

Description

BACKGROUND

Technical Field

[0001] The invention generally relates to the field of electrical connectors, and finds non-limiting applications in the automotive industry, for example in automotive networking applications.

[0002] It is concerned, more particularly, with a single wire seal (SWS) for use, inter alia, in a sealed multi-port connector, e.g., a high-speed data connector system.

Related Art

[0003] The approaches described in this section could be pursued, but are not necessarily approaches that have been previously conceived or pursued. Therefore, unless otherwise indicated herein, the approaches described in this section are not prior art to the claims in this application and are not admitted to be prior art by inclusion in this section.

[0004] In the automotive industry, high-speed data and high-power electrical systems are required to connect two systems for feature-rich, highly automated vehicles. One of the examples of a high speed data connector is a High-Speed Modular Twisted-Pair Data (H-MTD®) is a proprietary Ethernet cable connector system, of the company Rosenberger Hochfrequenztechnik GmbH und Co. KG, Germany, used in automotive networking applications that is designed to support frequencies up to 20 GHz and data transmission rates up to 56 Gbit/sec. It includes a miniaturized terminal system that can be enclosed within modular, compact housings and headers.

[0005] Electrical connectors known in the art comprise a connector housing which has a plurality of receptacles for holding electrical terminals. The electrical terminals are generally in the form of a plug or pin and are electrically connected to respective cables. They are adapted to be connected to a corresponding mating counterpart, namely a pin or socket, respectively, of a dedicated mating counter-connector, for example. To assemble the electrical connector, the cables and the electrical terminals attached to them must be inserted into the receptacles of the electrical connector housing and held there tightly.

[0006] In order to meet the requirements for the relative distances between the outermost electrically conductive part of adjacent terminals, on the other hand, the wires of these connectors pass through a separate spacer element which is sealingly mounted on the connector housing. This spacer is generally further configured as a closure cap adapted to seal the electrical connector housing.

[0007] Constraining sealing properties must be guaranteed. To that end, sealing members are used to prevent the intrusion of moisture or other contaminants such as

water, dust, oil or dirt into the electrical connector housing.

[0008] An integral sealing member of a known type for sealing a plurality of cables into a multi-port connector housing is commonly of a flat shape, and is sometimes referred to as a "sealing mat" or "mat(t)(e) seal" or "mat(t)(e) gasket". Such a flat gasket is adapted to be placed at the rear opening of a connector cavity. It has through-holes disposed in row(s) and/or column(s), and one end of each cable, fitted with a terminal, passes through one of these holes into said connector housing cavity. The seal is designed to fit over the rear opening of the connector housing to seal the cavity.

[0009] The disadvantage of matt gaskets is that terminal assembly (automated and/or manual) is complicated by the handling of multiple terminals inserted through the gasket and into the housing cavity. Assembling a large number of terminals can therefore be very critical and complex.

[0010] An alternative to the existing seal designs based on matt seal members as discussed in what precedes, can be a sealed multi-port connector design using a plurality of Single Wire Seal (SWS) members, each mounted on the cable sheath of one of the cables and adapted to seal into respective apertures of a cable spacer.

[0011] Such alternative solution, however, has more influence on the pitch distance between terminals, and usually it results in an increased connector size.

[0012] Further, the compression of each SWS element by a plurality of cables which are usually arranged in a matrix of rows and columns results in an unpredictable deformation and position of seal lips around the cable sheath of each wire, which can cause improper sealing. For instance, abnormal deflection of seal lips due to the squeezing of the seal inside connector, can result in improper sealing. Also, due to the excessive strain in the seal, some portions of the seal find weak zone to relief the strain during insertion into the connector.

[0013] WO 2013178726 A1 discloses a single wire seal, SWS, for sealing an electrical cable in an aperture of a socket or connector housing. The SWS has a substantially cylindrical shape and a through-hole for the electrical cable. The SWS also includes a crimp portion for crimping the crimp section of a terminal to both the SWS and the electrical cable. The SWS is moulded in a first elastic material, preferably relatively flexible, having a Young's modulus E1. To reduce deformation of the SWS due to crimping, the SWS is also provided with a reinforcing element arranged at the crimping part. The reinforcing element is preferably provided with at least one ring-shaped part. The reinforcing element is moulded in a second material which has a higher Young's modulus E2 than the modulus E1 of the first material (E2>E1).

[0014] Such a bi-material design could be considered to overcome the disadvantages described above, in the context considered, in order to limit deformation of the

SWS upon insertion into respective apertures of the cable spacer. However, this two-material design leads to an inhomogeneous constitution of the SWS, which makes the manufacturing process much more complex and therefore leads to a significant increase in manufacturing costs.

SUMMARY

[0015] The invention aims to remedy all or some of the disadvantages of the above identified prior art.

[0016] To address these needs, a first aspect of the proposed solution relates to a Single Wire Seal, SWS, defined by the features as claimed in claim 1.

[0017] More precisely, there is proposed a single wire seal, SWS, for sealing an electric cable having a cable sheath surrounding at least one electrical wire, into an aperture of an electrical connector housing, said seal being provided with an essentially cylindrical shape and with a central through hole for receiving the electric cable, which extends along a longitudinal axis of the seal, said seal comprising:

- a first sealing portion having at least one outer sealing lip for cooperation with an inner wall of the connector housing,
- a second sealing portion having at least one inner sealing lip for cooperation with the outer periphery of the cable sheath,

wherein the first sealing portion and the second sealing portion are substantially axially spaced apart from each other along the longitudinal axis of the seal.

[0018] Thanks to these features, the proposed SWS makes it possible to remedy, or at least significantly mitigate, technical problems such as those mentioned above, encountered with multiport connector assemblies of the prior art.

[0019] Further embodiments of the proposed solution are defined in the dependent claims.

[0020] A second aspect of the proposed solution relates to a multiport electrical connector assembly according to claim 12, comprising:

- a connector housing made of dielectric material and having an inner cavity,
- a plurality of cables,
- terminals adapted to be mounted on one end of a respective cable and to be received in the cavity of the connector housing through a respective aperture in the connector housing, and,
- a plurality of single wire seals, SWS, according to the afore-mentioned first aspect for sealing the cables in the apertures in the connector housing.

[0021] In one possible embodiment, the inner cavity of the connector housing can be open to the outside of said housing through a rear opening, for easing the instalment of the terminals in dedicated receptacles therein. The assembly can then further comprise a closing cap for closing the connector housing, which is adapted to seal said rear opening of said housing when mounted thereon. The cap has mutually adjacent apertures arranged in a matrix configuration, for respectively receiving the cables and for spacing said cables one from another. Stated otherwise, the cap simultaneously operates as a closure for the connector housing and/or as a spacer for the cables.

[0022] The electrical connector assembly according to the second aspect allows improving the assembly of the connector. This is because the terminals (previously electrically and mechanically connected to a respective cable) can be more easily and more predictably positioned relative to the closing and/or spacing cap or to any suitable rear portion of the connector housing, while sealing between the cables and the cap is provided by the SWS according to embodiments. The terminals can then be inserted into the cavity of the connector housing, and are put in place within their respective receptacles inside the cavity of the connector housing. Then, the closing and/or spacing cap is pushed to a closing position at the rear of the connector housing whereby the terminals are locked in position inside the connector cavity while the cavity is closed and sealed by said cap, so as to prevent each terminal from being pulled-out from the cavity and to prevent ingress of any contaminants into the connector housing.

[0023] With such a configuration, it is relatively easy to assemble the connector, with the rear spacing and closing cap and with terminals already connected to the cables, even when there is not much space around the rear face of the connector.

[0024] In addition, tight tolerances can be achieved by positioning the cables next to each other in a matrix configuration at the rear of the connector, without compromising sealing efficiency.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] Embodiments of the present invention are illustrated by way of example, and not by way of limitation, in the figures of the accompanying drawings, in which:

- Figure 1 is an exploded view of a prior art multi-port connector assembly adapted to accommodate, in a sealed manner, e.g., four high-speed data plugs in a 2x2 configuration, i.e., in a two-row, two-column matrix seal arrangement.
- Figure 2A is an axial cross-sectional view of Single Wire Seal (SWS) known in the prior art.
- Figure 2B is an axial cross-sectional view showing

the SWS of Figure 2A in an operational condition, *i.e.*, while being inserted in a cavity of a connector housing and while having one wire extending inside the longitudinal through-hole arranged within said SWS.

- Figure 2C is the same view as in Figure 2A which schematically illustrates the compression forces exerted on a sealing portion of the SWS in opposite transverse directions, namely inwardly by the inner walls of the connector housing and outwardly by the cable sheath of a single wire accommodated within said SWS.
- Figure 3A is a perspective view of a SWS according to embodiments of the first aspect.
- Figure 3B is a perspective view of the SWS of Figure 3A when fitted over a single cable near a high-speed data plug arranged at one end of said cable.
- Figure 3C is an axial cross-section view of the arrangement shown in Figure 3B.
- Figure 4A is an axial cross-sectional view showing the SWS according to embodiments as shown in Figure 3A through Figure 3C.
- Figure 4B is an enlarged view of a detail of the SWS according to embodiments, showing the preferred shape of an outer sealing lip of said SWS.
- Figure 5 is the same view as in Figure 4A showing a single wire accommodated within the SWS according to embodiments.
- Figure 6 is an exploded view of multiport electrical connector assembly according to embodiments.
- Figures 7A and 7B are axial cross-sectional views showing a rear closure grid for a multiport electrical connector wherein six cables are arranged in the 2x3

[0026] configuration, each cable being fitted within said grid by a respective SWS according to the prior art and according to embodiments, respectively.

DESCRIPTION OF PREFERRED EMBODIMENTS

[0027] The following figures and description illustrate specific exemplary embodiments of the invention. It is therefore obvious that those skilled in the art will be able to devise various arrangements which, although not explicitly described or illustrated herein, embody the principles of the proposed solution and are included within the scope of the claims. In addition, all examples described herein are intended to facilitate understanding of the principles of the solution and should be construed as

not being limited to the examples and provisions specifically disclosed. Accordingly, the scope of the claims is not limited to the specific embodiments or examples described below, but only by the features set forth in the claims and their equivalents.

[0028] In the figures of the accompanying drawings, like reference numerals refer to similar elements. In addition, unless specifically stated otherwise, the disclosures contained in the entire description can be applied analogously to the same parts with the same reference signs or the same component identifiers.

[0029] In the following description, functions or constructions well-known by the one skilled in the art are not described in detail since they would obscure the description in unnecessary detail.

[0030] There will be firstly described, with reference to Figure 1 of the accompanying drawings, a connector assembly comprising a hollow connector housing 2 and an interconnect having at least one cable 3 and preferably a plurality of such cables, for a multiport electrical connector assembly. One end of the cables is fitted with a respective terminal 4. The connector housing 2 is configured for accommodating the terminals 4.

[0031] In the context of the present description, there will be considered terminals 4 which, in one example as shown in the drawings, are male terminals (namely pins), *e.g.*, power and/or signal terminals. Of course, the embodiments are not limited to such examples and encompass, *inter alia*, applications wherein at least some of the terminals are female terminals (namely sockets). Each of the terminals 4 is connected to one or more wires arranged in a respective single cable 3. Cables 3 are part of an interconnect, *e.g.*, an interconnect of any power and/or control system on board of a vehicle, *e.g.*, a car vehicle.

[0032] In one application as shown, embodiments comprise high-speed data terminals such as a H-MTD® (standing for "High Speed Modular Twisted-Pair-Data") plug, for automotive and/or multi GHz applications. H-MTD® is a registered trademark of Rosenberger Hochfrequenztechnik GmbH & Co. KG. Connectors of said system are meant to allow data transmission up to 15 GHz or 20 Gbps while having a small package size. Non-limiting applications in the automotive field for the H-MTD® system are, *e.g.*, 4K camera systems, autonomous driving, radar, lidar, high-resolution displays and rear seat entertainment.

[0033] The connector housing 2 is made of an electrically insulating material, which may be called a dielectric material, such as polyethylene terephthalate (PET) or polyamide (PA). The connector housing 2 has an inner cavity which is open to the outside of the housing via a rear opening 2b, designed to receive the cables 3 such that terminals 4 can be accommodated in dedicated receptacles (not shown) within the connector housing 2.

[0034] In the example as shown, the housing 2 is a single-piece element, which can be obtained by, *e.g.*, any appropriate moulding technique. The one with ordinary

skills in the art will appreciate, however, that the housing can be made of one or more components moulded from dielectric material(s). For example, the housing can comprise an outer housing component and an inner housing component, said inner housing component comprising at least one cavity for accommodating the terminals.

[0035] In the example shown, the assembly is designed to connect four cables 3 whose respective ends are fitted with a terminal 4, in this case a high-speed data terminal. The terminals are intended to be housed, in a sealed manner, in a cavity arranged within the housing 2. The cables 3 are elongated cables which, in operation, run generally parallel to each other along a connection direction or axial direction A of the connector housing 2, as shown. In order not to overload the exploded view in Figure 1, only two of these cables 3, each equipped with their respective terminals 4, are shown at the rear of the rear opening 2b of the connector housing 2.

[0036] By way of convention, terms like "rear" and "front", "behind" and "ahead", "**back (or rear) side**" and "**front side**", "**backward**" and "**forward**", and derivatives such as "**in (the) front of**", an "**in the rear of**" as well as associated verbs and derived nouns or expressions, are used herein in reference to the direction of insertion of the terminals 4 into the connector housing 2, through the opening 2b, along the longitudinal axis A of said housing.

[0037] For reasons relating to the compactness required by the narrow areas of use, which is particularly critical in automotive applications, the cables are arranged to penetrate the connector housing cavity in a matrix configuration. In the example as shown in Figure 1, the four cables 4 are thus mounted in a 2x2 matrix configuration, i.e., in two rows and two columns arrangement.

[0038] Another stringent requirement in the automotive sector is the need to prevent any intrusion into the connector housing 2 of water or moisture, and other contaminants such as dust, oil or dirt, for example. To this end, the housing 2 forms a sealed box with a closing cover 5 (or closing cap) having through-holes 5a arranged in the afore-mentioned matrix configuration. The through-holes 5a are each suitable for the insertion of a respective cable 3 along the longitudinal direction A of the connector housing 2, from the rear face of the closing cover 5. In order to prevent moisture, dust, etc. from entering this box, a cover gasket 1 is provided between the housing 2 and the front face of the closing cover 5. In the example shown, which reflects solutions known in the art, the cover gasket 1 is a matte seal 1 whose shape and dimensions match those of the rear opening 2b of the housing 2.

[0039] With further reference to Figure 1 illustrating the prior art, the matte seal 1 as shown is substantially flat in shape and is adapted to be disposed at the rear opening 2b of the cavity inside the connector housing 2. The seal 1 has through apertures 1a in number, size and positions corresponding to the through-holes 5a of the closing

cover 5, through which a respective terminal 4 of one of the cables 3 can be inserted forwardly, that-is-to-say from the rear to the front.

[0040] More precisely, the matte seal 1 comprises a layer sealing portion and a plurality of tubular cable sealing portions that protrude from the rear side of the layer sealing portion. The matte seal 1 may be formed from an elastomeric material, for example silicone rubber. Its layer portion is shaped to fit within and through the rear opening 2b of the connector housing 2, into which it is clamped by locking elements of the closing cover 5. Sealing to the connector housing 2 is achieved by the sealing layer portion through compression by the cover 5. Sealing with respect to any of the cables 3 is provided by the form fit between the tubular cable sealing portions and the outer periphery of the cable sheath. The cover 5 can be secured and sealed to an annular portion of the connector housing 2 forming the edges of the rear opening 2b of the housing cavity 2a, by a click connection, i.e., a snap-fit engagement.

[0041] Nevertheless, matt-seal arrangement designs of that kind have the disadvantages that they will lead to complications in the terminal assembly. Indeed, and irrespective of whether mounting is automated or performed manually, it requires handling of multiple terminals getting inserted through the matte seal and then into the cavity of the housing. Assembly of many terminals can thus be very critical and complex. Further, matte seals known in the art tend to be damaged during the insertion of the terminals, namely the cables.

[0042] In an attempt to alleviate the aforementioned problems arising from the use of seal designs with one integral matt-seal element for sealing a multiport connector, it may be envisaged to use a design with a plurality of separate single wire seal (SWS) elements.

[0043] Unlike a single sealing element of the known type suitable for sealing multiple cables into a multiport electrical connector, such as a prior art matte seal as described in the foregoing, a multiport connector assembly as proposed herein will, indeed, comprise a plurality of single wire seals (SWS), each of which is suitable for sealing a respective one of the plurality of cables 3 individually.

[0044] Such a SWS, as currently known in the prior art, is depicted in the axial cross-sectional view of Figure 2A. Figure 2B is an axial cross-sectional view like the view in Figure 2A, showing said seal 20 in the context of its use to seal one cable 3 into a cavity 2a of a hollow connector housing 2. More specifically, the single wire seal of Figure 2B has been inserted in a cavity 2a inside a connector housing 2, while having one cable 3 extending inside the longitudinal through-hole 24 arranged within said seal. Indeed, the single wire seal 20 as shown is substantially cylindrical in shape, and has a central, longitudinally extending through-hole 24 for receiving the electric cable 3. Stated otherwise, the through-hole 24 extends along a longitudinal axis B of the cylindrical and hollow seal 20, from a front opening 26 to a rear opening 27 thereof. The

seal consists of a front main portion 21, adjacent and coaxial to a tail portion 22 which extends rearwardly from said main portion 21 in the direction of the longitudinal axis B. Parts 21 and 22 form one integral element. This element can be produced by injection moulding, in a material of rubber type, such as an elastomer, for example silicone.

[0045] The main part 21 is provided with sealing means comprising outer sealing lips 211 designed to cooperate with an inner wall of the rear opening of the connector housing 2, and inner sealing lips 212 designed to cooperate with the cable sheath of one cable 3. These lips 211 and 212 are formed by annular projections extending radially in opposite directions, namely outwards and inwards, respectively, from the same longitudinal sleeve which, in the example shown, represents the entire longitudinal extension of the main part 21.

[0046] The single wire seal 20 is initially assembled on a cable 3, slightly behind the terminal 4, as shown on the left side of Figure 2B. More precisely, the end of cable 3 which is fitted with the terminal 4 to be accommodated into the connector housing 2, is inserted into the central through-hole 24 of the seal 20, from the rear opening 27 to the front opening 26. It is entirely passed through said hole 24, until a desired longitudinal gap is obtained between the front end of the main portion 21 of seal 20 and the rear end of terminal 4. Said terminal 4 is then inserted into the connector housing cavity 2a.

[0047] After successful assembly of the terminal in the connector housing, the single-wire seal 20 is pushed along the axis of the terminal, *i.e.*, along the cable 3, from the rear to the front, by manipulating the rear part 22, until it reaches a desired position, as illustrated in Figure 2B, for example. In this position of the seal 20, its front portion 21 has at least partially entered the cavity 2a and at least some of the outer sealing lips 211 are compressed radially towards the centre of the through-hole 24 (*i.e.*, towards the central longitudinal axis B), thereby sealing towards the inner wall of the connector housing 2.

[0048] During this operation, however, the inner lips 212 of the seal 2 are already in an expanded position on the outer surface of the cable sheath of the cable 3. Consequently, when the seal 20 is pushed further into the connector housing 2 along the cable 3, the inner lips 212 of the seal 2 are compressed and deform in the direction of the axis B.

[0049] As a result of this constraining environment, the lips 211 responsible for sealing with the inner wall of the connector are deflected in an irregular direction. In Figure 2C, the inner wall of connector housing 2 is symbolised by an horizontal black bar, and the pressure exerted by said wall against the main portion 21 of the seal 2 is illustrated by vertical arrows oriented from the top to the bottom of the drawing. Similarly, the outer surface of the cable sheath of cable 3 is symbolised by a similar horizontal black bar, and reaction by the said cable sheath against the main portion 21 of the seal 2 is represented by vertical black arrows oriented from the bottom to the top of the

drawing.

[0050] These contrary efforts in opposite transverse directions, together with the sliding movement of the seal 20 forced along the longitudinal direction, generate uneven constraints during displacement of the seal 20 toward its operational position, which are symbolised by horizontal arrows in Figure 2C. Due to these excessive strains in the seal 20, some angular portions of the seal find weak zones to relief the strain while insertion into the connector housing is ongoing. The overall result is an abnormal position, deformation and/or orientation of the sealing lips 211 and 212. Such abnormal deflection of the seal lips due to the squeezing of the single-wire seal 20 inside the connector housing 2 may results in improper sealing.

[0051] The above-mentioned disadvantages have to be compensated for by greater manufacturing tolerances and, consequently, have an influence on the distance between terminals (*i.e.*, pitch) in a transverse plane. In general, the use of SWS to seal cables in multi-port electrical connectors thus results in an increase in connector size.

[0052] Embodiments of a SWS according to the first aspect of the present technical disclosure, allow to mitigate this inconvenient. These embodiments shall now be described with reference to Figures 3A-3C, 4A-4B, 5 and 6.

[0053] Like the prior art single wire seal 20 of Figures 2A through 2C, the single wire seal 30 as proposed herein and as shown in Figure 3A, is adapted for sealing an electric cable 3 as previously discussed and shown in Figure 1. Use of seals 30 according to embodiments is similar to the use of seals 20 according to the prior art.

[0054] Cable 3 has a cable sheath surrounding at least one electrical wire, and more specifically two wires in the case of a high-speed data connector system as in the exemplary application contemplated here. Cable 3 is intended to and adapted for being passed into an aperture of an electrical connector housing such as connector housing 2 of Figure 1. Still like the prior art SWS, the SWS according to embodiments may be made of silicone rubber or any other suitable elastomeric material.

[0055] In embodiments according to the second aspect, there is provided a set of a plurality of single wire seals like the seal 30 as shown in Figures 3A, for respectively sealing a plurality of cables in respective apertures in the connector housing 2. Stated otherwise, and with reference to Figure 6, a given number N of seals 30 as proposed, where N is an integer greater than unity, which are part of a multi-port electrical connector assembly comprising:

- a connector housing 2 made of dielectric material and having an inner cavity 2a,
- a plurality of cables 3, and more specifically N such cables; and,

- N terminals 4, each adapted to be mounted on one end of a respective cable 3 and to be received in the cavity 2a of the connector housing 2 through a respective one of N apertures 6a in said connector housing 2.

[0056] The inner cavity 2a of the connector housing 2 can be open to the outside of said housing 2 through a rear opening 2b. In embodiments, the assembly shall further comprise a closure cap 6 for closing the connector housing 2 in a sealed manner. Stated otherwise, the closure cap 6 can be adapted to seal the rear opening 2b of said housing 2 when mounted thereon, and which has mutually adjacent apertures 6a for respectively receiving the cables 3 sealed therein by the single wire seals 30.

[0057] In embodiments as shown in Figures 3A-3C, 4A-4B, 5 and 6, the apertures 6a are arranged in a matrix configuration of rows and columns. This is in favour of compacity of the connector. When possible, that-is-to say when N is a power of two, e.g., when N equals four like in the example as shown, the matrix is regular, e.g., a 2x2 matrix of two rows and two columns as shown. Another example would be, e.g., N=9 and the matrix would be a 3x3 matrix. This provides good results in terms of compacity at the rear of the connector housing 2, namely it allows designing very compact connectors. If N equals 6, for example, the matrix shall comprise two rows and three columns, or three rows and two columns. Stated otherwise, it would be a 2x3 or a 3x2 matrix, respectively. One will appreciate that embodiments are not intended to be limited to these examples.

[0058] In embodiments, further, the first sealing portion 31 may be ring-shaped, i.e., the outer sealing lips 310 may be ring-shaped. In these embodiments, the openings 6a in the connector housing are rounded openings, preferably round through-holes.

[0059] In embodiments as shown in Figure 4B, the outer sealing lips 310 are shaped like a shark's fin, with a leading edge on the front side of seal 30. Stated otherwise, the outer lips 310 can be curved toward the rear of the seal 30, which results in a cross-sectional shape like a shark's fin. This allows greater contact surface of the lip 310 with the connector wall when the lip 310, as shown in Figure 4B, is bent towards the longitudinal axis due to the pressure exerted transversely by the inner walls of the connector housing 2. Thus, sealing properties are enhanced.

[0060] In the embodiments illustrated in Figures 3A-3C, 4A-4B, 5 and 6, the single-wire seals 30 are overall, i.e., entirely provided with an essentially cylindrical shape. They have a central hole 34 for receiving the electrical cable 3, the internal cross-section of which preferably corresponds to the external cross-section of the cable sheath of cable 3. Stated otherwise, and like the known SWS, the proposed seals are tubular. In one example, these cross-sections are round in shape. As shown in Figures 3A-3C, 4A, 5 and 6, the central through-

hole 34 of the seal 30 extends along a longitudinal axis B of said seal.

[0061] With reference more specifically to Figure 5, the central through-hole 34 has a front opening 36 and a rear opening 37, through which one cable 3 is allowed to be received in said through-hole 34. As shown in Figures 3B, 3C, 5 and 6, the seal 30 is adapted for being mounted around a single wire 3, upstream of the end of the wire 3 at which said wire is connected to a terminal 4. In other words, the wire 3 passes through a through-hole 34 which extends in the direction of the longitudinal axis of the seal 30.

[0062] As shown with more detail, e.g., in Figures 3C, 4A, 5 and 6, the seal comprises, at least:

- a first sealing portion 31 having at least one, and as in the shown example three outer sealing lips 310 for cooperation with an inner wall 2b of the connector housing 2, and,
- a second sealing portion 32a having at least one, and as in the shown example three inner sealing lips 320 for cooperation with the outer periphery of the cable sheath of cable 3.

[0063] According to the teachings as proposed herein, the first sealing portion 31 and the second sealing portion 32a are substantially axially spaced apart from each other along the longitudinal axis B of the seal 30. In the shown example, the first sealing portion 31 is arranged upfront of the second sealing portion 32a. Stated otherwise, the second sealing portion 32a is adjacent to, and rearwards of the first, front sealing portion 31.

[0064] With specific reference to Figure 4A, the seal lips 310 and 320 are subjected to deformation in different zones along the longitudinal axis B of the seal, that-is-to-say, also, along the axial extension of cable 3. This allows easy insertion of the cable 3 into the seal 30, and efficient positioning of said seal 30 along said cable 3. entry area of the connector, namely without unwanted and/or erratic deformation of the lips 310 and 320. The axial shift between the respective sealing portions 31 and 32a has the technical result the sealing the outer sealing lips 310 and the inner sealing lips 320 sealing lips is more predictable when subjected to compression by the inner wall of the connector 2 and by the sheath of cable 3, respectively.

[0065] In advantageous, yet non-compulsory embodiments, the single wire seal 30 can further comprise a scraping portion 32b. This scraping portion 32a has at least one, and as in the shown example three scraping lips 330. These are configured to cooperate with the outer periphery of the cable sheath, to remove dust from the surface of the wire, if any, upon insertion of wire 3 into the through-hole 34 of seal 30 by the end of cable 3 which is fitted with terminal 4 entering the back opening 37 first. The scraping lips 330 in the scraping portion 32b are smaller, hence more flexible than the inner sealing lips

320 of the sealing portion 32b.

[0066] As illustrated by Figure 5, the scraping lips 330 prevent the ingress of foreign bodies 8 as the seal 30 moves along the cable 3 (or, vice versa, when the cable 3 is moved inside the through-hole 34 of the seal 30) upon relative insertion and positioning of the cable 3 with respect to the seal 30. This prevents any sealing failure at level of the sealing portion 32a which could otherwise be caused by dust, sand, oil, grease, water, and any other contaminants of that kind, depending on any specific application.

[0067] To that end, the scraping portion 32b is arranged in a longitudinal position between the second sealing portion 32a and the rear opening 37 of the central through-hole 34 of the seal 30 preferably adjacent to the second sealing portion 32a in order to conserve longitudinal dimensions of the seal 30. For the same reason, the scraping portion 32b can preferably be arranged, along the longitudinal axis B of the seal 30, at level of the rear opening 37 of the central through-hole 34 of the seal 30.

[0068] In the examples as shown in the drawings, the second sealing portion 32a and, such being the case, also the scraping portion 32b, are part of a tail portion 32 of the seal 30, which extends longitudinally rearwards from the rear of the first, front sealing portion 31 of said seal 30.

[0069] In the shown embodiments, the external diameter of the front portion 31 is larger than the external diameter of the tail portion 32 sealing portion 32. That way, the tail portion 32 can be used as a handling portion for moving the seal 30 along the cable 3, and/or for inserting and positioning the cable 3 fitted with said seal 30 into the rear opening 2a of the connector housing 2.

[0070] In some embodiments, the first sealing portion 31 and/or the second sealing portion 32a and/or the scraping portion 32b, namely the front portion 31 and the tail portion 32 of the seal 30, are ring-shaped. More generally, the whole seal 30 can be rotation symmetrical, which eases the mounting by avoiding any necessity of angularly positioning the seal 30 onto the cable 3, and then the cable 3 fitted with the seal 30 at the entry 2a of the connector housing 2.

[0071] Sealing lips 310 and 320 are formed by annular projections extending radially in opposite directions, namely outwards and inwards, respectively, from respective longitudinal sleeves which represent the longitudinal extension of the front, first sealing portion 31 and of the second sealing portion 32a. As shown in Figure 4A, the sealing against the connector housing 2 is achieved in the front-end portion 31 by sealing elements in the form of the outer lips 310. Stated otherwise, the outer sealing lips 310 are designed to cooperate with the periphery of an aperture arranged at the rear of a connector housing, e.g., an aperture in a closing cap as shown in Figure 6, which is configured to close the rear opening 2b of the connector housing 2. Sealing with respect to any of the cables 3 is provided by sealing elements in the form of the

inner lips 320 of the rear portion 32 of the seal 30, through compression against the outer periphery of the cable sheath of cable 3 as further shown in Figure 4A.

[0072] The one with ordinary skills in the art will appreciate that, whenever the outer sealing lips 310, the inner sealing lips 320 and/or the scraping lips 330, respectively, are plural, they do extend in a respective longitudinal area of the seal 30 which have a determined longitudinal extension. Therefore, and in order to assess the relative axial position of each of these areas with respect to the other(s), and in particular in order to assess the axial shift of the front, first sealing portion 31 with respect to the second (let us say, rear) sealing portion 32a, one can consider the axial position, that is to say the position along the longitudinal axis B, of respective central transverse planes within said longitudinally extending areas. Stated otherwise, the axial position along axis B of the front sealing portion 31 can be held to correspond to the centre along direction of axis B of a zone of implantation of the outer sealing lips 310 within said portion 31. Similarly, the axial position along axis B of the rear sealing portion 32a can be held to correspond to the centre of the zone of implantation of the inner sealing lips 320 within said portion 32a. Finally, the axial position of the scraping portion 32b can be held to correspond to the centre along direction of axis B of a zone of implantation of the scraping lips 330.

[0073] In preferred embodiments, the outer sealing lips 310 of the front portion 31 do not overlap in the axial direction B with the inner sealing lips 320 of the rear sealing portion 32a. The best results are thus obtained regarding the function of the sealing lips of each of the inner and outer sealing elements. In addition, these results are best predictable in the context of dual compression in opposite transverse directions, around the cable sheath and inside the connector housing, respectively, compared with a design of the SWS according to the prior art.

[0074] In other embodiments, the outer sealing lips 310 of the front sealing portion 31 could partially overlap in the axial direction B with the inner sealing lips 320 of the rear sealing portion 32a. Such a partial overlap in the axial direction B could be less than 50 percent of the total axial length of the front sealing portion 31 and the rear sealing portion 32a, preferably less than 30 percent, and even more preferably less than 15 percent. A relatively larger overlap leads to a more compact design of the SWS, due to smaller longitudinal dimensions. A relatively smaller overlap leads to a more flexible arrangement consisting of the SWS equipped with a cable and/or mounted in an opening of the connector housing, making the connector assembly easier to mount, and making the respective function of the sealing lips 310 and 320 more predictable when they are both subjected to compression around the cable 30 received within the connector housing 2.

[0075] Thanks to the use of single-wire seals according to first aspect embodiments as described in what precedes, which achieve more reliable and more predictable

sealing properties, second aspect embodiments further allow reduction in the spacing between adjacent cables (pitch) at the rear of the multiport electrical connector. Due to the rotary symmetry of the SWS, pitch reduction can be attained in both row and column directions of the matrix configuration of said cables arrangement at the rear of the connector.

[0076] This is illustrated by the representation, given in Figures 7A and 7B, of a rear closure cap 60 for a multiport electrical connector adapted for housing six terminals 4 in a 2x3 matrix configuration.

[0077] Figure 7A is a cross-sectional view, in a plane transverse to the cables 3, rearwards of the SWS, of an exemplary application wherein prior art single-wire seals 20 according to Figures 2A-2C are used. Each of the terminals 4 is fitted to a respective cable 3 which passes through a corresponding aperture within the grid 5 of Figure 1, while being sealed therein by a respective single-wire seal 20 as known in the art. The pitch which can best be attained is 9 millimetres in this example, in both the direction of lines and the direction of columns, of the matrix configuration of the parallel extending cables 3 at the rear of connector housing 2.

[0078] Figure 7B is a view similar to the view in Figure 7A, that is a cross-sectional view in a plane transverse to the cables 3, rearwards of the SWS, but wherein said SWS are seals 30 according to first aspect embodiments as described in what precedes and as shown in particular in Figures 4A-4C. As indicated in Figure 7B, and all other things being equal, the pitch can be reduced by 1 millimetre to 8 millimetres, in both the direction of lines and the direction of columns, of the matrix configuration of the cables 3, compared to the art according to Figure 7A. This represents better than a 10% improvement. It significantly improves the spatial requirements that can be met in many practical applications.

[0079] While there has been illustrated and described what are presently considered to be the preferred embodiments of the present invention, it will be understood by those skilled in the art that various other modifications may be made, and equivalents may be substituted, without departing from the true scope of the claims. Additionally, many modifications may be made to adapt a particular situation to the teachings of the present disclosure without departing from the central inventive concept described herein. Furthermore, an embodiment of the present invention may not include all of the features described above. Therefore, it is intended that the proposed solution be not limited to the particular embodiments disclosed, but includes all embodiments falling within the scope of the appended claims.

[0080] A person skilled in the art will readily appreciate that various parameters disclosed in the description may be modified and that various embodiments disclosed and/or claimed may be combined without departing from the scope of the solution as claimed.

[0081] Expressions such as "comprise", "include", "incorporate", "contain", "is" and "have" are to be construed

in a non-exclusive manner when interpreting the description and its associated claims, namely construed to allow for other items or components which are not explicitly defined also to be present. Reference to the singular is also to be construed in be a reference to the plural and vice versa. Finally, it is stipulated that the reference signs in the claims do not limit the scope of the claims but are merely inserted to enhance the legibility of said claims.

Claims

1. A single wire seal, SWS, for sealing an electric cable (3) having a cable sheath surrounding at least one electrical wire, into an aperture (6a) of an electrical connector housing (2), said seal (30) being provided with an essentially cylindrical shape and with a central through hole (34) for receiving the electric cable (3), which extends along a longitudinal axis (B) of the seal (30), said seal comprising:

- a first sealing portion (31) having at least one outer sealing lip (310) for cooperation with an inner wall (2b) of the connector housing (2),
- a second sealing portion (32a) having at least one inner sealing lip (320) for cooperation with the outer periphery of the cable sheath,

wherein the first sealing portion (31) and the second sealing portion (32a) are substantially axially spaced apart from each other along the longitudinal axis (B) of the seal (30).

2. Single wire seal according to Claim 1, wherein the outer sealing lips (310) of the first sealing portion (31) do not overlap in the axial direction (B) of the seal (30) with the inner sealing lips (320) of the second sealing portion (32a).

3. Single wire seal according to Claim 1, wherein the outer sealing lips (310) of the first sealing portion (31) do partially overlap in the direction of the longitudinal axis (B) of the seal (30) with the inner sealing lips (320) of the second sealing portion (32a), preferably by less than 50 percent, more preferably less than 30 percent, and still more preferably less than 15 percent of the total length of said first sealing portion (31) and said second sealing portion (32a).

4. Single wire seal according to claim 1 or 2, wherein the outer sealing lips (310) of the first sealing part (31) of the seal (30) are shaped like a shark's fin, with a leading edge on the front side of said.

5. Single wire seal according to any one of the preceding claims, further comprising a scraping portion (32b) having at least one scraping lip (330) for cooperation with the outer periphery of the cable

sheath, said scraping portion (32b) being arranged in a longitudinal position between the second sealing portion (32a) and the rear opening (37) of the central through-hole (34).

6. Single wire seal according to Claim 5, wherein the scraping portion (32b) is arranged, along the longitudinal axis (B) of the seal (30), at level of the rear opening (37) of the central through-hole (34). 5
7. Single wire seal according to any one of the preceding claims, wherein the first sealing portion (31) and/or the second sealing portion (32a) and/or the scraping portion (32b) are ring-shaped. 10
8. Single wire seal according to any one of the preceding claims, wherein the second sealing portion (32a) and/or the scraping portion (32b) are part of a tail portion (32) of the seal (30) which extends longitudinally rearwards from the rear of the first sealing portion (31) of said seal (30). 20
9. Single wire seal according to claim 8, wherein the external diameter of the first ring-shaped sealing portion (31) is larger than the external diameter of the tail portion (32). 25
10. Single wire seal according to any one of the preceding claims, wherein said seal (30) is rotation symmetrical. 30
11. Single wire seal according to any one of the preceding claims, wherein:
 - the first sealing portion (31) has three outer sealing lips (310) adjacent one to another along the longitudinal axis (B) of the seal (2), 35
 - the second sealing portion (32a) has three inner sealing lips (320) adjacent one to another along the longitudinal axis (B) of the seal (2), 40
 - and/or
 - the scraping portion (32b) has three scraping lips (330) adjacent one to another along the longitudinal axis (B) of the seal (2). 45
12. A multi-port electrical connector assembly comprising:
 - a connector housing (2) made of dielectric material and having an inner cavity (2a) 50
 - a plurality of cables (3);
 - terminals (4), each adapted to be mounted on one end of a respective cable (3) and to be received in the cavity (2a) of the connector housing (2) through a respective aperture (6a) 55
 - in said connector housing (6); and,
 - a plurality of single wire seals (30), SWS, according to any one of claims 1 to 11 for re-

spectively sealing the cables in the apertures (6a) in the connector housing (2).

13. A multi-port electrical connector assembly according to claim 12, wherein the inner cavity (2a) of the connector housing (2) is open to the outside of said housing (2) through a rear opening (2b), the assembly further comprising a closure cap (6) for the connector housing (2) which is adapted to seal said rear opening (2b) of said housing (2) when mounted thereon, and which has mutually adjacent apertures (6a) for respectively receiving the cables (3) sealed therein by the single wire seals (30).
14. A multi-port electrical connector assembly according to claim 12 or 13, wherein the apertures (6a) are arranged in a matrix configuration of rows and columns.
15. A multi-port electrical connector assembly according to any one of claims 12 through 14, wherein the apertures (6a) are round through-holes.

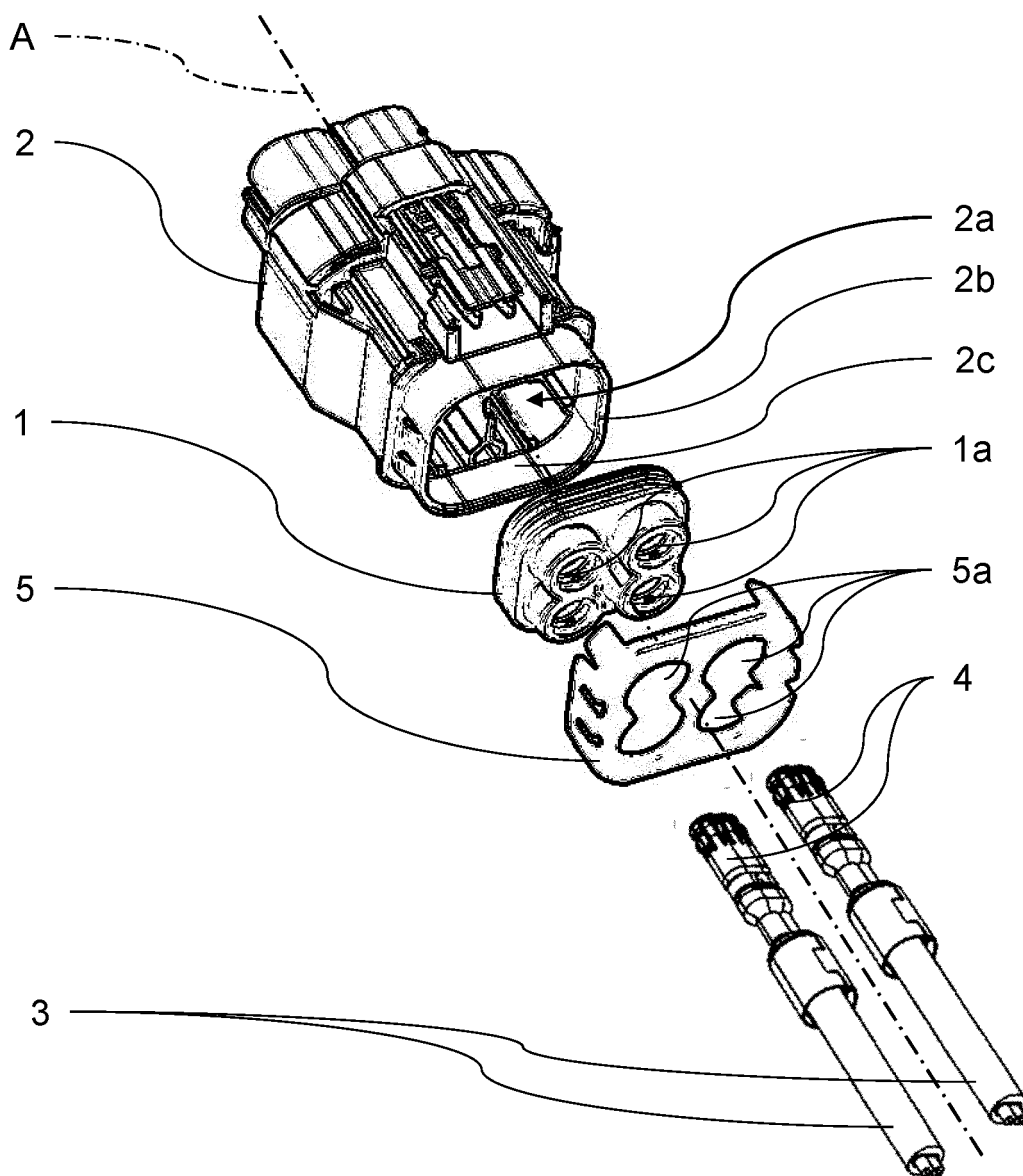


Fig.1

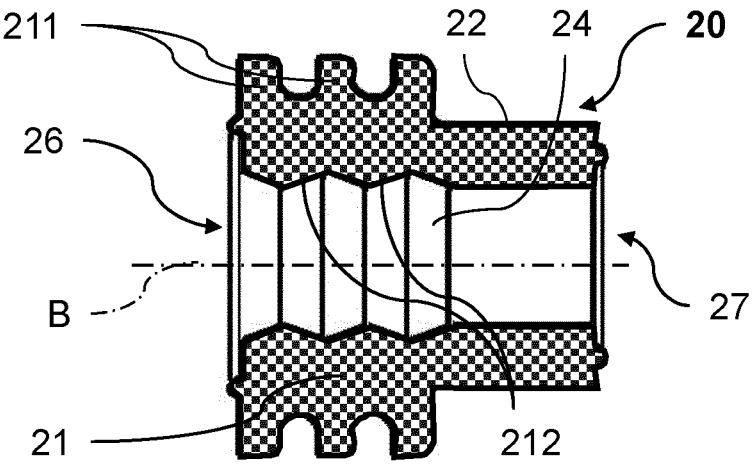


Fig. 2A

PRIOR ART

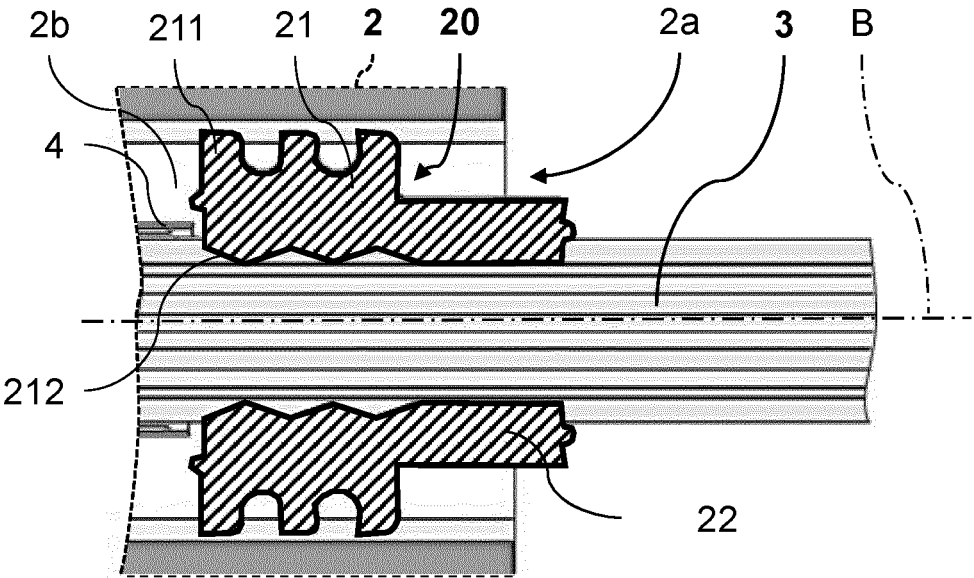


Fig. 2B

PRIOR ART

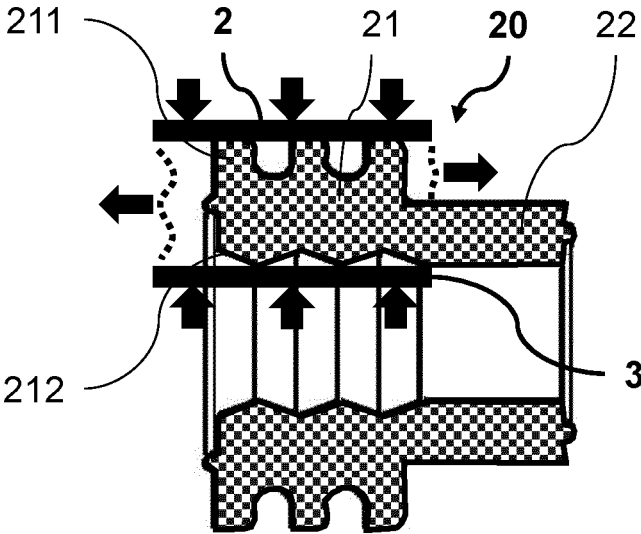


Fig. 2C

PRIOR ART

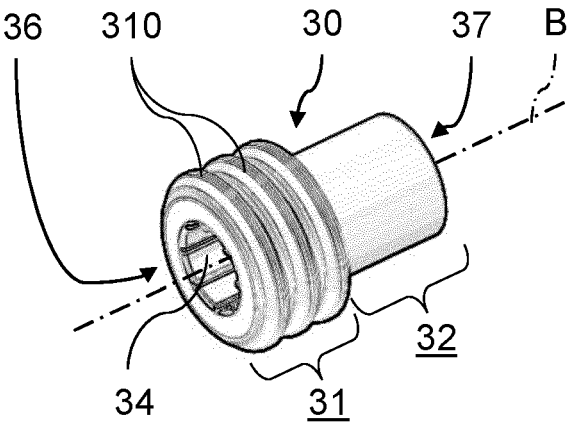


Fig.3A

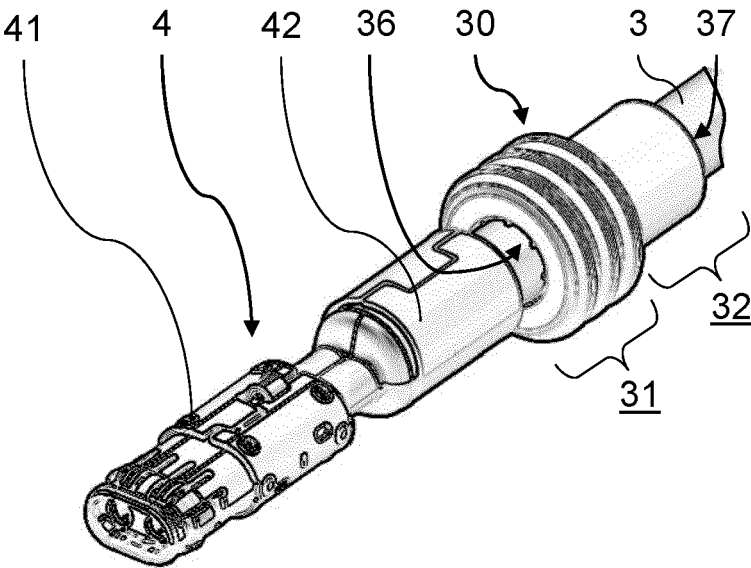


Fig.3B

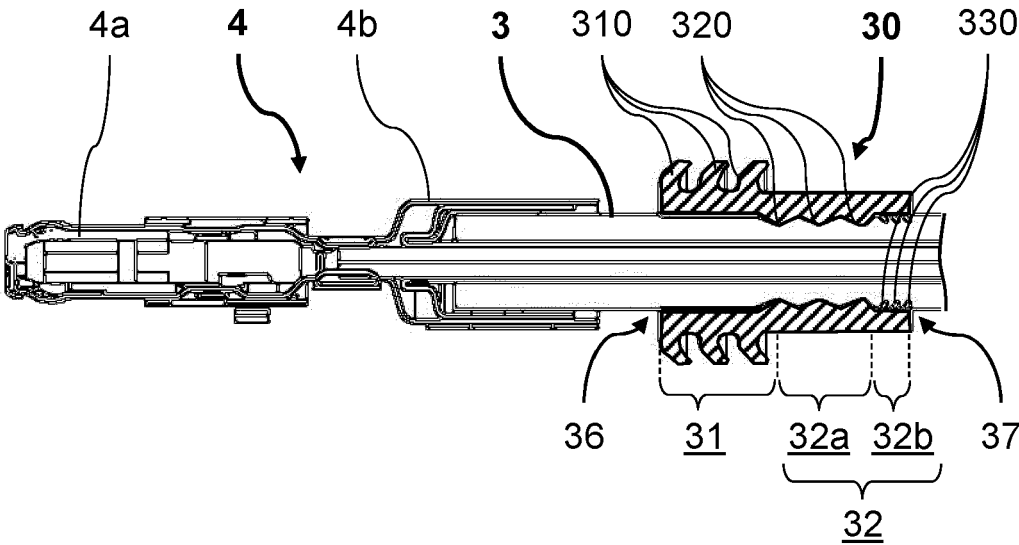


Fig.3C

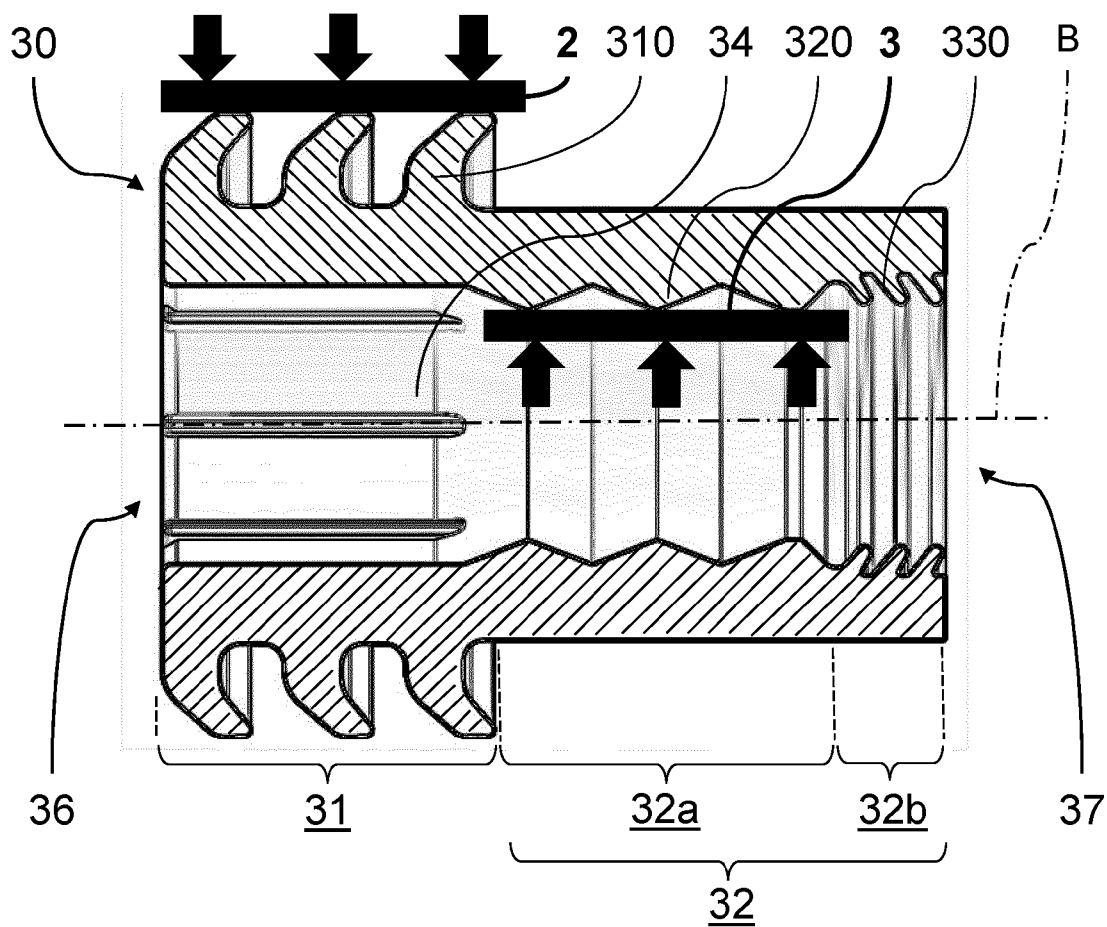


Fig.4A

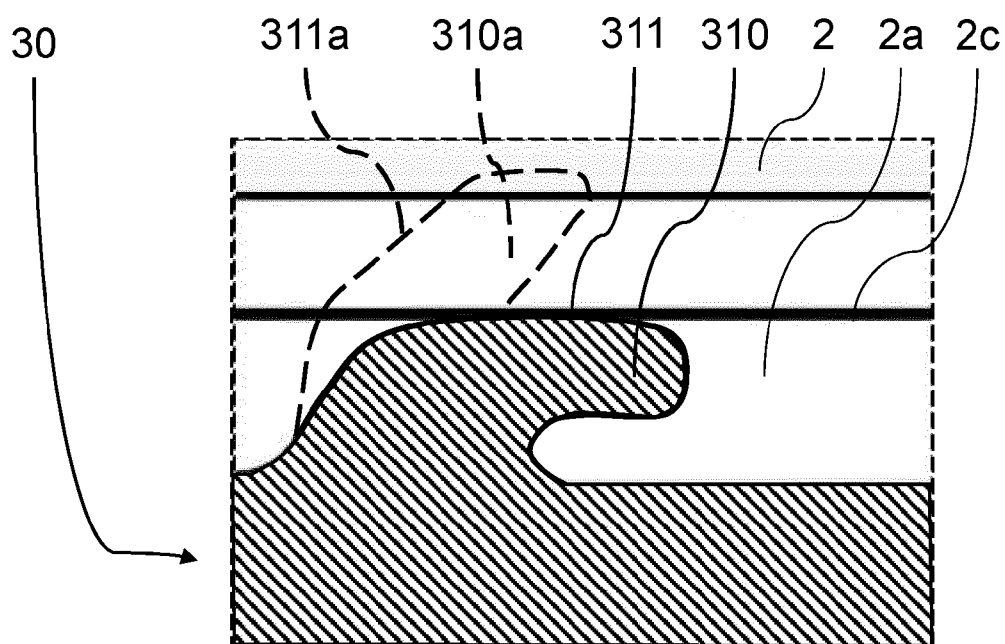


Fig.4B

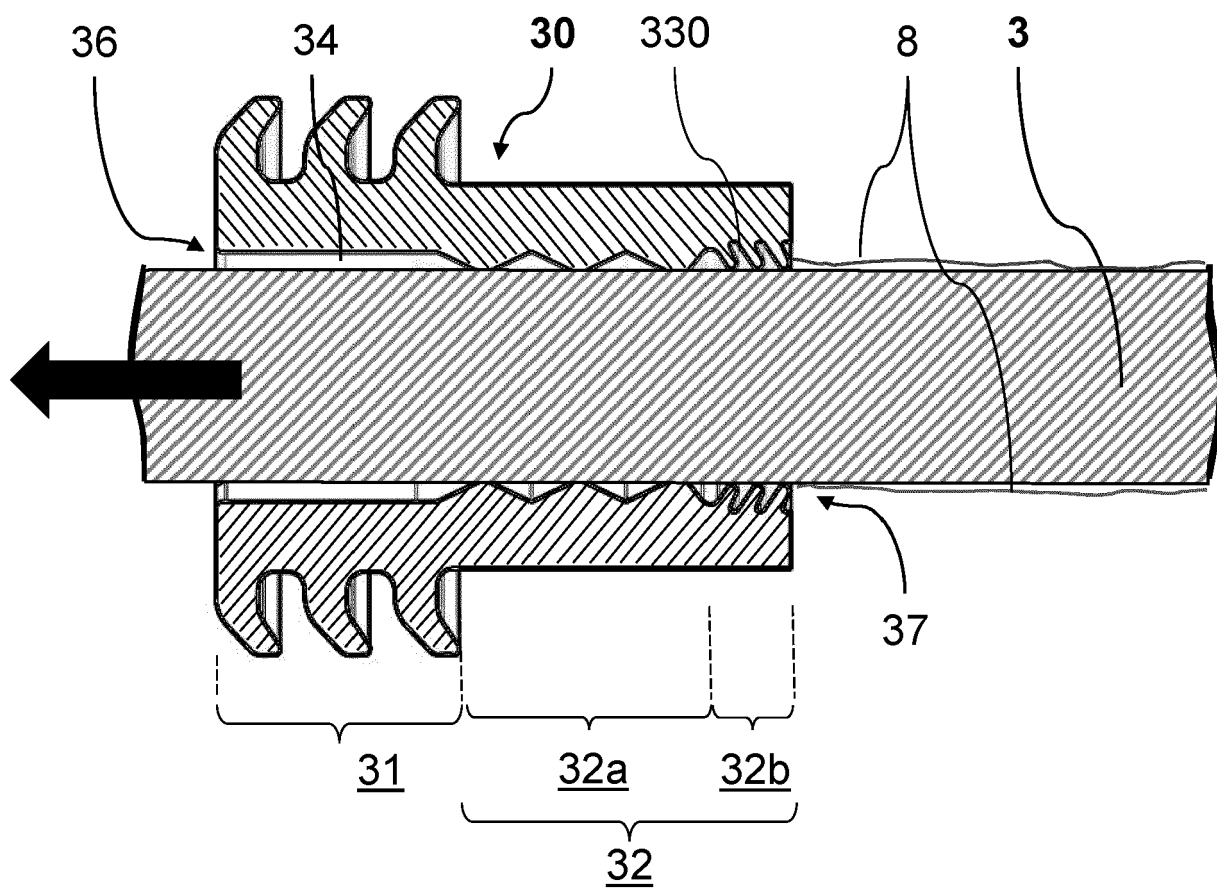


Fig.5

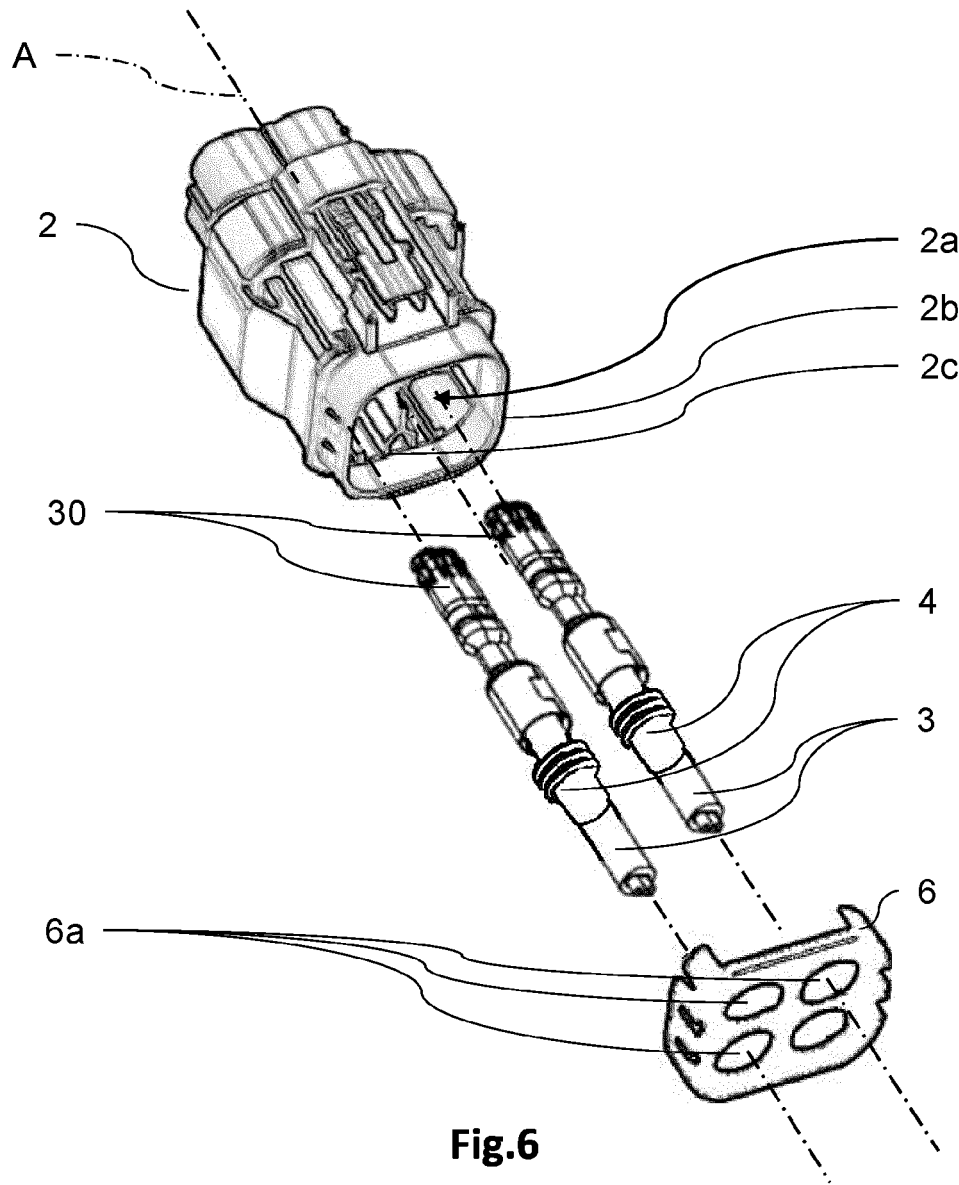


Fig.6

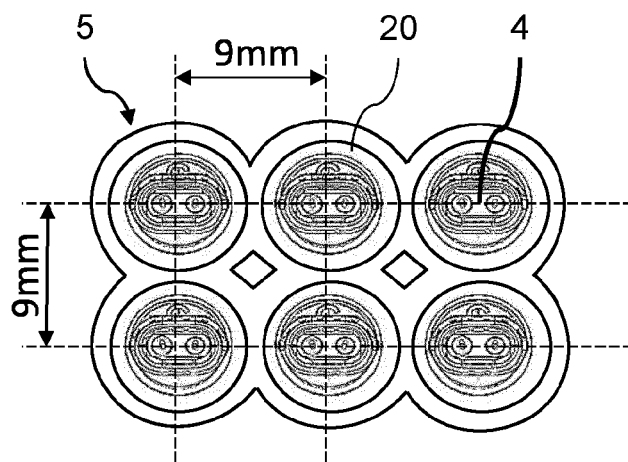


Fig.7A

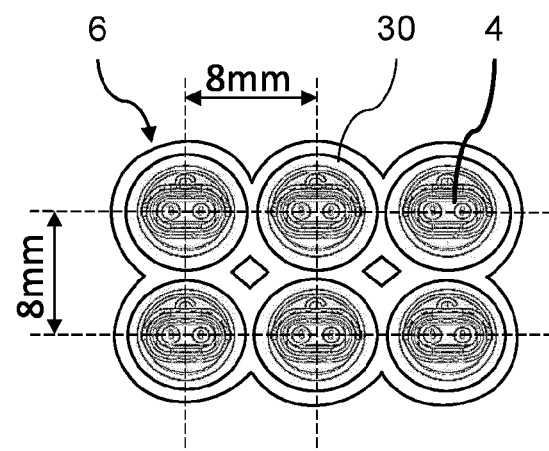


Fig.7B



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Application Number

EP 23 19 4564

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A	* column 3, line 29 - line 38; figure 1 *	1	
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A	* paragraph [0004] - paragraph [0010]; figure 3 *	1	
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			H01R
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
The Hague		6 February 2024	Bouhana, Emmanuel
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