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(54) **ELECTRICAL CABLE AND MOTOR VEHICLE WITH SUCH A CABLE**

ELEKTRISCHES KABEL UND KRAFTFAHRZEUG MIT EINEM SOLCHEN KABEL

CÂBLE ÉLECTRIQUE ET VÉHICULE AUTOMOBILE ÉQUIPÉ D'UN TEL CÂBLE

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## Description

**[0001]** The invention relates to an electrical cable with a solid round electrical conductor to which a connecting element is contacted. The invention further relates to a motor vehicle with such an electrical cable.

**[0002]** In the automotive sector, solid round conductors are often used as so-called "bus-bars", on which a connecting element is arranged. Such connecting elements are also called terminals and are used for the electrical connection of the conductor to an electrical component. To connect the round conductor to the terminal, it is regularly provided that the round conductor is flattened and fastened to the terminal with the flattened end part.

**[0003]** Such an arrangement, in which a round conductor with a flattened end part is attached to a terminal, can be taken from DE 10 2010 005 841 B4, for example. The terminal has a shell-shaped section in which the round conductor, which may be insulated, is accommodated. The terminal also has a flat section adjoining the shell-shaped section, on which the flattened end part of the round conductor is electrically contacted. In the area of the shell-shaped section, a fastening device is provided for fastening of the round conductor. The fastening device is intended to provide a reliable, vibration-proof fastening of the round conductor to the terminal and the flattened end part is held in a defined position in relation to the flattened section of the terminal in order to form a reliable electrical contact.

**[0004]** CN 115411538 A shows a terminal with a shell-shaped receptacle in which a conductor is inserted which is flattened on one side. This flattened side interacts with a welding head to produce a welded joint.

**[0005]** WO 2023/024971 A1 shows a connection between two conductors with the help of an adapter part, the adapter part having a shell-shaped end for connecting with one of the conductors.

**[0006]** JP 2013 242991 A describes a joint between a stranded copper wire and a stranded aluminium wire, wherein the end of the copper wire is shaped to form a groove into which the aluminium wire is fitted and welded to the copper wire.

**[0007]** JP S54 34083 A describes a crimp terminal which is connected to a stranded wire.

**[0008]** It is the task of the invention to provide an electrical cable with a solid round electrical conductor and a connecting element connected thereto, which is easy to manufacture.

**[0009]** According to the invention, a solid electrical round conductor is provided for this purpose, on which a connecting element is electrically contacted, the latter having a connecting section and a shell-shaped section with a curvature corresponding to the round conductor. A round end part of the round conductor is welded, especially ultrasonic welded, to the shell-shaped section of the connecting element. The round end part lies in the cavity formed by the shell-shaped section. The shell-shaped section has a concavely curved, in particular partially

cylindrical, inner surface on its inner side, on which the end part rests. Preferably, the shell-shaped section is formed by a partial cylinder and has preferably a constant wall thickness.

**[0010]** It is emphasised that the round conductor is not flattened, especially in its end part. The end part of the round conductor, which has a circular cross-section, therefore lies directly in the shell-shaped section of the connecting element and is welded to it there.

**[0011]** This design is based on the consideration that, on the one hand, the flattening of an end part of the round conductor is associated with an additional manufacturing effort, which is therefore not necessary and also not provided for in the design according to the invention.

**[0012]** Furthermore, this design is based on the consideration that flattened end parts usually require additional installation space and are therefore disadvantageous in confined installation spaces. A compact design is therefore achieved with the design according to the invention.

**[0013]** Finally, such flattened end parts are potential points of failure.

**[0014]** All in all, the design according to the invention achieves a simple-to-produce and compact electrical and mechanical connection between a solid round conductor and a connecting element, which requires only little installation space and is also less susceptible to faults.

**[0015]** The round conductor is in particular a round conductor with an insulation sheath, the round end part of which is stripped. Alternatively, it can also be a bare round conductor. The round conductor generally has a circular cross-section over its entire length, preferably with a constant diameter over the entire length.

**[0016]** Solid round conductor is understood to be a solid wire or rod made of solid material.

**[0017]** The connecting section is arranged in particular opposite the shell-shaped section and is designed for an electrical connection to an electrical component. The connecting element is connected to the electrical component with this connecting section in the assembled state. The connecting section is designed, for example, for screw contact with a corresponding connection pole or also for a direct welded connection.

**[0018]** Preferably, a flexible intermediate section is arranged between the shell-shaped section and the connecting section, which is designed to enable length compensation. The flexible and in particular elastic intermediate section can therefore compensate for changes in length. This is based on the consideration that the solid round conductor has a high inherent rigidity and, for example, thermally induced changes in length can lead to a high mechanical load on a connection point between the connecting element and an electrical component connected to it. The flexible intermediate section therefore enables and compensates for a change in length directly through the connecting element itself.

**[0019]** Preferably, the intermediate section is undulated or corrugated so that a desired length compensa-

tion can be achieved by compressing or stretching the undulated intermediate section. In particular, the intermediate section is formed by a bent, especially by a multiple bent flat metal strip.

**[0020]** According to the invention the connecting element has a multilayer structure consisting of a plurality of individual layers. Preferably each layer is a metal layer.

**[0021]** The layers are not connected to each other at least in the intermediate section, especially in the bended sections. Therefore, the individual layers may slide to some extent relative to each other. Due to this the (bending) flexibility of the intermediate section is high.

**[0022]** Preferably, the individual layers are connected, especially welded to each other only in the end sections of the connection element, that means in the shell-shaped section and in the connecting section.

**[0023]** Preferably, the connecting section is formed as a flat metal strip. This allows easy electrical contact with the electrical component, especially in the case of a welded connection.

**[0024]** Preferably, the connecting element is attached with the connecting section to the electrical component by welding. Especially in such an arrangement, the flexible intermediate section is of particular importance in order to minimise the load on the two welding positions, once towards the round conductor and once towards the electrical component.

**[0025]** The electrical component is in particular a plug which has a connection piece. The connecting section is attached to the connection piece, in particular by welding. The connection piece of the plug is in particular a flat, in particular strip-shaped metal part on which the preferably also flat connecting section of the connecting element rests. In particular, the connection piece protrudes from a housing of the plug. A pre-assembled cable is therefore provided, which can be connected to a further electrical component by a simple plug-in connection. The further electrical component is, for example, an electrical consumer, such as an electric motor, an inverter etc.

**[0026]** Preferably, the connecting element is both electrically contacted and mechanically connected to the round conductor exclusively by welding. Therefore, no additional measures are provided, for example for mechanical fastening. The effort for establishing the contact connection between the round conductor and the connecting element is therefore low.

**[0027]** The round conductor is in particular an inherently rigid round metal conductor with a diameter of at least 10 mm and preferably of at least 20 mm.

**[0028]** In a preferred embodiment, the line only extends in a straight line and has no bends.

**[0029]** In general, the round conductor and the connection element are made of metal. Preferably, the round conductor is an aluminium round conductor. It is therefore made of aluminium or an aluminium alloy typically with an aluminium content of more than 90 %.

**[0030]** In contrast, the connecting element is preferably made of copper or a copper alloy.

**[0031]** Preferably a connecting element is attached to each of the round end parts of the round conductor, as described above.

**[0032]** The line is preferably mounted in a motor vehicle when assembled.

**[0033]** The round conductor is used in particular as a so-called busbar, especially in a motor vehicle electrical system. The cable preferably forms a main supply line and thus a so-called backbone or is part of such a backbone. Such a backbone typically connects a front vehicle part with a rear vehicle part for power supply. The round conductor, and thus also the cable, typically has a length of at least 0.5 m and preferably of at least 1 m or also of at least 1.5 m.

**[0034]** In particular, the cable is a single-core cable with only one solid round conductor.

**[0035]** The pre-assembled cable is preferably formed by the round conductor with the connecting element connected at least at one end. Preferably, connecting elements are attached on both sides.

**[0036]** Preferably, the pre-assembled cable has additionally at one end and in particular at both ends an electrical component, in particular a plug, which is connected to the respective connecting element.

**[0037]** An embodiment of the invention is explained in more detail below with reference to the figures. These show:

FIG 1 a side view of a pre-assembled cable with a solid round conductor, to the two opposite ends of which a plug is connected by means of a connecting element,

FIG 2 an enlarged view of the left end region of the pre-assembled cable according to FIG 1.

**[0038]** A pre-assembled electrical cable 8 according to FIG 1 and FIG 2 has, in the embodiment shown, a solid round conductor 2 which is surrounded by an insulation sheath 4. A plug 6 is attached to each end of the round conductor 2 as an electrical component. The round conductor 2 has a blank end part 9 at each of its two opposite ends, which has a round cross-section. The cross-section of the round conductor 2 is preferably constant over its entire length. The round conductor 2 is therefore undeformed at the end parts 9.

**[0039]** The round conductor 2 and thus also the pre-assembled cable 8 extend generally in longitudinal direction L from the right end to the left end.

**[0040]** The connection between the round conductor 2 and the respective plug 6 is made via a connecting element 10, which, viewed in the longitudinal direction L, first has a shell-shaped section 12, followed by a flexible intermediate section 14 and then a connecting section 16.

**[0041]** The connecting element 10 is in particular a metallic one-piece element and in one embodiment a monolithic component. In a preferred embodiment the connecting element 10 is a (flexible) multilayer construc-

tion with a plurality (>3, especially >5) of thin metal layers 17. The layers 17 are only illustrated in a very simplified way in FIG 2 and only in the intermediate section 14. The layers 17 are welded together especially (only) at the end sides. Therefore, in a preferred embodiment, in the intermediate section 14 the layers 17 are not fixed to each other, for example they are not welded together. Therefore, the individual layers 17 can slide to some extent relative to each other. Due to this the flexibility of the intermediate section 14 is high

**[0042]** The connecting element 10 is therefore in particular a metal bent part, which is preferably produced by forming from a flat metal strip. This generally has two opposite flat sides which are connected to each other via two opposite narrow sides.

**[0043]** To form the shell-shaped section 12, one end of the flat metal strip is preferably bent around a bending axis oriented parallel to the longitudinal direction L.

**[0044]** The shell-shaped section 12 extends in the circumferential direction, for example, over an angular range of less than 180° and in particular also of less than 120° or less than 90°. For example, the shell-shaped section 12 extends over an angular range of 30° to 60°. The shell-shaped section 12 preferably has a radius of curvature which is adapted to the radius of the round conductor 2, so that the outer side of the round conductor 2, which is freed from the insulation sheath 4, lies with its cylindrical surface on an inner side of the shell-shaped section 12. This inner side forms a partially cylindrical surface. In particular, the radius of curvature corresponds to the radius of the round conductor 2.

**[0045]** The shell-shaped section 12 extends in the longitudinal direction L over a comparatively short length, which in the embodiment example is for example shorter than a diameter of the round conductor 2.

**[0046]** The curved, shell-shaped section 12 merges into the intermediate section 14, which is formed by a section of the flat metal strip, wherein said section is bent. The intermediate section 14, and thus the metal strip, are formed as a whole in a curved shape and therefore are undulated. The intermediate section 14 has at least one arc section 18 and preferably a plurality of arc sections 18. In particular, two or three arc sections are formed. The intermediate section 14 is flexible in the longitudinal direction and is specifically elastic. The flexible intermediate section 14 can therefore be compressed or stretched and thus serves to compensate for length. A respective arc section 18 is bent around a bending axis which is oriented perpendicular to the longitudinal direction L and parallel to the flat sides of the flat metal strip.

**[0047]** The intermediate section 14 finally merges into the connecting section 16, which extends in particular in a straight line and in particular in the longitudinal direction L.

**[0048]** The connecting section 16 is electrically and mechanically connected to a respective plug 6 via a welded connection. For this purpose, a respective plug 6 preferably has a connection piece 20, which in turn is

designed in particular as a flat metal strip.

**[0049]** The respective plug 6 generally has an insulating housing in which a contact terminal not shown in more detail here is arranged, for example a socket or a plug pin, this contact terminal being electrically contacted on the connection piece 20. The connection piece 20 emerges from the housing and is connected to the connecting element 10 at its emerging part.

**[0050]** For electrical contacting as well as for mechanical fastening between the round conductor 2 and the shell-shaped section 12, the blank, round end part 9 is inserted into the shell-shaped section 12 and joined to it by welding.

**[0051]** Due to the electrical and mechanical connection of the undeformed circular end part 9, the particular advantage is achieved that additional machining and treatment of the end part 9, in particular flattening, is not necessary and is not carried out.

**[0052]** The round conductor 2 described here with the connecting element 10 connected to it is preferably used in the installed state in a motor vehicle and there specifically as a so-called bus bar or in particular at least as part of a so-called backbone supply cable. In particular, the round conductor 2 and in particular also the entire cable 8 is part of a direct current supply during operation.

List of reference signs

**[0053]**

|    |                               |
|----|-------------------------------|
| 2  | Round conductor               |
| 4  | Insulation sheath             |
| 6  | Plug                          |
| 8  | Cable                         |
| 9  | End part                      |
| 10 | Connecting element            |
| 12 | shell-shaped section          |
| 14 | Flexible intermediate section |
| 16 | Connecting section            |
| 17 | Layers                        |
| 18 | Arc section                   |
| 20 | Connection piece              |

L longitudinal direction

**Claims**

1. Electrical cable (8), in particular for a motor vehicle, having a solid electrical round conductor (2) and a connecting element (10) which is connected to the round conductor (2) and which has a connecting section (16) for electrical connection to an electrical component (6), wherein the connecting element (10) furthermore has a shell-shaped section (12), wherein a round end part (9) of the round conductor (2) is welded to the shell-shaped section (12) of the connecting element (10), **characterised in that** a flexible intermediate section (14) for length compensa-

tion is arranged between the shell-shaped section (12) and the connecting section (16) and that the connecting element (10) has a multilayer structure with a plurality of layers, wherein the layers are not fixed to each other within the intermediate section (14).

2. Electrical cable (8) according to the preceding claim, **characterised in that** the flexible intermediate portion (14) is undulated.
3. Electrical cable (8) according to one of the preceding claims, **characterised in that** the connecting section (16) is formed as at least a flat metal strip.
4. Electrical cable (8) according to any one of the preceding claims, **characterised in that** the connecting element (10) is fixed with the connecting section (16) to the electrical component (6) by welding.
5. Electrical cable (8) according to one of the preceding claims, **characterised in that** the connecting section (16) is welded to a connection part (20) of a plug (6).
6. Electrical cable (8) according to one of the preceding claims, **characterised in that** the connecting element (10) is both electrically contacted and mechanically connected to the round conductor (2) exclusively by welding.
7. Electrical cable (8) according to one of the preceding claims, **characterised in that** the round conductor (2) is an inherently rigid round conductor (2) with a diameter of at least 10 mm and preferably of at least 20 mm.
8. Electrical cable (8) according to one of the preceding claims, **characterised in that** the round conductor (2) is an Aluminium conductor.
9. Electrical cable (8) according to one of the preceding claims, **characterised in that** connecting elements (10) are attached to round end parts (9) on both sides of the round conductor (2).
10. Motor vehicle with an electrical cable (8) according to one of the preceding claims.

#### Patentansprüche

1. Elektrisches Kabel (8), insbesondere für ein Kraftfahrzeug, das einen massiven elektrischen Rundleiter (2) und ein Verbindungselement (10) aufweist, das mit dem Rundleiter (2) verbunden ist und das einen Verbindungsabschnitt (16) zur elektrischen Verbindung mit einem elektrischen Bauteil (6) auf-

weist, wobei das Verbindungselement (10) weiter einen schalenförmigen Abschnitt (12) aufweist, wobei ein runder Endteil (9) des Rundleiters (2) an den schalenförmigen Abschnitt (12) des Verbindungselements (10) geschweißt ist, **dadurch gekennzeichnet, dass** ein flexibler Zwischenabschnitt (14) zum Längenausgleich zwischen dem schalenförmigen Abschnitt (12) und dem Verbindungsabschnitt (16) angeordnet ist und dass das Verbindungselement (10) einen mehrschichtigen Aufbau mit einer Vielzahl von Schichten aufweist, wobei die Schichten innerhalb des Zwischenabschnitts (14) nicht aneinander fixiert sind.

2. Elektrisches Kabel (8) nach dem vorstehenden Anspruch, **dadurch gekennzeichnet, dass** der flexible Zwischenabschnitt (14) gewellt ist.
3. Elektrisches Kabel (8) nach einem der vorstehenden Ansprüche, **dadurch gekennzeichnet, dass** der Verbindungsabschnitt (16) als mindestens ein flacher Metallstreifen gebildet ist.
4. Elektrisches Kabel (8) nach einem der vorstehenden Ansprüche, **dadurch gekennzeichnet, dass** das Verbindungselement (10) mit dem Verbindungsabschnitt (16) an dem elektrischen Bauteil (6) durch Schweißen fixiert ist.
5. Elektrisches Kabel (8) nach einem der vorstehenden Ansprüche, **dadurch gekennzeichnet, dass** der Verbindungsabschnitt (16) an einen Verbindungsteil (20) eines Steckers (6) geschweißt ist.
6. Elektrisches Kabel (8) nach einem der vorstehenden Ansprüche, **dadurch gekennzeichnet, dass** das Verbindungselement (10) ausschließlich durch Schweißen mit dem Rundleiter (2) sowohl elektrisch kontaktiert als auch mechanisch verbunden ist.
7. Elektrisches Kabel (8) nach einem der vorstehenden Ansprüche, **dadurch gekennzeichnet, dass** der Rundleiter (2) ein eigensteifer Rundleiter (2) mit einem Durchmesser von mindestens 10 mm, vorzugsweise mindestens 20 mm, ist.
8. Elektrisches Kabel (8) nach einem der vorstehenden Ansprüche, **dadurch gekennzeichnet, dass** der Rundleiter (2) ein Aluminiumleiter ist.
9. Elektrisches Kabel (8) nach einem der vorstehenden Ansprüche, **dadurch gekennzeichnet, dass** an runden Endteilen (9) an beiden Seiten des Rundleiters (2) Verbindungselemente (10) angebracht sind.
10. Kraftfahrzeug mit einem elektrischen Kabel (8) nach einem der vorstehenden Ansprüche.

## Revendications

1. Câble électrique (8), en particulier pour un véhicule automobile, comportant un conducteur électrique rond (2) à âme massive et un élément de connexion (10) qui est connecté au conducteur rond (2) et qui présente une partie de connexion (16) pour connexion électrique à un composant électrique (6), l'élément de connexion (10) présentant en outre une partie en forme de coque (12), une partie terminale ronde (9) du conducteur rond (2) étant soudée à la partie en forme de coque (12) de l'élément de connexion (10), **caractérisé en ce qu'**une partie intermédiaire flexible (14) est, pour compensation de la longueur, disposée entre la partie en forme de coque (12) et la partie de connexion (16) et **en ce que** l'élément de connexion (10) a une structure multicouche comportant une pluralité de couches, les couches n'étant pas fixées entre elles à l'intérieur du segment intermédiaire (14). 5 10 15 20
2. Câble électrique (8) selon la revendication précédente, **caractérisé en ce que** la partie intermédiaire flexible (14) est ondulée. 25
3. Câble électrique (8) selon l'une quelconque des revendications précédentes, **caractérisé en ce que** la partie de connexion (16) est configurée sous forme d'au moins une bande métallique plate. 30
4. Câble électrique (8) selon l'une quelconque des revendications précédentes, **caractérisé en ce que** l'élément de connexion (10) est fixé avec la partie de connexion (16) au composant électrique (6) par soudage. 35
5. Câble électrique (8) selon l'une quelconque des revendications précédentes, **caractérisé en ce que** la partie de connexion (16) est soudée à une partie de connexion (20) d'une fiche (6). 40
6. Câble électrique (8) selon l'une quelconque des revendications précédentes, **caractérisé en ce que** l'élément de connexion (10) est à la fois mis en contact électrique avec le et connecté mécaniquement au conducteur rond (2) exclusivement par soudage. 45
7. Câble électrique (8) selon l'une quelconque des revendications précédentes, **caractérisé en ce que** le conducteur rond (2) est un conducteur rond (2) intrinsèquement rigide ayant un diamètre d'au moins 10 mm et de préférence d'au moins 20 mm. 50
8. Câble électrique (8) selon l'une quelconque des revendications précédentes, **caractérisé en ce que** le conducteur rond (2) est un conducteur en aluminium. 55
9. Câble électrique (8) selon l'une quelconque des revendications précédentes, **caractérisé en ce que** des éléments de connexion (10) sont fixés à des parties terminales rondes (9) des deux côtés du conducteur rond (2). 5
10. Véhicule automobile comportant un câble électrique (8) selon l'une quelconque des revendications précédentes. 10

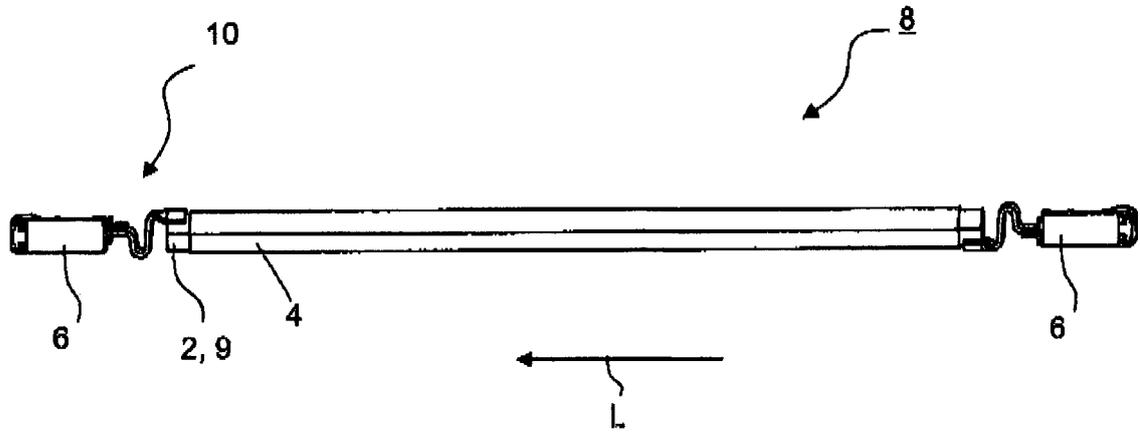


FIG 1

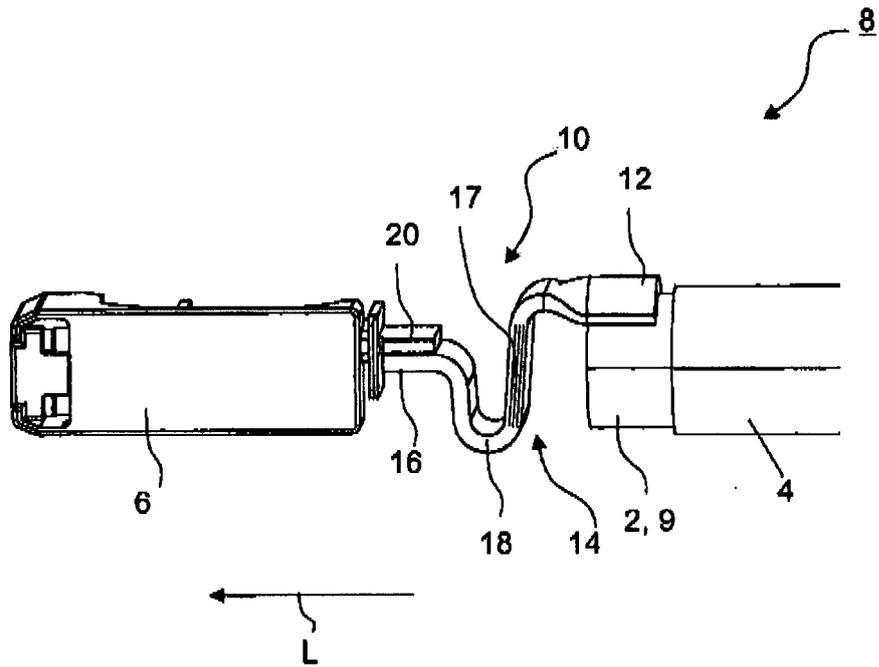


FIG 2

**REFERENCES CITED IN THE DESCRIPTION**

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