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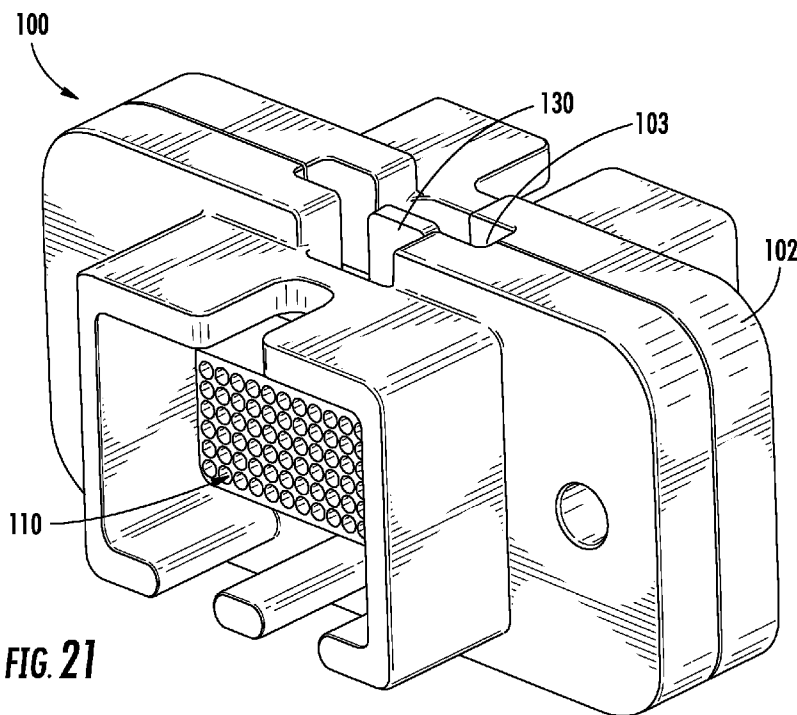
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[Continued on next page]

(54) Title: SPLICING CONNECTORS ALONG WITH ADAPTERS THEREFOR



(57) Abstract: Adapters for receiving high-fiber count splicing connector assemblies are disclosed. The adapter includes a splice guide insert having a first plurality of bores that extend from a first end of the splice guide and a second plurality of bores that extend from a second end of the splice guide. The splice guide aligns the optical fibers of respective splicing connector assemblies received on opposite ends of the adapter for making an optical connection. Additionally, methods are disclosed for laser processing multiple rows of fibers.



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SPLICING CONNECTORS ALONG WITH ADAPTERS THEREFOR

RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application No. 61/305,733 filed on February 18, 2010 and entitled “Methods for Laser Processing Optical Fibers and Splicing Connectors Having a Gel Reservoir,” the entire contents of which are hereby incorporated by reference. The present application is also related to U.S. Application Ser. No. _____ filed even date herewith and entitled “Methods for Laser Processing Arrayed Optical Fibers Along with Splicing Connectors”, the entire contents of which are hereby incorporated by reference.

BACKGROUND

[0002] The disclosure is directed to methods for laser processing optical fibers and fiber optic connectors. More specifically, the disclosure is directed to methods for laser processing optical fibers arranged in arrays and splicing connectors having a dense array of optical fibers.

[0003] Optical fiber is increasingly being used for a variety of applications, including but not limited to broadband voice, video, and data transmission. As bandwidth demands increase there is an unresolved need for high fiber count fiber optic connectors and methods for making the same. Moreover, the high fiber count fiber optic connectors become increasingly difficult to make as the fiber count increases since the number of fibers that must be aligned increases. In other words, the relatively small cores of the array of optical fibers must be aligned with suitable transmission loss levels for all the fibers of the array.

SUMMARY

[0004] The disclosure is also directed to splicing connectors and adapters that provide optical connection between a plurality of optical fibers. Also disclosed are methods for laser processing an array of optical fibers. The methods for laser processing include the steps of providing a structure having a plurality of optical fibers arranged in a plurality of rows, inserting a protection element adjacent to the optical fibers, and then laser processing the first row of optical fibers.

[0005] 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 same as described herein, including the detailed description that follows, the claims, as well as the appended drawings.

[0006] It is to be understood that both the foregoing general description and the following detailed description present embodiments that are intended to provide an overview or framework for understanding the nature and character of the claims. The accompanying drawings are included to provide a further understanding of the disclosure, 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.

BRIEF DESCRIPTION OF THE FIGURES

[0007] **FIGS. 1-6** schematically depict a first method for laser processing a plurality of optical fibers using a protection element disposed between a first row and a second row of optical fibers;

[0008] **FIGS. 7-11** schematically depict a second method for laser processing a plurality of optical fibers using a protection element disposed between a first row and a second row of optical fibers;

[0009] **FIGS. 12-17** schematically depict a third method for laser processing a plurality of optical fibers using a protection element disposed between a first row and a second row of optical fibers;

[0010] **FIGS. 17A-17G** depict another protection element for laser processing a plurality of optical fibers in a plurality of rows;

[0011] **FIG. 18** shows various views of a pair of fiber optic splicing connectors having an array of optical fibers mated together using an adapter;

[0012] **FIG. 19** is a partial sectional view of the fiber optic splicing connector of **FIG. 18**;

[0013] **FIG. 20** is an exploded view of the fiber optic splicing connector of **FIG. 19**;

[0014] **FIG. 21** is a perspective view of an adapter for mating fiber optic splicing connectors having a fiber guide for aligning and splicing optical fibers therein;

[0015] **FIG. 22** is a cross-sectional view of the adapter of **FIG. 21**;

- [0016] **FIGS. 22A-22C** are cross-sectional views showing other adapters having lens-based transmission elements;
- [0017] **FIG. 23** is a perspective view of another adapter for mating fiber optic splicing connectors having a fiber guide for aligning and splicing optical fibers therein;
- [0018] **FIG. 24** is a cross-sectional view of the splicing connector of **FIG. 23**;
- [0019] **FIG. 25** is a partial sectional view of the splicing connector of **FIG. 23** showing details of the gel reservoir entry;
- [0020] **FIG. 26** is a schematic cross-sectional view of the splicing connector of **FIG. 23** showing the profile of the gel reservoir; and
- [0021] **FIGS. 27 and 28** respectively depict an end view and a plan view of the splicing connector of **FIG. 20**;
- [0022] **FIG. 29** shows an optional geometry for the fiber guide bores of the adapter.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

- [0023] Reference will now be made in detail to the preferred embodiments of the disclosure, examples of which are illustrated in the accompanying drawings. Whenever possible, like reference numbers will be used to refer to like components or parts.
- [0024] The embodiments and methods described herein are suitable for preparing and/or making optical connections employing a plurality of optical fibers. The concepts of the disclosure advantageously allow the simple, quick, and economical connection between relatively large numbers of optical fibers. Reference will now be made in detail to the preferred embodiments, examples of which are illustrated in the accompanying drawings. Whenever possible, like reference numbers will be used to refer to like components or parts.
- [0025] **FIGS. 1-6** schematically depict a first method for laser processing the ends of a plurality of optical fibers **10** of structure **30** using a protection element **40**. Laser processing of optical fibers provides a quick and efficient method for producing a high-quality end face on the optical fiber for termination or the like. Structure **30** may be a fiber optic cable, a ribbon, or other suitable structure having an array of optical fibers known in the art or later developed. By way of example, structure **30** may have multiple

ribbons stacked within a cable jacket of the fiber optic cable, thereby defining an array of optical fibers. Other arrangements for the fibers of structure **30** can include one or more groups of loose fibers, loose fibers with ribbonized ends, etc. Although structure **30** shows the array of optical fibers located in linear array other arrangements are possible. Moreover, as used herein “row” means a grouping of optical fibers and is not limited to a linear arrangement. Other structures **30** may have the array of optical fibers included within one or more ribbon matrix materials. The array of optical fibers may be arranged in multiple rows of optical fibers as shown, but the array can have other fiber counts, arrangements, and the like. Additionally, any suitable fiber size, type, and/or spacing arrangement may be used with the concepts disclosed herein for preparing and creating a fiber structure processed using a laser for one or more steps.

[0026] By way of explanation, an end of a cable or assembly can be prepared for securing the optical fibers in a suitable structure by first removing a portion of the cable jacket and then grouping or organizing the fibers as desired for insertion into the structure (i.e., fiber organizer). The structure secures the optical fibers at a common location for inhibiting relative movement among the fibers in the array. Moreover, the structure may be used for holding the same in fixturing, thereby providing a convenient and common location for reference. Thereafter, the optical fibers may be processed as desired for connectorization. For instance, the laser may be used for cleaning, removing and/or ablating one or more coatings on the optical fiber, but other types of mechanical processing methods are possible for removing the coating from the fiber. Further, the laser may be used for cleaving and/or shaping the end of the optical fiber as desired, but may also include a mechanical cleaving and/or polish in addition to the laser processing. Thereafter, the laser processed fibers may be used with suitable connectors or assemblies that may or may not use a ferrule for holding the fibers.

[0027] More specifically, **FIGS. 1-6** depict a first method for laser processing a plurality of optical fibers **10** using a protection element **40**. Protection element **40** is used for protecting optical fibers in the array that are not intended for laser processing since they are located at a further distance from the laser than the optical fibers intended for processing. By way of example, structure **30** has optical fibers disposed in a first row **16** at a first distance and a second row **18** at a second distance so that the laser could not be

focused for both distances. As shown, the first row **16** and second row **18** of optical fibers **10** are schematically shown disposed within a generic structure **30**. The protection element **40** can reflect, absorb and/or disperse the laser energy after it passes the optical fibers being processed depending on the type of material used for the same. For instance, if the protection element **40** is a material that has a smooth surface such as a machined aluminum, stainless steel, etc. it will have a high-degree of reflection. On the other hand, if the protection element **40** is formed from a mica, carbon, ceramic plate or other similar porous material it will have a high-degree of absorption. Still further, the degree of dispersion caused by protection element **40** can depend on the surface finish. In other words, the rougher the surface the greater the dispersion. Examples of surface finishes on protection element **40** that can create dispersion are grooves, knurling, etc.

[0028] Although protection element **40** is shown having a rectangular shape in the drawings other shapes are possible. By way of example, the protection element **40** may be a square or round disc making it easier to rotate and/or translate the same as part of the laser processing of optical fibers. Simply stated, the protective element **40** may move by being rotated and/or translated to provide a fresh surface thereby providing heat dissipation, a clean surface, and/or allow wiping of glass residue from the protection element **40**. Consequently, the life of the protection element is extended by rotating and/or translating the same. Other more sophisticated protection elements are also possible as discussed herein. For instance, the protection element can include a hinged portion having a slot for receiving the current working array of fibers and protecting the array of fibers above and/or below the working array of fibers, thereby making it easier for processing fiber arrays having a relatively small pitch or spacing between fibers.

[0029] In this first explanatory method, protection element **40** has a smooth surface that has a relatively high degree of reflection of the laser energy that impinges on the same. Protection element **40** allows the laser energy to reach the optical fibers being processed, but inhibits the laser energy from damaging the optical fibers not being processed, other portions of structure **30**, or from creating a safety issue, but the protection element may also absorb and/or disperse a portion of the energy depending on the material used. This first method also uses an optional laser absorption element **42** to contain the reflected laser energy. As shown by **FIG. 1**, protection element **40** is

positioned near the ends of the optical fibers **10** and a laser absorption element **42** is disposed above the first row **16** of optical fibers **10** to inhibit the travel of any reflected laser energy from protection element **40**.

[0030] **FIGS. 2-6** depict the other steps for processing optical fibers using the first method. **FIG. 2** shows protection element **40** being positioned adjacent to the plurality of the optical fibers for presenting a first row (i.e., first group) of optical fibers for laser processing and shielding a second row (i.e., second group) of optical fibers from the laser processing. As depicted in this configuration, protection element **40** is inserted between the first row **16** and the second row **18** of optical fibers **10** as represented by the arrow so that the first row of optical fibers **16** may be laser processed while the second row **18** of optical fibers is shielded from the laser. Thereafter, the protection element **40** may optionally translate for pushing the second row **18** of optical fibers away from the first row **16** of optical fibers as represented by the arrow in **FIG. 3**. Pushing the second row **18** of optical fibers away from the first row **16** creates more space between the first row **16** of optical fibers and protection element **40**. As shown in **FIG. 4**, the created space allows the laser energy to diverge before impacting protection element **40** and being reflected. Allowing a laser beam **48** to diverge after processing the optical fibers can inhibit excess removal of the coating from the optical fiber by reducing the energy density (i.e., the energy is spread over a larger area compared with the beam waist). In other words, the increased space allows the laser beam **48** to diverge after contacting the optical fibers and before being reflected.

[0031] Other variations for using the protection element **40** and/or laser absorbing element **42** are possible. As a variation on **FIG. 4**, the laser beam **48** may initially pass thru an opening on top plate **42** before impacting the fibers so that the top plate **42** also acts as a shield for the incoming laser beam **48**. Additionally, the methods and configurations for laser processing disclosed herein may use lenses, mirrors, beam splitters or the like for directing the laser beam to the optical fibers. Although the laser beam of **FIG. 4** is shown approaching from a single-side, other embodiments that directed the laser beam one or more sides such as from both sides are contemplated with the concepts disclosed herein.

[0032] **FIG. 5** depicts a portion of the laser beam **48** being reflected off protection element **40** and a reflected beam **48'** impacting absorption element **42**. During laser processing, the laser beam **48** may be swept across the first row **16** in any suitable manner to process the optical fibers **10**. **FIG. 6** depicts structure **30** after laser processing the first row **16** of optical fibers **10**. Thereafter, a similar process may be repeated on the second row **18** of optical fibers **10** or repeated for a further row or grouping of fibers. Additionally, protection element **40** may be rotated and/or translated as represented by the arrow in **FIG. 6** for presenting a fresh surface as described above.

[0033] **FIGS. 7-11** schematically depict a second method for laser processing a plurality of optical fibers **10** using protection element **40**. The second method is similar to the first method, except that the protection element **40** is formed from a material having a high degree of absorption (i.e., ideally no reflection). **FIG. 8** shows protection element **40** being inserted between the first row **16** and the second row **18** of optical fibers **10** as represented by the arrow. Thereafter, the protection element **40** may optionally translate for pushing the second row **18** of optical fibers away from the first row **16** of optical fibers as represented by the arrow in **FIG. 9**. Pushing the second row **18** of optical fibers away from the first row **16** creates more space between the first row **16** of optical fibers and protection element **40**. Additionally, an optional absorption element (not shown) may be placed above the first row **16** of optical fibers for safety. As shown in **FIG. 10**, the created space allows the laser energy to diverge before impacting protection element **40**. Allowing a laser beam **48** to diverge from the beam waist after contacting and processing the optical fibers reduces the energy density that impacts protection element **40** and generally speaking prolongs its life. During laser processing, the laser beam **48** may be swept across the first row **16** in any suitable manner to process the optical fibers **10**. **FIG. 11** shows the first row **16** of optical fibers **10** after laser processing and a similar process may be repeated on the second row **18** of optical fibers **10** such as by flipping the structure **30** or using a second laser from the other side.

[0034] **FIGS. 12-17** schematically depict a third method for laser processing a plurality of optical fibers **10** using protection element **40**. The third method is similar to the first and second methods, except that the protection element **40** is formed from a material having a high degree of dispersion. **FIG. 13** shows protection element **40** being

inserted between the first row **16** and the second row **18** of optical fibers **10** as represented by the arrow. Thereafter, the protection element **40** may optionally translate for pushing the second row **18** of optical fibers away from the first row **16** of optical fibers as represented by the arrow in **FIG. 14**. As stated before, pushing the second row **18** of optical fibers away from the first row **16** creates more space between the first row **16** of optical fibers and protection element **40**, thereby allowing the laser beam to diverge before impacting protection element **40** as shown in **FIG. 15**. Additionally, an optional absorption element (not shown) may be placed above the first row **16** of optical fibers for safety. **FIG. 16** depicts the laser beam **48** diverging after being reflected from protection element **40**. As with the other methods, the laser beam **48** may be swept across the first row **16** in any suitable manner to process the optical fibers **10**. **FIG. 17** shows the first row **16** of optical fibers **10** after laser processing and a similar process may be repeated on the second row **18** of optical fibers **10** such as by flipping the structure **30** or using a second laser from the other side.

[0035] Although the methods disclosed show processing an array of optical fibers having two rows as shown, structures having more rows and/or other array arrangements of optical fibers can be processed using the concepts disclosed herein. For instance, processing more than two rows may involve bending the upper rows out of the way such as by using a second protective element so that particular individual rows can be exposed and processed with the laser beam. Consequently, much larger arrays of optical fibers may be laser processed using the concepts disclosed herein.

[0036] **FIGS. 17A-17G** depict another protection element **140** configured as a fiber separation device having a hinge **146** for laser processing an array of optical fibers. Protection element **140** aids when processing optical fibers **10** of structure **30** having a relatively small pitch among the groups of fibers (i.e., relatively tight spacing among the fibers) and especially advantageous when there are three or more rows of fibers. **FIG. 17A** shows the fiber separation device having a lower portion (or first portion) **142** and an upper portion (or second portion) **144** connected by hinge **146**, thereby allowing relative movement between the lower portion **142** and upper portion **144**. **FIG. 17B** shows the protection element **140** positioned about the optical fibers of structure **30**. Moreover, the lower portion **142** and the upper portion **144** form a space **148** between hinge **146** so that

the one or more fibers being processed by the laser can pass through the space **148** as best shown in **FIG. 17C**. Protection element **140** may also optionally include one or more recesses or trays **143** for positioning optical fibers therein.

[0037] In other words, the protective element **140** is positioned so that the hinge **146** is pointing towards the ends of the optical fibers of structure **30** as shown by **FIG. 17A**. The fibers of structure **30** intended for processing are positioned so that they enter the space **148** of protection element **140** and are positioned between lower portion **142** and upper portion **144** as shown in **FIG. 17B**. The other rows of fibers not intended for laser processing are located either below the lower portion **142** or above the upper portion **144** so that they are positioned out of the way. Thereafter, the lower portion **142** and/or upper portion **144** can rotate (i.e., be spread apart) for providing access to the row of optical fibers intended for processing such as shown by **FIG. 17C**. **FIG. 17D** shows the laser beam **48** being used to process a row of optical fibers and how the other fibers are shielded from the laser beam **48** using protective element **140**. As one row of fibers is finished with laser processing, the structure **30** is moved outward to remove the processed fibers and downward to align the next row of fibers with the space **148** as the protection element is positioned to laser process the next row of fibers as shown in **FIG. 17E**. **FIG. 17F** shows a rear perspective view showing the laser processed fibers protected by the upper portion **144** and the fiber that still require processing protected by the lower portion **142**. It is also possible to index the laser off a portion of the structure **30** and/or other locations for maintaining similar lengths of fibers in the array after laser processing. Protection element **140** may also be used with a device/element **160** for energy capture as depicted in **FIG. 17G**.

[0038] The protection elements disclosed herein can have other features that aid in the laser processing and/or inhibit damage to the optical fibers. For instance, the outer surface of the upper portion can have a relatively soft insert in recess **143** for cushioning the processed optical fibers, thereby inhibiting damage to the same. Likewise, the protection element can have an active cooling element such as running water through passages in the same for dissipating heat from the protective structure. As discussed above, the protection element can have a surface that reflects, absorbs and/or disperses a portion of the energy depending on the material and/or surface finishing selected. Of

course other suitable structures are possible using the concepts disclosed herein. For instance, a protection element configured as a fiber separation device can be formed from two portions that operate in a similar manner to protection element **140** but are attached in another suitable manner besides a hinge such as a rib and slot for alignment and opening. Although protection element **140** is shown as having a hinge with a movable portion it is possible to fix the first and second portions at a fixed angle with a space therebetween and use the device in a similar manner by inserting the row of fibers for processing through the space of the device. After laser processing one or more structures having an array of optical fibers, the structure(s) may be used with a suitable fiber optic connector or other termination devices, thereby permitting a plurality of optical connections. This is advantageous since the craft can quickly and easily make a large number of optical connections with a relatively small footprint (i.e., high connection density). For instance, a fiber optic connector can have 24-fibers or more such as 36-fibers, 48-fibers or 72-fibers. Examples of fiber optic connectors and/or termination devices for use with these structures is disclosed herein, but other types of fiber optic connectors and/or termination devices may also employ optical fibers processed using the methods described herein.

[0039] **FIG. 18** depicts a side view, a perspective view, and top view of two fiber optic splicing connectors **50** (hereinafter splicing connector) having an array of optical fibers **52** mated together using an adapter **90**. The optical fibers **52** of splicing connectors **50** may be processed using a laser according to one of the methods disclosed herein, but other methods of process the same are possible.

[0040] **FIG. 19** is a partial sectional view along with an enlarged detail portion of splicing connector **50** showing a relatively long length of optical fibers **52** protruding from a fiber guide **54** within an outer housing **56**. Optical fibers **52** have a relatively long length that extends beyond fiber guide **54** since they are aligned and spliced to complimentary mating optical fibers within adapter **90** without the use of a ferrule. In other words, the splicing connectors disclosed do not use a ferrule to support and mate optical fibers like conventional fiber optic connectors; but, rather are spliced with complimentary optical fibers in the adapter as discussed below. Simply stated, fiber guide **54** is used for supporting and aligning optical fibers **52** when mating splicing

connector **50** within a splice guide of the adapter **90**. Moreover, fiber guide **54** is biased to a forward position and can move relative to optical fibers **52** (i.e., translate backwards) for exposing a longer length of the same to extend into the splice guide of adapter **90**.

[0041] **FIG. 20** is an exploded view of splicing connector **50** depicting the component and assembly of the same. As shown, splicing connector **50** includes fiber guide **54**, outer housing **56**, a spring push **58**, a spring **60**, a crimp body **62**, a crimp band **64**, and a boot **68**. When assembled, fiber guide **54**, spring push **58** and spring **60** are disposed between the outer housing **56** and crimp body **62**. In other words, crimp body **62** includes a pair of latching fingers (not numbered) that cooperate with latching windows (not numbered) at the rear of outer housing for securing the components together. Consequently, fiber guide **54** is disposed within outer housing **56** as shown in **FIG. 19** and is biased to the forward position by spring **60**. Outer housing **56** can have any suitable configuration and is sized, shaped, keyed, latching features, etc. for mating with adapter **90**. Crimp body **62** includes a passageway therethrough so that the optical fibers **52** may be routed to therethrough to the front portion of splicing connector **50**. Crimp body **62** also includes a crimp portion at the rear for securing strength members of a fiber optic cable or the like using crimp band **64**, thereby providing strain relief. Thereafter, boot **68** may be placed over the rear portion of the crimp body **62** for completing the assembly. Other constructions for splicing connector are possible and splicing connectors may be mated with any suitable adapter for making splicing connections among optical fibers.

[0042] **FIGS. 21 and 22** respectively depict a perspective view and cross-sectional view of one explanatory adapter **100** for receiving and mating splicing connectors similar to splicing connectors **50**. Adapter **100** includes a housing **102**, a splice guide **110**, and a cap **130**. Splice guide **110** is used for aligning and splicing optical fibers from the splicing connectors therein. Additionally, splice guide **110** includes a cavity **114**. Cavity **114** can include one or more transmission elements for aiding the transmission of optical signals between the fibers of the splicing connectors received in opposite ends of adapter **100**. For instance, the cavity can use a transmission element such as an index-matching material or beam expanding lenses for aiding the optical signal transmission therethrough. As an example, the cavity **114** may be a reservoir for

an index matching material located between the fiber ends. Cavity **114** has an opening **118** for filling the cavity **114** and securing reservoir cap **130**. Cavity **114** may be filled with a suitable index-matching material such as a gel for improving the optical connection between spliced optical fibers as known in the art. Thereafter, reservoir cap **130** may be secured splice guide **110** to inhibit the index-matching material from escaping. Additionally, housing **102** may have any suitable geometry for mounting, latching the splice connector, keying the splice connector, etc.

[0043] Other structures and methods are also possible for aligning the fibers for transmitting optical signals between the arrays of fibers inserted into the adapter. For instance, the adapter could include beam expanding lenses between the arrays of fibers. By way of example, the cap could be modified to include a plurality of beam expanding lens for transmitting signals between the optical fibers inserted from each end. **FIGS. 22a-22c** depict alternative adapters **100'** similar to adapter **100**, but use a lens element **130'** as the transmission element within the cavity **114** instead of an index-matching material. In particular, **FIGS. 22a-22c** shows different lens elements **130'** that respectively use a plurality of convex lenses **132**, a plurality of concave lenses **134**, and a plurality of graded refractive index (GRIN) lenses **136** for beam expansion. As with cap **130**, the lens elements **130'** are removable for allowing cleaning and/or replacement of the same. Embodiments using the GRIN lenses are advantageous since they may be used with an index matching material which allows the fibers to abut the GRIN lenses, whereas the concave or concave lenses are preferably dry (i.e., no index matching material) and the fiber are located at or near the the focal point of the lens. Also the GRIN lenses may have a well for receiving the index-matching material if desired.

[0044] In these embodiments, adapters **100** and **100'** include a splice guide **110** configured as an insert that fits into housing **102**. Configuring splice guide **110** as an insert of adapter **100** or **100'** is advantageous for manufacturing since the high-precision structure can be manufactured into the insert and not the entire assembly (i.e., the housing). Splice guide **110** includes a rib **116** that fits into a groove (not numbered) of housing **102** as shown for seating the same with respect to housing **102**. Housing **102** also includes an opening **103** for receiving reservoir cap **130** or lens element **130'** therethrough. To assemble the adapters, the splice guide **110** is inserted into housing **102**

so that rib **116** is seated into the groove of housing **102**. Thereafter, the reservoir cap **130** or lens element **130'** can be inserted through the opening **103** of housing **102** so that it attaches to the opening **118** of cavity **114** of the splice guide **110**. For the embodiments using an index-matching material, cavity **114** of splice guide **110** may be filled with an index-matching material at any suitable time such as before inserting the splice guide **110** into housing **102**, before attaching the reservoir cap **130**, or the reservoir cap **130** may be removed after assembly to fill cavity **114**.

[0045] As best shown in **FIG. 22**, splice guide **110** has a plurality of bores (not numbered) that extend from a first end and a plurality of bores (not numbered) that extend from a second end. The plurality of bores disposed on the first and second ends of the splice guide **110** extend into a cavity **114**. The bores include a fiber lead-in portion **112** for guiding each respective optical fiber to a precision opening (not numbered) adjacent to cavity **114**. In other words, the lead-in portion **112** receives the respective optical fiber from the splicing connector and provides coarse alignment and guides the optical fiber to the precision opening. Consequently, mating optical fibers from each mating splicing connector inserted into adapter **100** are precisely aligned and abutted within the cavity **114** that has the index-matching material therein. In the case of adapters **100'**, the mating optical fibers from each mating splicing connector are inserted into adapter **100'** are precisely aligned and adjacent and/or abutted to the respective lenses of lens cap **130'**. When the splice connector is inserted into adapter **100** the optical fibers are received in respective lead-in portions **112** of the splice guide, then as the fiber guide of the splice connector abuts splice guide of the adapter **100**, the fiber guide slides rearward relative to the optical fibers so they can be fully inserted into the splice guide **110**. Moreover, the optical fibers may have a slight overlength for mating, thereby keeping the optical fibers abutted in physical contact with a small spring force and/or slight bend in the optical fibers to ensure good optical connectivity.

[0046] **FIGS. 23 and 24** respectively are a perspective and cross-sectional view of another adapter **200** for mating splicing connectors, thereby making high-density optical connections. Adapter **200** is similar to adapter **100** in operation and other respects, but it has a fiber guides **210** that are integral with the housing, thereby eliminating the number of components. However, adapter **200** may be more difficult to

manufacture since the high-precision portions are integrated with the housing (not numbered). Adapter **200** includes fiber guides **210** having a plurality of bores that respectively extend from a first end and a second end to a cavity **214**. Cavity **214** is configured for receiving an index-matching material therein for improving the optical connection between abutting optical fibers. Additionally, cavity **214** has an opening **218** for filling the same with an index-matching material and which may be closed or sealed with a cap or other suitable structure (not shown). As best shown in **FIGS. 24 and 25**, the side of fiber guides **210** adjacent to cavity **214** includes a plurality of tunnels **213** for aiding manufacturing. **FIG. 26** is a schematic cross-sectional view of adapter **200** showing the profile of the cavity **214**. **FIGS. 27 and 28** respectively depict an end view and a plan view of adapter **200** showing details like keying features **219** and the like.

[0047] **FIG. 29** shows an optional geometry for the fiber guide of an adapter. Specifically, **FIG. 29** shows the detail of a bore **240** of the fiber guide that includes a plurality of ribs **242**. Ribs **242** act as a centering structure allowing alignment of the optical fibers within the bore by centering the optical fiber therein. Other configurations of ribs may use other shapes, positions, and/or other numbers for providing centering for the optical fibers.

[0048] Although the disclosure has been illustrated and described herein with reference to preferred embodiments and specific examples thereof, it will be readily apparent to those of ordinary skill in the art that other embodiments and examples can perform similar functions and/or achieve like results. All such equivalent embodiments and examples are within the spirit and scope of the disclosure and are intended to be covered by the appended claims. It will also be apparent to those skilled in the art that various modifications and variations can be made to the present invention without departing from the spirit and scope of the same. Thus, it is intended that the present invention cover the modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents.

We claim:

1. An adapter for a splicing connector, comprising:
a splice guide insert having a first plurality of bores that extend from a first end of the splice guide insert and a second plurality of bores that extend from a second end of the splice guide insert, and a cavity, wherein the first plurality of bores and the second plurality of bores extend to the cavity, wherein the cavity is configured for receiving a transmission element; and
a housing that receives the splice guide insert.
2. The adapter of claim 1, wherein the cavity is a gel reservoir.
3. The adapter of claim 2, wherein the gel reservoir contains an index matching material.
4. The adapter of claims 1-3, further including a cap that is removable from the splice guide insert.
5. The adapter of claim 4, the cap having a plurality of lenses.
6. The adapter of claims 1-5, wherein at least some of the plurality of bores has a plurality of ribs.
7. The adapter of claims 1-6, wherein the splice guide has a plurality of rows.
8. The adapter of claims 1-7, wherein the adapter can mate thirty-six or more fibers.
9. The adapter of claim 1, wherein the cavity receives a plurality of beam expanding lenses.
10. The adapter of claim 9, wherein the plurality of beam expanding lenses are selected from the group consisting of: concave lenses, convex lenses, and GRIN lenses.

11. The adapter of claims 1-10, further including a plurality of laser processed optical fibers disposed within the splice guide.
12. A splicing connector assembly, comprising:
 - a fiber guide having a plurality of bores, the plurality of bores extending from a rear end of the fiber guide to a front end of the fiber guide;
 - a plurality of optical fibers, each one of the plurality of optical fibers being disposed in a respective bore of the fiber guide;
 - a spring for biasing the fiber guide to a forward position; and
 - an outer housing, wherein the fiber guide can translate relative to the plurality of optical fibers.
13. The splicing connector assembly of claim 12, the fiber guide having a plurality of rows for receiving the plurality of optical fibers.
14. The splicing connector assembly of claims 12 or 13 being attached to an adapter.
15. The splicing connector assembly of claims 12-14, the plurality of optical fibers being laser processed.
16. The splicing connector assembly of claim 12 being attached to an adapter having a plurality of lenses or an index-matching material.
17. The splicing connector assembly of claims 12-16, the plurality of optical fibers being laser process using a protection element.
18. The splicing connector assembly of claim 12, wherein the plurality of optical fibers are laser processed in a method comprising the steps of:
 - providing a plurality of optical fibers arranged in a plurality of rows;

inserting a protection element adjacent to a first row of optical fibers and a second row of optical fibers for shielding the second row of fibers; and
laser processing the first row of optical fibers.

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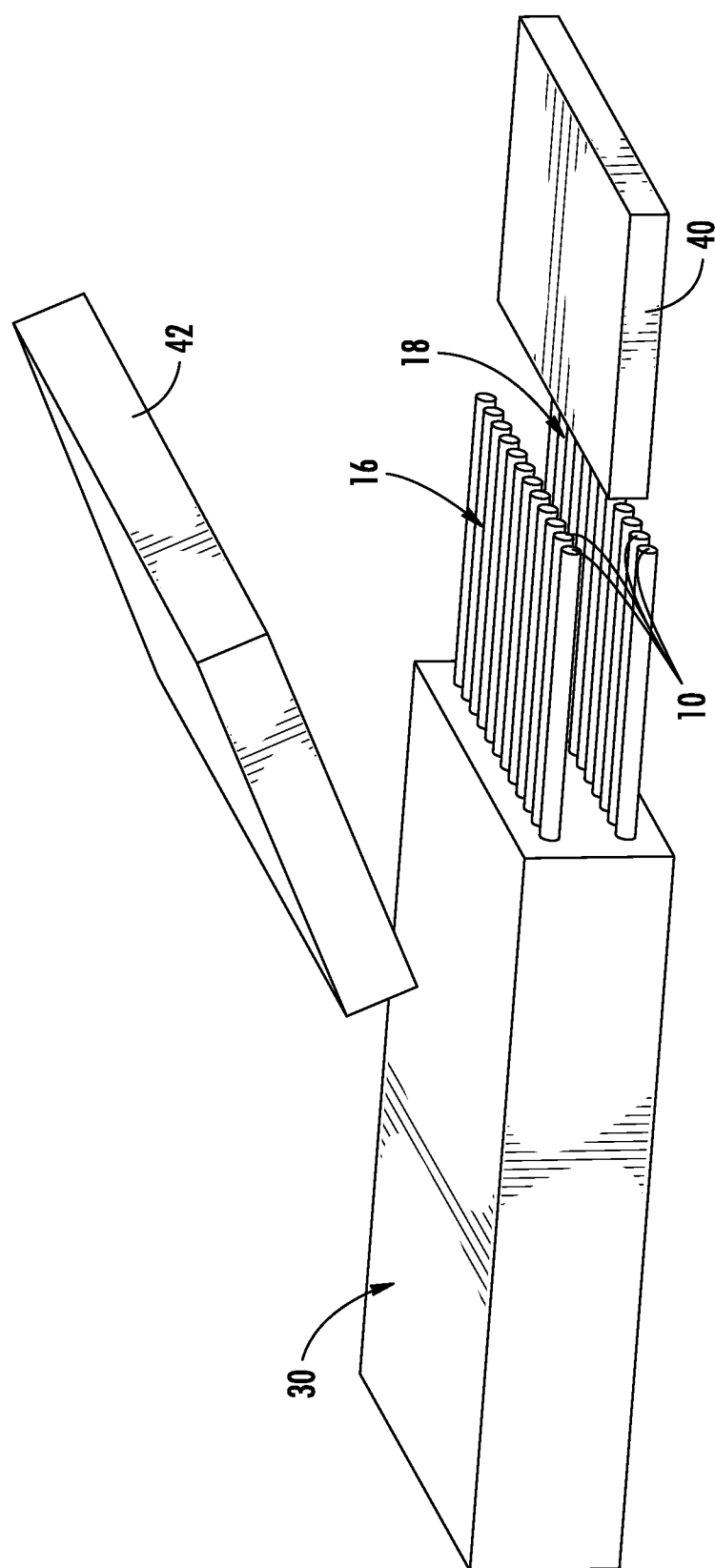


FIG. 1

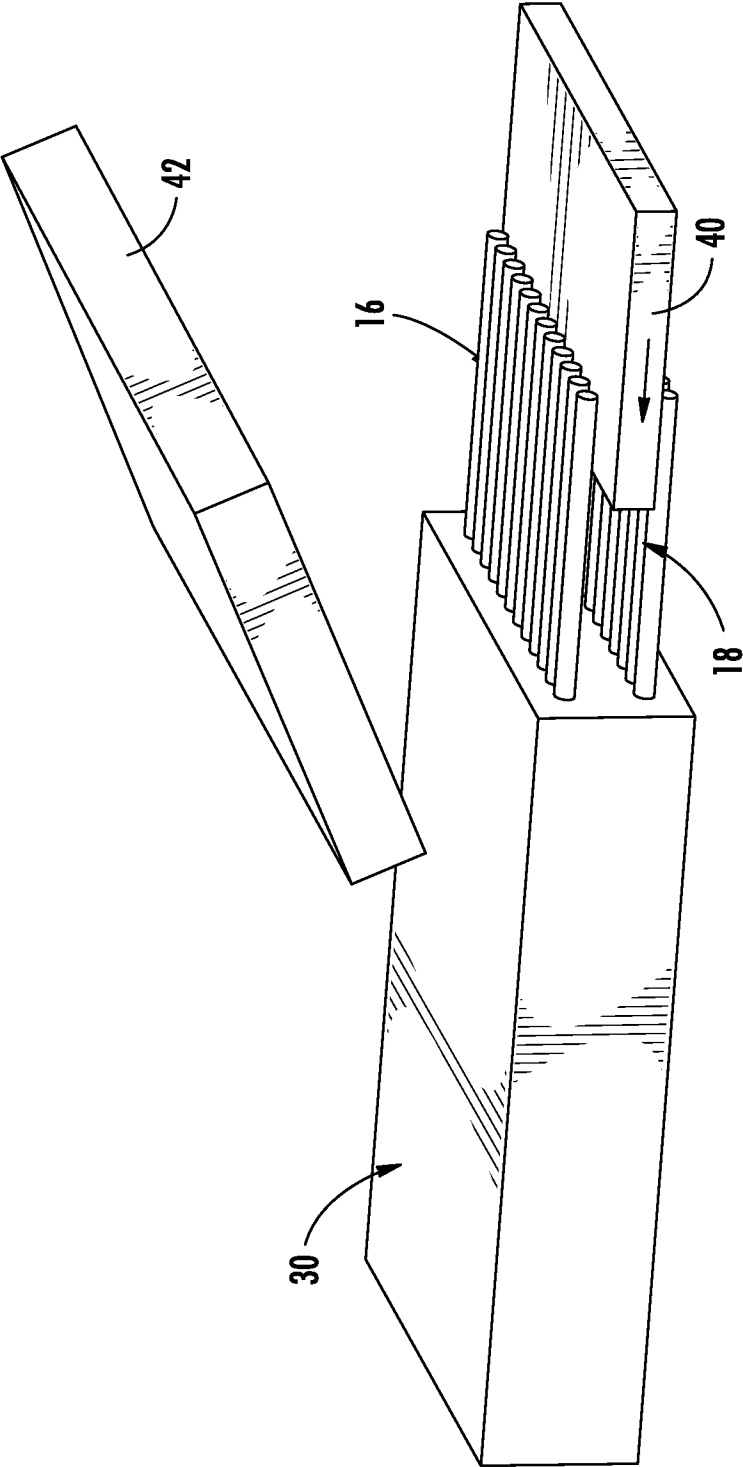


FIG. 2

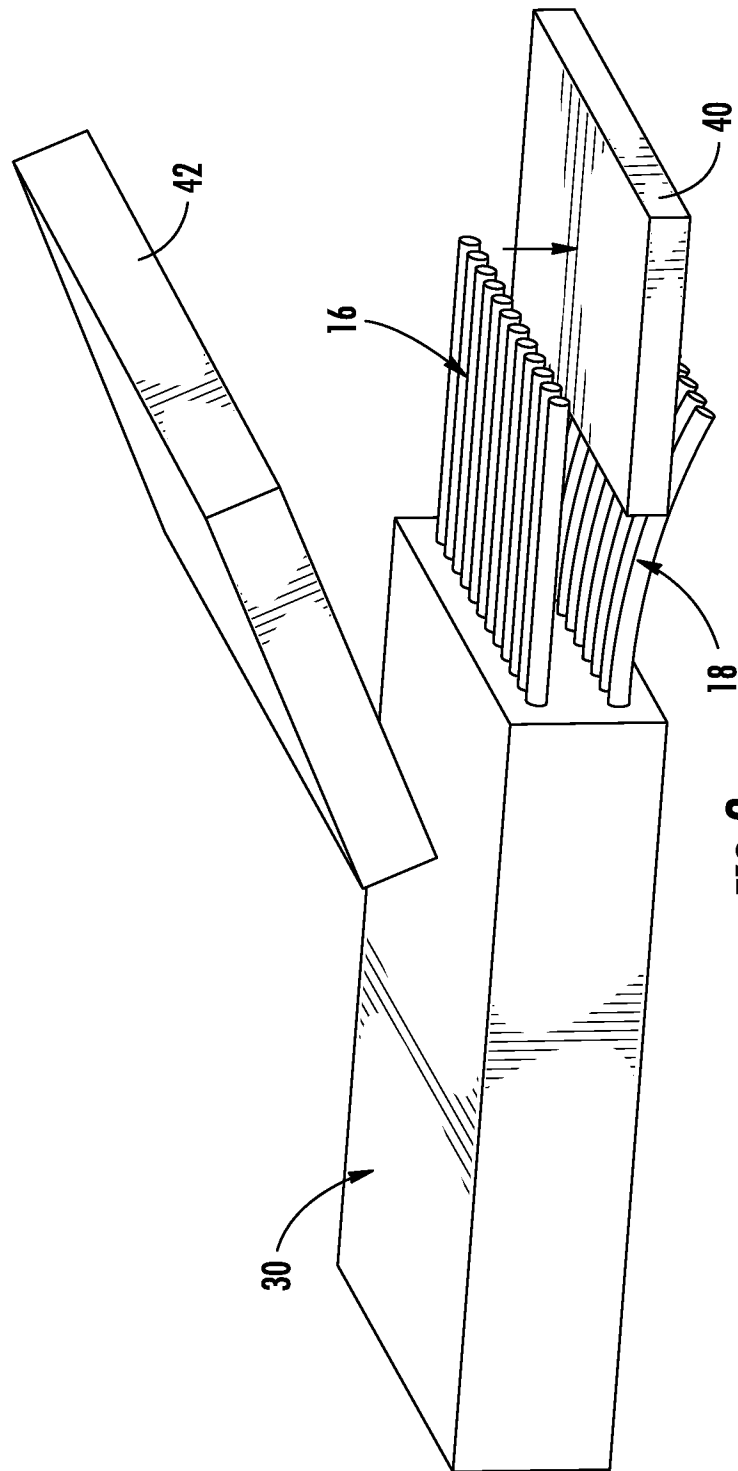


FIG. 3

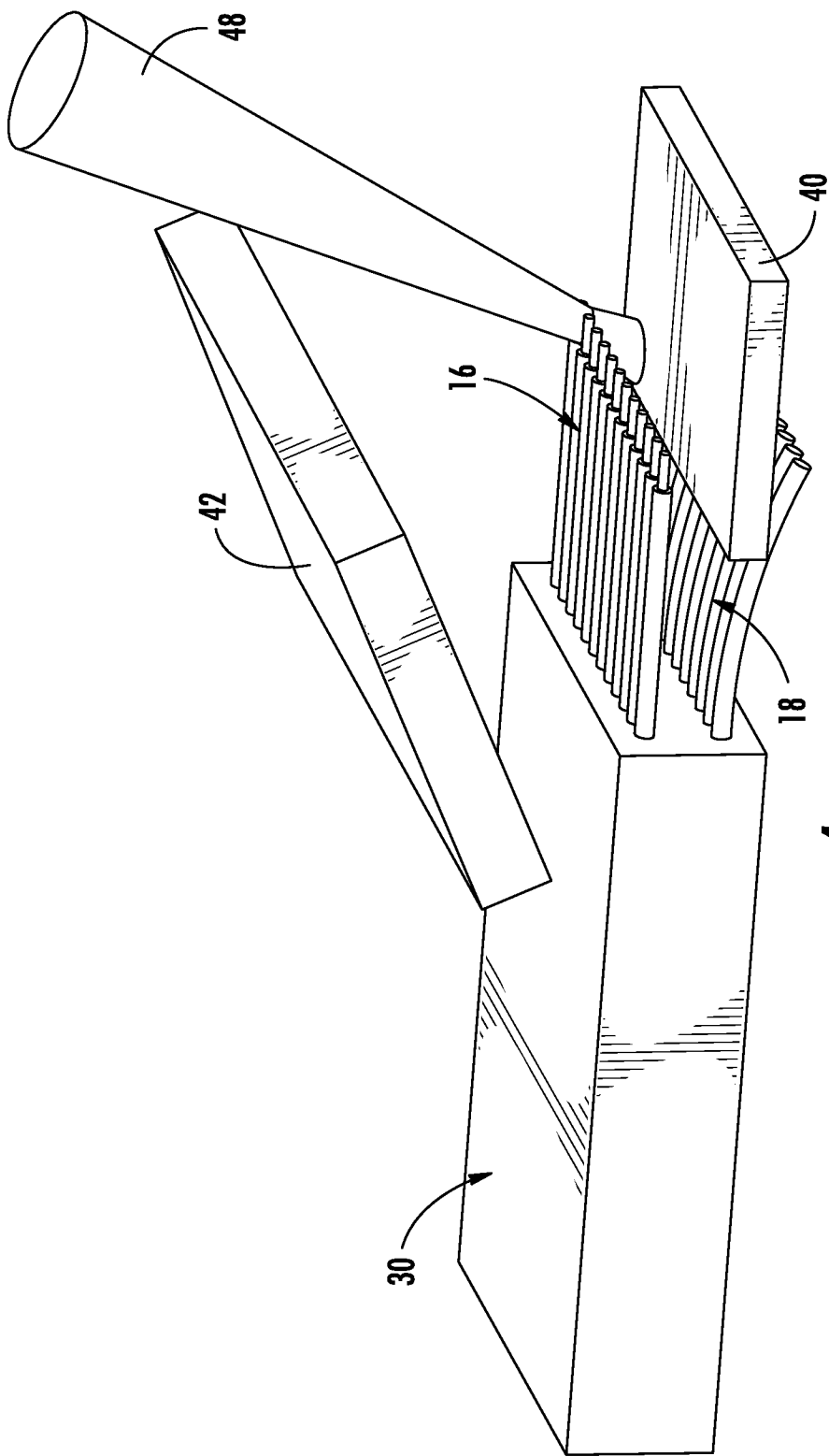


FIG. 4

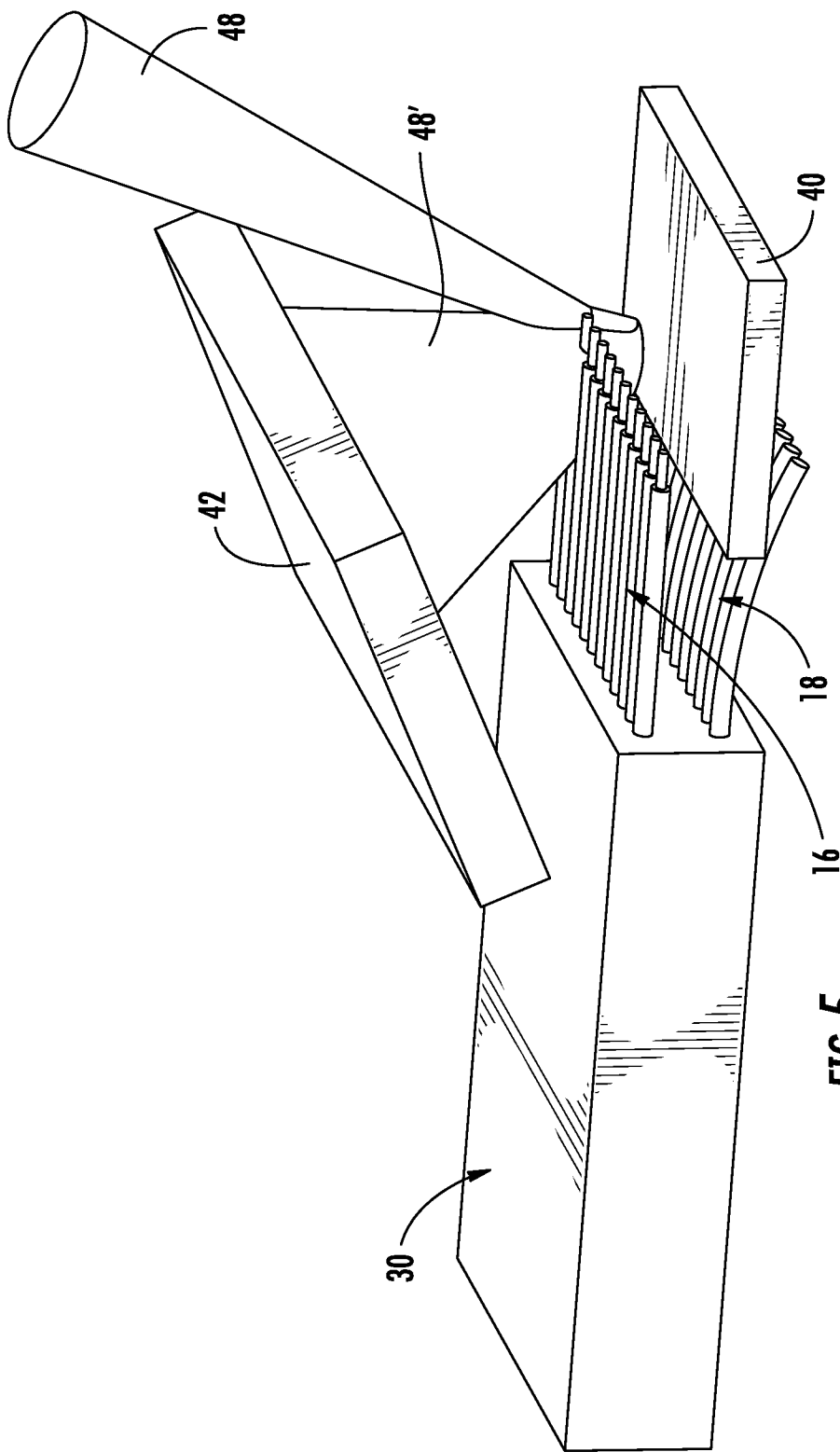


FIG. 5

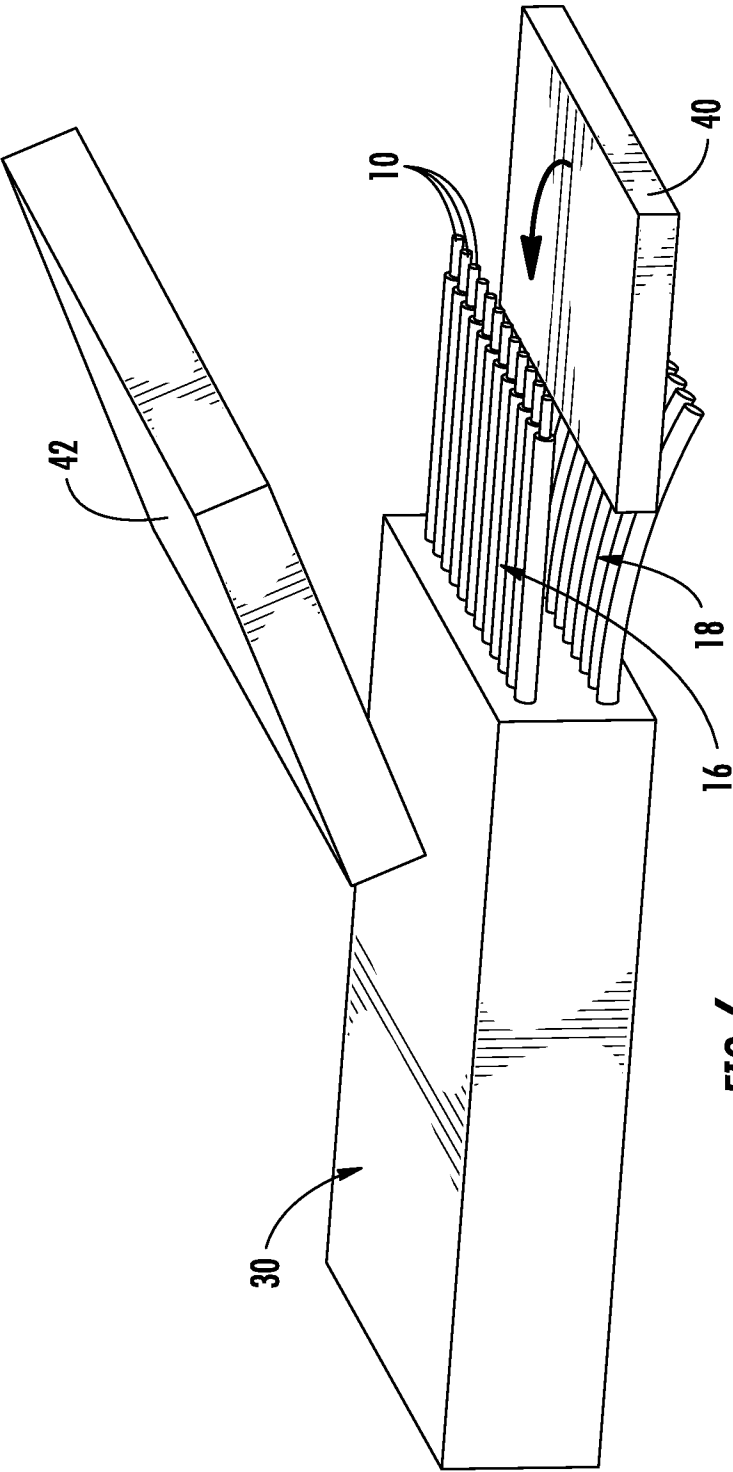
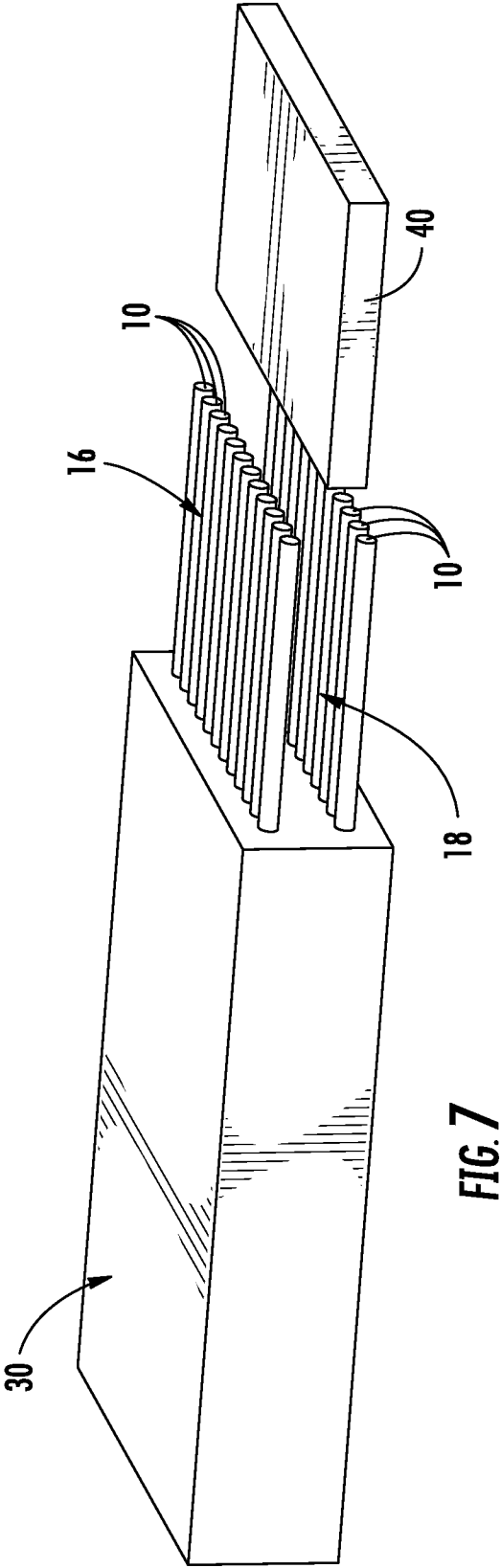


FIG. 6



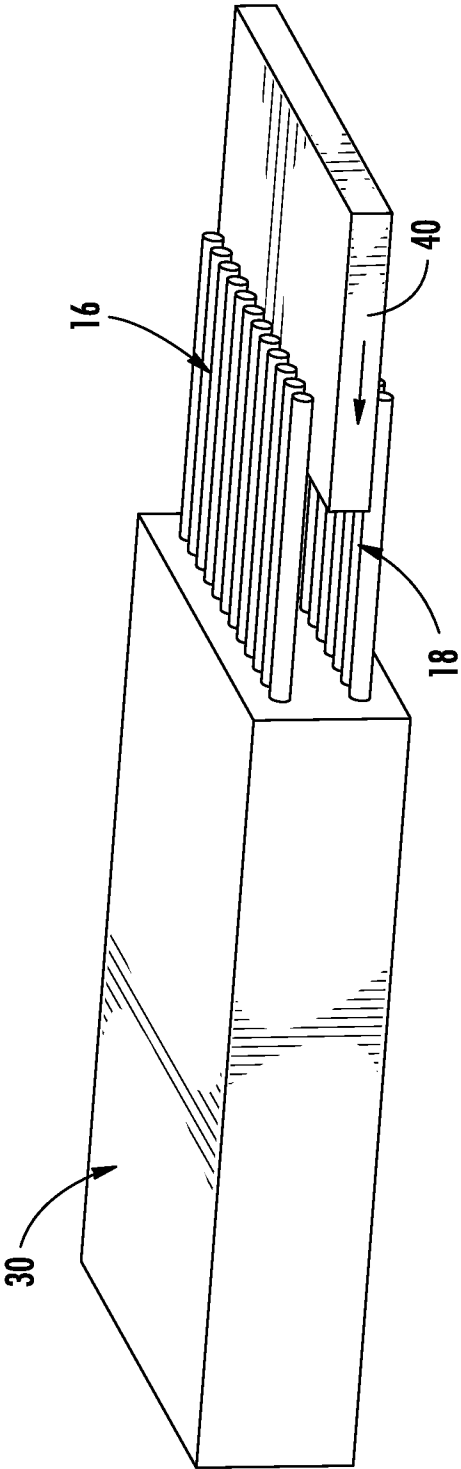
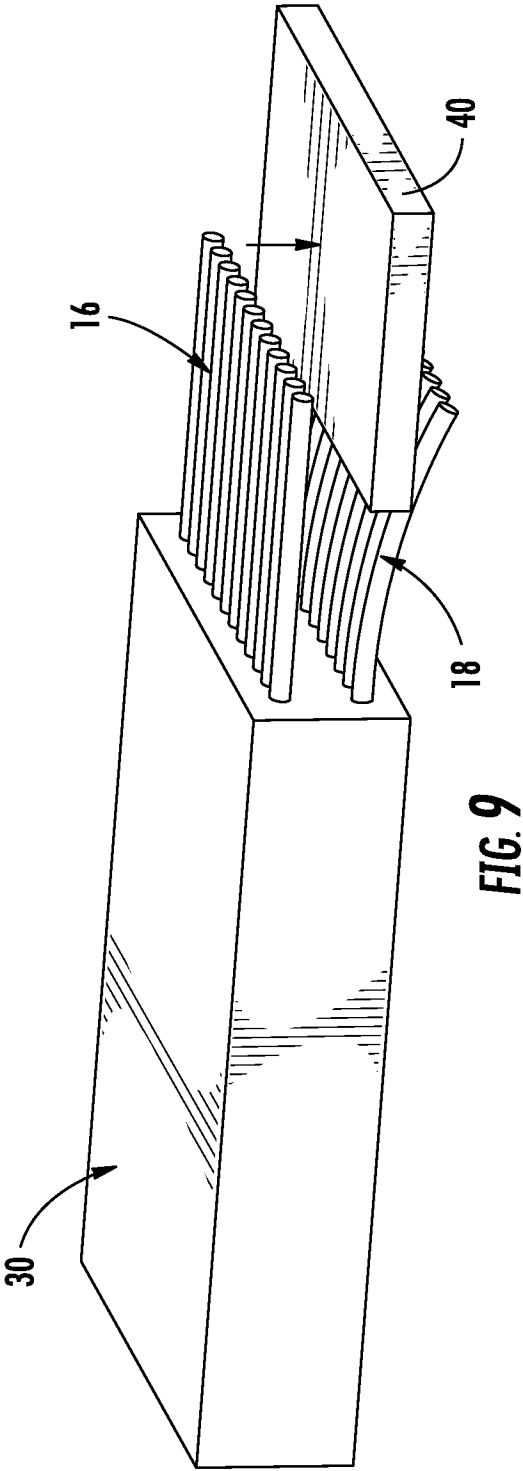


FIG. 8



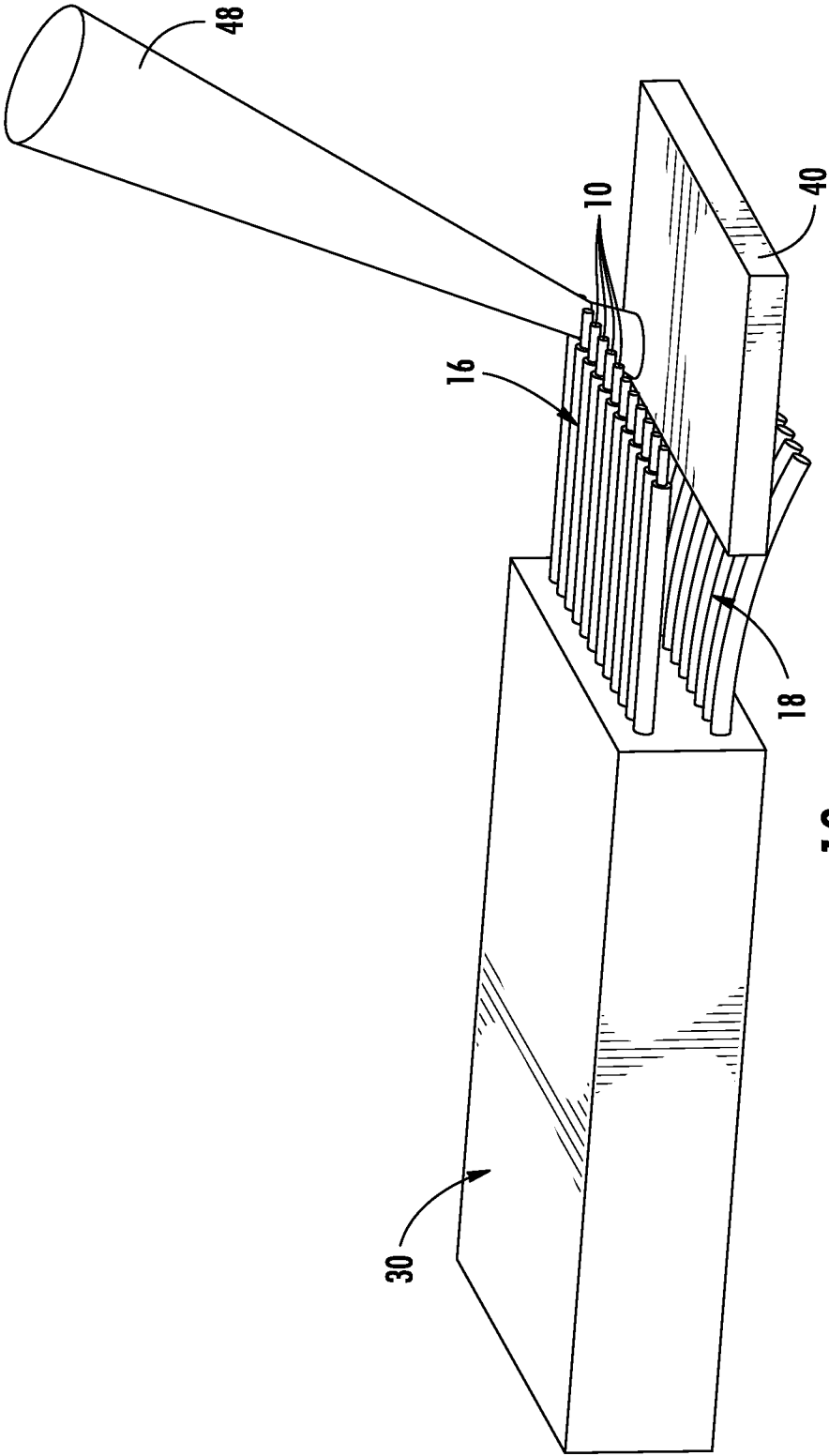
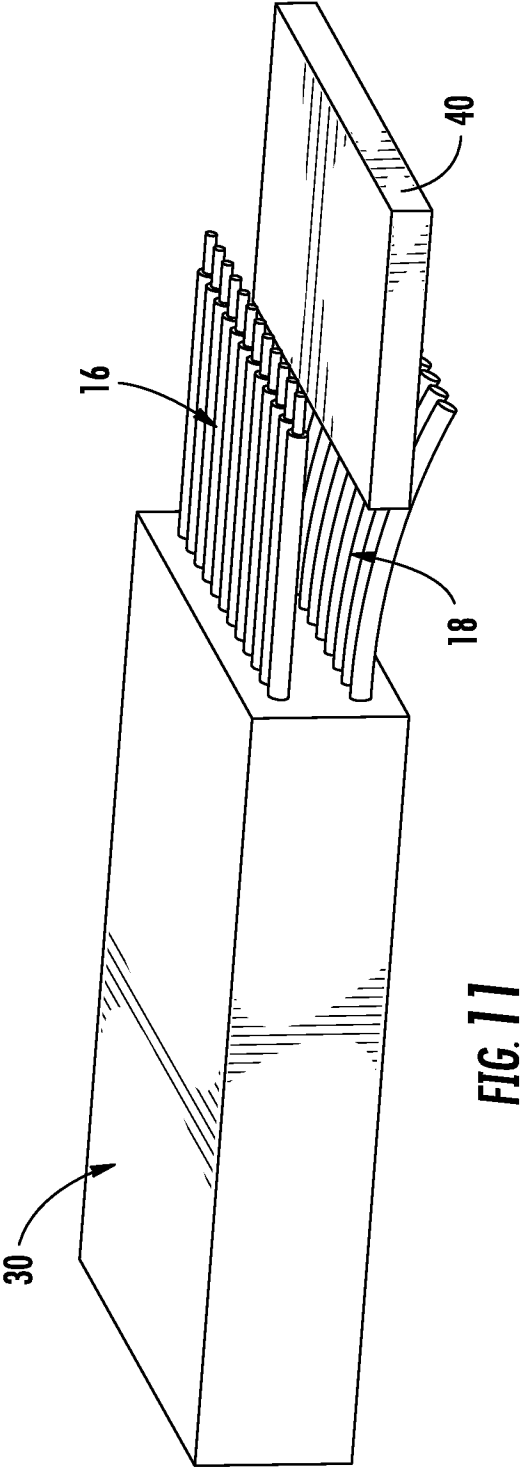


FIG. 10



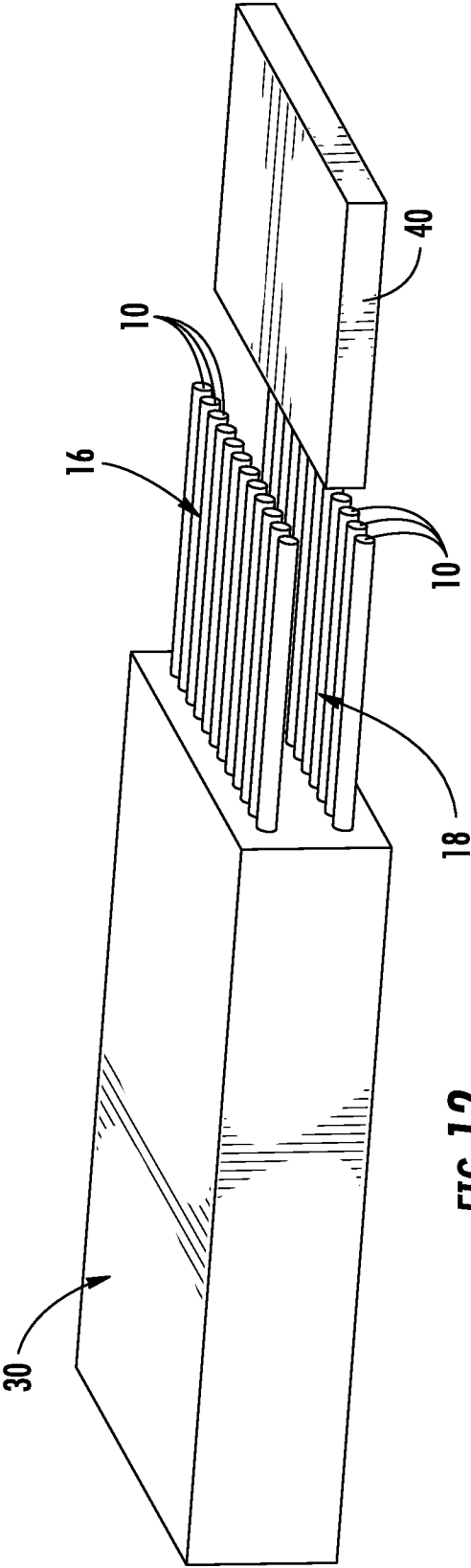


FIG. 12

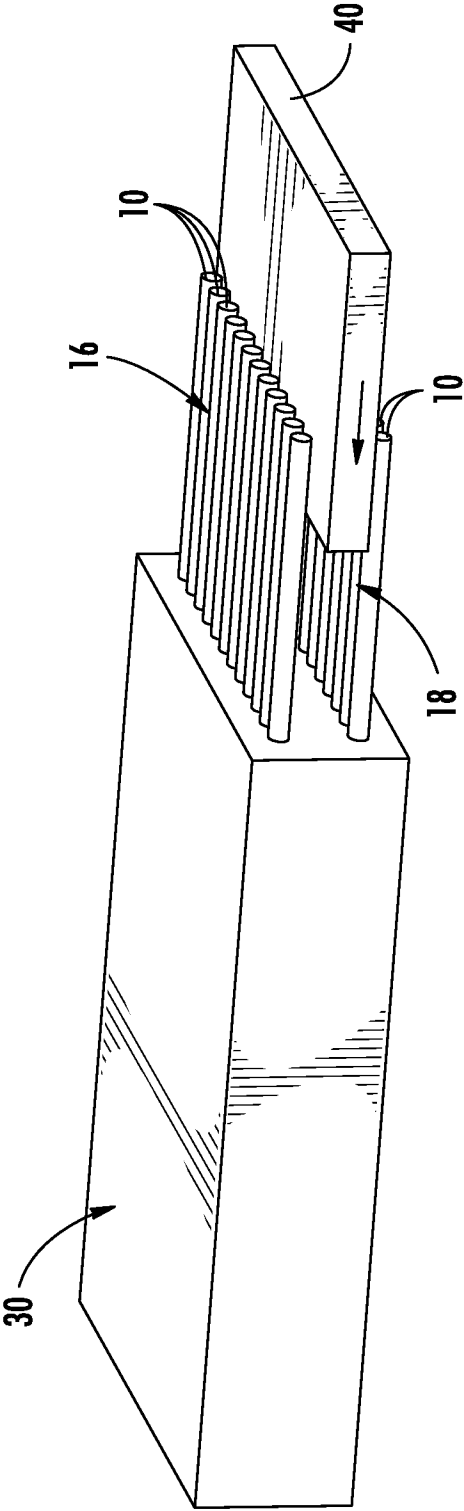
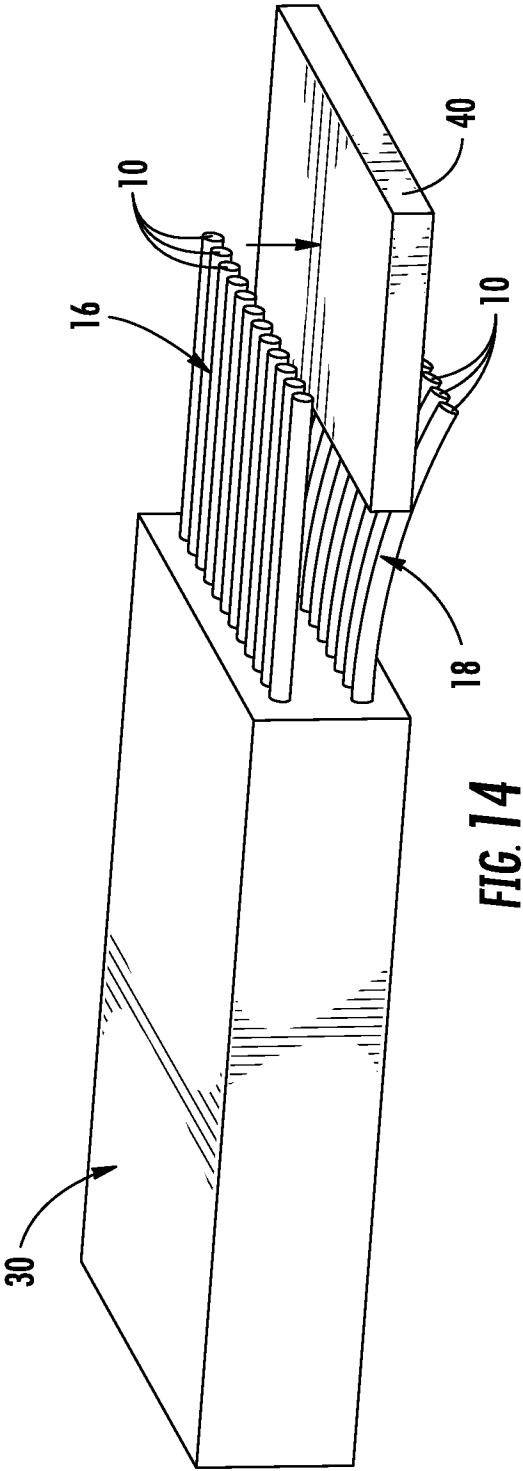


FIG. 13



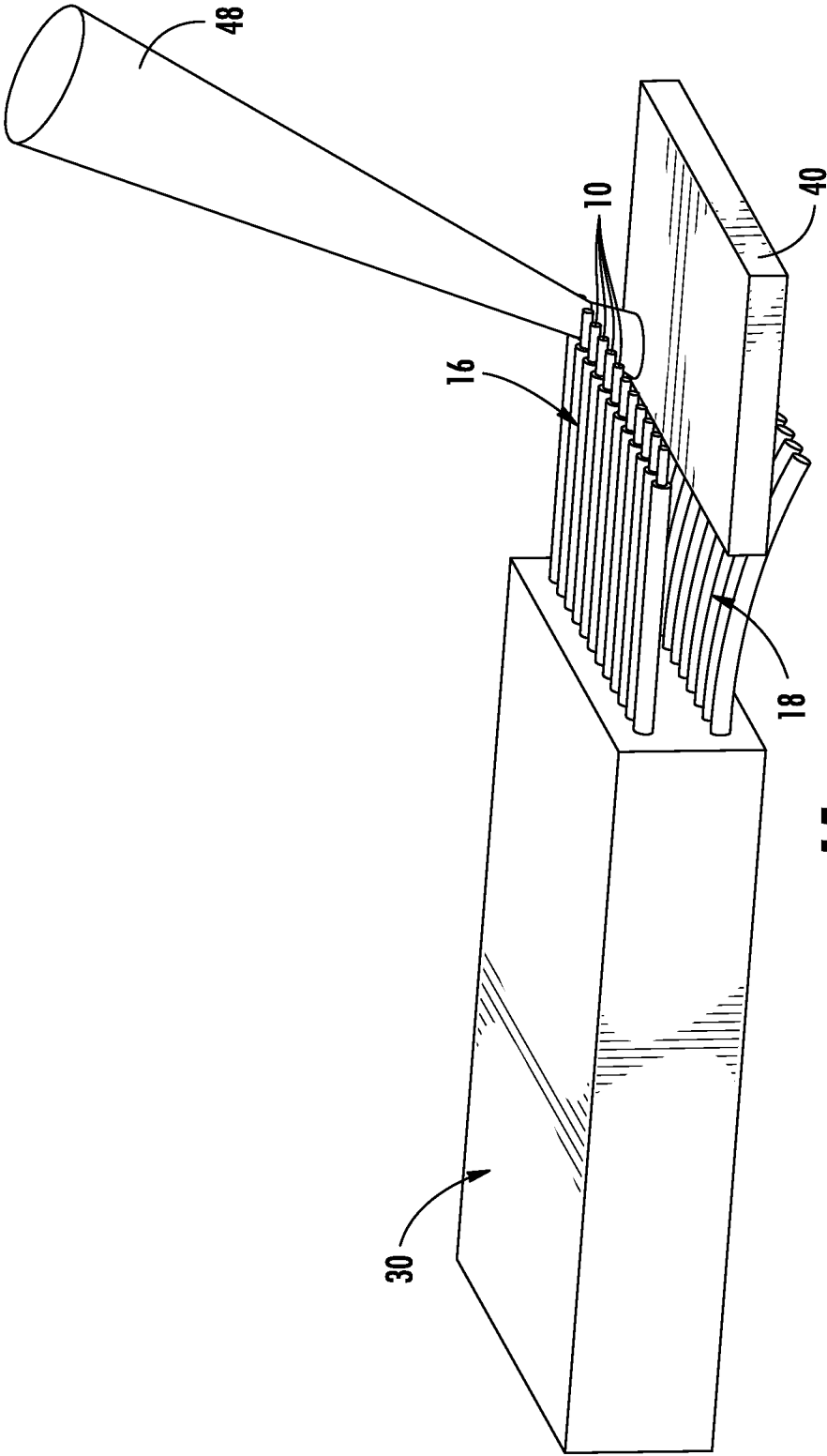


FIG. 15

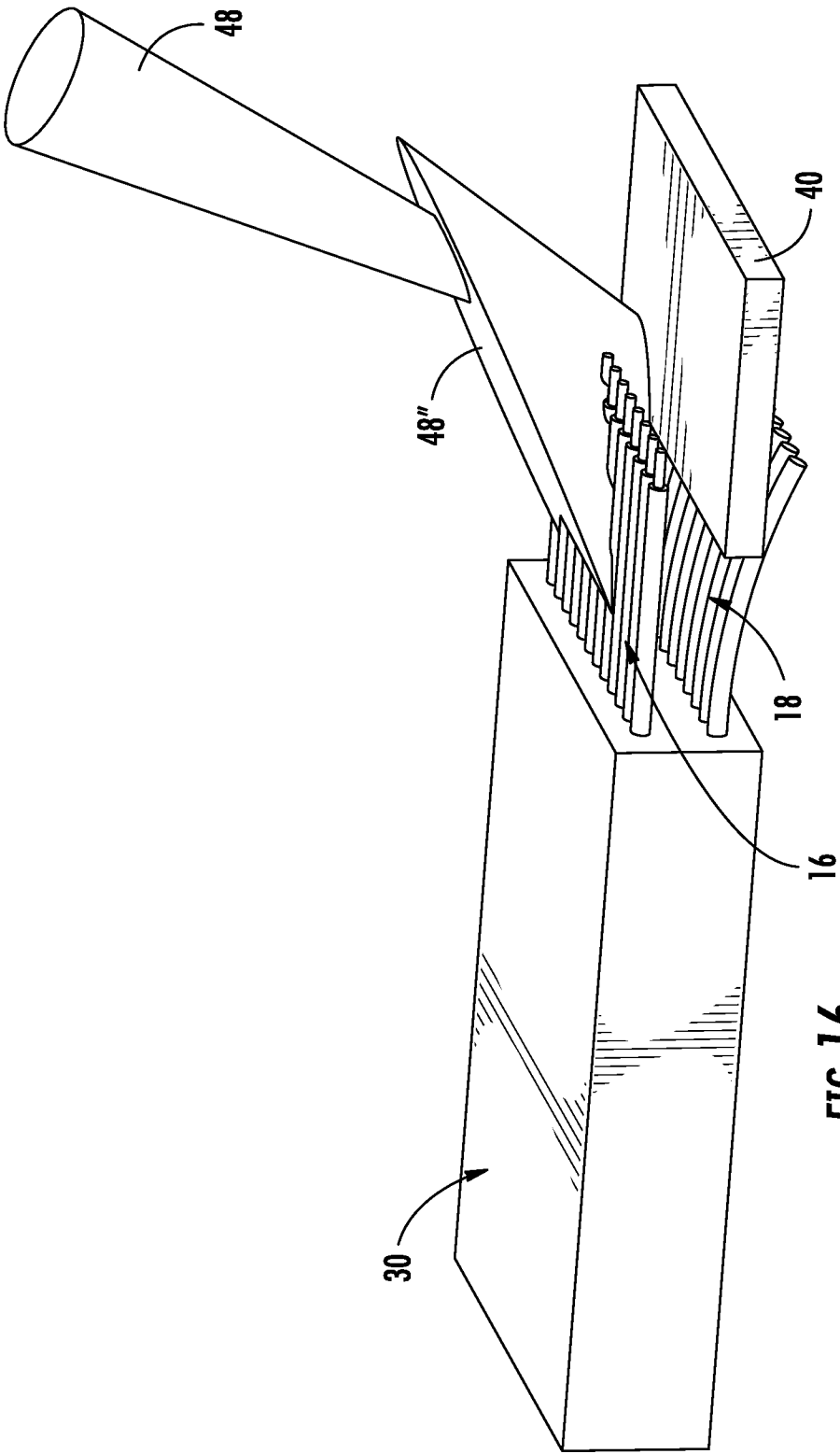
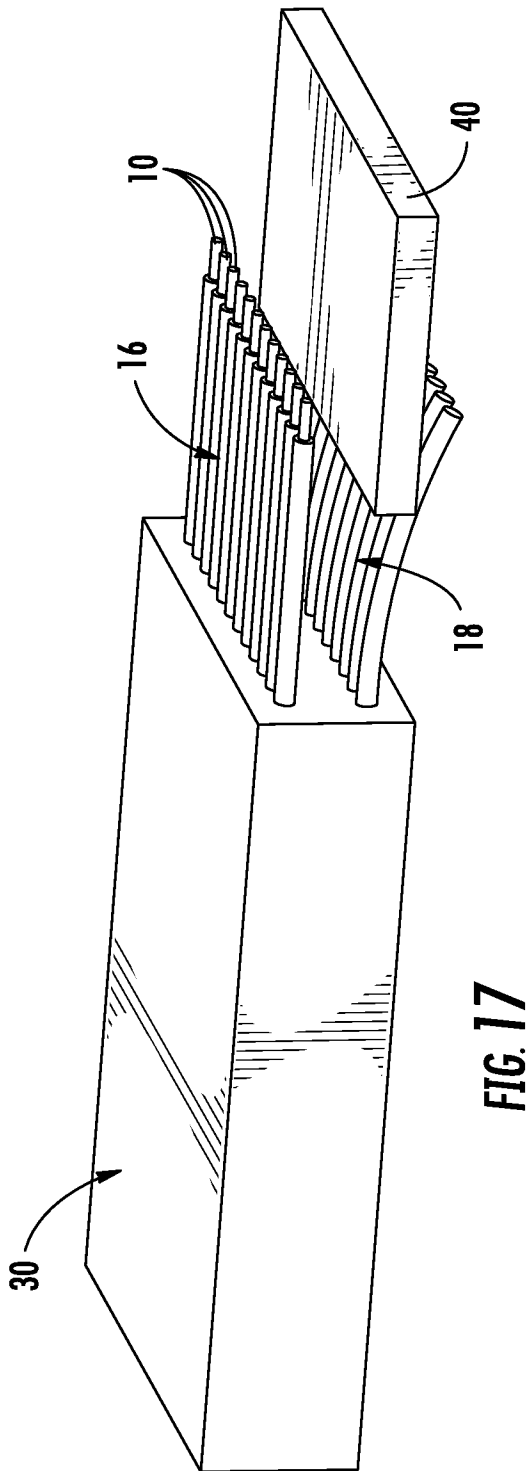
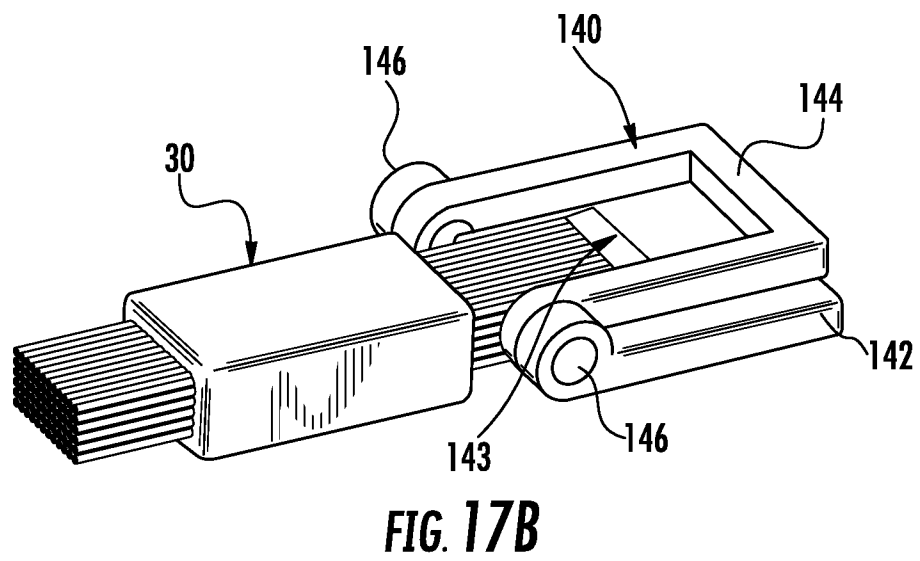
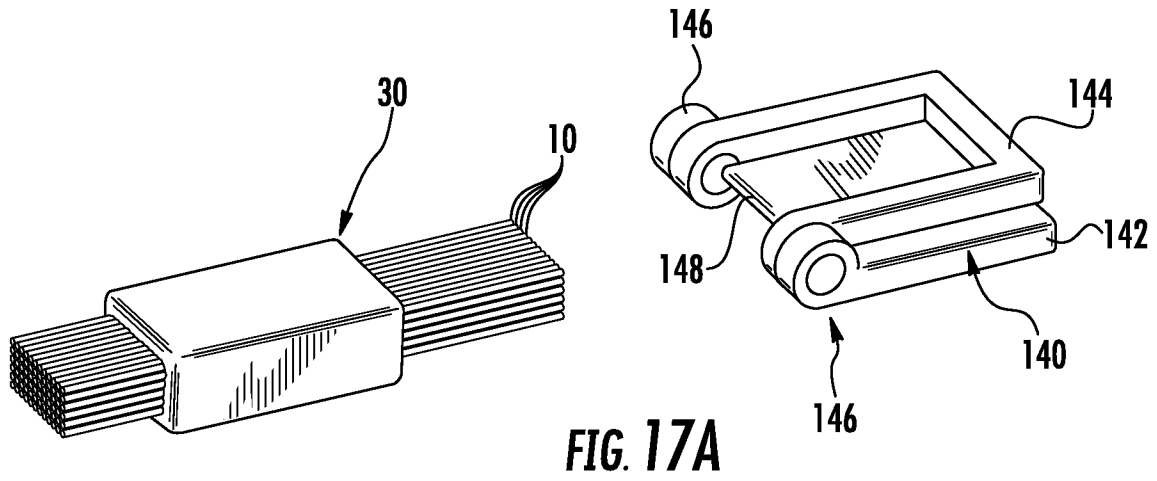


FIG. 16



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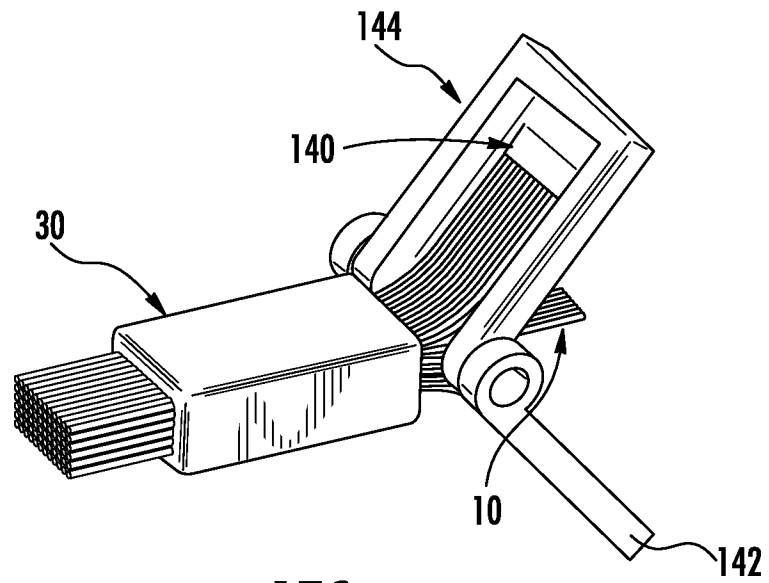


FIG. 17C

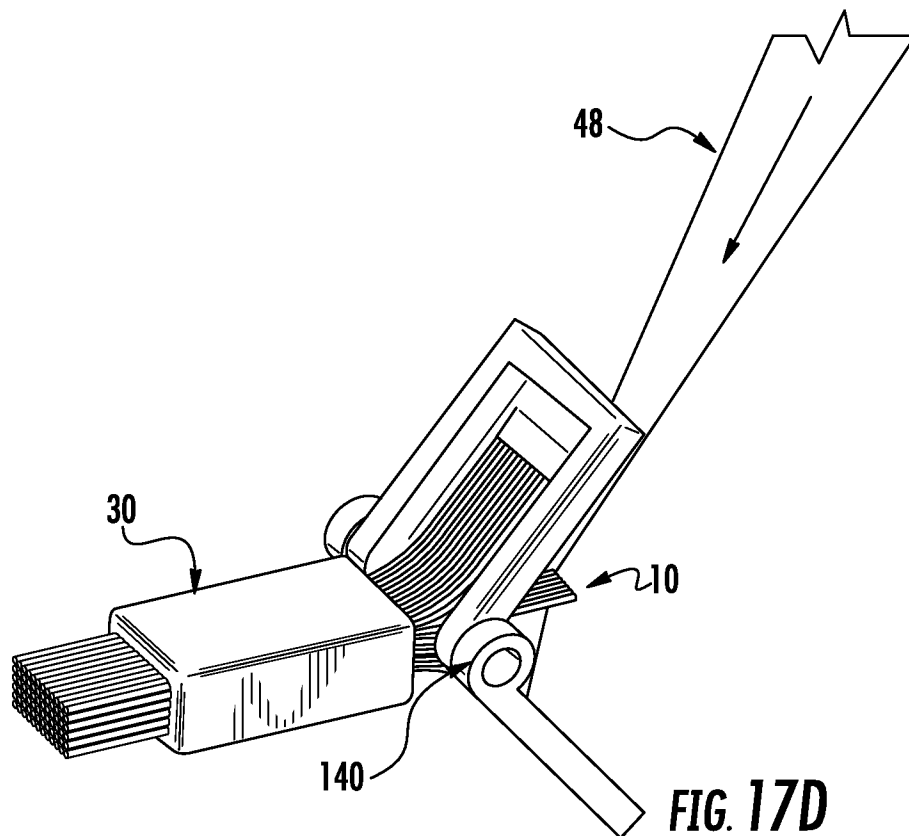


FIG. 17D

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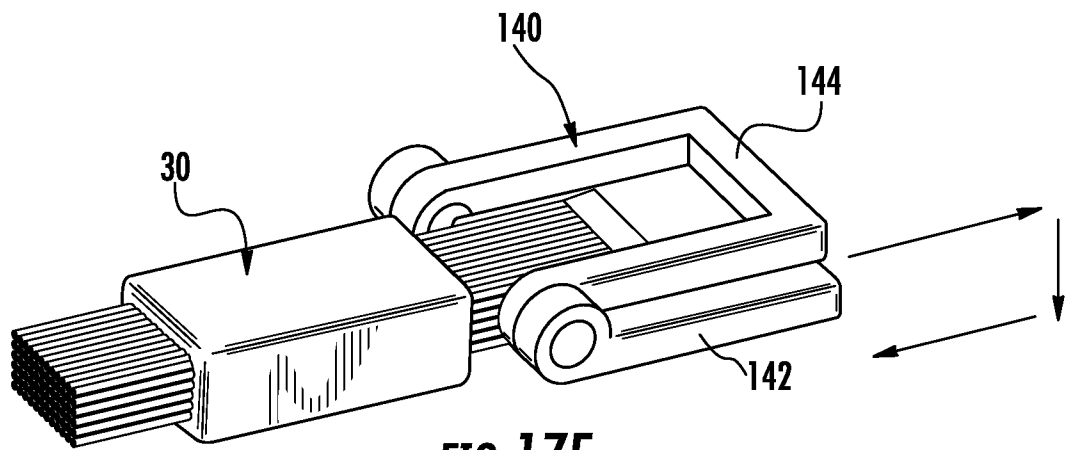


FIG. 17E

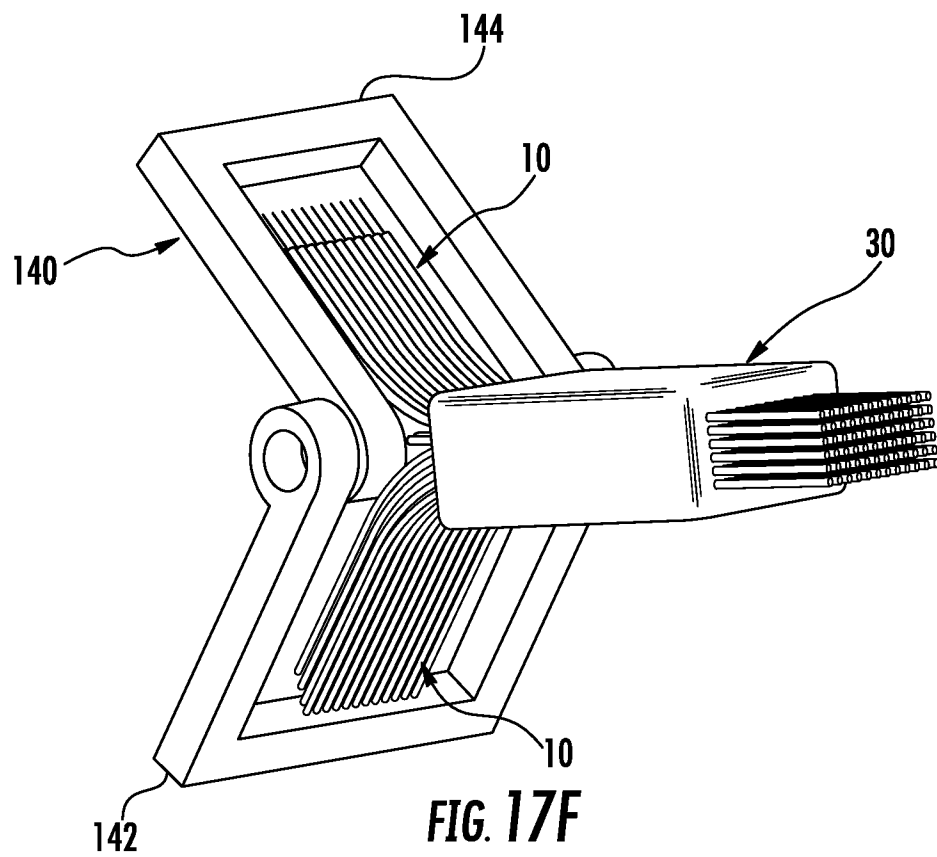


FIG. 17F

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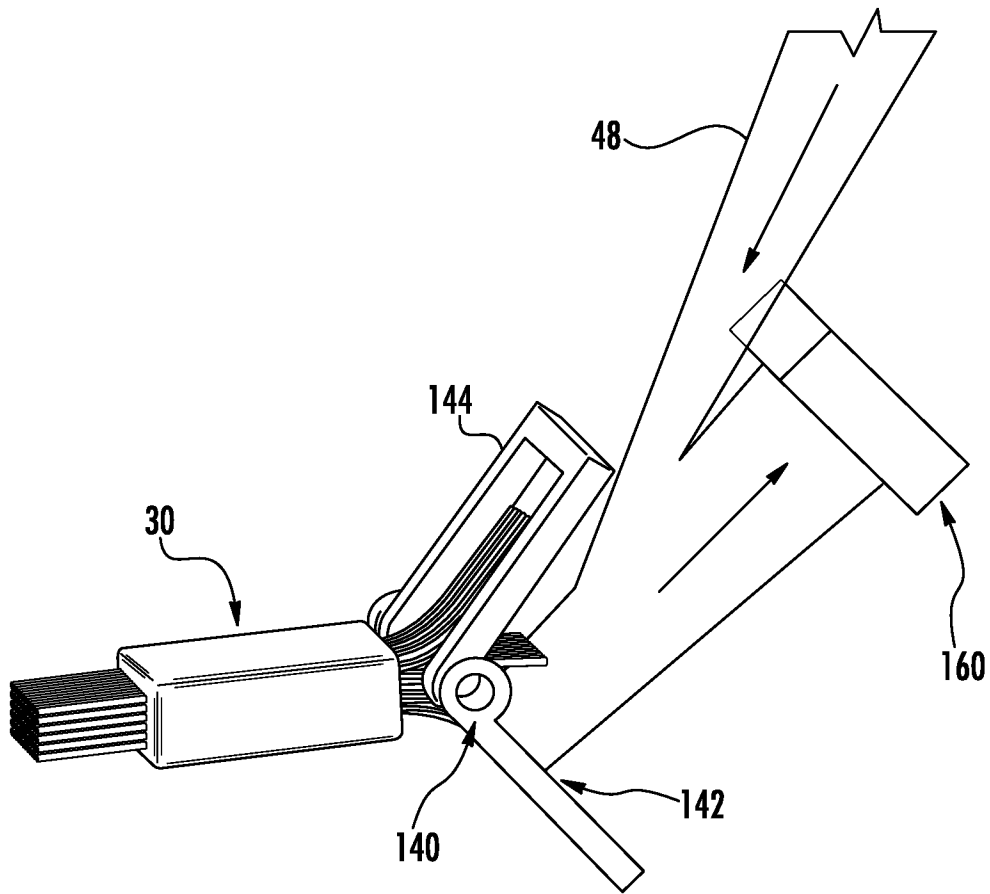
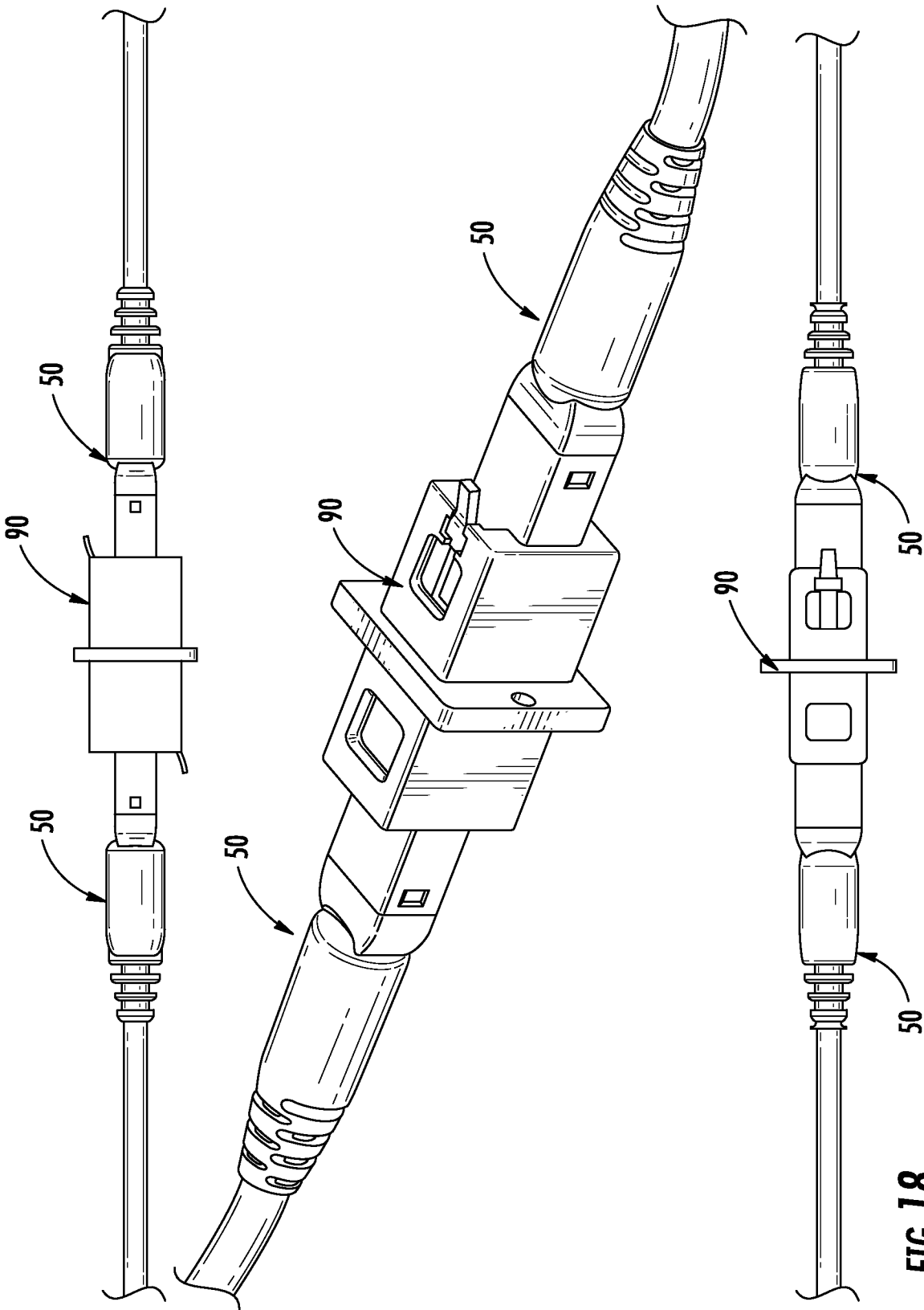
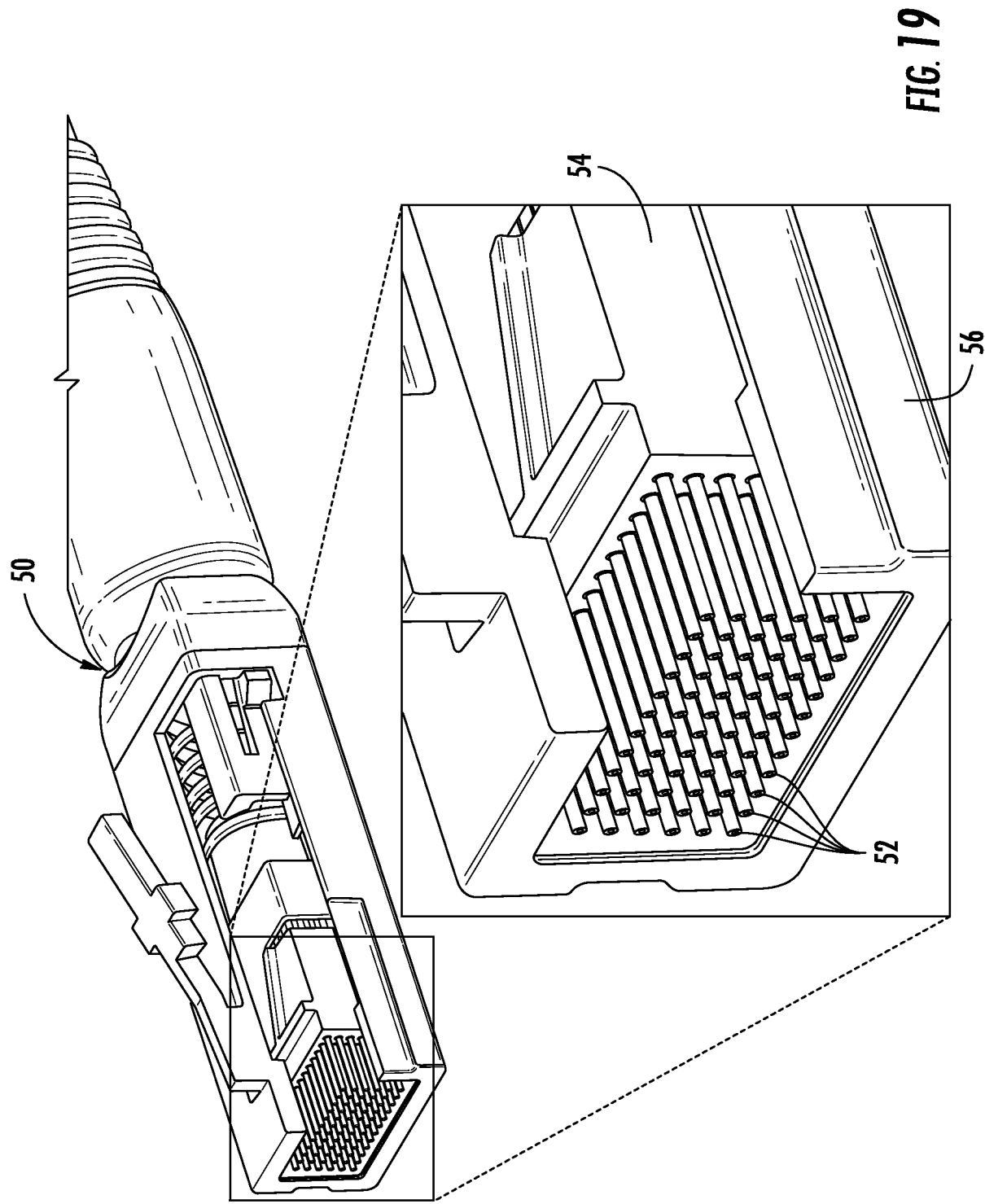


FIG. 17G





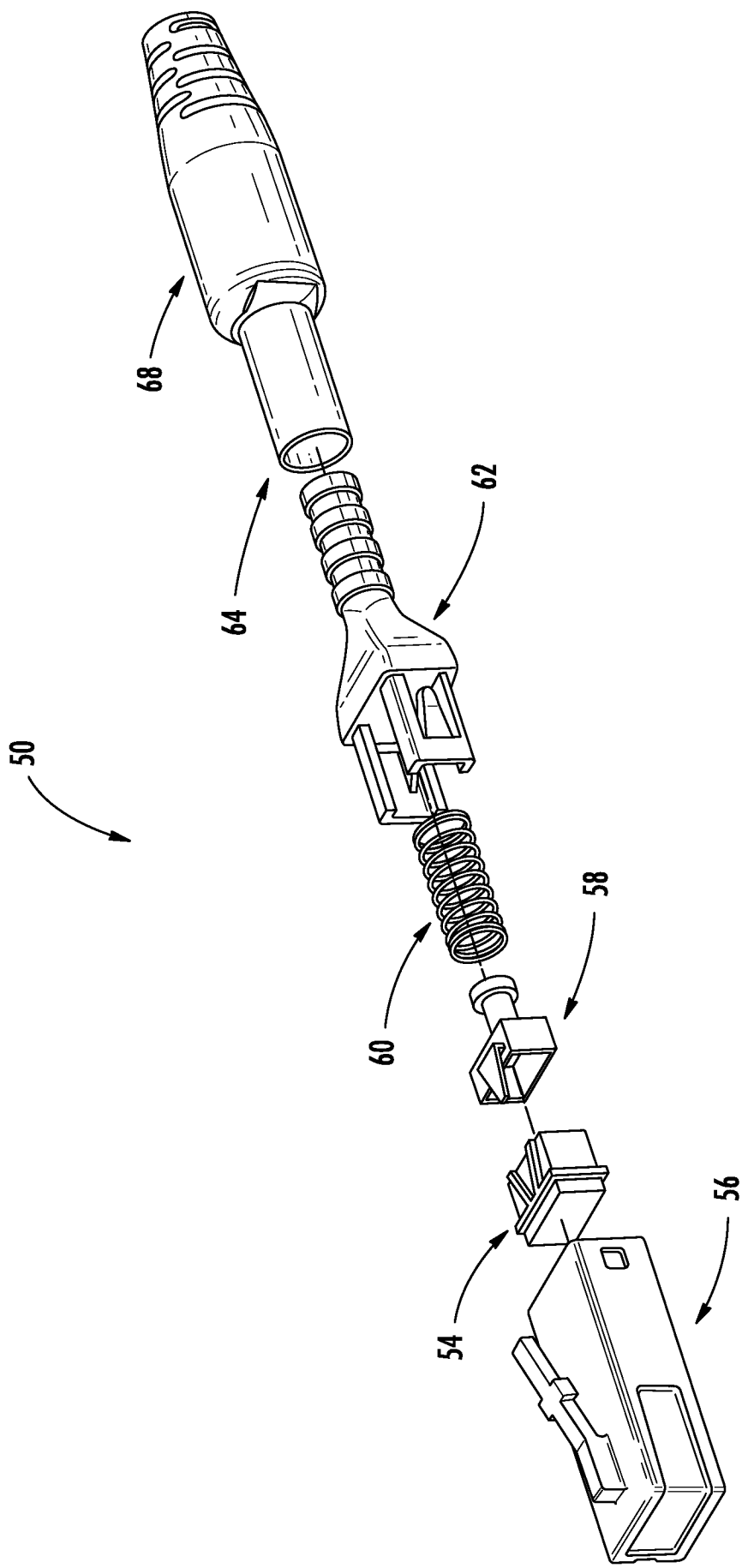
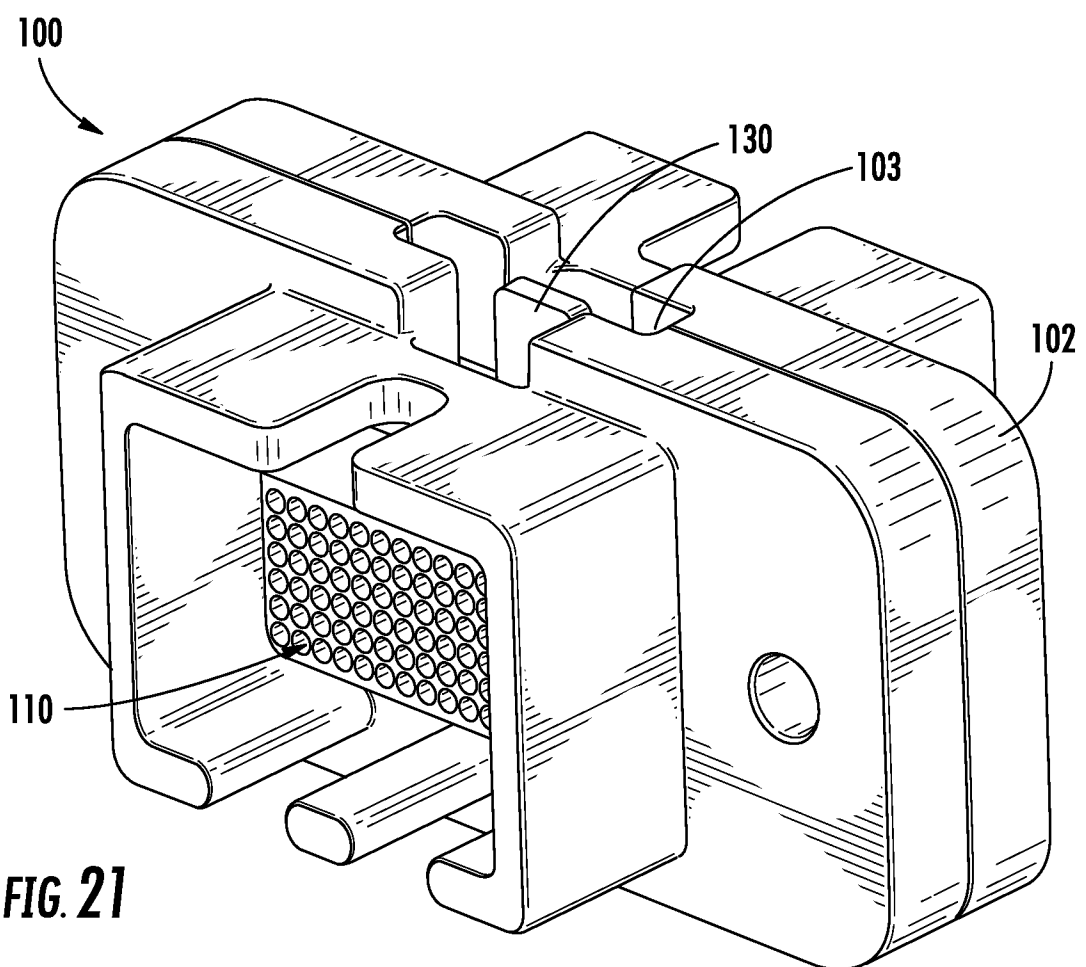
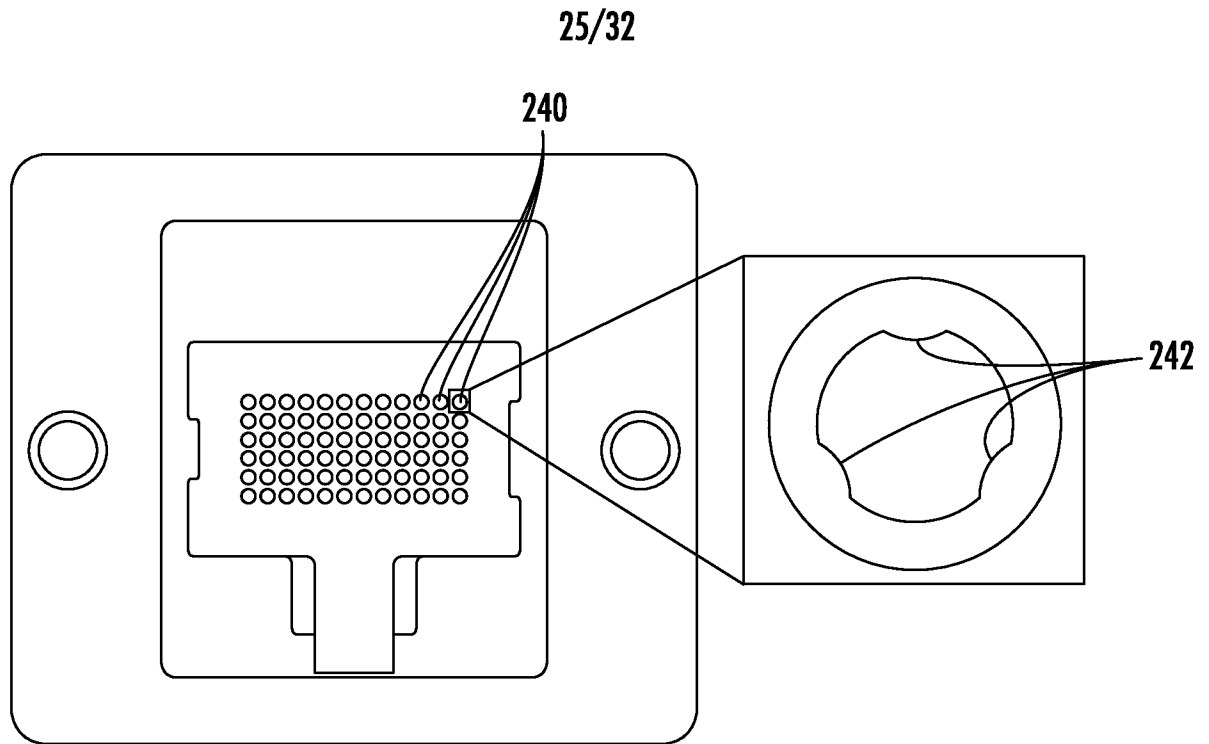
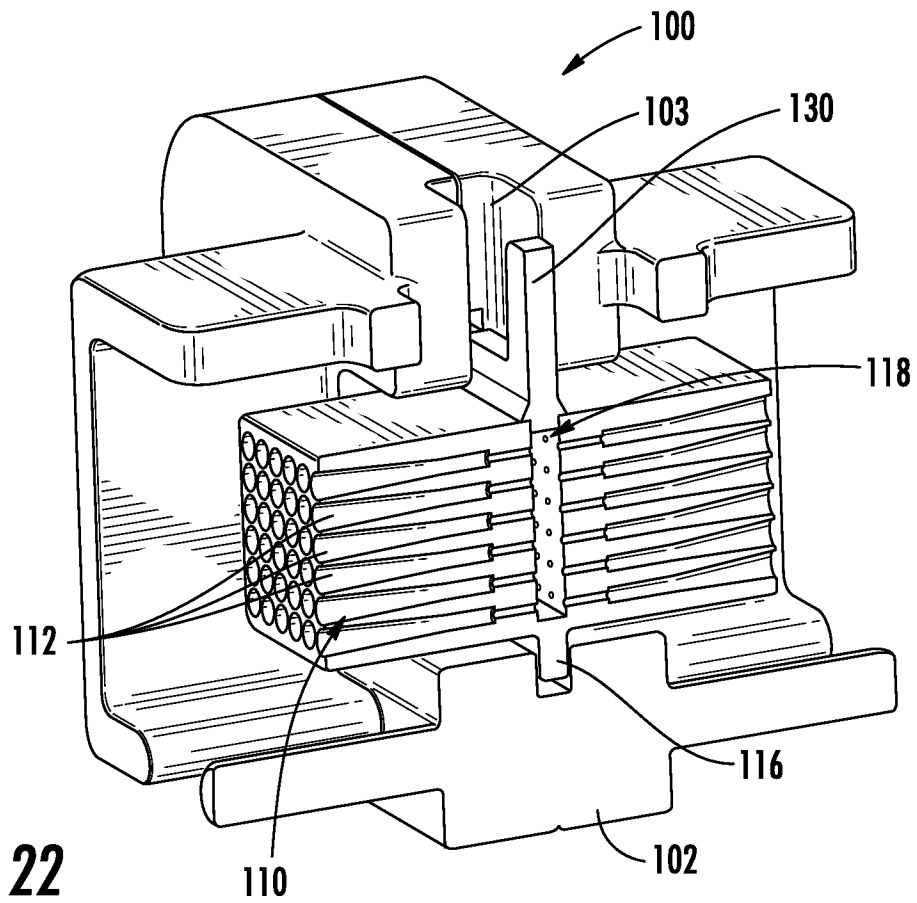
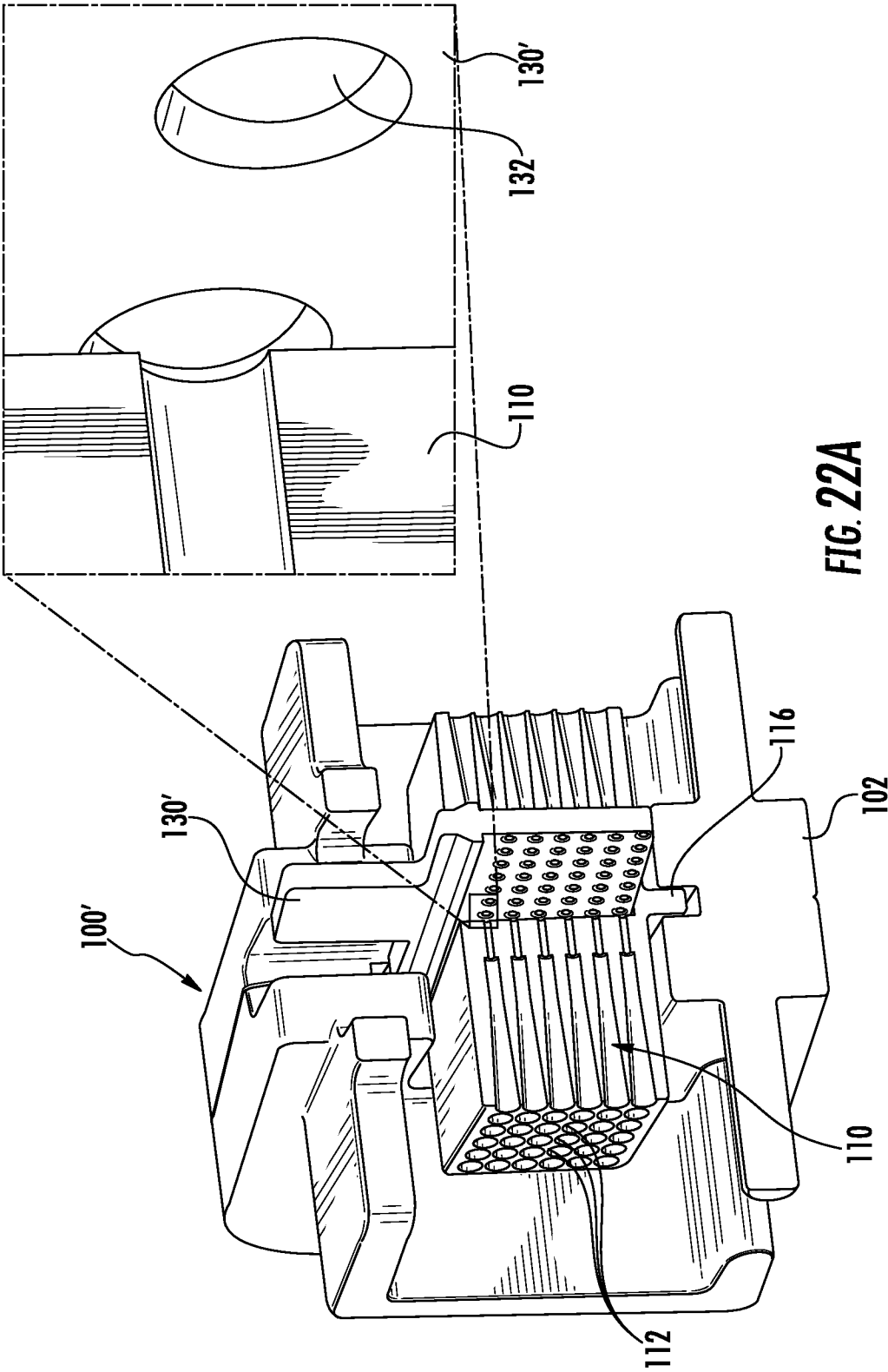


FIG. 20

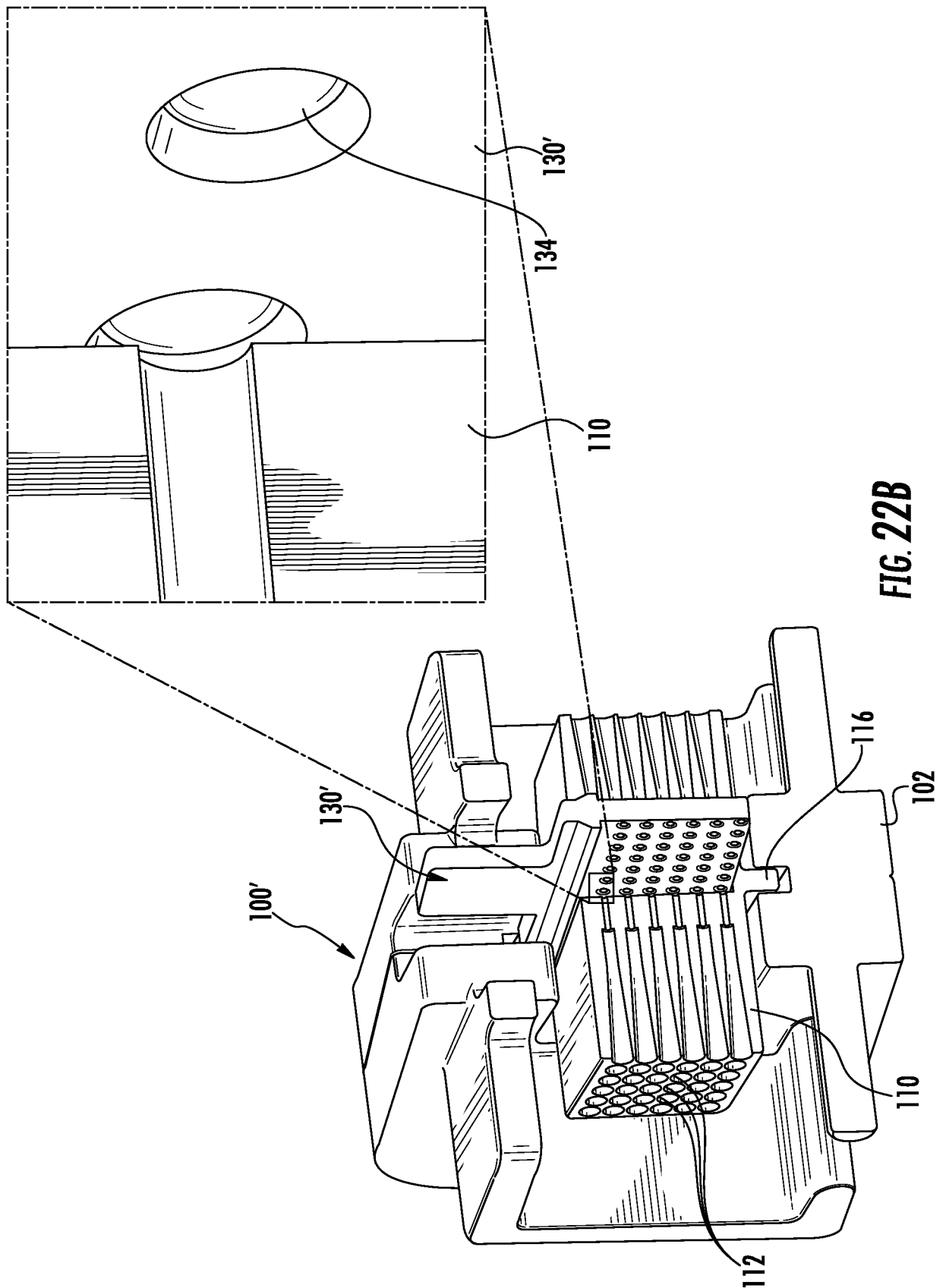


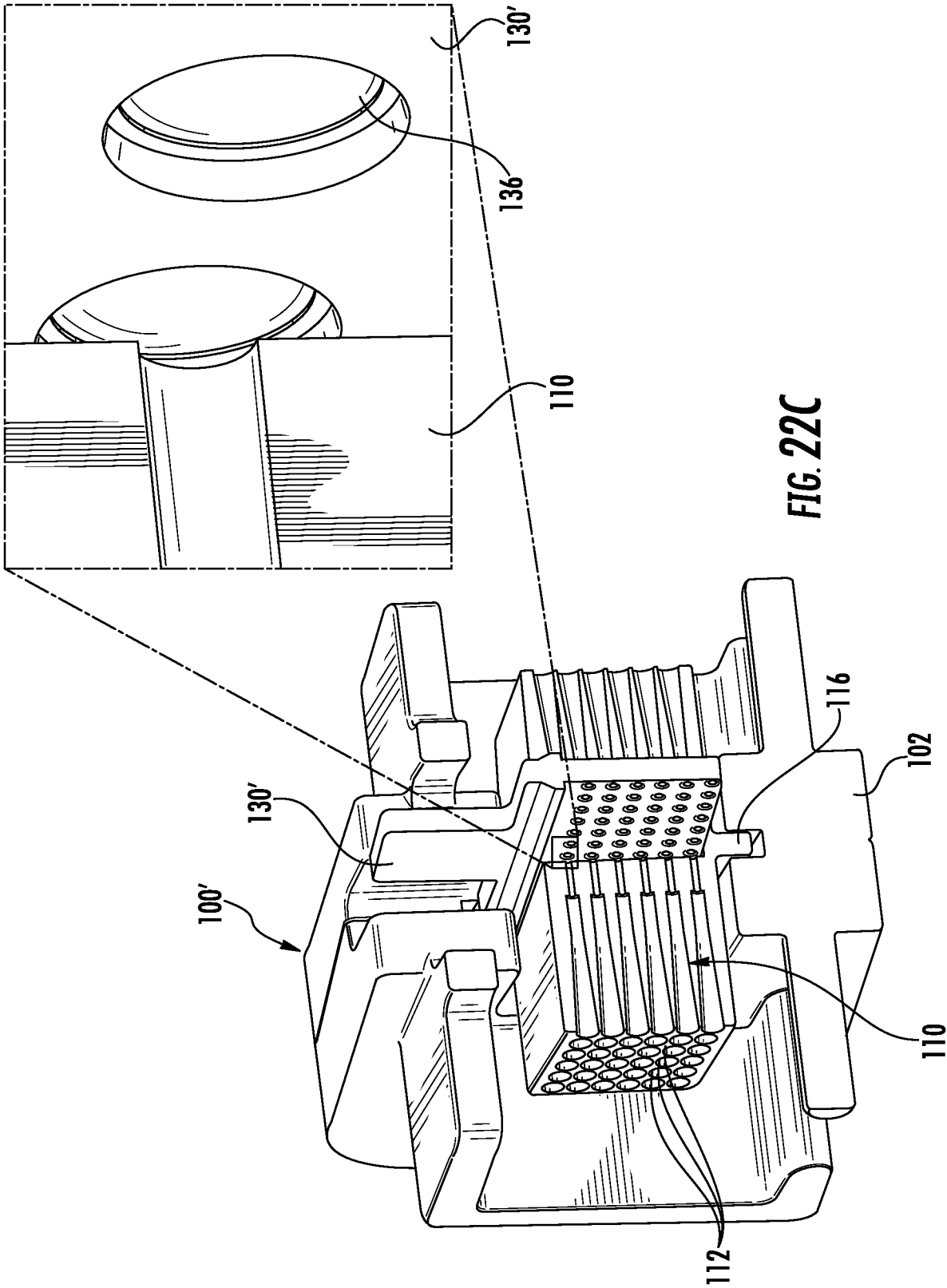
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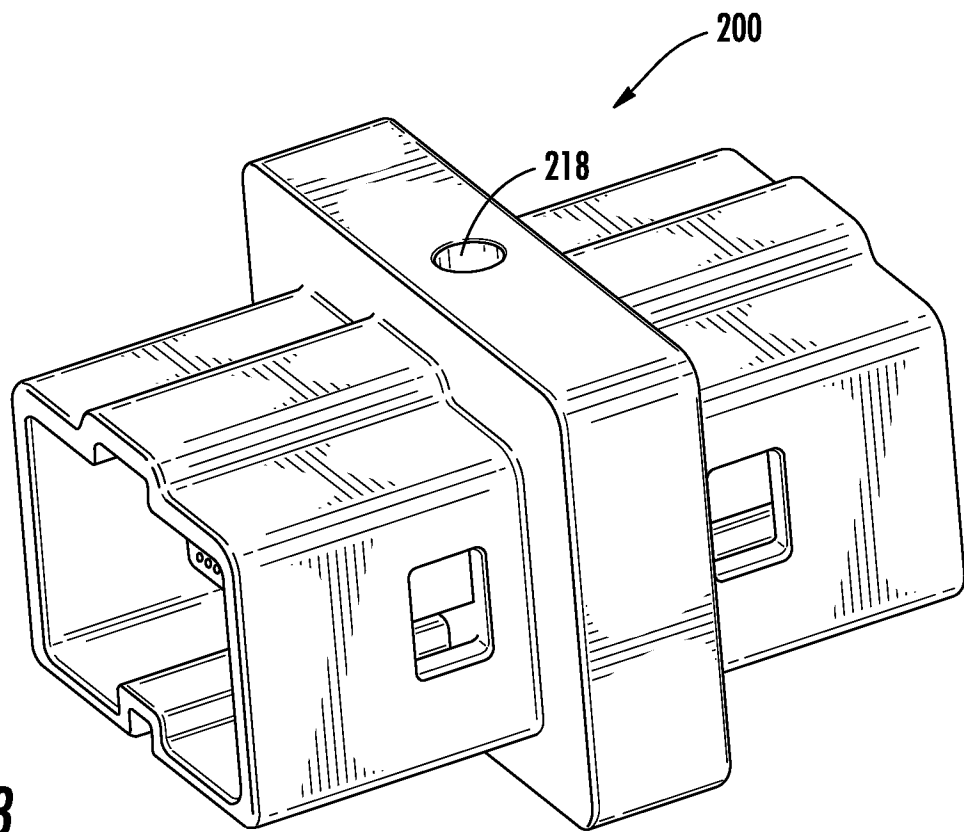


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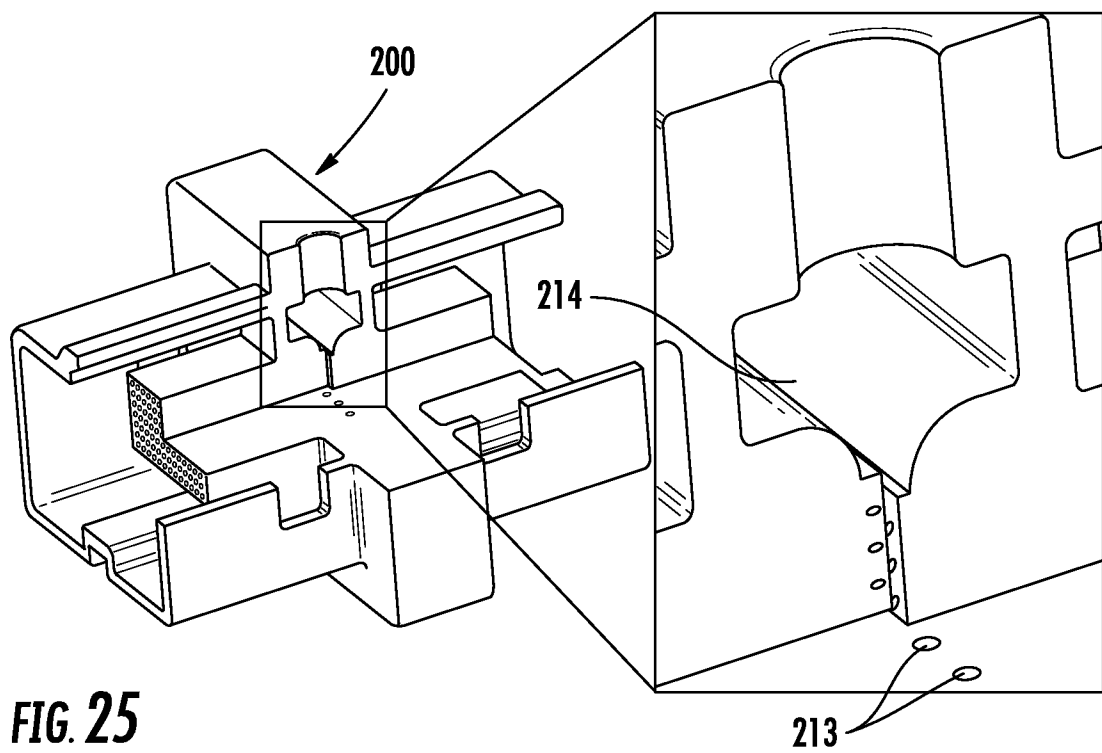
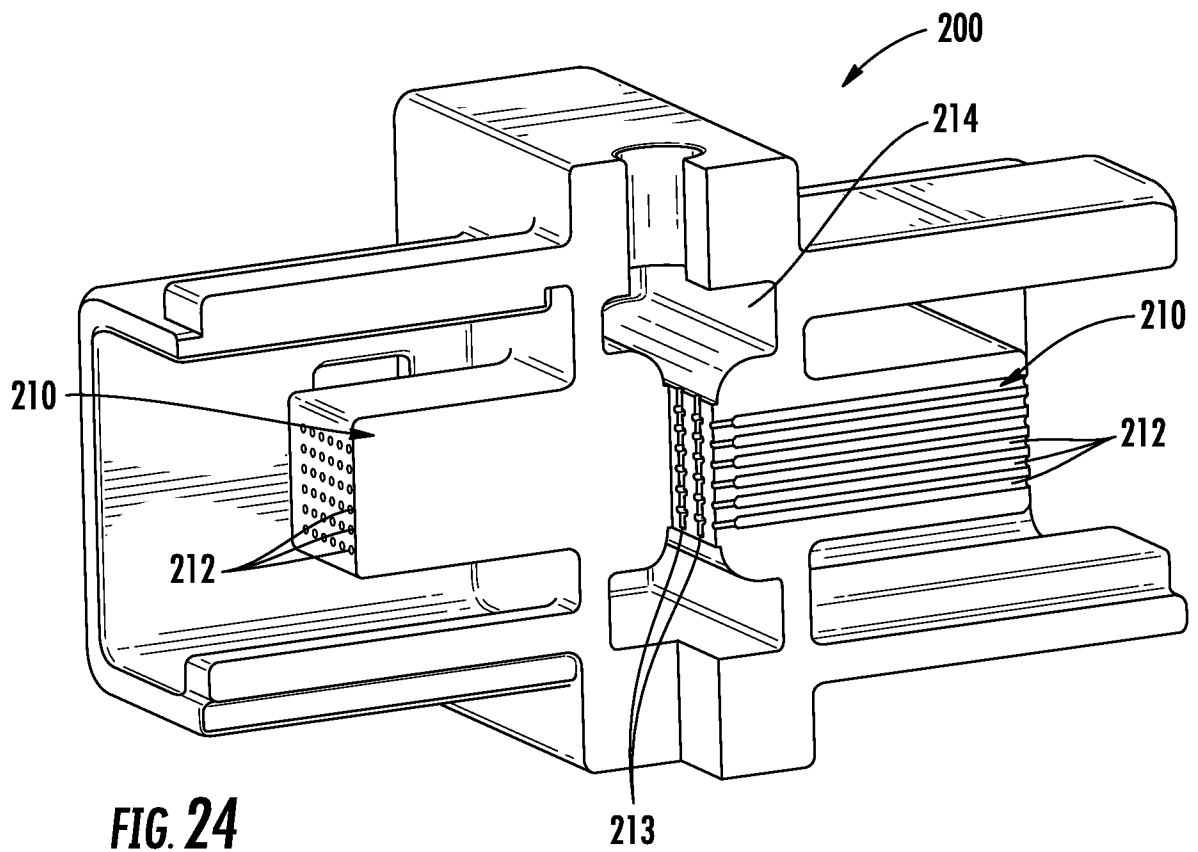




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FIG. 26

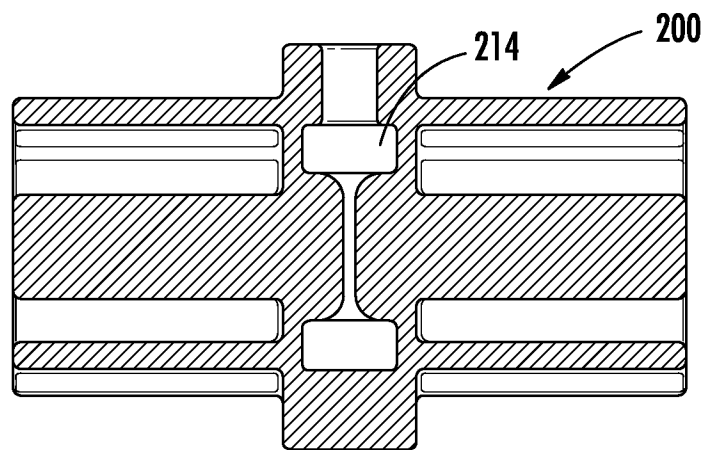


FIG. 27

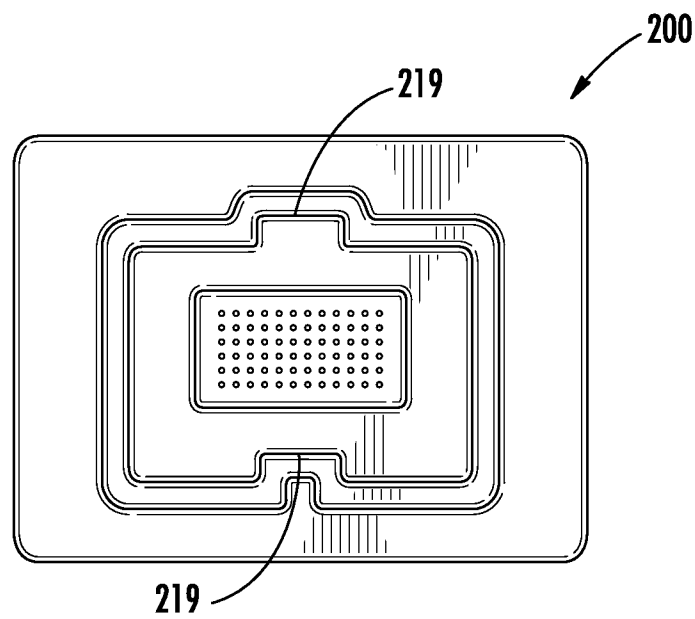


FIG. 28

