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(54) **ELECTRICAL CONNECTOR FOR CONNECTING ELECTRICAL CABLES TO ELECTRICAL TERMINALS**

ELEKTRISCHER VERBINDER ZUM VERBINDELN VON ELEKTIRSCHEN LEITUNGEN ZU ELEKTRISCHEN ANSCHLÜSSEN

CONNECTEUR ÉLECTRIQUE POUR CONNECTER DES CÂBLES ÉLECTRIQUES À DES TERMINAUX ÉLECTRIQUES

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Description

[0001] The object of the present invention is an electrical connector for connecting electrical cables to electrical terminals. DE102007005810A1 indicates a state of the art for such connectors. Furthermore, WO 2004/047 227 A1 indicates a connector according to the preamble of claim 1.

[0002] Single piece electrical connectors made of copper are known, which form a cable connection portion, for example a tubular or C-shaped seat suitable for receiving one end of an electric cable and for being compressed around such an end so as to obtain, a press-fit connection, as well as a terminal connection portion suitable for being connected in pressing contact, for example through a bolt, against an electrical terminal of a use.

[0003] This known type of electrical connector can be applied to make electrical contacts in the civil, industrial and rail fields.

[0004] However, due to a considerable increase in the cost of copper and to the consequent frequent theft of conductors made from such a metal, over the last years there has been an increase in the use of conductors made from aluminium for transportation and distribution of electrical energy.

[0005] The electric conductors made of aluminium must be connected to the pre-existing terminals made of copper and also to the more common recently installed terminals which are still now very frequently made of copper.

[0006] Therefore, a requirement has arisen of being able to have electrical connectors for connecting cables made of aluminium to existing terminals made of copper.

[0007] Analogous requirements have arisen for connecting cables made of copper to terminals made of aluminium, for connecting cables of steel to terminals made of copper and *vice versa*, as well as for connecting cables made of steel to terminals made of aluminium and *vice versa*.

[0008] There are connectors (so called cable terminal connectors) made of aluminium the use of which however leads to a contact which is exposed to the environment between metals with different galvanic potential, such as copper and aluminium, with consequent risks of galvanic crevice corrosion in the contact area between the connector made of aluminium and the terminal made of copper.

[0009] In order to avoid the problem of the galvanic corrosion which could occur in the contact area between the aluminium and the copper, bi-metal connectors are currently sold on the market having a cable seat in aluminium that is suitable for being compressed onto the conductor, as well as a terminal connection portion made of copper that is suitable for being connected in contact with a terminal, in which the cable seat and the terminal connection portion are welded to one another.

[0010] Such a solution, although solving the problem of the crevice corrosion in a satisfactory manner, is not

without drawbacks.

[0011] The manufacturing process of the single parts made of aluminium and copper and their subsequent joining through welding is, on one hand, complex and costly and, on the other hand, is not able to obtain a copper-aluminium connection that is sufficiently reliable and resistant for applications in which the connectors undergo vibrations. One example of electrical connections exposed to the external environment and undergoing vibrations and cyclical mechanical stress is the connection between electrical cables and train rails.

[0012] The purpose of the present invention is therefore that of proposing an electrical connector (so called cable terminal) for the connection of electrical cables made of a first metal (for example aluminium) to terminals made of a second metal (for example copper), having characteristics such as to withstand mechanical stress, in particular vibrations, and avoid the phenomenon of galvanic crevice corrosion.

[0013] These and other purposes are achieved with a connector (cable terminal) according to claim 1 for connecting an electric cable to a terminal, comprising a tubular body that forms a cable connection portion that is suitable for receiving one end of an electric cable and a terminal connection portion suitable for being connected in contact with a terminal, in which the tubular body comprises one inner layer that is substantially made of a first conductive metal that forms an inner surface of the tubular body and one outer layer that is substantially made of a second conductive metal that is different from the first conductive metal and that forms an outer surface of the tubular body, in which the outer surface forms a terminal contact surface of the terminal connection portion and the inner surface forms a cable contact surface of the cable connection portion, in which said inner layer and said outer layer are metallurgically bonded. The connection between the two layers can be made through melting of the material in the transition area between the outer layer and the inner layer, for example through the manufacture of the bi-layer or multi-layer tubular body through drawing or co-extrusion.

[0014] The cable terminal thus configured makes it possible to obtain the specific advantages of a bi-metal cable terminal (no difference of galvanic potential in the area of contact between the cable terminal and the terminal) with low costs and with mechanical resistance that is suitable for applications undergoing vibrations.

[0015] Moreover, the use of a multi-layer tubular body manufactured through drawing or co-extrusion allows a production of the connector on a large scale with low costs and with a close and resistant joining between the layers themselves.

[0016] In the present description the terms "substantially made of a first metal" and "substantially made of a second metal" or, more specifically "substantially made of copper" and "substantially made of aluminium" do not exclude alloys of such metals as long as the metals indicated form the main portion of the alloy itself. In the

preferred embodiment, the expressions "substantially made of copper" and "substantially made of aluminium" refer to the two metals as usually found on the market and used as conductors for the electrical and electro-technical industry.

[0017] In order to better understand the invention and to appreciate the advantages thereof, in the following description we shall describe some of its embodiments given as an example and not for limiting purposes, with reference to the attached figures, in which:

figures 1A - 1E are side, front and rear views of a connector (cable terminal) for connecting an electric cable to a terminal of a user, according to a first embodiment;

figure 1F is a longitudinal section view of the connector in figure 1A;

Figure 1G is a perspective view of the connector in figure 1A;

figures 2A - 2E are side, front and rear views of a connector (cable terminal) for connecting an electric cable to a terminal of a user, according to a second embodiment;

figure 2F is a longitudinal section view of the connector in figure 2A;

figure 2G is a perspective view of the connector in figure 2A;

figure 3 illustrates the connector of figure 1 applied to an electric conductor;

figure 4 is a longitudinal section view of the conductor - connector group in figure 3;

figures 4A and 4B illustrate variant embodiments of the connector;

figure 5 is a cross-section view of the conductor - connector group in figure 3;

figure 6 illustrates an application of the connector for the electrical connection of a cable to a train track;

figure 7 is a section view of the connection in figure 6.

[0018] With reference to the figures, a connector 1 (so called cable terminal) for connecting an electric cable 2 to a terminal 3 comprises a tubular body 8 that forms a cable connection portion 4 that is suitable for receiving an end of the electric cable 2 and a terminal connection portion 6 that is suitable for being connected in contact with the terminal 3. The tubular body 8 comprises an inner layer 9 that is substantially made of a first conductive metal (for example aluminium, alternatively steel, copper) that forms an inner surface 17 of the tubular body 8 and an outer layer 10 substantially made of a second conductive metal (for example copper, alternatively aluminium, steel) that is different from the first conductive metal and that forms an outer surface 18 of the tubular body 8, in which the outer surface 18 forms a terminal contact surface of the terminal connection portion 6 and the inner surface 17 forms a cable contact surface of the cable connection portion 4.

[0019] The inner layer 9 and the outer layer 10 are

connected to one another with continuity of material substantially over the entire surface, for example through melting of the material in the interface or transition area 19 between the outer layer and the inner layer. Consequently the inner layer is to all effects welded to the outer layer. This can be obtained for example through the manufacture of the bi-layer or multi-layer tubular body 8 through drawing or co-extrusion.

[0020] According to one aspect of the invention, in the interface or transition area 19 between the two layers, the latter are metallurgically bonded. Such a metallurgical bond between the two metal layers can be obtained for example through the manufacture of the bi-layer or multi-layer tubular body through drawing. According to one embodiment a bi-layer or multi-layer tube previously preassembled is equipped with an inner floating mandrel and is cold drawn through one or a series of outer matrices so that the high pressure between the tube layers generates the aforementioned metallurgical bond.

[0021] Alternatively, the metallurgical bond between the two metal layers can be obtained by manufacturing the bi-layer or multi-layer tubular body through co-extrusion or, in other words, through co-extrusion welding (CEW) in which the two different metals are, for example, extruded simultaneously and together through the same matrix so that the high pressure and the high temperature generate the metallurgical bond in the transition area 19 between the two adjacent layers of the tube.

[0022] According to a further aspect of the invention, the metallurgical bond between the two metal layers can be obtained through the manufacture of the bi-layer or multi-layer tubular body through roll welding (ROW) in which the different metals are joined during their forced passage between the lamination rollers so that the high pressure and, if foreseen, the high temperature generate the metallurgical bond between the layers of the tube.

[0023] In technical jargon the connection between the two layers thus obtained, that is to say the metallurgical bond of the two different metal materials, is sometimes called "metallurgical cladding". This connection is obtained through layers having preferably uniform thicknesses and not too thin and provides, together with minimum thicknesses of the metal layers involved of at least 0.5 mm, preferably from 0.5 mm to 10 mm, the most favourable mechanical and galvanic characteristics for the electrical connector.

[0024] In accordance with one embodiment, the tubular body 8 is a two-layer tubular body with the inner layer 9 made of aluminium and the outer layer 10 made of copper, in which the inner layer 9 has a thickness ranging from 0.5 mm to 10 mm and the outer layer 10 has a thickness ranging from 0.5 mm to 2 mm.

[0025] In the present invention by the term "metallurgical bond" we mean that the lattice structure of the two metals is forced in mutual conformance with sharing of electrons in the interface between the two layers which generates a bond at the atomic level.

[0026] Advantageously, in the interface (transition ar-

ea 19) between the two layers, the latter are metallurgically bonded and locally interpenetrated.

[0027] According to one aspect of the invention, the transition area 19 with metallurgical bond extends continuously and uninterruptedly for the entire extension of the interface between the two layers. Preferably, both metal layers (and also the interface between them) substantially extend on the entire extension of the tubular body, the wall of which is therefore multi-layer all over and substantially without monolayer portions.

[0028] The cable terminal thus configured makes it possible to obtain the specific advantages of a bi-metal cable terminal (no difference of galvanic potential in the contact area between the cable terminal and the terminal) with low costs and with mechanical resistance that is suitable for applications undergoing vibration.

[0029] Moreover, the use of a multi-layer tubular body manufactured through drawing or co-extrusion allows a production of the connector on a large scale at low costs and with a close and resistant connection between the layers themselves.

[0030] In accordance with one embodiment, the terminal connection portion 5 is formed by a flattened end, for example through cold plastic deformation, of the multi-layer tubular body 8 and can be equipped with a through hole 11 that is suitable for receiving a bolt 12 or a connection screw.

[0031] This facilitates making a connection in pressing contact through bolting down the connector 1 to the terminal 3, for example to a terminal of a train rail 13 (Figures 6, 7).

[0032] In accordance with one embodiment, the cable connection portion 4 is formed by one open end portion (tubular, for example cylindrical) of the tubular body 8, opposite to the flattened end, and suitable for receiving an end of the electric cable 2 as well as for being compressed around it so as to make a press-fit and shape connection (Figures 3, 4).

[0033] In accordance with a further embodiment, at at least one or both the free ends 14, 15 of the tubular body 8 and, therefore, at the terminal connection portion 6 and/or at the cable connection portion 4, the outer layer 10 extends beyond the inner layer 9, so that only the outer layer 10 is exposed to the external environment.

[0034] Such a configuration of the free edges of the tubular body 8 can be made for example through boring or milling of the ends of the tubular body 8 so as to eliminate an end section of the inner layer 9. The end section of the outer layer above the inner layer can be folded towards the inside of the tubular body 8 to prevent exposure of the inner layer to the environment.

[0035] This makes it possible to eliminate also the residual galvanic differential in the free edges of the connector.

[0036] In the embodiment illustrated in figures 2A - 2G, the flattened terminal connection portion is substantially symmetrical with respect to the cable connection portion.

[0037] Alternatively, in the embodiment illustrated in

figures 1A - 1G, the flattened terminal connection portion 6 defines a contact plane 16 that is substantially tangent to the outer surface 18 of the cable connection portion 4 or radially outside of it or inclined with respect to it, so that said contact plane 16 does not intersect the cable connection portion 4.

[0038] This facilitates the connection of the connector 1 to extended flat terminals or flat and extended surfaces in general.

[0039] From the description given, a man skilled in the art will appreciate how the connector 1 synergically reconciles the requirements of:

- an electrical connection between two different metals, such as for example aluminium and copper, and the consequent problems of galvanic corrosion,
- a mechanical and electrical connection that can withstand vibrations and adverse weather conditions,
- a simple structure that can be manufactured on a large scale and at low cost.

[0040] Of course, a person skilled in the art, with the purpose of satisfying contingent and specific requirements, may carry out further modifications and variants to the connector according to the present innovation, all moreover covered in the scope of protection of the invention, as defined by the following claims.

30 Claims

1. Connector (1) for connecting an electric cable (2) to a terminal (3), said connector (1), comprising a tubular body (8) that forms a cable connection portion (4) suitable for receiving the electric cable (2) and a terminal connection portion (6) suitable for being connected in contact with the terminal (3), wherein the tubular body (8) is a multi-layer tubular body having an inner layer (9) of a first conductive metal that forms an inner surface (17) of the tubular body (8) and an outer layer (10) of a second conductive metal different from the first conductive metal and that forms an outer surface (18) of the tubular body (8), in which the outer surface (18) forms a terminal contact surface of the terminal connection portion (6) and the inner surface (17) forms a cable contact surface of the cable connection portion (4) **characterized in that** the tubular body (8) is a multi-layer tube selected from the group consisting of:

drawn multi-layer tubes,
coextruded multi-layer tubes,
laminated multi-layer tubes,
 and said outer (10) and inner (9) layers are metallurgically bonded.

2. Connector (1) according to claim 1,

wherein the inner layer (9) and the outer layer (10) substantially extend on the entire extension of the tubular body (8).

3. Connector (1) according to claim 1 or 2, wherein said outer layer (10) and said inner layer (9) are metallurgically bonded and locally interpenetrated. 5
4. Connector (1) according to one of the previous claims, wherein the terminal connection portion (5) is formed from a flattened end of the tubular body (8). 10
5. Connector (1) according to any one of the previous claims, wherein the terminal connection portion (5) defines a through hole (11) suitable for receiving a bolt 12 or a connection screw, said through hole (11) extending through both the outer and inner layers (10, 9.). 15
6. Connector (1) according to any one of the previous claims, wherein the cable connection portion (4) is formed from an open end portion of the tubular body (8), opposite to the flattened end, and suitable for receiving an end of the electric cable (2) as well as for being compressed around it so as to make a press-fit connection. 20
7. Connector (1) according to any one of the previous claims, wherein at least one free end (14, 15) of the tubular body (8) the outer layer (10) extends beyond the inner layer (9), so that only the outer layer (10) is exposed to the external environment. 25
8. Connector (1) according to the previous claim, wherein an end section of the outer layer (10) above the inner layer is bent towards the inside of the tubular body (8). 30
9. Connector (1) according to any one of the previous claims, wherein the terminal connection portion (6) is flattened and defines a contact plane (16) oriented so as not to intersect the cable connection portion (4). 35
10. Connector (1) according to any one of the previous claims, wherein said first conductive metal is selected from the group consisting of aluminium, copper, steel, and said second conductive metal is selected from the group consisting of copper, steel, aluminium. 40
11. Connector (1) according to any one of the previous claims, wherein the thickness of the inner layer (9) is substantially uniform and equal to or greater than 0.5 mm. and the thickness of the outer layer (10) is substantially uniform and equal to or greater than 0.5 mm. 45
12. Connector (1) according to claim 12, wherein the tu- 50

bular body (8) is a two-layer tubular body with the inner layer 9 made of aluminium and the outer layer 10 made of copper, wherein the inner layer 9 has a thickness ranging from 0.5 mm to 10 mm and the outer layer 10 has a thickness ranging from 0.5 mm to 2 mm.

Patentansprüche

1. Verbinder (1) zum Verbinden eines elektrischen Kabels (2) mit einem Anschluss (3), wobei der Verbinder (1) einen röhrenartigen Körper (8), der einen Kabelverbindungsbereich (4) geeignet zur Aufnahme des elektrischen Kabels (2) ausbildet, und einen Anschlussverbindungsbereich (6) umfasst, der geeignet ist, mit dem Anschluss (3) kontaktierend verbunden zu werden, wobei der röhrenartige Körper (8) ein röhrenartiger Multischichtkörper ist, der eine innere Schicht (9) aus einem ersten leitenden Metall, das eine innere Oberfläche (17) des röhrenartigen Körpers (8) ausbildet, und eine äußere Schicht (10) aus einem zweiten leitenden Metall aufweist, das von dem ersten leitenden Metall verschieden ist und die eine äußere Oberfläche (18) des röhrenartigen Körpers (8) ausbildet, wobei die äußere Oberfläche (18) eine Anschlusskontaktfäche des Anschlussverbindungsbereichs (6) ausbildet und wobei die innere Oberfläche (17) eine Kabelkontaktefläche des Kabelkontaktebereichs (4) ausbildet, **dadurch gekennzeichnet, dass** der röhrenartige Körper (8) eine Multischichtröhre ist, die aus der Gruppe ausgewählt ist, die besteht aus:
- gezogenen Multischichtröhren,
coextrudierten Multischichtröhren,
laminierten Multischichtröhren,
und wobei die äußere (10) und innere (9) Schicht metallurgisch verbunden sind.
2. Verbinder (1) nach Anspruch 1, wobei die innere Schicht (9) und die äußere Schicht (10) sich im wesentlichen über die gesamte Erstreckung des röhrenartigen Körpers (8) erstrecken.
 3. Verbinder (1) nach Anspruch 1 oder 2, wobei die äußere Schicht (10) und die innere Schicht (9) metallurgisch verbunden sind und sich lokal gegenseitig durchdringen.
 4. Verbinder (1) nach einem der vorhergehenden Ansprüche, wobei der Anschlussverbindungsbereich (5) aus einem abgeflachten Ende des röhrenartigen Körpers (8) ausgebildet ist.
 5. Verbinder (1) nach irgend einem der vorhergehenden Ansprüche, wobei der Anschlussverbindungs-

- bereich (5) ein Durchgangsloch (11) definiert, das geeignet ist zum Aufnehmen eines Bolzens (12) oder einer Verbindungs schraube, wobei sich das Durchgangsloch (11) sowohl durch die äußere als auch die innere Schicht (10, 9) hindurch erstreckt.
6. Verbinder (1) nach irgend einem der vorhergehenden Ansprüche, wobei der Kabelverbindungs bereich (4) aus einem offenen Endbereich des röhrenartigen Körpers (8) gegenüberliegend zu dem abgeflachten Ende ausgebildet ist und geeignet ist zur Aufnahme eines Endes des elektrischen Kabels (2) sowie auch zum darum herum komprimiert werden, um eine Presspassungsverbindung herzustellen.
7. Verbinder (1) nach irgend einem der vorhergehenden Ansprüche, wobei an mindestens einem freien Ende (14, 15) des röhrenartigen Körpers (8) sich die äußere Schicht (10) über die innere Schicht (9) hinaus erstreckt, so dass nur die äußere Schicht (10) der externen Umgebung ausgesetzt ist.
8. Verbinder (1) nach dem vorhergehenden Anspruch, wobei ein Endabschnitt der äußeren Schicht (10) über der inneren Schicht hin zu dem Inneren des röhrenartigen Körpers (8) gebogen ist.
9. Verbinder (1) nach irgend einem der vorhergehenden Ansprüche, wobei der Anschlussverbindungs bereich (6) abgeflacht ist und eine Kontakt ebene (16) definiert, die orientiert ist, so dass sie nicht den Kabelverbindungs bereich (4) schneidet.
10. Verbinder (1) nach irgend einem der vorhergehenden Ansprüche, wobei das erste leitende Metall aus der Gruppe ausgewählt ist, die besteht aus Aluminium, Kupfer, Stahl, und wobei das zweite leitende Metall aus der Gruppe ausgewählt ist, die besteht aus Kupfer, Stahl, Aluminium.
11. Verbinder (1) nach irgend einem der vorhergehenden Ansprüche, wobei die Dicke der inneren Schicht (9) im Wesentlichen gleichförmig und gleich oder größer als 0,5 mm ist und wobei die Dicke der äußeren Schicht (10) im Wesentlichen gleichförmig und gleich oder größer als 0,5 mm ist.
12. Verbinder (1) nach Anspruch 11, wobei der röhrenartige Körper (8) ein röhrenartiger Zwei-Schicht-Körper ist, wobei die innere Schicht (9) aus Aluminium gemacht ist und die äußere Schicht (10) aus Kupfer gemacht ist, wobei die innere Schicht (9) eine Dicke im Bereich von 0,5 mm bis 10 mm aufweist und die äußere Schicht (10) eine Dicke im Bereich von 0,5 mm bis 2 mm aufweist.

Revendications

5. 1. Connecteur (1) pour connecter un câble électrique (2) à un terminal (3), ledit connecteur (1) comprenant un corps tubulaire (8) qui forme une partie de connexion pour câble (4) adaptée pour recevoir le câble électrique (2) et une partie de connexion pour terminal (6) adaptée pour être connectée au terminal (3), dans lequel le corps tubulaire (8) est un corps tubulaire multicouches ayant une couche interne (9) d'un premier métal conducteur qui forme une surface interne (17) du corps tubulaire (8) et une couche externe (10) d'un second métal conducteur différent du premier métal conducteur et qui forme une surface externe (18) du corps tubulaire (8), dans lequel la surface externe (18) forme une surface de contact de terminal de la partie de connexion au terminal (6) et la surface interne (17) forme une surface de contact de câble de la partie de connexion au câble (4), **caractérisé en ce que** le corps tubulaire (8) est un tube multicouches sélectionné dans le groupe constitué par:
- des tubes multicouches tréfilés,
des tubes multicouches co-extrudés,
des tubes multicouches laminés,
et lesdites couches externe (10) et interne (9)
sont en liaison métallurgique.
10. 2. Connecteur (1) selon la revendication 1, dans lequel la couche interne (9) et la couche externe (10) s'étendent substantiellement sur la totalité du corps tubulaire (8).
15. 3. Connecteur (1) selon la revendication 1 ou 2, dans lequel ladite couche externe (10) et ladite couche interne (9) sont en liaison métallurgique et s'interpénètrent localement.
20. 4. Connecteur (1) selon l'une des revendications précédentes, dans lequel la partie de connexion au terminal (5) est formée à partir d'une extrémité aplatie du corps tubulaire (8).
25. 5. Connecteur (1) selon l'une quelconque des revendications précédentes, dans lequel la partie de connexion au terminal (5) définit un trou traversant (11) adapté pour recevoir un boulon (12) ou une vis de connexion, ledit trou traversant (11) s'étendant à travers les couches externe et interne (10, 9).
30. 6. Connecteur (1) selon l'une quelconque des revendications précédentes, dans lequel la partie de connexion au câble (4) est formée à partir d'une extrémité ouverte du corps tubulaire (8), à l'opposé de l'extrémité aplatie, et adaptée pour recevoir une extrémité du câble électrique (2) ainsi que pour être

compressée autour d'elle, de manière à former un ajustement à pression.

7. Connecteur (1) selon l'une quelconque des revendications précédentes, dans lequel au moins une extrémité libre (14, 15) du corps tubulaire (8) la couche externe (10) s'étend au-delà de la couche interne (9), de sorte que seule la couche externe (10) est exposée à l'environnement extérieur. 5
8. Connecteur (1) selon l'une quelconque des revendications précédentes, dans lequel une section terminale de la couche externe (10) au-dessus de la couche interne est recourbée vers l'intérieur du corps tubulaire (8). 10 15
9. Connecteur (1) selon l'une quelconque des revendications précédentes, dans lequel la partie de connexion au terminal (6) est aplatie et définit un plan de contact (16) orienté de manière à ne pas créer d'intersection avec la partie de connexion au câble (4). 20
10. Connecteur (1) selon l'une quelconque des revendications précédentes, dans lequel ledit premier métal conducteur est sélectionné dans le groupe constitué par l'aluminium, le cuivre, l'acier, et ledit second métal conducteur est sélectionné dans le groupe constitué par le cuivre, l'acier, l'aluminium. 25
11. Connecteur (1) selon l'une quelconque des revendications précédentes, dans lequel l'épaisseur de la couche interne (9) est foncièrement uniforme et supérieure ou égale à 0,5 mm et l'épaisseur de la couche externe (10) est foncièrement uniforme et supérieure ou égale à 0,5 mm. 30 35
12. Connecteur (1) selon la revendication 11, dans lequel le corps tubulaire (8) est un corps tubulaire à deux couches, la couche interne (9) étant faite d'aluminium et la couche externe (10) étant faite de cuivre, dans lequel la couche interne (9) a une épaisseur allant de 0,5 mm à 10 mm et la couche externe (10) a une épaisseur allant de 0,5 mm à 2 mm. 40 45

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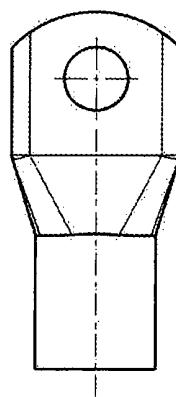


FIG. 1A

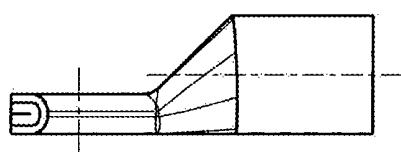


FIG. 1D

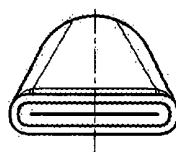


FIG. 1E

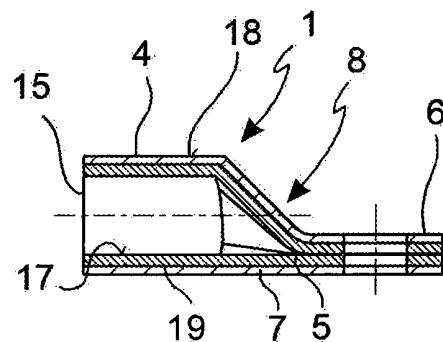


FIG. 1F

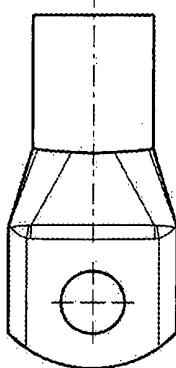


FIG. 1B

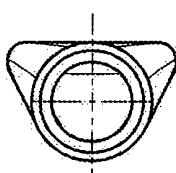


FIG. 1C

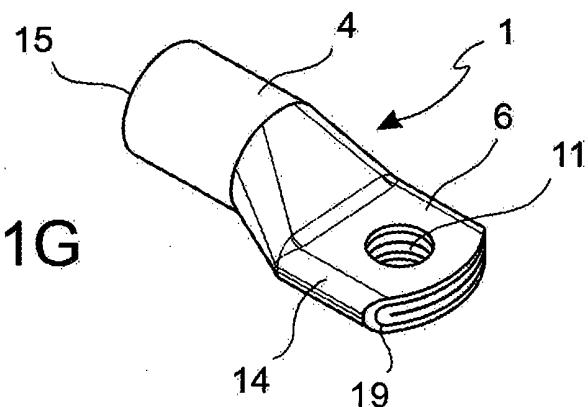


FIG. 1G

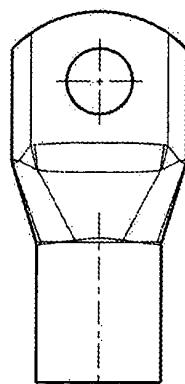


FIG. 2A

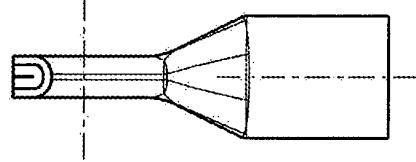


FIG. 2D

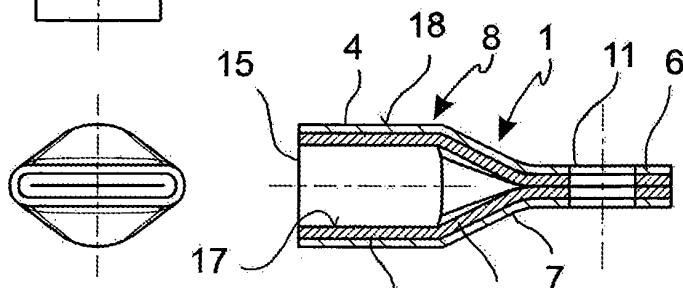


FIG. 2E

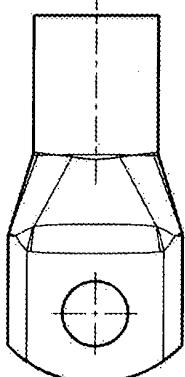


FIG. 2F

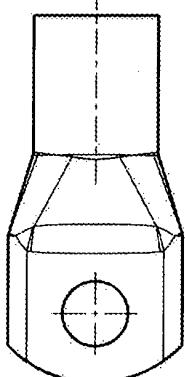


FIG. 2B

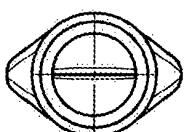


FIG. 2C

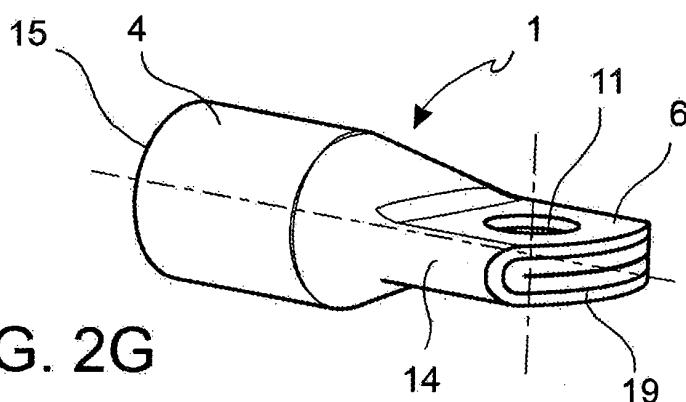


FIG. 2G

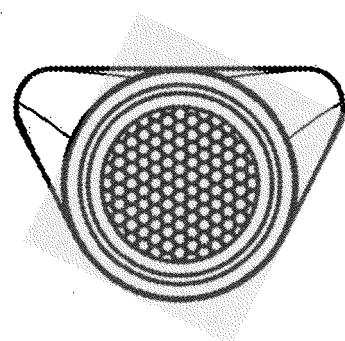
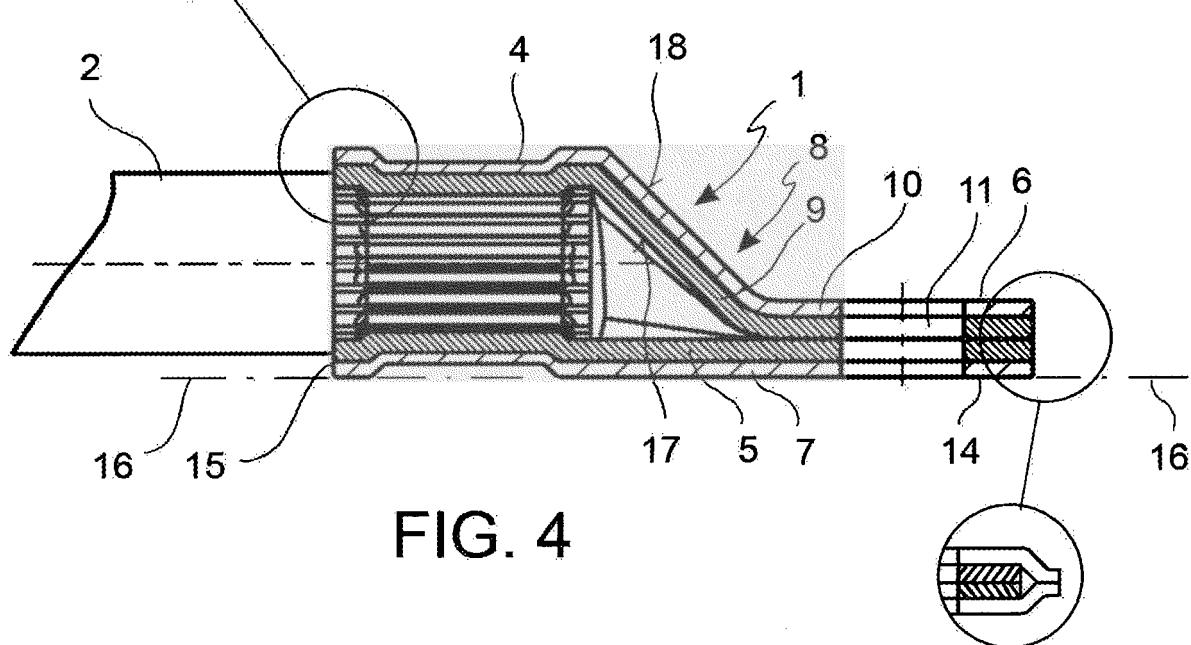
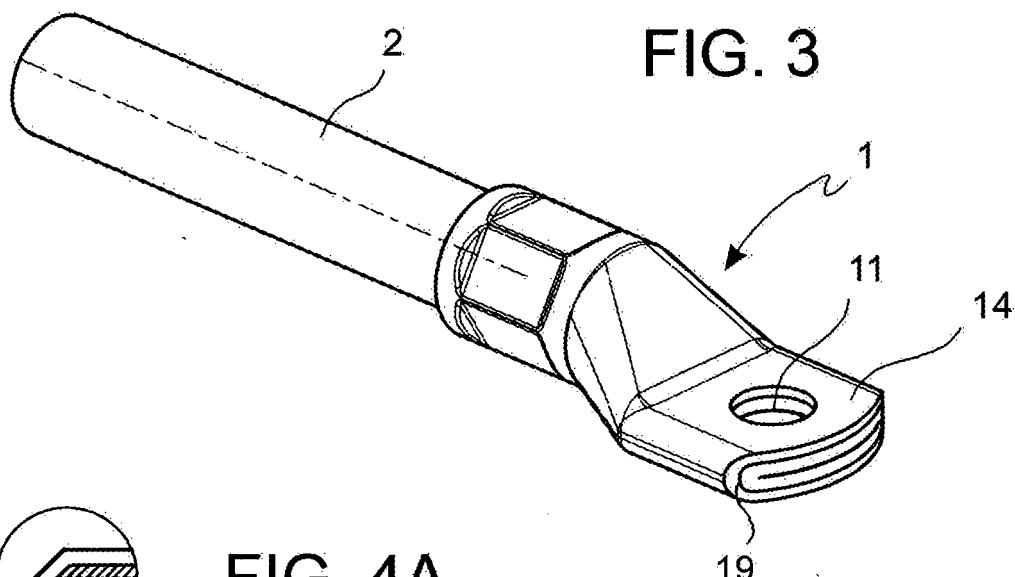


FIG. 4B

FIG. 5

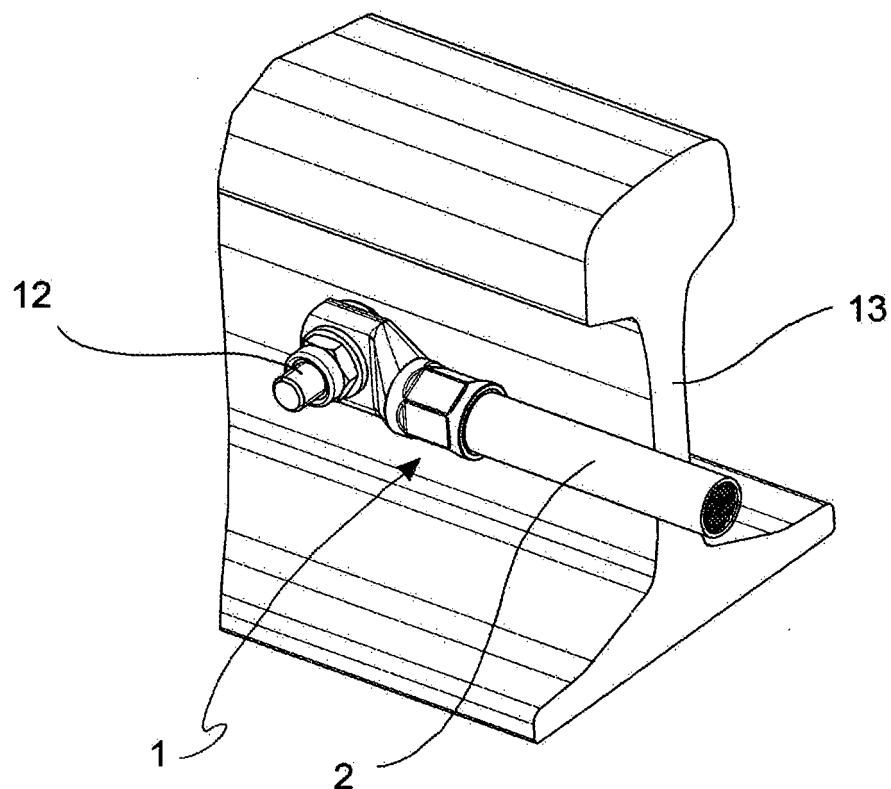


FIG. 6

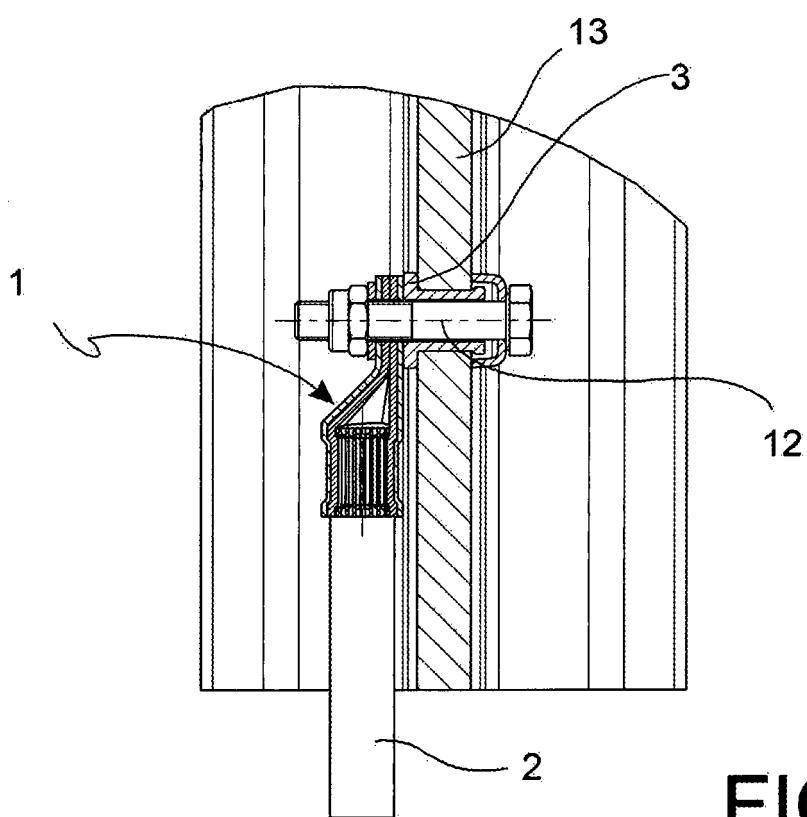


FIG. 7

REFERENCES CITED IN THE DESCRIPTION

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