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(54) **Title**: MULTI-PORT OPTICAL CONNECTION TERMINAL ASSEMBLIES SUPPORTING OPTICAL SIGNAL SPLITTING, AND RELATED TERMINALS AND METHODS

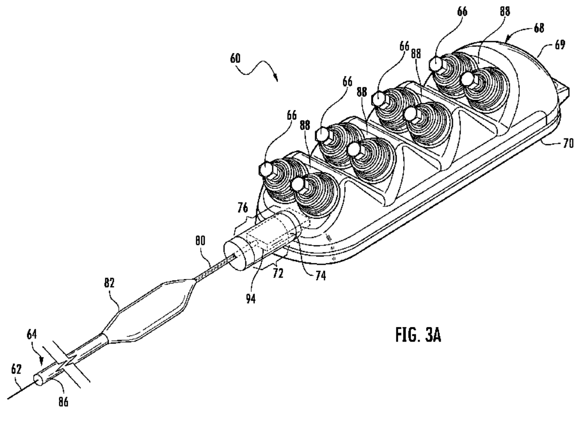

FIG. 3A

(57) **Abstract**: Multi-port optical connection terminal assemblies, related terminals and methods are disclosed herein. In one embodiment, a multi-port optical connection terminal assembly may include an enclosure (68) including an internal cavity, an input orifice (89), and optical connection nodes (66). The multi-port optical connection terminal assembly may also include an optical splitter (92) comprising a body (94), an input optical fiber (96), and output optical fibers (98). At least a portion of the body of the optical splitter may be disposed outside the internal cavity of the enclosure. The input optical fiber of the optical splitter may be disposed outside the internal cavity of the enclosure, and the plurality of the output optical fibers of the optical splitter may be disposed inside the internal cavity. In this manner, the enclosure of the multi-port optical connection terminal assembly is not required to be sized to completely contain the optical splitter.

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MULTI-PORT OPTICAL CONNECTION TERMINAL ASSEMBLIES SUPPORTING OPTICAL SIGNAL SPLITTING, AND RELATED TERMINALS AND METHODS

RELATED APPLICATIONS

[0001] This application claims the benefit of priority under 35 U.S.C. § 119 of U.S. Provisional Application Serial No. 61/503,173 filed on June 30, 2011, the content of which is relied upon and incorporated herein by reference in its entirety.

BACKGROUND

Field of the Disclosure

[0002] The technology of the disclosure relates to multi-port optical connection terminals and assemblies which may be used to distribute optical signals from optical fibers.

Technical Background

[0003] Benefits of optical fiber use include extremely wide bandwidth and low noise operation. Because of these advantages, optical fiber is increasingly being used for a variety of applications, including but not limited to broadband voice, video, and data transmission. As a result, fiber optic communications networks include a number of interconnection points at which multiple optical fibers are interconnected. Fiber optic communications networks also include a number of connection terminals, examples of which include, but are not limited to, network access point (NAP) enclosures, aerial closures, below grade closures, pedestals, optical network terminals (ONTs), and network interface devices (NIDs). In certain instances, the connection terminals include connector ports or nodes, typically opening through an external wall of the connection terminal. The connection terminals are used to establish optical connections between optical fibers terminated from the distribution cable and respective optical fibers of one or more "preconnectorized" drop cables, extended distribution cables, tether cables or branch cables, collectively referred to herein as "drop cables," unless specified otherwise. The connection terminals are used to readily extend fiber optic communications services to a subscriber. In this regard, fiber optic networks are being developed that deliver “fiber-to-the-curb” (FTTC), “fiber-to-the-business” (FTTB), “fiber-to-the-home” (FTTH) and “fiber-to-the-premises” (FTTP), referred to generically as “FTTx.”

[0004] In conventional FTTx deployments depicted in **FIG. 1**, a fiber optic network **10** is provided. The fiber optic network **10** typically delivers service to subscribers **12** through optical fiber distribution cables **14** and subscriber cables **16**. For example, the fiber optic network **10** may begin at a trunk cable **18** originating from a central office **20** leading to a splitter/splice cabinet **22** in the field where a distribution cable **14** is connected. The distribution cable **14** may then be routed aerially or below ground through the residential neighborhood served by the fiber optic network **10**. The subscriber cables **16** servicing individual subscribers **12** may be connected with the distribution cable **14** through terminations at mid-span access points **24**, branch cables **26**, connector ports **28** of multi-port splitter boxes **30**, and cables **32**.

[0005] **FIGS. 2A** to **2B** depict a conventional multi-port splitter box **30** including a base **34**, cover **36**, and eight (8) connector ports **28**. An optical management shelf **38** is installed into the multi-port splitter box **30** that includes an optical splitter **40** and a splice protector **42** attached to its top surface **44**. An optical fiber **46** of a cable **32** enters an entry orifice **48** of the multi-port splitter box **30** and wraps around containment surfaces **50** around an orifice **52** in the top surface **44** of the optical management shelf **38**. The optical fiber **46** may be spliced to an input optical fiber **54** in the splice protector **42**. The input optical fiber **54** is attached to the optical splitter **40** which may have output optical fibers **56**. The output optical fibers **56** include connectors **58** attached to their distal ends which may be subsequently attached to the connector ports **28** of the multi-port splitter box **30**.

[0006] In general, the performance of input optical fiber **54**, the output optical fibers **56**, and the optical splitter **40** can be affected by mechanical and environmental issues surrounding the output splitter box **30**. Mechanical issues may include small-radius bends and cyclical and episodic movements of the optical fibers. For example, standard single-mode fiber may experience high optical attenuation at small-radius bends. Environmental issues may be water when the output splitter box **30** is installed underground. Thus, the conventional approach has been to locate the input optical fiber **54**, output optical fibers **56**, and the optical splitter **40** inside of the output splitter box **30**.

This conventional approach has resulted in the multi-port splitter box **30** becoming too large in many cases for installation in the field. Ideally, the multi-port splitter box **30** should be sufficiently small in size to be able to pass through ducts and small passageways underground during installation to service subscribers **12**, as an example.

SUMMARY OF THE DETAILED DESCRIPTION

[0007] Embodiments disclosed in the detailed description include multi-port optical connection terminal assemblies, related terminals and methods. In one embodiment, a multi-port optical connection terminal assembly is disclosed. This multi-port optical connection terminal assembly may include an enclosure including an internal cavity, an input orifice, and a plurality of optical connection nodes. The multi-port optical connection terminal assembly may also include an optical splitter comprising a body, an input optical fiber, and plurality of output optical fibers. At least a portion of the body of the optical splitter may be disposed outside the internal cavity of the enclosure. The input optical fiber of the optical splitter may be disposed outside the internal cavity of the enclosure, and the plurality of the output optical fibers of the optical splitter may be disposed inside the internal cavity. In this manner, the enclosure of the multi-port optical connection terminal assembly is not required to be sized to completely contain the optical splitter. In this regard as a non-limiting example, the enclosure of the multi-port optical connection terminal may be provided of a smaller size enabling easier installation through narrow passageways and ducts because of the smaller enclosure size.

[0008] In another embodiment, a multi-port optical connection terminal assembly is provided. The multi-port optical connection terminal assembly may comprise an enclosure, an optical splitter, and a splice point. The enclosure may comprise an internal cavity, an input orifice, and a plurality of optical connection nodes. The optical splitter may comprise a body, an input optical fiber extending from the body, and plurality of output optical fibers extending from the body. The splice point may be located on the input optical fiber and configured to contact an optical fiber of a cable. A portion of the body of the optical splitter may be disposed between the splice point and the enclosure. The plurality of the output optical fibers may be disposed inside the internal cavity, and the input optical fiber may be located outside the internal cavity. In this manner, the multi-port optical connection terminal assembly may, for example, have a smaller size enabling it to be installed through narrow passageways and ducts because of the smaller enclosure.

[0009] In another embodiment, a method of assembling a multi-port optical connection terminal assembly is disclosed. This method may be comprised of providing an optical splitter comprising a body, an input optical fiber, and a plurality of output optical fibers. This method may also comprise providing an enclosure comprising an internal cavity, an input orifice, and a plurality of optical connection nodes. In a later step of the method, a furcation structure may be created. Next, the method may also comprise a step to attach the furcation structure to the enclosure. Finally, the enclosure may be sealed with a cover of the enclosure. At least a portion of the body of the optical splitter may be disposed outside the internal cavity of the enclosure. The input optical fiber may be disposed outside the internal cavity of the enclosure, and the plurality of output optical fibers may be disposed inside the internal cavity. In this manner, the method of assembling the multi-port optical connection terminal assembly may, for example, be less expensive to manufacture because of the smaller enclosure.

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

[0011] It is to be understood that both the foregoing general description and the following detailed description present embodiments, and are intended to provide an overview or framework for understanding the nature and character of the disclosure. The accompanying drawings are included to provide a further understanding, and are incorporated into and constitute a part of this specification. The drawings illustrate various embodiments, and together with the description serve to explain the principles and operation of the concepts disclosed.

BRIEF DESCRIPTION OF THE FIGURES

[0012] **FIG. 1** is a schematic diagram of subscribers of a fiber optic network connected to a distribution cable with multi-port splitter assemblies and cables in the prior art;

[0013] **FIG. 2A** is a perspective view illustrating a multi-port splitter assembly in the prior art, with an optical management shelf removed;

[0014] **FIG. 2B** is a perspective view of the multi-port splitter assembly of **FIG. 2A** in the prior art, with an optical management shelf installed;

[0015] **FIG. 3A** illustrates a perspective view of an exemplary multi-port optical connection terminal assembly optically connected to a cable;

[0016] **FIG. 3B** depicts an exploded view of the multi-port optical connection terminal assembly of **FIG. 3A**;

[0017] **FIG. 4** is a flowchart diagram illustrating an exemplary process that may be employed to manufacture and/or assemble the multi-port splitter assembly of **FIG. 3A**;

[0018] **FIG. 5A** is a perspective, close-up view of the optical splitter of **FIG. 3A**;

[0019] **FIG. 5B** is a perspective, close-up view of the enclosure of **FIG. 3A**;

[0020] **FIG. 6** illustrates a perspective view of an input optical fiber of the optical splitter of **FIG. 3A**, and a strain relief jacket disposed around at least a portion of the input optical fiber of the optical splitter;

[0021] **FIG. 7** depicts a perspective view of a protective tube disposed around a portion of the strain relief jacket and the input end of the optical splitter of **FIG. 6**;

[0022] **FIG. 8** illustrates a perspective view of a furcation tube disposed around the protective tube, the input end of the body of the optical splitter, and the portion of the strain relief jacket of **FIG. 7**;

[0023] **FIG. 9** depicts a perspective view of a furcation structure comprising the furcation tube of **FIG. 8**;

[0024] **FIG. 10** illustrates a side view of the furcation structure of **FIG. 9**, wherein an output end of the body of the optical splitter is disposed within the enclosure of **FIG. 3A**;

[0025] **FIG. 11** depicts a side view of the furcation structure of **FIG. 10**, wherein a second protective tube is disposed around at least a portion of the furcation tube and a portion of the enclosure;

[0026] **FIG. 12** illustrates a side view of the second protective tube securely attached to the portion of the furcation tube and the portion of the enclosure of **FIG. 11**;

[0027] **FIG. 13** depicts a perspective view of the bottom of the enclosure illustrating the portion of the furcation tube secured to the enclosure of **FIG. 12** with a clamp;

[0028] **FIG. 14** illustrates a perspective view of alternative embodiments of the multi-port optical connection terminal assembly including various quantities of optical connection nodes;

[0029] **FIG. 15** depicts a side view of the resulting multi-port optical connection terminal assembly of **FIG. 13** adjacent to an optical fiber of a cable;

[0030] **FIG. 16** depicts a side view of the multi-port optical connection terminal assembly of **FIG. 15** optically attached to the optical fiber of the cable;

[0031] **FIG. 17** depicts a side view of the multi-port optical connection terminal assembly of **FIG. 16** with a splice protector disposed around a splice point of the input optical fiber of the optical splitter;

[0032] **FIG. 18** illustrates a perspective view of another embodiment of a furcation structure including one or more interface surfaces; and

[0033] **FIG. 19** depicts a side view of a different embodiment of a furcation structure installed as part of a multi-port optical connection terminal assembly wherein a body of the optical splitter is disposed outside the internal cavity.

DETAILED DESCRIPTION

[0034] Reference will now be made in detail to the embodiments, examples of which are illustrated in the accompanying drawings, in which some, but not all embodiments are shown. Indeed, the concepts may be embodied in many different forms and should not be construed as limiting herein; rather, these embodiments are provided so that this disclosure will satisfy applicable legal requirements. Whenever possible, like reference numbers will be used to refer to like components or parts.

[0035] Embodiments disclosed in the detailed description include multi-port optical connection terminal assemblies, related terminals and methods. In one embodiment, a multi-port optical connection terminal assembly is disclosed. This multi-port optical connection terminal assembly may include an enclosure including an internal cavity, an input orifice, and a plurality of optical connection nodes. The multi-port optical connection terminal assembly may also include an optical splitter comprising a body, an input optical fiber, and plurality of output optical fibers. At least a portion of the body of the optical splitter may be disposed outside the internal cavity of the enclosure. The input optical fiber of the optical splitter may be disposed outside the internal cavity of the enclosure, and the plurality of the output optical fibers of the optical splitter may be disposed inside the internal cavity. In this manner, the enclosure of the multi-port optical connection terminal assembly is not required to be sized to completely contain the optical splitter. In this regard as a non-limiting example, the enclosure of the multi-port optical connection terminal may be provided of a smaller size enabling easier installation through narrow passageways and ducts because of the smaller enclosure size.

[0036] In this regard, **FIGS. 3A** and **3B** illustrate a schematic diagram and an exploded view, respectively, of one embodiment of a multi-port optical connection terminal assembly **60**. It may be configured to split an optical signal carried by an optical fiber **62** in a cable **64** and deliver a plurality of split optical signals downstream at each of a plurality of optical connection nodes **66**. As non-limiting examples, the cable **64** may be a branch cable, distribution cable, a stub cable, tether cable, or any other type of cable. The cable **64** may be unconnectorized as provided in **FIGS. 3A** and **3B** or connectorized in other embodiments. In **FIG. 3A** the main external components of the multi-port optical connection terminal assembly **60** in this embodiment are depicted. In this embodiment, the multi-port optical connection terminal assembly **60** includes an enclosure **68** which comprises a base **69** and a cover **70**. The cover **70** operates as part of the enclosure **68** to seal an internal cavity **78** of the enclosure **68** from the environment outside. Sealing the internal cavity **78** may be important because the multi-port optical connection terminal assembly **60** may be, for example, underground or suspended from a utility pole.

[0037] A furcation structure **72** may be attached to a portion **74** of the enclosure **68** by a second protective tube **76**. This enables at least a portion of a body of an optical splitter (introduced below as element **94**) within the furcation structure **72** to be located at least partially outside of the enclosure **68**. The furcation structure **72** may be used to reduce the size of the enclosure **68** and to protect the body of the optical splitter outside of the enclosure **68**.

[0038] A strain relief jacket **80** extends from the furcation structure **72** towards the cable **64**. A splice protector **82** may be disposed between the cable **64** and the strain relief jacket **80** to optically couple an optical fiber (introduced below) in the strain relief jacket **80** to the optical fiber **62** of the cable **64.** The splice protector **82** may also serve to environmentally protect optical fibers within by forming a tight contact seal with the strain relief jacket **80** and a cable jacket **86** of the cable **64**.

[0039] The plurality of optical connection nodes **66** may be attached to a plurality of angled exterior surfaces **88** of the enclosure **68** to allow for optimal orientation of downstream cables and their associated connectors (not shown) to carry the split optical signals downstream from the multi-port optical connection terminal assembly **60** to subscribers.

[0040] **FIG. 3B** provides more detail as to the components of the multi-port optical connection terminal assembly **60**. The enclosure **68** may comprise the base **69** and the cover **70**. The base **69** and the cover **70** may be formed as thin-walled components made of a strong generally liquid-impermeable material, for example, such as plastic or metal. The base **69** and the cover **70** may be manufactured, for example, using stamping or injection molding techniques as non-limiting examples.

[0041] The plurality of optical connection nodes **66** may seal a plurality of output orifices **90** of the enclosure **68**. The plurality of output orifices **90** may be disposed in the plurality of angled exterior surfaces **88** as shown in **FIG. 3B**. The plurality of optical connection nodes **66** may be connected to the plurality of output orifices **90** through, for example, a threaded connection.

[0042] The internal cavity **78** may be formed by a volume enclosed by the base **69** and cover **70** and accessible when the cover **70** is attached by the plurality of output orifices **90** and an input orifice **89**. Although the plurality of output orifices **90** and the input orifice **89** are depicted in **FIGS. 3A** to **3B** as being within the base **69** of the enclosure **68**, some or all of the plurality of output orifices **90** and the input orifice **89** may also be included as part of the cover **70**. It is noted that the cover **70** may be a non-limiting embodiment of the multi-port optical connection terminal assembly **60**. Other embodiments of the enclosure **68** may be one-piece, or have the cover **70** permanently attached or otherwise secured to the base **69**.

[0043] With continuing reference to **FIG. 3B**, the multi-port optical connection terminal assembly **60** may utilize an optical splitter **92** to split optical signals from the optical fiber **62** of the cable **64**. The purpose of the optical splitter **92** may be to transmit at least a portion of the optical information to or from the cable **64** to or from the plurality of optical connection nodes **66**. The optical splitter **92** may include a body **94** where the optical signals are split. Each optical fiber may contain many independent channels of information, each having a different wavelength of light. The body **94** of the optical splitter **92** may be compatible with either single-mode fiber optical cables or multi-mode optical cables. The body **94** of the optical splitter **92** may have components to support wave-division multiplexing (WDM), code division multiplexing (CDM), course wave division multiplexing (CWDM), and/or dense wave division multiplexing (DWDM). Many of these data handling approaches may allow for multiple signals to be efficiently transported on a single carrier wave by the optical fiber **62** in the cable **64** before being split by the optical splitter **92** into their component signal parts to be available for downstream optical fibers (not shown) connected at the plurality of optical connection nodes **66**. In these approaches, the information available at each of the optical connection nodes **66** may be at least a portion of the multiple signals carried by the optical fiber **62** of the cable **64**.

[0044] Continuing the discussion of the optical splitter **92**, the body **94** may include an optical de-multiplexer comprising thin film filter (TFF) technology; a fiber bragg grating (FBG) with optical circulators; and/or arrayed waveguide gratings (AWG). The body **94** of the optical splitter **92** may have a rectangular cross-section as shown in **FIG. 3B**. Alternatively, other cross section shapes may be utilized, such as an oval-type, or polygon-type.

[0045] The optical splitter **92** may also include an input optical fiber **96** and a plurality of output optical fibers **98** connected directly to the body **94** of the optical splitter **92**. The input optical fiber **96** may be a single-mode or multi-mode optical fiber extending from an input end **100** of the body **94** of the optical splitter **92**. A splice point **102** may be disposed on the input optical fiber **96**, where the input optical fiber **96** may be optically coupled to the optical fiber **62** of the cable **64**. The optical coupling (also known as splicing) may be accomplished mechanically or by fusing the optical fibers **62, 96** together. Note that the terms “input” output fiber and “output” optical fiber are not limited to and do not imply a limitation of a direction of optical signals. The optical splitter **92** may be configured such that optical signals can flow uni-directional in either direction, or bi-directionally between the input optical fiber **96** and the output optical fibers **98**. All possibilities are contemplated by the optical splitter **92** and the optical splitters disclosed herein.

[0046] The input optical fiber **96** of the optical splitter **92** may include a protective jacket between the splice point **102** and the body of the optical splitter **92** for additional environmental and mechanical protection. In this regard, the strain relief jacket **80** may be disposed between the input optical fiber **96** and the body **94** of the optical splitter **92** to help provide additional protection. The strain relief jacket **80** may be cylindrical with an orifice through the axis by which may be disposed a portion **103** of the input optical fiber **96**. The strain relief jacket **80** may abut the input end **100** of the body **94** of the optical splitter **92** to provide protection adjacent to the body **94**. Mechanical protection of the input optical fiber **96** may be particularly important next to the body **94**, because the body **94** may be rigid and accordingly, bending forces transmitted from the cable **64** may cause a sharp bend in the input optical fiber **96** that may cause optical attenuation or damage. For example, traditional optical fibers could suffer optical attenuation for certain bend radii.

[0047] The optical fiber **62** of the cable **64** may include the cable jacket **86**, as previously discussed, to protect the optical fiber **62** from environmental issues. The cable jacket **86** may be partially stripped from a terminating end **104** of the cable **64** to expose the optical fiber **62** that may be subsequently spliced to the input optical fiber **96**. Accordingly, a splice protector **82** may be utilized to protect the splice point **102** and the terminating end **104** of the cable **64**. The splice protector **82** may be comprised of one or more components **82(1), 82(2)** or may be formed as a single overmolded component surrounding the splice point **102** and the terminating end **104**. The advantage of being a single overmolded component may be that a tight seal may be formed around the splice point **102**.

[0048] The plurality of output optical fibers **98** extend from the body **94** of the optical splitter **92** at an output end **106** of the body **94**. The plurality of output optical fibers **98** deliver the output signals of the optical splitter **92** to the plurality of optical connection nodes **66**, and may be comprised of single-mode or multi-mode optical fibers. In a non-limiting example, the plurality of output optical fibers **98** may be in the form of a fiber optic ribbon cable wherein each of the plurality of output optical fibers **98** may exit the body **94** of the optical splitter **92** in an array of optical fibers one (1) fiber high and “n” (n) fibers across, or in other words (“1 x n”). Typical non-limiting values for “n” may be 2, 4, 8, 16 and 32. Other output configurations and quantities of the plurality of output optical fibers **98** may also occur. The plurality of output optical fibers **98** may also include a protective cable jacket (not shown) to protect the plurality of output optical fibers **98** between the body **94** and the plurality of optical connection nodes **66**. Each of the plurality of output optical fibers **98** may also comprise a plurality of optical fiber connectors **108** to connect the plurality of output optical fibers **98** to the plurality of optical connection nodes **66**. The advantage of having optical fiber connectors **108** may be that the plurality of output optical fibers **98** may have the optical fiber connectors **108** attached in a facility enabling a quicker assembly in the field.

[0049] An output strain relief device **107** may be attached to the output end **106** of the body **94**. The output strain relief device **107** may be utilized to protect the plurality of output optical fibers **98** from being bent more than the minimum bend radius of the plurality of output optical fibers **98** that may be allowed before damage or unacceptable optical attenuation occurs.

[0050] As to the topic of attaching components of the multi-port optical connection terminal assembly **60**, a protective tube **110** may be used to attach the strain relief jacket **80** to the body **94** of the optical splitter **92**. The protective tube **110** may be in a cylindrical form and comprise an orifice surface **112**, which may be concentric around a longitudinal axis $\mathbf{A_1}$ of the protective tube **110**. A portion **114** of the strain relief jacket **80** and a portion **116** of the body **94** of the optical splitter **92** may form the attachment with the orifice surface **112** of the protective tube **110**. A tight attachment between the protective tube **110** and the portions **114, 116** may be optionally enhanced by an inclusion of an adhesive lining **118** upon the orifice surface **112** of the protective tube **110**. The adhesive lining **118** may comprise epoxy or another adhesive compatible with plastic, rubber, or metal, such as aluminum for example.

[0051] Moreover, the protective tube **110** may be sensitive to heat wherein, upon heating above a specified temperature, a material of the protective tube **110** may constrict, causing the protective tube **110** to tighten around the portions **114, 116** and thereby increase a frictional attachment strength between the orifice surface **112** and the portions **114, 116**. The protective tube **110** may be made from a strong tear-resistant material such as metal or plastic. The protective tube **110** may be a heat shrink tube.

[0052] Also, a furcation tube **120** in combination with a potting compound **122** (discussed below in regard to **FIG. 9**) may provide further strength and rigidity to the attachment between the protective tube **110** and the portions **114, 116**. A portion **123** of the furcation tube **120** may be attached to the enclosure **68** through the second protective tube **76**. The furcation tube **120** in this embodiment comprises a second orifice surface **124** which may be concentric around a longitudinal axis $\mathbf{A_1}$ of the furcation tube **120**. The furcation tube **120** may surround at least a portion of the protective tube **110**, as well as the portions **114, 116**. The potting compound **122** may be disposed between the furcation tube **120**, specifically the second orifice surface **124**, and the protective tube **110**. The furcation tube **120** may be made of metal or plastic, for example, that may be strong and tear-resistant. The potting compound **122** may be comprised of epoxy or a different potting compound compatible with metal and/or plastic.

[0053] In order to simplify the subsequent discussion, the furcation structure **72** describes the strengthened attachment between the body **94** of the optical splitter **92**, the strain relief jacket **80**, and the associated components required to attach this strengthened attachment to the enclosure **68**. The furcation structure **72** may be comprised of the furcation tube **120**, the potting compound **122**, the protective tube **110**, the portion **114** of the strain relief jacket **80** and the portion **116** of the body **94** of the optical splitter **92**.

[0054] Next, the furcation tube **120** of the furcation structure **72** may be attached to the enclosure **68**. The second protective tube **76** may be utilized to attach the furcation tube **120** to the portion **74** of the enclosure **68**. The portion **74** of the enclosure **68** may be an outer surface of a neck portion protruding as part of the enclosure **68**, and thereby provide a convenient surface for attachment as shown in **FIG 3B**.

[0055] Moreover, the second protective tube **76** may be in cylindrical form and comprise a third orifice surface **128** which may be concentric around a longitudinal axis $\mathbf{A_1}$ of the second protective tube **76**. The portion **123** of the furcation tube **120** and the portion **74** of the enclosure **68** come into contact with the third orifice surface **128** to form an attachment. A tight attachment between the third orifice surface **128** of the second protective tube **76** and the portion **123** of the furcation tube **120** and the portion **74** of the enclosure **68** may be enhanced by an inclusion of a second adhesive lining **130** along the third orifice surface **128** of the second protective tube **76**. The second adhesive lining **130** may comprise epoxy or another adhesive compatible with plastic, rubber, or metal, such as aluminum for example. The material of the second protective tube **76** may be a strong tear-resistant material and may be different than the material of the protective tube **110**. Examples of suitable materials are metal or plastic.

[0056] The second protective tube **76** may be sensitive to heat, wherein upon heating above a specified temperature, the second protective tube **76** may constrict causing the second protective tube **76** to tighten around the portion **123** of the furcation tube **120** and the portion **74** of the enclosure **68**, and thereby increase the strength of the attachment between the third orifice surface **128** and the portion **123** of the furcation tube **120** and the portion **74** of the enclosure **68**. The second protective tube **76** may be a heat shrink tube.

[0057] The attachment between the furcation structure **72** and the enclosure **68** may be enhanced by a clamp **132** attached to the furcation structure **72** or a second portion **136** of the body **94** of the optical splitter **92** with a fastener **134**. The clamp **132** may be located inside the internal cavity **78** of the enclosure **68** for protection against environmental and mechanical issues. The clamp **132** may be attached itself to the enclosure **68**, or alternatively may merely form an interference fit with the enclosure **68** to thereby prevent the furcation structure **72** from separating from the enclosure **68**.

[0058] The second portion **136** of the body **94** of the optical splitter **92** may or may not be located within the internal cavity **78** of the enclosure **68**. In embodiments where the optical splitter **92** is located within, the optical splitter **92** may enter the internal cavity **78** at the input orifice **89** of the enclosure **68**.

[0059] The cover **70** may be fastened to the base **69** with one or more fasteners **140** to make up the enclosure **68**. The cover **70** may include seals (not shown) to form a tight protective attachment with the enclosure **68** and thereby help better isolate the internal cavity **78** of the enclosure **68** from the outer environment. The seals may prevent contaminants such as liquid from entering the interior cavity **78**. Other methods for fastening may also be employed which do not employ fasteners, such as induction welding, sonic welding, and chemical bonding, as non-limiting examples.

[0060] **FIG. 4** depicts an exemplary method **142** of assembling a multi-port optical connection terminal assembly as depicted in **FIGS. 3A** to **3B**. The first step of the method **142** may be comprised of providing the optical splitter **92** and the enclosure **68** (step **144** in **FIG. 4**). Next, the furcation structure **72** may be created (step **146**). In the next step the furcation structure **72** may be attached to the enclosure **68** (step **148**). Once these are completed, then the enclosure **68** may be sealed with the cover **70** of the enclosure **68** (step **150**). Lastly, the input optical fiber **96** may be optically coupled to an optical fiber **62** of the cable **64** at the splice point **102** disposed in the input optical fiber **96** (step **152**). Each of these steps will be discussed in more detail below with continuing reference to **FIGS. 5A** to **19**.

[0061] In this regard, **FIGS. 5A** to **5B** illustrate details of providing the optical splitter **92** and the enclosure **68** (step **144** in **FIG. 4**) in two sub-steps. A first sub-step **154** in **FIG. 5A** may consist of providing the optical splitter **92**, which may comprise a body **94**, an input optical fiber **96**, and a plurality of output optical fibers **98**. A second sub-step **156**, depicted in **FIG. 5B**, may consist of providing the enclosure **68** comprising the base **69**, the cover **70**, the internal cavity **78**, the input orifice **138**, and the plurality of optical connection nodes **66**.

[0062] Next, **FIG. 6** illustrates a first sub-step **158** of creating the furcation structure (step **146**). The purpose of the furcation structure **72** may be to locate at least a portion of the body **94** of the optical splitter **92** outside of the enclosure **68** so that the multi-port optical connection terminal assembly **60** may be smaller in size while providing sufficient protection for the body **94** of the optical splitter **92**. In sub-step **158**, the strain relief jacket **80** may be disposed around at least the portion of the input optical fiber **96** and abutted against the input end **100** of the body **94** of the optical splitter **92**. The input optical fiber **96** may extend outside the body **94** of the optical splitter **92** from the input end **100** of the body **94** of the optical splitter **92**.

[0063] Continuing with step **146** in **FIG. 4**, **FIG. 7** illustrates a second sub-step **160** of creating the furcation structure **72**, wherein the protective tube **110** may be disposed around at least the portion **114** of the strain relief jacket **80** and the input end **100** of the body **94** of the optical splitter **92**. The protective tube **110** may be configured to attach the strain relief jacket **80** to the input end **100** of the body **94** of the optical splitter **92**.

[0064] In the case that the protective tube **110** is a heat shrink tube, then heat may be applied above a specified temperature to the protective tube **110**. The heat may tighten the protective tube **110** around the portion of the strain relief jacket **114** and the input end **100** of the body **94** of the optical splitter **92**. The tightening may increase the strength of the attachment between the portion of the strain relief jacket **114** and the input end **100** of the body **94**. The advantage of using a heat shrink tube may be that it may be installed quickly, with low cost, and has sufficient strength.

[0065] With regard to step **146** in **FIG. 4**, **FIGS. 8** to **9** illustrate a third sub-step **162** of creating the furcation structure. The purpose of this third sub-step may be to further protect the input optical fiber **96** and a portion of the body **94** of the optical splitter **92** by creating a larger rigid structure. In this sub-step **162**, the strain relief jacket **80** may be bound to the input end **100** of the body **94** of the optical splitter **92** by disposing the furcation tube **120** around the at least the portion **111** of the protective tube **110**, the input end **100** of the body **94** of the optical splitter **92**, and the at least the portion **114** of the strain relief jacket **80**. Next, the potting compound **122** may be disposed inside the furcation tube **120** and around at least a portion **111** of the protective tube **110**. The potting compound **122** may be, for example, epoxy or another substance providing a high rigidity when cured.

[0066] With regard to step **148** in **FIG. 4**, **FIG. 10** illustrates a first sub-step **164** of attaching the furcation structure **72** to the enclosure **68**. The purpose of sub-step **164** may be to protect the output end **106** of the body **94** of the optical splitter **92**. In sub-step **164**, the output end **106** of the body **94** of the optical splitter **92** may be disposed within the internal cavity **78** of the enclosure **68**. The plurality of output optical fibers **98** may extend outside the body **94** of the optical splitter **92** from the output end **106** of the body **94** of the optical splitter **92**. Although embodiments of the multi-port optical connection terminal assembly **60** may seek to minimize the volume of the internal cavity of the enclosure **68** to save space, having the output end **106** of the optical splitter **92** disposed within the enclosure **68** has two advantages. First, the output end **106** is better protected within the internal cavity **78** of the enclosure **68**. The second is that the furcation structure **72** may be made shorter in the longitudinal direction. Thus, when the furcation structure **72** is rigidly connected to the enclosure **68** as a cantilever, there may be less risk of breakage from accidental impacts during handling or transportation.

[0067] In the second sub-step of step **148** in **FIG. 4**, **FIGS. 11** to **12** illustrate a second sub-step **166** of attaching the furcation structure **72** to the enclosure **68**. The purpose of sub-step **166** may be to both attach the body **94** of the optical splitter **92** to the enclosure **68** and to close the input orifice **89** of the enclosure **68**. In sub-step **166**, the second protective tube **76** may be disposed around at least the portion **123** of the furcation tube **120** and the portion **74** of the enclosure **68** to begin to form the attachment. **FIG. 12** depicts the second protective tube **76** securely attached to the portion **123** of the furcation tube **120** and the portion **74** of the enclosure **68**. This secure attachment may be the result of changing the shape of the second protective tube **76** by, for example, heating, or by providing a second protective tube **76** with an inner surface closely matching the outer surfaces of the furcation tube **120** and the portion **74** of the enclosure **68**. Further, **FIG. 12** depicts two separate descriptions of the location of the optical splitter. In the first, at least the portion **116** of the body **94** of the optical splitter **92** may be disposed outside the internal cavity **78** of the enclosure **68** and the plurality of output optical fibers **98** may be disposed inside the internal cavity **78** of the enclosure **68**. In the second, the portion **116** of the body **94** of the optical splitter **92** may be disposed between the splice point **102** and the enclosure **68**, and the input optical fiber **96** may be located outside the internal cavity **78**.

[0068] In the third sub-step of step **148** in **FIG. 4**, **FIG. 13** illustrates a third sub-step **168** of attaching the furcation structure **72** to the enclosure **68**. The purpose of sub-step **168** may be to further secure the attachment of the body **94** of the optical splitter **92** to the enclosure **68**. In sub-step **168** the portion **123** of the furcation tube **120** may be secured to the enclosure **68** with a clamp **132**. The clamp **132** may be tightened with the fastener **134** which may be, for example, comprised of a nut and bolt set, or wing nut assembly.

[0069] In the last sub-step **170** of step **148** in **FIG. 4**, attaching the furcation structure **72** to the enclosure **68** may be shown by continued reference to **FIG. 13**. The purpose of sub-step **170** may be to optically couple the plurality of the optical connection nodes **66** to the optical splitter **92**. The plurality of the optical connection nodes **66** may be comprised of the plurality of optical fiber connectors **108** and may be optically connected to each of the plurality of output optical fibers **98**. As shown in **FIG. 11** and previously discussed, the plurality of optical fiber connectors **108** may be optically attached to the plurality of output optical fibers **98** prior to being attached to the plurality of optical connection nodes **66**. Any number of optical connection nodes **66** may be optically coupled downstream from the optical splitter **92** consistent with the method **142** as depicted in **FIG. 14**. The number of optical connection nodes **66** may be dependent on the number of subscribers serviced, cost, or other installation considerations.

[0070] In step **150** in **FIG. 4**, **FIG. 13** further illustrates sealing the enclosure **68** with the cover **70** of the enclosure **68**. The purpose of step **150** may be to seal the internal cavity **78** of the enclosure **68** from the outside. For example, the fasteners **140** may be used to seal the cover **70** to the base **69**. The multi-port optical connection terminal assembly **60** may be installed either within a sheltered building, underground in a wet trench, or suspended from a utility pole during inclement weather, so sealing the enclosure **68** may be critical. Other components (not shown) may be utilized for sealing the enclosure **68**, for example, rubber gaskets placed between the cover **70** and base **69**.

[0071] **FIG. 13** also shows that the plurality of output optical fibers **98** are connected to the plurality of the optical connection nodes **66** without the use of the optical management shelf **38,** as may be needed for some current designs. Accordingly, the present embodiment has a lower quantity of parts and thereby may be less expensive to manufacture.

[0072] Other non-limiting embodiments to the method **142** are now also disclosed. These embodiments may be beneficial by either further reducing the size of the internal cavity **78** or improving the attachment of the furcation structure **72** to the enclosure **68**. For example, one or more interface surfaces **178** may be made in the furcation structure **72** as depicted in **FIG. 18**. The one or more interface surfaces **178** may be created, for example, by a material removal process at a milling machine. The one or more interface surfaces **178** may be used advantageously to contact complementary surfaces in the portion **74** of the enclosure **68** to further improve attachment by preventing a twist of the furcation structure **72** relative to the enclosure **68**. Also, one or more interface surfaces **178** may serve as one or more contact surfaces (not shown) with the clamp **132**.

[0073] Another non-limiting embodiment to the method **142** comprises disposing the furcation tube **120** and potting compound **122** around the entire body **94** of the optical splitter **92**. This embodiment depicted in **FIG. 19** enables the furcation structure **72** to be attached to the enclosure **68** so that the body **94** of the optical splitter **92** may be disposed outside the internal cavity **78**. In this manner, the size of the internal cavity **78** may advantageously be made even smaller.

[0074] Next, in a first sub-step **172** of step **152** in **FIG. 4**, **FIGS. 15** to **16** illustrate optically coupling the input optical fiber **96** to the optical fiber **62** of the cable **64** at the splice point **102** disposed in the input optical fiber **96**. The purpose of first sub-step **172** may be to optically couple the optical fiber **62** of the cable **64** to the optical splitter **92**. **FIG. 15** depicts the splice point **102** disposed in the input optical fiber **96** and the cable **64** prior to optical coupling. **FIG. 16** illustrates the optical fiber **62** of the cable **64** optically coupled to the input optical fiber **96** at the splice point **102**. Optically coupling (or splicing) may involve either mechanically splicing or fusion splicing. Mechanically splicing may involve alignment devices (not shown) configured to hold the two fiber ends in a precisely aligned position to enable light to pass from one optical fiber to the other. Fusion splicing may involve splicing equipment (not shown) that precisely aligns the two ends of different optical fibers together and then energy may fuse or weld together these ends. The energy may be provided from an electric arc or other heat source.

[0075] Next, in a second sub-step **174** of step **152** in **FIG. 4**, **FIG. 17** illustrates the splice protector **82** disposed around the splice point **102**, a second portion **176** of the strain relief jacket **80**, and the cable jacket **86** of the cable **64**. The purpose of the second sub-step **174** may be to protect the splice point **102**, the input optical fiber **96**, and the optical fiber **62** of the cable **64** by keeping out contaminants and preventing harmful bending. At optical coupling locations the input optical fiber **96** and the optical fiber **62** of the cable **64** may be stripped of protective coatings and strength members and thereby may be generally be vulnerable to tensile and bending forces as well as contaminants without the splice protector **82**. For example, some unprotected optical fibers may only have a maximum safe tensile strength of 0.5 to 1.5 pounds as a non-limiting example. The splice protector **82** may comprise over-molded plastic, heat shrink tubing, silicone gel, and/or mechanical crimp protectors to keep the splice point **102** protected from outside elements and breakage. Alternative embodiments of the splice protector **82** may allow a second optical fiber (not shown) of the cable **64** to exit the splice protector **82** in parallel to the optical fiber **62** of the cable **64** and be available for optical coupling downstream.

[0076] As used herein, it is intended that terms "fiber optic cables" and/or "optical fibers" include all types of single mode and multi-mode light waveguides, including one or more optical fibers that may be up-coated, colored, buffered, ribbonized and/or have other organizing or protective structure in a cable such as one or more tubes, strength members, jackets or the like. The optical fibers disclosed herein can be single mode or multi-mode optical fibers. Likewise, other types of suitable optical fibers include bend-insensitive optical fibers, or any other expedient of a medium for transmitting light signals. An example of a bend-insensitive, or bend resistant, optical fiber is ClearCurve® Multimode fiber commercially available from Corning Incorporated. Suitable fibers of this type are disclosed, for example, in U.S. Patent Application Publication Nos. 2008/0166094 and 2009/0169163, the disclosures of which are incorporated herein by reference in their entireties. Many modifications and other embodiments not set forth herein will come to mind to one skilled in the art to which the embodiments pertain having the benefit of the teachings presented in the foregoing descriptions and the associated drawings. As non-limiting examples, the type of enclosure for the multi-port connector optical connect terminal assembly, number of ports, types of splices, types of splice protections, type of cable, and type and configuration of optical splitters can vary as desired.

[0077] Therefore, it is to be understood that the description and claims are not to be limited to the specific embodiments disclosed and that modifications and other embodiments are intended to be included within the scope of the appended claims. It is intended that the embodiments cover the modifications and variations of the embodiments provided they come within the scope of the appended claims and their equivalents. Although specific terms are employed herein, they are used in a generic and descriptive sense only and not for purposes of limitation.

What is claimed is:

1. A multi-port optical connection terminal assembly, comprising:

an enclosure including an internal cavity, an input orifice, and a plurality of optical connection nodes; and

an optical splitter comprising a body, an input optical fiber, and plurality of output optical fibers,

wherein at least a portion of the body of the optical splitter is disposed outside the internal cavity of the enclosure, the input optical fiber is disposed outside the internal cavity of the enclosure, and the plurality of the output optical fibers are disposed inside the internal cavity.

2. The multi-port optical connection terminal assembly of claim 1, wherein the body of the optical splitter is fixed in a stationary relationship to the enclosure.

3. The multi-port optical connection terminal assembly of claim 1, wherein the plurality of output optical fibers extend outside the body of the optical splitter from an output end of the body of the optical splitter, and the input optical fiber extends outside the body of the optical splitter from an input end of the body of the optical splitter.

4. The multi-port optical connection terminal assembly of claim 1, further comprising a splice point disposed in the input optical fiber configured to optically couple the input optical fiber to an optical fiber of a cable.

5. The multi-port optical connection terminal assembly of claim 1, wherein the plurality of connection nodes are comprised of a plurality of fiber optic connectors optically connecting each of the plurality of the output optical fibers.

6. The multi-port optical connection terminal assembly of claim 3, wherein the output end of the body of the optical splitter being disposed within the internal cavity of the enclosure.

7. The multi-port optical connection terminal assembly of claim 3, further comprising a strain relief jacket disposed around at least a portion of the input optical fiber of the optical splitter and abutting the input end of the body of the optical splitter.

8. The multi-port optical connection terminal assembly of claim 3, wherein the output end of the body of the optical splitter is disposed opposite the input end of the body of the optical splitter.

9. The multi-port optical connection terminal assembly of claim 4, further comprising:

a strain relief jacket disposed around at least a portion of the input optical fiber of the optical splitter; and

a splice protector disposed around the splice point, the strain relief jacket, and a cable jacket of the cable.

10. The multi-port optical connection terminal assembly of claim 7, wherein the strain relief jacket is formed as a cylinder member receiving the at least the portion of the input optical fiber.

11. The multi-port optical connection terminal assembly of claim 7, further comprising a protective tube disposed around at least a portion of the strain relief jacket and the input end of the body of the optical splitter, the protective tube configured to attach the strain relief jacket to the input end of the body of the optical splitter.

12. The multi-port optical connection terminal assembly of claim 11, further comprising:

a furcation tube disposed around the protective tube, the input end of the body of the optical splitter and the portion of the strain relief jacket; and

potting compound disposed inside the furcation tube,

wherein the potting compound binds the strain relief jacket to the input end of the body of the optical splitter.

13. The multi-port optical connection terminal assembly of claim 12, wherein the furcation tube is formed as a second cylinder member receiving at least a portion of the protective tube, the input end of the body of the optical splitter, and the portion of the strain relief jacket.

14. The multi-port optical connection terminal assembly of claim 12, wherein the potting compound comprises epoxy.

15. The multi-port optical connection terminal assembly of claim 13, further comprising a second protective tube disposed around the furcation tube and a portion of the enclosure, the second protective tube configured to attach the furcation tube to the enclosure.

16. The multi-port optical connection terminal assembly of claim 15, further comprising a clamp to secure the furcation tube to the enclosure.

17. A multi-port optical connection terminal assembly, comprising:

an enclosure including an internal cavity, an input orifice, and a plurality of optical connection nodes;

an optical splitter comprising a body, an input optical fiber extending from the body, and plurality of output optical fibers extending from the body; and

a splice point on the input optical fiber configured to contact an optical fiber of a cable,

wherein a portion of the body of the optical splitter is disposed between the splice point and the enclosure, and the plurality of the output optical fibers are disposed inside the internal cavity, and the input optical fiber is outside the internal cavity.

18. A method of assembling a multi-port optical connection terminal assembly, comprising:

providing an optical splitter comprising a body, an input optical fiber, and plurality of output optical fibers;

providing an enclosure comprising an internal cavity, an input orifice, and a plurality of optical connection nodes,

creating a furcation structure;

attaching the furcation structure to the enclosure; and

sealing the enclosure with a cover of the enclosure,

wherein at least a portion of the body of the optical splitter is disposed outside the internal cavity of the enclosure, the input optical fiber is disposed outside the internal cavity of the enclosure, and the plurality of output optical fibers are disposed inside the internal cavity.

19. The method of assembling the multi-port optical connection terminal assembly of claim 18, wherein the creating the furcation structure comprises

disposing a strain relief jacket around at least a portion of the input optical fiber; and abutting the strain relief jacket against an input end of the body of the optical splitter,

wherein the input optical fiber extends outside the body of the optical splitter from the input end of the body of the optical splitter.

20. The method of assembling the multi-port optical connection terminal assembly of claim 18, wherein the attaching the furcation structure to the enclosure further comprises disposing a second protective tube around at least a portion of the furcation structure and a portion of the enclosure.

21. The method of assembling the multi-port optical connection terminal assembly of claim 18, wherein the attaching the furcation structure to the enclosure further comprises securing a portion of the furcation structure to the enclosure with a clamp.

22. The method of assembling the multi-port optical connection terminal assembly of claim 19, wherein the creating the furcation structure further comprises disposing a protective tube around at least a portion of the strain relief jacket and the input end of the body of the optical splitter, the protective tube configured to attach the strain relief jacket to the input end of the body of the optical splitter.

23. The method of assembling the multi-port optical connection terminal assembly of claim 19, further comprising optically coupling the input optical fiber to an optical fiber of a cable at a splice point disposed in the input optical fiber.

24. The method of assembling the multi-port optical connection terminal assembly of claim 20, wherein the second protective tube is a heat shrink tube with a second adhesive lining.

25. The method of assembling the multi-port optical connection terminal assembly of claim 22, wherein the creating the furcation structure further comprises binding the strain relief jacket to the input end of the body of the optical splitter by disposing a furcation tube around at least a portion of the protective tube, the input end of the body of the optical splitter, and the at least the portion of the strain relief jacket, and disposing potting compound inside the furcation tube.

26. The method of assembling the multi-port optical connection terminal assembly of claim 22, wherein the attaching the furcation structure to the enclosure further comprises

disposing an output end of the body of the optical splitter within the internal cavity of the enclosure,

wherein the plurality of output optical fibers extend outside the body of the optical splitter from the output end of the body of the optical splitter.

27. The method of assembling the multi-port optical connection terminal assembly of claim 23, wherein the optically coupling the input optical fiber to the optical fiber of the

cable further comprises disposing a splice protector around the splice point, a portion of the strain relief jacket, and a cable jacket of the cable.

28. The method of assembling the multi-port optical connection terminal assembly of claim 25, wherein the potting compound comprises epoxy.

29. The method of assembling the multi-port optical connection terminal assembly of claim 25, wherein the protective tube is a heat shrink tube.

30. The method of assembling the multi-port optical connection terminal assembly of claim 26, wherein the attaching the furcation structure to the enclosure further comprises optically connecting the plurality of the optical connection nodes comprised of a plurality of fiber optic connectors to each of the plurality of output optical fibers.

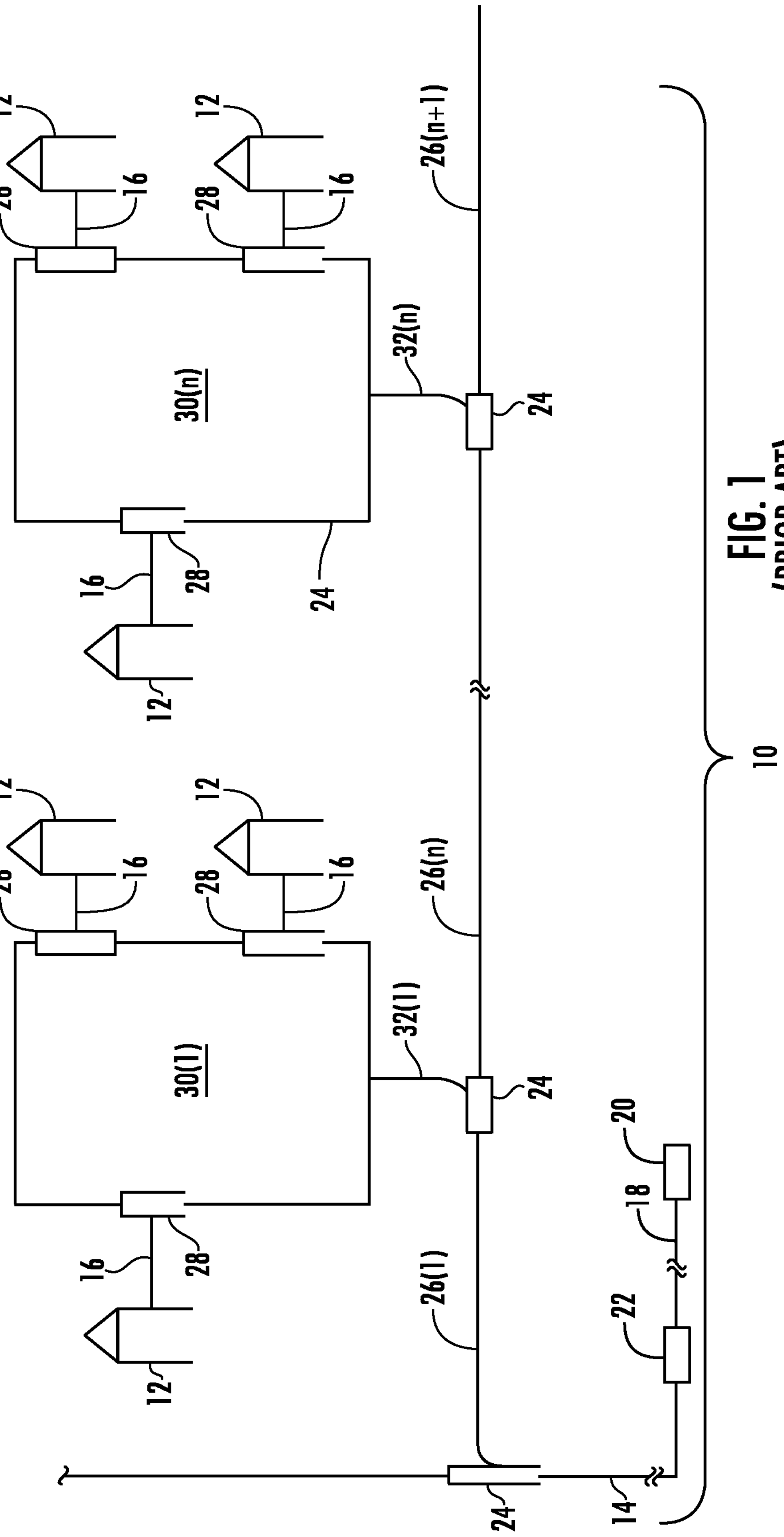


FIG. 1
(PRIOR ART)

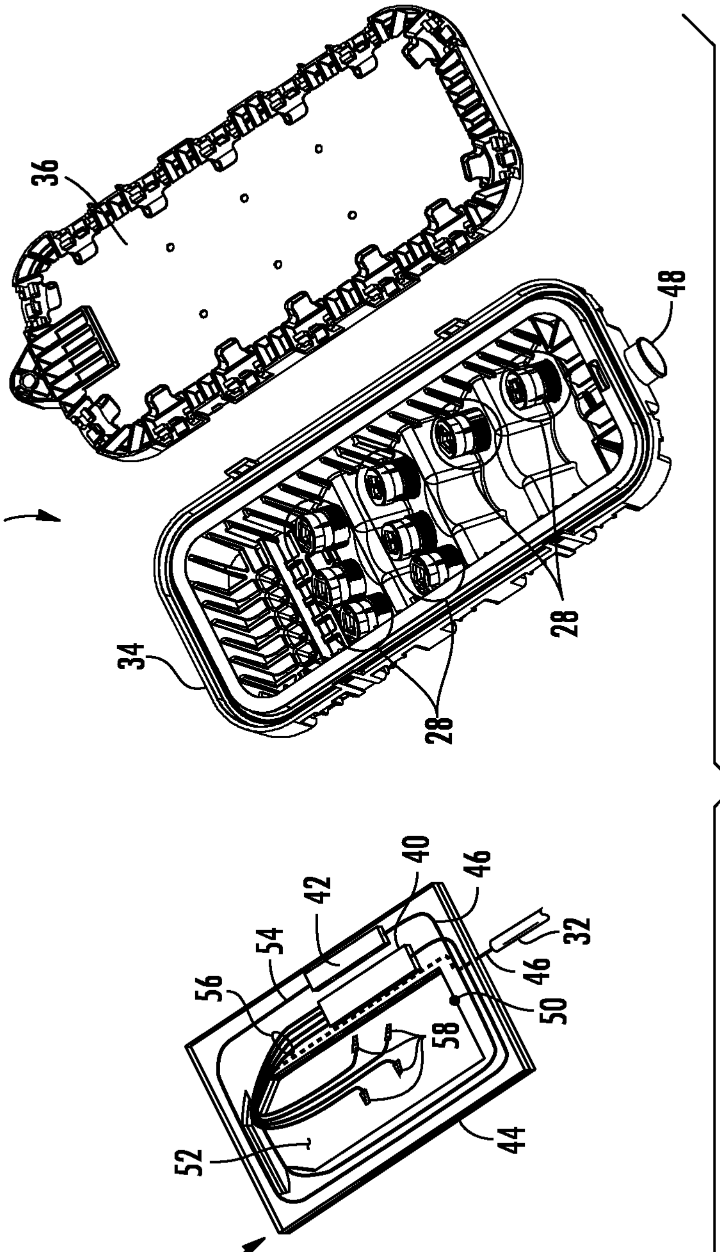


FIG. 2A
(PRIOR ART)

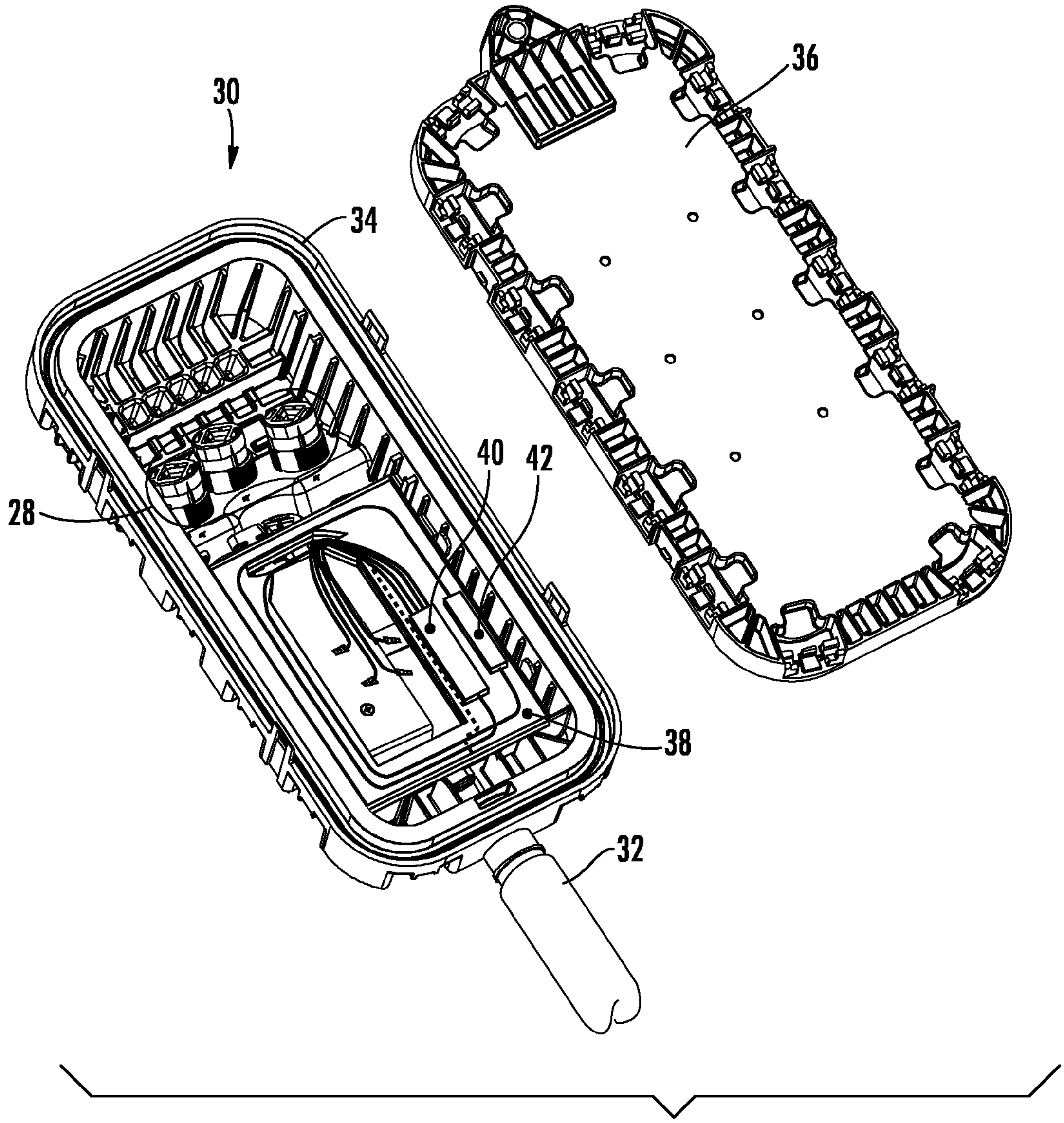


FIG. 2B
(PRIOR ART)

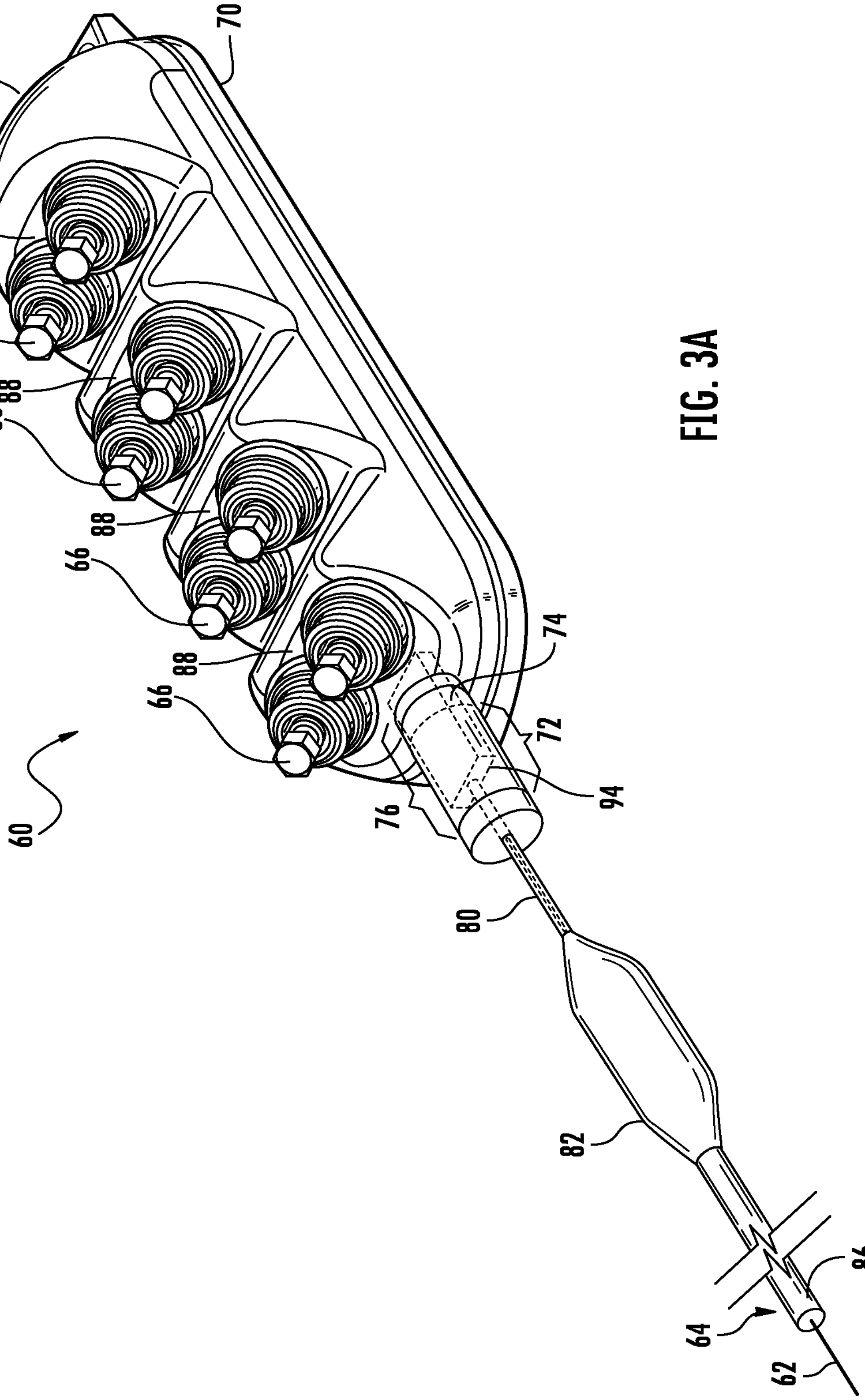
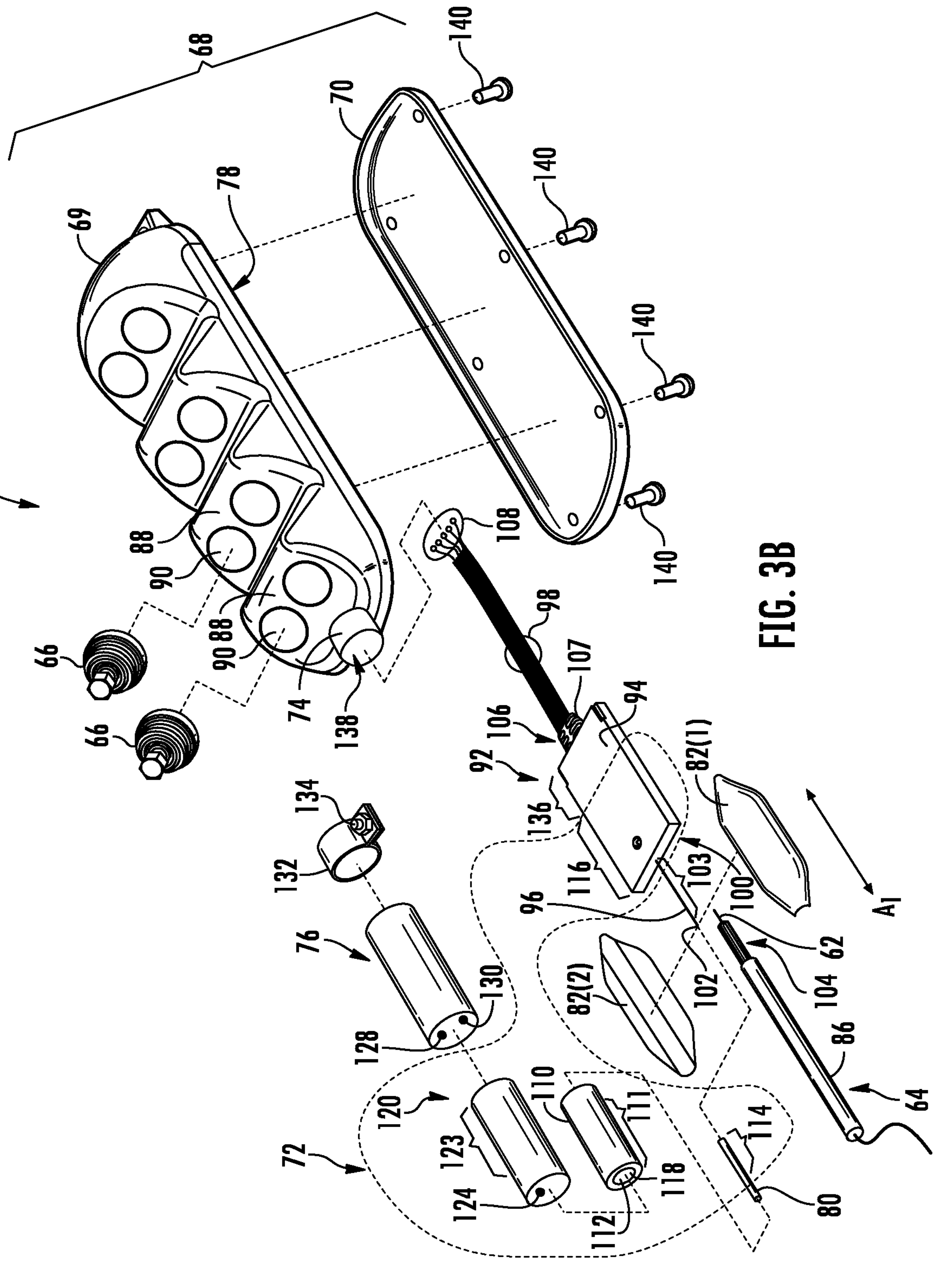


FIG. 3A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106
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136
134
132
116
103
100
82(1)
96
76
130
128
102
82(2)
62
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110
111
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72
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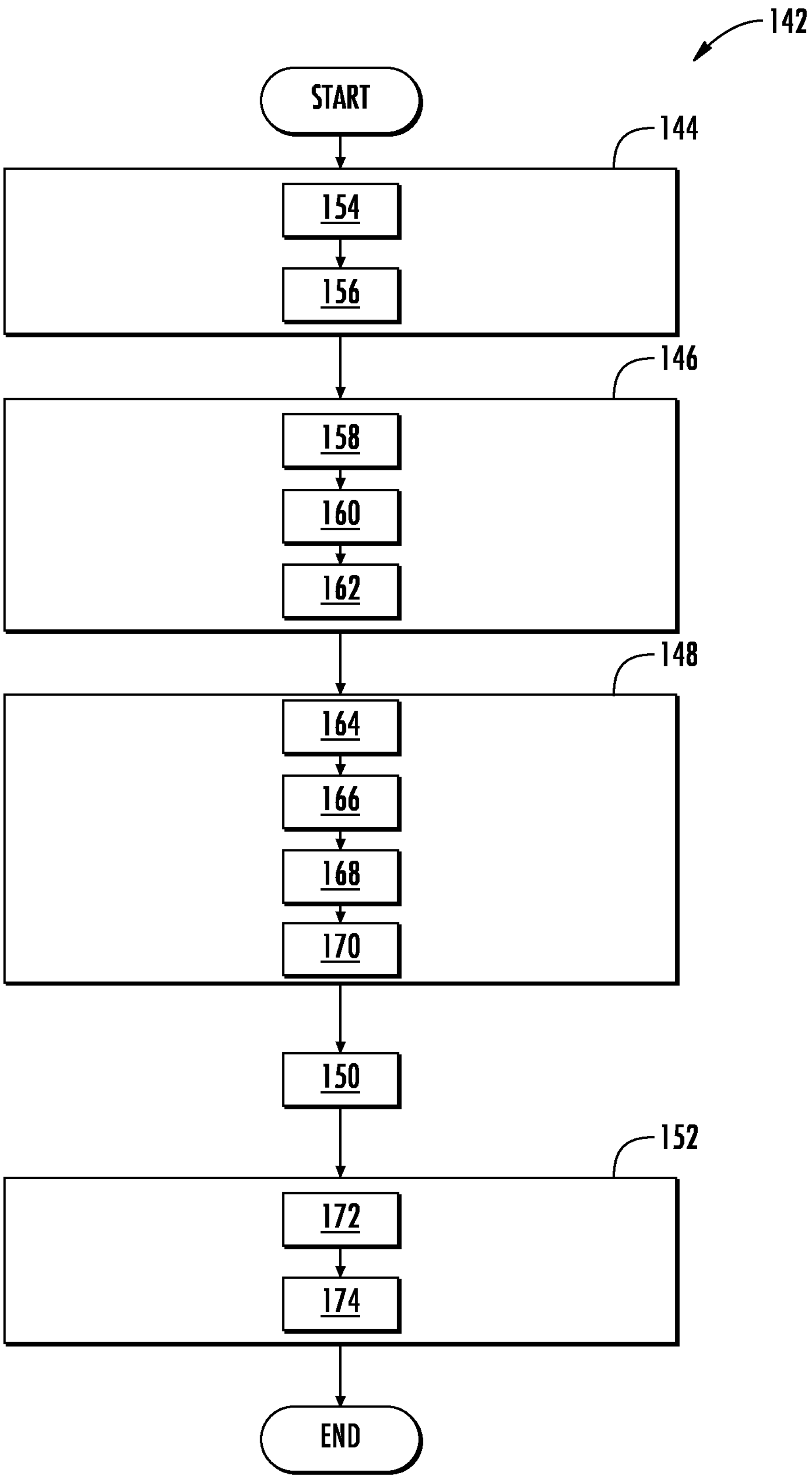
118
112
114
80

FIG. 3B



142
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166
168
170
150
152
172
174
END

FIG. 4

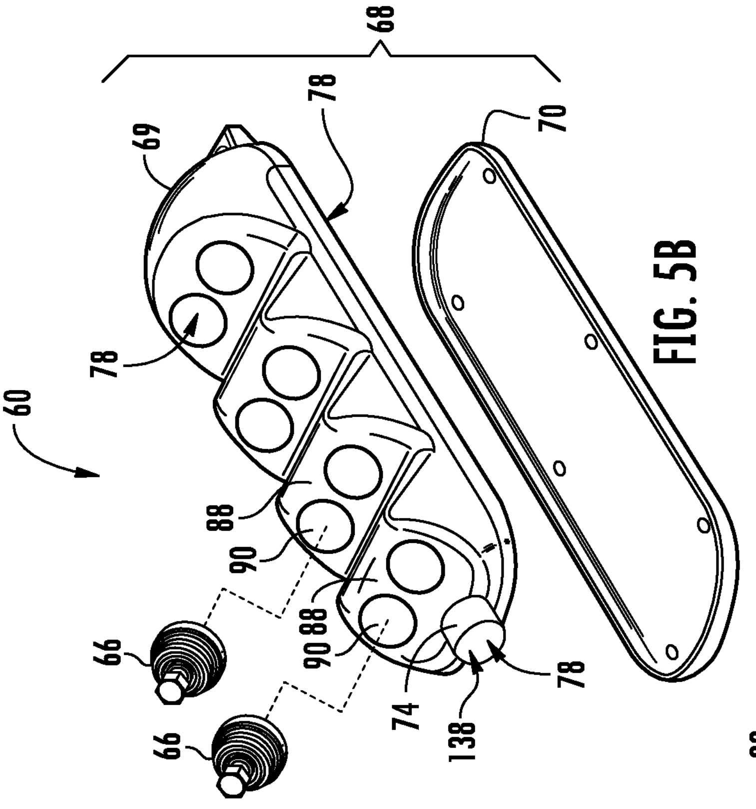


FIG. 5B

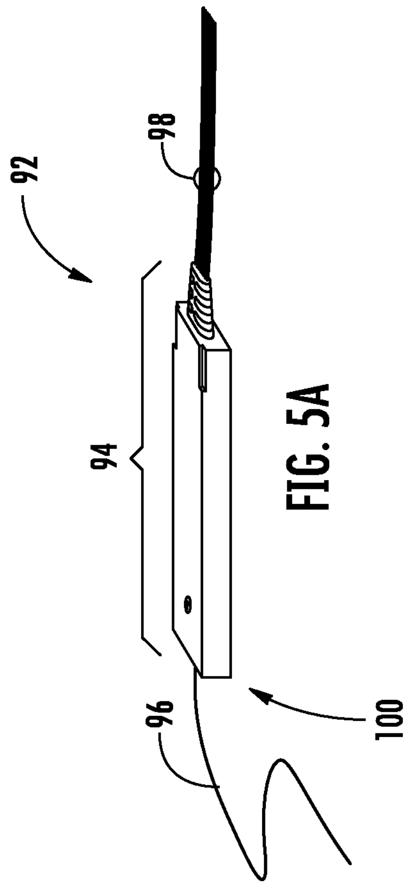


FIG. 5A

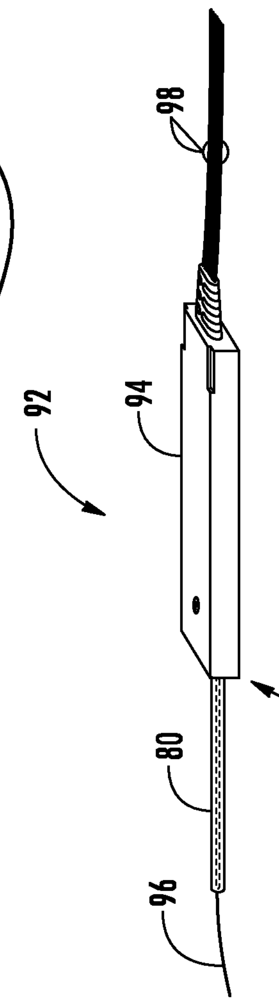
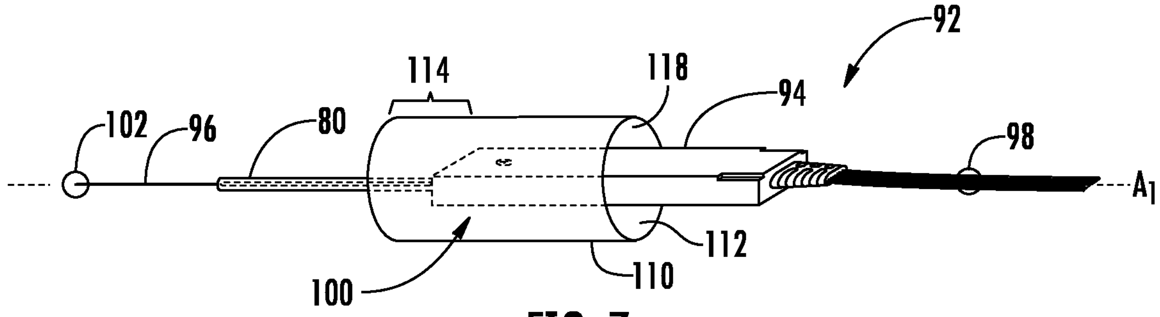
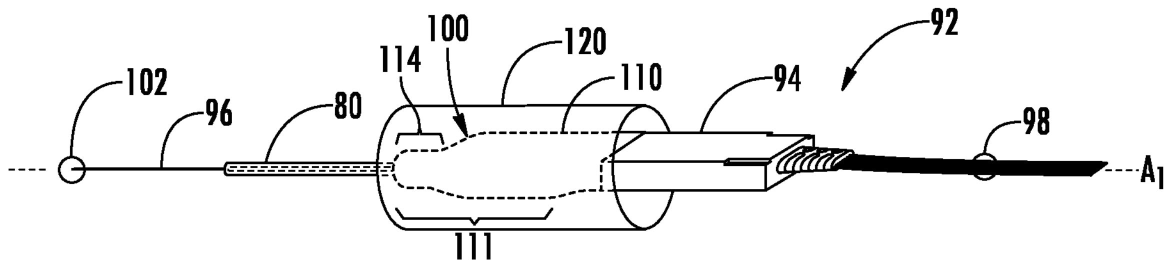


FIG. 6



92
114
118
94
102
96
80
98
A_1
112
110
100

FIG. 7



100
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114
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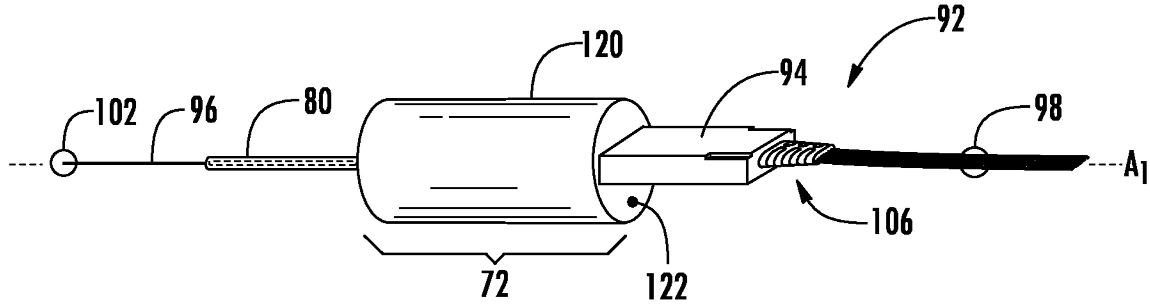
80
98
A_1
111

FIG. 8


120
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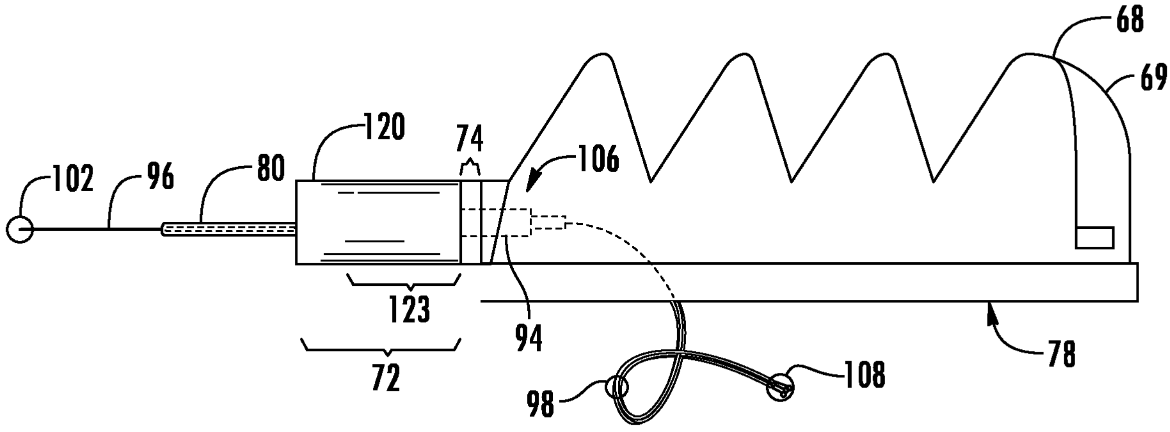
A1
106
72
122

FIG. 9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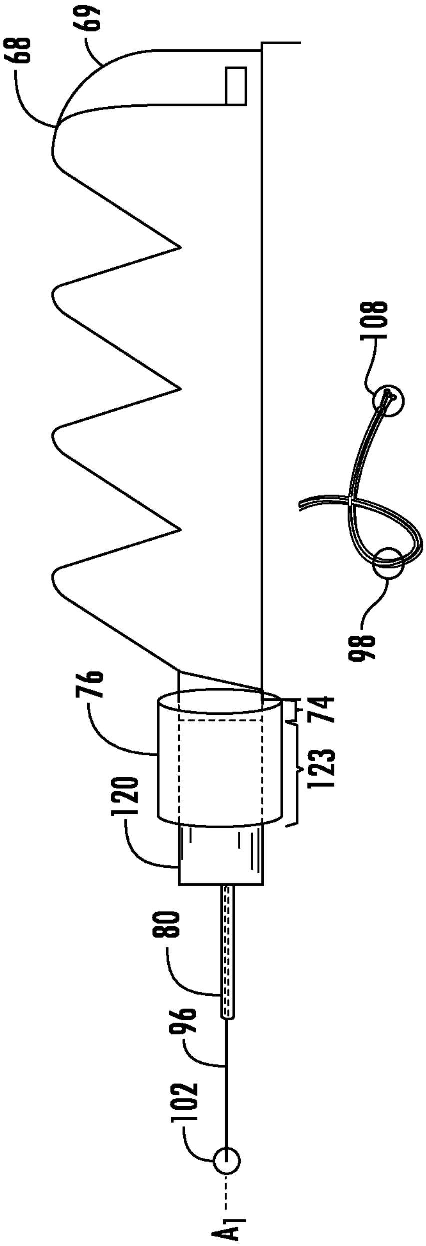
108

FIG. 10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A_1
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FIG. 11

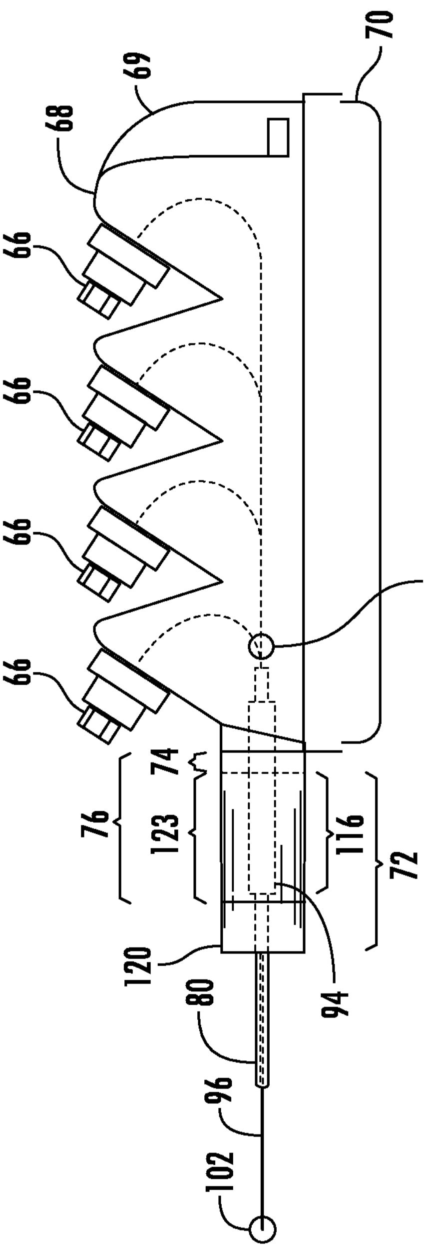
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FIG. 12

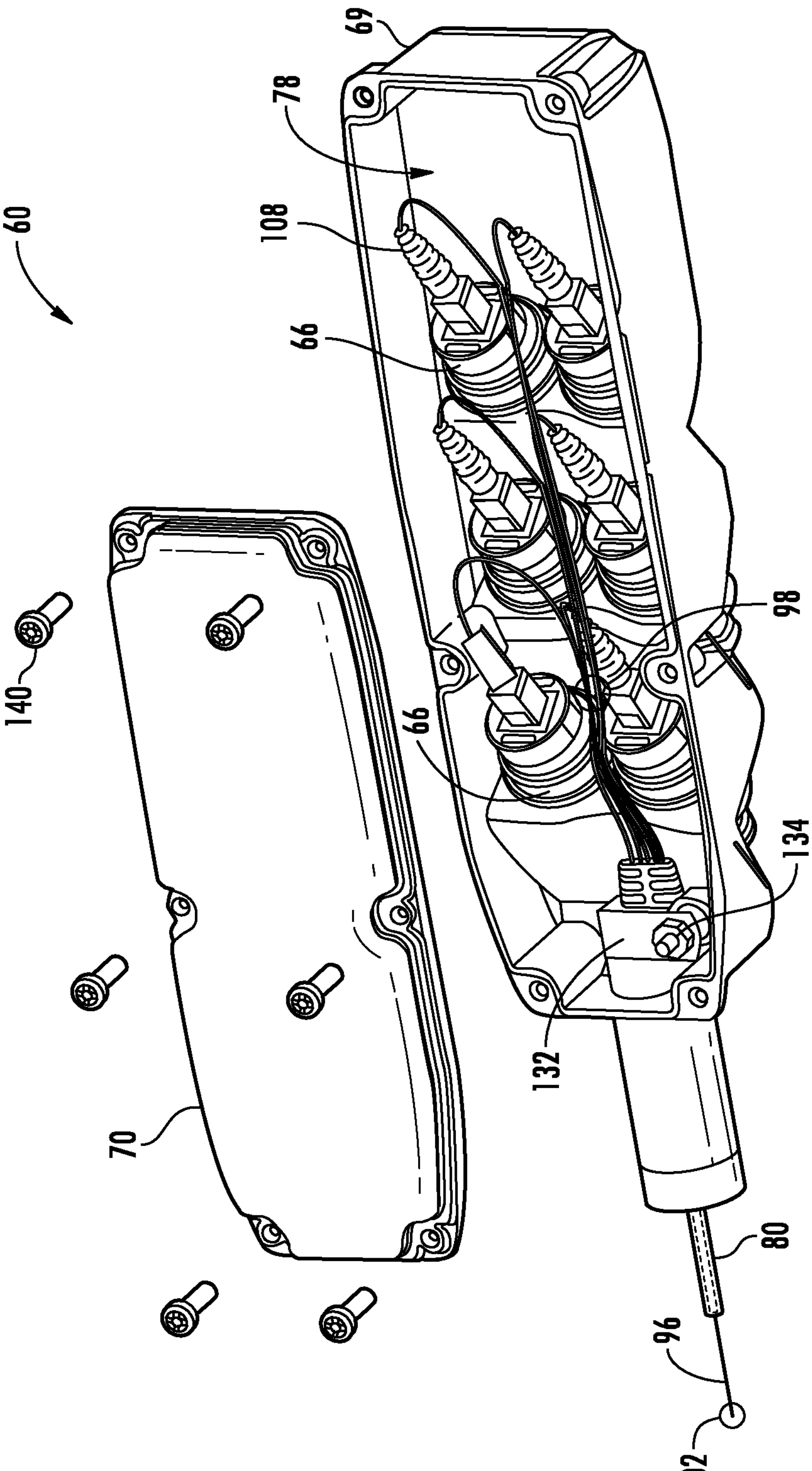

FIG. 13

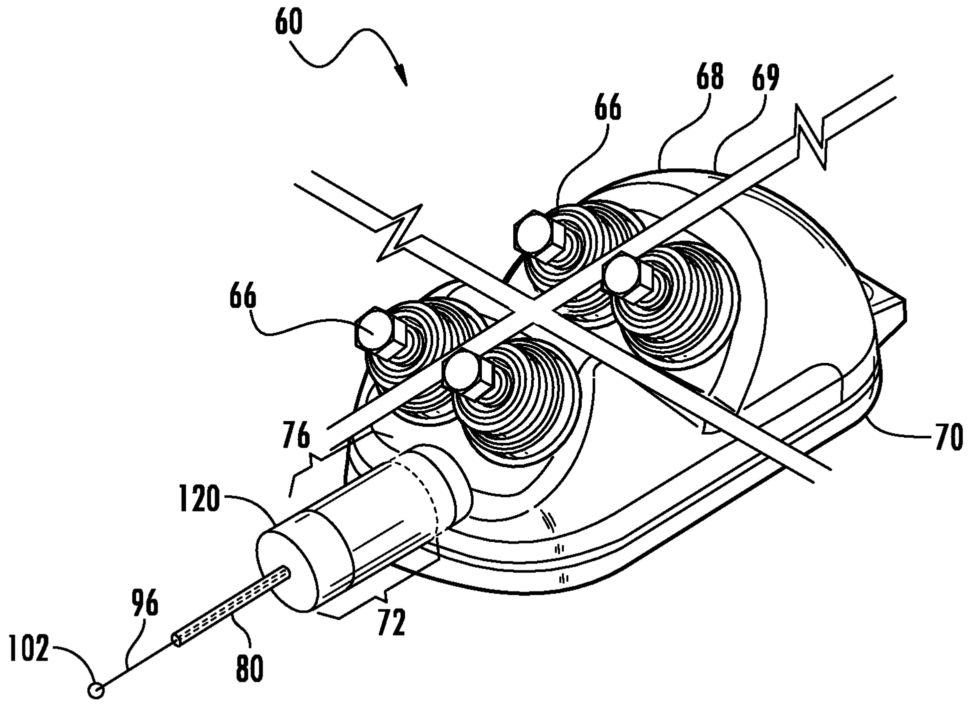

FIG. 14

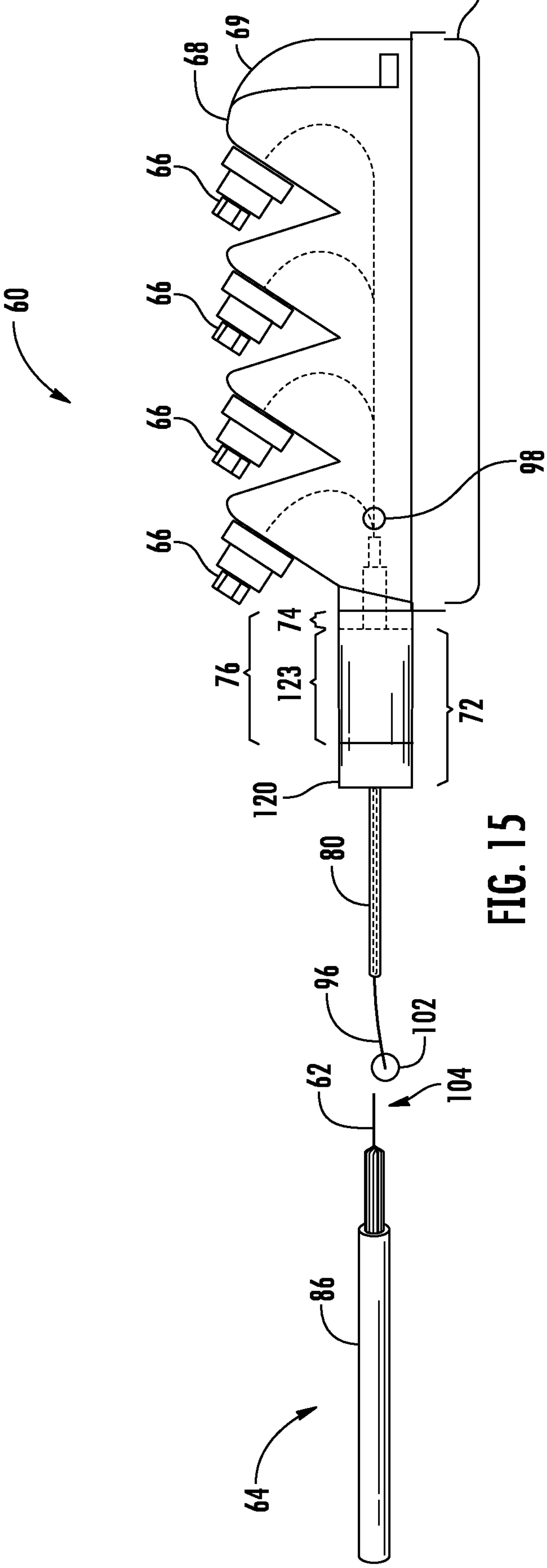

FIG. 15

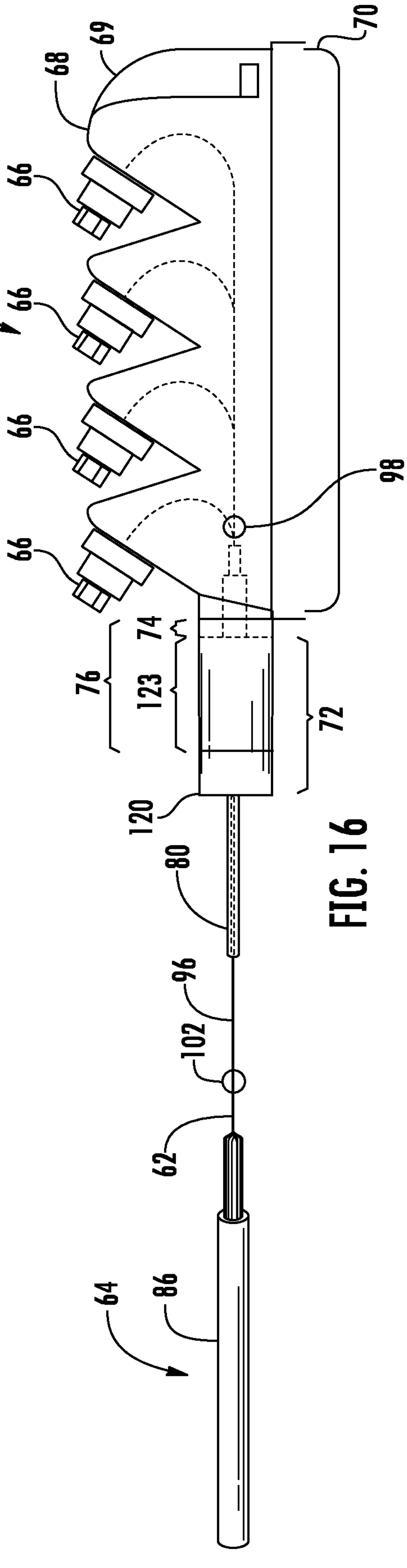
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FIG. 16

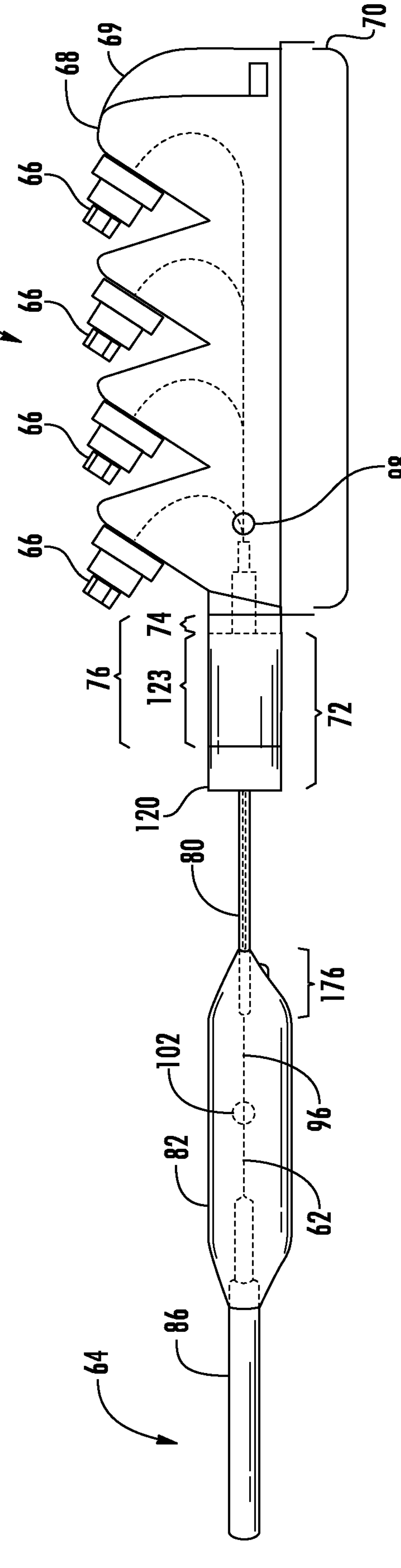
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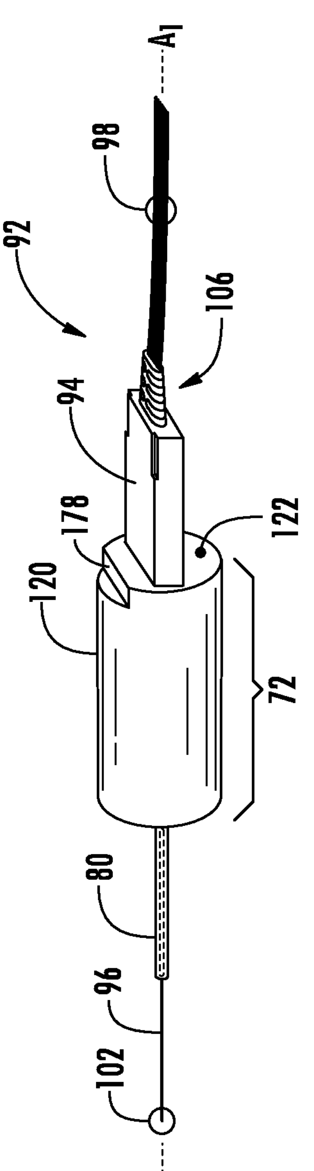
FIG. 17



A1
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FIG. 18

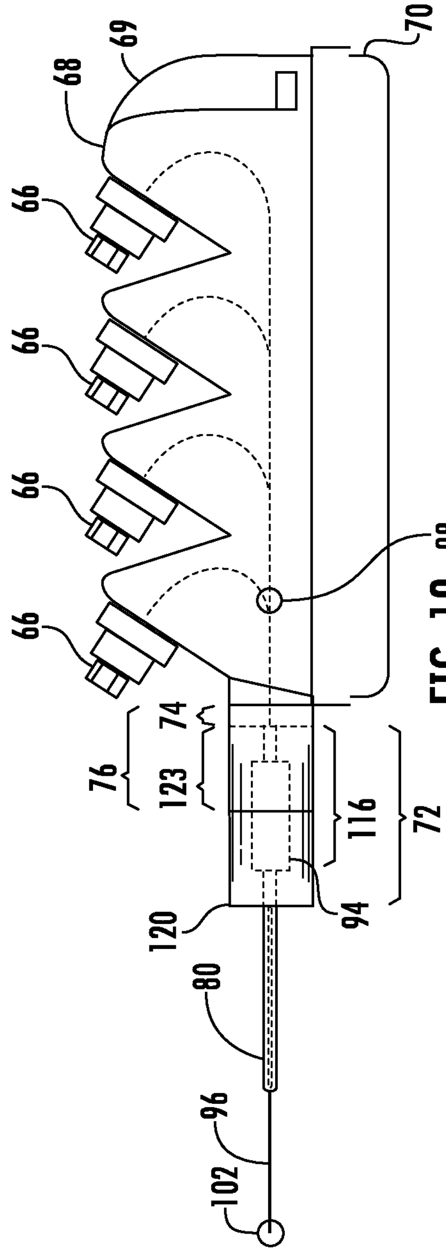

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FIG. 19

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2012/043553

A. CLASSIFICATION OF SUBJECT MATTER
INV. G02B6/44
ADD.

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

B. FIELDS SEARCHED

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

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2011/097050 A1 (BLACKWELL JR CHOIS A [US] ET AL) 28 April 2011 (2011-04-28) paragraphs [0036] - [0048]; figures 1-4	1,3-5,8, 16-18
X	US 2006/269208 A1 (ALLEN BARRY [US] ET AL) 30 November 2006 (2006-11-30) paragraphs [0043] - [0048], [0063] - [0075]; figures 2, 3, 9-12	1,3-5, 7-15, 17-25, 27-30
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A	US 2005/163448 A1 (BLACKWELL CHOIS A JR [US] ET AL BLACKWELL JR CHOIS A [US] ET AL) 28 July 2005 (2005-07-28) the whole document	1-30

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

☒ See patent family annex.

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"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
17 August 2012	28/08/2012

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

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
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