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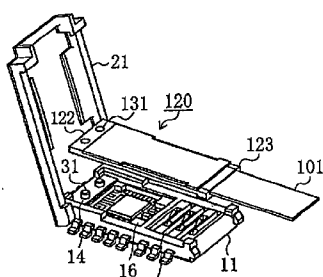


FIG. 13a

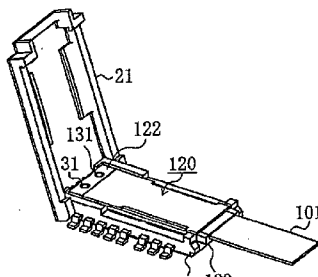


FIG. 13b

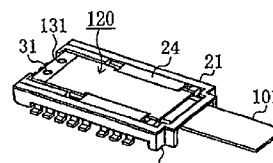


FIG. 13c

(57) Abstract: A hybrid connector includes a connector housing (11) with a lock member (21) and is configured to receive a plug (120) which is connected to a hybrid cable (101) including an optical waveguide and conductive traces. The lock member is configured to be movably mounted on the connector housing between a first position (Fig. 13a) at which the plug may be inserted and removed and a second position (Fig. 13c) at which the lock member locks the plug in operative engagement with the connector housing. The plug includes a plug side guide portion (122), a plug side optical connection portion, and a plug side electrical connection portion. The connector housing includes a guide portion (131), an optical connection portion (16), and an electrical connection portion (17). Upon mounting the plug in the connector housing, the guide portions engage so that the optical connection portions and the electrical connection portions are opposed, respectively. Upon moving the lock member to the second position, the plug is securely retained within the connector housing in an electrically and optically operative position.



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FLAT OPTO-ELECTRIC HYBRID CONNECTOR SYSTEM

BACKGROUND OF THE INVENTION

Field of the Invention

5 The present invention relates to a hybrid connector system which is able to achieve simultaneous connection of an optical waveguide and electrically conductive circuits.

Description of the Related Art

10 Conventionally, in an electronic apparatus (such as a personal computer, a mobile telephone, a personal digital assistant (PDA), a digital camera, a video camera, a music player, a game machine, or a vehicle navigation device), in order to achieve both size reduction of the housing and enlargement of the visual display, the housing is formed of multiple components that are rotatable relative to each other. In this case, electrically conductive cables such as a thin-wire coaxial cables and/or a flexible circuit boards are arranged so as to pass through an opening (having, for example, an inner diameter of about 4 mm) in a hinge provided to permit such pivotal and/or rotational movement between the housing components such that signal transmission may occur between the components.

20 High-quality images require faster transmission of signals but the reduced size of the component housings have made it more difficult to have a large enough opening inside the hinge in order to receive an appropriate cable for such high-quality images. Some small cables may seem

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to operate adequately, but they can cause problems with electro-magnetic interference (EMI).

Light transmission may subsequently reduce EMI while permitting the serial transmission of high speed signals.

5 An example of an optical system is shown in Japanese Patent Application Laid-Open No. 2004-348123. Referring to Fig.

15, optical fiber cable 901 has an end attached to an optical connector body 920. Photoelectric conversion

module 850 is mounted on a circuit board (not shown) and is

10 formed as a rectangularly-shaped or an array-shaped module on which a light emitting element and a light receiving

element are mounted. A connector holder 801 holds the optical connector body 920, which is mounted on the circuit board so as to cover the photoelectric conversion module

15 850. The connector holder 801 has a main body 811 thereof formed of sheet metal and includes a pair of latch arms 821 on an upper surface thereof. The latch arms 821 are configured such that curved protrusions thereof are opposed to each other.

20 When the optical connector body 920 is connected to the photoelectric conversion module 850, the optical connector body 920 is pushed downward by the latch arms 821.

When a lower surface of the optical connector body 920 comes to a position facing the upper surface of the

25 photoelectric conversion module 850. The optical connector body 920 is connected to the photoelectric conversion module 850.

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However, in the conventional optical connector, the width and the thickness of the optical connector body 920 attached to the end of the optical fiber cable 901 is substantially larger than the width and the thickness of the optical fiber cable 901, respectively. As described above, a critical dimension is the size of the opening inside of the hinge between housing components. Consequently, if the optical connector body 920 is large, it and thus optical fiber cable 901 cannot pass through the hinge.

Since the connection between the optical connector body 920 and the photoelectric conversion module 850 is maintained by latch arms 921, it is difficult to reduce the size of the components yet maintain alignment of the optical connector body 920 and the photoelectric conversion module 850.

Japanese Patent Application Laid-Open Publication No. 2006-162834 discloses an assembly enabling serial transmission of high speed signals and an integral arrangement of both an optical waveguide with electromagnetic interference (EMI) protection and electrically conductive circuitry.

Referring to Figs. 16a-c, a conventional connector for simultaneously connecting an optical waveguide and electrically conductive traces is disclosed. Hybrid cable 901 includes an optical waveguide 911 formed therein and conductive traces 951 formed on a surface thereof. A plug

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connector 920 is attached to an end of the cable 901. Plug connector 920 has a connection surface 920a on which contact pads 952, which are connected to the conductive traces 951, are located and also include an exposed end face 911a of the optical waveguide 911. The end face 911a is formed so as to be flush with the connection surface 920a of the plug connector 920.

When the plug connector 920 is connected to a board side connector (not shown), the connection surface 920a abuts a connection surface of the board side connector on which a light receiving element, a light emitting element and counterpart contact pads are arranged. Accordingly, the contact pads 952 are connected to the counterpart contact pads to transmit/receive an electrical signals and the end surface 911a of the optical waveguide 911 faces the light receiving element and the light emitting element to transmit/receive optical signals.

In the conventional connector of Figs. 16a-c, the cable 901 is bent at a substantially right angle in order to form the end surface 911a of the optical waveguide 911 so as to be flush with the connection surface 920a of the plug connector 920. Since the dimension of the plug connector 920 in its thickness-direction needs to accommodate this bend, the plug connector 920 becomes much larger or thicker than the thickness of cable 901. This is undesirable because, as described above, there are significant size limitations on any cable that is intended

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to pass through the inside of a hinge of housing components that are rotatably connected to one another.

Further, the plug connector 920 utilizes a peripheral wall surface surrounding the connection surface 920a to align the surfaces when mating the plug connector with the board side connector. Since the end surface 911a of the optical waveguide 911 is substantially positioned at a the center of the connection surface 920a, it is difficult to maintain alignment accuracy.

10

SUMMARY OF THE INVENTION

The present invention aims at solving problems of the prior art and thus, it is an object of the present invention to provide a hybrid connector assembly in which a plug connected to a hybrid cable having an optical waveguide and conductive traces is mated to a connector. The connector housing has a lock member that is moveable between an open position at which the plug may be received and a closed position at which the plug is operatively secured to the connector housing.

15

20

According to one aspect of the present invention, a hybrid connector includes a connector housing into which a plug connected to a hybrid cable is inserted. The hybrid cable includes both an optical waveguide and electrically conductive traces. A lock member is mounted on the connector housing and is moveable between first and second positions. At the first position, the lock member is

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positioned so that the plug may be inserted into the connector. At the second position, the plug is locked into the connector. The plug is provided with a plug side guide portion, a plug side optical connection portion and a plug side electrical connection portion. The connector housing is similarly provided with a guide portion, an optical connection portion, and an electrical connection portion. Upon mounting the plug in the connector housing, the plug side optical connection portion and the plug side electrical connection portion are opposed to the optical connection portion and the electrical connection portion of the connector housing, respectively. In addition, the guide portion of the plug engages the guide portion of the connector housing to accurately align the optical and electrical components. After the components of the plug are aligned with those of the connector, the lock member may be moved to the second position to lock the housing and plug and thereby optically and electrically connect the hybrid cable to the hybrid connector.

In another aspect of the present invention, the connector housing is a flat plate-shaped member in which the guide portion, the optical connection portion and the electrical connection portion are arranged in a tandem manner. The plug is a flat plate-shaped member in which the guide portion, the plug side optical connection portion and the plug side electrical connection portion are also arranged in a tandem manner. The plug is mounted on the

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connector housing such that a lower surface thereof faces an upper surface of the connector housing.

In another aspect of the present invention, the plug includes a connection region, formed on a leading end of the hybrid cable, and a plug housing in which the connection region is inserted. The connection region includes the plug side optical connection portion and the plug side electrical connection portion, and the plug housing includes the guide portion of the plug.

In accordance with still another aspect of the present invention, the optical connection portion includes a light receiving element which receives light emitted from the optical waveguide and/or a light emitting element which emits light incident to the optical waveguide.

In accordance with another aspect of the present invention, the electrical connection portion includes electrical connection terminals which contact the conductive traces.

In accordance with another aspect of the present invention, the lock member includes a hooked portion formed on one end thereof, a pivot shaft formed on the other end thereof, and a plug pressing portion formed between the two ends thereof. The pivot shaft is rotatably supported by the connector housing, the hooked portion is hooked to a boss portion of the connector housing when the lock member is positioned at the closed position thereof, and the plug pressing portion presses the plug onto the connector

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housing.

In accordance with still another aspect of the present invention, the hybrid connector is configured in a manner such that the plug having the guide portion is

5 connected to the hybrid cable and the plug is mounted in a connector housing to bring the guide portion into

engagement with a guide portion of the connector housing when the lock member is positioned at the open position

thereof. The position of the lock member may then be

10 changed such that the lock member is positioned at the closed position thereof in order to establish and maintain an interconnection between the plug and connector.

Accordingly, an interconnection operation of the hybrid cable can be easily performed, and an optical connection

15 with an optical waveguide and an electrical connection with conductive traces can be simultaneously and accurately

performed by a simple operation. The structure of the hybrid connector can be simplified such that it is easy to

20 operate yet the manufacturing cost of the hybrid connector assembly is relatively low.

These and additional objects, features and advantages of the present invention will become apparent after reading the following detailed description of a preferred embodiment of the invention taken in conjunction

25 with the appended drawings.

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BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a perspective view showing a hybrid connector according to an embodiment of the present invention in a state in which a lock member is opened
5 before a hybrid cable is connected;

Fig. 2 is an exploded perspective view showing the hybrid cable and plug of Fig. 1;

Fig. 3a is a plan view of the plug housing according to the embodiment of the present invention;

10 Fig. 3b is a side view of the plug housing of Fig. 3a;

Fig. 3c is a sectional view taken generally along line Z-Z in Fig. 3a;

15 Fig. 4 is a plan view showing the top-plate of the plug according to the embodiment of Fig. 1;

Fig. 5 is a perspective view of the connection region of the hybrid cable of Fig. 1 viewed from above the cable and at an angle thereto;

20 Fig. 5b is a perspective view similar to Fig. 5a but viewed from the bottom and at an angle thereto,

Fig. 5c is an enlarged view of the circled portion of Fig. 5b;

Fig. 6a is a side cross-sectional view of the connection region of the hybrid cable of Fig. 1;

25 Fig. 6b is an enlarged, somewhat schematic side cross-sectional view of a portion of the connection region of Fig 6a;

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Fig. 7a is a perspective view of the plug of Fig. 1 prior to assembling the plug;

Fig. 7b is a perspective view similar to Fig. 7a but with the plug assembled;

5 Fig. 8a is a plan view of the plug of Fig. 1 during assembly;

Fig. 8b is a cross-sectional view taken generally along line Y-Y of Fig. 8a;

10 Fig. 8c is a cross-sectional view similar to Fig. 8b but after the plug is fully assembled;

Fig. 9 is a perspective view showing the receptacle connector of Fig. 1 with certain parts exploded therefrom;

15 Fig. 10a is a plan view of the connector housing and lock member of Fig. 1 with the lock member in the locked position;

Fig. 10b is a cross-sectional view taken generally along line W-W of Fig. 10a;

Fig. 11a is plan view of the connector housing with the lock member positioned alongside the connector housing;

20 Fig. 11b is a bottom view similar to Fig. 11a;

Fig. 12a is a perspective view of the connector housing of Fig. 1 prior to mounting a seal plate thereto;

25 Fig. 12b is a perspective view similar to Fig. 12a but after the seal plate has been mounted on the connector housing;

Fig. 13a is a perspective view showing a state in which the plug is positioned above the receptacle connector

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prior to mating the plug therein and the latch member is in the open position;

Fig. 13b is a perspective view similar to Fig. 13a but wherein plug is mated to the receptacle connector and latch member is in the open position;

Fig. 13c is a perspective view similar to Fig. 13b but where the latch member is in the closed or locked position;

Fig. 14a is a plan view of the receptacle connector with the plug is fitted therein;

Fig. 14b is a cross-sectional view taken generally along line V-V of Fig. 14a;

Fig. 14c is a cross-sectional view taken generally along line U-U of Fig. 14a;

Fig. 14d is an enlarged view of the encircled portion D of Fig. 14b;

Fig. 14e is an enlarged view of the encircled portion E of Fig. 14b;

Fig. 14f is a somewhat schematic view showing the optical path of light entering the hybrid cable;

Fig. 14g is a somewhat schematic view similar to Fig. 14f but showing the optical path of light emitted from the hybrid cable;

Fig. 15 is a perspective view showing a conventional optical connector;

Fig. 16a is a perspective view showing a conventional plug connector for simultaneously connecting

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an optical waveguide and electrically conductive traces;

Fig. 16b is a cross-sectional view of the conventional connector of Fig. 16a taken generally along line A-A in Fig. 16a; and

5 Fig. 16c is a perspective view of the cable of Fig 16a without the plug connector mounted thereon.

DETAILED DESCRIPTION

10 Preferred embodiments of the present invention will be described below in detail with reference to the accompanying drawings. The following description is intended to convey the operation of exemplary embodiments of the invention to those skilled in the art. It will be
15 appreciated that this description is intended to aid the reader, not to limit the invention. As such, references to a feature or aspect of the invention are intended to describe a feature or aspect of an embodiment of the invention, not to imply that every embodiment of the
20 invention must have the described characteristic.

Referring first to Fig. 1, a receptacle connector generally designated 1 is mounted on the surface of a circuit member such as a printed circuit board (not shown) and functions as a hybrid cable connector for connecting a
25 hybrid cable 101 to the circuit member.

The hybrid cable 101 is a composite cable into which an optical waveguide and electrically conductive circuitry

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151 are incorporated. The hybrid cable may be formed in a number of ways such as by attaching and laminating a flexible flat planar electrical cable such as a flexible printed circuit (FPC) member to one surface of a planar optical waveguide or by forming or otherwise applying a conductive pattern on one surface of the planar optical waveguide.

A plug 120 is attached to a leading end of the hybrid cable 101 to form a hybrid cable assembly. Hybrid cable 101 may be adapted for a variety of uses, but is especially useful in an electronic apparatus in which a housing is divided into multiple components and adjacent components are rotatably connected such as a notebook computer, a mobile telephone, a PDA, a digital camera, a video camera, a music player, a game machine, or a vehicle navigation device. In particular, this structure is useful when the housing is configured so that a cable passes through the inside of a hinge that rotatably connects the adjacent housing components. By using optical fibers or waveguides, electromagnetic interference (EMI) may be eliminated or significantly reduced in a system in which a large number of signals are transmitted at high speeds.

In this embodiment, representations of directions such as up, down, left, right, leading, trailing, and the like, used for explaining the structure and movement of each portion of receptacle connector 1, the hybrid cable 101, the plug 120, and the like, are not absolute, but

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relative. These representations are appropriate when each portion of the receptacle connector 1, the hybrid cable 101, the plug 120 and the like, is in the position shown in the drawing figures. If the position of any of these components changes, these representations must also change in a like manner.

Receptacle connector 1 includes an elongated connector housing 11 which is integrally formed of an insulating material such as synthetic resin together with an elongated lock member 21 integrally formed of an insulating material such as synthetic resin or a metallic material. Lock member 21 is rotatably mounted on connector housing 11 such that it is movable between an open or first position (as shown in Fig. 1) at which the plug 120 may be mounted on or in the connector housing 11 and a closed or second position at which plug 120 is locked on or in connector housing 11. The lock member 21 may be manufactured by bending and pressing a single piece of sheet metal material. The lock member 21 has a pair of sidewall portions 22 extending longitudinally (i.e., in the axial direction of the hybrid cable 101 when inserted into connector 1) and a generally planar plug pressing portion 24 is integrally connected to each sidewall portion 22 so as to extend inward from the inner side surface of the sidewall portion 22. Lock member 21 functions to press plug 120 onto connector housing 11 from the top.

The connector housing 11 is a generally planar,

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elongated rectangular member and has, in serial order, a guide portion 14, an optical connection portion 16 and an electrical connection portion 17. In other words, the three portions are arranged one after another in the longitudinal direction when viewed from a leading end to a trailing end of housing 11. Guide portion 14 acts as a positioning member, and is provided with a flat upper guide surface with guide posts or projections 31 projecting therefrom. Guide projections 31 guide plug 120 during insertion thereof into connector housing 11 so that by engaging guide holes 131 on plug 120, the plug will be precisely positioned relative to connector housing 11. As such, the guide projections 31 act as a reference for positioning the plug 120 relative to receptacle connector 1. The plug 120 is a thin, elongated, generally planar rectangular-shaped member. When the plug 120 is mounted on the connector housing 11, the lower surface or mating face thereof abuts the upper surface or mounting face of the connector housing 11.

The optical connection portion 16 of connector 1 transmits/receives light to/from the optical waveguide of the hybrid cable 101 and has an opening or recess for receiving an optical device such as a control IC 71 with a light reception/emission control element having a control circuit for controlling a light receiving element 72 and a light emitting element 73. Optical connection portion 16 is formed to also receive therein electrically conductive

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optical terminals 61 made of metal that are connected to light receiving element 72, light emitting element 73 and control IC 71. Each optical terminal 61 has a tail portion 63 as board connection portion connectable to contact pads
5 formed on the surface of the circuit member (not shown) such as by soldering, and the tail portions 63 protrude from the side surfaces of the connector housing 11.

The electrical connection portion 17 of connector 1 electrically connects to conductive circuit traces 151 of
10 the hybrid cable 101 and has an opening or recess for receiving electrical connection terminals 51 formed of a conductive material such as metal and the like. The electrical connection terminals 51 have tail portions 53 as
15 board connection portions connectable to contact pads formed on the surface of the circuit member (not shown) such as by soldering, and the tail portions 53 protrude from the side surface of the connector housing 11.

Hybrid cable 101 is a thin, elongated, strip-shaped planar member, but only the portion of the hybrid cable 101
20 in the vicinity of a leading end is shown in Fig. 2 (the left end in the drawing). Connection region 102 extends from a leading end surface 102b a predetermined length and is thicker than the rest of cable 101.

On the lower surface of the hybrid cable 101, a
25 plurality (for example, six) of thin foil-like conductive traces 151 are formed of a conductive material such as metal and are arranged on an electrically insulating layer

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of the hybrid cable 101 in parallel and with a predetermined pitch or spacing. The lower side of each conductive trace 151 is covered by an additional insulating layer as is known in the art. The additional insulating layer is removed from appropriate portions of the connection region 102 such that the lower surface of a portion of each conductive trace 151 (namely, contact pad 152) is exposed in this region.

Contact pads 152, each having a relatively large width, are formed at the extreme ends of the conductive traces 151. The contact pads 152 are formed at positions corresponding to electrical connection terminals 51 located in the electrical connection portion 17 of the connector housing 11 when the hybrid cable 101 is positioned on receptacle connector 1. The portion in which the contact pads 152 are arranged functions as a plug side electrical connection portion 153. The arrangement of the contact pads 152 may be positioned as desired, as is known by one skilled in the art. However, it is preferable that the contact pads 152 be arranged in a "zig-zag" fashion as shown in the drawing or are linearly arranged in tandem in the axial direction of the hybrid cable 101. It is desirable to arrange the plurality of contact pads 152 so as not to increase the width of the connection region 102 and, correspondingly the width of the plug 120.

Referring to Figs. 5a-6b, an optical path conversion portion 161 is formed in connection region 102 at a

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location closer to the leading end 102b than electrical contact pads 152 and operates as an optical connection area. The optical path conversion portion 161 has a sloping or angled surface 162 which functions as a mirror surface and redirects light transmitted by the optical waveguides in a direction that is substantially at a right angle to the path along the optical waveguides. That is, light traveling along the optical path in the axial direction of the hybrid cable 101 is changed or diverted to an optical path that is perpendicular to the lower surface of the hybrid cable 101. In other words, the light transmitted along the optical waveguides is downwardly emitted from the lower surface of the hybrid cable 101 and light entering from the lower surface of the hybrid cable 101 is redirected and transmitted to the optical waveguide. The optical path conversion portion 161 is formed at a position so as to be aligned with both the light receiving element 72 and the light emitting element 73 of the optical connection portion 16 when the hybrid cable 101 is positioned on receptacle connector 1.

Referring to Figs. 2-3c, plug housing 130 has an elongated, rectangularly-shaped frame member 121 extending in the axial direction of hybrid cable 101 and a rectangularly-shaped top plate 126 also extending in the axial direction of hybrid cable 101. Frame 121 is integrally formed of an insulating material such as synthetic resin and has a pair of sidewall portions 124

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extending in the longitudinal or axial direction, a leading lateral cross member or beam 122 for connecting the leading ends of the sidewall portions 124, and a trailing lateral cross member or beam 123 for connecting the trailing ends of the sidewall portions 124. A rectangular opening 125 extends through plug housing 121 in the thickness or vertical direction thereof and is defined by both sidewall portions 124, the leading lateral beam 122 and the trailing lateral beam 123.

Each of the sidewall portions 124 is an elongated rod-like member having a rectangular cross-section and functions as a portion to be pressed downward due to engagement by the plug pressing portion 24 of the lock member 21 from the top. The dimension of sidewall portion 124 in its thickness or vertical direction is substantially equal to that of the connection region 102 of the hybrid cable 101. The inner side surface 124a of sidewall portion 124 is in contact with or abuts a side surface 102a of the connection region 102 of hybrid cable 101 such that the hybrid cable 101 is secured laterally within frame 121.

The leading lateral beam 122 is rectangularly shaped and has a flat lower surface used as a guiding surface and further has guide holes 131 passing therethrough in the thickness direction. The leading lateral beam 122 functions to properly position and guide plug 120 during mounting on the connector housing 11. Namely, guide holes 131 engage the guide projections 31 of the connector

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housing 11 and the lower surface of the leading lateral beam 122 engages the upper surface of guide 14 of connector housing 11. The lower surface of the leading lateral beam 122 is formed so as to be flush with the lower surface of the sidewall portion 124. A trailing end surface 122a of the leading lateral beam 122 contacts or abuts the leading end surface 102b of the connection region 102 of the hybrid cable 101 so that the hybrid cable 101 is aligned in the axial direction. The dimension of the leading lateral beam 122 in its thickness direction is substantially equal to the sum of the thickness of the plug top-plate 126 plus the thickness of sidewall portion 124.

The trailing lateral beam 123 is rectangularly shaped and has a flat upper surface. The upper surface of the trailing lateral beam 123 contacts the lower surface of the connection region 102 of hybrid cable 101 so as to support the hybrid cable 101 from below. Since the upper surface of the trailing lateral beam 123 is connected to the sidewall portions 124 so as to be flush with the lower surfaces of the sidewall portions 124, a trailing end surface of the plug housing 121 is substantially U-shaped when viewed from the trailing side.

The top-plate 126 is a thin, elongated rectangular planar member and is attached to the housing 121 so as to close the opening 125 from the top. Housing 121 and top-plate 126 are separately formed in the embodiment depicted in the drawings but the plug housing 121 and the plug top-

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plate 126 could be integrally formed as one part. It is preferable that the top-plate 126 functions as a conductive shield plate and, as such, is formed of, for example, a metallic plate, a metallic plate molded integrally by synthetic resin material, a composite lamination plate including a metallic layer, or a conductive composite material obtained by mixing a conductive material such as metal or carbon with a compound such as a synthetic resin.

The length of top-plate 126 is substantially equal to the dimension from the trailing end surface 122a of the leading lateral beam 122 to the leading end surface of the trailing lateral beam 123 in the plug housing 121, and the width of top-plate 126 is substantially equal to the dimension from the outer side surface of one sidewall portion 124 to the outer side surface of the other sidewall portion 124. Elongated rectangular cutout portions 127 are formed at both sides of top-plate 126.

When the top-plate 126 is mounted or seated on the plug housing 121 such that the leading end surface of the top-plate 126 is brought into contact with the trailing end surface 122a of the leading lateral beam 122, the plug housing assembly 130 is complete. As can be seen in the figures, the entire area of the opening 125 as well as the upper surfaces of the sidewall portions 124 are covered by the plug top-plate 126 except that the upper surfaces of the sidewall portions 124 are externally exposed in portions thereof which correspond to the cut-away portions

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127. Alternatively, if housing 121 and top-plate 126 are integrally formed, top-plate 126 will be already connected and attached to the plug housing 121.

In the completed plug housing assembly 130, the upper surface of the leading lateral beam 122 and the top surface of the top-plate 126 are flush with each other and the outer side surfaces of the sidewall portions 124 and the side surfaces of the plug top-plate 126 are even with each other, except for the areas of the cut-away portions 127.

The hybrid cable 101 according to the disclosed embodiment is an elongated generally planar flexible member with a laminated structure obtained by laminating a layer of the conductive traces 151 onto the lower side of the layer of the optical waveguides. As described above, the conductive traces 151 are exposed in the connection region 102 and the optical path conversion portion 161 is formed forward, or towards the leading end side, of the contact pads 152 of hybrid cable 101.

As shown in Fig. 6b, the optical waveguide includes a core 111 which forms a light transmission path for transmitting light and cladding 112 surrounding the core 111 on both sides and functioning to confine the light in the core 111 as is known in the art.

The optical waveguide may be of a single mode type, a multi mode type, a step index type or a propagation type. As depicted herein, the optical waveguide is of the multi

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mode type. The refractive index of the cladding 112 is preferably lower than that of core 111, and the optical waveguide is preferably formed of a material of which the refractive index difference between the core 111 and the cladding 112 is equal to or greater than 0.01. The optical waveguide is not limited to these shapes and may have any shape in which a core for transmitting light and the cladding for confining the light in the core are included. Examples of such optical waveguides would be an optical waveguide created by laminating materials, by etching, or by using a photonic crystal structure.

The optical waveguide may be formed of any material that satisfies the refractive index conditions, and may be formed of, for example, a silicon substrate, a glass substrate, a hybrid substrate formed of an organic material and an inorganic material, or a flexible resin film. In the embodiment shown, the optical waveguide is formed of flexible resin film.

An insulating film 113 is attached to the lower surface of the cladding 112 as an insulating layer. The insulating film 113 is formed of any flexible material that is capable of transmitting light and is an insulator. As depicted, the insulating film 113 is formed of polyimide. Since the insulating film 113 has the appropriate light transmission property, light passes through the insulating film 113 so as to be emitted downward from the lower side of hybrid cable 101 or alternatively so as to pass through

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the lower side of the hybrid cable 101 from the outside.

The conductive traces 151 are attached to the lower surface of the insulating film 113. The conductive traces 151 may be formed of any material having electric conductivity. The conductive traces 151 may be formed of, for example, a copper foil or a gold foil and may be formed by plating a surface of copper foil with gold.

A support film 114 is attached to the upper surface of the upper cladding 112 as a support member. The support film 114 has the same width as the hybrid cable 101, is attached or bonded to the entire area of the connection region 102, and applies a certain degree of rigidity to the connection region 102 so as to prevent deformation of the connection region 102 and maintain it in a generally planar shape. Accordingly, due to the relative stiffness of connection region 102, the operation of attaching the housing 121 to the connection region 102 is relatively easy and adhesion between the connection region 102 and the housing 130 after attachment is improved. Support film 114 is formed of synthetic resin and may be any material that has sufficient rigidity and insulative properties.

Referring to Fig. 6b, optical path conversion portion 161 has an equilateral triangular-shaped cross section, with an elongated recess extending in the width direction of the hybrid cable 101, and the sloped surface 162 thereof functions as a mirror surface. The sloped surface 162 is inclined at an angle of substantially 45

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degrees with respect to the axial direction and the thickness direction (the vertical direction in Fig. 6b) of the hybrid cable 101, in order to reflect the light transmitted through the optical waveguide so as to be emitted downward from hybrid cable 101 and, likewise, reflect a light being transmitted upward from a region underneath the hybrid cable 101 to be introduced into the optical waveguide.

The angle of inclination of the sloped surface 162 may be appropriately changed in view of the refractive indexes of the core 111 and the cladding 112 in order to optimize or minimize light loss. The sloped surface 162 may be formed by either dicing, die cutting, or laser processing. More specifically, before the support film 114 is attached, a groove which opens upward and has an equilateral triangular-shaped cross section is formed so as to extend in the width direction of the optical waveguide by means of the aforesaid dicing, die cutting, or laser processing. Thereafter, the support film 114 is bonded by applying adhesive or the like to the upper surface of the cladding 112 to close the uppermost face of the groove. The uppermost face of the optical path conversion portion 161 is closed by the support film 114 in order to reduce the likelihood that foreign matter such as dust could enter into the optical path conversion portion 161 and become attached to the sloped surface 162. The lower end of the groove is formed so as to cut into the cladding 112 located

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underneath core 111, but should not penetrate through the lower surface of cladding 112.

As shown in Fig. 7a, during the assembly of housing 130 to the connection region 102 of hybrid cable 101, an adhesive 128 is applied to the lower surface of top-plate 126 of plug housing 130. The adhesive 128 may be the same as that used to bond support film 114 to hybrid cable 101.

Subsequently, as shown in Fig. 7a, plug housing 130 and hybrid cable 101 are aligned in such a manner that the trailing end surface of the housing 121 and the leading end surface 102b of the connection region 102 are opposed to each other, and then the hybrid cable 101 is moved forward relative to the plug housing 130. The connection region 102 is then inserted from the trailing side of the plug housing 130 into the space defined by the sidewall portions 124 of the plug housing 121 and the plug top-plate 126.

At this point, as shown in Fig. 8b, the upper surface of the connection region 102 slides along the lower surface of top-plate 126 and the lower surface of the connection region 102 slides along the upper surface of the trailing lateral beam 123, so that the insertion of the connection region 102 is successfully guided. At this stage, the side surfaces 102a of the connection region 102 slide along the inner side surfaces 124a of the sidewall portions 124. The hybrid cable 101 is further moved forward relative to the plug housing 130, as denoted by an arrow in Fig. 8b. In this case, since the vertical

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direction, that is, the thickness direction, of the connection region 102 is defined by the plug top-plate 126 and the trailing lateral beam 123, and since the horizontal direction, that is, the width direction, of the connection region 102 is defined by the sidewall portions 124, the connection region 102 is inserted into the plug housing 130 in a state where the proper positioning of the connection region 102 is adequately achieved.

Finally, as shown in Figs. 7b and 8c, when the leading end surface 102b of connection region 102 contacts the trailing end surface 122a of the leading lateral beam 122, the insertion of the connection region 102 is completed. At this point, whatever steps are necessary to cure the adhesive occur (such as applying heat or ultraviolet rays) and the support film 114 of the connection region 102 and the plug top-plate 126 of the plug housing 130 are securely bonded together. The lower surface of top-plate 126 is closely positioned relative to the upper surface of the connection region 102 and the lower surface of the leading lateral beam 122 is flush with the lower surfaces of the sidewall portions 124. In addition, the trailing lateral beam 123 functions to prevent peeling and the connection region 102 is supported from the lower side to prevent the connection region 102 from being peeled from the top-plate 126.

In the assembled plug 120, the leading end surface 102b of the connection region 102 contacts the trailing end

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surface 122a of the leading lateral beam 122 so that the hybrid cable 101 is located in position with respect to the plug housing 130 in the axial direction. Accordingly, the optical path conversion portion 161 and the electrical connection portion 153 are accurately positioned relative to the leading end surface 102b in the axial direction. The distance in the axial-direction from the guide holes 131 formed in the leading lateral beam 122 to the optical path conversion portion 161 and the electrical connection portion 153 can be exactly and readily defined by bringing the leading end surface 102b of the connection region 102 into contact with the trailing end surface 122a of the leading lateral beam 122.

The side surface 102a of the connection region 102 contacts the inner side surface 124a of the sidewall portion 124 such that the hybrid cable 101 is positioned in the width direction relative to the plug housing 130. By properly positioning the optical path conversion portion 161 and the electrical connection portion 153 in the width direction relative to the side surfaces 102a, lateral alignment can be exactly and readily defined by bringing the side surface 102a of the connection region 102 into contact with the inner side surface 124a of the sidewall portion 124.

Since the guide holes 131, the optical path conversion portion 161 and the electrical connection portion 153 are all arranged in tandem along a line in the

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axial direction and are not arranged in parallel, there is no necessity of increasing the width of plug 120 and such dimension is only be slightly larger than that of the hybrid cable 101. More specifically, the dimension in the width-direction of the plug 120 can be set such that only the dimension in the width-direction of the pair of sidewall portions 124 is added to the width-direction dimension of the hybrid cable 101. In this case, since each of the sidewall portions 124 is an elongated rod-shaped member, the dimension in the width-direction of each sidewall portion 124 can be very small and as a result, the width-direction dimension of the entire plug 120 is only slightly larger than that of the hybrid cable 101.

The optical path conversion portion 161 requires positioning accuracy greater than that of the electrical connection portion 153. As a result, optical path conversion portion 161 is positioned closer to guide holes 131 than electrical connection portion 153. Since the mating of the receptacle connector 1 and the plug 120 is performed after positioning the guide projections 31 in the guide holes 131, the light receiving element 72 and/or the light emitting element 73 and the optical path conversion portion 161 are optically connected to each other with a high degree of positioning accuracy and thus, it is possible to realize a low light loss in connection between the receptacle connector 1 and hybrid cable 101.

Since the thickness of the plug 120 can be

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determined by adding only the thicknesses of the top-plate 126 to that of the connection region 102, the thickness of the plug 120 is only slightly greater than that of the hybrid cable 101. In use, when the hybrid cable 101 passes through the inside of a hinge, the interconnection operation is relatively easy to achieve because the plug 120 attached to the end of hybrid cable 101 is very small and only slightly larger than hybrid cable 101.

Referring to Fig. 9, the connector housing 11 is generally elongated and rectangular and has a pair of generally parallel sidewall portions 12 extending in the axial direction. A round bearing hole 13 is formed adjacent the vicinity of each leading end (the left end in Fig. 10b) of the respective sidewall portions 12, and cylindrical pivotal shafts 23 of the lock member 21 are inserted into the bearing holes 13 so as to be rotatably supported therein. Tail portions 53 of electrical connection terminals 51 and tail portions 63 of an optical terminal 61 protrude from the sidewall portions 12.

A trailing end wall 15 at the trailing end of connector housing 111 extends in the width direction so as to connect the sidewall portions 12. The respective sidewall portions 12 are connected together at the leading ends thereof by the guide 14 extending in the width direction and at the middle portions thereof by a partitioning wall 35 also extending in the width direction and operating to provide a partition between the optical

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connection portion 16 and the electrical connection portion 17. Locking bosses 15a are formed at positions in the vicinity of the outside edges of the trailing end wall 15 in the width-direction thereof, that is, at positions on the trailing end faces of the sidewall portions 12, as hooks protruding rearwardly, or away from guide 14. When the lock member 21 is rotated to the closed position thereof, locking projections 25a, which are formed as a hooked portion, snap over and engage the locking bosses 15a so as to lock the lock member 21 to the connector housing 11.

Leading projecting walls 18 protrude upward and extend in the longitudinal or axial direction and extend from the upper surfaces of the sidewall portions 12 in the vicinity of the leading end of the connector housing 11. The leading projecting walls 18 include auxiliary portions 18a which are integrally connected to the leading ends of the leading projecting walls 18 and extend in a direction perpendicular or transverse to the longitudinal or axial direction. Each leading projecting wall 18 together with its auxiliary portion 18a define an L-shape and engage and position the corners of the leading ends of the plug 120. Namely, the inner side surfaces of the leading projecting walls 18 and the trailing side surfaces of the auxiliary portions 18a are configured and dimensioned to contact or abut the side surfaces and the leading end face of the leading end of plug 120, respectively.

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Trailing projecting walls 19 protrude upward and extend from the upper surfaces of the sidewall portions 12 at the trailing end of the connector housing 11. In other words, they protrude upward at the upper surfaces of both outside ends of the trailing end wall 15 and are separated in the width-direction by the trailing end wall 15. The inner side surfaces of the trailing projecting walls 19 engage the side surfaces of plug 120 in the vicinity of the trailing end of the plug 120.

Proper alignment of connector housing 11 and plug 120 is primarily achieved by using guide 14 as a reference. Alignment in the vertical or thickness direction is achieved by utilizing the upper surface of guide 14. In the longitudinal or axial direction as well as the transverse or width direction, alignment is achieved by utilizing guide projections 31. In the example shown in the figures, two guide projections 31 are used. However, the number could also be one or three or more. It is preferable but not necessary that the number of guide projections 31 is more than one.

Optical devices such as control IC 71, light receiving element 72 and light emitting element 73 are received in the optical connection portion 16. In the example shown in the drawings, the light receiving element 72 is disposed at the right side and the light emitting element 73 is disposed at the left side with respect to an axial line directed between the leading and trailing ends.

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Alternatively, the light receiving element 72 may be disposed at the left side and the light emitting element 73 may be disposed at the right side. Although the drawings show only one light receiving element 72 and one light emitting element 73, the number of light receiving elements 72 and light emitting elements 73 may be optionally selected and may, for example, be two or more, respectively. The light receiving element 72 and the light emitting element 73 are positioned directly beneath the sloped surface 162 of the optical path conversion portion 161 when plug 120 is properly positioned in the receptacle connector 1.

The control IC 71 connected to the light receiving element 72 and the light emitting element 73 may be disposed at any position in the optical connection portion 16 or outside the optical connection portion 16, but is preferably positioned close to the light receiving element 72 and the light emitting element 73 in view of the transmission/reception of the signal of the light receiving element 72 and the light emitting element 73. Control IC 71 does not need to be formed independently of the light receiving element 72 and the light emitting element 73 and may be integrally formed with such elements.

In addition to the light receiving element 72, the light emitting element 73 and the control IC 71 being respectively connected at the optical connection portion 16, the optical terminals 61 for connecting control IC 71 and

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the contact pads formed for connection to the surface of the circuit member (not shown) are also located at portion 16. Portions connected to contact pads formed on the surface of a substrate of the optical terminal 61 protrude outward from the connector housing 11 as tail portions 63. The tail portions 63 do not always need to protrude from the outer side surfaces of the sidewall portions 12 and may protrude from the leading end face of the guide 14 as shown in Figs. 10 and 11. The number and the arrangement of the tail portions 63 may be arbitrarily set depending on the specific constraints of the application.

A thin planar seal plate 41 (Fig. 12) is mounted on the upper surface of the optical connection portion 16 and is formed of a light transmission material such as glass. As shown in Fig. 12, an adhesive 42 is applied on the upper surface of the recess or opening in the optical connection portion 16. The adhesive 42 is used to bond the glass seal plate 41 to the upper surface of optical connection portion 16 in order to seal such portion as shown in Fig. 12b. The adhesive 42 is subsequently cured by heating or by irradiation of ultraviolet rays. Accordingly, the optical connection portion 16 is sealed and foreign matter such as dust and the like is prevented from entering optical connection portion 16 to contaminate the light receiving element 72, the light emitting element 73, the control IC 71 and the optical terminals 61. Since the seal plate 41 has the desired light transmission property (i.e., is

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transparent), the light receiving element 72 and the light emitting element 73 received in the optical connection portion 16 can receive and emit light through the seal plate 41.

5 The electrical connection terminals 51 are received in the electrical connection portion 17. A gap maintaining member 32 (Figs. 11a, 11b) that is configured to hold thereon the electrical connection terminals 51 is provided for preventing neighboring electrical connection terminals
10 51 from contacting each other and is received in the electrical connection portion 17.

 In the example shown in the drawing, each electrical connection terminal 51 is a cantilever-shaped member and extends in the width direction of the connector housing 11
15 and has a base end supported by one sidewall portion 12 and a free end positioned at the other sidewall portion 12, opposite the sidewall retaining the base end of that electrical connection terminal 51. A contact portion 52 formed in the vicinity of the free end is positioned within
20 the electrical connection portion 17 and the tail portion 53 extending at the opposite side of the contact portion 52 protrudes outward from the outer side surface of the sidewall portion 12. The contact portion 52 protrudes from the upper surface of the sidewall portion 12 so as to be in
25 contact with a contact pad 152 of the hybrid cable 101 and has a substantially inverted V-shape.

 As best seen in Fig. 11a, the terminals 51 are

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inserted in an alternating array whereby adjacent terminals are retained at opposite sidewall portions 12. In other words, the base ends of the adjacent electrical connection terminals 51 are arranged so as to be alternatively

5 supported by the left and right sidewall portions 12. Each contact portion 52 is located closer to the sidewall portion 12 opposed to the sidewall portion 12 supporting its base end. The contact portions 52 are arranged in a single plane in a "zig-zag" manner while forming a tandem
10 arrangement in the longitudinal direction of the connector housing 11, so that the arrangement of the contact portions 52 corresponds to that of the contact pads 152 of the hybrid cable 101. Since the portion between the contact portion 52 and the base end is relatively long, it

15 functions as an elastically deformable spring such that the electrical connection terminals 51 are not plastically-deformed and the contact force of the contact portions 52 against the contact pads 152 is sufficiently large. The number and the arrangement of the electrical connection
20 terminals 51 may be arbitrarily selected and set so long as they correspond to the contact pads 152 of the hybrid cable 101.

The gap maintaining member 32 is inserted into the electrical connection portion 17 through the open bottom of
25 the electrical connection portion 17 and is fixed thereto. Gap maintaining member 32 has a plurality of terminal receiving grooves 33 with each having an open upper end and

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extending in the width direction of the connector housing 11. Portions of the electrical connection terminals 51 are received in the terminal receiving grooves 33 and thus separated in order to prevent neighboring electrical connection terminals 51 from contacting each other.

Lock member 21 is substantially arch-shaped and has a pair of elongated rod-shaped sidewall portions 22 and a connection bridge 25 for connecting one end of each sidewall portion 22 together. Pivot shafts 23 extend inward and are formed at the end of the sidewall portions 22 opposite connection bridge 25. Pivot shafts 23 are inserted into the bearing holes 13 of the connector housing 11 and are rotatably supported therein so that lock member 21 is rotatably or pivotally attached to the connector housing 11.

Each locking projection 25a protrudes toward the opposite end of its respective sidewall portion 22 and is formed at opposite ends of connection bridge 25. As shown in Fig. 10b, when the lock member 21 is positioned at the closed position, the locking projections 25a extend over and are hooked to locking bosses 15a of connector housing 11. Accordingly, the lock member 21 is latched or hooked to connector housing 11 and thus plug 120 is locked in connector 1.

Lock member 21 has a planar plug pressing portion 24 integrally connected to each sidewall portion 22 so as to extend inwardly from the inner side surface of each

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sidewall portion 22 generally in the longitudinal middle section of the sidewall portion 22. When lock member 21 is positioned at the closed position, plug pressing portion 24 presses the top of plug 120 onto the upper surface of the connector housing 11. More specifically, engaging portions 27 are slightly thicker than the rest of plug pressing portions 24. When the plug pressing portions 24 press the top of plug 120, the engaging portions 27 engage the aforementioned cut-away portion 127 of the plug top-plate 126, and contact the upper surfaces of the respective sidewall portions 124 that are exposed through the corresponding cut-away portion 127. Thus, the engaging portions 27 press the sidewall portions 124 of the plug 120 from the top thereof.

If the lock member 21 is comprised of a metallic material and is formed by bending a metal plate, the plug 120 may be adequately forced downward due to the elasticity of the metal plate itself. In such case, the plug pressing portion 24 extends inwardly from the inner side surface of the sidewall portion 22 and is bent so as to slope toward a plug 120 mounted in the receptacle connector 1 or downward as viewed in Fig 10b. Since the plug pressing portion 24 has elasticity or resiliency, the plug 120 can be pressed downward using the elasticity of the metal plate even if plug pressing portions 24 do not include engaging portions 27.

As shown in Fig. 13a when inserting plug 120 into

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receptacle connector 1, the lock member 21 is positioned at its open position and the plug 120 is positioned above the connector housing 11. In this case, the lower surface of the plug 120 (i.e., the exposed surfaces of the contact pads 152), is opposed to the upper surface of the connector housing 11, the leading lateral beam 122 of the plug 120 is positioned immediately above guide 14 of connector housing 11, and the trailing lateral beam 123 of the plug 120 is positioned immediately above the upper side of the trailing end wall 15 of the connector housing 11.

Subsequently, plug 120 is moved downward relative to connector housing 11 so that it fits within connector housing 11. As this occurs, guide projections 31 of connector housing 11 are inserted into guide holes 131 of plug 120 and the plug 120 is moved downward. Accordingly, the guide projections 31 are engaged in the guide holes 131 and the plug 120 is highly accurately seated in position with respect to the connector housing 11 in both the axial direction and in the width direction relative to hybrid cable 101. As a result, the optical connection portion 16 and the electrical connection portion 17 of the connector housing 11 are respectively opposed to the optical path conversion portion 161 and the electrical connection portion 153 of the plug 120. The lower surface of the leading lateral beam 122 is brought into contact with the upper surface of the guide 14 such that accurate positioning in the thickness direction is also achieved.

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Since the corners of the leading end of the plug 120 are engaged by the leading projecting walls 18 of the connector housing 11 and the side surfaces in the vicinity of the trailing end of the plug 120 are engaged by the trailing projecting walls 19 of the connector housing 11, the positional relationship between the plug 120 and the connector housing 11 is securely maintained. Accordingly, the positional relationship should not be changed by external forces.

Subsequently, lock member 21 is rotated from its open position to its closed position as shown in Fig. 13c so that the plug 120 is locked within connector 1. In this case, the locking projections 25a of the lock member 21 engage the locking bosses 15a of the connector housing 11 such that the lock member 21 is hooked or latched to the connector housing 11. The engaging portions 27 formed on the inside edges of the plug pressing portions 24 engage the cut-away portions 127 of the top-plate 126 of the plug 120. This action thereby brings the upper surface of the sidewall portion 124, which is exposed by the cut-away portion 127, into contact with engaging portions 27. Accordingly, the plug 120 cannot be moved relative to the connector housing 11 in the vertical, longitudinal or lateral directions. Through such an action, the plug 120 and thus hybrid cable 101 are properly mated to the receptacle connector 1, and the hybrid cable 101 and the receptacle connector 1 are optically and electrically

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connected.

When the plug 120 is mated to the receptacle connector 1, as shown in Fig. 14b, the lower surface of the plug 120 is closely positioned next to or abouts the upper surface of the connector housing 11. As shown in the encircled area "c" of Fig. 14c, the sidewall portions 124 of the plug 120 are pressed from the top by the engaging portion 27 of the plug pressing portions 24 of the lock member 21. The contact portions 52 of the electrical connection terminals 51 corresponding to the contact pads 152 of the hybrid cable 101 are also pressed from the top. Accordingly, the electrical connection terminals 51 are elastically deformed to generate a spring force, the contact portions 52 are pressed against the contact pads 152 by the spring force, and good, reliable contact is made between the contact portions 52 and the contact pads 152.

As shown in Fig. 14d, since the guide holes 131 engage the guide projections 31, the plug 120 is accurately positioned with respect to connector housing 11 in both the axial direction and in the transverse direction of the hybrid cable 101. Consequently, the contact pads 152 of the hybrid cable 101 and the contact portions 52 of the electrical connection terminals 51 of the receptacle connector 1 are accurately aligned and in contact with each other to establish the desired electrical connection.

As shown in Fig. 14e, the optical path conversion portion 161 of hybrid cable 101 is positioned directly

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above the light emitting element 73 of receptacle connector 1. The core 111 corresponding to, or aligned with, the light emitting element 73 is also laterally aligned with the light emitting element 73 of hybrid cable 101.

5 Similarly, the optical path conversion portion 161 of hybrid cable 101 is positioned directly above the light receiving element 72 of the receptacle connector 1 and the core 111 corresponding to the light receiving element 72 is also laterally aligned with the light receiving element 72.

10 Hence, the hybrid cable 101 and the receptacle connector 1 are optically connected to each other.

That is, as shown in Fig. 14f, the light emitted from the light emitting element 73 travels to the sloped surface 162 of the optical path conversion portion 161
15 where it is reflected substantially at a right angle so as to be introduced into the core 111 corresponding to the light emitting element 73 and is transmitted in the core 111 in the axial direction of the hybrid cable 101. An arrow shown in Fig. 14f indicates the optical path of the
20 light emitted from the light emitting element 73.

Similarly as shown in Fig. 14g, light transmitted in the axial direction of hybrid cable 101 through core 111 is reflected substantially at a right angle by the sloped surface 162 of the optical path conversion portion 161, and
25 is emitted from the hybrid cable 101 downward where it is received by the light receiving element 72. An arrow shown in Fig. 14g indicates the optical path of the light

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received by light receiving element 72.

In the depicted embodiment, connector housing 11 of receptacle connector 1 receives plug 120 connected to the hybrid cable 101 and is locked in place by lock member 21 mounted on housing 11. The plug 120 has the leading lateral beam 122 functioning as a positioning portion, the optical path conversion portion 161 functioning as part of the optical connection portion and the electrical connection portion 153 functioning to establish part of the electrical connection portion. Connector housing 11 has the guide 14 functioning as a positioning portion, the optical connection portion 16 functioning as the other part of the optical connection and the electrical connection portion 17 functioning as the other part of the electrical connection. When the lock member 21 is positioned at the open position, plug 120 may be mounted in connector housing 11 such that the guide 14 engages the leading lateral beam 122 of hybrid cable 101 and the optical path conversion portion 161 and the plug side electrical connection portion 153 of the hybrid cable are opposed to the optical connection portion 16 and the electrical connection portion 17 of housing 11, respectively. When the lock member 21 is moved to the closed position thereof, the plug 120 is locked to the connector housing 11 and the receptacle connector 1 is optically and electrically connected to the hybrid cable 101. Therefore, by moving the position of the lock member 21 to the closed position, it is possible to

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realize accurate and reliable optical and electrical connection with the hybrid cable 101.

The connector housing 11 is a flat, plate-shaped member in which the guide 14, the optical connection portion 16 and the electrical connection portion 17 are arranged in a line, and the plug 120 is a flat plate-shaped member in which the leading lateral beam 122, the optical path conversion portion 161 and the plug side electrical connection portion 153 are also arranged in a line. When the plug 120 is mounted in the connector housing 11, the lower surface of the plug is opposed to the upper surface of the connector housing 11.

Through this structure, it is possible to miniaturize the connector housing 11 and the plug 120 and, more particularly, reduce the width and the thickness of the plug 120 and simplify the overall shape. Since the plug 120 is a small simple shape, it is possible to easily perform the interconnection operation between hybrid cable 101 and receptacle 1.

The optical connection portion 16 of housing 11 has the light receiving element 72 for receiving the light emitted from the optical waveguide, the light emitting element 73 for emitting the light to the optical waveguide, and the control IC 71 for controlling the operations of the light receiving element 72 and the light emitting element 73. Since all of the optical devices are positioned in the connector housing 11 and are not positioned in the plug 120,

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configuration of plug 120 is simplified. This permits modification of the optical devices without needing to modify plug 120.

Although the present invention has been described
5 with reference to a specific embodiment thereof, the description is illustrative and is not to be construed as limiting the invention. Various modifications to the present invention may be made to the preferred embodiment by those skilled in the art without departing from the true
10 spirit and scope of the invention as defined by the appended claims.

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WHAT IS CLAIMED IS:

1. A hybrid connector (1) comprising:

a connector housing (11) configured to receive a plug (120), which is connected to a hybrid cable (101) including an optical waveguide and conductive traces (151);
5 and

a lock member (21) configured to be movably mounted on the connector housing (11) between a first position at which the plug may be inserted and removed and a second position at which the lock member (21) locks the plug in operative engagement with the connector housing, wherein:

the plug (120) includes a guide portion (122), a plug side optical connection portion (161), and a plug side electrical connection portion (153);

15 the connector housing (11) includes a guide portion (14), an optical connection portion (16), and an electrical connection portion (17);

the plug (120) is mounted in the connector housing (11) such that upon engaging the guide portion of the plug (14) with the guide portion (122) of the connector housing, the plug side optical connection portion (161) and the plug side electrical connection portion (153) are opposed to and operatively connected to the optical connection portion (16) and the electrical connection portion (17) of the connector housing, respectively, and , when the lock member is in the second position; and

upon moving the lock member to the second position,

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the plug is securely retained within the connector housing in an electrically and optically operative position.

2. The hybrid connector (1) according to claim 1, wherein:

5 the connector housing (11) is formed in a flat plate-shaped member, in which the positioning portion (14), the optical connection portion (16) and the electrical connection portion (17) are arranged in tandem,

10 the plug (120) is formed in a flat plate-shaped member in which the positioned portion (122), the plug side optical connection portion (161) and the plug side electrical connection portion (153) are arranged in tandem, and

15 the plug (120) is mounted in the connector housing (11) such that a lower surface thereof is arranged to face an upper surface of the connector housing (11).

3. The hybrid connector (1) according to claim 1, wherein:

20 the plug (120) includes a connection region (102) formed on a leading end of the hybrid cable (101) and a plug housing (130) in which the connection region (102) is inserted,

25 the connection region (102) includes the plug side optical connection portion (161) and the plug side electrical connection portion (153), and

the plug housing (130) includes the positioned portion (122).

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4. The hybrid connector (1) according to claim 1,
wherein the optical connection portion (16) includes a
light receiving element (72) capable of receiving a light
emitted from the optical waveguide and/or a light emitting
5 element (73) capable of emitting a light incident to the
optical waveguide.

5. The hybrid connector (1) according to claim 1,
wherein the electrical connection portion (17) includes
electrical connection terminals (51) which come in contact
10 with the conductive traces (151).

6. The hybrid connector (1) according to claim 1,
wherein:

the lock member (21) includes a hooked portion (25a)
formed in one end thereof, a pivotal shaft (23) formed on
15 the other end thereof, and a plug pressing portion (24)
formed on a middle portion thereof,

the pivotal shaft (23) is rotatably supported by the
connector housing (11), and

the hooked portion (25a) is hooked to a hook portion
20 (15a) of the connector housing (11) so that the plug
pressing portion (24) presses the plug (120) to the
connector housing (11), when the lock member (21) is
positioned at a close position thereof.

7. A hybrid connector configured to mate with a
25 plug (120) which is connected to a hybrid cable (101)
having an optical waveguide and conductive traces (151),
the plug (120) including guide portion (122), an optical

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connection portion on said plug side (161) and an electrical connection portion on said plug side (153), all of which are arranged in tandem in an axial direction of the hybrid cable, said hybrid connector (1) comprising:

5 a connector housing (11) including a guide portion (14), an optical connection portion (16) and an electrical connection portion (17), all of which are arranged in tandem in a longitudinal direction of the connector housing (11), whereby upon mounting the plug (120) in the connector
10 housing (11), the guide portion (14) of the housing is engaged with the guide portion (122) of the plug, and the optical connection portion on plug side (161) and the electrical connection portion on plug side (153) are opposed to the optical connection portion (16) and the
15 electrical connection portion (17) of the housing, respectively.

8. The hybrid connector (1) according to claim 7, wherein:

20 both the connector housing (11) and the plug (120) are, respectively, formed in a flat plate-shaped member and, the plug (120) is mounted in the connector housing (11) such that a lower surface thereof is opposed to an upper surface of the connector housing (11).

25 9. The hybrid connector (1) according to claim 7, wherein the optical connection portion on plug side (161) is arranged at a position neighboring to the positioned portion (122) and the optical connection portion (16) is

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arranged at a position neighboring to the positioning portion (14).

10. The hybrid connector (1) according to claim 7, wherein the optical connection portion (16) includes a
5 light receiving element (72) capable of receiving a light emitted from the optical waveguide and/or a light emitting element (73) capable of emitting a light to be incident to the optical waveguide.

11. The hybrid connector (1) according to claim 7,
10 wherein:

the plug (120) includes a connection end (102) formed in a front end of the hybrid cable (101) and a plug housing (130) in which the connection end (102) is inserted,

15 the connection end (102) includes the optical connection portion on plug side (161) and the electrical connection portion on plug side (153), and,

the plug housing (130) includes the positioned portion (122).

12. The hybrid connector (1) according to claim 11,
20 wherein:

the optical connection portion on plug side (161) is an optical path conversion portion (161) formed in an optical waveguide within the connection end (102),

25 the electrical connection portion on plug side (153) includes connection pads (152) formed in respective front ends of the conductive lines (151) and,

the positioned portion (122) is a plate member

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having a hole (131) to be guided, which is bored through the plate member in a plate thickness direction thereof.

13. A plug (120) adapted for permanent connection to a hybrid cable (101) having an optical waveguide and
5 conductive traces (151), comprising:

a guide portion (122), an optical connection portion (161) and an electrical connection portion (153), which are arranged in tandem in an axial direction of the hybrid cable (101).

10 14. The plug (120) according to claim 13, comprising a connection end (102) formed in a front end of the hybrid cable (101) and a plug housing (130) in which the connection end (102) is inserted, wherein:

15 the connection end (102) includes the optical connection portion (161) and the electrical connection portion (153) and,

the plug housing (130) includes the positioned portion (122).

15. The plug (120) according to claim 14, wherein:

20 the optical connection portion (161) comprises an optical path conversion portion (161) formed in the optical waveguide within the connection end (102),

the electrical connection portion (153) includes connection pads (152), respectively, formed in front ends of
25 the conductive lines (151), and

the positioned portion (122) comprises a plate member having a hole (131) to be guided, which is bored

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through the plate member in a thickness direction thereof.

16. The plug (120) according to claim 14, wherein:

the optical path conversion portion (161) includes a slope surface (162) capable of reflecting a light and,

5 the slope surface (162) reflects a light transmitted through the optical waveguide to be emitted toward a region underneath the connection end (102) and reflects a light being incident from a region underneath the connection end (102) to introduce the light into the optical waveguide.

10 17. The plug (120) according to claim 14, wherein:

the plug housing (130) comprises a frame-shaped plug housing body (121) having a rectangular opening (125) extending in an axial direction of the hybrid cable (101) and a plug top-plate (126) for closing one surface of the opening (125) while functioning as a shield plate and,

15 the connection end (102) is inserted into a space defined by the plug housing body (121) and the plug top-plate (126), an upper face of the connection end being adhered and fixed to the plug top-plate (126).

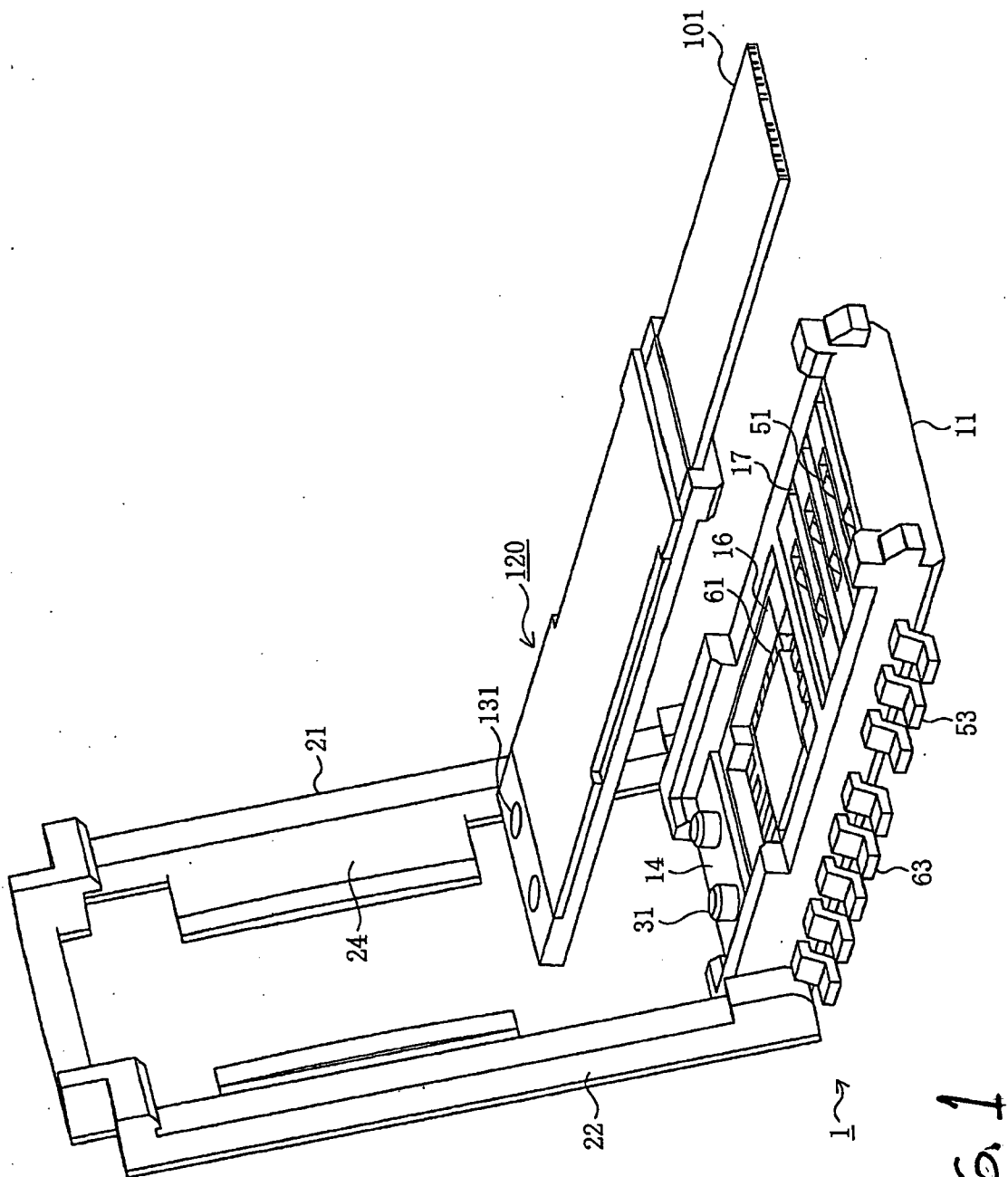
20 18. The plug (120) according to claim 17, wherein:

the plug housing body (121) comprises a pair of sidewall portions (124) extending in the axial direction of the hybrid cable (101), and the positioned portion (122) configured to connect front ends of the sidewall portions (124) and,

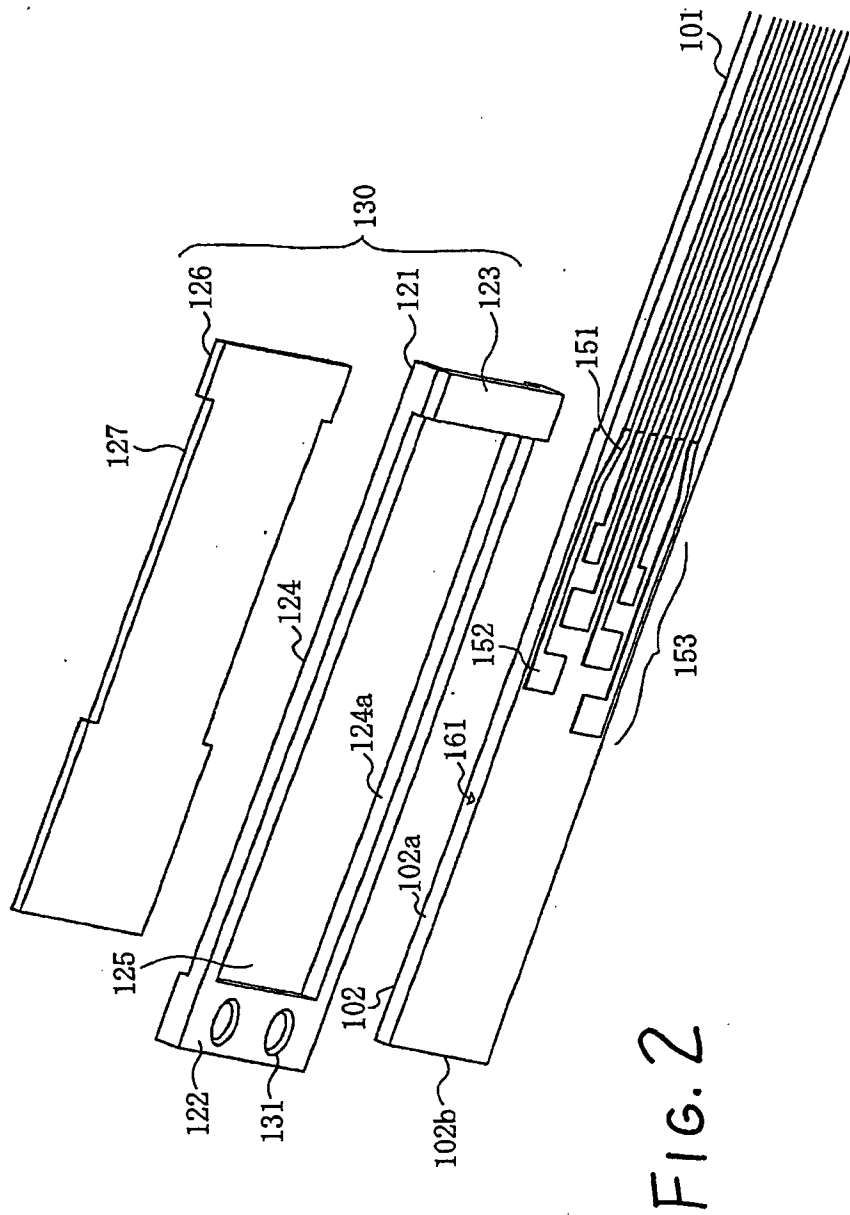
25 the connection end (102) is positioned with respect to the positioned portion (122) such that a front end

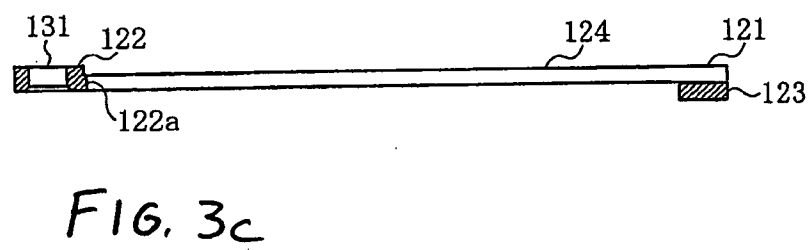
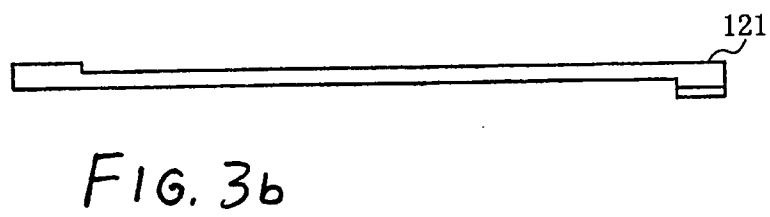
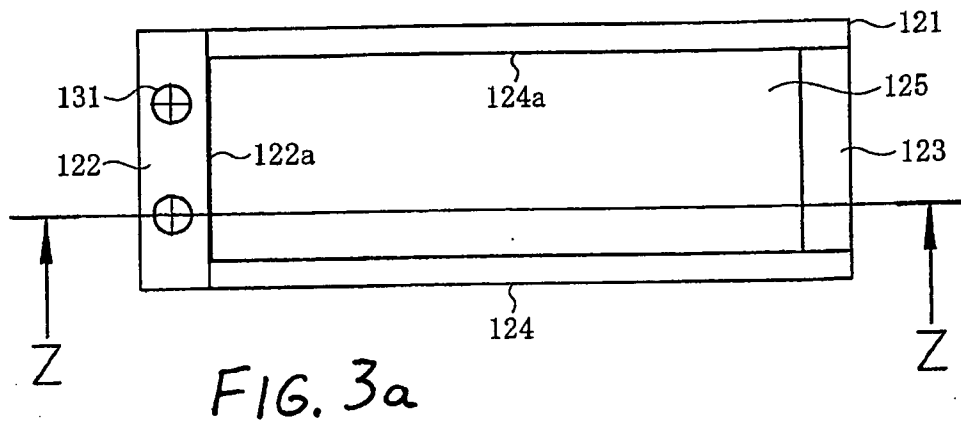
- 53 -

surface (102b) thereof comes in contact with a rear end surface (122a) of the positioned portion (122).



161





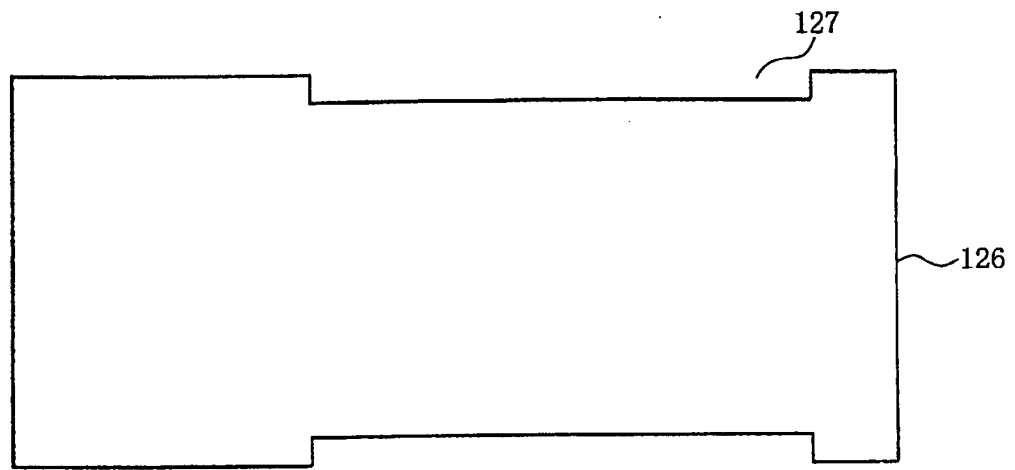
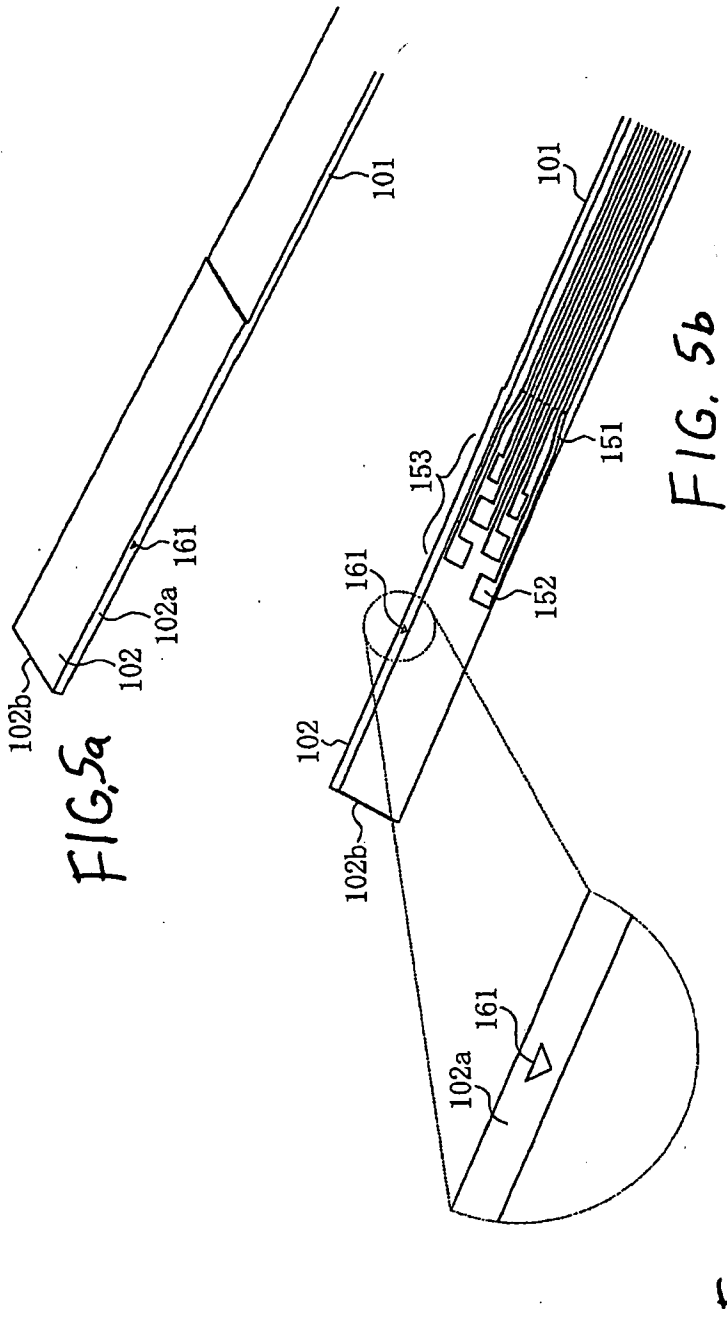
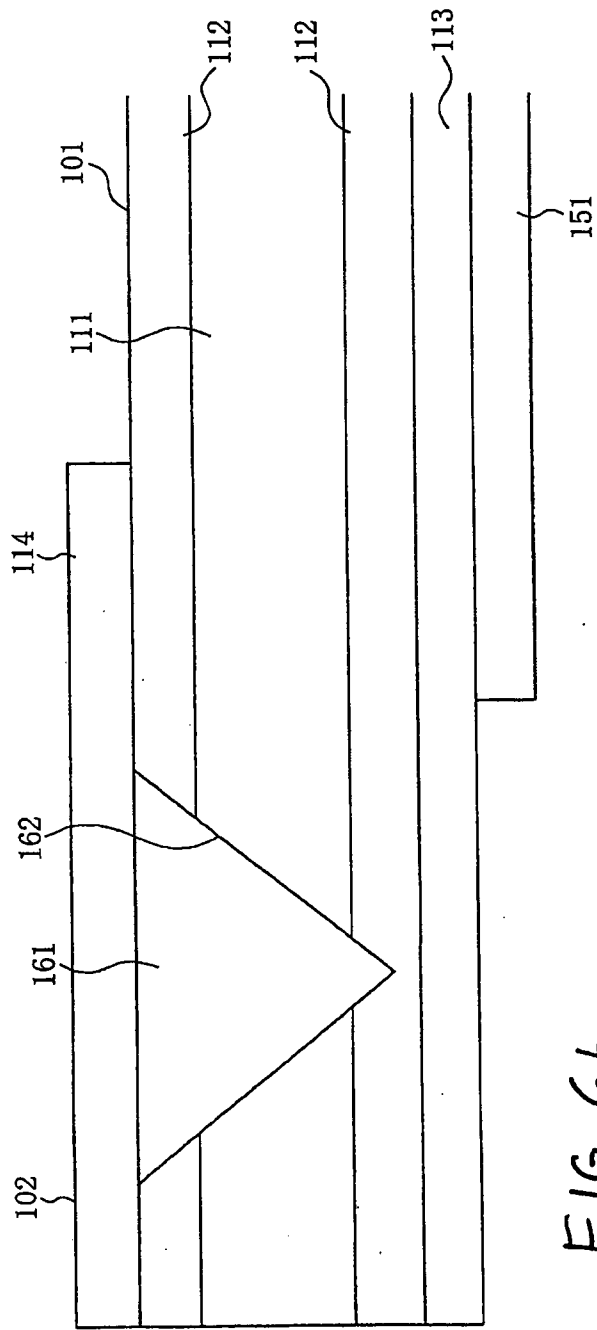
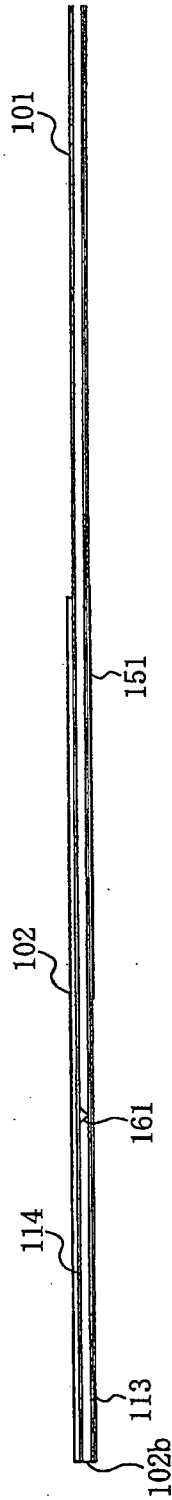
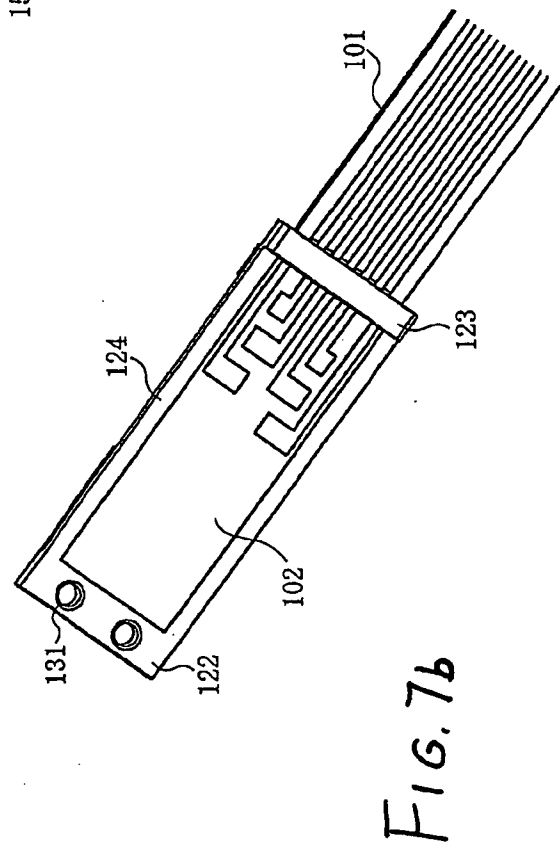
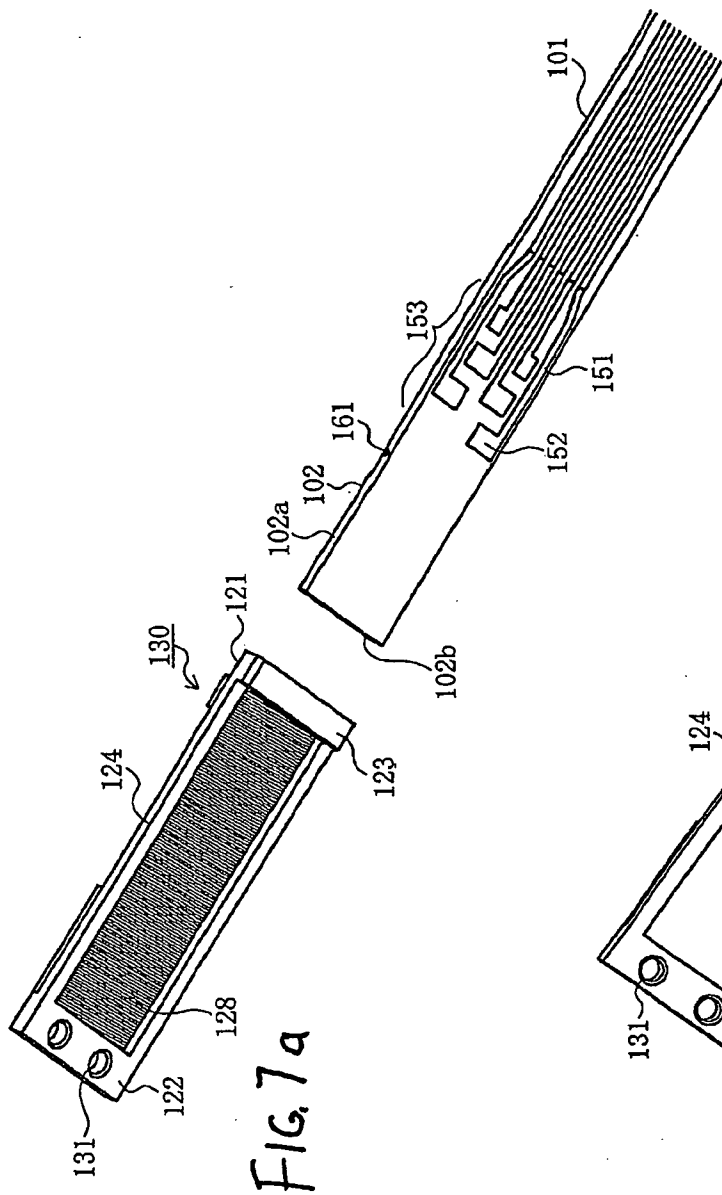


FIG. 4







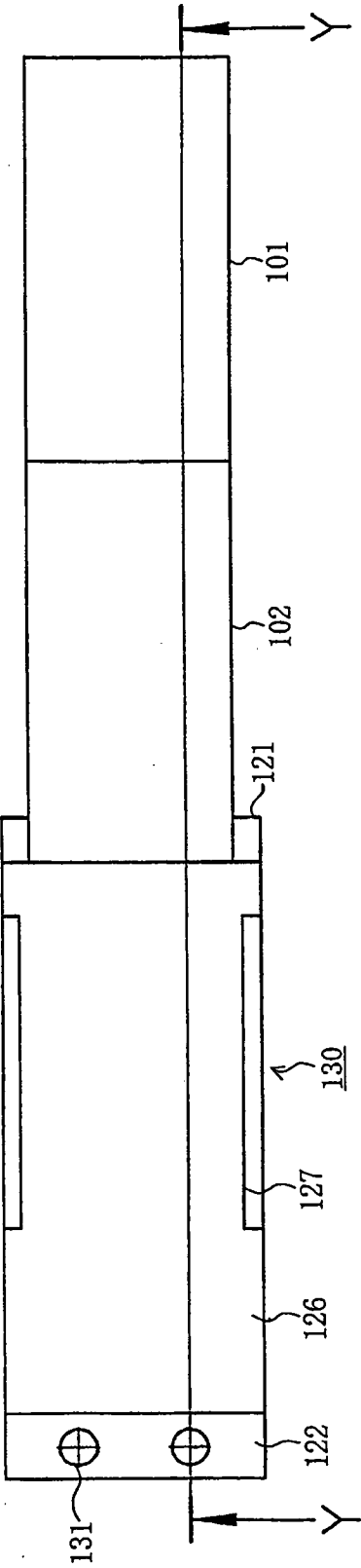


FIG. 8a
8/16

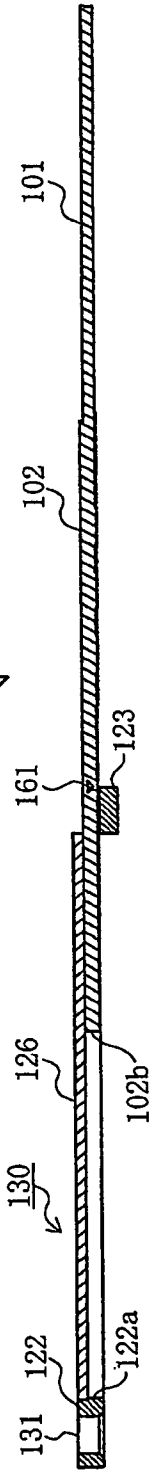
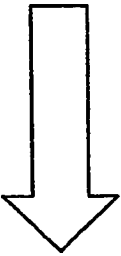


FIG. 8b

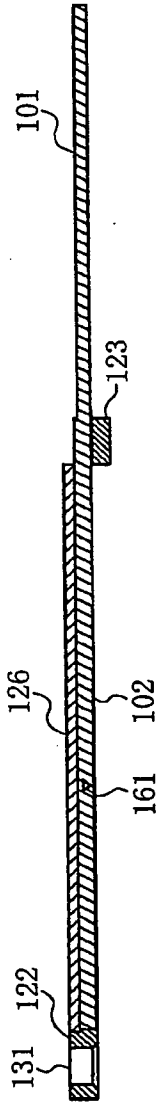
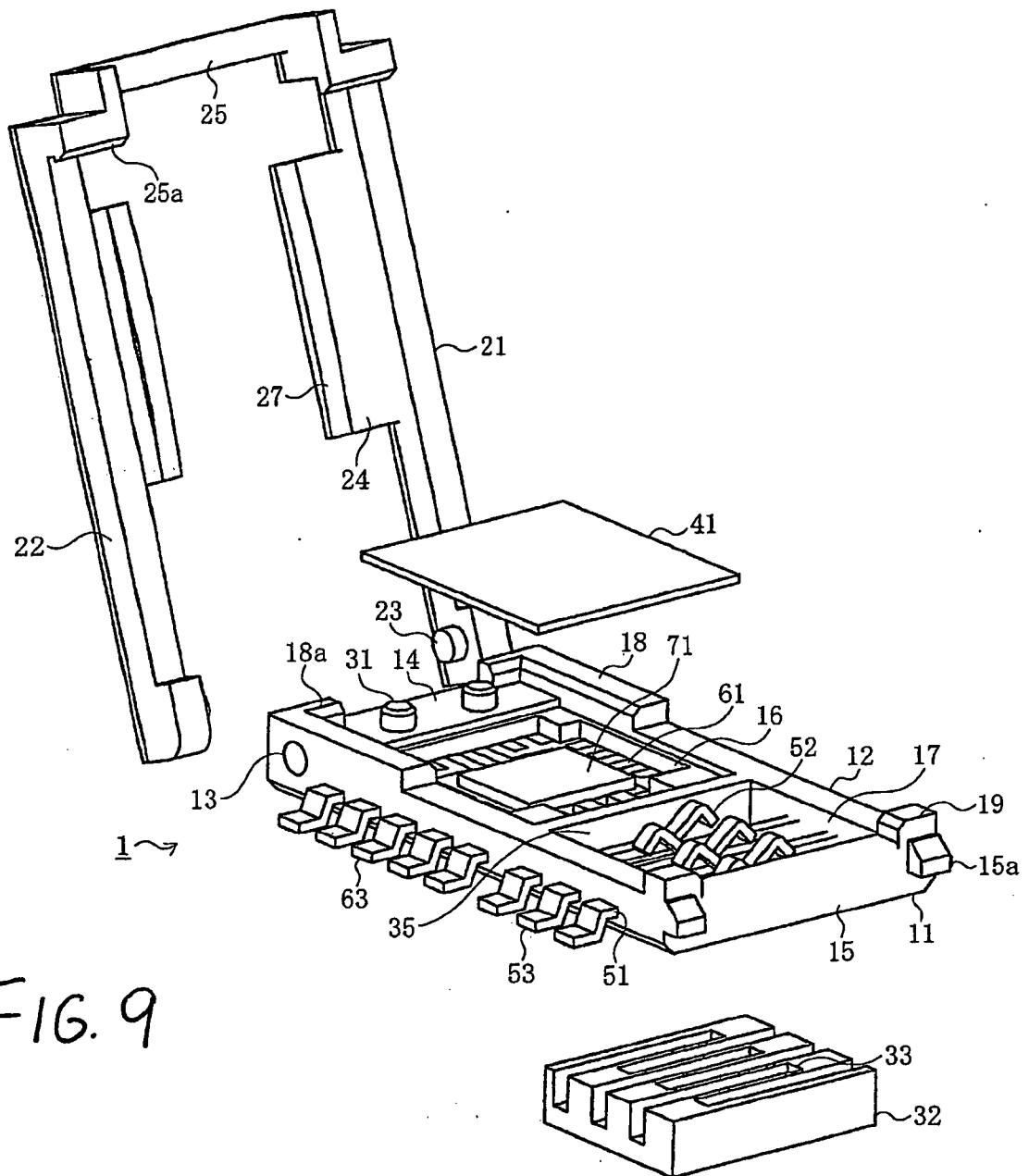


FIG. 8c



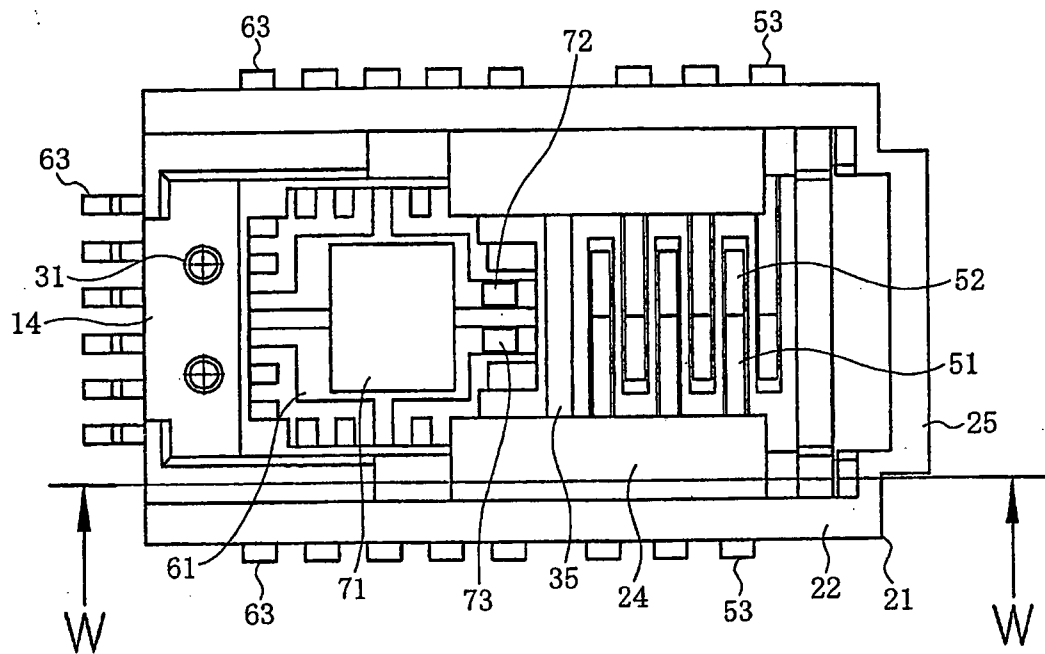


FIG. 10a

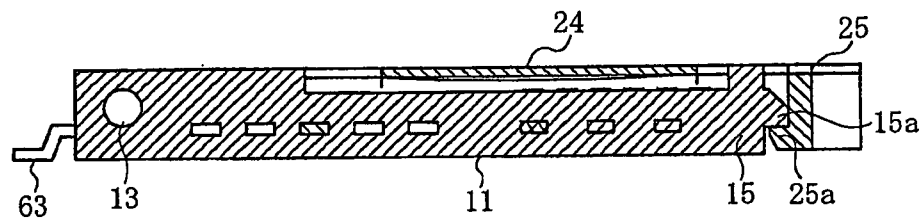
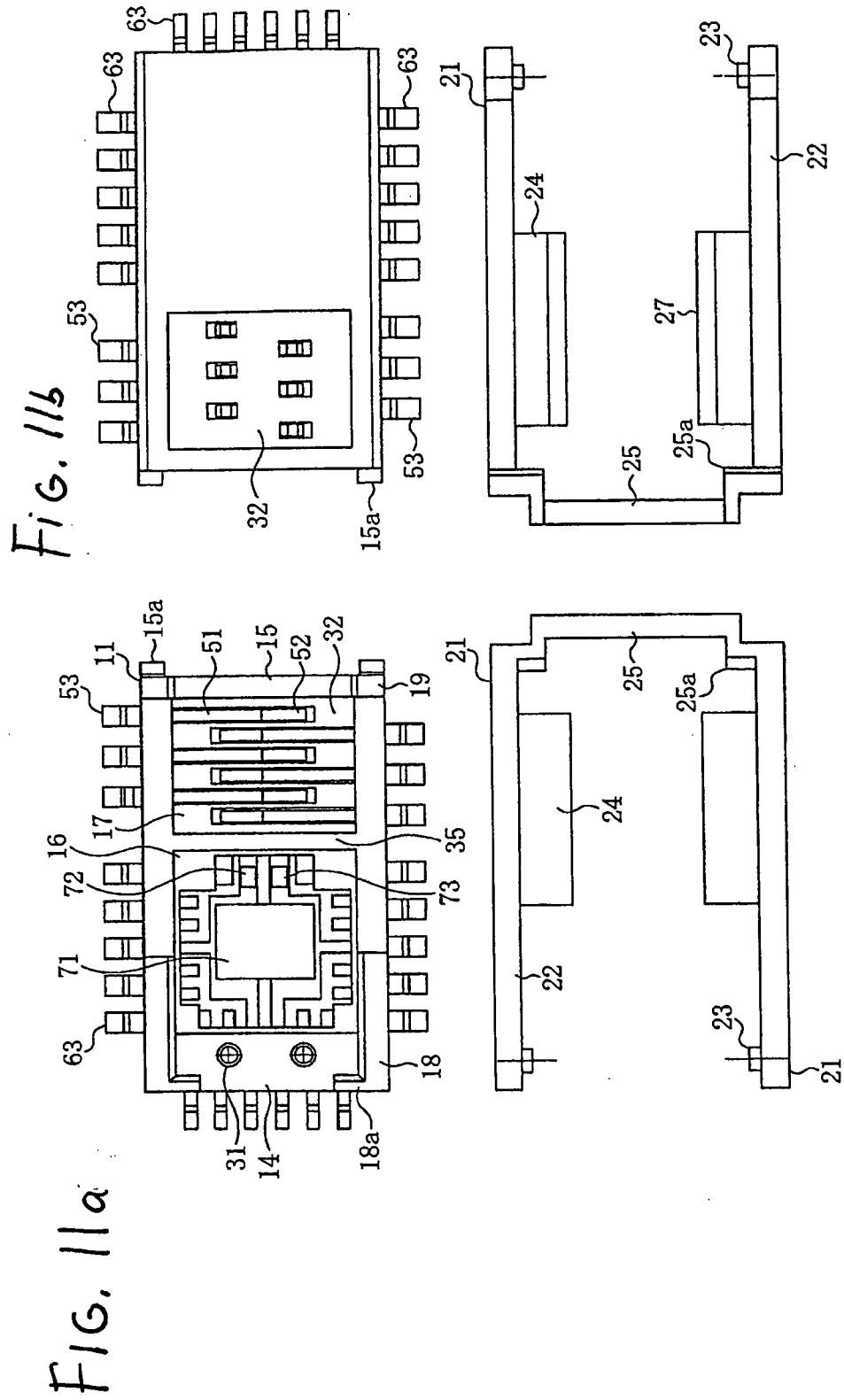


FIG. 10b



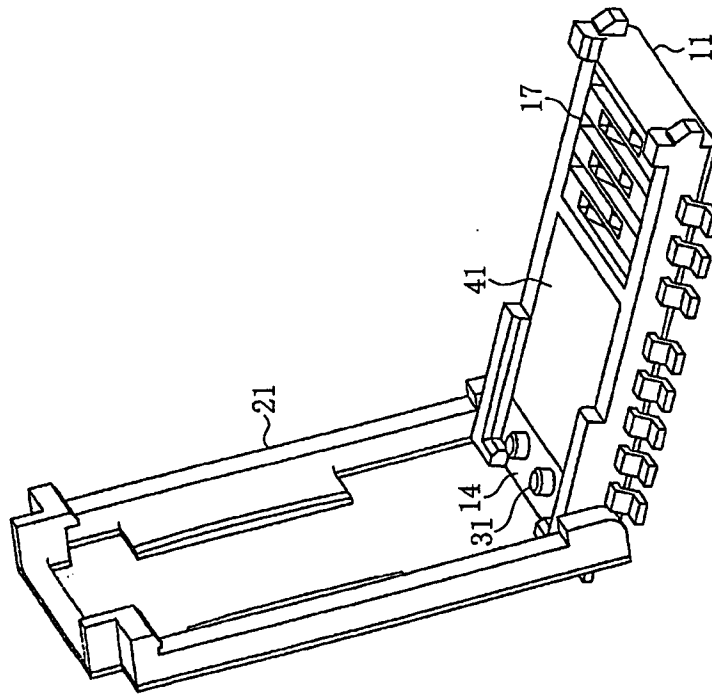


FIG. 12b

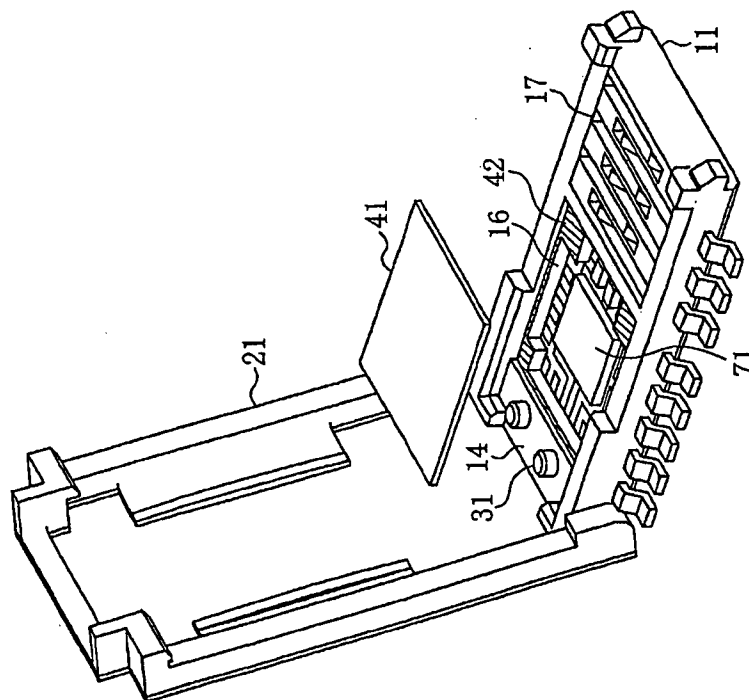


FIG. 12a

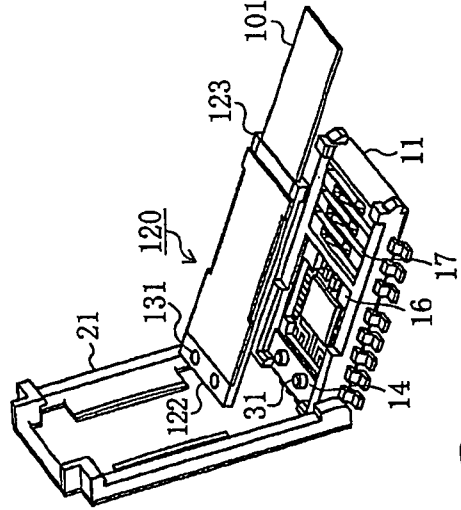


FIG. 13a

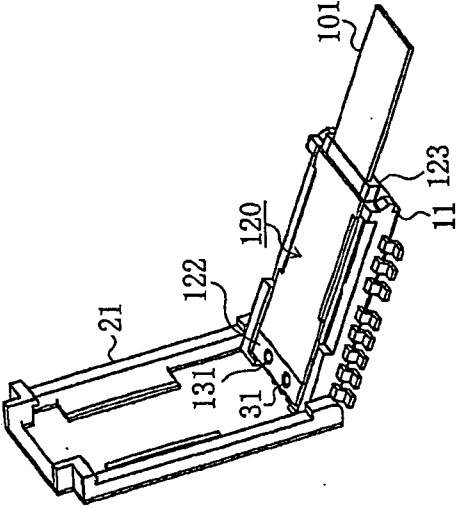


FIG. 13b

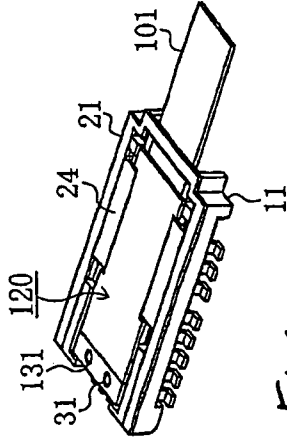


FIG. 13c

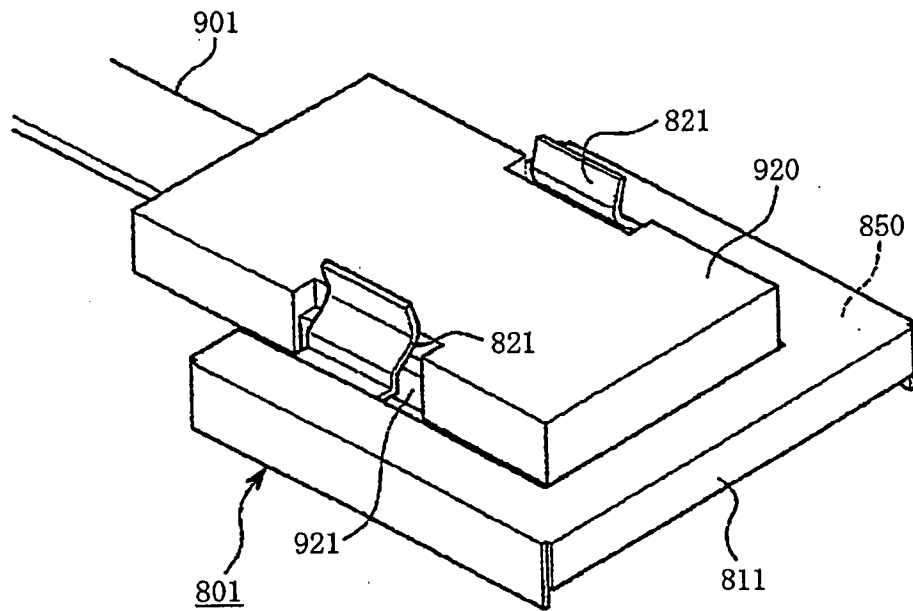
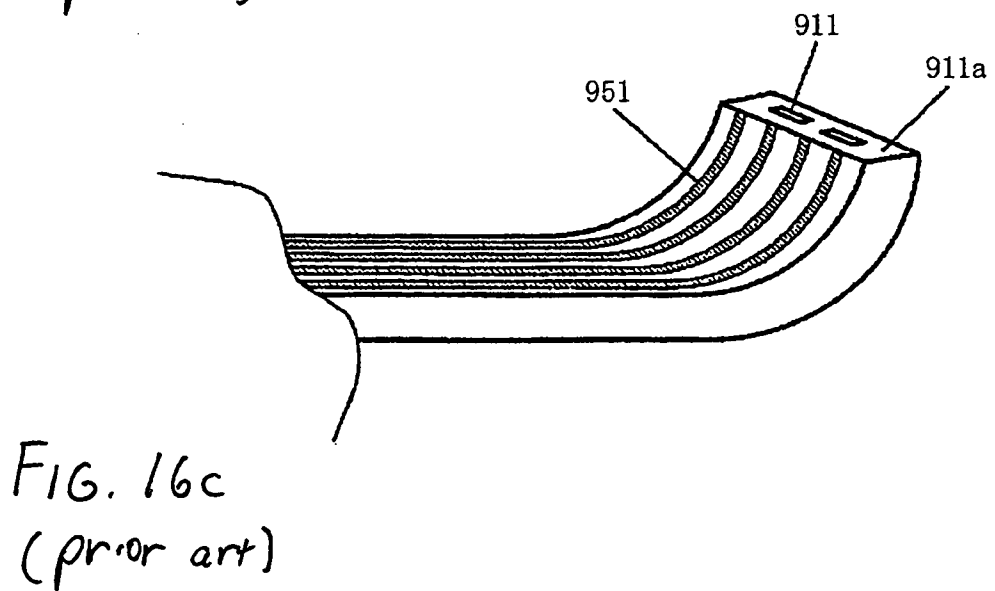
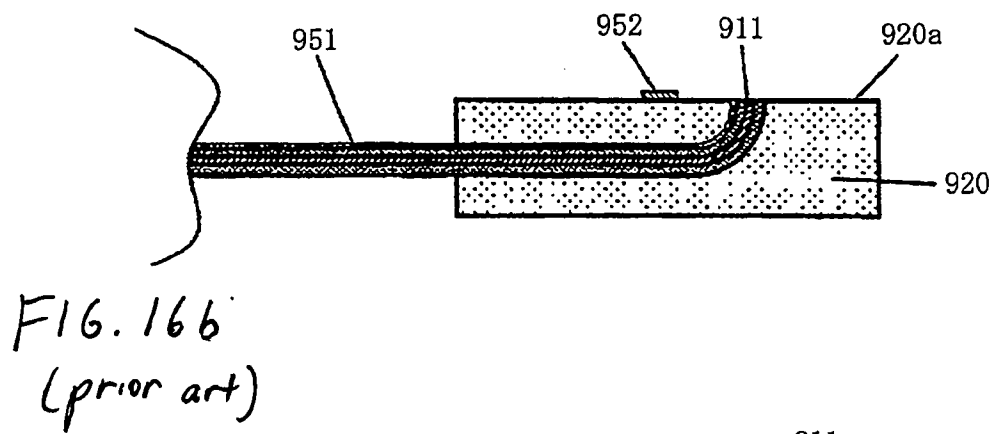
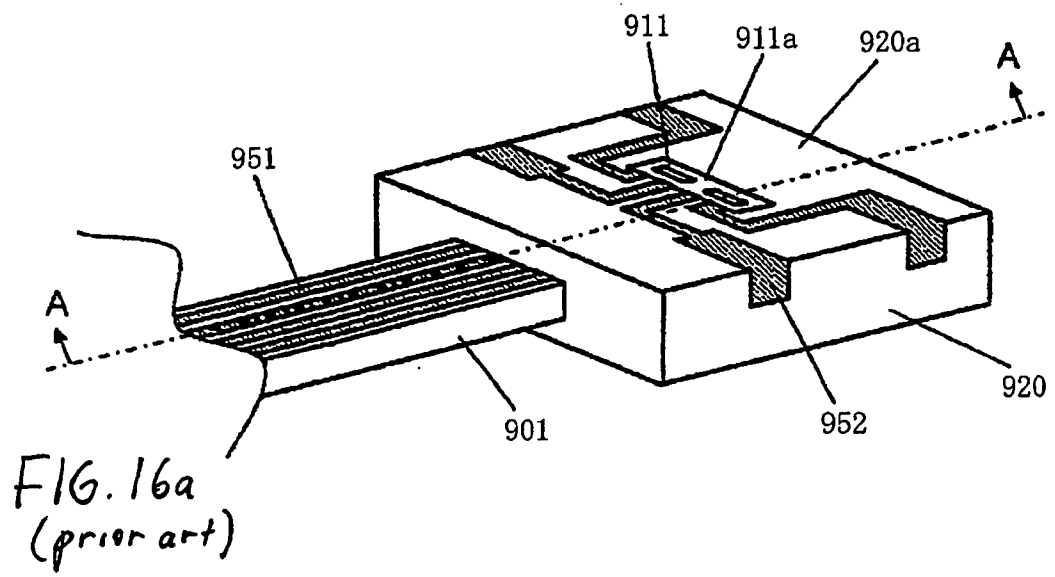


FIG. 15
(Prior art)



INTERNATIONAL SEARCH REPORT

International application No

PCT/US2008/011259

A. CLASSIFICATION OF SUBJECT MATTER
 INV. G02B6/38 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 practical, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2006/068045 A (MATSUSHITA ELECTRIC WORKS LTD [JP]; HARANO TOMOKAZU [JP]; IIDA MITSURU) 29 June 2006 (2006-06-29) figures	1-14, 17, 18
X, P	-& US 2008/090450 A1 (HARANO TOMOKAZU [JP] ET AL) 17 April 2008 (2008-04-17) figures 6, 7a, 916, 17, 20a-h, 22 paragraphs [0001], [0002] paragraphs [0038], [0039] paragraphs [0056] - [0060] paragraphs [0070], [0071] paragraph [0094]	1-14, 17, 18
X	US 5 242 315 A (O'DEA JOHN [US]) 7 September 1993 (1993-09-07) abstract; figure 2 ----- -/--	13

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☒ See patent family annex.

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Date of the actual completion of the international search

23 January 2009

Date of mailing of the international search report

30/01/2009

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Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	JP 2006 162834 A (MATSUSHITA ELECTRIC IND CO LTD) 22 June 2006 (2006-06-22) cited in the application abstract; figures -----	1,7,8, 12,13,15
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International application No

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