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(71) Applicant *(for all designated States except US)*: **CORNING CABLE SYSTEMS LLC** [US/US]; Intellectual Property Department, SP-TI-3-1, Corning, New York 14831 (US).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **LIU, Ziwei** [US/US]; 8305 Greylock Drive, Fort Worth, Texas 76137 (US). **YOW, JR., Charles A.** [US/US]; 4732 Grant Park Avenue, Fort Worth, Texas 76137 (US).

(74) Agent: **CARROLL, JR., Michael E.**; Corning Cable Systems LLC, 800 17th Street NW, P.O. Box 489, Hickory, North Carolina 28603 (US).

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(54) Title: DUST CAP ASSEMBLY FOR SEALING AN OPTICAL FIBER FERRULE AND METHODS THEREOF

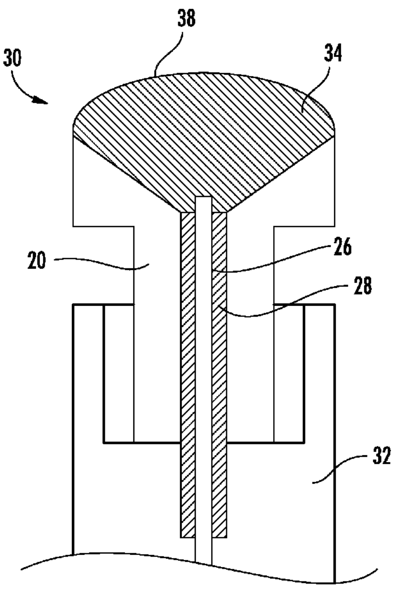

FIG. 3B

(57) Abstract: A dust cap assembly includes a sleeve and a sealant that seals an end face portion of a fiber optic ferrule from contaminants and, upon removal, provides remedial cleaning of any foreign matter present on the ferrule when the dust cap assembly was initially installed along with methods of making the same. The sleeve of the dust cap assembly has a through bore and a distal end for receiving the sealant. Further, the sealant may optionally have advantageous mechanical and optical properties such that the dust cap assembly may function as a terminator for testing.

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DUST CAP ASSEMBLY FOR SEALING AN OPTICAL FIBER FERRULE AND METHODS THEREOF

RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application Serial Nos. 61/182,379 and 61/182,361 both filed on May 29, 2009, the entire contents of both which are incorporated herein by reference.

BACKGROUND

Technical field

[0002] The disclosure relates to dust cap assemblies for fiber optic ferules used in fiber optic connectors. Specifically, the dust cap assembly seals the fiber optic ferrule from contaminants during its incumbency and, upon removal, provides remedial cleaning of any foreign matter present on the ferrule when the dust cap assembly was initially installed. In other embodiments, the dust cap assembly may optionally function as a terminator for testing the integrity of an optical cable assembly or as enabling a non-contact continuity test for fiber optic patch cables.

Technical background

[0003] The capacity to send information over a wire revolutionized communication. Copper wire was the standard for more than 150 years, with ease of use and interconnection, but as bandwidth demand increased, it was necessary to seek alternative mediums. Optical fiber, developed and perfected over the past three decades, has made its presence felt, providing secure, high capacity signal transmission; in the past used primarily for long distance signal transmission due to its tremendous efficiency and security, but unable to easily leverage these attributes in more localized arenas. With developments in the joining of truncated fibers, suddenly optical fiber was becoming as versatile as copper. Optical fiber could be cut and easily rejoined via splicing, either by laser, electric arc or mechanical splicing, and by other mechanical processes. Of the mechanical processes developed, the ability to mate and de-mate an optical fiber to another optical fiber completed the versatility picture. Fiber optic ferrules and fiber optic connectors provided easy junction points in the field that tremendously increased the ease of use of optical fibers. Polishing optical fibers within appropriate ferrules is necessary to efficiently join two fibers end to end in such a way as to preserve the integrity of the optical signal with as little signal loss (attenuation) as possible.

[0004] To create a typical fiber optic cable assembly a fiber optic cable is terminated, a fiber optic connector is assembled at an end of the cable and the ferrule end face polished. The exactitude of the polished face of a fiber optic ferrule is such that any minute amounts of debris on that end face can block or decrease signal transmission or even damage the end face. Polished ferrule end faces can represent the end result of hours of manufacturing providing a polished ferrule end face to mate to another polished ferrule end face and thereby transfer signals from one fiber into another. Protecting the polished end faces of fiber optic ferrules is extremely important: protection from residual dust from the connector housing; protection from airborn contaminants in the manufacturing facility; protection from the effects of water, oils and chemicals; protection from the effects of temperature cycling, just to name a few. Dust caps as known in the art provide a shield from the physical contact of the delicate ferrule end faces with the outside environment, but do not inherently prevent ingress of moisture, remediate existing contaminants, and can actually deposit contaminants onto the very ferrule end faces they are designed to protect. Thus, there is an unresolved need for dust cap assemblies that will literally seal the optical ferrule end face, insuring the integrity of the factory polished ferrule, one that is inexpensive, easy to install and remove, and that prevents contamination by water, oil, dust, particulates, damage due to handling, etc.

SUMMARY

[0005] The disclosure refers generally to a dust cap assembly for a fiber optic connector and methods for making the same. Specifically, the dust cap assembly physically engages and seals a polished fiber optic ferrule, thereby preserving the cleanliness of the fiber optic ferrule end face. The dust cap assembly comprises at least two components: a sleeve and a sealant. The sleeve has a through bore that physically engages the fiber optic ferrule by a frictional fit. A distal end of the sleeve may include an encapsulating feature that provides a suitable application point for the sealant. The distal end is proximal to the fiber optic ferrule end face, thereby allowing application of the sealant to the encapsulating feature of the sleeve and the fiber optic ferrule end face at the same time.

[0006] In one embodiment, the sealant comprises a curable liquid polymer, wherein the curable liquid polymer is easily applied and generally conforms to the geometry present on the distal end of the sleeve and the fiber optic ferrule end face. The sealant transitions from liquid to solid upon curing, encapsulating the fiber optic ferrule end face and protecting it from contaminants such as water, oils, dust, particulates, etc., thereby ensuring the integrity of the polished fiber optic ferrule end face.

[0007] In the event that contaminants are present prior to the application of the sealant, the sealant will adhere to such contaminants and lock them in the polymer upon curing. The contaminants, locked in the cured sealant, will come away with the dust cap assembly when the craft removes it from the fiber optic ferrule, leaving a fiber optic ferrule end face surface that may be cleaner than before the dust cap assembly was installed.

[0008] A further optional advantage of the present disclosure is the interaction of the dust cap assembly and optical testing equipment used by the craft. In one embodiment, the index of refraction of the cured sealant allows the dust cap assembly to act as a terminator so that the craft can remotely test the optical integrity of an optical system after the system has been installed. If the dust cap assembly is installed on each end of a cable, as in a fiber optic jumper, the encapsulating convex shape of the index matching sealant serves as a lens, allowing light to enter from an external light source sufficient to travel the length of the cable and exit the opposite dust cap assembly and be detected by a photodetector. This helps the craft to quickly determine continuity within the jumper without having to remove the dust cap assembly or optically connect the jumper cable to either the external light source or the testing apparatus. Removing the dust cap and plugging the ferrule into testing equipment runs the risk of damaging or contaminating the polished fiber optic ferrule end face.

[0009] The present disclosure provides assurance to the end user that the factory installed, polished fiber optic ferrules remain pristine and in excellent condition for and until their intended use–transmission of optical signals from one optical fiber into another optical fiber.

[0010] It is to be understood that both the foregoing general description and the following detailed description present embodiments of the invention, and are intended to provide an overview or framework for understanding the nature and character of the invention as it is claimed. The accompanying drawings are included to provide a further understanding of the invention, and are incorporated into and constitute a part of this specification. The drawings illustrate various embodiments of the invention, and together with the description serve to explain the principles and operation of the invention.

BRIEF DESCRIPTION OF THE FIGURES

[0011] Embodiments of the disclosure are illustrated by the accompanying drawings, in which:

[0012] **Figs. 1A** and **1B** show two views of an embodiment of the sleeve of a dust cap assembly;

[0013] **Figs. 2A** and **2B** show two views of another embodiment of a sleeve having a shoulder;

[0014] **Fig. 3A** shows a sectional view of a fiber optic connector with the sleeve installed and **Fig. 3B** shows a sectional view of the same fiber optic connector and sleeve with the sealant in place;

[0015] **Fig. 4A** shows a sectional view of a fiber optic connector with another sleeve installed and **Fig. 4B** shows a sectional view of the same fiber optic connector connector and sleeve with the sealant in place;

[0016] **Fig. 5A** shows a sectional view of a fiber optic connector with another sleeve installed and **Fig. 5B** shows a sectional view of the same fiber optic connector and sleeve with the sealant in place;

[0017] **Fig. 6A** shows a sectional view of a fiber optic connector with another sleeve installed and **Fig. 6B** shows a sectional view of the same fiber optic connector and sleeve with the sealant in place;

[0018] **Fig. 7** shows a multi-fiber fiber optic ferrule assembly with the dust cap assembly installed;

[0019] **Fig. 8** depicts a first method of sealing a fiber optic ferrule end face using a dispensing head to deposit the sealant and then curing the same;

[0020] **Fig. 9** is a second method of sealing a fiber optic ferrule end face by dipping the sleeve and polished end face into the sealant and then curing the same;

[0021] **Fig. 10A** shows an artistic rendering of a "clean" polished end face before application of the dust cap assembly and **Fig. 10B** shows an artistic rendering of the polished end face of **Fig. 10A** after the dust cap assembly was removed;

[0022] **Fig. 11A** shows an artistic rendering of a "dirty" polished end face before application of the dust cap assembly and **Fig. 11B** shows an artistic rendering of the polished end face of **Fig. 10B** after the dust cap assembly was removed

[0023] **Fig. 12** schematically shows a jumper cable assembly with the dust cap assembly on each end during continuity testing;

[0024] **Fig. 13** schematically shows a jumper cable assembly with a first connector optically connected to a test apparatus and a second connector having a dust cap assembly during testing for backreflection; and

[0025] **Fig. 14** shows a fiber optic cable assembly with a trunk cable and tether, the tether having a dust cap assembly acting as a terminator.

DETAILED DESCRIPTION

[0026] Reference will now be made in detail to the preferred embodiments of the present invention, examples of which are illustrated in the accompanying drawings, in which some, but not all embodiments of the invention are shown. Indeed, the invention may be embodied in many different forms and should not be construed as limited to the embodiments set forth 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.

[0027] The disclosure generally relates to a dust cap assembly and methods of making the same. The dust cap assembly comprises at least two components for sealing a polished end face of a fiber optic ferrule of a fiber optic ferrule assembly. Sealing a polished end face of a fiber optic ferrule is advantageous to inhibit encroachment of contaminants on the polished end face from the time the polished end face is polished to the time the fiber optic connector assembly is deployed in the field. Simply stated, the disclosure is directed to a dust cap assembly for sealing a fiber optic connector assembly having at least one fiber optic ferrule assembly including a fiber optic ferrule having at least one optical fiber therein. The sleeve has a proximal end and a distal end with a through bore therebetween and is disposed on the at least one fiber optic ferrule, and a sealant at least partially disposed on the sleeve for sealing a portion of the polished end face of the fiber optic ferrule.

[0028] **Figs. 1A** and **1B** show two different views of a sleeve **10** of the dust cap assembly of the disclosure. In this embodiment, the sleeve **10** is generally straight and has a proximal end **14** and a distal end **16**. The proximal end **14** and distal end **16** have a through bore **12** therebetween, creating a generally hollow component. An encapsulating feature **18** proximal to the distal end **16** is in communication with the through bore **12**, wherein the encapsulating feature **18** enables the sealing of the polished end face of a fiber optic ferrule. **Figs. 2A** and **2B** show two different views of a second embodiment of a sleeve **20.** Sleeve **20** includes a shoulder **22** for easing the removal of the same from the fiber optic ferrule assembly (e.g., the assembly includes a portion of the fiber optic ferrule and the end of the optical fiber). Sleeve **20** also has distal end **16** and proximal end **14** with a through bore **12** therebetween. Encapsulating feature **18** is proximal to distal end **16** and in communication with through bore **12**.

[0029] **Figs. 3A-B** through **Figs. 6A-B** show two different sectional views of respective dust cap assemblies **30** disposed on a fiber optic connector **32** (hereinafter "connector"). **Figs. 3A, 4A, 5A** and **6A** show connector **32** having a ferrule **28** with a single fiber **26** and respective embodiments of sleeve **20**. Ferrules include, but are not limited to, LC, SC and MT, utilizing APC, UPC, pencil tips or flat configurations, made of steel, ceramic, polymer or any other suitable ferrule material. Each ferrule **28** has an exposed polished end face **27**, the polished end face **27** having polished fiber face **27A** protruding slightly, but the fiber face **27A** may be flush or recessed. For purposes of this disclosure polished end face **27** and polished end face **27A** are proximal to each other and any further mention of polished end face **27** is meant to include by inference polished fiber face **27A**. However, the concepts of the present application may be used on ferrule assemblies that are not polished, where protection is desired. **Fig. 3A** shows sleeve **20** having an encapsulating feature **18** shaped as a chamfer **24** that extends from the through bore **12** to distal end **16**. In a similar fashion, **Figs. 4A, 5A** and **6A** show respective embodiments of dust cap assembly **30**, each having sleeve **20** with different configurations of encapsulating feature **18**. In **Fig. 4A** encapsulating feature **18** is shaped as a radius **40**. In **Fig. 5A**, encapsulating feature **18** is shaped as a step **42** and in **Fig. 6A** encapsulating feature **18** is shaped as a lip **44**. Of course, other suitable geometries are possible as the encapsulating feature. Each of respective **Figs. 3B, 4B, 5B** and **6B** show sealant **34** generally covering respective portions of the through bore **12** and encapsulating feature **18**. Sealant **34** is advantageous for sealing the polished end face **27** and is in direct contact with polished end face **27** as well as portions of encapsulating feature **18**.

[0030] **Fig. 7** shows a multi-fiber ferrule assembly **50** having a dust cap assembly employing the concepts disclosed herein. In other words, the dust cap assembly includes a sleeve **48** and sealant **34** for sealing a plurality of polished fiber faces and a portion of polished end face **37** of the multi-fiber ferrule **46**. Multi-fiber ferrule sleeve **48** is generally rectangular, having proximal end **14** and distal end **16** that generally surrounds the end of multi-fiber ferrule assembly **50** as shown. Specifically, sleeve **48** surrounds a portion of multi-fiber ferrule polished end face **37** of multi-fiber ferrule **46**. Multi-fiber ferrule sleeve **48** has a through bore **49** and encapsulating feature **24** shaped as a chamfer, but other geometries are possible. Sealant **34** is in direct contact with chamfer **24** and multi-fiber ferrule polished end face **37**, thereby sealing and protecting the multi-fiber ferrule polished end face **37**. Multi-fiber ferrule assemblies **50** may include guide pins **47** disposed therein for mating with a complementary ferrule assembly. As shown, guide pins **47** are received and protected from encroachment of sealant **34** by guide pin cavities **49A** and **49B** formed in sleeve **48**. The multi-fiber ferrule sleeve **48** shown in **Fig. 7** may have other variations similar to sleeves **10** and **20** of **Figs. 1-6** such as alternative encapsulating features for receiving the sealant **34** for sealing multi-fiber ferrule polished end face **37**. Other embodiments of the multi-fiber sleeve may have other geometries such as including one or more protrusions for fitting into the guide pin bores of the ferrule if it does not include guide pins.

[0031] Sleeves **10, 20** and **48** of the disclosure may use any suitable material and the bores frictionally engage their respective ferrules, slightly deforming to tightly slide along a medial portion of the respective ferrule. This prevents sealant **34** from wicking down the medial portion of the ferrule, keeping sealant **34** on polished end face **27**. By way of example, the sleeve may be a polymer such as a thermoplastic like polycarbonate and a polyacrylate, though other suitable thermoplastics may be used.

[0032] Sealant **34** may be any suitable material having the desired properties for sealing and/or optical transmission. In one embodiment, sealant **34** is a curable liquid polymer. The curable liquid polymer starts as a liquid having a viscosity range of generally less than 1000 poise at 23 degrees Celsius, with a preferred range of about 250 poise to about 850 poise at 23 degrees Celsius. This range provides advantageous physical characteristics, e.g., ease of handling, tackiness, and surface tension qualities. For instance, sealant **34** of **Figs. 3-7** shows a generally convex shape **38** distal from the sealed polished end face **27**, enabled by the surface tension of sealant **34** while in liquid state; however, other shapes for the sealant such as generally flat are possible. Upon curing, sealant **34** retains its geometry and hardens, enabling sealant **34** to fully integrate with respective sleeves **10, 20** or **48**. Encapsulating feature **18** is configured in such a way that when dust cap assembly **30** is removed sealant **34** releases sealed polished end face **27**, revealing polished end face **27**. The sealant **34** viscosity range allows sealant **34** to flow sufficiently to fully cover polished end face **27** and encapsulating feature **18**.

[0033] The curable liquid polymer may be a heat curable liquid polymer, an ultraviolet light curable liquid polymer or a chemically reactive liquid polymer. One preferred embodiment of sealant **34** is an ultraviolet light curable liquid polymer for providing the speed and ease of processing. By way of example, one suitable ultraviolet light curable liquid polymer is a UV acrylate that consists essentially of an aliphatic urethane diacrylate, a difunctional acrylate oligomer, and a photoinitiator. The range of ratios of each ingredient are:

100 parts aliphatic urethane diacrylate;

0-40 parts difunctional acrylate oligomer; and

2-6 parts photoinitiator,

with a preferred ratio being 100 parts aliphatic urethane diacrylate, 10 parts difunctional acrylate oligomer and 3 parts photoinitiator. This ratio of ingredients provides appropriate sealing, viscosity and optical qualities, enabling sealing, cleaning and testing advantages for dust cap assembly **30**.

[0034] Additionally, sealant **34** is preferably a hydrophobic polymer, resisting water absorption that can contaminate sealed polished end faces **27**. Water ingress can leave deposits on polished end face **27**, degrading transmission quality of mated fiber optic connectors. Keeping water and oils away from polished end face **27**

effectively insures that contaminants are also prevented from contacting polished end face **27**.

[0035] **Figs. 8** and **9** illustrate two different methods for making the dust cap assemblies disclosed herein. Generally speaking, the methods of sealing a fiber optic ferrule end face includes the steps of: providing a fiber optic connector assembly having at least one fiber optic ferrule assembly therein that includes at least one fiber optic ferrule and at least one optical fiber therein, wherein the fiber optic ferrule has a polished end face thereon; providing a sleeve having a proximal end and a distal end with a through bore therebetween; placing the sleeve onto the fiber optic ferrule via the through bore, whereby the polished end face is proximal to the distal end of the sleeve; and depositing a sealant onto the sleeve to cover a portion of the polished end face of the fiber optic ferrule and a portion of the distal end of the sleeve for sealing the fiber optic ferrule end face.

[0036] Sleeve **10** is placed onto the ferrule and frictionally engages a medial portion of a ferrule within a fiber optic connector assembly **51**. The sleeve **10** is slid onto the ferrule a suitable distance so that the distal end **16** is proximal to polished end face **27**. Encapsulating feature **18** exposes polished end face **27**, thereby providing a suitable catchment area for the sealant **34** (see **Figs. 3-7**). In other words, the distal end **16** may extend beyond the polished end face or be substantially flush with the polished end face **27**. Additionally, polished end face **27** may extend slightly beyond distal end **16**, but polished end face **27** should be proximal to distal end **16**. Sealant **34** is applied by any suitable application means in sufficient quantity to cover both the polished end face **27** and at least a portion of the distal end **16**. If there is an encapsulating feature **18** associated with the distal end **16**, the sealant **34** should cover the polished end face **27** and the encapsulating feature **18**.

[0037] **Fig. 8** specifically illustrates a method of sealing a fiber optic ferrule end face where a plurality of fiber optic ferrule end faces of respective fiber optic connector assemblies **51** are sealed. As shown, fiber optic connector assemblies **51** having sleeves **10** installed are secured to a common connector holder **52** at regular intervals. Thereafter, dispensing head **60** with a plurality of nozzles matching the regular intervals is brought adjacent to the distal end **16** of the respective sleeves. A controlled amount of sealant **34** within dispensing head **60** is deposited out by mechanical, pneumatic, and/or electrical means onto the resepective distal ends **16**, covering a portion of distal ends **16** and polished end faces **27** of respective fiber optic connector assemblies **51**. Then, connector holder **52** is moved to a curing station as represented by the arrow. In this embodiment, an ultraviolet light curable polymer sealant is used and an ultraviolet light source **54** for curing the same. A suitable dose and exposure time is selected for ultraviolet light **55**, thereby providing the desired cure as shown.

[0038] **Fig. 9** illustrates another explanatory method of sealing a fiber optic ferrule end face where a plurality of fiber optic ferrule end faces of respective fiber optic connector assemblies **51** are sealed. Like the other method, the plurality of fiber optic connector assemblies **51** having respective sleeves **10** are secured to connector holder **52**. The plurality of fiber optic connector assemblies **51** are inverted and the distal ends **16** of sleeves **10** are brought into contact with the surface of sealant **34**, allowing a small quantity of sealant **34** contained within a suitable container to adhere to the distal end **16** and polished end face **27**. The viscose properties of the sealant **34** will promote even coating on the surfaces. Thereafter, connector holder **52** is reverted until the dust cap assembles **30** point vertically upwards and then moved into proximity of an ultraviolet light source, or other curing means as appropriate. Thereafter, the dust cap assemblies **30** are exposed to a suitable amount of ultraviolet light **55** for curing the sealant. Although the methods discussed disclosed making a plurality of dust cap assemblies at once, the concepts are applicable to making individual dust cap assemblies.

[0039] Referring to **Figs. 10A-B** and **11A-B**, one can see the results of sealing polished end face **27** of a ferrule assembly through artistic renderings of actual test samples. **Fig. 10A** shows an artistic rendering of actual clean, newly polished end face **27** and polished fiber face **26**. **Fig. 10B** shows an artistic rendering of actual polished end face **27** of **Fig. 10A** after dust cap assembly **30** was installed and removed. As shown, the polished end faces **27** in both illustrations are clean. In other words, the end face was clean at the time of manufacture and sealing, and retained its clean state when the dust cap assembly was removed.

[0040] **Fig. 11A** shows an artistic rendering of actual polished end face that is contaminated at the time of manufacture such as by dust and the like. Dust cap assembly **30** was installed and **Fig. 11B** shows artistic rendering of the results after dust cap assembly **30** was removed. The same polished end face **27** of **Fig. 11A** is very clean in **Fig. 11B** after removing the dust cap assembly. Simply stated, dust cap assembly **30**, utilizing sealant **34**, is able to remedially clean polished end faces **27**. This is advantageous due to the environmental conditions within a processing facility; dust, pollen, particulate matter, moisture, oils, lint, etc., are usually floating in the air and can stick to polished end face **27**. Dust cap assembly **30** protects polished end face **27** while residing on the ferrule, and further, upon removal, cleans any incidental contaminants present on polished end face **27** at the time of the installation of dust cap assembly **30**.

[0041] Additionally, the dust cap assembly **30** can provide other optional functionality. For instance, sealant **34** such as disclosed herein can have advantageous post-cure optical properties. The pre-cure viscosity range allows the sealant to create a convex shape **38** about the sealed polished end face **27**. By way of example, the convex shape **38** may have a tangential contact angle of greater than about 5 degrees and less than about 90 degrees, preferably about 10 degrees. Additionally, the formulation of the sealant may provide a post-cure index of refraction (RI) within the range of between about 1.45 to about 1.48 at 23 degrees Celsius and at a wavelength of 589 nm, most preferably between about 1.460 and about 1.466 at 23 degrees Celsius. At 1310 nm wavelength RI of the cured sealant at 23 degrees Celsius should be about 1.45. This range of RI closely matches most commercial optical fiber and allows the optical signal to travel into the sealant. This RI range also helps the dust cap assembly to withstand very high power levels, as high as 23dBm for testing as discussed below.

[0042] Simply stated, the convex shape **38** of the sealant coupled with the preferred RI of the cured sealant **34**, allows light to enter the dust cap assembly with great efficiency since there is no gap between the sealant **34** and polished end face **27** and then escape from the sealant. Illustratively, **Fig. 12** shows a jumper cable assembly **85** with dust cap assemblies **30** installed on both ends. An external light source **80** is proximal to a first dust cap assembly **30** and a photoreceptor **81** is proximal to a second dust cap assembly **30**. Emitted light **57** from the external light source **80** (represented by the arrows) enters the first dust cap assembly **30** and travels along the jumper cable assembly **85** and then exits the second dust cap assembly **30** where it is detected by photoreceptor **81**. This enables a continuity test for jumper cable assembly **85**. Photoreceptor **81** is useful to determine the amount of actual light transmitted, regardless of wavelength. If external light source **80** is a visible light source the photoreceptor **81** may be simply the human eye (not shown). The continuity test advantageously does not require removal of dust cap assemblies **30**, thereby maintaining a pristine end face until the dust cap assemblies are removed for installation of the jumper cable assembly **85**.

[0043] Other improvements in testing are possible with assemblies using the dust cap assemblies disclosed herein. **Fig. 13** and **14** use the geometric and optical qualities of dust cap assembly **30** for improving a reflectance test. The reflectance test is useful since it can reveal a lot of useful information to the craft such as the integrity of a cable assembly. An unterminated distal connector (e.g., not connected to another connector, other device, or other means to inhibit backreflection) without the dust cap assembly disclosed herein can be a source of a large backreflection spike. This large spike in reflected signal is detrimental to the quality of light emitting devices such as VCSELs that rely on amplified internal reflections to boost their signal. Backreflected light entering such a light emitting device can cause noise or utterly disrupt the signal.

[0044] In the past discrete terminators needed to be installed as conventional dust caps did not have the inherent utility of a terminator. Placing an index matching gel, or index matching block was one way to terminate a cable assembly. Mandrel wrapping the cable multiple times to a radius beyond the minimum bend radius of the particular optical fiber was another, causing the light signal to reflect out of the cladding wall instead of being reflected from the end. However, this mandrel wrapping method is not effective with new bend-insensitive optical fibers that direct light along their specialized core almost regardless of bend radius. Thus, another type of terminator is necessary in such cases. Dust cap assembly **30** optionally provides a ready made terminator along with the functionality of sealing, protecting and cleaning the polished end face **27**.

[0045] Terminating the distal fiber optic connector assembly **71** eliminates the spike in backreflection, causing the light from the light source or test apparatus **83** to pass out of the dust cap assembly **30** as shown in **Fig. 13**. Specifically, the convex shape **38** of the sealant prevents most light from reflecting back into the optical fiber, and by consequence, back to the light source or test apparatus **83**. **Fig. 13** shows a first fiber optic connector assembly **70** of jumper cable assembly **85** optically connected to test apparatus **83**. A second fiber optic connector assembly **71** is not optically connected to any device, but has dust cap assembly **30** installed. Test apparatus **83**, such as an OTDR or the like, sends a pulse of light into jumper cable assembly and takes minute amounts of backreflection and determines the integrity of the fiber optic cable assembly. The dust cap assembly **30** serves as a terminator to prevent the large spike in backreflection commonly associated with light passing from a polished fiber face into air. The amount of backreflection allowed by the dust cap assembly **30** is not more than -50dB, and in most cases as little as -60dB. **Fig. 14** shows a cable assembly having a fiber optic trunk cable **90** and a cable access point **91** with a fiber optic tether cable **86** issuing from the cable access point **91**. The distal end of the fiber optic tether cable **86** has fiber optic connector assembly **71**, with dust cap assembly **30** installed. Light from a remote upstream source such as a central office (not shown) or the like can be sent from the fiber optic trunk cable **90**, into the fiber optic tether cable **86** and to the fiber optic connector assembly **71**, to pass out of the dust cap assembly **30**, again greatly reducing the backreflection spike commonly found at the polished fiber face/air interface.

[0046] The foregoing is a description of various embodiments of the disclosure that are given here by way of example only. Although a dust cap assembly for sealing a fiber optic ferrule according to the disclosure has been described with reference to preferred embodiments and examples thereof, other embodiments and examples may perform similar functions and/or achieve similar results. All such equivalent embodiments and examples are within the spirit and scope of the present invention and are intended to be covered by the appended claims.

We claim:

1. A dust cap assembly for sealing a fiber optic connector assembly comprising:

at least one fiber optic ferrule assembly including a fiber optic ferrule having at least one optical fiber therein, wherein the fiber optic ferrule assembly has a polished end face;

a sleeve, having a proximal end and a distal end with a through bore therebetween, the sleeve being disposed on the at least one fiber optic ferrule; and

a sealant at least partially disposed on the sleeve for sealing a portion of the polished end face of the fiber optic ferrule.

2. The assembly of claim 1, wherein the sleeve frictionally engages a portion of the fiber optic ferrule.

3. A dust cap assembly for sealing a multi-fiber fiber optic connector assembly comprising:

at least one multi-fiber fiber optic ferrule assembly including the at least one multi-fiber optic ferrule having a plurality of optical fibers therein, wherein the multi-fiber fiber optic ferrule assembly has a polished end face with a plurality of polished fiber faces thereon;

a sleeve having a proximal end and a distal end with a through bore therebetween, the sleeve being disposed on the at least one multi-fiber fiber optic ferrule; and

a sealant at least partially disposed on the sleeve for sealing a portion of the multi-fiber fiber optic ferrule end face and the polished optical fiber end faces.

4. The assembly of claim 3, wherein the sleeve frictionally engages a portion of the multi-fiber fiber optic ferrule.

5. The assembly of claims 1-4, wherein the sealant is a curable liquid polymer selected from the group consisting of a heat curable liquid polymer, an ultraviolet light curable liquid polymer and a chemically reactive liquid polymer.

6. The assembly of claim 5, wherein the curable liquid polymer has a pre-cure viscosity range of about 1000 poise or less at 23 degrees Celsius.

7. The assembly of claim 5, wherein the curable liquid polymer has a pre-cure viscosity range of about 250 poise to about 850 poise at 23 degrees Celsius.

8. The assembly of claims 6 or 7, wherein the curable liquid polymer has a post-cure index of refraction between about 1.45 to about 1.48 at 23 degrees Celsius.

9. The assembly of claims 6 or 7, wherein the curable liquid polymer has a post-cure index of refraction between about 1.460 to about 1.466 at 23 degrees Celsius.

10. The assembly of claims 1-9, wherein the sealant is a hydrophobic polymer.

11. The assembly of claims 1-10, wherein the sealant is an ultraviolet light curable hydrophobic polymer consisting essentially of an aliphatic urethane diacrylate, a difunctional acrylate oligomer, and a photoinitiator.

12. The assembly of claims 1-11, the sleeve having a distal end and a proximal end with a through bore therebetween, wherein the through bore is in communication with at least one encapsulating feature on at least the distal end.

13. The assembly of claim 12, wherein the encapsulating feature consists of a chamfer, a lip, a step and a radius.

14. The assembly of claims 1-13, wherein at least a portion of the sealant generally forms a convex shape.

15. The assembly of claim 14, wherein the convex shape has a tangential contact angle of greater than about 5 degrees but less than about 90 degrees.

16. The assembly of claims 1-15, the dust cap assembly providing remedial cleaning of the polished end face upon removal of the dust cap assembly.

17. The assembly of claims 1-16, wherein the sleeve is comprised of a thermoplastic.

18. The assembly of claim 17, the thermoplastic being selected from the group consisting of a polycarbonate, a polyolefin, a polyamide and a polyacrylate.

19. A method of sealing a fiber optic ferrule end face, comprising the steps of:

providing a fiber optic connector assembly having at least one fiber optic ferrule assembly therein, the at least one fiber optic ferrule assembly having at least one fiber optic ferrule and at least one optical fiber therein, wherein the fiber optic ferrule has a polished end face thereon;

providing a sleeve, the sleeve having a proximal end and a distal end with a through bore therebetween;

placing the sleeve onto the fiber optic ferrule via the through bore, whereby the polished end face is proximal to the distal end;

depositing a sealant onto the sleeve to cover a portion of the polished end face of the fiber optic ferrule and a portion of the distal end of the sleeve for sealing the fiber optic ferrule end face.

20. The method of claim 19, wherein the at least one fiber optic ferrule is a multi-fiber fiber optic ferrule.

21. The method of claim 19, the step of depositing a sealant forming a convex shape.

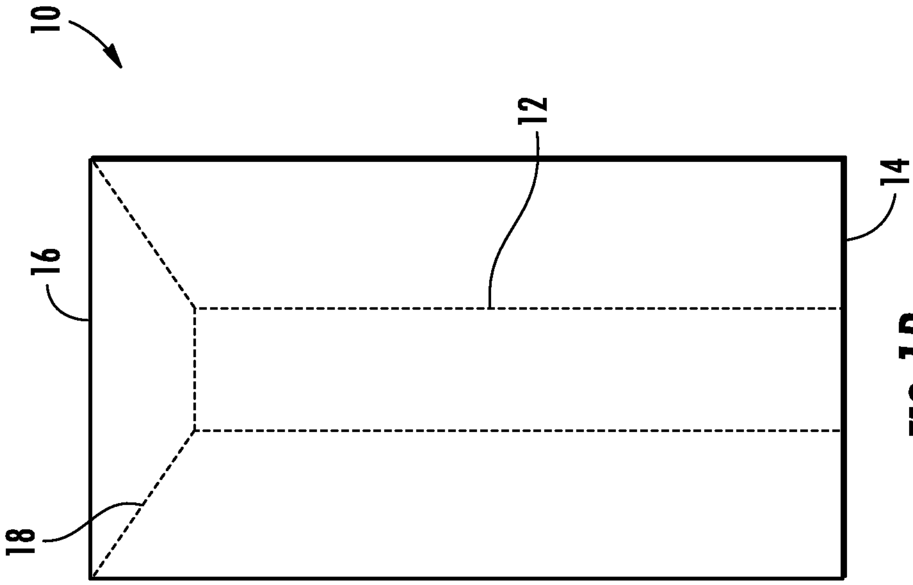

FIG. 1B

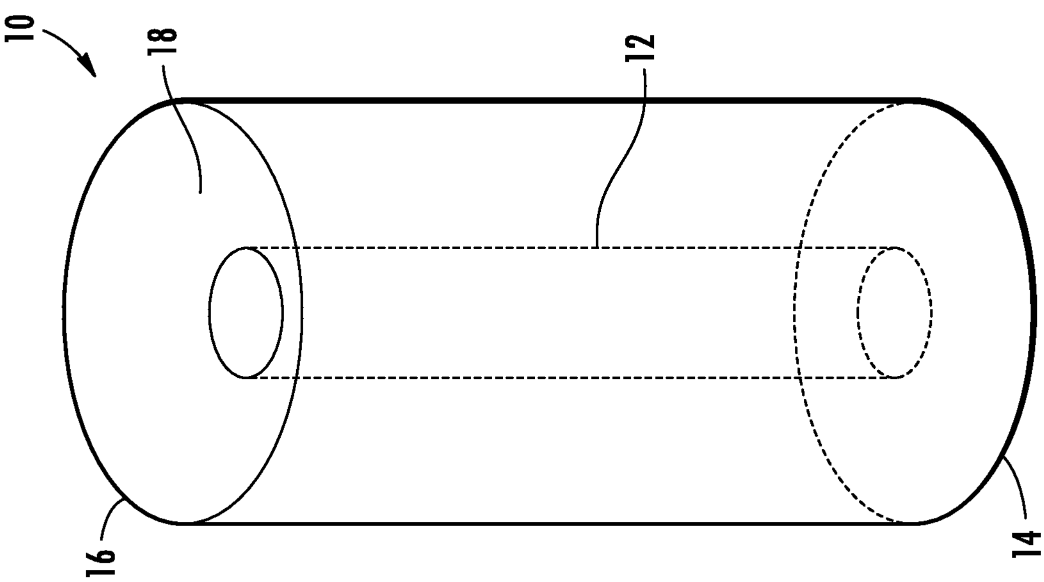

FIG. 1A

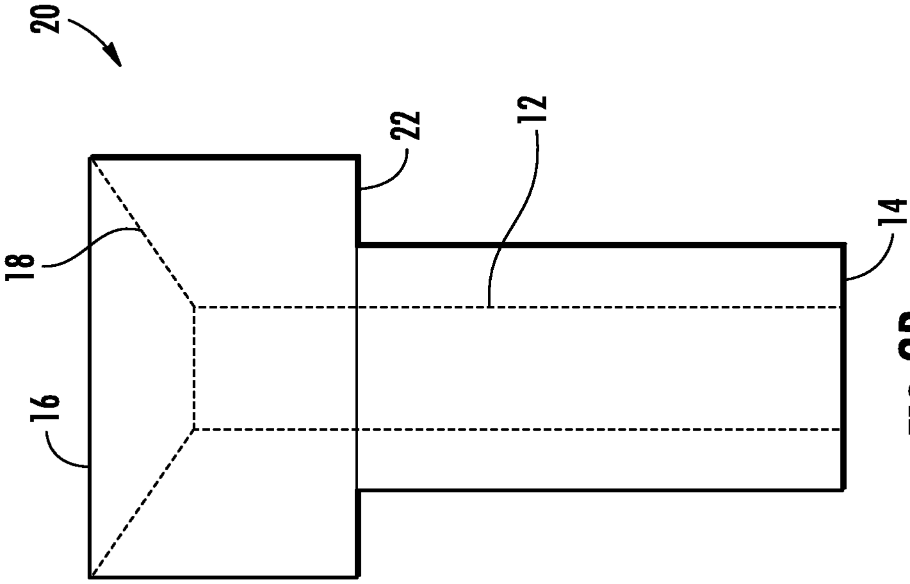

FIG. 2B

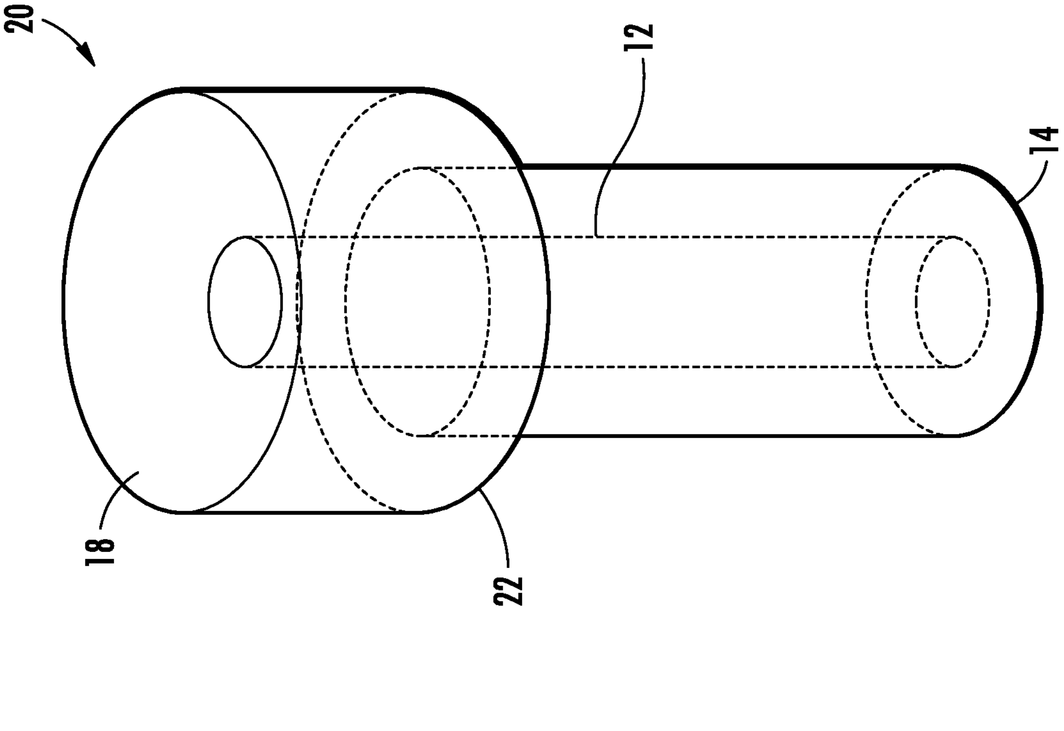

FIG. 2A

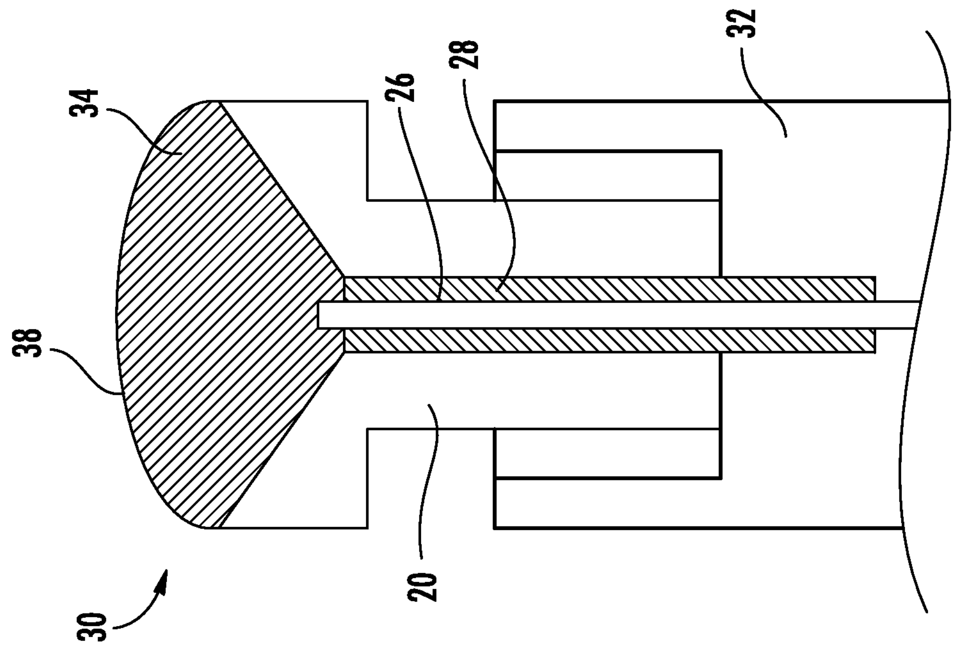

FIG. 3B

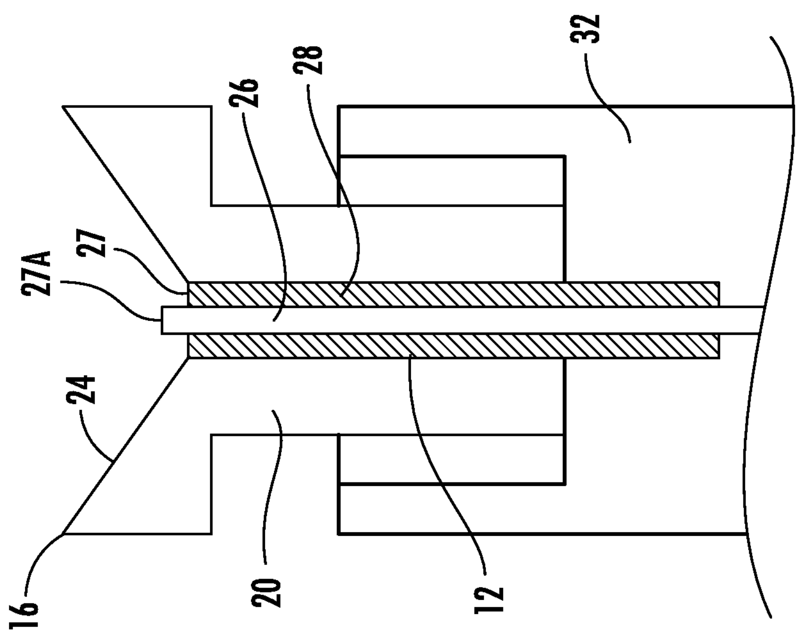

FIG. 3A

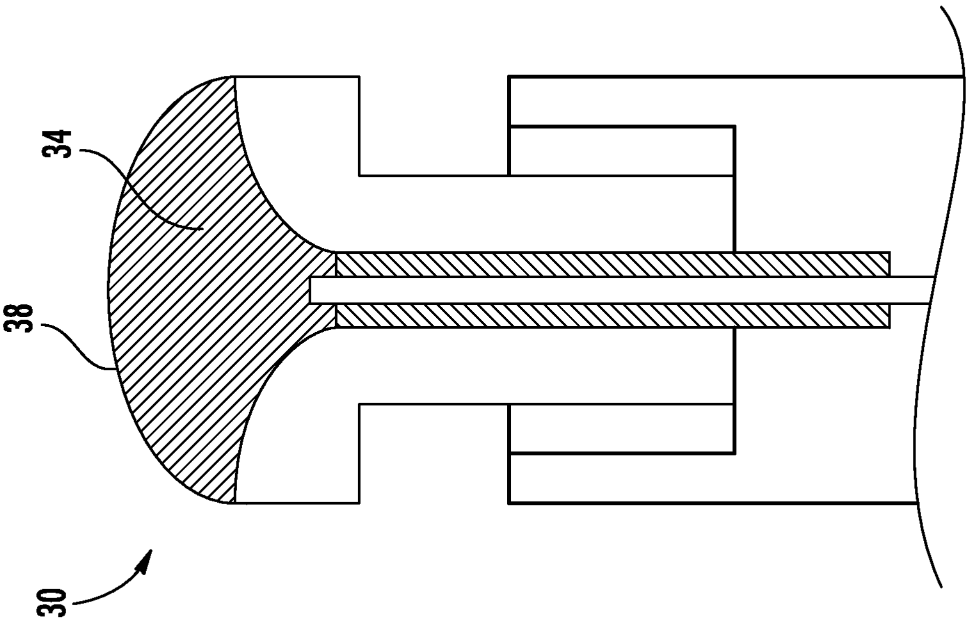

FIG. 4B

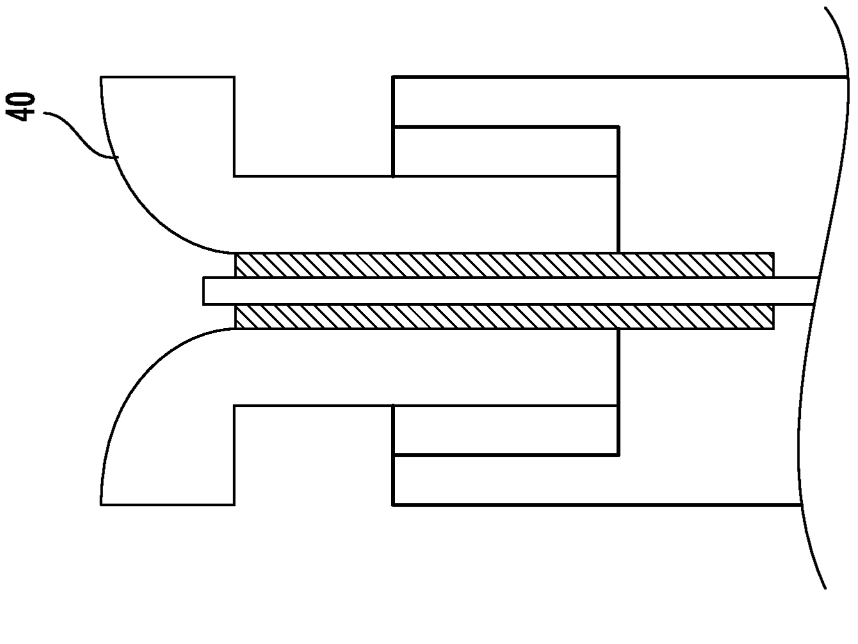

FIG. 4A

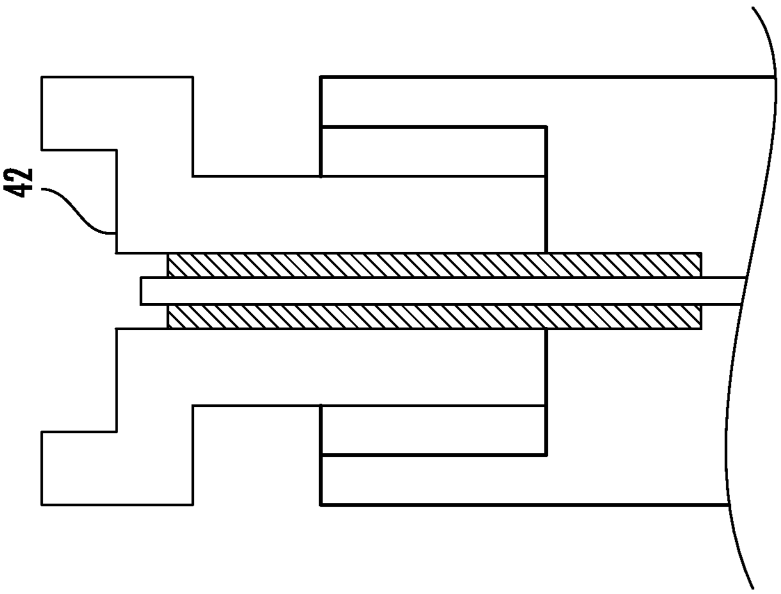

FIG. 5A

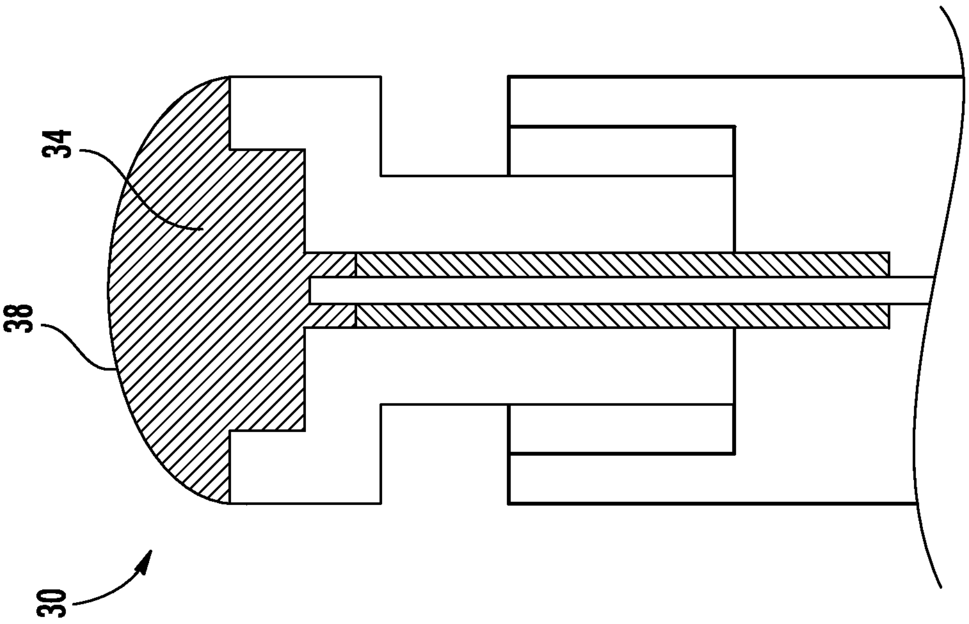

FIG. 5B

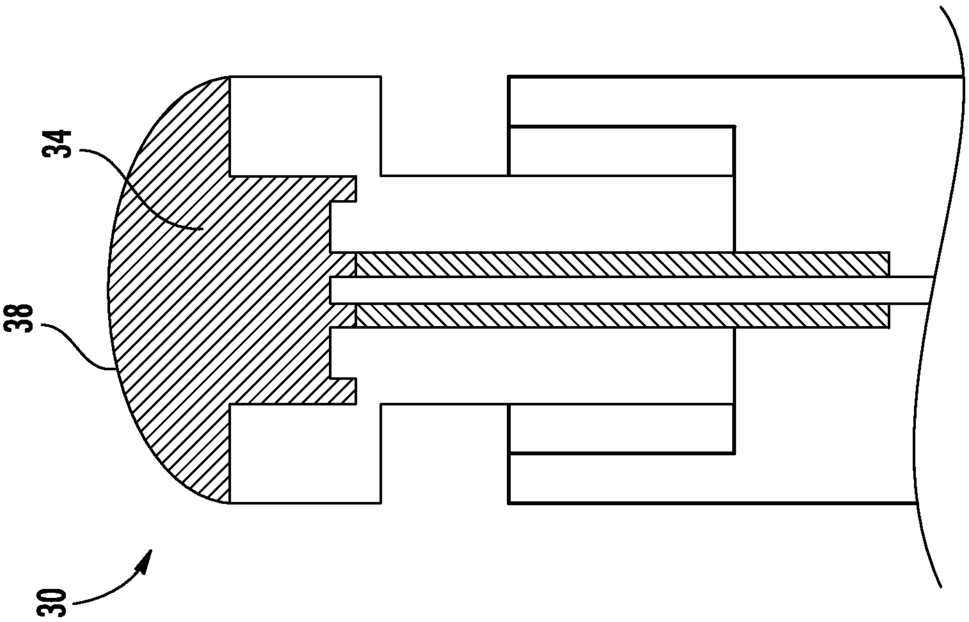

FIG. 6B

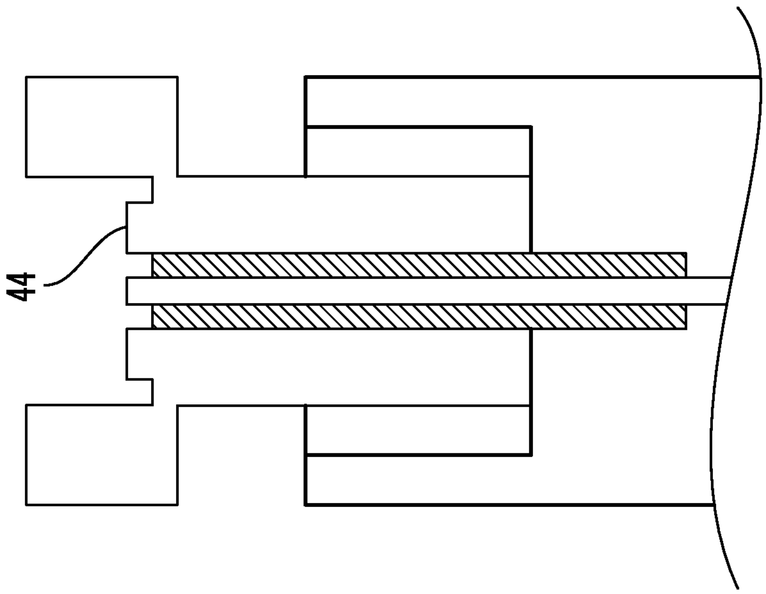

FIG. 6A

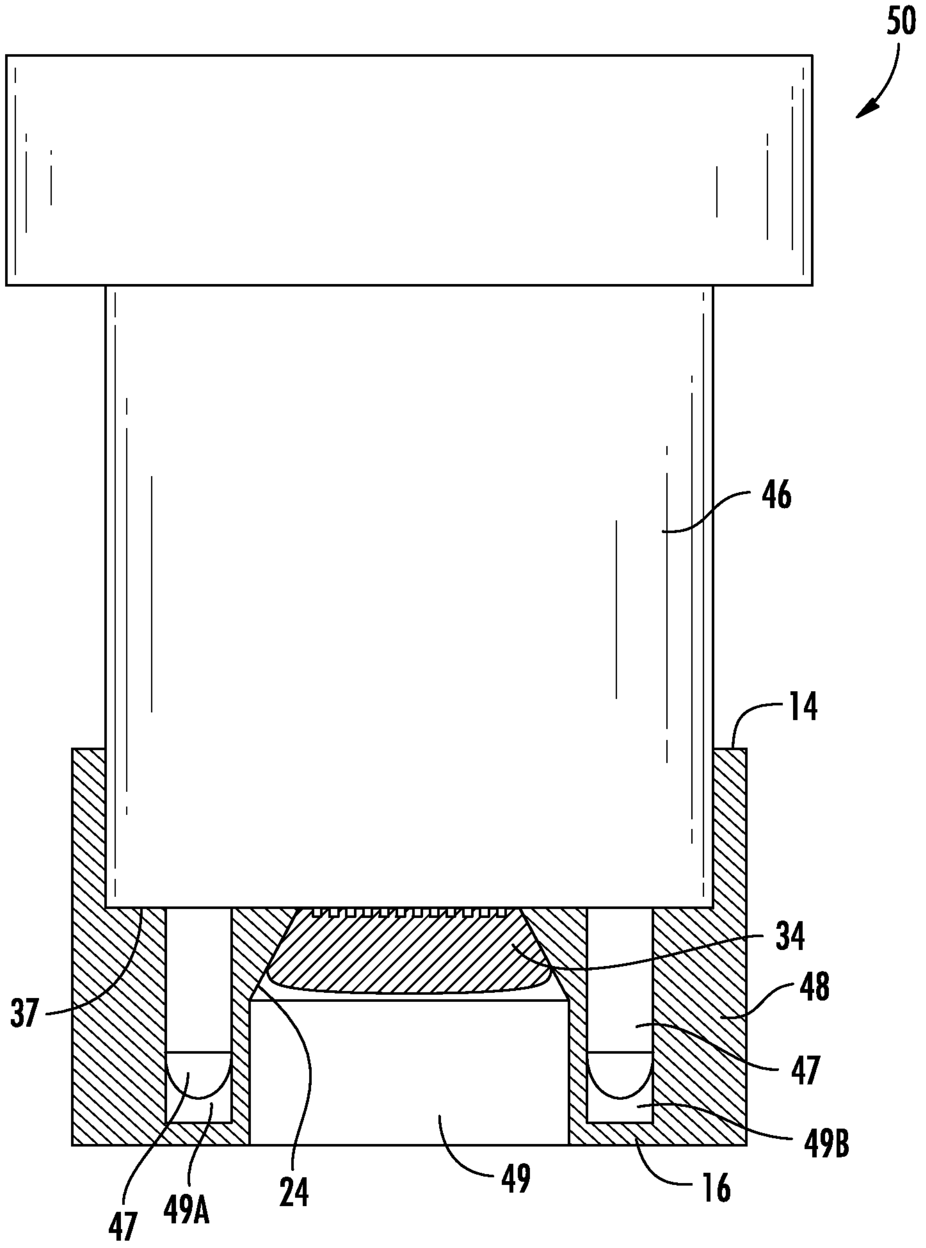

FIG. 7

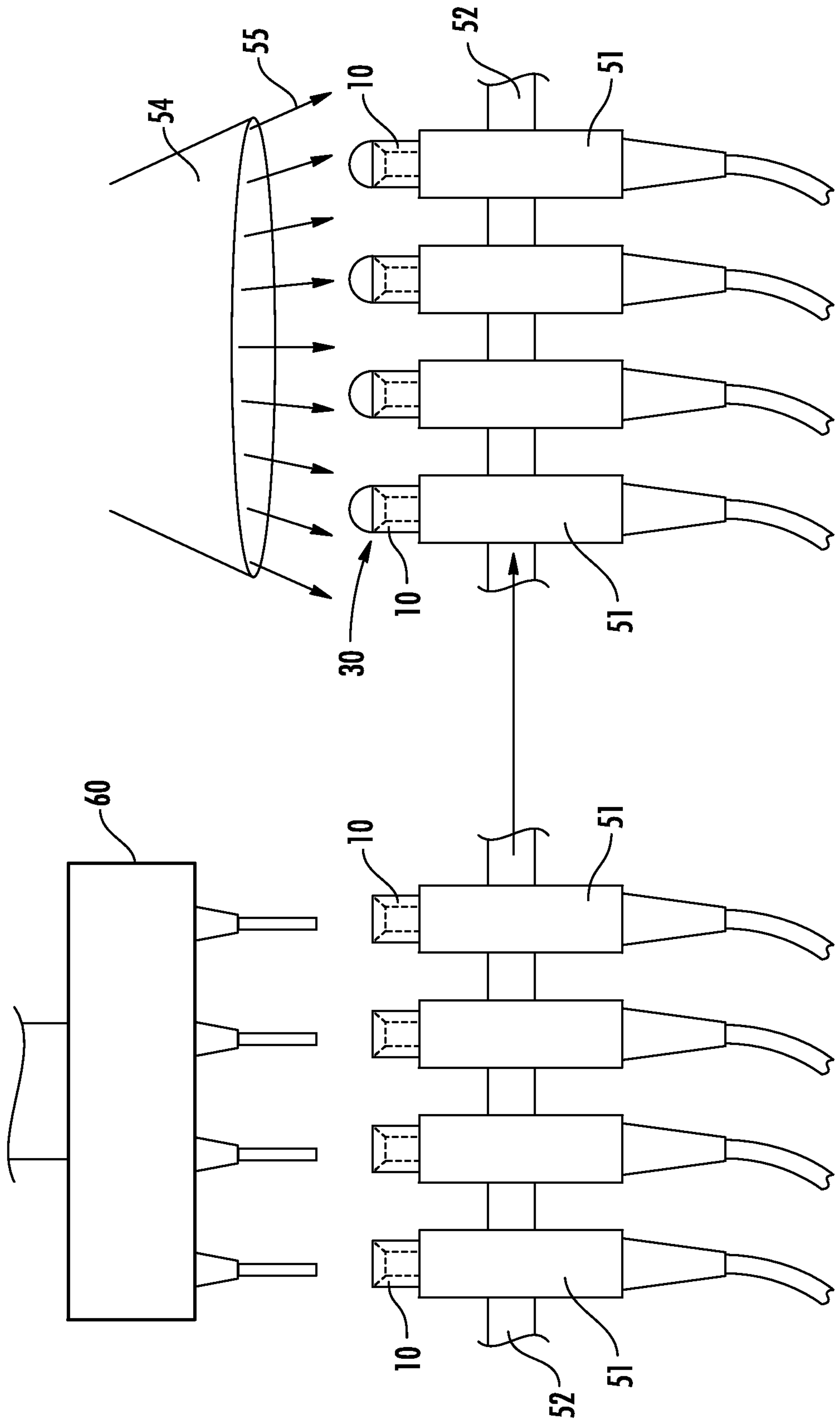

FIG. 8

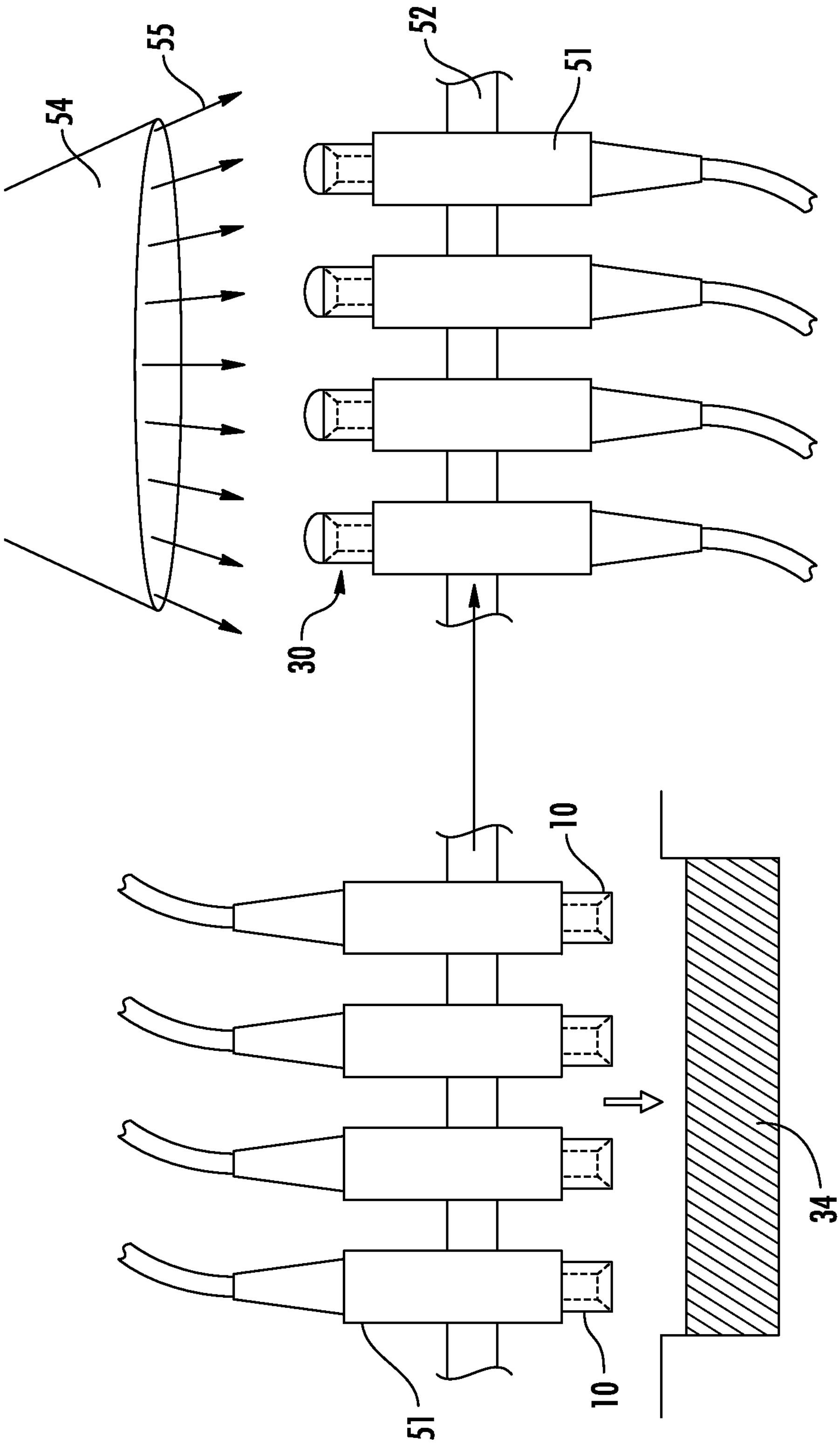

FIG. 9

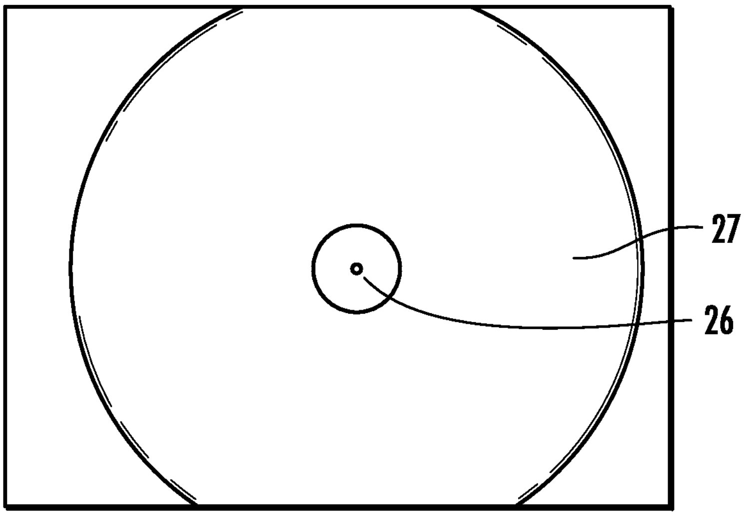

FIG. 10A

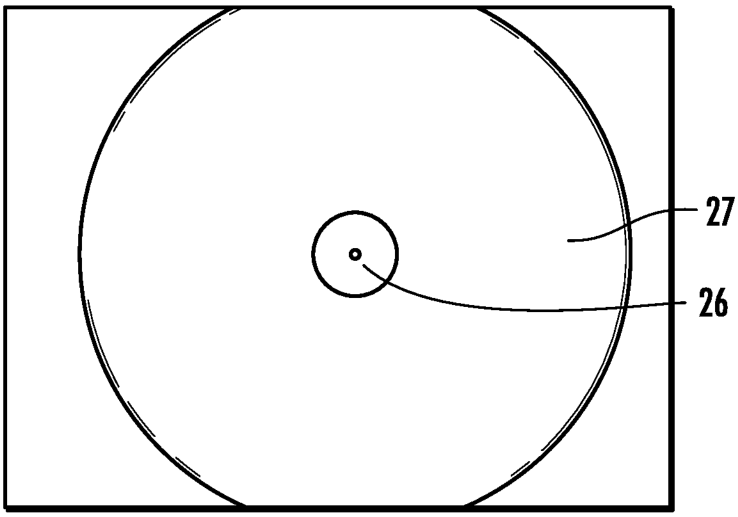

FIG. 10B

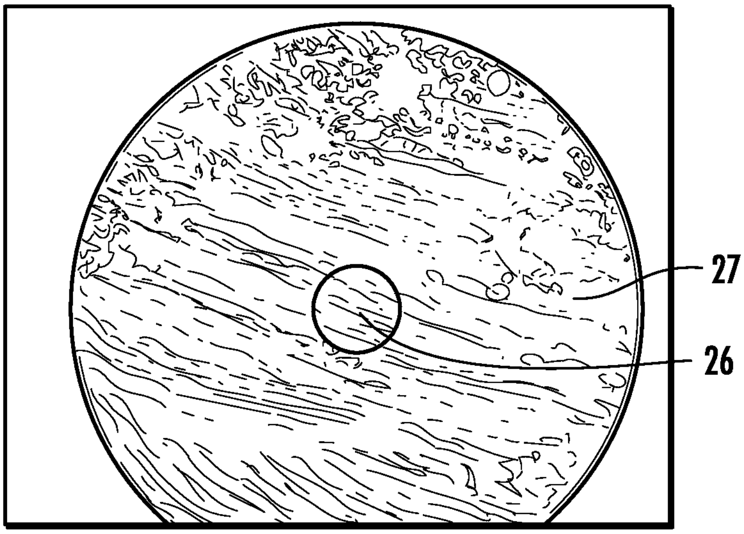

FIG. 11A

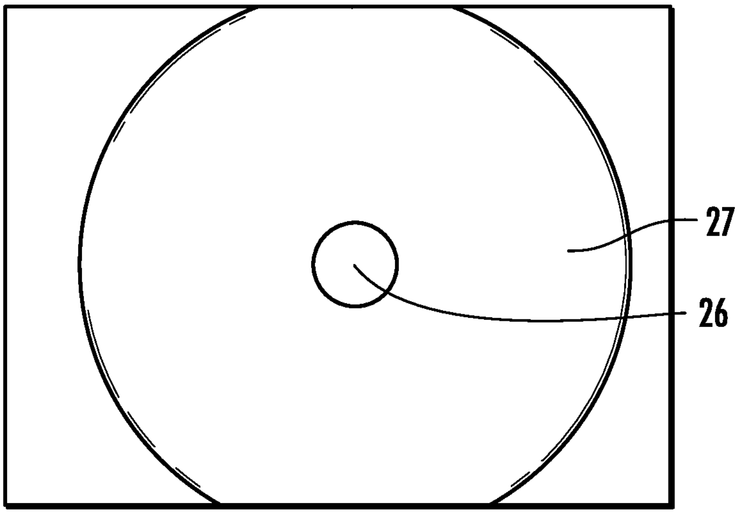

FIG. 11B

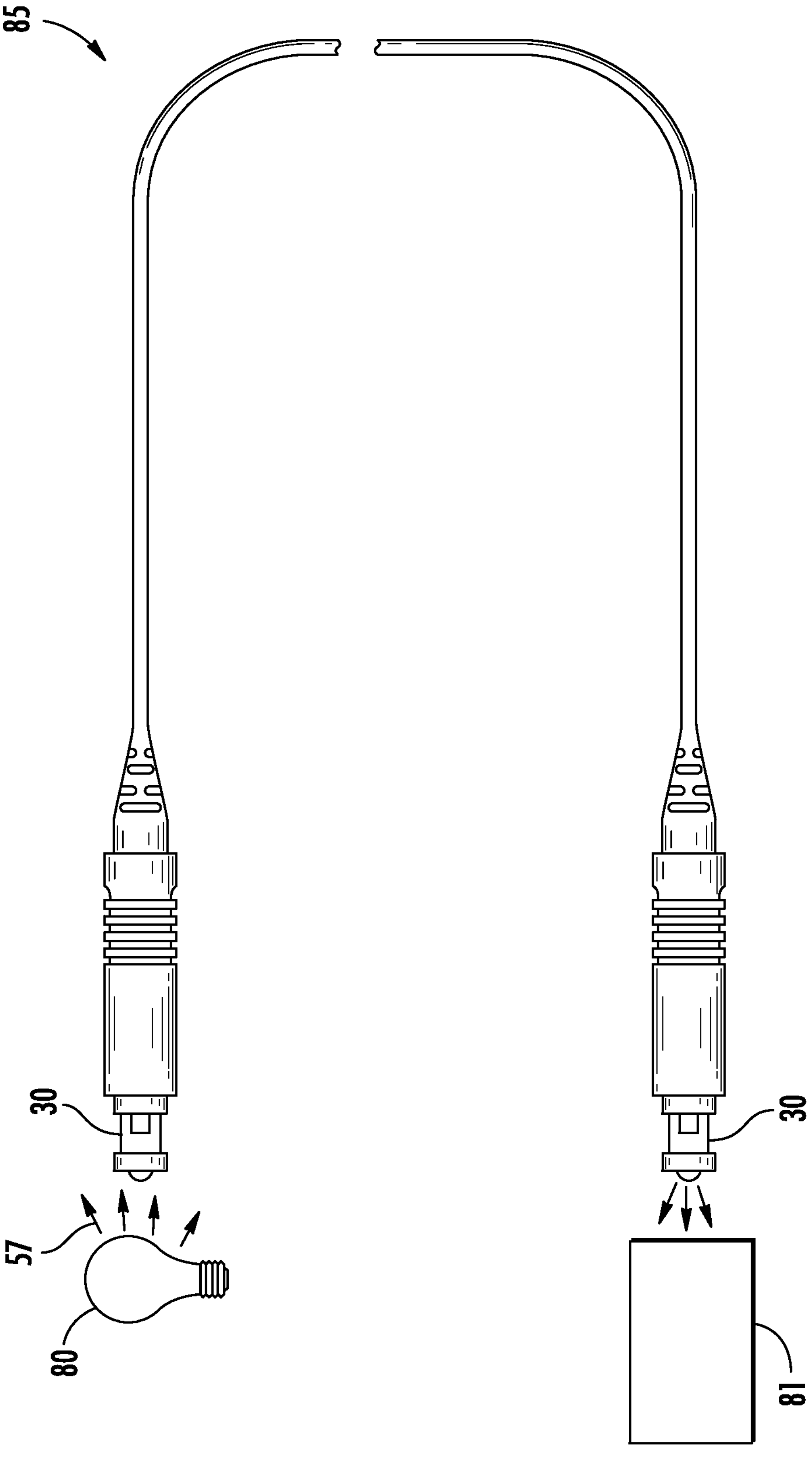

FIG. 12

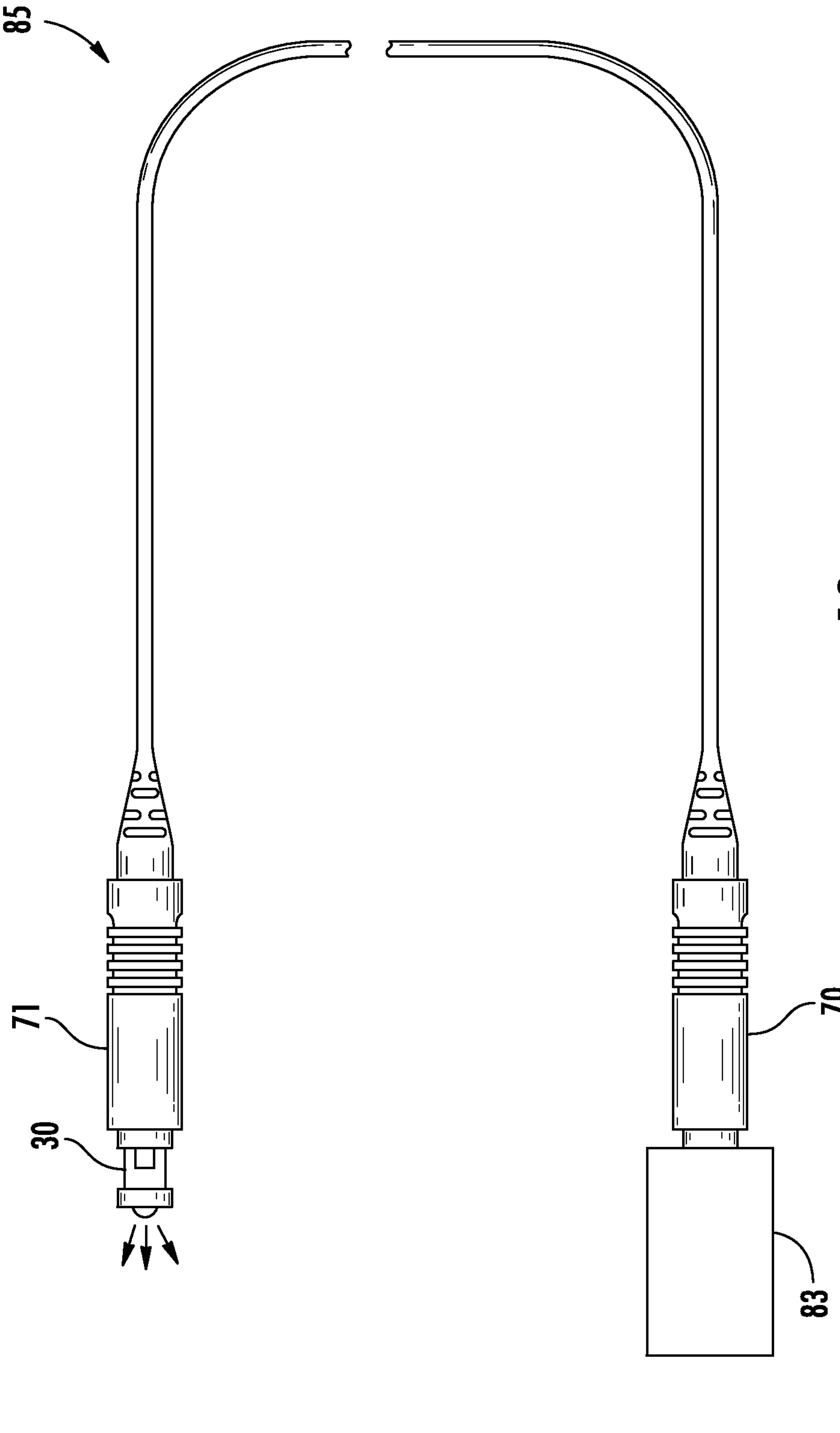

FIG. 13

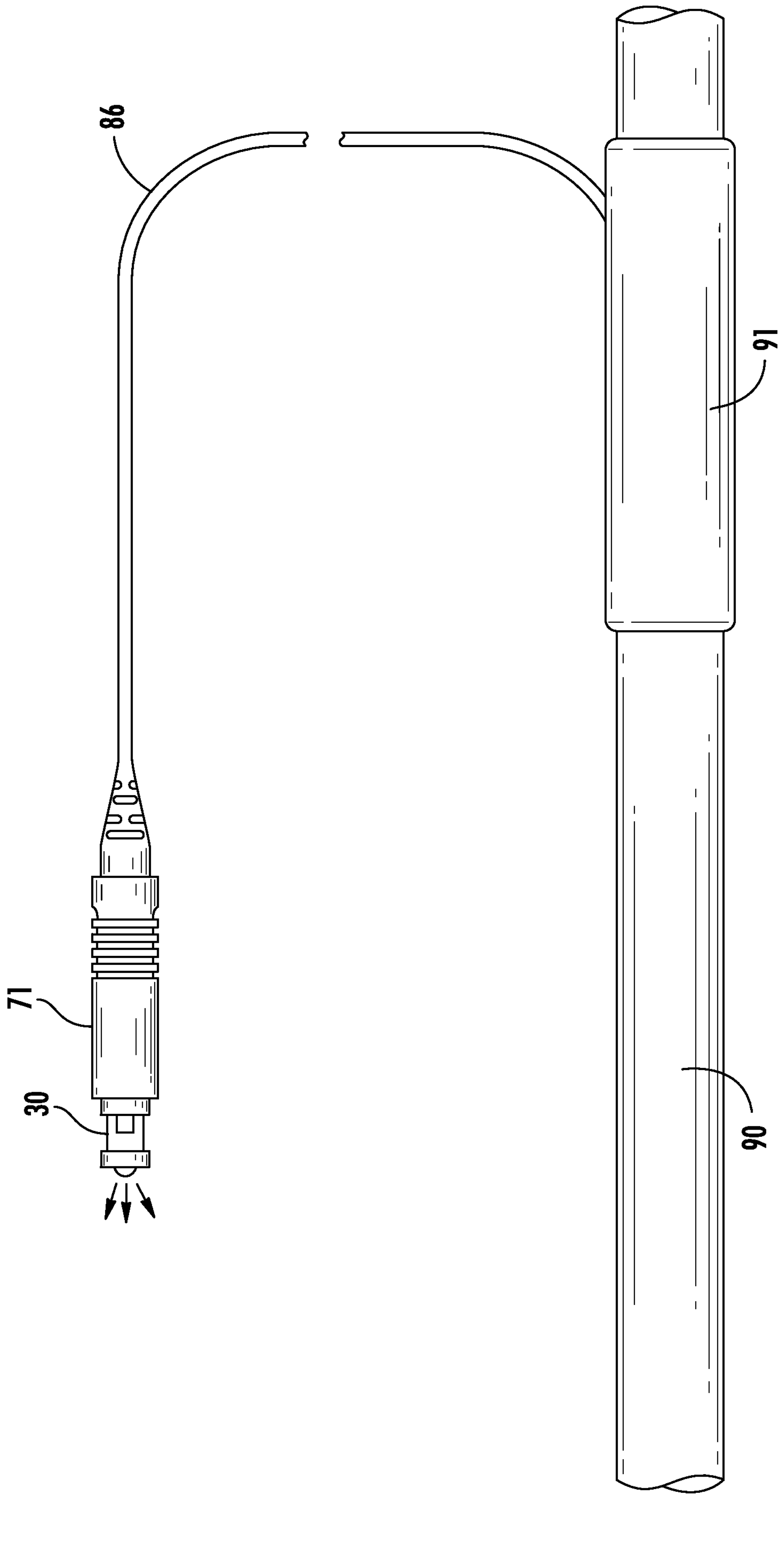

FIG. 14

INTERNATIONAL SEARCH REPORT	International application No. PCT/US 10/36376

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - G02B 6/00 (2010.01)
USPC - 385/134
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8): G02B 6/00 (2010.01)
USPC: 385/134

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
IPC(8): G02B 6/00 (2010.01) (keyword limited; terms below)
USPC: 385/70, 72, 134, 138, 139, 147 (keyword limited; terms below)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Electronic Databases Searched: USPTO, DialogClassic, Google Scholar, Google Patents, EPO
Search Terms Used: dust, cap, assembly, seal, optical, fiber, multiple, ferrule, sleeve, friction, polish, end, face, proximal, distal, liquid, polymer, ultraviolet, light

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2008/0310795 A1 (PARKMAN, III et al.) 18 December 2008 (18.12.2008), Figs. 3, 5; para [0025-0026], [0028], [0030]	1-7, 19-21
Y	US 2008/0304804 A1 (ZIMMEL et al.) 11 December 2008 (11.12.2008), Figs. 20, 33-36; para [0051-0052], [0057], [0066-0067], [0069]	1-7, 19-21
A	US 2007/0172172 A1 (THEUERKORN et al.) 26 July 2007 (16.07.2007)	1-7, 19-21
A	US 2007/0160327 A1 (LEWALLEN et al.) 12 July 2007 (12.07.2007)	1-7, 19-21
A	US 2005/0241089 A1 (BRUNNER et al.) 03 November 2005 (03.11.2005)	1-7, 19-21

☐ Further documents are listed in the continuation of Box C. ☐

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

Date of the actual completion of the international search	Date of mailing of the international search report
19 July 2010 (19.07.2010)	04 AUG 2010
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Authorized officer: Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 10/36376

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

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

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

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

3. ☒ Claims Nos.: 8-18
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

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

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

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

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

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

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

Remark on Protest

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

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

☐ No protest accompanied the payment of additional search fees.