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(54) **CONDUCTIVE LINK**

(57) The present invention is directed to a conductive chain comprising a plurality of conductive links. Each conductive link (10) is made of an electrically conductive material and comprises a first end portion (11) and a second end portion (12). The first end portion (11) and the second end portion (12) are configured so that the first end portion (11) is able to accommodate and hold a second end portion (12) of another conductive link (10) of the conductive chain.

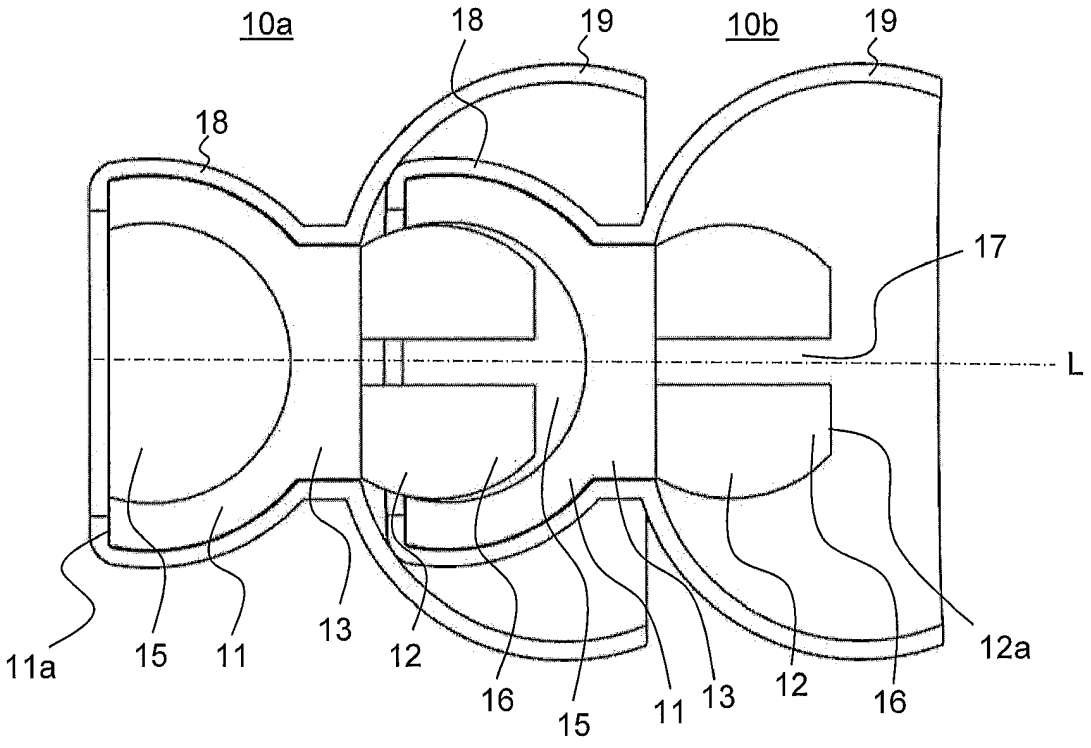

Fig. 2

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Description

[0001] The present invention refers to a conductive link and to a conductive chain formed by conductive links. Such a conductive chain formed by conductive links may be used, for example, as a modular flexible bus bar.

[0002] In electric vehicles, different ways are known for establishing an electrical connection between the battery and electrical loads such as the electrical motor.

[0003] In a prior art example, braided wires are used which are composed of a number of small strands of wire braided together so that the resulting cable is flexible. For the purpose of achieving this flexibility, however, the cross section of the cable is limited so that a current loss occurs during the transmission of electric power from the battery to the motor. Other prior art solutions include a solid copper bus bar which is arranged within a cable conduit made of plastic.

[0004] When an accident of the vehicle such as a severe impact occurs, the insulation of the braided wires cable or the plastic cable conduit may be damaged so that current may flow into the metal parts of the vehicle. Further, the motor may continue to run after the accident since there is no breakage in the current flow. This may result in an injury of the passengers, further damage of the vehicle, and even fire.

[0005] The object of the present invention therefore is to provide an electrical connection which has less current loss during a normal operation and increases safety in the case of an accident.

[0006] The object is achieved by a conductive link according to claim 1, a terminal link according to claim 15, or a conductive chain according to claim 15. Further developments of the invention are specified in the dependent claims, respectively.

[0007] The conductive link according to the invention is made of an electrically conductive material and comprises a first end portion and a second end portion. The first end portion and the second end portion are configured so that the first end portion is able to accommodate and hold a second end portion of another conductive link of the conductive chain. The conductive link formed in this way makes it possible, for example, to connect a plurality of conductive links together to form a conductive chain by which an electrical connection may be established, for example between the battery and electrical loads such as the electrical motor of an electrical vehicle. Establishing an electrical connection in this way makes it possible, for example to reduce a current loss during a normal operation and to increase safety in the case of an accident

[0008] Preferably, the conductive link further comprises an intermediate portion which is arranged between the first end portion and the second end portion and connects the first end portion and the second end portion to each other. This makes it possible, for example, to increase the length of a single conductive link.

[0009] Preferably, the first end portion, the second end portion, and the intermediate portion, if present, are made of a metal, preferably copper, and/or the first end portion, the second end portion, and the intermediate portion, if present are formed as a monolithic piece. This makes it possible, for example, to easily manufacture the conductive link and/or to give the conductive link a higher stability.

[0010] Preferably, the first end portion and the second end portion are configured so that the first end portion is able to hold the second end portion of the other conductive link of the conductive chain by form fit and/or by press fit. This makes it possible, for example, to avoid that the first end portion and the second end portion separate from each other by themselves.

[0011] Preferably, the first end portion has a concavely formed section configured to accommodate and hold a second end portion of another conductive link of the conductive chain. This makes it possible, for example, to realize a specific form how enabling the first end portion to hold the second end portion.

[0012] Preferably, the second end portion has a convexly formed section configured be accommodated in and held by the first end portion of another conductive link of the conductive chain. This makes it possible, for example, to realize a specific form how the second end portion is held the first end portion.

[0013] Preferably, the second end portion comprises two ore more partial segments which are separated by gaps from each other. This makes it possible, for example, to increase an elasticity of the second end portion.

[0014] Preferably, the two ore more partial segments are elastically deformable. This makes it possible, for example, to facilitate the introduction of the second end portion in to the first end portion

[0015] Preferably, the first end portion and the second end portion are configured so that the first end portion is able to accommodate and hold the second end portion of the other conductive link of the conductive chain in a way that the conductive link and the other conductive link may be pivoted or articulated with regard to each other. This makes it possible, for example, to achieve a flexible chain when a plurality of conductive links are connected together.

[0016] Preferably, the first end portion and the second end portion are configured so that the first end portion is able to accommodate and hold the second end portion of the other conductive link of the conductive chain in a way that the connection between the conductive link and the other conductive link is disengaged at a predetermined force. This makes it possible, for example, to break an electrical interconnection formed by a conductive chain comprising a plurality of conductive links connected to each other, for example between the battery and electrical loads such as the electrical motor of an electrical vehicle, in the state on an accident of the vehicle. This makes it possible, for example, to automatically interrupt a current flow from the battery to the motor, thus increasing safety in the case of an accident.

[0017] Preferably, the first end portion and the intermediate portion, if present, are covered with an electrically insulating material, preferably a plastic, and a bowl of an electrically insulating material, preferably a plastic, is formed at the second end portion. The bowl is formed to protrude further in the longitudinal direction L than the free end of the second end portion. The bowl is further formed to be able to accommodate the first end portion of another conductive link of the conductive chain which is connected to the second end portion. This makes it possible, for example, to insulate a conductive chain comprising a plurality of conductive links connected to each other to the outside, wherein the insulation is also maintained if the chain is broken. This makes it possible, for example, to avoid that the conductive core of the broken chain comes into contact, for example, with metallic parts of a vehicle, thus increasing safety in the case of an accident.

[0018] Preferably, the conductive link has a rotationally symmetric shape. This makes it possible, for example, to easily manufacture the conductive link.

[0019] Preferably, the conductive link comprises two or more first end portions, each configured to be able to accommodate and hold a second end portion of another conductive link, and/or two or more second end portion, each configured to be able to be accommodated in and held by a first end portion of another conductive link. This makes it possible, for example, to realize a cable fan-out in a conductive chain comprising a plurality of conductive links connected to each other.

[0020] The terminal link according to the invention comprises a connection portion and a terminal portion. The connection portion is configured to accommodate and hold a second end portion of a conductive link. Alternatively, the connection portion is configured to be accommodated in and held by the first end portion of a conductive link. The terminal portion is configured to establish an electrical connection to an external device. Such a terminal link makes it possible, for example, to connect a conductive chain formed by a plurality of conductive links for example to the battery and electrical loads such as the electrical motor of an electrical vehicle. Establishing an electrical connection in this way makes it possible, for example to reduce a current loss during a normal operation and to increase safety in the case of an accident.

[0021] The conductive chain according to the invention comprises a plurality of conductive links connected to each other, and preferably at least one terminal link connected to the first one and/or the last one of the conductive links forming the chain. Such a chain makes it possible, for example, to establish an electrical connection, for example between the battery and electrical loads such as the electrical motor of an electrical vehicle. Establishing an electrical connection in this way makes it possible, for example to reduce a current loss during a normal operation and to increase safety in the case of an accident.

[0022] Further features and advantages of the invention will arise from the description of embodiments with reference to the enclosed figures.

Fig. 1 shows a sectional view of two conductive links according to an embodiment of the present invention in a state in which they are separated from each other.

Fig. 2 shows a sectional view of the two conductive links shown in Fig. 1 in a state in which they are connected to each other.

Fig. 3 shows a lateral view of a first end portion of a conductive link shown in Fig. 1.

Fig. 4 shows a lateral view of a second end portion of a conductive link shown in Fig. 1.

Fig. 5 shows a lateral view of a terminal link according to an embodiment of the present invention connected to a conductive link.

Fig. 6 shows a sectional view of the terminal link shown in Fig. 5 connected to the conductive link.

Fig. 7 shows a lateral view of another terminal link according to an embodiment of the present invention connected to a conductive link shown in Fig. 1.

Fig. 8 shows a sectional view of the second terminal link shown in Fig. 7 connected to the conductive link.

Fig. 9 shows a lateral view of a conductive chain.

[0023] According to the present invention, an electrical connection between the battery and electrical loads such as the electrical motor is made by a conductor having a modular design. The conductor is realized as a conductive chain comprising a plurality of conductive links.

[0024] An embodiment of such a conductive chain comprising a plurality of conductive links is described below with reference to Figs. 1 to 10.

[0025] Fig. 1 shows a sectional view of two conductive links in a state in which they are separated from each other.

[0026] The two conductive links 10a, 10b have the same construction. Each conductive link comprises a first end portion 11 and a second end portion 12 arranged opposite to each other in a longitudinal direction L, and an intermediate portion 13 arranged between the first end portion 11 and the second end portion 12 and connecting the first end portion 11 and the second end portion 12 to each other.

[0027] The first end portion 11, the second end portion 12 and the intermediate portion 13 are made of an elec-

trically conductive material. The conductive material may be a metal, preferably copper. Preferably, the copper has a high purity of at least 99.9 %. The first end portion 11, the second end portion 12 and the intermediate portion 13 are formed as a monolithic piece of material.

[0028] The first end portion 11 has a concavely formed section 15. In the present example, the concave section 15 has an inner surface in the shape of a spherical segment. The segment extends over more than a half-sphere so that the maximum diameter is not at the outer end 11a (left end in Fig. 1) of the first end portion 11. In other words, the maximum diameter is at a distance from the outer end 11a of the

[0029] The second end portion 12 has a convexly formed section 16. In the present example, the convex section 16 has an outer surface in the shape of a spherical segment. Also here, the maximum diameter is not at the outer end (right end in Fig. 1) of the second end portion 12. The function of a gap 17 shown in the second end portion 12 is described later with reference to Fig. 4

[0030] The intermediate portion 13 has a cylindrical shape.

[0031] The first end portion 11 and the intermediate portion 13 are covered with an electrically insulating material 18, preferably a plastic. The insulating material 18 also covers at least an outer portion of the exposed free end 11a of the first end portion 11. A bowl 19 of the electrically insulating material is formed in the shape of a spherical shell segment at the second end portion 12 so that it protrudes further in the longitudinal direction L than the second end portion 12. The insulating cover 18 and the insulating bowl 19 are formed as a monolithic piece of material.

[0032] Fig. 2 shows a sectional view of the two conductive links in a state in which they are connected to each other.

[0033] In this state, the convex section 16 of the second end portion 12 of the conductive link 10a (left in Fig. 2) is accommodated in the concave section 15 of the first end portion 11 of the conductive link 10b (right in Fig. 2). The diameters of the spherical segments of the inner surface of the concave section 15 and the outer surface of the convex section 16 are approximately equal so that a low electrical transition resistance is achieved between the conductive links 10a, 10b in the connected state.

[0034] The bowl 19 surrounding the second end portion 12 of the conductive link 10a is formed large enough so that it can accommodate the first end portion 11 of the conductive link 10b.

[0035] Due to the fact that the maximum diameter of the first end portion 11 is not at the outer end, some force is required to push the second end portion 12 of the conductive link 10a into the first end portion 11 of the conductive link 10b. Due to the same reason, the second end portion 12 cannot easily free itself from the first end portion 11, but engages in the concave section 15 and thus is held by the first end portion 11 in the connected state. In order to disengage the connection, some force is required, too.

[0036] The first end portion 11 and the second end portion 12 thus are held together by form fit or positive fit. Depending on the dimensions used, they may also be held together by press fit or friction fit.

[0037] Since the inner surface of the concave section 15 and the outer surface of the convex section 16 are formed as spherical segments, they together form a spheroid joint or ball and socket joint. It is therefore possible to move the second end portion 12 of the conductive link 10a within the first end portion 11 of the conductive link 10b in a way that an angle between the longitudinal direction L of the conductive link 10b and the longitudinal direction L of the conductive link 10a can be changed to a certain amount, i.e. the two conductive links may be pivoted or articulated with regard to each other, while the two conductive links 10a, 10b remain in the connected state.

[0038] Fig. 3 shows a lateral view of the first end portion 11 of the conductive link 10. In the present example, the first end portion 11 has a rotationally symmetric shape so that the lateral view shows all the elements as circles. In this view, the free end 11a of the first end portion 11 is shown, surrounded and partly covered by the insulating cover 18. In the interior, the concave section 15 can be seen. In the background, the rear of the insulating bowl 19 surrounding the second end portion (not visible in the figure) is shown.

[0039] Fig. 4 shows a lateral view of the second end portion 12 of the conductive link 10. Also the second end portion 12 generally has a rotationally symmetric shape so that its elements are shown as circles, or at least as circle segment. In the present example, the second end portion 12 comprises four partial segments 41-44 which extend in the longitudinal direction of the conductive link 10 and are separated from each other by gaps 46-49. The gap 17 shown in Figs. 1 and 2 corresponds to one of those gaps 46-49.

[0040] Since each of the partial segments 41-44 has a smaller cross-section than the entire second end portion 12 and are separated from each other, they are elastically deformable to a higher degree than a massive or solid second end portion 12 would be. This facilitates the introduction of the convex section 16 of the second end portion 12 into the concave 15 of the first end portion 11.

[0041] Fig. 5 shows a lateral view of a terminal link 50 connected to a conductive link 10, and Fig. 6 shows a sectional view of the terminal link 50 connected to the conductive link 10.

[0042] The terminal link 50 comprises a connection portion 51 and a terminal portion 52 arranged opposite to each other, and an intermediate portion 53 arranged between the connection portion 51 and the terminal portion 52 and connecting the connection portion 51 and the terminal portion 52 to each other.

[0043] The connection portion 51, the terminal portion 52 and the intermediate portion 53 are made of an electrically conductive material. The conductive material may

be a metal, preferably copper. Preferably, the copper has a high purity of at least 99.9 %. The connection portion 51, the terminal portion 52 and the intermediate portion 53 are formed as a monolithic piece of material.

[0044] The connection portion 51 is formed in a similar way as the second end portion 12 of a conductive link 10 so that it can be accommodated in and held by the first end portion 11 of a conductive link 10 by form fit and/or friction fit. In the present example, the connection portion 51 is formed without gaps. The terminal portion 52 is formed in a way to permit establishing an electrical connection to an electrical device such as the battery or motor of the electric vehicle. In the present example, the terminal portion 52 is formed as a plate having a through-hole 55 through which the plate may be screwed to an electrical terminal of the electrical device.

[0045] Fig. 7 shows a lateral view of another terminal link 70 connected to a conductive link 10, and Fig. 8 shows a sectional view of the other terminal link 70 connected to the conductive link 10.

[0046] The terminal link 70 comprises a connection portion 71 and a terminal portion 72 arranged opposite to each other, and an intermediate portion 73 arranged between the connection portion 71 and the terminal portion 72 and connecting the connection portion 71 and the terminal portion 72 to each other.

[0047] The connection portion 71, the terminal portion 72 and the intermediate portion 73 are made of an electrically conductive material. The conductive material may be a metal, preferably copper. Preferably, the copper has a high purity of at least 99.9 %. The connection portion 71, the terminal portion 72 and the intermediate portion 73 are formed as a monolithic piece of material.

[0048] The connection portion 71 is formed in a similar way as the first end portion 11 of a conductive link 10 so that it can accommodate and hold the second end portion 12 of a conductive link 10 by form fit and/or friction fit. The terminal portion 72 is formed in a way to permit establishing an electrical connection to an electrical device such as the battery or motor of the electric vehicle. In the present example, the terminal portion 72 is formed as a plate having a through-hole 75 through which the plate may be screwed to an electrical terminal of the electrical device.

[0049] Fig. 9 shows a lateral view of a conductive chain.

[0050] The conductive chain 90 comprises a plurality of conductive links 10 connected to each other, and two terminal links 50, 70 according to claim 13 connected to the first one and the last one of the conductive links 10, respectively.

[0051] In the state in which the conductive links 10 are connected to form a chain, no metal part is accessible from the outside with the exception of the terminal portions 52, 72 of the terminal links 50, 70. The conductive cores of the conductive links 10 are electrically insulated to the outside by the insulating covers 18 and bowls 19 of the conductive links 10. Also the connection portions 51, 71 the terminal links 50, 70 are electrically insulated to the outside by the insulating cover 18 and bowl 19 of the adjacent conductive links 10.

[0052] An electrical connection can established by connecting the terminal portions 52, 72 of the terminal links 50, 70 to the elements between which an electrical connection is desired. Since the conductive chain 90 is electrically insulated to the outside, no further insulation such as cable housings or cable conduits are required.

[0053] Due to the degree of freedom in the movement between the conductive links 10 forming the conductive chain 90, this connection has a certain flexibility so that the chain may for example be bent to a certain amount. Since the conductive links 10 are made from a solid conductive material, a better conductivity can be achieved than in the case of using braided wire, resulting in less current loss.

[0054] As described above, a certain amount of force is required in order to disengage the connection between adjacent conductive links 10. This force may be predetermined in a way that the conductive chain 90 is broken at a force as it typically occurs during a severe impact of the vehicle. For this purpose, the form of the first end portion 11 and the second end portion 12 and/or the amount of the form fit and/or by press fit between them is selected so that the first end portion 11 and the second end portion 12 are disengaged from each other at the predetermined force.

[0055] Thereby, the electrical connection between the battery and the motor is automatically interrupted and the motor is prevented from continuing to run after the accident. Further, the electrical insulation by the insulating cover 18 which also covers at least an outer portion of the exposed free end 11a of the first end portion 11 and by the insulating bowl 19 that protrudes further than the second end portion 12 prevents conductive parts of the chain 90 from coming into contact with metal parts of the vehicle. Thus, safety in the case of an accident is increased.

[0056] The chains may be pre-assembled at the factory, or they may individually be assembled at the customer's site in order to match different requirements. The modular design of the chain makes it possible to make the chain shorter or longer in order to achieve any required length of the interconnection.

[0057] The present invention is not restricted to the specific example described above, but can be modified in different ways.

[0058] For example, multiple types of end fitments may be used for the first end portion 11 and the second end portion 12. The second end portion 12 may for example be formed without gaps. Instead of the spherical concave and convex sections 15, 16, other configurations may be used which enable the first and second end portions 11, 12 to be held together by form fit (positive fit) and/or press fit (friction fit).

[0059] Further, the two end portions 11, 12 need not have the same longitudinal direction, but may be arranged in an angle, for example in an L-form. Still further,

a conductive link may have two or more first end portions 11 and/or second end portions 12 and be arranged, for example, in a T-form, Y-form, or X-form. Such forms make it possible, for example, to realize a cable fan-out.

[0060] The first end portion 11, the second end portion 12 and the intermediate portion 13 may be formed by separate pieces connected to each other instead of being formed as a monolithic piece of material. Similarly, the connection portion 51, 71, the terminal portion 52, 72 and the intermediate portion 53, 73 may be formed by separate pieces.

[0061] Also the insulating cover 18 and the insulating bowl 19 may be formed by separate pieces.

[0062] The intermediate portions 11, 53, 73 may also be omitted. In this case, the first end portion 11 and the second end portion 12 of a conductive link 10 and/or the connection portion 51, 71 and the terminal portion 52, 72 of a terminal link 50, 70 are directly connected to each other.

[0063] The present invention is not limited to the use of the conductive chain within an electrical vehicle. It may also be used for any other application in which an electrical connection is required. It is specially suited for applications in which braided wire and bus bars are currently used.

Claims

1. A conductive link (10) for a conductive chain, wherein the conductive link (10) is made of an electrically conductive material,
the conductive link (10) comprises a first end portion (11) and a second end portion (12), and
the first end portion (11) and the second end portion (12) are configured so that the first end portion (11) is able to accommodate and hold a second end portion (12) of another conductive link (10) of the conductive chain.

2. The conductive link (10) according to claim 1, further comprising an intermediate portion (13) arranged between the first end portion (11) and the second end portion (12) and connecting the first end portion (11) and the second end portion (12) to each other.

3. The conductive link (10) according to claim 1 or 2, wherein
the first end portion (11), the second end portion (12), and the intermediate portion (13), if present, are made of a metal, preferably copper, and/or
the first end portion (11), the second end portion (12), and the intermediate portion (13), if present, are formed as a monolithic piece.

4. The conductive link (10) according to any one of claims 1 to 3, wherein
the first end portion (11) and the second end portion (12) are configured so that the first end portion (11) is able to hold the second end portion (12) of the other conductive link (10) of the conductive chain by form fit and/or by press fit.

5. The conductive link (10b) according to any one of claims 1 to 4, wherein the first end portion (11) has a concavely formed section (15) configured to accommodate and hold a second end portion (12) of another conductive link (10a) of the conductive chain.

6. The conductive link (10a) according to any one of claims 1 to 5, wherein the second end portion (12) has a convexly formed section (16) configured be accommodated in and held by the first end portion (11) of another conductive link (10b) of the conductive chain.

7. The conductive link (10) according to any one of claims 1 to 6, wherein the second end portion (12) comprises two ore more partial segments (41-44) which are separated by gaps (46-49) from each other.

8. The conductive link (10) according to claim 7, wherein the two ore more partial segments (41-44) are elastically deformable.

9. The conductive link (10) according to any one of claims 1 to 8, wherein the first end portion (11) and the second end portion (12) are configured so that the first end portion (11) is able to accommodate and hold the second end portion (12) of the other conductive link (10a) of the conductive chain in a way that the conductive link (10) and the other conductive link (10a) may be pivoted or articulated with regard to each other.

10. The conductive link (10) according to any one of claims 1 to 9, wherein the first end portion (11) and the second end portion (12) are configured so that the first end portion (11) is able to accommodate and hold the second end portion (12) of the other conductive link (10a) of the conductive chain in a way that the connection between the conductive link (10b) and the other conductive link (10a) is disengaged at a predetermined force.

11. The conductive link (10) according to any one of claims 1 to 10, wherein
the first end portion (11) and the intermediate portion (13), if present, are covered with an electrically insulating material (18), preferably a plastic, and
a bowl (19) of an electrically insulating material, preferably a plastic, is formed at the second end portion (12),
wherein the bowl (19) is formed to protrude further

than the second end portion (12), and
the bowl (19) is formed to be able to accommodate the first end portion (11) of another conductive link (10b) of the conductive chain which is connected to the second end portion (12).

12. The conductive link (10) according to any one of claims 1 to 11, having a rotationally symmetric shape.

13. The conductive link (10) according to anyone of claims 1 to 12, comprising
two or more first end portions (11), each configured to be able to accommodate and hold a second end portion (12) of another conductive link (10), and/or
two or more second end portion (12), each configured to be able to be accommodated in and held by a first end portion (11) of another conductive link (10).

14. A terminal link (50, 70) for a conductive chain, comprising a connection portion (51, 71) and a terminal portion (52, 72),
wherein the connection portion (51, 71) is configured to accommodate and hold a second end portion (12) of a conductive link (10) according to any one of claims 1 to 12, or to be accommodated in and held by the first end portion (11) of a conductive link (10) according to any one of claims 1 to 13, and
the terminal portion (52, 72) is configured to establish an electrical connection to an external device.

15. A conductive chain (90), comprising a plurality of conductive links (10) according to any of claims 1 to 13 connected to each other,
wherein the conductive chain (90) preferably further comprises at least one terminal link (50, 70) according to claim 13 connected to the first one and/or the last one of the conductive links (10) forming the chain (90).

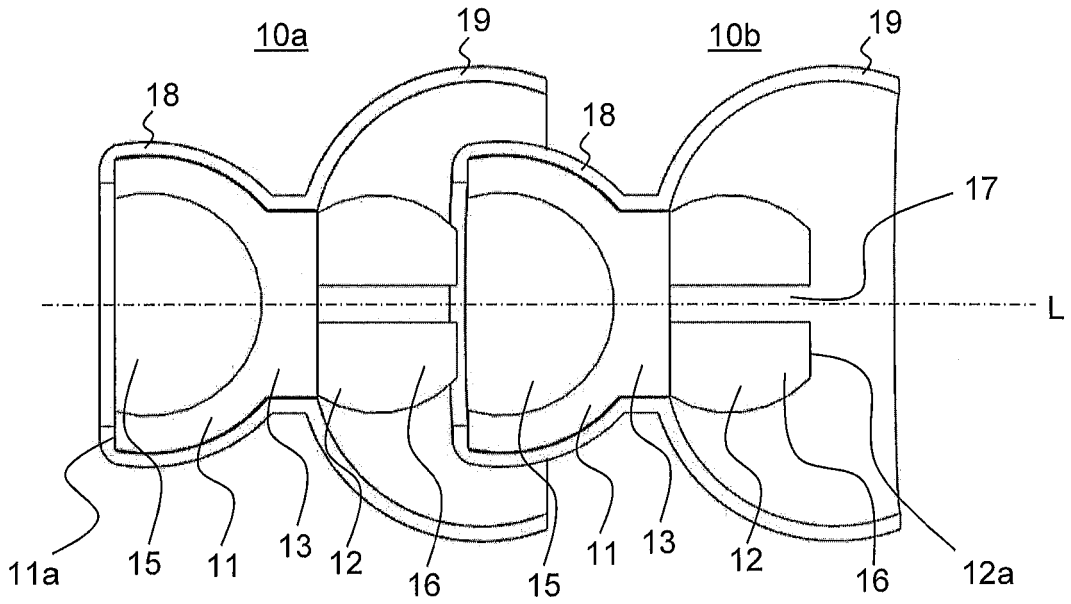
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Fig. 1

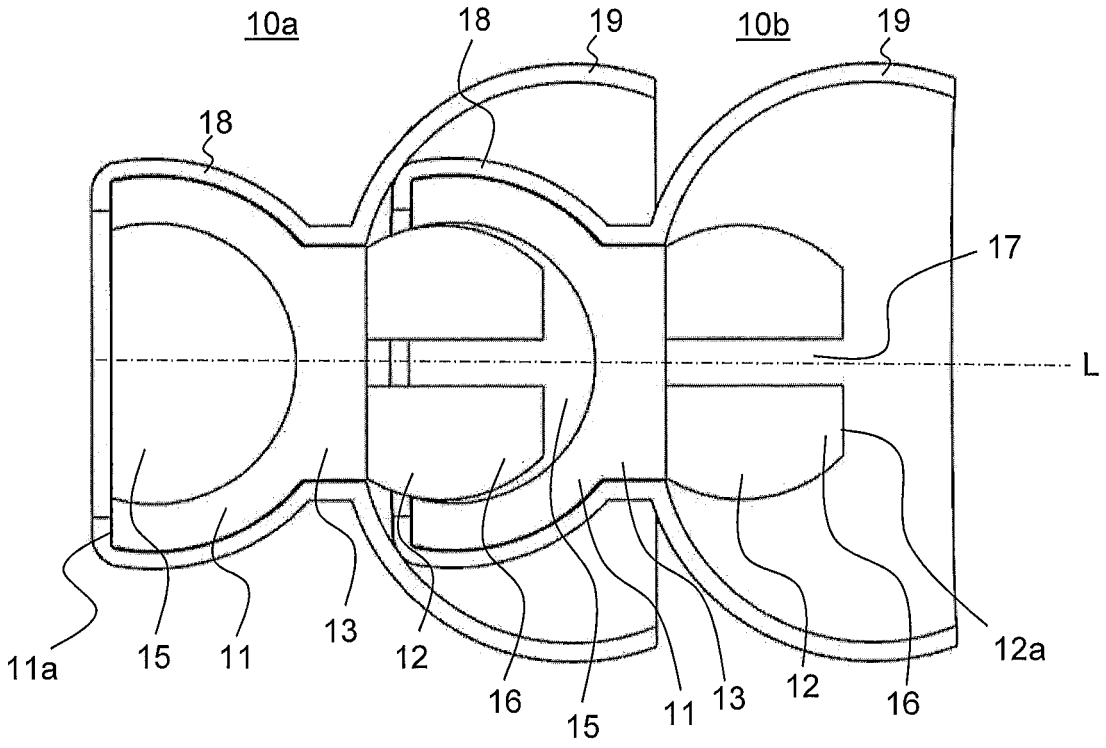
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Fig. 2

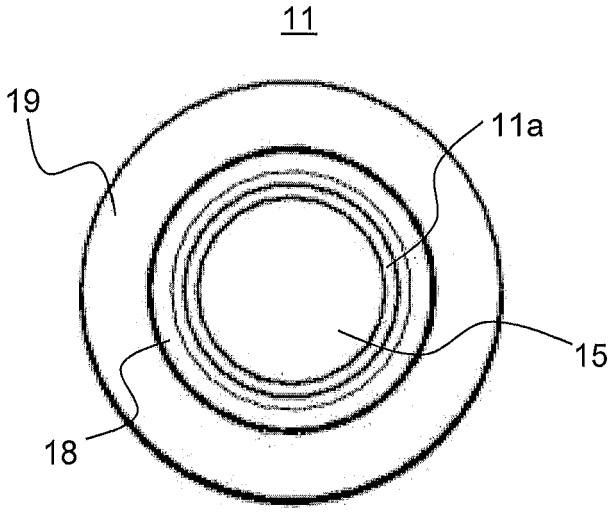

Fig. 3

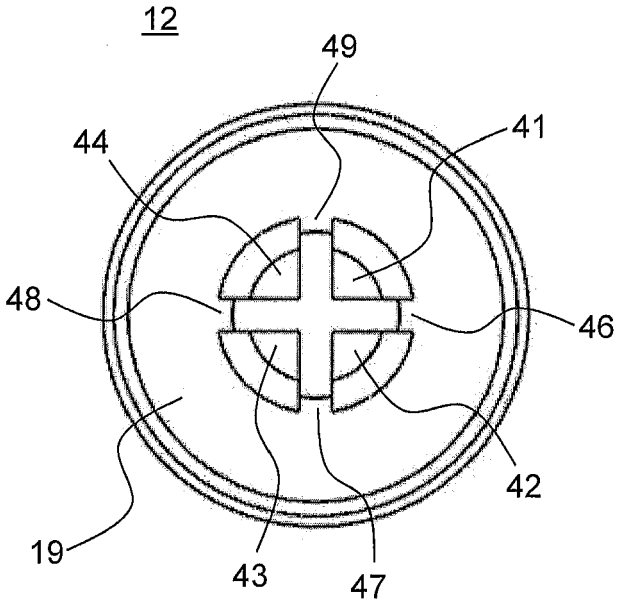

Fig. 4

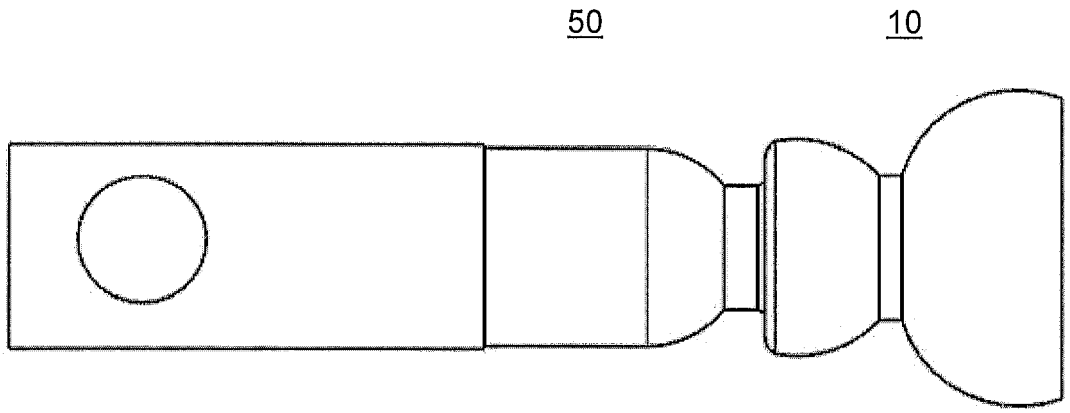

Fig. 5

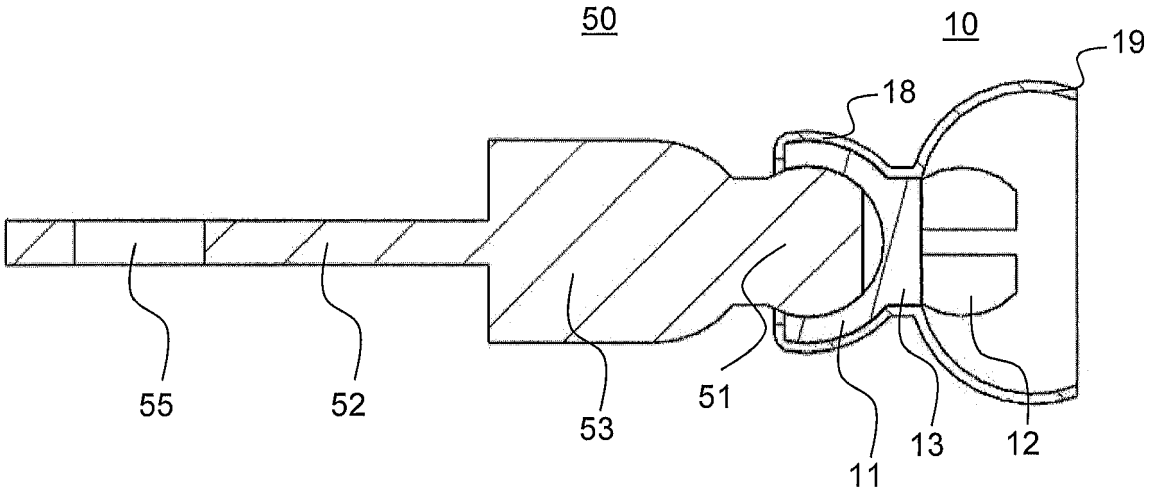

Fig. 6

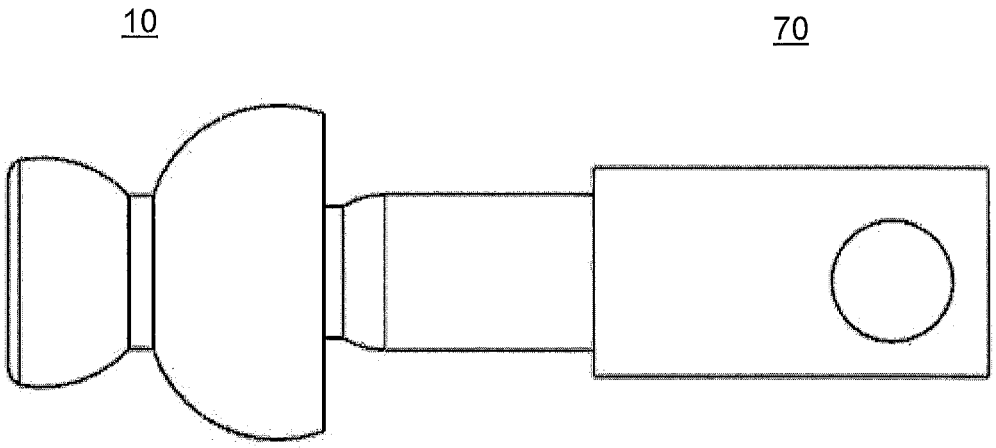

Fig. 7

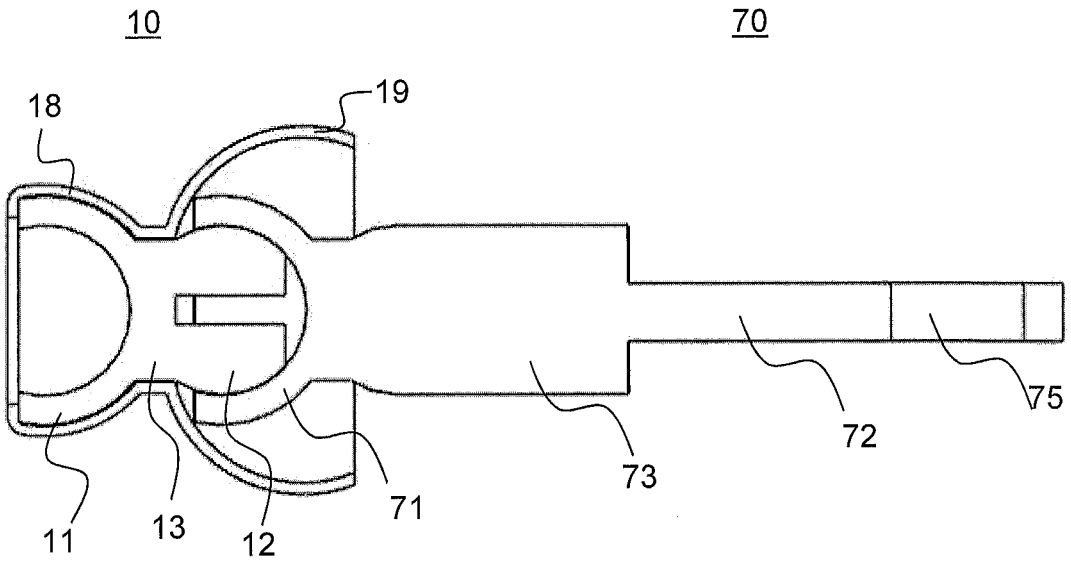

Fig. 8

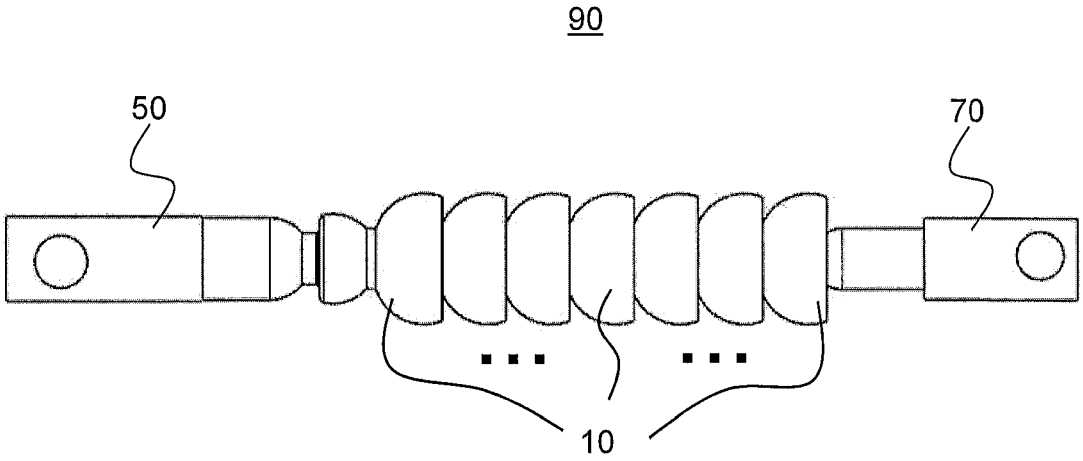

Fig. 9

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EUROPEAN SEARCH REPORT

Application Number
EP 18 17 4170

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	DE 10 2012 204543 A1 (BOSCH GMBH ROBERT [DE]) 26 September 2013 (2013-09-26) * abstract; figures 1-6 * -----	1-15	INV. H01R35/04 H01R4/58
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TECHNICAL FIELDS SEARCHED (IPC)

H01R

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	2 October 2018	Georgiadis, Ioannis

CATEGORY OF CITED DOCUMENTS

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02-10-2018

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