technician next uses his/her right hand RH to hold a clear plastic sleeve **110** and then insert with his/her left hand LH the end portion **102** of optic cable **104** into one end of the clear plastic sleeve **110**. FIG. **1**D shows the technician using his/her right hand RH to grip the plastic sleeve **110** and slide the plastic sleeve **110** to the left along optic cable **104**.

[0059] Step 2: Insert Optic Fiber into a Fiber Holder and then into Thermal Stripper. FIG. **2**A presents the technician holding in his/her left hand LH a fiber holder **112** having a hinged cover **114**. The technician first places the optic fiber **104** in the fiber holder **112** (see FIG. **2**A), with the end portion **102** of the optic fiber **104** extending from about 1 inch to about 1.25 inches from the fiber holder **112**. The technician thereafter uses the hinged cover **114** to secure the optic fiber **104** to the fiber holder **112**, with the end portion **102** of the optic fiber **104** extending from about 1 inch to about 1.25 inches from the fiber holder **112**. (Please see FIG. **2**B.) The technician next places the fiber holder **112** (now clinching the end portion **102**) into a thermal stripper **116** (Please refer to FIGS. **2**B and **2**C) to strip insulation from the end optic fiber **104** from the end portion **102**. (Please refer to FIG. **2**D.)

[0060] Step 3: Clean Optic Fiber with Cleaning Fluid and Cleave in Precision Cleaver. FIG. **3**A shows the technician holding in his/her left hand LH a cleaning cloth **118** to which was applied a preselected cleaning fluid. The technician then uses cleaning cloth **118** with an effective amount of cleaning fluid to clean the insulation stripped portion of optic fiber **104** (FIG. **2**A) extending from the fiber holder **112** (FIG. **2**A).

[0061] The technician next inserts the fiber holder **112** containing the optic fiber **104** with its now insulation-stripped and “cleaned” end portion **102** into a precision cleaver **120** to cleave the end face of the end portion **102** (FIG. **2**B) as illustrated by FIG. **3**B.

[0062] Steps 1-3 and the figures associated with steps 1-3 represent preparation of an end face of the optic cable in accordance with the present subject matter, one advantage of which is a longer fiber stub length for the optic fiber, providing up to three opportunities to splice a connector correctly instead of the sole opportunity currently to splice optic fiber end faces correctly. Steps 4-8 that follow, and figures associated with steps 4-8, represent preparation of an end face of another optic fiber, to which the longer fiber stub end face can be joined up to three times if “failure” occurs, which results in reduced time and expense to correct such failure.

[0063] Step 4: Place Fiber Holder in Fusion Splicer and Prepare Another Optic Fiber. Next, the technician is shown using his/her right hand RH to position the fiber holder **112** (now containing the freshly-cleaved end face of the optic fiber **104**) within a fusion splicer **122**. (Please refer to FIG. **4**A.) Also shown, a pigtail assembly **200** for another optic fiber is prepared for a similar insulation-stripping procedure. The pigtail assembly **200** includes another optic fiber **202** extending from a back of an optic fiber connector **204** (FIG. **4**A). To prepare to strip insulation from an end portion of the other optic fiber **202**, the technician uses both hands to insert the connector pigtail assembly **200** (FIG. **4**A) into another fiber holder **206** (FIG. **4**B).

[0064] Step 5: Next, Place Fiber Holder into Thermal Stripper to Strip Off Insulation. Next, the technician places the other fiber holder **206** (containing the connector pigtail assembly **200**—see FIG. **4**A) into the thermal stripper **116** (FIGS. **5**A and **5**B) to strip off insulation from an end portion of the other optic cable **202** (see FIG. **4**A).

[0065] Step 6: Remove Other Optic Cable From Stripper and Clean End Portion. After insulation which had been on the end portion **210** of the other optic fiber **202** has been stripped away by operation of the thermal stripper **116** (FIG. **6**A), the insulation-stripped end portion **210** of the other optic fiber **202** is cleaned by the technician using an effective amount of cleaning fluid on the cloth **118**, for cleaning the insulation-stripped end portion **210** of the other optic fiber **202** (FIGS. **6**A, **6**B).

[0066] Step 7: Put Clean End Portion in Cleaver; Put Fiber Holder into Fusion Splicer. Next, the other fiber holder **206**, which I shall now refer to as the “second” fiber holder **206** containing the connector pigtail assembly **200** with its freshly-cleaned and insulation-stripped end portion **210** of the second optic fiber **202** (see FIG. **4**A), is inserted into the precision cleaver **120** (see FIG. **7**A) by the technician for the purpose of cleaving the end face of the freshly-cleaned and insulation-stripped end portion **210** of the second optic fiber **202**. Then, after the end face of the cleaned and insulation-stripped away end portion **210** of the other optic cable **202** has been cleaved by the technician using the precision cleaver **120** (please see FIG. **7**A), the technician next inserts the second fiber holder **206** (containing the now-cleaved end face of second optic fiber **202**) into the fusion splicer **122** (please see FIG. **7**B).

[0067] Please note that the fusion splicer **122**, at this time, also contains the fiber holder **112** (containing the cleaved end face of end portion **102** of optic fiber **104**) that the technician inserted into fusion splicer **122** earlier. (See FIG. **4**A and step 4.)

[0068] Also please note that the fusion splicer **122** includes an operational portion **126** (for fusing together the cleaved end faces of abutting optic fibers) and a cover portion **128** connected to the operational portion **126** by a hinged assembly that is unitary with both the operational portion **126** and the cover portion **128** (FIG. **7**B).

[0069] Step 8: Close Cover of Splicer and Fuse End Faces of Optic Fibers Together. Next, cover **128** is closed over the abutting end faces of the first and second optic fibers **104**, **202** (FIG. **8**A). Then, fusion splicer **122** (FIG. **7**A) is used by the technician to fuse abutting end faces of the first and second optic fibers **104**, **202** together. A panel **130** associated with fusion splicer **122** provides a visual assessment of the progress of the fusion of abutting end faces of the first and second optic fibers **104** and **202**. Also, broken lines **132**, when displayed on panel **130** (FIG. **8**A), indicate that fusion is “in progress,” while a solid line **134** displayed on panel **130** (FIG. **8**B) indicates fusion of abutting end faces is completed. And fusion splicer **122** indicates when end-face fusion of the two optic fibers is successful. An example of successful end-face fusion is as follows: After panel **130** of the fusion splicer **122** indicates that end-face fusion of the two optic fibers **104**, **202** has been completed (FIG. **8**B), the fusion splicer **122** is opened. Successful end-face fusion of the two optic fibers **104** and **202** is shown as having occurred (FIG. **8**C), with the technician holding in his/her right hand, RH, the first optic fiber **104**. In FIG. **8**C, the first optic fiber **104** is shown as still retained by the first fiber holder **112**. Also, the second optic fiber **202** is shown as still retained by the second optic fiber holder **206**. In addition, the second optic fiber connector **204** is clearly shown attached to an end portion of the second optic fiber **202**, which is opposite the fused end-face portion of the second optic fiber **202**. In FIG. **8**D, the first optic fiber **104**, now removed from the first fiber holder **112**, is shown being held in the right hand, RH, of the technician. Also shown is the second optic fiber **202**, which is now joined to the first optic fiber **104** at a fused end-face plane **138**, within a fused end-face region **140**. (Please see FIG. **8**D.)

[0070] Failure to Successfully Fuse Optic Fiber End Faces: Hypothetical Example 1. Yet, the fusion splicer **122** also notifies the technician when end-face fusion of the two optic fibers has “failed.” Let us assume, therefore, that end-face fusion of the two optic fibers **104** and **202** has failed, and that corrective action is now required.

[0071] Step 9, Part 1: Open Splicer; Remove Optic Fibers; Cut; Re-Fuse End Faces. Because the fusion splicer **122** indicated a “failure” at the end-face plane **138**, (within the now-joined end-face region **140**), it became necessary to open the fusion splicer **122**. This is done by removing cover **128** from operational portion **126**. The technician next removed now-joined first and second optic fibers **104** and **202** from their respective first and second fiber holders **112** and **206**. (Please refer to FIG. **9**A.) After determining that “failure” resulted from a “fault” in the optic fibers **104**, **202**, it became necessary for the technician to use a pair of wire cutters **300** to cut optic fibers **104**, **202** to remove the “fault.” (Please refer to FIG. **9**B.) To properly fuse the end faces of the optic fibers **104**, **202**, steps 2-8 were repeated.

[0072] Failure to Successfully Fuse Optic Fiber End Faces: Hypothetical Example 2. Let us assume that the fusion splicer **122** has notified the technician that end-face fusion of the optic fibers has again “failed,” and that corrective action is required.

[0073] Step 9, Part 2: Open Splicer; Remove Optic Fibers; Cut; Re-Fuse End Faces. Because the fusion splicer **122** indicated a “failure” at the end-face plane **138**, (within the now-joined end-face region **140**), it shall again be necessary to open the fusion splicer **122**. (Please refer to Step 9-1 and FIG. **9**A.) After determining that “failure” resulted from a “fault” in the optic fibers **104** and **202**, it became necessary for the technician to use a pair of wire cutters **300** to cut optic fibers **104** and **202**

to remove the “fault.” (Please refer to Step 9-1 and FIG. **9**B.) Finally, in order to properly fuse the end faces of the optic fibers **104**, **202**, steps 2-8 were repeated.
[0074] Step 10: End-Face Fusion of Optic Fibers Successful; Open Fusion Splicer. The end-face fusion of freshly-cleaved end portions of the optic fibers **104**, **202** was again completed, which fusion splicer **122** indicated (FIG. **10**A). This time, after steps 2-8 had been performed three times, end-face fusion was successful; and the fusion splicer **122** was opened by pivoting cover **128** toward panel **130** (FIG. **10**B).
[0075] Step 11: Move Sleeve Over End-Spliced Area; Transfer Sleeved Area to Oven. After removing the spliced-together optic fibers **104**, **202** (FIG. **10**B) from the fusion splicer **122**, the technician then slides protective plastic sleeve **110** (FIG. **11**A) over an area surrounding the spliced optic fibers **104**, **202** (FIG. **11**B). Next, the technician transfers the sleeved, spliced optic fibers **104**, **202** into an oven **150** (FIG. **11**C), and brings an oven cover **152** over the sleeved area (FIG. **11**D), to melt the sleeve **110** to protect the fused end-faces of the two optic fibers **104**, **202**.
[0076] Step 12: Melt-Protection Completed; Remove Optic Fiber; Bring Up Boot. After the procedure to protect optic fibers **104**, **202** by melting protective plastic sleeve **110** over their fused end-faces is completed (FIG. **12**A), fused optic fibers **104**, **202** are removed from oven **150** (FIG. **12**B). Next, the technician brings up the boot **100** by sliding the boot **100** along the joined optic fibers **104** and **202** (FIG. **12**B) toward optic fiber connector **204** (FIG. **12**C). The technician then attaches boot end portion **108** opposite the tip **106** (FIG. **12**D) to the optic fiber connector **204**. This completes the process to fuse optic fiber end faces together.
[0077] Prior Art Rubber Boot vis-à-vis Example of Boot of Present Subject Matter. FIG. **13** depicts a prior art rubber boot **100**A and an associated connector joined at an end of the prior art boot **100**A. FIG. **13** also depicts another rubber boot **100**B which is an illustrative example of the present subject matter. Prior art boots for FC, LC, SC, and ST type optic fiber connectors are about 40 millimeters (“mm”) in length. Prior art boots for MPO optic fiber connectors are about 8 mm in length. Rubber boots of the present subject matter, for FC, LC, SC, and ST type optic fiber connectors are about 130 mm in length, and for MPO connectors is about 126 mm.
[0078] Prior Art Fiber Stub Length vis-à-vis Stub Length of Present Subject Matter. FIG. **14** depicts a prior art rubber boot **100**A separated from an associated connector **204**A, and an optic fiber fused end-face region **140**A located between the rubber boot **100**A and connector **204**A. For prior art, an optic fiber stub **400**A extending from the connector **204**A to optic fiber fused end-face region **140**A is a piece of optic fiber measuring about 10 mm to about 15 mm in length. FIG. **14** also depicts a rubber boot **100**B, which is another example of the present subject matter, separated from an associated connector **204**B, and an optic fiber fused end-face region **140**B located between the rubber boot **100**B and connector **204**B.
[0079] In this example of the present subject matter, an optic fiber stub **400**B extending from connector **204**B to optic fiber fused end-face region **140**B is a piece of optic fiber measuring about 1 mm to 130 mm in length, preferably 125 mm in length.
[0080] An operational re-spliceable splice-on connector as well as a process for making it is described. While the present subject matter is disclosed in relation to embodiments, the present subject matter is not limited to these embodiments. On the contrary, alternatives, changes, and/or modifications shall become apparent to a person of ordinary skill in the art (“POSITA”) after the present patent specification including the associated drawing FIGS. are reviewed. As a result alternatives, changes, or modifications are to be treated as forming a part of the present subject matter insofar as they fall within the spirit and scope of appended patent claims.

Claims

1. An operational re-spliced splice-on connector produced by a process which comprises the following steps numbered (1) through (5): (1) stripping insulation away from an end portion of a first optic fiber; (2) stripping insulation away from an end portion of a second optic fiber having a connector body fixed to an opposite end portion thereof, wherein an end portion of the connector body is dimensioned and configured to be removably insertable into an end portion of an elongated hollow member; (3) splicing together the first and second fiber optic end portions to produce a splice-on connector ("SOC") or a re-spliced splice-on connector ("RSSOC"), wherein the SOC has a predetermined length to enable cutting at three predetermined locations spaced from the connector body; (4) if an operational fault is caused in a system using the SOC or RSSOC, cutting the SOC or the RSSOC at one of the three predetermined regions; and (5) repeating step (3), thereby producing the operational re-spliced splice-on connector.

2. The operational re-spliced splice-on connector of claim 1, wherein the hollow member is cylindrical, has a length ranging from about 110 millimeters ("mm") to about 150 mm, and an opposite end portion defining a frustoconical tip.

3. The operational re-spliced splice-on connector of claim 2, wherein the second optic fiber has a length ranging from about 110 millimeters ("mm") to about 132 mm.

4. The operational re-spliced splice-on connector of claim 3, wherein a first one of the three locations is spaced from about 91 mm to about 99 mm from the connector body, wherein a second one of the three locations is spaced from about 70 mm to about 80 mm from the connector body, and wherein a third one of the three locations is spaced about 52 mm to about 58 mm from the connector body.

5. An operational re-spliced splice-on connector produced by a process which comprises the following steps numbered (1) through (18): (1) disposing an end portion of a first optic fiber into and longitudinally through one end portion of an elongated hollow member such that the first fiber end portion extends from an opposite end portion of the hollow member; (2) stripping insulation away from the end portion of the first optic fiber; (3) cleaning the insulation-stripped end portion of the first optic fiber with a preselected cleaning fluid to provide the first fiber with a clean end face; (4) cleaving the first optic fiber clean end face to provide a cleaved end portion; (5) positioning the first optic fiber cleaved end portion within a fusion splicer; (6) stripping insulation away from an end portion of a second optic fiber having a connector body fixed to an opposite end portion thereof, wherein an end portion of the connector body is dimensioned and configured to be removably inserted into the opposite end portion of the hollow member; (7) cleaning the insulation-stripped end portion of the second optic fiber with a preselected cleaning fluid to provide the second fiber with a clean end face; (8) cleaving the second fiber clean end face to produce a cleaved end portion; (9) closely spacing the cleaved end portions of the first and second optic fibers; (10) using the splicer to splice together the closely spaced cleaved end portions of the optic fibers, to thereby produce either a splice-on connector ("SOC") or a re-spliced splice-on connector ("RSSOC"), wherein the SOC has a predetermined length effective for cutting the SOC or the RSSOC at three predetermined locations spaced seriatim from the connector body; (11) positioning a heat-meltable sleeve relative to the spliced-together first and second optic fiber end portions such that the sleeve encloses the first and second optic fiber spliced-together end portions, wherein the sleeve is sized and configured to fit within an interior region of the hollow member; (12) inserting the spliced-together fiber end portions enclosed by the sleeve into an oven having an interior heated to a predetermined temperature to cause the sleeve to melt onto the spliced-together optic fiber end portions; (13) moving the elongated hollow member relative to the spliced-together first and second optic fiber end portions such that the spliced-together optic fiber end portions are disposed within the hollow member interior region; (14) inserting the connector body end portion into the opposite end portion of the elongated hollow member; (15) if an operational fault is caused in a system using the SOC or the RSSOC, removing the connector body end portion from the hollow member, (16) cutting the SOC or the RSSOC at one of the three predetermined regions; (17) using the fusion splicer to splice together closely-spaced other pairs of cleaned-and-cleaved end portions of the first and second optic fibers; and (18) repeating step (11) through step (14), thereby producing the operational re-spliced splice-on connector.

6. The operational re-spliced splice-on connector of claim 5, wherein the hollow member is cylindrical, has a length ranging from about 110 millimeters ("mm") to about 150 mm, and an opposite end portion defining a frustoconical tip.

7. The operational re-spliced splice-on connector of claim 6, wherein the second optic fiber has a length ranging from about 110 millimeters ("mm") to about 132 mm.

8. The operational re-spliced splice-on connector of claim 7, wherein a first one of the three locations is spaced from about 91 mm to about 99 mm from the connector body, wherein a second one of the three locations is spaced from about 70 mm to about 80 mm from the connector body, and wherein a third one of the three locations is spaced about 52 mm to about 58 mm from the connector body.