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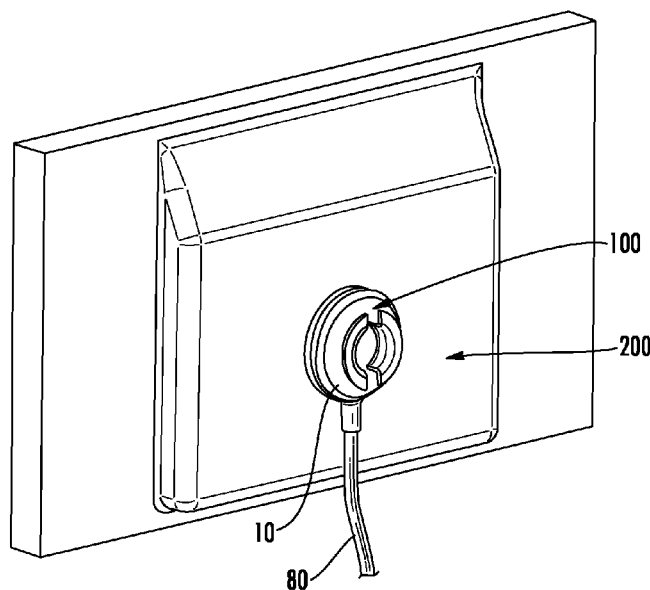


FIG. 1

(57) Abstract: Disclosed are optical connectors and methods for making the same. In one embodiment, the optical connector comprises an optical body, one or more first magnetic materials attached to the optical body, a housing, and one or more second magnetic materials attached to the housing. The first magnetic material(s) provide alignment with an optical element of a complimentary receptacle and the optical body may include one or more openings for receiving the first magnetic materials. The second magnetic materials) attached to the housing provide retention of the optical connector with the complimentary receptacle when mated together. Consequently, the optical connector allows for quick and easy assembly along with a robust structure for a large number of mating/unmating cycles. In other embodiments, the optical devices disclosed may further include one or more electrical contacts for making a hybrid connection or have a TIR surface integrated into a portion of a housing.

OPTICAL CONNECTORS AND COMPLIMENTARY OPTICAL RECEPTACLES HAVING MAGNETIC ATTACHMENT

PRIORITY APPLICATION

[0001] This application claims the benefit of priority under 35 U.S.C. § 119 of U.S. Provisional Application Serial No. 62/053,980, filed on September 23, 2014, the content of which is relied upon and incorporated herein by reference in its entirety.

FIELD

[0002] The disclosure is directed to an optical connectors and complimentary optical receptacles for making an optical connection between a cable assembly and an electronic device. More specifically, the disclosure is directed to optical connectors and complimentary optical receptacles having at least one optical channel and one or more magnet materials.

BACKGROUND

[0003] Optical fibers have displaced copper-based connectivity in much of the traditional long-haul and metro telecommunication networks for numerous reasons such as large bandwidth capacity, dielectric characteristics and the like. As consumers require more bandwidth for consumer electronic devices such as smart phones, televisions, high-definition displays, laptops, tablets and the like optical fibers and optical ports for optical signal transmission are being considered for replacing the conventional copper-based connectivity for these applications. However, there are significant challenges for providing optical connectivity in consumer devices compared with copper-based connectivity. By way of example, with flat-panel displays and televisions that are closely mounted to a wall it may be desirable to have a blind mating capability for an optical connection without damaging the optical interface. Additionally, devices such as smart phones, laptops and tablets are exposed to rough handling and harsh environments and the consumer will expect optical connectivity to handle these demanding conditions. Further, these types of devices may require a large number of mating/unmating cycles during their lifetime.

[0004] Thus, there is an unresolved need for optical connectors and optical receptacles in consumer devices and other devices that can accommodate blind mating requirements along with the potential for harsh treatment in a consumer environment along with the potential for a large number of mating/unmating cycles expected during the lifetime of the electronic device.

SUMMARY

[0005] One embodiment the disclosure is directed to an optical device comprising an optical body comprising at least one optical channel having an optical interface portion, a total internal reflection (TIR) surface for turning the optical signal of the at least one optical channel, and at least one fiber lead-in aligned to the TIR surface. The optical body forms a portion of the housing for directly mating with a complimentary device. Thus, the optical device has few components since the TIR surface is integrated into a portion of the housing and there is no need to align an individual TIR component to the housing. The optical device may be an optical connector such as a plug, a receptacle of the like and may comprise one or more of the features disclosed herein.

[0006] In another embodiment, the disclosure is directed to an optical connector comprising an optical body, one or more first magnetic materials, a housing and one or more second magnetic materials. The optical body comprises at least one optical channel having an optical interface portion, a total internal reflection surface (TIR) surface for turning the optical signal of the at least one optical channel, and at least one fiber lead-in aligned to the TIR surface. The one or more first magnetic materials are attached to the optical body and the one or more second magnetic materials are attached to the housing. The optical connector can include other optical features or structure such as the housing having second magnet recesses, the housing having alignment features, or having electrical contacts for making a hybrid connector.

[0007] In one embodiment, the disclosure is directed to an optical receptacle comprising a receptacle optical body, one or more first magnetic materials, a housing and one or more second magnetic materials. The receptacle optical body comprises at least one optical channel having an optical interface portion. The one or more first magnetic materials are attached to the receptacle optical body and the one or more second magnetic

materials are attached to the housing. The optical receptacle can include other optical features or structure such as the housing having second magnet recesses, the housing having alignment features, or having electrical contacts for making a hybrid connector.

[0008] The first magnetic materials may be attached to the optical body of the optical connector or optical receptacle in any suitable arrangement or manner. If desired, the optical body may include one or more openings for receiving and securing one or more of the first magnetic materials. The one or more openings may be located on any suitable side of the optical body as desired. The first magnetic materials provide optical alignment with a complimentary device having an optical interface. Consequently, the optical connectors and optical receptacles allow for quick and easy connection and are easy to manufacture. Further, the optical devices provide a robust structure for a large number of mating/unmating cycles if required. In other embodiments, the optical connectors and optical receptacles disclosed may further include one or more electrical contacts for making a hybrid connection.

[0009] The disclosure is also directed to method for making an optical device. One explanatory method of making optical devices such as optical connectors or optical receptacles according to the concepts disclosed. One explanatory method of making an optical device comprises providing an optical body comprising at least one optical channel with an optical interface portion, providing one or more first magnetic materials, attaching one or more of the first magnetic materials to the optical body, providing a housing and one or more second magnetic materials, and attaching the one or more second magnetic materials to a portion of the housing. The method may also optionally include the step of providing a housing with one or more alignment features, attaching one or more electrical contacts to the optical body, and/or having the optical body being a portion of an optical connector or an optical receptacle. Additionally, the method may also optionally further include the step of providing a housing having one or more second magnet recesses.

[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 same 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 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

[0012] **FIG. 1** is a perspective view of a cable assembly having an optical connector that is attached (e.g., mated) to an electronic device configured as a flat-panel display such as a television according to the concepts disclosed herein;

[0013] **FIG. 2** is a perspective view showing the cable assembly and flat-panel display of **FIG. 1** in an unmated condition;

[0014] **FIG. 3** is a detailed perspective view similar to **FIG. 2** showing the optical connector of the cable assembly with a portion of the housing removed for showing assembly details of the optical connector;

[0015] **FIG. 4** is a partially exploded view of the optical connector of **FIGS. 1 and 2** showing representative details of the construction;

[0016] **FIG. 5** is another detailed perspective view showing details of the optical receptacle and the mating side of the optical connector of **FIGS. 1 and 2**;

[0017] **FIG. 6** is a partially exploded view of the optical receptacle of **FIGS. 1 and 2** showing representative details of the construction;

[0018] **FIG. 7** is a cross-sectional view of the optical connector and the optical receptacle of **FIG. 2** in a mated condition generally taken along the optical axis of the optical connector;

[0019] **FIG. 8** is a cross-sectional view of the optical connector and the optical receptacle of **FIG. 2** in a mated condition generally taken perpendicular to the optical axis of the optical connector;

[0020] **FIG. 9** is a detailed cross-sectional view of the optical connector and the optical receptacle of **FIG. 2** in a mated condition showing a portion of the mating interface therebetween;

[0021] **FIG. 10** is a cross-sectional view of the optical body of the optical connector and the optical body optical receptacle of **FIG. 1** in a mated condition showing details of the optical pathways and mating interface;

[0022] **FIGS. 11 and 12** respectively are a schematic representation and ray trace of the optical path for the optical channels defined by the mating between the optical body of the optical connector and the optical body of the complimentary optical receptacle;

[0023] **FIG. 13** is a perspective view of another cable assembly having an optical connector that is attached (e.g., mated) to an electronic device such as a flat-panel display such as a television having a complimentary optical receptacle according the concepts disclosed herein;

[0024] **FIG. 14** is a perspective view showing the alternative embodiment of the optical connector according to the concepts disclosed herein; and

[0025] **FIG. 15** schematically depicts the mating interface between the optical connector of **FIGS. 13 and 14** along with its complimentary optical receptacle for an electronic device.

DETAILED DESCRIPTION

[0026] Reference will now be made in detail to the 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.

[0027] The optical devices such as optical connectors and optical receptacles are disclosed herein that enable high-speed data applications for transmitting optical signals to and from electronic devices. In other embodiments, the optical connectors and optical receptacles can have hybrid connections for transmitting optical and electrical signals and/or electrical power over electrical conductors. The optical connectors and optical receptacles disclosed are useful for blind mating (e.g., mating where it is difficult to see and/or access the mating interface) due to the magnetic retention and alignment features. Further, the optical connectors and optical receptacles enable optical connections that may have a relatively small and compact footprint so that they are useful for use with

devices having small form-factors as well as large form-factors such as displays. Likewise, the complimentary optical receptacles may be used on electronic devices such as consumer devices, as well as other suitable applications such as docking stations and the like. For instance, electronic devices that may use the optical receptacle include smart phones, televisions, high-definition displays, laptops, tablets, docking stations and the like. One optical connector disclosed includes an optical body comprising at least one optical channel having an optical interface portion, a total internal reflection (TIR) surface for turning the optical signal of the at least one optical channel, and at least one fiber lead-in aligned to the TIR surface, one or more first magnetic materials attached to the optical body, and one or more second magnetic materials attached to the housing. The optical connector also includes a housing. The optical body may be integrally formed with a portion of the housing or may be a discrete component as desired. If the optical body is a discrete component it may be attached to a portion of the housing in a fixed manner or have a resilient mounting allowing movement. The optical body is used for receiving and/or transmitting optical signals and may optionally include one or more openings for receiving the one or more first magnetic materials that are used primarily for optical alignment. The one or more second magnetic materials are attached to the housing and used for providing a stronger retention force for the optical connector and for aiding with blind mating as appropriate.

[0028] As used herein, “magnetic material” or “magnetic materials” means a magnetic material or a ferrous material that is attracted to a magnet material. The magnetic material allows for quick and easy mating of the optical connection between the optical connector and the optical receptacle along with providing a robust and compact footprint for applications requiring a large number of mating/unmating cycles if needed. By way of example, a first side of an optical connection such as an optical connector may use a first magnet and a second side of the optical connection such as an optical receptacle may use a second magnet of opposite polarity for making an attachment between the first and second sides of the optical connection; alternatively, a first side of an optical connection such as optical connector may use a first magnet and a second side of the optical connection such as the optical receptacle may use a ferrous material for making an attachment between the first and second sides of the optical connection or vice versa.

[0029] **FIG. 1** is a perspective detailed view of a cable assembly **100** that is used for making an optical connection when mated with a complementary electronic device **200** according to the concepts disclosed herein. **FIG. 2** is a perspective view showing the cable assembly **100** being aligned with the complementary electronic device **200** in an unmated condition. Cable assembly **100** includes an optical connector **10** attached to a cable **80** having at least one optical fiber **82** (**FIG. 3**) and electronic device **200** includes an optical receptacle **210** for mating with optical connector **10**. In this embodiment, the optical receptacle **210** is located at a backwall **201** of the electronic device such as a display or high-definition television which may make accessing the same difficult when closely mounted to a wall as is common-practice.

[0030] **FIGS. 3-9** show various views and details of optical connector **10** and/or optical receptacle **210**. **FIG. 3** depicts the optical connector **10** unmated from the optical receptacle **210** and with a portion of a housing **70** removed from optical connector **10** for showing details within the optical connector **10** and **FIG. 4** is a partially exploded view of optical connector **10**. Housing **70** of optical connector **10** has a first portion **70a** and a second portion **70b** and the second portion **70b** of housing **70** is removed from the optical connector **10** shown in **FIG. 3**, thereby depicting internal details of the assembly. Housing **70** may also optionally include one or more ears **71** as a grip for installing/removing the optical connector **10**. In this embodiment, an optical body **20** is integrally formed with a portion of housing **70**. Specifically, the optical body **20** is integrally formed with first portion **70a** of housing **70** such as in a molding operation. In other embodiments, the optical body **20** may be a discrete component separate from the housing **70** according to the concepts disclosed herein. Further, if optical body **20** is a discrete component from the housing **70** it may have a fixed attachment to a portion of the housing or it may have a floating attachment to a portion of the housing **70**.

[0031] Optical connector **10** comprises an optical body **20** formed as a portion of housing **70** and optical receptacle **210** includes a complementary receptacle optical body **220** (hereinafter optical body **220**) that cooperate when mated together for making an optical connection as best shown in **FIGS. 10-12**. Optical body **20** comprises at least one optical channel **OC1** having an optical interface portion **26** along with a total-internal reflection (TIR) surface **23** for turning the optical signal of the at least one optical

channel **OC1**, and at least one fiber lead-in **21** aligned to the TIR surface **23**. As shown in **FIG. 3**, the at least one optical fiber **82** of the cable **80** is attached to the optical body **20** so it is in optical communication with of optical connector **10**. The optical receptacle **210** of electronic device **200** has a portion of optical body **220** exposed at the mating interface for cooperating with the exposed portion of optical body **20** of optical connector **10** when mated together. When the optical connector **10** of cable assembly **100** is attached to the optical receptacle **210** of electronic device **200** an optical connection is enabled between optical body **20** of the optical connector **10** and optical body **220** of optical receptacle **200** for optical communication at a mating interface **101**.

[0032] **FIG. 4** is a partially exploded view of cable assembly **100** showing details of optical connector **10** and cable **80**. In this embodiment, optical connector **10** comprises optical body **20** integrally formed with a first portion **70a** of housing **70**, one or more first magnetic materials **30** for attachment to the optical body **20**, and one or more second magnetic materials **74** that are attached to a portion of housing **70**. As depicted in this embodiment, housing **70** further optionally comprises one or more second magnet pockets **72**. Second magnetic material pockets **72** receive respective second magnetic materials **74** therein. Specifically, the second magnetic material pockets **72** are integrally formed with housing **70**. Although second magnetic material pockets **72** are depicted on first portion **70a** of housing **70**, the pocket may be disposed on either the first portion **70a** or second portion **70b** of housing **70**. Any suitable number of second magnetic materials may be used in any suitable arrangement for providing the desired retention force for the mated optical connection.

[0033] In this embodiment, optical connector **10** optionally includes one or more electrical contacts **86**. Electrical contacts **86** may be any suitable type of electrical contact. Likewise, electrical contacts may be disposed in any suitable locations such as in the optical body or in the housing as desired. By way of example, the one or more electrical contacts maybe pogo pin electrical contacts disposed in one or more bores. In the embodiment shown, the electrical contacts **86** are disposed in bores **29** formed in the optical body **20**. Cable **80** includes one or more optical fibers **82** and may optionally include one or more electrical conductors **84** such as copper wires. When assembled, the

optical fibers **82** are optically attached to the optical body **20** and the electrical conductors **84** are electrically attached to electrical contacts **86**.

[0034] As shown in **FIG. 5**, optical body **20** includes at least one optical channel **OC1** (**FIG. 12**) having an optical interface portion **26** disposed on a first side **20a**. **FIG. 5** also shows a rear-side perspective view of the optical receptacle **210**. In this embodiment, optical body **20** is formed from a suitable material such as LEXAN that allows the transmission of optical signals therethrough at the desired wavelength. Optical body **20** includes two optical channels **OC1**, but the optical body **20** may include any suitable number of optical channels in any suitable arrangement or array as desired. In this configuration, optical body **20** includes an optional lens **25** on total internal reflection (TIR) surface **23** for manipulating the optical signal when turning the optical signal of the at least one optical channel **26** as shown in **FIG. 10**. However, other embodiments of the optical bodies may not use a lens at the TIR surface. The TIR surface **23** is formed by the different refractive indexes between the material of the optical body **20** and the air interface causing the optical signals to reflect and turn back into the optical body and continue along their optical path. Stated another way, the material/air interface causes the optical signal to turn within the optical body **20**. Consequently, the TIR surface **23** can change the direction of travel for (e.g., turning) the optical signal(s). By way of example, the TIR surface **23** changes the direction of the optical channel **OC1** from the direction aligned with the fiber lead-in **21** to a direction that is generally perpendicular to the fiber lead-in **21**. Consequently, the optical connector can have a compact footprint for applications where an angled connector is advantageous; however, the concepts disclosed may be used with optical connectors having an in-line optical channel and omit the TIR surface as desired. The fiber lead-in **21** is used for receiving an optical fiber of cable **80** and aligning the fiber with the respective optical channel **OC1** of the optical body **20**.

[0035] In this embodiment, optical body **20** also includes one or more openings **22** for receiving one or more first magnetic materials **30** as best shown in **FIG. 4**. Openings **22** may have any suitable shape and/or size for receiving a respectively sized first magnetic material **30** therein. The one or more openings **22** may be disposed on any suitable side of the optical body **20** such as the same side as the optical interface portion **26**, a side

adjacent to the optical interface portion **26** (e.g., a short side), or a side opposite to the optical interface portion **26** as desired. In other embodiments, the first magnetic materials **30** may be attached to an outer side or periphery of the optical body **20**. In this embodiment, the one or more openings **22** are disposed on a second side **20b** of the optical body **20**. The second side **20b** being different than the first side **20a** of the optical body **20**. More specifically, optical body **20** has the first side **20a** located on an opposite side from the second side **20b**. Thus, the magnetic materials **30** may be inserted into the respective openings **22** from rear and secured in place.

[0036] As discussed herein, each of the first magnetic materials **30**, **230** of optical bodies **20,220** or the second magnet materials **74,274** are respectively selected as a (1) magnet; or (2) a ferrous material that is attracted to a magnet so as to cooperate with the complimentary mating magnetic material disposed in the optical body or housing for providing a magnetic attractive force therebetween. For instance, the magnetic attractive force between the optical body **20** and optical body **220** aligns and holds the optical connection therebetween when mated and may be overcome with sufficient force for unmating the optical connection when desired. By way of example, the magnetic materials may be magnets with the desired pole, ferrous material that is attracted to a magnet, or combinations of magnets and ferrous materials. Magnetic materials may be secured with a friction fit, a mechanical fit, or an adhesive or the like as desired. Moreover, the openings **22** of optical body **20** need not extend to the first side **20a** so that the first side **20a** of optical body **20** may have a generally flush surface at the first side **20a** about the magnetic material **30**; however, the opening could extend to the first side **20a** if desired. Consequently, the first side **20a** (i.e., the mating surface) may have a smooth appearance about the magnetic material locations for aesthetics and/or inhibiting adhesive from reaching the first side **20a** of optical body **20** having the optical interface portion **26**.

[0037] The optical body **20** may have any suitable number of openings **22** arranged in any suitable pattern for receiving the first magnetic material. In this particular embodiment, the one or more openings **22** of optical body **20** are two L-shaped openings arranged on the second side **20b** of the optical body **20**; however, other suitable shapes and/or arrangements are possible. By way of example, the optical body could have two

rectangular or circular openings disposed on opposite sides of the optical interface portion **26** for the first magnetic materials **30** if desired. When optical body **20** of optical connector **10** is mated to the optical receptacle **200** as shown in **FIG. 1**, the first magnetic materials **30** of the optical body **20** are attracted to complimentary second magnetic materials **230** (**FIG. 5**) of optical body **220** of a complimentary electronic device **200**. Further, the first magnetic materials **30,230** may have slightly different sizes and/or shapes so that the assembly of components may only occur in one orientation and avoid issue with attractive forces.

[0038] Optical body **20** can have any suitable arrangement relative to housing **70** as desired. As shown, the optical body **20** is integrally formed with a portion of housing **70** such as first portion **70a**; however, other embodiments are possible where the optical body **20** is a discrete component. For instance if optical body **20** is a discrete component, then optical body **20** may be fixed to housing **70** so that movement is inhibited such as a mechanical fit or securing with an adhesive. In other arrangements, optical body **20** may have a floating or bias arrangement to allow some limited movement of the optical body **20** during mating if it is a discrete component. By way of example, the optical body **20** may be biased to a forward position using one or more resilient members and be allowed to move rearward a few millimeters. As examples, the resilient member may be one or more leaf springs, a wave washer or other suitable components for biasing and allowing small movements of the optical body. Likewise, optical body **220** could have similar mounting arrangements in the optical receptacle.

[0039] As discussed, the optical bodies **20,220** may have solely an optical interface or optionally have a hybrid optical and electrical interface if desired. Illustratively, optical body **20** further includes one or more bores **29** adjacent to the optical interface portion **26** for receiving one or more electrical contacts **86**. In optical body **20** and optical body **220**, the bores **229** are located at outboard sides of the optical interface portions **26** and **226** and are arranged to provide physical contact between respective electrical contacts when mated together. In this case, optical body **20** includes two bores **29**, but any suitable number of bores is possible. Optical bodies may use any suitable type of electrical contacts as desired. By way of example, optical body **20** has one or more pogo pin electrical contacts disposed in the one or more bores **24**. The electrical contacts may be

used for power and/or data transmission as desired. The electrical contacts are electrically connected to electrical conductors of cable **80** for the cable assembly **100** or electrically connected to the circuit board of the electronic device for the optical port.

[0040] Additionally, optical connector **10** and/or the optical receptacle **210** may further optionally include one or more alignment features for keying and/or gross alignment during mating. Moreover, the respective alignment features of the optical connector **10** and optical receptacle **210** may be complimentary in nature. As shown in **FIG. 3**, optical receptacle has alignment features **275** disposed above and below optical body **220**. In this embodiment, the alignment features **275** of optical receptacle **210** are shaped recesses formed in the housing that may be symmetric or asymmetric as desired. Alignment features **275** cooperate with alignment features **75** that are disposed on a portion of housing **70**. Specifically, portion **70a** of housing **70** includes complementary protrusions **75** on opposite sides of optical body **20** for cooperating with alignment features **275** of optical receptacle **210**. Of course, the placement of the recesses and protrusion may be reversed between the optical connector **10** and optical receptacle **210** as desired or with any other complementary alignment features. Other suitable alignment features are possible such as other types of protrusions, castellations, alignment pins and holes, or the like disposed in the housing or optical bodies as desired.

[0041] As shown in **FIG. 10**, optical body **20** may optionally include a well **27** that opens to the at least one fiber lead-in **21**. The well **27** is located at a position where it may receive a suitable index-matching material such as an adhesive for securing the one or more optical fibers of the cable **80** to the optical body **20**. Further, the well **27** may be arranged so that is open to multiple fiber lead-ins **21** and may receive the adhesive for securing all of the optical fibers to the optical body **20**. Optical bodies may also optionally include one or more lenses (not numbered) on other surfaces as part of the optical channel of the optical body as desired. The one or more lenses may be arranged at any suitable location on the optical body **20** besides the TIR surface **23**, but other suitable locations are possible.

[0042] **FIG. 6** is a partially exploded view of the optical receptacle **210** from the rear-side (e.g., from inside the electronic device **200**). Optical receptacle **210** comprises optical body **220** having at least one optical channel **OC2** having an optical interface

portion **226**, one or more first magnetic materials **230** attached to the optical body **220**, a housing **270**, and one or more second magnetic materials **274** attached to the housing **270**.

[0043] The optical receptacle **210** may also optionally include one or more electrical contacts **286**. Like the optical connector **10**, electrical contacts **286** may be any suitable type of electrical contact. Likewise, electrical contacts may be disposed in any suitable locations such as in the optical body or in the housing as desired. By way of example, the one or more electrical contacts may be pogo pin electrical contacts disposed in one or more bores. In the embodiment shown, the electrical contacts **286** are disposed in bores **229** formed in the optical body **220** to cooperate with electrical contacts **86** of optical connector **10**. When assembled, the optical fibers **282** of the electronic device **200** are optically attached to the optical body **220** and the electrical conductors are electrically attached to electrical contacts **286**.

[0044] Optical body **220** of optical receptacle **210** is a portion of electronic device **200**. Optical body **220** is attached to housing **270** of optical receptacle in a suitable manner for the desired application such as discussed with optical body **20**. As shown in **FIG. 7**, optical body **220** is similar to optical body **20**, and includes many of the same features for the same purposes such as a TIR surface **223**, a fiber lead-in **221** and a well **227**; however, other variations could have an optical body **220** provides optical communication by way of in-line optical channel that is in optical communication with one or more active components.

[0045] Stated another way, although optical body **220** is shown having optical channels that turn the optical signals with optical fibers attached thereto and in optical communication therewith, other embodiments of the optical body in optical communication with active components are possible using the concepts disclosed. If optical body **220** has in-line optical channels in optical communication with one or more active components, instead of turning the optical signals, then optical body **20** of optical connector **10** may have a floating attachment to accommodate the fixed optical body **220**. In other words, if an optical body has one or more in-line optical channels they are aligned with active components disposed on the circuit board. On the transmit channels active components such as vertical-cavity side-emitting lasers (VCSELs) or laser diodes

transmit optical signals to the optical body and on receive channels active components such as photodiodes receive optical signals from optical body. However, other embodiments may have all transmit or all receive channels if desired. Thus, the optical signals transmitted to the optical receptacle may be converted into electrical signals and vice versa for transmitting signals to and from a complimentary electronic device that is optically connected to a cable assembly or the like.

[0046] In this embodiment, the optical body **220** of the optical receptacle **210** has an optical channel **OC2** that directs the optical signals to optical fibers **282** by way of TIR surface **223**. Further, optical body **220** may optionally include one or more lenses **225** on the TIR surface **223** or in other locations as desired. If used, the one or more lenses of the optical body may be used for collimating or focusing the optical signal.

[0047] As discussed, optical body **220** cooperates with optical body **20** for providing an optical connection at the mating interface **101** between the optical bodies **20,220** when coupled (e.g., mated) together. Optical body **220** has at least one optical channel **235** having an optical interface portion **226** on a first side **220a** and one or more openings **222** on a second side **220b** for receiving one or more first magnet materials **230**.

[0048] For instance, optical body **220** may include a retaining feature **239** such as a flange for positioning the optical body **220** relative to the faceplate **6**, thereby inhibiting forces from disturbing the optical body alignment with the active components **8** on the circuit board **7** of the electronic device **5**. When assembled and installed, the optical body **220** is a portion of the electronic device **5**.

[0049] Like optical body **20**, optical body **220** is formed from a suitable material such as LEXAN that allows the transmission of optical signals therethrough at the desired wavelength. Like complimentary optical body **20**, optical body **220** includes two optical channels **226**, but the optical body **220** may include any suitable number of optical channels in any suitable arrangement or array as desired, and is typically matched to the complementary optical body for optical communication. Optical body **220** may also optionally include one or more openings **222** for receiving one or more first magnetic materials **230** as best shown in **FIG. 5**. As with optical body **20**, openings **222** of optical body **220** may have any suitable shape and/or size for receiving a respectively sized first magnetic material **230**. The one or more openings **222** may be disposed on any suitable

side of the optical body **220** such as the same side as the optical interface portion **226**, a side adjacent to the optical interface portion **226** (e.g., a short side), or a side opposite to the optical interface portion **226** as desired. In this embodiment, the one or more openings **222** are disposed on a second side **220b** of the optical body **220** with the second side **220b** being different than the first side **220a** of the optical body **220**. More specifically, optical body **220** has the first side **220a** located on an opposite side from the second side **220b**. Thus, the first magnetic materials **230** may be inserted into the respective openings **222** from the second side **220b**. Moreover, since the first magnetic materials **30,230** are not exposed at the first sides **20a,220a** of respective optical bodies **20,220** the first magnetic materials **30,230** may be protected from environmental effects such as inhibiting corrosion and allowing easier cleaning of the respective first sides. In this particular embodiment, the one or more openings **222** of optical body **220** are two L-shaped openings arranged on the second side **220b** to cooperate with optical body **20**; however, other arrangements are possible such as rectangular or circular. Further, the optical bodies may include one or more coatings such as anti-reflection or anti-scratch coatings if desired.

[0050] Optical receptacle **210** also includes a housing **270**. Housing **270** may be integrally formed with a portion of electronic device **200** or be formed as a discrete component such as a panel or module that drop-fits into an opening of the electronic device **200** as desired. The housing further optionally comprises one or more second magnet pockets **272**. Second magnetic material pockets **272** receive respective second magnetic materials **274** therein. Specifically, the second magnetic material pockets **272** are integrally formed with housing **270**. The housing **270** may have any suitable number of second magnetic materials with any suitable arrangement for providing the desired retention force for the mated optical connection.

[0051] FIGS. 7-9 depict various cross-sectional views of the optical connector **10** mated to optical receptacle **210**. FIG. 7 is a cross-sectional view generally taken along the optical axis of the optical connector, FIG. 8 is a cross-sectional view generally taken perpendicular to the optical axis of the optical connector near the center line, and FIG. 9 is a cross-section showing details of an optional moat feature **77** disposed near the base of and an optional chamfer **73** of housing **70**. The chamfer **73** aids in guiding and centering

the optical connector **10** with the optical receptacle **210** during mating and the moat feature **77** an area for dirt and debris to collect and inhibit collection on the optical interface **26**. The housing **70** also includes an optional floor recess **79**. Floor recess **79** is configured to be slightly below the mating surface such as 25 to 50 microns for allowing an area for any dirt or debris to collect and inhibits it from interfering with the mating between the optical connector **10** and optical receptacle **210**. Moreover, the structure of the optical connector **10** and optical receptacle **210** allow access for the user to easily clean the optical interfaces **26,226** when needed.

[0052] In other embodiments, the optical interface portions **26,226** may have a cover that is attached to the optical body **20, 220** and lenses that are integrally molded into the respective optical bodies **20,220** if desired. Cover may be any suitable materials such as a polymer or glass composition that allows the transmission of optical signals therethrough. Moreover, cover may include any suitable coating(s) as desired.

[0053] Optical connector and optical receptacles can have other configurations and/or shapes according the disclosed concepts. **FIGS. 13-15** depict another optical connector **10'** and another complimentary optical receptacle **210'** that are similar to optical connector **10** and optical receptacle **210**, but that have different shapes. **FIG. 13** is a perspective view of another cable assembly **100'** that is similar to cable assembly **100**, having an optical connector **10'** that is attached (e.g., mated) to an electronic device **200'** having a complimentary optical receptacle **210'** according the concepts disclosed herein.

[0054] As shown in **FIG. 14**, optical connector **10'** has a rectangular or diamond shape instead of round shape like optical connector **10**.

[0055] **FIG. 15** depicts the mating interfaces of optical connector **10'** optical receptacle **210'**, which are functionally the same as optical connector **10'** and optical receptacle **210'** so the details will be omitted for brevity. In this embodiment, optical body **20'** and complementary optical body **220'** are configured as generally round elements at the optical interface portions **26',226'**. However, the shapes of the optical bodies **20',220'** could be rectangular with only a round portion at the optical interface portions **26',226'**. Additionally, the housing **70'** of the optical connector **10'** and housing **270'** of optical receptacle **210'** have rectangular or diamond shapes that are complimentary. Likewise,

the housings 70' and 270' have respective alignment features 75',275' that are complimentary in nature.

[0056] The disclosure is also directed to method for making an optical devices such as optical connectors or optical receptacles according to the concepts disclosed. One explanatory method of making an optical device comprises providing an optical body comprising at least one optical channel with an optical interface portion, providing one or more first magnetic materials, attaching one or more of the first magnetic materials to the optical body, providing a housing and one or more second magnetic materials, and attaching the one or more second magnetic materials to a portion of the housing. The method may also optionally include the step of providing a housing with one or more alignment features, attaching one or more electrical contacts to the optical body, and/or having the optical body being a portion of an optical connector or an optical receptacle. Additionally, the method may also optionally further include the step of providing a housing having one or more second magnet recesses.

[0057] Although the disclosure has been illustrated and described herein with reference to 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 concepts disclosed without departing from the spirit and scope of the same. Thus, it is intended that the present application cover the modifications and variations provided they come within the scope of the appended claims and their equivalents.

We claim:

1. An optical device, comprising:
an optical body comprising at least one optical channel having an optical interface portion, a total internal reflection (TIR) surface for turning the optical signal of the at least one optical channel, and at least one fiber lead-in aligned to the TIR surface, wherein the optical body forms a portion of the housing for directly mating with an complimentary device.
2. The optical device of claim 2, further comprising one or more first magnetic materials attached to the optical body or the housing.
3. The optical device of claims 1 or 2, the housing having one or more magnet recesses.
4. The optical device of any one of claims 1-3, further including one or more electrical contacts.
5. The optical device of claim 4, the one or more electrical contacts being one or more pogo pin electrical contacts disposed in one or more bores.
6. The optical device of claim 5, the one or more bores for the electrical contacts being formed in the optical body.
7. The optical device of any one of claims 1-6, further including a lens as a portion of the at least one optical channel.
8. The optical device of claim 2, wherein the optical body further includes one or more openings for the one or more first magnetic materials.
9. The optical device of claim 8, wherein the optical interface portion is on a first side of the optical body and one or more openings are on a second side of the optical body.

10. The optical device of claim 9, wherein the first side is located on an opposite side from the second side.

11. The optical device of any one of claims 1-10, the housing comprising one or more alignment features.

12. The optical device of claim 11, wherein the one or more alignment features are protrusions.

13. The optical device of any one of claims 1-12, the optical body further including a well that opens to the at least one fiber lead-in.

14. The optical device of any one of claims 1-13, the optical connector being a portion of a cable assembly.

15. An optical connector, comprising:
an optical body comprising at least one optical channel having an optical interface portion, a total internal reflection (TIR) surface for turning the optical signal of the at least one optical channel, and at least one fiber lead-in aligned to the TIR surface;
one or more first magnetic materials attached to the optical body;
a housing; and
one or more second magnetic materials attached to the housing.

16. The optical connector of claim 15, the housing having one or more second magnet recesses.

17. The optical connector of claims 15 or 16, further including one or more electrical contacts.

18. The optical connector of claim 17, the one or more electrical contacts being one or more pogo pin electrical contacts disposed in one or more bores.

19. The optical connector of claim 18, the one or more bores for the electrical contacts being formed in the optical body.

20. The optical connector of any one of claims 15-19, further including a lens as a portion of the at least one optical channel.

21. The optical connector of any one of claims 15-20, wherein the optical body further includes one or more openings for the one or more first magnetic materials.

22. The optical connector of claim 21, wherein the optical interface portion is on a first side of the optical body and one or more openings are on a second side of the optical body.

23. The optical connector of claim 22, wherein the first side is located on an opposite side from the second side.

24. The optical connector of any one of claims 15-23, the housing comprising one or more alignment features.

25. The optical connector of claim 24, wherein the one or more alignment features are protrusions.

26. The optical connector of any one of claims 15-25, the optical body further including a well that opens to the at least one fiber lead-in.

27. The optical connector of any one of claims 15-26, the optical connector being a portion of a cable assembly.

28. An optical receptacle, comprising:

a receptacle optical body comprising at least one optical channel having an optical interface portion;

one or more first magnetic materials attached to the receptacle optical body;

a housing; and

one or more second magnetic materials attached to the housing.

29. The optical receptacle of claim 28, the receptacle optical body further comprising a total internal reflection (TIR) surface for turning the optical signal of the at least one optical channel.

30. The optical receptacle of claims 28 or 29, further including one or more electrical contacts.

31. The optical receptacle of claim 30, the one or more electrical contacts being one or more pogo pin electrical contacts disposed in one or more bores.

32. The optical receptacle of claim 31, the one or more bores for the electrical contacts being formed in the receptacle optical body.

33. The optical receptacle of any one of claims 28-32, further including a lens as a portion of the at least one optical channel.

34. The optical receptacle of any one of claims 28-33, wherein the receptacle optical body further includes one or more openings for the one or more first magnetic materials.

35. The optical receptacle of any one of claims 28-34, wherein the optical interface portion is on a first side of the receptacle optical body and one or more openings are on a second side of the receptacle optical body.

36. The optical receptacle of claim 35, wherein the first side is located on an opposite side from the second side.

37. The optical receptacle of any one of claims 28-36, the housing comprising one or more alignment features.
38. The optical receptacle of any one of claims 28-37, the housing further comprising one or more second magnet material pockets.
39. The optical connector of any one of claims 28-38, the optical receptacle being a portion of an electronic device.
40. A method for making an optical device, comprising:
providing an optical body comprising at least one optical channel with an optical interface portion;
providing one or more first magnetic materials;
attaching one or more of the first magnetic material to the optical body;
providing a housing and one or more second magnetic materials; and
attaching one or more second magnetic materials to a portion of the housing.
41. The method of claim 40, wherein the housing includes one or more alignment features.
42. The method of claims 40 or 41, further including the step of attaching one or more electrical contacts to the optical body.
43. The method of any one of claims 40-42, wherein the optical body is a portion of an optical connector or an optical receptacle.

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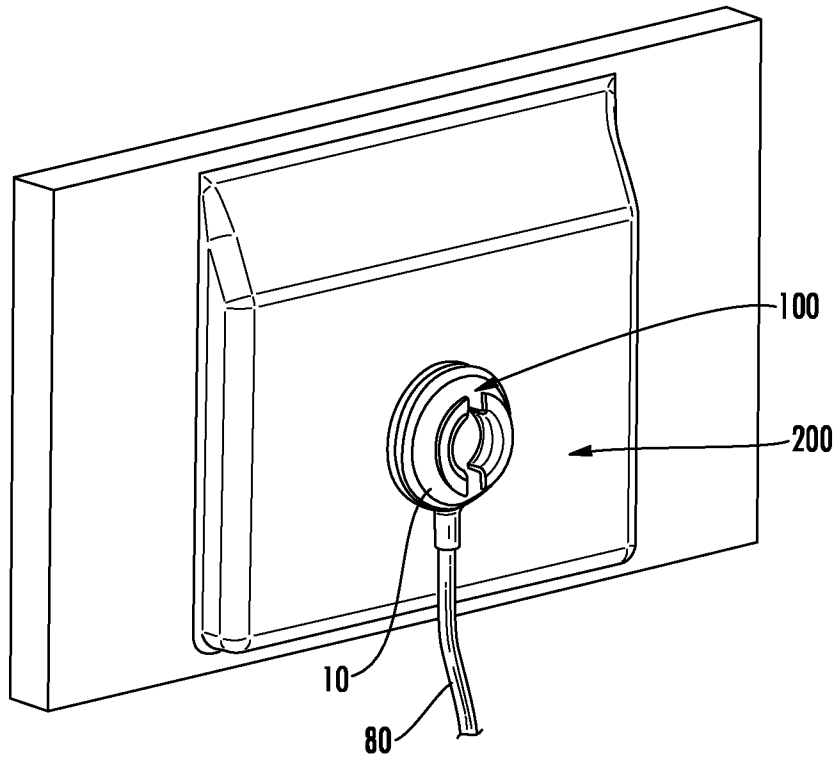


FIG. 1

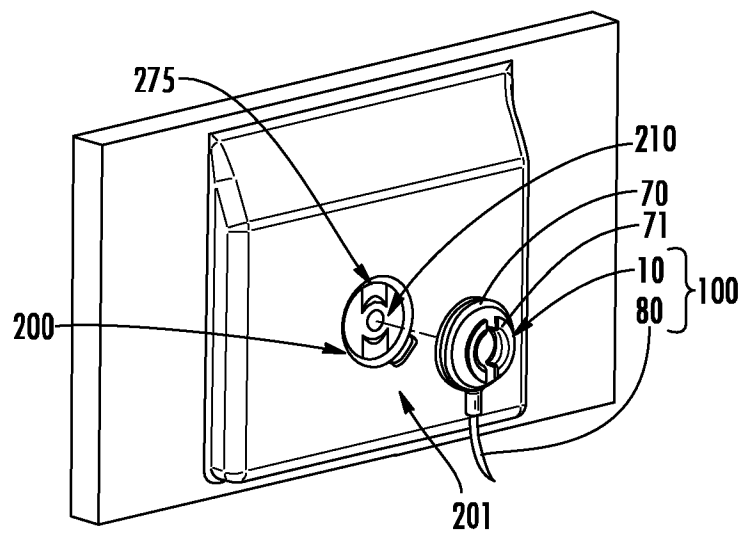


FIG. 2

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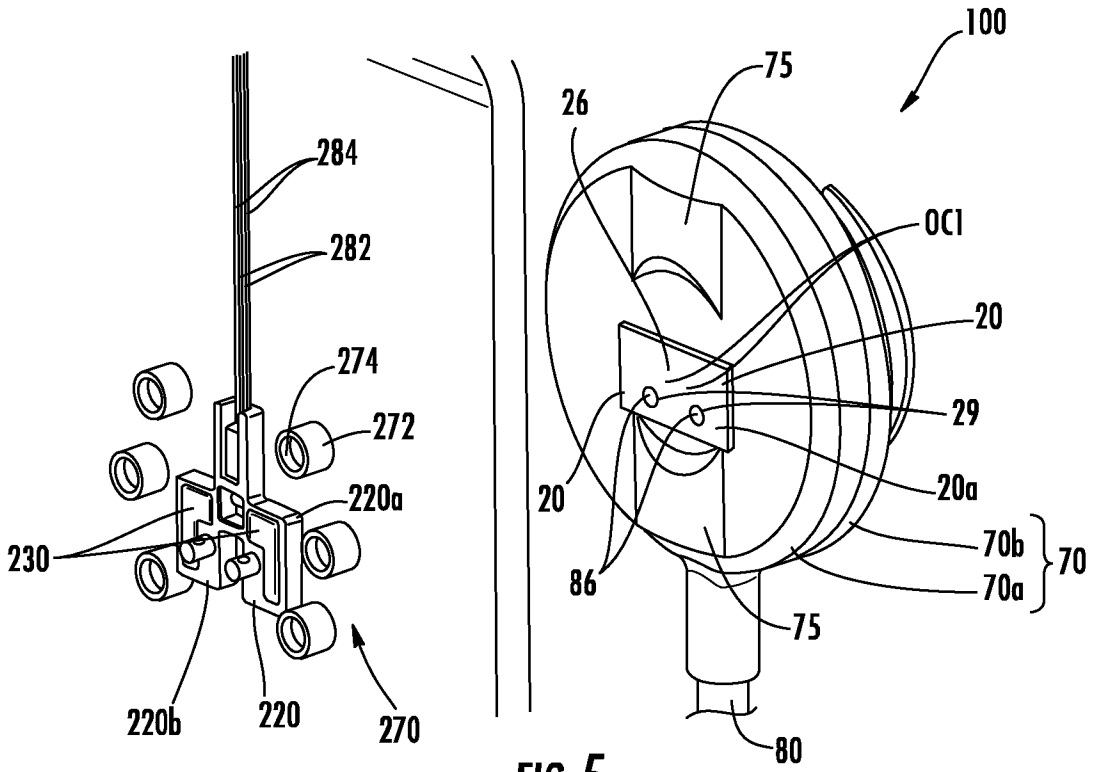


FIG. 5

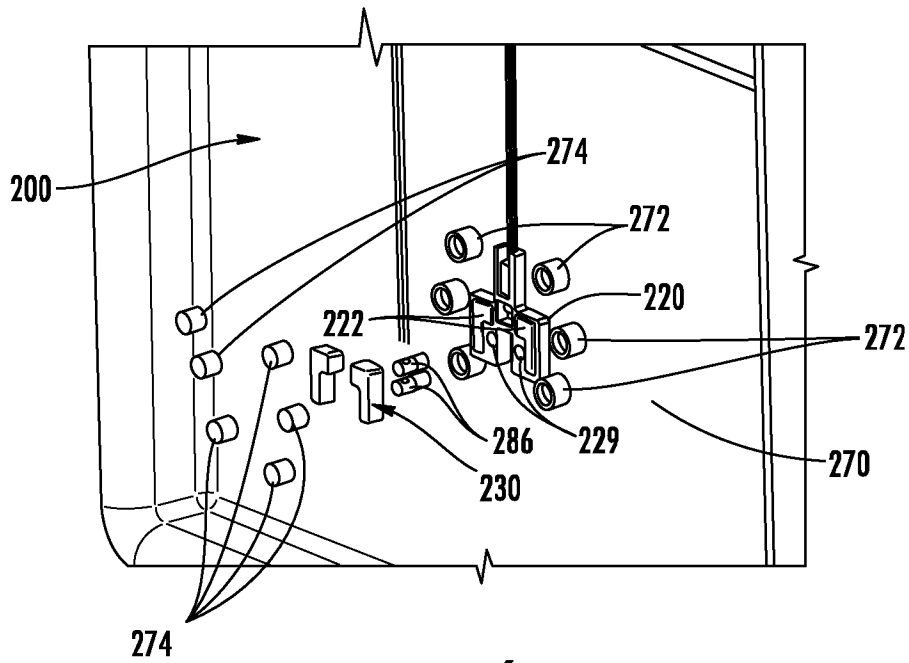


FIG. 6

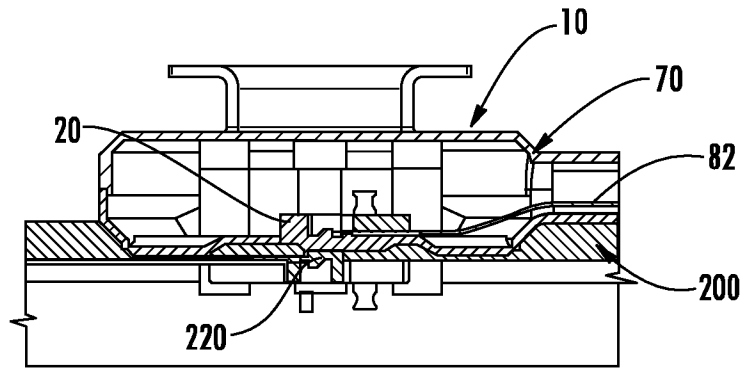


FIG. 7

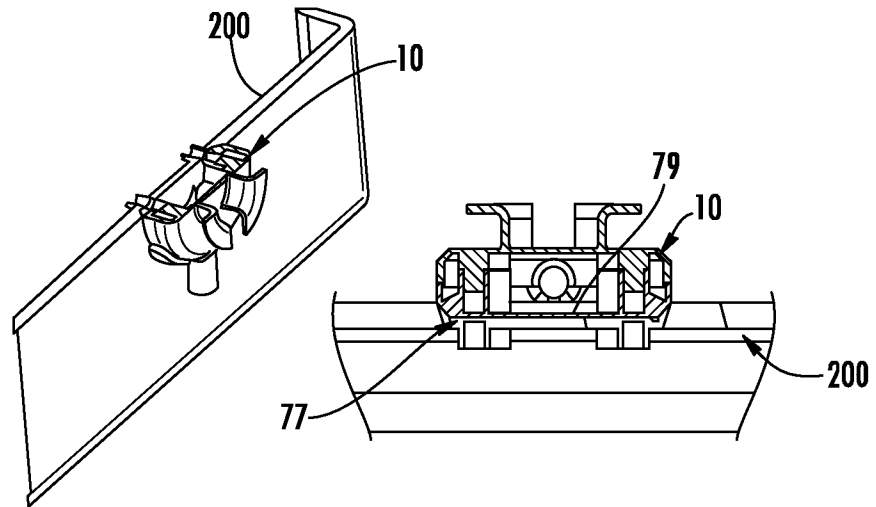


FIG. 8

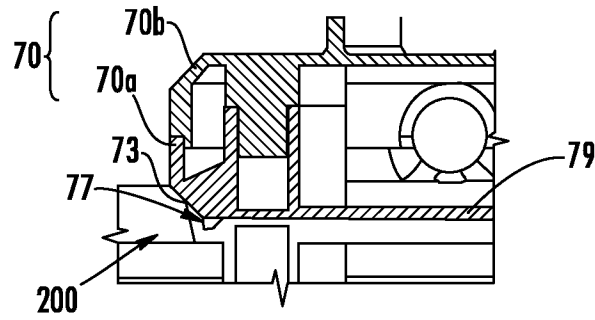


FIG. 9

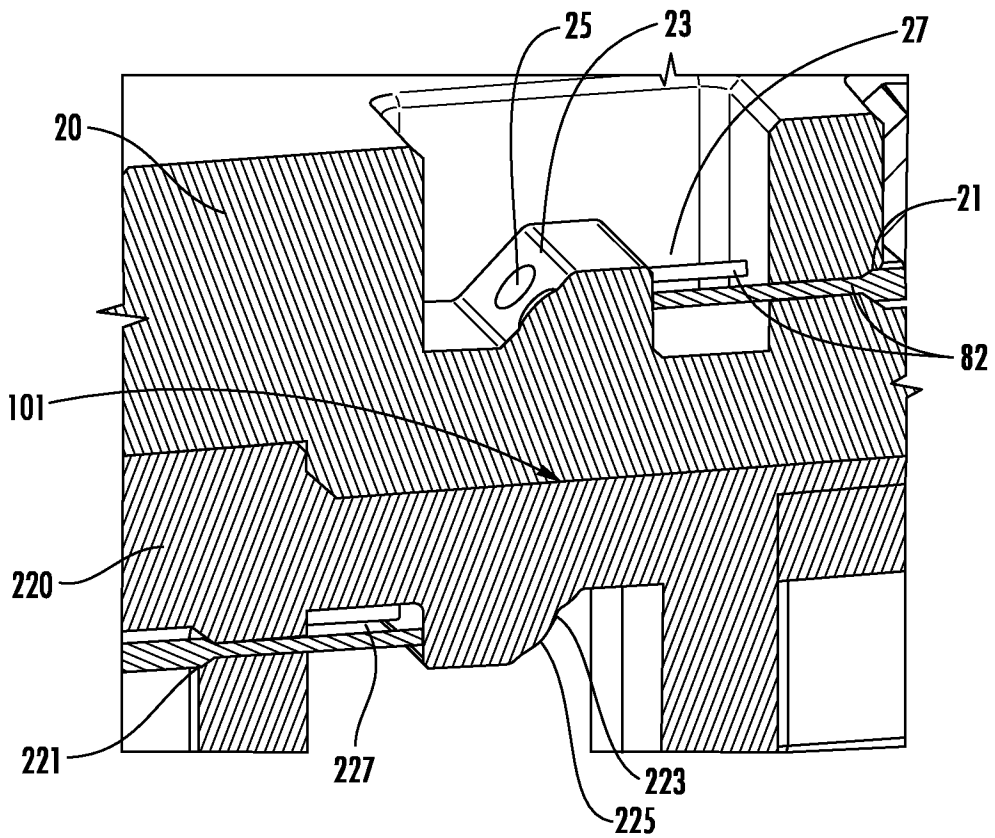


FIG. 10

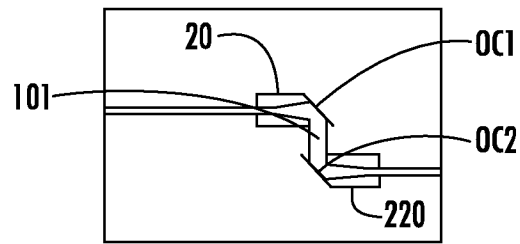


FIG. 11

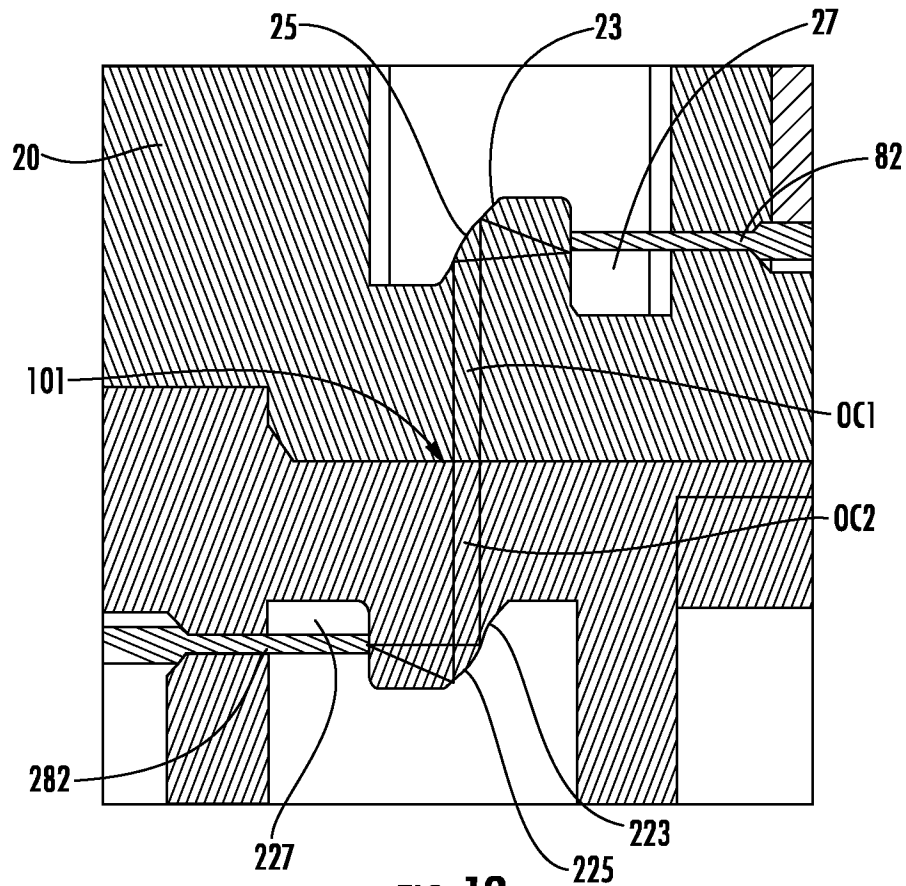


FIG. 12

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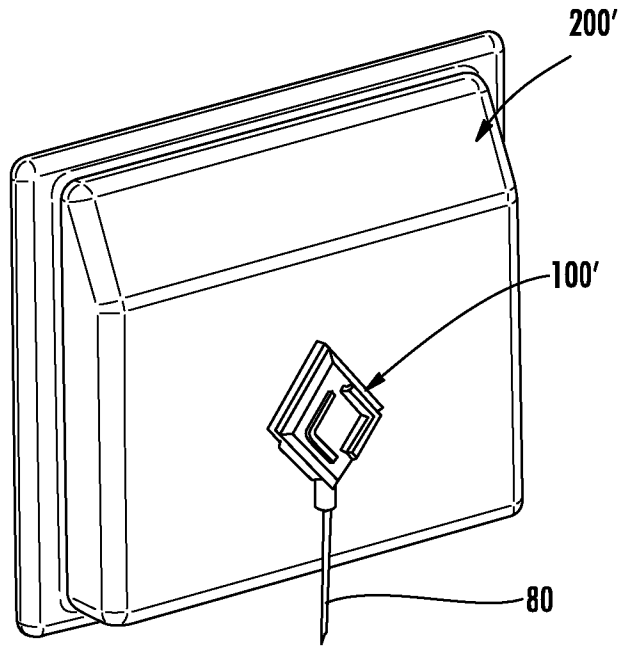


FIG. 13

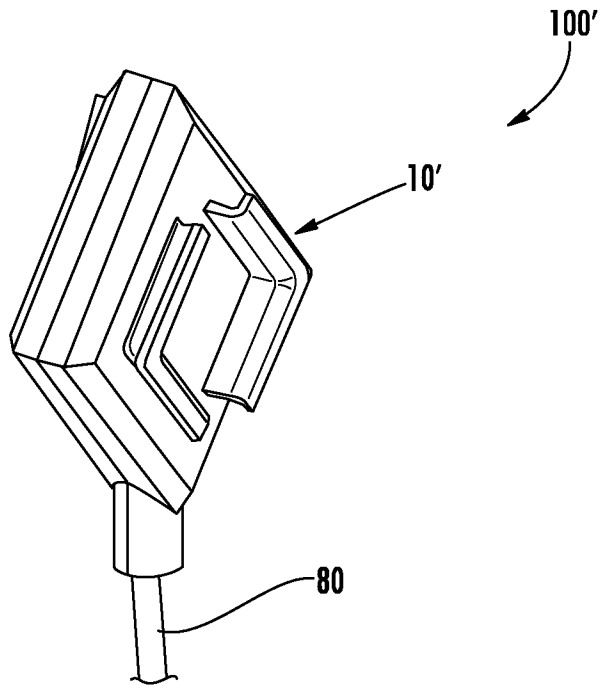


FIG. 14

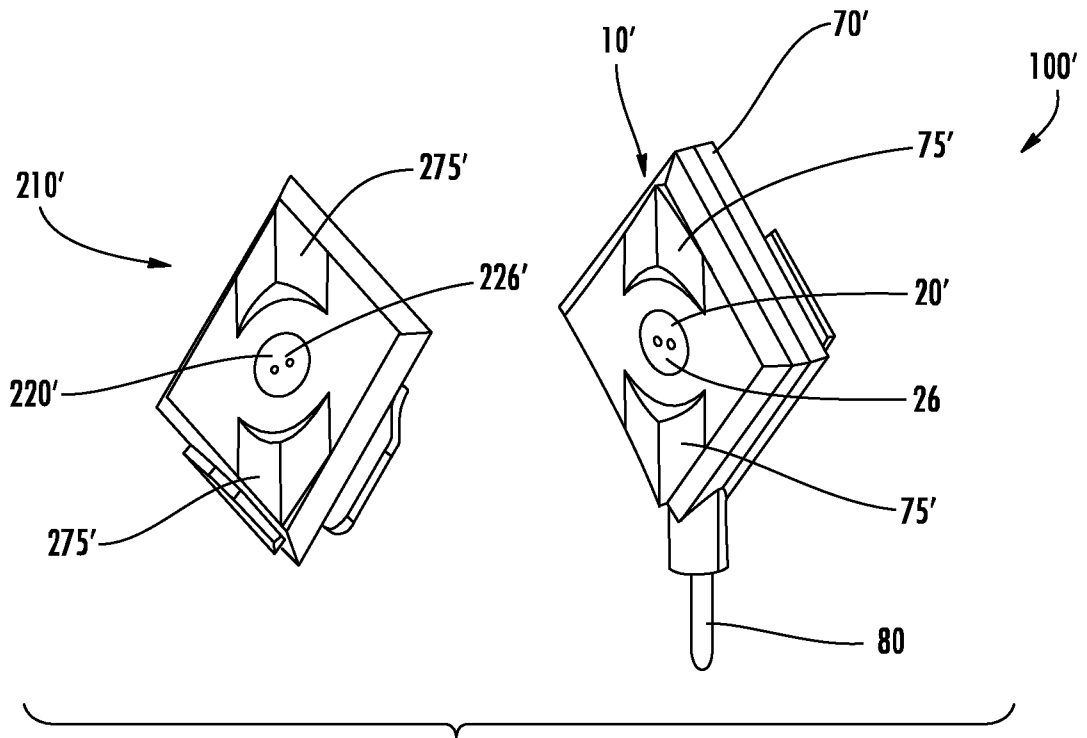


FIG. 15

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2015/050927

A. CLASSIFICATION OF SUBJECT MATTER
 INV. G02B6/38
 ADD. G02B6/42

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.
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X	US 2012/155803 A1 (BENJAMIN SELDON D [US] ET AL) 21 June 2012 (2012-06-21) paragraphs [0007], [0008], [0047], [0061]; figures 1-3B paragraph [0067] - paragraph [0069]; figures 11,13C paragraph [0086] - paragraph [0087]; figure 15 ----- -/--	1-43

Further documents are listed in the continuation of Box C.

See patent family annex.

* Special categories of cited documents :

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"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search 17 November 2015	Date of mailing of the international search report 25/11/2015
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Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Bourhis, J
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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2015/050927

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Information on patent family members

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