



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
24.05.2017 Bulletin 2017/21

(51) Int Cl.:
H01R 13/623 (2006.01) **H01R 13/52** (2006.01)
H01R 13/516 (2006.01) **H01R 13/24** (2006.01)
H01R 24/64 (2011.01) **H01R 13/66** (2006.01)

(21) Application number: **15195864.2**

(22) Date of filing: **23.11.2015**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD

(72) Inventors:
• **Panis, Martinus EJ**
5275 Den Dungen / LE (NL)
• **Jaeger, Peter Dirk**
4271 Dussen / BP (NL)
• **Riezebos, Dirk-Jan**
6661 Elst / SP (NL)

(74) Representative: **Grünecker Patent- und Rechtsanwälte**
PartG mbB
Leopoldstraße 4
80802 München (DE)

(71) Applicant: **TE Connectivity Nederland B.V.**
5222 AR 's Hertogenbosch (NL)

(54) **ETHERNET CONNECTOR SYSTEM**

(57) The present invention relates to an ethernet connector system with a male and a female connector device (100; 200), wherein the female connector (200) has a female housing 202 and wherein the male connector 100 has a male housing 102, which housings 102, 202 are joinable and provided with locking means (104, 204) for releasable locking the male housing (102) against the female housing (202) and wherein the female connector 200 has female contact elements 208 and wherein the

male connector 100 has a male contact elements 134. For improving this system, the contact elements (134; 208) of each connector device 100; 200 are arranged parallel to a contact axis (CA) extending transverse to the mating direction (MD) and wherein contact surfaces (135; 212) of each connector device (100; 200) are sealingly received between the two housings in the locked stage of the two housings.

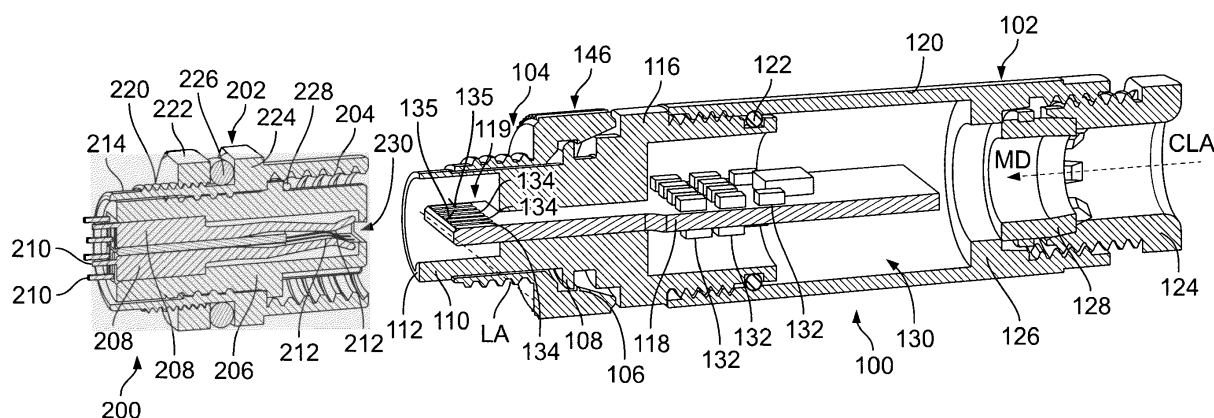


Fig. 1

Description

[0001] The present invention relates to a connector system with a male and a female connector devices. Each of those devices has a housing. Said housings are joinable with each other and provided with locking means for releasably locking the male housing against the female housing or vice versa. The male connector device has male connector elements. The female connector device has female connector elements which will effect electrical contact as both connector devices are coupled.

[0002] Present commonly used Ethernet connector systems have a female connector device which is usually attached to a housing of a component, such as e.g. a computer, and a male connector housing which is usually connected to a cable.

[0003] The male connector device in the meaning of the present invention is the part of the connector system being inserted into an opening of the female connector device when mating the two housings. In presently available Ethernet connector systems, the female connector elements are arranged on one side of a rectangular opening to make contact with the male contact elements arranged next to each other in a single plane opposite to the female contact elements. Opposite to those female contact elements, the female contact device has a locking slot which cooperates with a resilient latch provided by the male housing.

[0004] It is an object of the present invention to propose an improved connector system.

[0005] As a solution to the above object, the present invention specifies a connector system with the features of claim 1.

[0006] In the inventive connector system, contact surfaces of each connector device are arranged parallel to a contact axis. The contact surfaces of the male or the female connector device are provided by the female or the male contact elements, respectively. On a regular basis, a single contact element provides a single contact surface which may define one or more points of contact with the mating contact surface of the other of the male and the female contact devices. The contact axis extends transverse to the mating direction in which the connector devices are moved when being mated or joined for effecting mechanical and electrical contact between the male and the female connector device.

[0007] Further, and according to the present invention, respective contact surfaces when being connected with each other, i.e. in the mated or locked stage of the connector devices are sealingly received between the male and the female housing. The sealing is such, that dirt, moisture and water can usually not reach the contact surfaces and thus negatively affect the electrical contact between the male and the female connector device. Sealing is usually attained by means of a compressible sealing element which is compressed in the locked stage of the two connector devices. This compressible sealing element is usually compressed between the male and

the female housing to hermetically seal the contact surfaces in the locked stage of the two housings.

[0008] Thus, the inventive connector system is adapted to allow electrical contact in a harsh environment. The locking means provide a thorough mechanical connection between the male and the female connector device, which mechanical connection is usually of such quality that even a more severe strain on a cable connected to one of the male or the female connector device will not mechanically and thus electrically disconnect the connection. Provision of the contact surface along the contact axis is advantageous in comparison to a regular M8 or M12-connector having a plurality of contact pins projecting from an insulated surface of the male housing mating with assigned sleeves provided by the female housing. Provision of multiple of those contact pins within a rather limited space will be costly and troublesome. By using a high density planar structure it is possible to achieve a dense and preferably symmetrical design with ground planes in close proximity to act as a return path as well as separate differential pairs. By using planar structure, especially a PCB it is easy to integrate electronic components, especially when the electronic design requires a multiple layer design.

[0009] According to a preferred embodiment of the present invention, a first row of contact surfaces is arranged next to each other on one side of the contact axis and a second row of contact surfaces is arranged next to each other on the other side of respective contact axis. Such connector system can make keying of the plug and the jack, i.e. the male and the female connector device, dispensable. The contact surfaces of each connector device are arranged with equal distance relative to the contact axis in a direction perpendicular to the contact axis. Respective provision is realized preferably for all male contact surfaces and preferably for all female contact surfaces provided parallel to the contact axis define a functional pair, wherein the two contact surfaces of each functional pair are arranged point symmetrically.

[0010] Preferably, for each functionality, two contact surfaces are provided as female contact surfaces and two other contact surfaces are provided as male contact surfaces. This preferred embodiment is supposed to enhance redundancy and to provide a highly reliable, preferably point symmetrical connection. Those two contact surfaces of identical functionality are arranged on opposite sides relative to the contact axis. Those contact surfaces of one pair for identical functionality are preferably arranged point symmetrically relative to a central axis of the connector device extending in a mating direction, which central axis usually is the central longitudinal axis of the male or the female connector device surfaces. Thus, the two connector devices can be connected in a mating direction perpendicular to the extension of the contact axis with each other and still provide the required electrical functionality irrespective of whether the male connector device is inserted into the female connector device in a first orientation or a second orientation which

is 180° rotated about an axis which is parallel to the axis of insertion.

[0011] The provision of all contact surfaces arranged parallel to the contact axis as functional pairs of identical functionality can go along with terminal ends of respective pairs of contact surfaces to be identical for contacting the surfaces of the functional pair with a single cable strand of a cable leading to the male or the female connector device. In other words, for each pair of contact surfaces of identical functionality, a single terminal end is provided within the housing of the connector device or at an end opposite to the locking means.

[0012] According to a preferred embodiment, those locking means are adapted to allow locking of the female housing against the male housing in at least two different orientations. Those orientations are usually rotated by 180° around the central longitudinal axis or the axis of inserting the male connector into the female connector i.e. mating.

[0013] Each of the above-discussed features of the invention as such or in combination will allow to refrain from keying the male connector element relative to the female connector element. With present connector systems, 50% of all joining actions between the male connector and the female connector device require rotation of one of the connector devices to properly key the two. Those disadvantages are remedied with the present invention.

[0014] The present invention may be utilized as a hybrid connector system for connecting contact elements assigned to data and power in a single connection operation within a single connector system. Thus, the present invention is in particular suitable for Ethernet upon according to IEEE802 and/or 802.3bp (1000Base-T1, i.e. 1 pair Gigabit Ethernet) with additional power connections. More specifically, the inventive connector system is to be used for industrial Ethernet, such as specified in IEC61158 and/or IEC61784-2. Apart from that, the inventive connector may be used for uncompressed data (MII) active plug and fieldbus protocols. As described above, the inventive connector system has contact elements which are fully symmetrically arranged relative to a central point on the longitudinal contact axis. This is possible as IEEE802.3bp uses a single twisted pair in which the polarization of the pair is not relevant as it will be compensated for by the Ethernet physical layer. According to the present invention, each single functional pair is preferably arranged in the point symmetrical fashion already discussed above. Further, lateral contact elements arranged on opposite end positions of the contact axis are preferably defining AC or DC power. With such a preferred embodiment, the connector system is adapted to connect data and power supply lines by avoiding keying and, thus, reducing the effort for effecting the connection. The opposite end positions of the contact sides are usually those positions which are near the lateral edges of an elongated electrically isolated substrate which is usually formed by a leadframe structure, an overmolded planar leadframe structure or a PCB and which sup-

ports the male contact elements defining the contact surfaces. In a corresponding way, the female contact surfaces are provided within the female connector device. The contact surfaces of the male connector device arranged parallel to the longitudinal contact axis are usually supported by the elongated electrically isolated substrate. As mentioned above, this substrate can be a PCB. The elongated electrically isolated substrate can furthermore likewise be a leadframe with an isolated basis supporting and holding individual contact elements each providing one contact surface.

[0015] In order to improve shielding for high speed connectors, it is likewise proposed to arrange contact elements assigned to ground to the lateral ends of the central longitudinal axis. For this, two pairs of contact surfaces are preferably assigned to ground and provided as the most lateral contact surfaces on both sides of the longitudinal contact axis. Thus, no further contact elements are provided between the lateral end of the elongated electrically isolated substrate or PCB and the contact element assigned to ground. In addition, a central functional pair which is arranged at the point of symmetry and can be connected by a line which intersects with the point of symmetry and is perpendicular to the contact axis may be assigned to ground and VDD, thus, define a power pair. Accordingly, the lateral ground contact elements do not contribute to the supply of electricity, but only to shielding of all other more centrally arranged contact elements along the contact axis.

[0016] In view of rather severe environments, the present invention proposes a connector system as defined in claim 7. This embodiment may utilize locking means as generally known for M8, M10 or M12 connector systems with a threaded sleeve and a counter-threaded sleeve of which at least one sleeve is rotatably supported by a housing of the male or female connector device for locking the connector devices against each other by screwing the threaded sleeves relative to each other. In other words and as the connector devices are joined, the threads provided on the threaded sleeve and the counter-threaded sleeve engage each other to securely lock both devices against each other. The connector system defined in any of the proceeding claims, characterized in that the threaded sleeve (102, 204) and the counter threaded sleeve (204) are provided with M8, M10 or M12 threads. At least one of the housings, which usually is the male housing, is provided with a cable receptacle adapted to sealingly guide a cable into the housing. Respective housing furthermore sealingly surrounds end terminals adapted to be contacted by strands of the cable. Each of the terminal ends are electrically connected to an assigned contact element of the male contact device. The housing does not necessarily have to define a hollow chamber adapted to receive the cable and to connect the same to the elongated electrically isolated substrate. The housing may for example be made from thermoplastic material which is injection molded around the cable and the elongated electrically isolated substrate after con-

necting strands of the cable with conductive paths formed on or within the electrically isolated substrate.

[0017] For facilitating description of the invention, some parts of the connector devices are described to be specifically assigned to either the female or the male connector device. However, the description in this respect can usually be understood as a description of a preferred embodiment of the other of the male and the female connector device. In the preferred embodiment, the housing of the male connector device is a sealed housing. Accordingly, the cable guided through the housing is sealed at the entrance into the housing on one hand. Further, the end terminals or terminal pads of the elongated electrically isolated substrate, each being adapted to be contacted with a strand of the cable, are usually sealingly received within the male housing. The assigned male contact surfaces are usually sealed relative to the end terminals or terminal pads of the elongated electrically isolated substrate.

[0018] The female contact surfaces are likewise preferably sealed in the locked stage by a rubber seal ring which is effective as both connector devices are connected to each other to avoid moisture to enter the contact area of both, the female and the male contact elements. The seal can be provided within or at an end of the threads of the threaded and/or counter-threaded sleeve.

[0019] Sealing means, in particular a sealing ring may likewise be provided between an end face of circular longitudinal element of one of the connector devices and a counter surface of the other of the two connector devices. According to a preferred embodiment of the present invention, both, the male and the female connector device have respective circular longitudinal elements which circumferentially surround the respective contact elements of the male or the female connector device. Those circular longitudinal elements usually extend parallel to the electrical path for each contact surface and are to guide the mating movement and/or surround and preferably with a sealing means sandwiched in-between seal the contact surfaces in the locked stage of the connector devices. The circular longitudinal elements of the male and the female contact device may be made from an electrically conductive material and form part of the shielding around a contact zone in which the female and the male contact surfaces contact each other. In such an event, the circular longitudinal element is connected to a shielding of an electrical cable at a side of the connector device opposite to the contact surfaces or the threaded sleeve. Thus, the circular longitudinal elements when being provided as circular longitudinal shield elements are provided with terminal ends within the connector housing or at an end of the housing opposite to the contact surfaces. Connection can e.g. be achieved with cable strands which are spring-loaded against the circular longitudinal shield element. The contact between the cable shield and the circular longitudinal shield element will, in this embodiment, define the contact end of the circular longitudinal element.

[0020] In a preferred embodiment and for the case in which the circular longitudinal element is a shield, the elongated electrically isolated substrate has a length adapted to contact the inner circumferential surface of the circular shield element. In such an embodiment, a distal end of the elongated electrically isolated substrate is thus sandwiched and directly contacted with the circular shield element for improving shielding of the data pairs within the connector device. A respective constitution is preferably embodied for the female device as well. The shielding can shield data from data or data from power. For obtaining this shielding functionality, the circular longitudinal element shall be manufactured from an electrically conductive material, in particular metal. Shielding is already attained by the existence of such circular longitudinal element without the need to contact this circular longitudinal element to a shielding of a cable. Nevertheless, in most cases, such connection is to be preferred for optimizing the performance.

[0021] In order to enhance shielding and thus high speed data transmission, the elongated electrically isolated substrate may comprise a central shielding layer, preferably exposed to the end sides of the elongated electrically isolated substrate. This central shielding layer should preferably make direct contact with the inner circumferential surface of the circular longitudinal element for optimizing shielding.

[0022] According to a preferred embodiment, the male housing is provided with a circular male longitudinal element having a circular male terminal end provided within the male housing. Respective circular male terminal end is usually sealed within the male housing. Further, an circular male exposed end surrounding the male contact elements is provided by the male longitudinal element. This exposed end usually contacts with its end face the aforementioned sealing ring. The female housing according to this preferred embodiment is provided with a circular female longitudinal element having a circular female exposed end surrounding the female contact elements. The male and the female longitudinal elements electrically conductive and are adapted to contact each other in the locked stage of the two housings, in order to provide a complete shielding of all contact elements in the contact area.

[0023] According to a preferred embodiment of the present invention, the rotatable threaded sleeve is rotatably supported on the outer circumference of one of the circular male or female longitudinal elements. The other of the threaded or counter-threaded sleeve according to this preferred embodiment is usually stationery and most preferably part of a connector device which is attached to the component.

[0024] According to a preferred embodiment of the present invention, a spring element is received within the male housing. The spring element is received within the male housing in a pretensioned manner and thus compressed between the elongated electrically isolated substrate, which is preferably a PCB, and the circular male

longitudinal element, which in this embodiment is electrically conductive, preferably made of metal. Due to the compression of the spring, heat generated by one or more components mounted on the PCB is transmitted through the spring, which spring is usually made of a good heat conductive material. This heat conducted through the spring is transmitted to the circular longitudinal element, which is at least partially exposed on the outer side of the male connector device to allow the heat to dissipate. Thus, the spring provides for effective cooling of the PCB. Moreover, the spring will press the PCB within the male housing against a surface of the male housing and thus position the PCB within the male housing in a predetermined way.

[0025] The components supported by the elongated electrically isolated substrate and received within the male housing can include sensors for sensing the proper mating of the male and the female contact devices, a temperature sensor, a humidity sensor or a vibration sensor. The sensors may be provided to sense the quality of the connection of the male and the female connector devices in the locked stage and/or monitor severeness of the harsh embodiments in particular in the contacting zone.

[0026] According to a preferred embodiment, at least one male contact pin is provided for making electrical contact with a mating sleeve. The respective contact pin extends parallel to the extension direction of the elongated electrically isolated substrate and is usually arranged to extend from a common isolated surface of the male contact device, in particular the male housing. Most preferably, two of respective contact pins are provided, which may be either arranged on the same side of the elongated electrically isolated substrate or on opposite sides thereof. These pins are preferably assigned to power GRD and VDD or VDD and VSS.

[0027] Further features and advantages will be evident from the following description of preferred embodiments of the present invention in combination with the drawing. In the drawing:

- Figure 1 is a sectional perspective view of a first embodiment of a connector system according to the present invention;
- Figure 2 - 4 are sectional perspective views of a second embodiment of the male connector device;
- Figure 5A to H is to elucidate assignment of connector surfaces to different functionalities along a longitudinal contact axis;
- Figure 6 is a perspective front view of the embodiment of the female connector device of Figure 1;
- Figure 7 is a perspective front view of the male

connector device adapted to meet with the connector device of Figure 6;

- Figure 8 is a front view of the male connector device of Figure 6;
- Figure 9 is a front view of the female connector device of Figure 7;
- Figure 10 is a front view of a variant to the embodiment of Figures 6 and 8;
- Figure 11 is a front view of a variant to the embodiment of Figures 7, 9;
- Figure 12 is a perspective view of a further embodiment of a male connector device.
- Figure 13 is a front view of the embodiment of Figure 12;
- Figure 14 is a front view of a variant to the embodiment of Figure 13.

[0028] In the following description of preferred embodiments, reference numeral 100 identifies a male connector device and reference numeral 200 identifies a female connector device. The male connector device 100 is in particular adapted to be contacted to a cable (not shown), while the female connector device 200 is adapted to be connected to a housing of a component like a computer or an industrial machine having a control which is connected via the Ethernet connecting system of the present invention.

[0029] The male connector device 100 has a housing 102, which housing 102 rotatably supports a threaded sleeve 104, which is secured to said male housing 102 in longitudinal direction of said male housing 102 by a securing rim 106 of the threaded sleeve 104 cooperating with a securing ring 108 of the male housing 102. The threaded sleeve 104 is rotatably supported by a circular male longitudinal element 110 provided by a metal tube, which projects the threaded sleeve 104 towards a distal end of the male connector device 100 for defining a circular male exposed end 112 and projects into the male housing 102 for defining a circular male terminal end 114 adapted to be connected with a shielding of the cable inside the male housing 102 (see Figure 2).

[0030] The male housing 102 has a distal male housing member 116, which may be provided by injection molding around of an elongated electrically isolated substrate which is provided in the present embodiment by a printed circuit board (PCB) 118. The PCB can likewise be replaced by an overmolded leadframe. This distal male housing member 116 provides the securing rim 106 and sealingly passes therethrough the PCB 118. A proximal end of the distal male housing member 116 is provided with an outer thread being connected with a housing

sleeve element 120 with a housing sealing ring 122 inter-disposed therebetween.

[0031] The proximal end of the housing sleeve element 120 is provided with an inner thread adapted to receive a compression element 124 having a central bore adapted to receive the cable. Between this compression element 124 and a partition 126 of the housing sleeve element 120, there is provided a cable sealing ring 128 adapted to cooperate with the cleading of the cable for sealing the cable at the entrance into a housing chamber 130 of the male housing 102.

[0032] Within said chamber 130, there is provided a proximal end of the PCB 118 carrying multiple electronic components 132, which render the connector device 100 an active play. The PCB 118 is guided through the distal male housing member 116 in a sealed way, either by molding the plastic material forming the distal male housing member 116 around the PCB 118, or by securely gluing the PCB 118 into a respective bore of the distal male housing member 116 receiving a portion of the PCB 118. The portion of the PCB 118 projecting the distal male housing member 116 is provided with plural male contact elements 134 defining male contact surfaces 135 which may be arranged in a way further exemplified in Figures 5A through H. Conductive paths of the PCB 118 electrically contact those male contact surfaces 135 to terminal ends (not shown) exposed within the chamber 130 to make electrical contact with selected strands of the cable.

[0033] The male contact surfaces 135 and a terminal or distal end 119 of the PCB 118 are surrounded by the circular male exposed end 112 of the circular male longitudinal element 110. As further evident from Figure 1, this circular male exposed end 112 projects the distal end of the threaded sleeve 104.

[0034] The female housing 202 is provided with a threaded sleeve 204 adapted to be threaded onto the outer threads of the threaded sleeves 104, which threaded sleeves 204 of the female connector device 200 is an embodiment of the counter-threaded sleeve of the present invention.

[0035] The female connector device 200 has a distal female housing member 206 made of an electrically insulating material like a thermoplastic material which surrounds and holds female contact elements 208, each being made of pieces of cut sheet metal, which are exposed at a proximal end base of the distal female housing member 206 to define female contact terminal ends 210 for connection of strands of a cable with assigned female contact elements 208. The distal female housing member 206 furthermore circumferentially surrounds female contact surfaces 212 of respective female contact elements which are adapted to electrically contact the male contact surfaces 139 in a joined state of the connector system, in which the male connector device 100 is inserted into the female connector device 200.

[0036] The distal female housing member 206 is circumferentially surrounded by a circular female longitudinal

element 214 made from an electrically conductive tube which provides a threaded sleeve 204. Further, the distal female housing member 206 provides a circular female exposed end 216 surrounding the female contact surfaces 212 and being formed by the threaded sleeve 204, which threaded sleeve 204 is a unitary portion of the a circular female longitudinal element 214.

[0037] Respective circular female longitudinal element 214 has an outer thread 220 meshing with a screw 222 cooperating in axial direction with an outer rim 224 of the female outer housing member 218 with a sealing ring 226 interdisposed therebetween to e.g. sealingly attach the female connector device 200 to the housing of a device.

[0038] In the described embodiment, both, the male and the female connector device 100, 200, each have a circular longitudinal element 110, 214 which can be coupled to ground and define circular longitudinal shield elements. Those longitudinal elements 110, 214 axially project the contact elements 134, 208, and thereby circumferentially seal the contact surfaces 135, 212. As further evident from Figure 1, a sealing ring 228 is received within a ring-shaped slot defined between the threaded sleeve 204 and the circular female longitudinal element 214, which sealing ring 228 cooperates with an end face of the circular longitudinal element 110. By means of this sealing ring 228, the contact area between the male contact elements 134 and the female contact elements 208 is sealed from ambient to avoid e.g. moisture or dirt to enter into the contact region.

[0039] Cooperation of the threaded sleeve 104 with the counter-threaded sleeve 204 allows both connector devices 100, 200 to be securely attached with each other. Thus, the connector system of the present invention is suitable for harsh and rough environments. There is no danger that the connection is accidentally disconnected.

[0040] Fig. 2 is a sectional prospective view of a second embodiment of the male connector device 100. Parts being identical or having the same functionality as in the previous embodiment are identified with identical reference numbers. In this graphic representation, a cable assigned to reference numeral 300 is sketched. The cable may be welded or glued into the male housing 102 for securing and sealing the cable 300 at the proximal end of the housing sleeve element 120.

[0041] For this second embodiment, terminal pads 136 provided for electrically contacting assigned strands of the cable 300 are exemplified on the surface of the PCB 118. Further, a shielding 302 of the cable is shown to cover the inner circumferential surface of the housing sleeve element 120 and to be contacted with the circular male terminal end 114 of the circular male longitudinal element 110. The housing sleeve element 120 is essentially a cylindrical body. The threaded sleeve 104 is not only rotatably supported on the circular male longitudinal element but also fixed thereon in axial direction by a groove 138 formed in the outer circumferential surface and cooperating with a radial projection 139 of the thread-

ed sleeve 104. Thus the threaded sleeve 104 is secured in a form fit manner against the circular male longitudinal element 110 in axial direction thereof.

[0042] On the PCB 118 there is mounted a LED 140. This LED 140 is positioned in axial direction between the proximal end of the threaded sleeve 104 and the distal end of the housing sleeve element 120. As further visible from Figs. 3 and 4, the distal male housing member 116 and the circular male longitudinal element 110 are each provided with a bore defining a window and being covered by a transparent window element 144. Thus, the light emitted by the LED is visible in the slot between the threaded sleeve 104 and housing sleeve element 120. Figs. 3 and 4 are furthermore illustrative to visualize the fact that the threaded sleeve 104 is provided with a knurled wheel 146 which wheel is a unitary part of the threaded sleeve 104.

[0043] The LED 140 can be a multicolor LED which may have different blinking schemes for visualizing different signals. The coded blinking schemes may be decoded with an app on a smart phone or another portable computer which is able to interpret the color and blinking of the LED and to provide information on the meaning of respective blinking. The LED could e.g. visualize proper or improper connection of the two connector devices 100, 200. The window element 140 may be provided by transparent glue placed into the bore 142. In particular, heat conductive transparent glue may be used to radiate dissipation, i.e. heat produced by the LED to the metal circular male longitudinal element 110. For that reason, the LED 140 shall be positioned close to the inner circumferential surface of the circular male longitudinal element 110. In the embodiment of Fig. 4, the distal male housing member 116 is provided with a radial bore receiving a thermal spring 145, which thermal spring 145 presses the PCB 118 against an assigned surface provided by the distal male housing member 116 and thus accurately positions the PCB relative to the distal male housing member 116. The thermal spring 145 is by selection of the material forming the thermal spring 145 and/or by an adapted design of the spring 145 in particular suitable to conduct heat from the PCB 118 to the circular male longitudinal element 110 being made of a metal. The thermal conductivity of this circular male longitudinal element 110 allows the heat dissipated from the PCB 119 to be radiated to the ambient. Thus, the thermal spring 145 effectively cools the PCB 118 and the electronic component 132, 140, arranged thereon. ICs or sensors, which likewise dissipate heat, may likewise be provided on the PCB 118.

[0044] Figs. 5C through H exemplify patterns for the male contact surfaces 135 on the PCB 118. Those Figs. exemplify a front view of the PCB at the distal end 119 of the PCB 118 for Figs. 5C through H and a slot generally referred to by reference numeral 230 defined by the distal female housing member 206, adapted to receive the PCB 118 and exposing therein the female contact elements 208. In the Figures, GRD means ground (0 potential, i.e.

mass) and VDD means positive polarity or voltage drain of the electricity supplied through the connector system. "S+" or "S-" is a twisted pair for data transmission. In the drawings, each pair is further identified with a number. "S1+" and "S1-" is the first pair; "S2+" and as "S2-" are the second pair and so on..

In Figs. 5A a hybrid single differential pair slot 230 is shown in a front view. The differential data pair S-/S+ is arranged in the middle of the slot 230 in a length wise direction thereof, which length wise direction is parallel to a contact axis identified with a CA in all Figs. 5. The differential data pair S-/S+ is arranged opposite to each other along a line T which runs transverse to CA. This line T and the contact axis CA define a plane which extends perpendicular to a mating direction MD. A contact pair VDD is arranged on lateral ends of the slot 230 while one female VDD is arranged on one side relative to CA and the other VDD on the other, i.e. opposite side of CA. The two VDD female contact elements are point symmetrical relative to a point of symmetry 400. The same is true for the female contact element for ground GND. A respective assignment is provided for the male contact elements (not shown). Thus, the specific constitution allows mating the female and the male connector device in two different directions without creating a short circuit while maintaining the data link.

[0045] A respective situation is exemplified in Fig. 5B. In addition to the first example of Fig. 5A, a second differential data pair S2-/S2+ is provided point symmetrically relative to the point of symmetry 400, to also provide redundancy for the data pair.

[0046] Figs. 5C through H exemplify the assignment of the male contact elements 134 to different functionalities.

[0047] In the embodiment of Fig. 5C, a ground pair is arranged as the differential pair of Fig. 1, i.e. in the center of the PCB (T) and opposite to each other. Four differential pairs ($S_1 \pm / S_2 \pm / S_3 \pm / S_4 \pm$) are provided. The embodiment may be utilized as a media dependent interface for four copper data.

[0048] The example of Fig. 5D is essentially identical with that shown in Fig. 5C. Instead of a ground pair a VDD/GND pair is provided as a central pair. The respective embodiment may be used as a media dependent interface for four copper pairs for data and one pair for power supply.

[0049] As in all embodiments, a ground plane 150 is provided along the contact axis, i.e. in the middle of the PCB 118 in thickness direction thereof. This ground plane 150 is provided by a conductive layer within the PCB 118 assigned to ground. The ground plane 150 may be used for shielding one side of the PCB relative to the other and/or for connecting ground through the connector system to the female connector device which will then be equipped with an assigned central ground connector.

[0050] The embodiments of Figs. 5F through H have the same functionality as the embodiments of Fig. 5C, 5D and 5E, respectively. However, as a most lateral male

contact element 134, a male connector element assigned to ground GND is provided on both sides relative to CA. Thus, all differential data pairs are arranged on the PCB 118 sandwiched between ground contact elements.

[0051] In the embodiment of Fig. 5A and E, the neutral positions of VDD and SGN on the bottom, i.e. lower side depicted in Figs. 5E and H, may change. Also, one or more VDD may be changed into additional SGN. The examples of Figs. 5E and 5H represent a media independent interface for an active plug with copper, fiber optics or polymer millimeter wave guide.

[0052] In particular, the embodiments of Figs. 5C through H cope with the problem of providing eight data pins on a smaller space, which data pins are required for high speed ethernet. The embodiments of Fig. 5C through H may not be suitable for being inserted in two different orientations relative to an axis of insertion. Instead, means for properly aligning the contacts relative to each other to safeguard for proper positioning can be provided as e.g. exemplified in Figs. 6 through 13. The solutions presented in Figs. 5C through H provide for a high number of contacts in a rather narrow space. The threaded sleeve 104 may, for example, be provided with an M8 thread which has a rather small diameter. Traditional M8 connectors with pin contacts can hardly be utilized to realize such high number of contacts at the interface between the male and the female connector device. The same is true for the media independent interface MII. In such an interface, signal and power that exit the female connector device is generic and only in the male contact device, which then needs to hold some components and will be an active plug. The signal is converted to a media dependent signal, e.g. copper, glass or polymer millimeter wave guide. This allows for upgradability (e.g. speed distance or otherwise). The solution proposed with the present invention can easily cope with those demands due to the high number of contact elements provided by the connector device on one hand and the possibility to mount electronic components 132 on the PCB 118 within the male housing 102 for providing an active plug.

[0053] Further, shielding in traditional M8 through M12 contact elements with contact pins projecting from an isolated plane of the housing is troublesome. Small shields provided to shield between different contact elements or pairs are expensive to produce and assemble. Moreover, it will be difficult to achieve sufficient impedance matching. The use of a flat insulating structure supporting the male contact elements with a middle layer for providing the ground plane 150 and which can be a copper layer within the elongated electrically isolated substrate supporting the male contact elements is cost-effective. It also allows for high speed data transmission.

[0054] In Figs. 6 through 11, female contact elements (jacks) are exemplified in Figs. 6, 8, 10, while the assigned male contact elements (plugs) are exemplified in Figs. 7, 9, 11, respectively. In each of those embodiments, the circular male longitudinal element 110 is pro-

vided with a nub 152, while the circular female longitudinal element 214 provides a guiding groove 232 adapted to receive the nub 152 for proper alignment of both, the male and the female contact devices 100, 200. In Figs. 6 through 9, the width of the PCB 118 and the assigned slot 130 is such that the slot 230 has lateral surfaces provided by the distal female housing member 206. Thus, the slot 230 is a closed slot. In Figs. 10 and 11 the PCB 118 is wider and contacts the inner circumference of the circular male longitudinal element 110. The slot 230 is an open slot not having the lateral walls provided by the distal female housing member 206. Instead, and as the male and the female connector devices 100, 200 are joined and coupled, the slot 230 is enclosed by the circular male longitudinal element 110.

[0055] The embodiment of Figs. 10 and 11 will allow for additional ground by the circular male longitudinal element 110, which improves signal integrity performance. The number of contacts will not necessarily be increased. Thus, the examples of Figs. 5C through E will show the same performance as those of Figs. 11 through H with lateral ground on the PCB 118. The number of contact surfaces in the female housing does not necessarily have to be increased. Connecting the contact pads on the lateral ends of the PCT 118 to the circular longitudinal shield will result in an additional improvement for signal integrity.

[0056] Figs. 12 through 13 exemplify further embodiments, wherein the embodiment of Figs. 12 and 13 is identical. In addition to the embodiment of Figs. 7 and 9, traditional pin contacts as in a regular M8 through M12 connector are provided, which male traditional pins are identified with reference numeral 154. Those male contact pins 154 may be used for power supply, i.e. VDD and GND or VDD and VSS. In the embodiment of Fig. 12 and 13, those additional male contact pins 154 are provided both on the same side of the PCB. In the other embodiment of Fig. 14, they are arranged on opposite sides of the PCB 118.

Reference Sign List

[0057]

100	male connector device
102	male housing
104	threaded sleeve
106	securing rim
108	securing ring
110	circular male longitudinal element
112	circular male exposed end
114	circular male terminal end
116	distal male housing member
118	PCB
119	distal end of PCB
120	housing sleeve element
122	housing sealing ring
124	compression element

126 partition
 128 cable sealing ring
 130 chamber
 132 electronic component
 134 male contact element
 135 male contact surface
 136 terminal pad on PCB
 138 groove of circular male shield element
 139 projection
 140 LED
 142 bore
 144 window element
 145 thermal spring
 146 knurled wheel
 150 ground plane
 152 nub
 154 male contact pin
 200 female connector device
 202 female housing
 204 threaded sleeve
 206 distal female housing member
 208 female contact element
 210 female contact terminal end
 212 female contact surfaces
 214 circular female longitudinal element
 220 outer threat
 222 screw
 224 outer rim
 226 sealing ring
 228 sealing ring
 230 slot
 232 guiding groove
 300 cable
 302 cable shielding
 400 point of symmetrie
 MD mating direction
 CLA central longitudinal axis
 CA contact axis

Claims

1. Connector system with a male and a female connector device (100 ;200), wherein the female connector (200) has a female housing (202) and wherein the male connector (100) has a male housing (102), which housings (102, 202) are joinable by relative movement of the housings in a mating direction (MD) and provided with locking means (104, 204) for releasable locking the male housing (102) against the female housing (202), wherein the female connector (200) has female contact elements (208) each providing a female contact surface (207) and wherein the male connector (100) has a male contact elements (134) each providing a male contact surface (135), wherein in a locked stage of the two housings (102; 202) one male contact surface (107) contacts an assigned female contact surface (212), wherein

the contact surfaces (135; 212) of each connector device (100; 200) are arranged parallel to a contact axis (CA), extending transverse to the mating direction (MD) and wherein contact surfaces (13; 2) of each connector device (100; 200) are sealingly received between the two housings in the locked stage of the two housings.

2. The connector system as defined in claim 1, wherein a first row of contact surfaces (135; 212) is arranged next to each other on one side of said contact axis (CA) and wherein a second row of contact surfaces (135; 212) is arranged next to each other on the other side of said contact axis (CA).

3. The connector system as defined in claim 1 or 2, **characterized in that** the locking means (104; 204) are adapted to allow locking of the female housing (202) against the male housing (102) in at last two different orientations of the respective housing (102; 202).

4. The connector system as defined in any of the claims 1 to 3, **characterized in that** two contact surfaces (135, 212) on opposite sides of the contact axis (CA) are arranged point symmetrically to define a functional pair.

5. The connector system as defined in any of the proceeding claims, **characterized in that** two contact surfaces (135, 209) of a functional pair are electrically connected with a single terminal end (136, 210).

6. The connector system as defined in any of the proceeding claims, **characterized in that** lateral contact surfaces (135; 212) arranged on opposite sides of the contact axis (CA) define an AC or DC power pair or are assigned to ground.

7. The connector system as defined in any of the preceding claims, **characterized by** an elongated electrically isolated substrate (118) provided with the male contact surfaces (135) and by at least one male contact pin (154) projecting parallel to an extension direction of the elongated electrically isolated substrate (118).

8. The connector system as defined in any of the proceeding claims, **characterized in that** one of the female housing (202) and the male housing (102) is provided with a rotatable threaded sleeve (104, 204) and the other of the female and the male housing (202; 102) is provided with a counter threaded sleeve (204) adapted to threadable engage the threaded sleeve (102) for locking the housings (102, 202), wherein at least one of the of the female housing and the male housing (202; 102) is provided with a cable receptacle (128) adapted to sealingly guide a cable

(300) into the housing (102) which sealingly surrounds end terminals (136) adapted to be contacted by strands of the cable (300) and each being electrically connected to the assigned contact surfaces (135; 212).

dinal element (110).

9. The connector system as defined in any of the preceding claims, **characterized in that** the male connector (100) has a distal male housing member (116) being projected by a PCB (118), wherein one end of the PCB (118) is exposed within a sleeve (104) and defines the male contact elements (106) and wherein the other end of the PCB (118) is sealingly received within the male housing (102).

5
10
15
10. The connector system as defined in any of the preceding claims, **characterized in that** a distal female housing member (206) defines a slot (230) adapted to receive a terminal end (119) of the elongated electrically isolated substrate (118), and that lateral walls of the slot (230) are defined by a circular male longitudinal element (110) in the locked stage of the two housings (102, 202).

20
11. The connector system as defined in any of the preceding claims, **characterized in that** the male housing (102) is provided with a circular male longitudinal element (110) having an circular male exposed end (112) surrounding the male contact elements (134) and that the female housing (202) is provided with a circular female longitudinal element (214) surrounding the female contact elements (208), wherein the male longitudinal element (110) and the female longitudinal element (214) are adapted to contact each other in the locked stage of the two housings (102; 202).

25
30
35
12. The connector system as defined in any of the preceding claims, **characterized in that** the rotatable threaded sleeve (104) is rotatable supported on the outer circumference of one of the circular male or female longitudinal elements (110, 214).

40
13. The connector system as defined in any of the preceding claims, **characterized by** sealing means (228) effective between the male housings (102) and the female housings (202) in the locked stage of the two housings (102, 202).

45
14. The connector system as defined in any of the preceding claims **characterized by** an LED (140) supported by the male or the female housing (102, 202).

50
15. The connector system as defined in any of the preceding claims, **characterized by** a spring element (145) received within the male housing (102) and pretensioned between the elongated electrically isolated substrate (118) and the circular male longitudinal element (110).

55

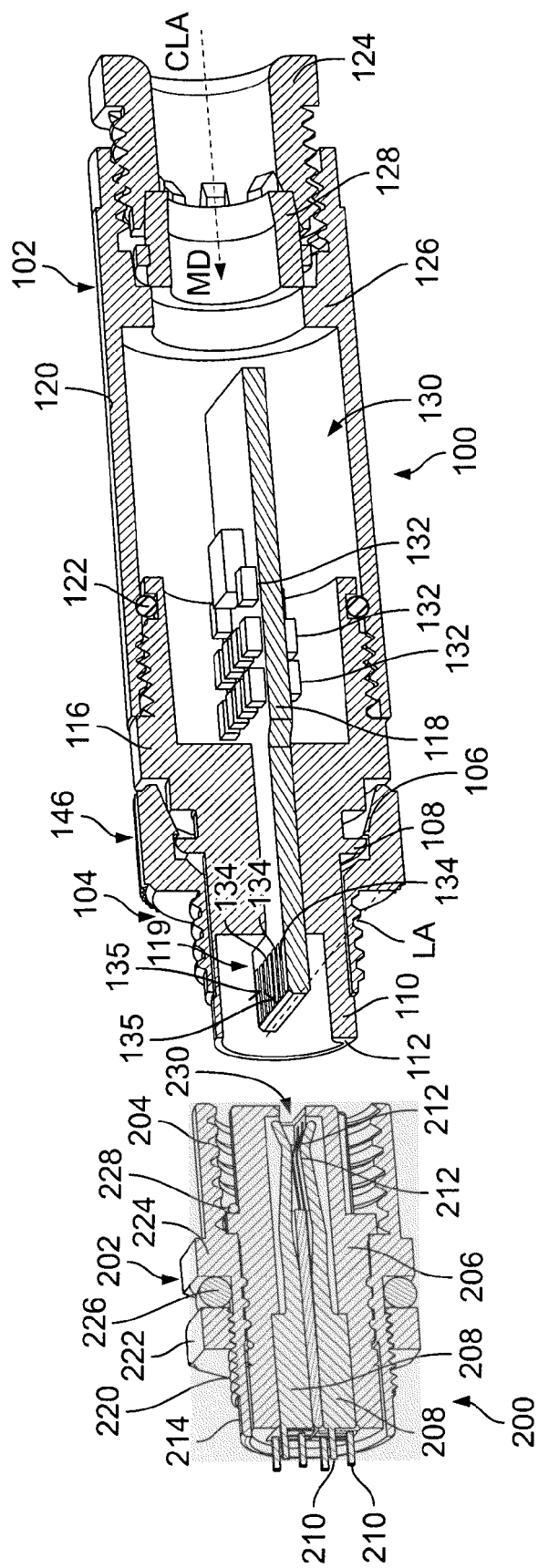


Fig. 1

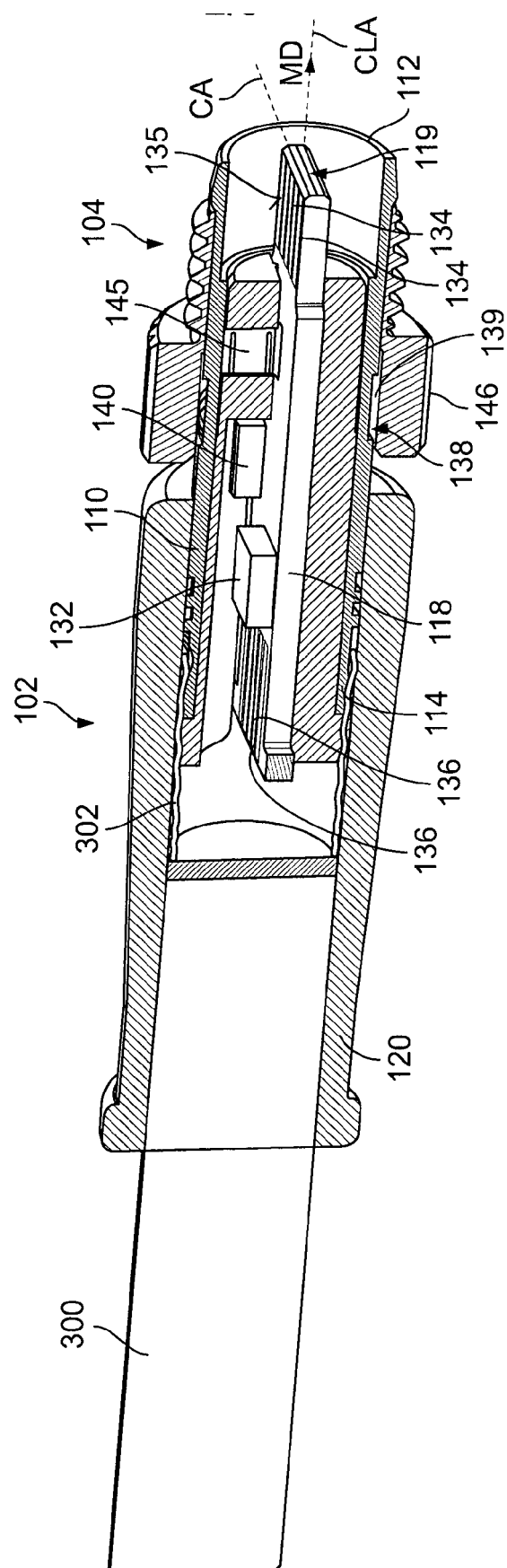


Fig. 2

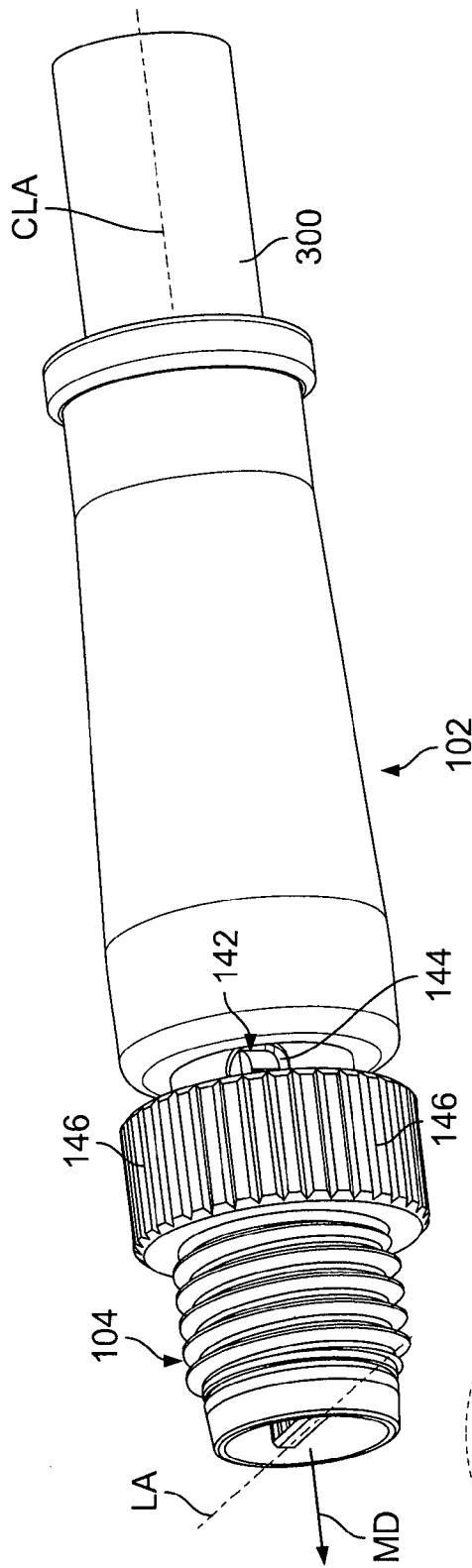


Fig. 3

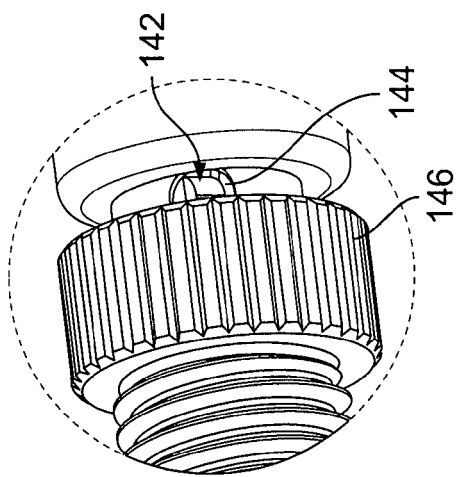


Fig. 4

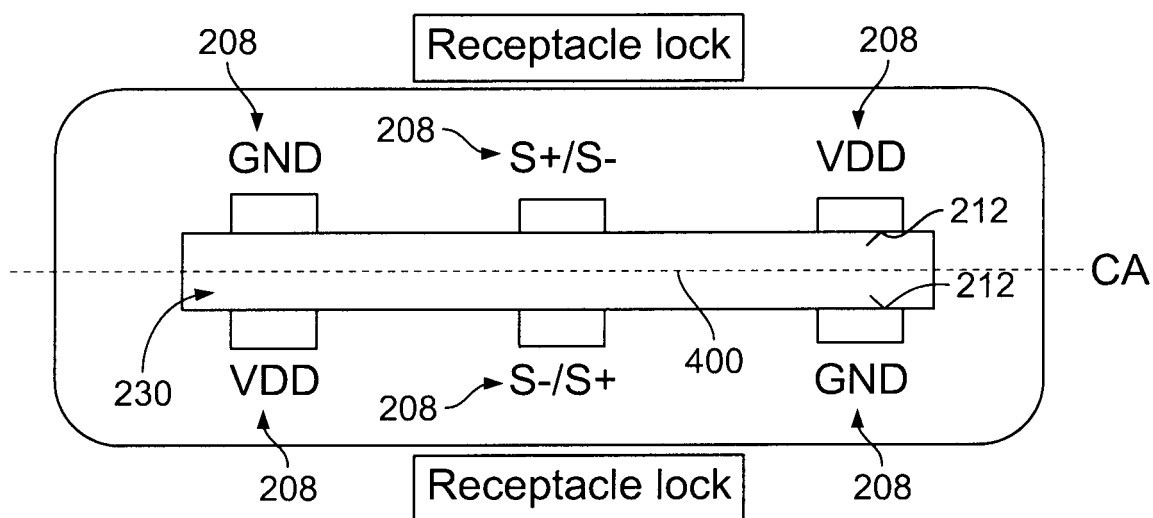


Fig. 5A

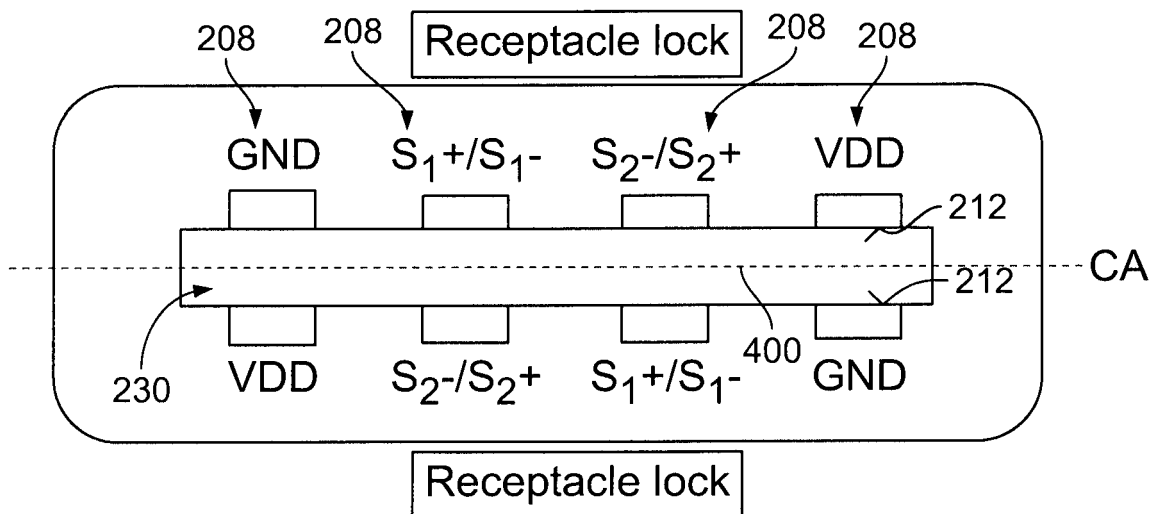


Fig. 5B

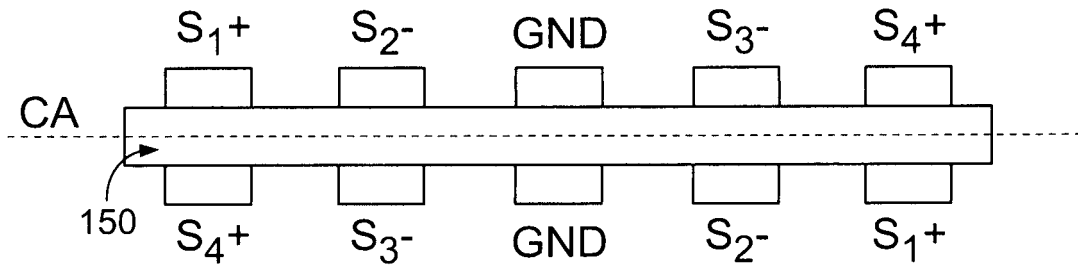


Fig. 5C

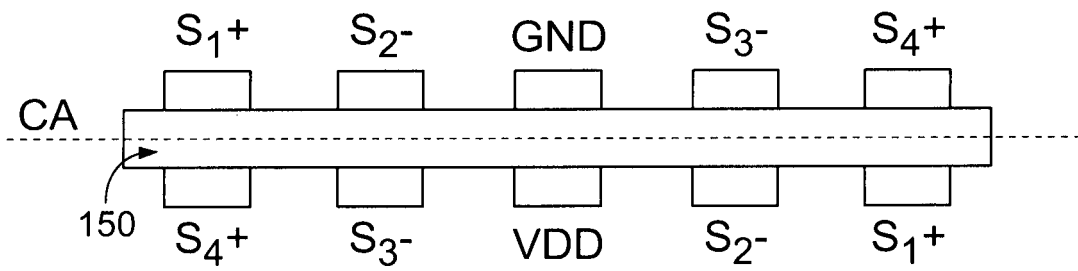


Fig. 5D

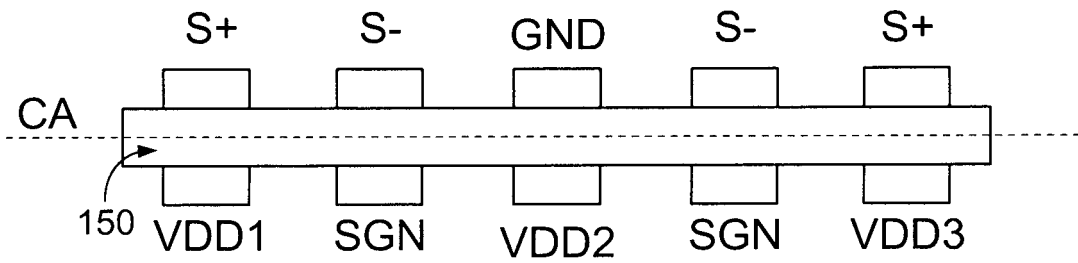


Fig. 5E

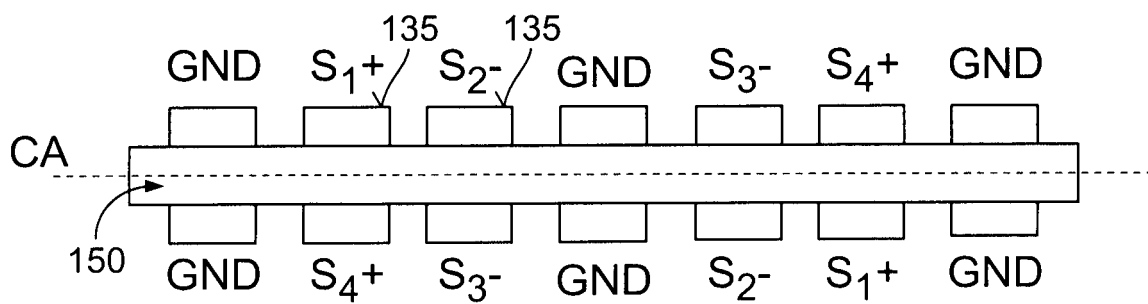


Fig. 5F

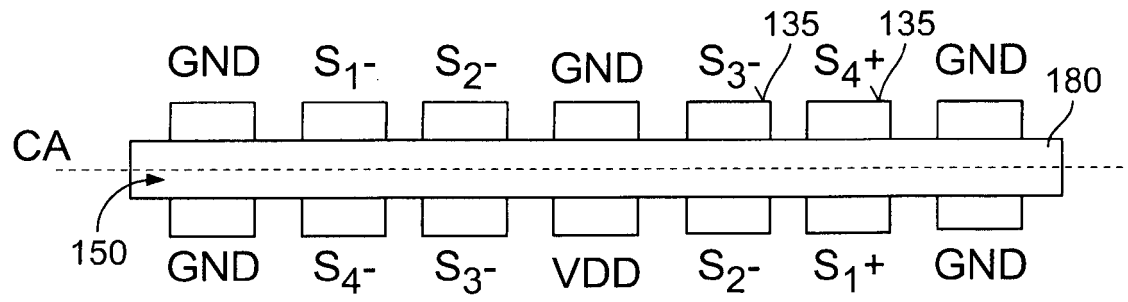


Fig. 5G

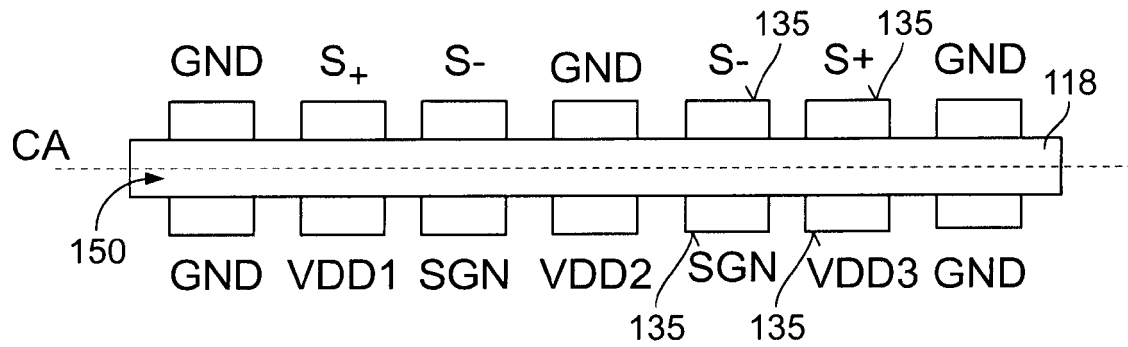


Fig. 5H

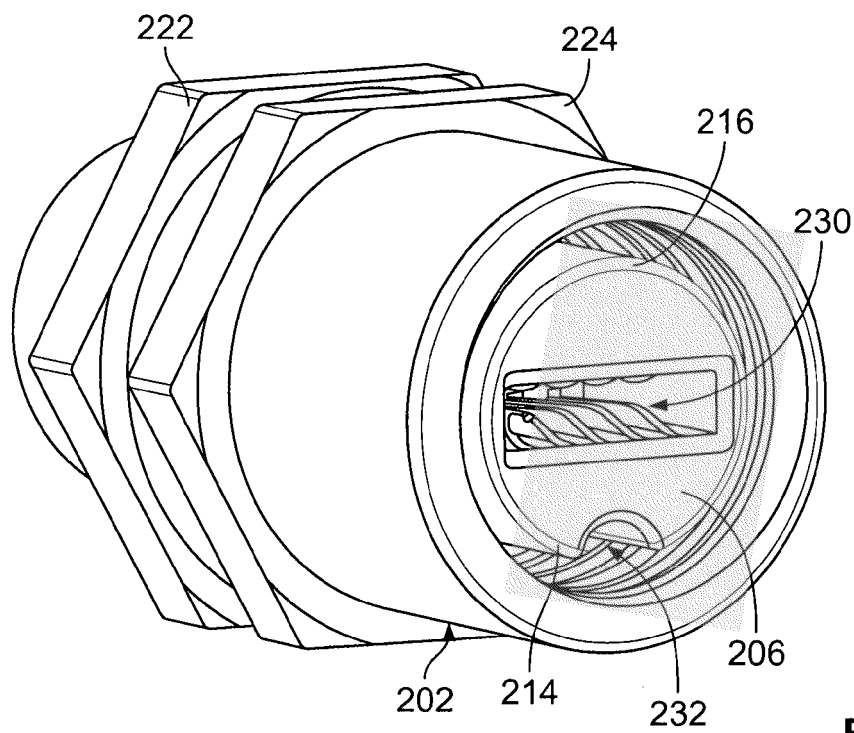


Fig. 6

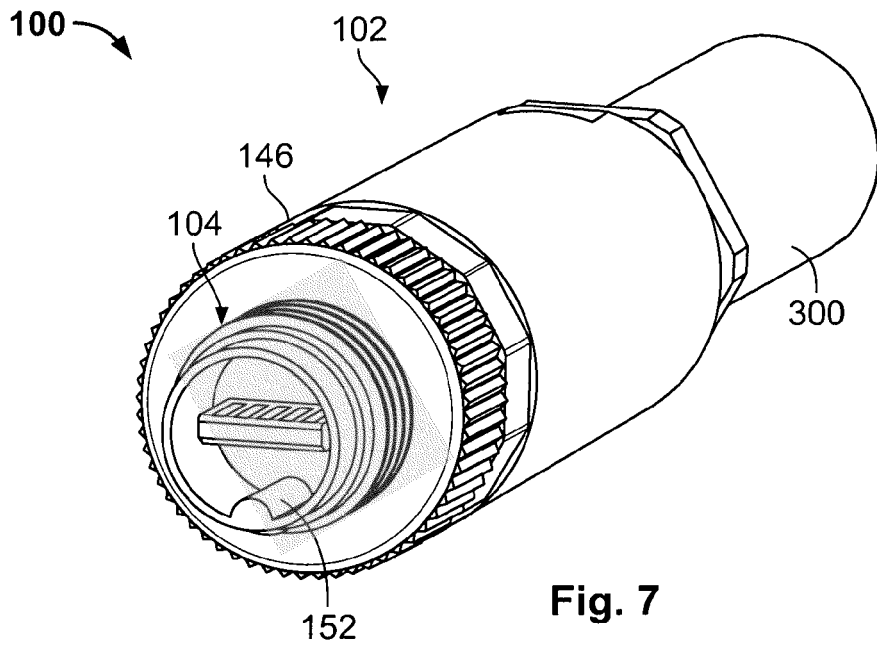


Fig. 7

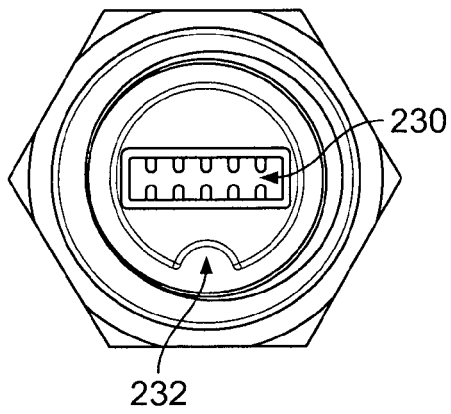


Fig. 8

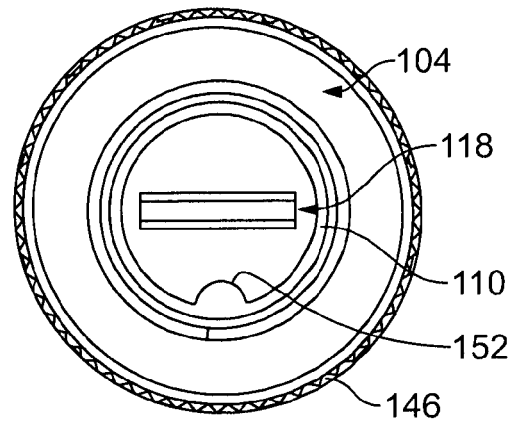


Fig. 9

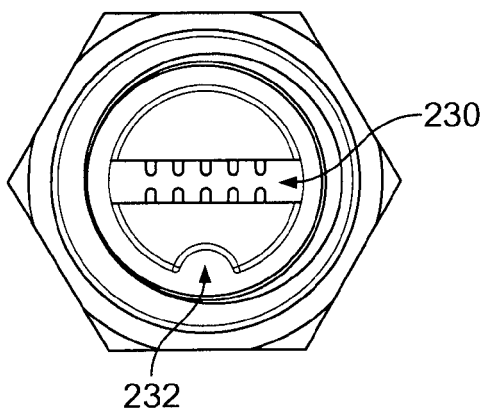


Fig. 10

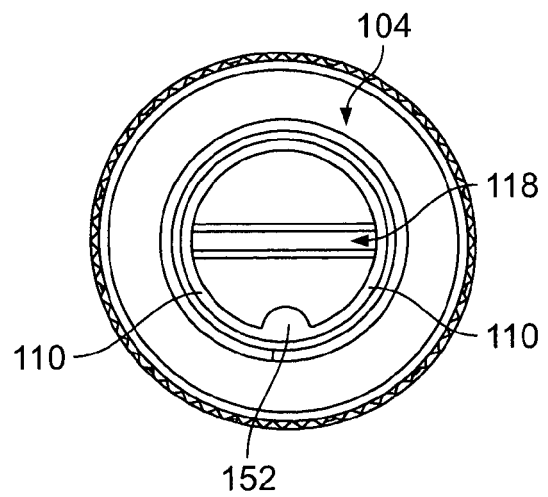


Fig. 11

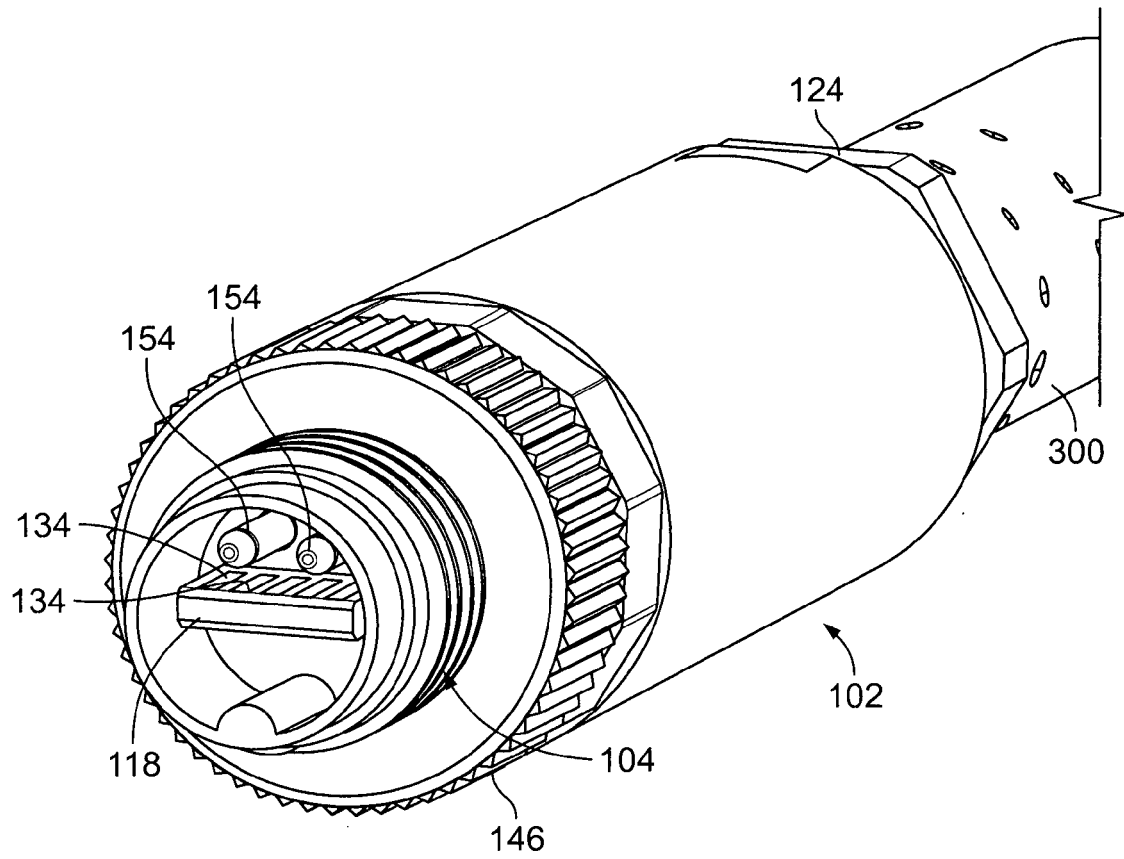


Fig. 12

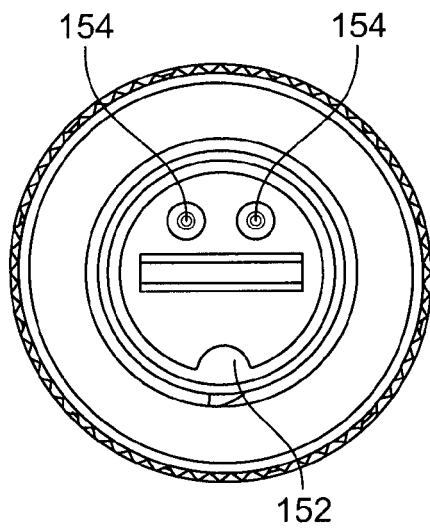


Fig. 13

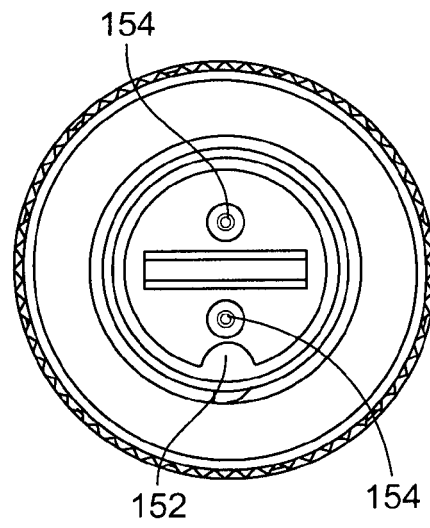


Fig. 14



EUROPEAN SEARCH REPORT

Application Number
EP 15 19 5864

5

10

15

20

25

30

35

40

45

50

55

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2014/060927 A1 (CHIU TEH-TSUNG [TW]) 6 March 2014 (2014-03-06)	1-3,8, 10-15	INV. H01R13/623
Y	* the whole document *	7,9	H01R13/52
A	-----	4-6	H01R13/516
X	US 2010/029114 A1 (HSU CHING-MIN [TW] ET AL) 4 February 2010 (2010-02-04)	1-3,8, 10-15	H01R13/24
	* the whole document *		H01R24/64
X	US 2007/087627 A1 (MATHEWS ROGER D [US]) 19 April 2007 (2007-04-19)	1,3-6,8, 10-15	ADD. H01R13/66
A	* the whole document *	2	
A	US 2015/200493 A1 (GAO ZHENG [US] ET AL) 16 July 2015 (2015-07-16)	1-6,10, 14,15	
	* the whole document *		
Y	US 2012/264335 A1 (FEYDER IGOR [US] ET AL) 18 October 2012 (2012-10-18)	7,9	
A	* the whole document *	1,2,4-6, 10,11, 14,15	TECHNICAL FIELDS SEARCHED (IPC)
	-----		H01R
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 18 April 2016	Examiner Gomes Sirenkov E M.
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 15 19 5864

5

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

18-04-2016

10

15

20

25

30

35

40

45

50

55

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2014060927 A1	06-03-2014	NONE	
US 2010029114 A1	04-02-2010	CN 101656374 A	24-02-2010
		CN 201266812 Y	01-07-2009
		TW 201006059 A	01-02-2010
		US 2010029114 A1	04-02-2010
US 2007087627 A1	19-04-2007	US 2007087627 A1	19-04-2007
		US 2008220647 A1	11-09-2008
US 2015200493 A1	16-07-2015	CN 104779490 A	15-07-2015
		CN 204315840 U	06-05-2015
		US 2015200493 A1	16-07-2015
		WO 2015105768 A1	16-07-2015
US 2012264335 A1	18-10-2012	CA 2833265 A1	18-10-2012
		CN 103620885 A	05-03-2014
		EP 2697871 A2	19-02-2014
		US 2012264335 A1	18-10-2012
		WO 2012142606 A2	18-10-2012

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82