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(71) Applicant: **Alcatel-Lucent Shanghai Bell Co., Ltd.**
Pudong Jinqiao
Shanghai 201206 (CN)

(72) Inventors:
- **Greiner, Martin**
  30179 Hannover (DE)
- **Mahlandt, Erhard**
  30179 Hannover (DE)

(74) Representative: **DREISS Patentanwälte PartG mbB**
Patentanwälte
Gerokstrasse 1
70188 Stuttgart (DE)

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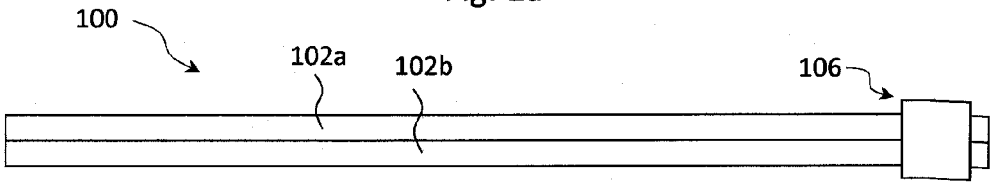
(54) Connecting element and method of manufacturing a connecting element

(57) The invention relates to a connecting element (100) for establishing an electrically conductive connection between two further elements (200, 300), particularly for connecting a body unit (200) of a grounding kit (1000) with a grounding element (300), wherein said connecting element (100) comprises at least two layers (102a, 102b) of electrically conductive material, wherein at least two layers (102a, 102b) comprise different material.

Fig. 1a



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Description

Field of the invention

[0001] The present invention relates to a connecting element for establishing an electrically conductive connection between two further elements. The invention further relates to a method of manufacturing such connecting element.

Background

[0002] Connecting elements of the aforementioned type are e.g. used as part of grounding kits for connecting a coaxial cable or a cable of another type in outdoor applications to a ground potential. Especially, such grounding kits may be used for grounding cables of cellular base stations and broadcast systems and the like. Such grounding is necessary to protect people and equipment from damages in case of lightning strikes and to prevent electrical potential differences to build up between the cable and other devices.

[0003] Disadvantageously, conventional grounding kits and their connection elements comprise crimp joints between different electrical conductors which are to be connected with each other. These crimp joints are comparatively complex to manufacture and do not provide for a reliable mechanical and electrical connection of elements under certain operational conditions.

[0004] Thus, it is an object of the present invention to provide an improved connecting element and an improved method of manufacturing a connecting element which avoid the disadvantages of the prior art.

Summary

[0005] According to the present invention, regarding a connecting element, this object is achieved in that said connecting element comprises at least two layers of electrically conductive material, wherein at least two layers comprise different material. I.e., according to one embodiment, a first layer of the connecting element is provided which comprises a first material, and a second layer of the connecting element is provided which comprises a second material different from said first material.

[0006] According to a preferred embodiment, the two or more layers of the connecting element are arranged in a stacked configuration such that a sandwich-type assembly is obtained.

[0007] According to a further embodiment, at least one layer of the connecting element may comprise a plurality of materials. However, according to further preferred embodiments, at least one layer of the connecting element is made of a specific material, i.e. does not comprise substantial portions of further materials.

[0008] According to a preferred embodiment, at least one layer, but preferably each layer, is comprised of a portion of sheet metal made of the respective material. According to a further embodiment, alternatively or in addition, at least one layer may be made of material other than sheet metal, as long as sufficient electrical conductivity is ensured.

[0009] According to a further preferred embodiment, at least one layer or the sheet metal which represents said layer, respectively, comprises a substantially rectangular shape wherein a width and a length of said layer are large compared to a layer thickness of the respective layer. For example, if L defines a length and W defines a width of the basically rectangular portion of sheet metal defining a specific layer, the thickness d of said layer is defined by $d < L/10$ and/or $d < W/5$. Thus, it is ensured, that the respective layer may easily be bent, so that an increased flexibility for mounting the connecting element is given in contrast to conventional solutions which comprise massive metal bars for implementing a connecting element.

[0010] According to a further embodiment, length L and width W may comprise a ratio of $L / W > 10$.

[0011] Advantageously, the stacked configuration of at least two layers of the connecting element according to an embodiment is mechanically flexible as opposed to monolithic connecting elements found in prior art, which facilitates mounting in the field and avoids additional machining for adapting the connecting element to different target systems.

[0012] A particular advantage of the connecting element according to the embodiments is the fact that at least two layers comprise different material which enables to combine materials with different properties, preferably regarding mechanical stability, in particular tensile strength, and regarding electrical conductivity.

[0013] For example, according to the principle of the embodiments, connecting elements may be provided which comprise a very good (i.e., high) electrical conductivity and which are thus ideally suited for grounding purposes or for establishing other electrical connections (i.e., other than to ground potential). At the same time, the connecting elements according to the embodiments comprise a comparatively high tensile strength contributing to a mechanically robust configuration. For example, according to some embodiments, maximum tensile strengths for the connecting element may be attained which are much higher than the tensile strength of conventional connecting elements comprising crimp joints.

[0014] According to a further preferred embodiment, at least one layer comprises copper and/or aluminium, whereby a low electric, i.e. Ohmic, resistance is attained. According to a further embodiment, a whole, i.e. complete, layer of the connecting element may be made of a specific material such as e.g. copper or aluminium. However, it is also possible to provide other material for implementing the layer such as alloys of copper and/or aluminium and the like. According to a further embodiment, a layer in the sense of the embodiments may also comprise different components such as sub-layers or the like, i.e. a layer in the sense of the embodiments is not restricted to a monolithic assembly as such.

[0015] According to a further preferred embodiment, at least one layer comprises a material other than copper or aluminium, preferably a material with a higher tensile strength than that of copper or aluminium. Particularly, it is preferred if at least one layer of the connecting element comprises stainless steel. As such, stainless steel comprises a lower electrical conductivity in comparison to copper or aluminium, however it comprises an increased tensile strength. Thus, a combination of aluminium and stainless steel (or copper and stainless steel) is particularly preferred, because it offers both a good electrical conductivity and a good maximum tensile strength thus withstanding high tensile forces.

[0016] According to a further embodiment, a plurality of layers of the connecting element may be made of the same material or may comprise the same material. For example, it is possible to provide a connecting element which comprises a first number of layers made of aluminium, and at least one further layer which is made of a different material, for example stainless steel or the like.

[0017] According to a further embodiment, there is no restriction regarding the order of layers or materials within the stacked configuration of the plurality of layers defining the connecting element. However, according to one embodiment, in order to avoid contact corrosion between adjacent conductors such as the connecting element and e.g. a grounding element (for example a foundation earth electrode) the connecting element is to be connected to, it may be advantageous to place e.g. stainless steel material in the outer layers of the stack configuration of the connecting element, and to place less noble materials in the inner layers of the connecting element.

[0018] For example, the outer layers of the connecting element could be made of stainless steel, whereas the inner layers could be made of copper of aluminium. Alternatively or in addition, the outer layers may even comprise a noble metal or at least a thin (i.e. galvanized) layer of noble metal such as silver to prevent contact corrosion.

[0019] According to a further embodiment, at least two layers have a same layer thickness, which advantageously enables to provide a large number of identical components for assembling a connecting element according to the embodiments. Alternatively, it is also possible that at least two layers have different layer thickness which provides further degrees of freedom regarding the construction of the connecting element.

[0020] Of course, it is also possible to provide different groups of layers, wherein each group comprises layers of identical thickness, and wherein different groups are associated with different layer thicknesses.

[0021] According to a further embodiment, at least one layer of the connecting element is at least partly surrounded by a jacket, which may e.g. be made of electrically isolating material. According to a preferred embodiment, all layers of the connecting element are commonly surrounded by a jacket made of electrically isolating material which protects the layers of the connecting element from environmental influences. A common jacket of non-isolating, i.e. conductive material, such as a metallic mesh or the like, is also possible, which contributes to mechanical stability of the stack arrangement of the connecting element without affecting mechanical flexibility.

[0022] I.e., a jacket may also be configured to provide mechanical stability for the stacked configuration of the various layers of the connecting element.

[0023] For example, it is possible that a common surrounding isolating jacket is the only means for keeping the various layers of the connecting element together in their stacked configuration. Alternatively or in addition thereto, a non-isolating jacket or metallic clamps or the like are also possible.

[0024] Of course, additional means for stabilizing the stacked configuration may also be provided. Such means may e.g. comprise soldering joints and/or welding joints and/or riveted bolts between one or more adjacent layers, clamps, screw connections comprising one or more adjacent layers and the like.

[0025] According to a further preferred embodiment, said connecting element comprises a mounting section for connection to said further element. Said mounting section may e.g. be configured for mechanical and electrically conductive connection to a body unit of a grounding kit or a grounding element of a building such as an antenna tower and the like.

[0026] According to a further embodiment, said mounting section comprises at least one hole whereby a screw connection and/or fastening by means of a bolt and the like is enabled. Alternatively or additionally, a threaded bolt may also be provided at the mounting section. Advantageously, according to a further embodiment, at least one component of said mounting section, i.e. a threaded bolt, may form an integral part of one or more layers of the connecting element, whereby superior mechanical stability and a low Ohmic resistance is ensured.

[0027] According to a further embodiment, for defining said mounting section, two groups of said layers of the connecting element are formed, wherein in an end portion of said connecting element both groups are arranged with a non-vanishing distance between each other to define a receiving section for receiving a component of said further element. I.e., in the receiving section, which is located between the different groups of connecting elements, a connecting element of a body unit of the grounding kit or the grounding element or the like may be arranged for connection with the connecting element.

[0028] According to a further embodiment, a cross-section of the connecting element, particularly an aggregated cross-section of all electrically conductive components or layers, respectively, is equal to or greater than about 10 mm^2 (square millimeter), which ensures a sufficient electric conductivity for handling electric currents, particularly surge currents during a lightning strike, without damage to the connecting element.

[0029] According to a further embodiment, the connecting element comprises a tensile strength (also referred to as "ultimate tensile strength", UTS) of about 2500 Newton or more. The tensile strength is also denoted as physical parameter "Rm" and defines the maximum stress that a material can withstand while being stretched before breaking. I.e., according to a preferred embodiment, the connecting element is designed such that it can withstand tensile forces of about 2500 Newton or more without breaking.

[0030] According to a further embodiment, the connecting element comprises an electrical resistance R of about 2 mOhm/m (milliohm per meter) or less, which ensures a particularly low voltage drop in case of surge currents.

[0031] A further solution to the object of the present invention is given by a grounding kit for connecting a cable to a grounding element. Such a grounding kit may e.g. be used for grounding a conductor of a cable or the like. Of course, instead of grounding (i.e. connecting to an electrical ground potential), generally, the grounding kit may also be used to establish an electrically conductive connection between different conductors, wherein said conductors are not required to comprise ground potential or any kind of reference potential.

[0032] According to an embodiment, the grounding kit comprises at least one connecting element according to the embodiments, and the grounding kit further comprises a body unit which is configured for establishing an electrically conductive connection with a component of said cable.

[0033] According to a further embodiment, said connecting element is detachably fixed to said body unit, particularly by means of one or more screws and/or a clamping mechanism, which facilitates easy installation of the grounding kit or the connecting element in the field. I.e., connecting elements of different lengths may be chosen to be connected with the body unit.

[0034] Particularly, it is beneficial to avoid crimping joints, which are comparatively difficult to establish with high quality, at least in the field, and which do not exhibit the same high tensile strength as the screw or bolt connections proposed according to the embodiments.

[0035] According to a further embodiment, said connecting element is non-detachably fixed to said body unit, particularly by means of welding, preferably ultrasonic welding. Thus, both the body unit and the connecting element of the grounding kit may form a monolithic conductor arrangement which is particularly robust.

[0036] According to a further embodiment, said body unit of the grounding kit enables to establish a watertight electrically conductive connection with the component of said cable. This may e.g. be achieved by said body unit comprising sealing means such us EPDM (ethylene propylene diene monomer) and/or other types of rubber and/or mastic.

[0037] A further solution to the object of the present invention is given by a method of manufacturing a connecting element for establishing an electrically conductive connection between two further elements, particularly for connecting the body unit of a grounding kit with a grounding element, wherein at least two layers of electrically conductive material are provided, wherein at least two of said layers comprise different material.

Brief description of the figures

[0038] Further features, aspects and advantages of the present invention are given in the following detailed description with reference to the drawings in which:

Figure 1a	depicts a side view of a connecting element according to a first embodiment,
Figure 1b to 1d	each depict a further embodiment of the connecting element,
Figure 2a to 2c	depict different embodiments of end sections of the connecting element,
Figure 3a	depicts a side view of an end portion of the connecting element according to an embodiment connected to a cable,
Figure 3b	depicts a partial cross-section of the configuration according to Figure 3a, and
Figure 4	depicts a schematic view of an operational scenario of a grounding kit according to an embodiment.

Description of the embodiments

[0039] Figure 1a depicts a schematic side view of a connecting element 100 according to a first embodiment. The connecting element 100 serves for establishing an electrically conductive connection between two further elements, which are not depicted in figure 1a.

[0040] It is to be noted that the drawings comprise schematic depictions of the embodiments and that the various elements depicted in the figures are not necessarily drawn to scale.

[0041] The connecting element 100 according to figure 1a comprises a first layer 102a of a first material, and a second layer 102b of a second material, which is different from the first material. According to a preferred embodiment, the various layers 102a, 102b of the connecting element 100 are arranged in a stacked configuration as depicted by figure 1a, i.e. the first layer is arranged on top of the second layer in the depiction of figure 1a. According to a further embodiment, both layers 102a, 102b are preferably made of sheet metal, wherein the first layer 102a is for example made of stainless steel, and wherein the second layer 102b is made of aluminium.

[0042] The material combination of stainless steel and aluminium offers a comparatively high mechanical robustness, particularly a high tensile strength, due to the stainless steel layer 102a. Moreover, a good electrical conductivity is ensured by using aluminium for the second layer 102b.

[0043] Further, the layer configuration of a plurality of layers 102a, 102b, each of which may e.g. be comparatively thin such as e.g. 0.1 mm to e.g. 2.0 mm, advantageously results in a high mechanical flexibility so that the connecting element 100 can easily be bent for installation purposes.

[0044] According to a further embodiment, at least one mounting section 106 is provided, which enables to establish a mechanical and/or electrical contact between the connecting element 100 and further elements to be connected thereto.

[0045] Figure 1b depicts a connecting element 100a according to a further embodiment. According to this embodiment, the first layer 102a comprises a layer thickness d2, whereas the second layer 102b comprises a layer thickness d1. Presently, the layer thickness d2 is larger than the layer thickness d1.

[0046] According to a further embodiment, each layer 102a, 102b may comprise a substantially rectangular cross-section. However, different layers may also exhibit different cross-sections or cross-sectional shapes.

[0047] As can be seen from figure 1b, according to a further embodiment, the mounting section 106 may also comprise one or more holes arranged within said layers 102a, 102b. Presently, each of both opposing end sections 104a, 104b comprises one hole, which enables mounting of said connecting element 100a by means of a bolt or a threaded bolt/screw connection or the like.

[0048] Figure 1c depicts a schematic side view of a further embodiment 100b, wherein the connecting element 100b comprises seven layers 102c, ..., 102d, which ensures a good electrical conductivity and a high mechanical flexibility. In contrast to braided wires of conventional connecting elements, the embodiment 100b does not require any crimp joints, but may rather also be attached to other elements by means of screws or bolts, which ensures both a low contact resistance and a mechanical robust connection to these other elements.

[0049] Figure 1d depicts a connecting element 100c according to a further embodiment.

[0050] The outer layers 102a, 102c (i.e. in Fig. 1d the top and bottom layers) of the connecting element 100c according to figure 1d are preferably made of stainless steel, wherein an intermediate layer 102b that is arranged within said stacked configuration between the outer layers 102a, 102c is e.g. made of copper or aluminium. Thus, a good electrical conductivity is ensured, while it is prevented that material of the intermediate layer 102b may be contacted at an outer surface of the connecting element 100c (with exception of the end sections of the connecting element 100c).

[0051] This advantageously avoids contact corrosion effects since stainless steel layers 102a, 102c reduce this undesired effect. At the same time, the stainless steel layers 102a, 102c advantageously contribute to the tensile strength of the connecting element 100c, while the intermediate aluminium or copper layer 102b effects a good electrical conductivity.

[0052] Figure 2a shows an end section 104b of a connecting element according to a further embodiment. As can be seen from figure 2a, a bolt or threaded bolt 106a may be provided integrally with said third layer 102c. This may e.g. be attained by providing a sheet metal for defining the layer 102c, by providing a threaded bolt 106a of the same or a different, but weldable, material, and by welding both components 102c, 106a to form one single monolithic component.

[0053] Further layers 102a, 102b are also provided, wherein layer 102a also is made of stainless steel to avoid contact corrosion, and wherein layer 102b is again made of aluminium or copper.

[0054] The end section 104b as depicted by figure 2a can e.g. be used for easy mounting of the connecting element to a further element which e.g. comprises a hole or nut portion that can cooperate with said threaded bolt 106a.

[0055] Figure 2b depicts a schematic view of one single layer of a connecting element according to a further embodiment. The layer 102a has in its end section at least one hole 106b which enables mounting by means of a screw connection or the like. Optionally, at least one further hole may also be provided in the end section.

[0056] According to a further preferred embodiment, at least one layer, presently e.g. layer 102a of figure 2b, or the sheet metal which represents said layer 102a, respectively, comprises a substantially rectangular shape wherein a width W and a length L of said layer 102a are large compared to a layer thickness d2 (fig. 1b) of the respective layer. For example, if L defines a length and W defines a width of the basically rectangular portion of sheet metal defining a specific layer 102a, the thickness of said layer is defined by $d < L/10$ and/or $d < W/5$. Thus, it is ensured, that the respective layer 102a may easily be bent, so that an increased flexibility for mounting the connecting element is given in contrast to conventional solutions which comprise massive metal bars for implementing a connecting element.

[0057] According to a further embodiment, length L and width W may comprise a ratio of $L / W > 10$, which results in a rectangular strip-type shape.

[0058] Figure 2c schematically depicts a side view of a connecting element 100d according to a further embodiment. In its end section 104b, three adjacent layers of the stack configuration of connecting element 100d are combined to form a first group g1 of layers, and three further layers of the connecting element 100d are combined to define a second group g2. Presently, the groups g1, g2 together comprise all six layers of the connecting element 100d. However, according to further embodiments, it is not required that all layers of the connecting element 100d are comprised of one of the groups g1, g2.

For example, between groups g1, g2 or outside thereof (not shown) further layers may be provided which contribute to an aggregated cross-section area and thus to electrical conductivity, but which do not contribute to mounting the connecting element 100d. Such further layers may also comprise a reduced length L (fig. 2b) as compared to the layers forming part of the groups g1, g2 to prevent them from extending into the end section 104b.

[0059] As depicted by figure 2c, the end sections of the different groups g1, g2 are spaced apart by a non-vanishing distance d3 from each other, whereby a receiving section 106c is defined. The end sections 104b of the groups g1, g2 may also comprise through holes 106b for applying a screw connection to a further mounting element that can be introduced into the receiving section 106c.

[0060] According to a further embodiment, any of the end sections depicted by figure 2a, figure 2b, figure 2c may be applied to either one end portion 104a, 104b or to both end portions 104a, 104b of any connecting element described above. I.e., according to an embodiment, a connecting element may have similar or identical end portions or mounting sections 106 or different end portions or mounting sections.

[0061] Figure 3a depicts connecting element 100d in a mounting position at a body unit 200, which is part of a grounding kit for a cable 400.

[0062] As can be seen, the body unit 200 is of the clamp type and comprises a basically C-shaped cross section, also cf. figure 3b.

[0063] The body unit 200 is mounted on the cable 400 such that a radially inner section of the body unit 200 (not shown) establishes electrically conductive contact with an outer conductor of the cable (not shown) of the cable 400. For this purpose, portions of an isolating jacket (not shown) of cable 400 must be removed to enable said contact.

[0064] The connecting element 100d is connected to the body unit 200 by means of two screws 106d, which are received in respective holes 106b (figure 2c) of the connecting element 100d. Due to its plurality of single layers, the connecting element 100d is mechanically flexible and can thus easily be mounted at the body unit 200 and the cable 400. Nevertheless, due to the aggregated cross section of the multiple layers, a good electrical connectivity is achieved. Moreover, a good tensile strength is also attained, because one or more layers may be formed of material having a greater tensile strength than the good electrical conductors aluminium or copper.

[0065] Moreover, the screw connection 106d can easily be made in the field, whereby costs for installing the connecting element 100d and the body unit 200 are reduced.

[0066] As already mentioned above, figure 3b depicts a partial cross-section of the arrangement of figure 3a. It can be seen that by means of the screws 106d (figure 3a) both the clamping mechanism of the body unit 200 is locked around the cable 400 and the electrical and mechanical connection between the body unit 200 and the connecting element 100d (figure 3a) is established by means of the screws 106d, which is advantageous since no further components are required for locking the connecting element 100d to the body unit 200 and for locking the body unit 200 to the cable 400. The configuration of fig. 3a has the further advantage of a very large contact surface between electrically conducting portions of the body unit 200 and the connecting element 100d, since surface portions of both groups g1, g2 of layers are used for establishing the contact, whereby a contact resistance is further reduced. Moreover, since both end sections of the C-shaped clamp element of the body unit 200 are contacted by a respective layer group g1, g2, the overall Ohmic resistance between the cable 400 and the connecting element 100d is even further reduced

[0067] Figure 4 depicts a schematic view of an operational scenario of a grounding kit 1000 according to an embodiment.

[0068] The grounding kit 1000 comprises e.g. a body unit 200 as explained above with reference to figure 3a, 3b and a connecting element according to any of the above explained embodiments.

[0069] Figure 4 depicts an antenna tower 440 which carries a remote radio head 420 that is connected to a base station antenna system 430. A base station unit 410 is arranged on a ground floor, i.e. in a separate building arranged close to the antenna tower 440. The cable 400 establishes an electric and/or optic connection between the base station unit 410 and the remote radio head 420. For protecting the units 410, 420, 430 against lightning strikes, the grounding kit 1000 according to the embodiments is provided which establishes an electrically conductive connection between e.g. a radially outer conductor of the cable 400, which may for example comprise a hybrid cable or a coaxial cable, and a grounding element 300 of the antenna tower 440, which may e.g. be integrated into a pedestal of the antenna tower 440 (for example as a foundation earth electrode) or which may be directly connected to a steel frame construction of the antenna tower 440 or the like.

[0070] For contacting the cable 400 or its outer conductor respectively, the body unit 200 as depicted by figure 3a, 3b is provided around the cable 400. An electrically conductive connection between the body unit 200 and the grounding element 300 of the antenna tower 440 is established by at least one connecting element according to the embodiments, which is not shown in figure 4. For example, connecting element 100d according to figure 3a may be used for establishing an electrically conductive connection between the body unit 200, the cable 400, and the grounding element 300 of the antenna tower 440.

[0071] According to a further preferred embodiment, more than one grounding kit 1000 may be provided for a cable (i.e. feeder cable 400) as depicted by Fig. 4. A first grounding kit may e.g. be placed close to the antenna, a second grounding kit may e.g. be placed as depicted by Fig. 4, and a third grounding kit may e.g. be placed close to the shelter 410, i.e. at a shelter entry, to provide further improved lightning protection for all components.

[0072] Due to its mechanical flexibility, which is enabled by the multi-layer construction according to the embodiments, an easy installation of the connecting element 100d is enabled.

[0073] Moreover, due to the material combination over the various layers according to the embodiments, both a good electrical conductivity, i.e. a low Ohmic resistance, and a large tensile strength is achieved for the connecting element 100, 100a, 100b, 100c, 100d, which is important since tensile forces resulting from electromagnetic field forces that may occur during a lightning strike may amount up to 2400 Newton and even more.

[0074] In contrast to conventional connecting elements, which require crimp connections, the connecting element according to the embodiments can be attached to and locked at further elements 200, 300 by using screw connections or bolts or the like, which are more robust than the crimp connections.

[0075] A particular advantage of the connecting element according to the embodiments is its high mechanical flexibility which facilitates installation on site, i.e. in the field.

[0076] According to an embodiment, by using dissimilar metals the highly conductive layers 102b (figure 1d) and the mechanical strong material layers (102a, 102c) are calculated such that on one hand the effective conductivity of the overall connecting element is equivalent to or higher than what is required by the relevant standards, which e.g. require a copper cross-section of 16 mm^2 or above for sufficient electrical conductivity.

[0077] On the other hand, the overall tensile strength of the connecting element should be high enough to survive the mechanical stress occurring during a lightning strike (tensile forces due to currents of up to 100 kilo Ampere flowing through the connecting element and their magnetic forces).

[0078] According to a further embodiment, the connecting element may be connected to a ground bar 300 of a building such as an antenna tower 440 or the like, the ground bar 300 usually being made of copper or stainless steel. In many cases, the ground bar may also be implemented in the form of a galvanized steel bar with a zinc surface. To avoid contact corrosion between the ground bar 300 and the connecting element according to the embodiments, the preferred embodiment proposes to use outer layers 102a, 102c (figure 1d) of stainless steel (or even noble metal or noble metal coating, i.e. silver coating), and one or more intermediate layers 102b of aluminium or copper, whereby contact corrosion is minimized and at the same time a low resistance is obtained.

[0079] Due to avoiding crimp joints, the connecting element according to the embodiments provides higher product reliability as compared to conventional systems. At the same time, the electrical contact resistance is reduced which leads to an improved lightning protection.

[0080] Also, due to the basically rectangular shape of the single layers and of the resulting stack of layers forming the connecting element according to some embodiments, a comparatively large outer surface is given for the connecting element, which improves heat dissipation thus further enabling larger maximum currents for the connecting element according to the embodiments.

[0081] Advantageously, the layer construction according to the embodiments may even be configured in the field, i.e. by cutting respective preformed pieces of sheet metal. Moreover, holes may e.g. be applied to the sheet metal by punching or drilling for enabling a screw connecting and the like. Advantageously, the layers of the connecting element according to an embodiment can be adapted with simple means or tools to different sizes of through holes and regarding the number of holes for the screw connections. Alternatively or in addition to screw connections, one or more layers of the connecting element may e.g. be non-detachably attached to the body unit 200 of the grounding kit, i.e. by welding, wherein a cost-effective ultrasonic welding process may be employed.

[0082] According to a further aspect, it is also possible to provide a connecting element with a multi-layer configuration, wherein all layers comprise - or are made of - the same material.

[0083] According to a further embodiment, a cross-section of the connecting element 100, particularly an aggregated cross-section of all electrically conductive components or layers 102a, 102b, respectively, is equal to or greater than about 10 mm^2 (square millimeter), which ensures a sufficient electric conductivity for handling electric currents, particularly surge currents during a lightning strike, without damage to the connecting element 100.

[0084] According to a further embodiment, the connecting element 100 comprises a tensile strength (also referred to as "ultimate tensile strength", UTS) of about 2500 Newton or more. The tensile strength is also denoted as physical parameter "Rm" and defines the maximum stress that a material can withstand while being stretched before failing / breaking. I.e., according to a preferred embodiment, the connecting element 100 is designed such that it can withstand tensile forces of about 2500 Newton or more without breaking.

[0085] According to a further embodiment, the connecting element 100 comprises an electrical resistance R of about 2 mOhm/m (milliohm per meter) or less.

[0086] Any combinations of the aforementioned embodiments are also possible. Particularly, the layer construction of the connecting element advantageously enables different layers to contribute to an overall, i.e. aggregated, cross-section and/or electric conductivity and/or tensile strength, wherein contributions to one or more of these parameters of individual layers may differ from those contributions of another layer. E.g., according to an embodiment, at least one layer 102a may primarily contribute to an overall low electric resistance, while another layer 102b may primarily contribute to an overall high tensile strength.

[0087] The description and drawings merely illustrate the principles of the invention. It will thus be appreciated that those skilled in the art will be able to devise various arrangements that, although not explicitly described or shown herein, embody the principles of the invention and are included within its spirit and scope. Furthermore, all examples recited herein are principally intended expressly to be only for pedagogical purposes to aid the reader in understanding the principles of the invention and the concepts contributed by the inventor(s) to furthering the art, and are to be construed as being without limitation to such specifically recited examples and conditions. Moreover, all statements herein reciting principles, aspects, and embodiments of the invention, as well as specific examples thereof, are intended to encompass equivalents thereof.

Claims

1. Connecting element (100) for establishing an electrically conductive connection between two further elements (200, 300), particularly for connecting a body unit (200) of a grounding kit (1000) with a grounding element (300), wherein said connecting element (100) comprises at least two layers (102a, 102b) of electrically conductive material, wherein at least two layers (102a, 102b) comprise different material.

2. Connecting element (100) according to claim 1, wherein at least one layer (102a) comprises copper and/or aluminium.

3. Connecting element (100) according to one of the preceding claims, wherein at least one layer (102c) comprises a material other than copper or aluminium, preferably a material with a higher tensile strength than that of copper or aluminium, particularly stainless steel.

4. Connecting element (100) according to one of the preceding claims, wherein a plurality of layers are made of the same material.

5. Connecting element (100) according to one of the preceding claims, wherein outer layers (102a, 102c) of said connecting element (100) are made of stainless steel, and wherein at least one inner layer (102b) of said connecting element (100), which is arranged between said outer layers (102a, 102c), is made of aluminium or copper.

6. Connecting element (100) according to one of the preceding claims, wherein at least two layers have a same or different layer thickness (d1, d2).

7. Connecting element (100) according to one of the preceding claims, wherein at least one layer, preferably all layers, are at least partly surrounded by a jacket.

8. Connecting element (100) according to one of the preceding claims, wherein said connecting element (100) comprises a mounting section (106) for connection to said further element (200, 300).

9. Connecting element (100) according to claim 8, wherein said mounting section (106) comprises at least one hole (106b) and/or a, preferably threaded, bolt (106a).

10. Connecting element (100) according to claim 8 or 9, wherein, for defining said mounting section (106), two groups (g1, g2) of said layers are formed, and wherein in an end portion (104b) of said connecting element (100) both groups (g1, g2) are arranged with a non-vanishing distance (d3) between each other to define a receiving section (106c) for receiving a component of said further elements (200, 300).

11. Connecting element (100) according to one of the preceding claims, wherein at least one of the following criteria is met:

a. a cross-section of the connecting element (100), particularly an aggregated cross-section of all electrically conductive components or layers (102a, 102b), respectively, is equal to or greater than about 10 square millimetre,
b. the connecting element (100) comprises a tensile strength, preferably an ultimate tensile strength, of about 2500 Newton or more,
c. the connecting element (100) comprises an electrical resistance of about 2 mOhm/m or less.

12. Grounding kit (1000) for connecting a cable (400) to a grounding element (300), wherein said grounding kit (1000) comprises at least one connecting element (100, 100a, 100b, 100c, 100d) according to one of the preceding claims, and wherein said grounding kit (1000) further comprises a body unit (200) configured for establishing an electrically conductive connection with a component of said cable (400).

13. Grounding kit (1000) according to claim 12, wherein said connecting element (100, 100a, 100b, 100c, 100d) is detachably fixed to said body unit (200), particularly by means of one or more screws (106d) and/or a clamping mechanism.

14. Grounding kit (1000) according to claim 12, wherein said connecting element (100, 100a, 100b, 100c, 100d) is non-detachably fixed to said body unit (200), particularly by means of welding, preferably ultrasonic welding.

15. Grounding kit (1000) according to one of the claims 12 to 14, wherein said body unit (200) enables to establish a watertight electrically conductive connection with a component of said cable (400).

16. Method of manufacturing a connecting element (100) for establishing an electrically conductive connection between two further elements (200, 300), particularly for connecting a body unit (200) of a grounding kit (1000) with a grounding element (300), wherein at least two layers (102a, 102b) of electrically conductive material are provided, wherein at least two of said layers (102a, 102b) comprise different material.

Amended claims in accordance with Rule 137(2) EPC.

1. Connecting element (100) for establishing an electrically conductive connection between two further elements (200, 300), for connecting a body unit (200) of a grounding kit (1000) with a grounding element (300), wherein said connecting element (100) comprises at least two layers (102a, 102b) of electrically conductive material, wherein at least two layers (102a, 102b) comprise different material, wherein said connecting element (100) is mechanically flexible.

2. Connecting element (100) according to claim 1, wherein at least one layer (102a) comprises copper and/or aluminium.

3. Connecting element (100) according to one of the preceding claims, wherein at least one layer (102c) comprises a material other than copper or aluminium, preferably a material with a higher tensile strength than that of copper or aluminium, particularly stainless steel.

4. Connecting element (100) according to one of the preceding claims, wherein a plurality of layers are made of the same material.

5. Connecting element (100) according to one of the preceding claims, wherein outer layers (102a, 102c) of said connecting element (100) are made of stainless steel, and wherein at least one inner layer (102b) of said connecting element (100), which is arranged between said outer layers (102a, 102c), is made of aluminium or copper.

6. Connecting element (100) according to one of the preceding claims, wherein at least two layers have a same or different layer thickness (d1, d2).

7. Connecting element (100) according to one of the preceding claims, wherein at least one layer, preferably all layers, are at least partly surrounded by a jacket.

8. Connecting element (100) according to one of the preceding claims, wherein said connecting element (100) comprises a mounting section (106) for connection to said further element (200, 300).

9. Connecting element (100) according to claim 8, wherein said mounting section (106) comprises at least one hole (106b) and/or a, preferably threaded, bolt (106a).

10. Connecting element (100) according to claim 8 or 9, wherein, for defining said mounting section (106), two groups (g1, g2) of said layers are formed, and wherein in an end portion (104b) of said connecting element (100) both groups (g1, g2) are arranged with a non-vanishing distance (d3) between each other to define a receiving section (106c) for receiving a component of said further elements (200, 300).

11. Connecting element (100) according to one of the preceding claims, wherein at least one of the following criteria is met:

a. a cross-section of the connecting element (100), particularly an aggregated cross-section of all electrically conductive components or layers (102a, 102b), respectively, is equal to or greater than about 10 square millimetre,
b. the connecting element (100) comprises a tensile strength, preferably an ultimate tensile strength, of about 2500 Newton or more,
c. the connecting element (100) comprises an electrical resistance of about 2 mOhm/m or less.

12. Grounding kit (1000) for connecting a cable (400) to a grounding element (300), wherein said grounding kit (1000) comprises at least one connecting element (100, 100a, 100b, 100c, 100d) according to one of the preceding claims, and wherein said grounding kit (1000) further comprises a body unit (200) configured for establishing an electrically conductive connection with a component of said cable (400).

13. Grounding kit (1000) according to claim 12, wherein said connecting element (100, 100a, 100b, 100c, 100d) is detachably fixed to said body unit (200), particularly by means of one or more screws (106d) and/or a clamping mechanism.

14. Grounding kit (1000) according to claim 12, wherein said connecting element (100, 100a, 100b, 100c, 100d) is non-detachably fixed to said body unit (200), particularly by means of welding, preferably ultrasonic welding.

15. Grounding kit (1000) according to one of the claims 12 to 14, wherein said body unit (200) enables to establish a watertight electrically conductive connection with a component of said cable (400).

16. Method of manufacturing a connecting element (100) for establishing an electrically conductive connection between two further elements (200, 300), namely for connecting a body unit (200) of a grounding kit (1000) with a grounding element (300), wherein at least two layers (102a, 102b) of electrically conductive material are provided, wherein at least two of said layers (102a, 102b) comprise different material, wherein said at least two layers (102a, 102b) of electrically conductive material are provided such that said connecting element (100) is mechanically flexible.

Fig. 1a

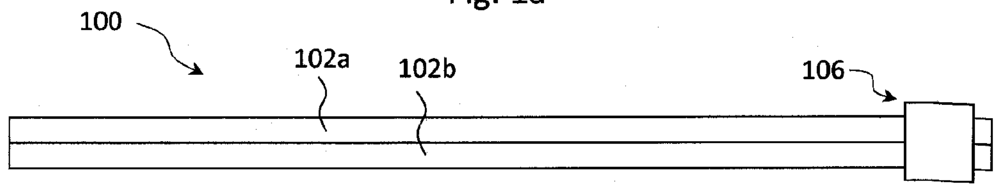


Fig. 1b

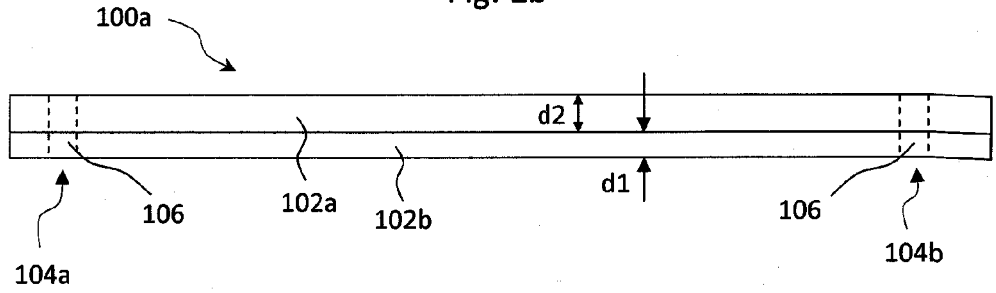


Fig. 1c

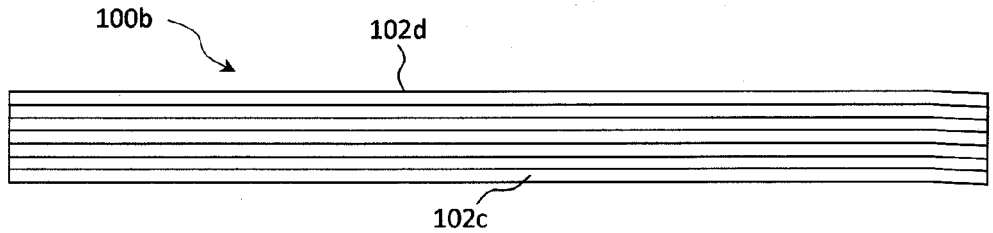


Fig. 1d

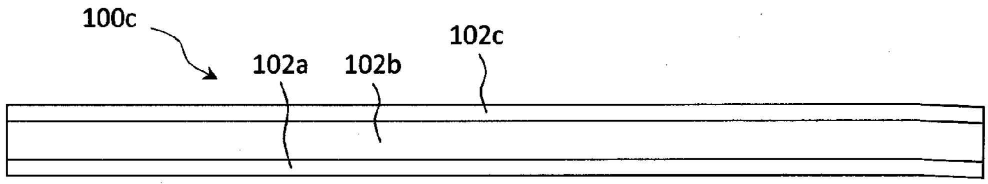


Fig. 2a

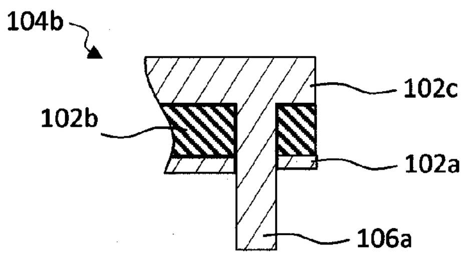


Fig. 2b

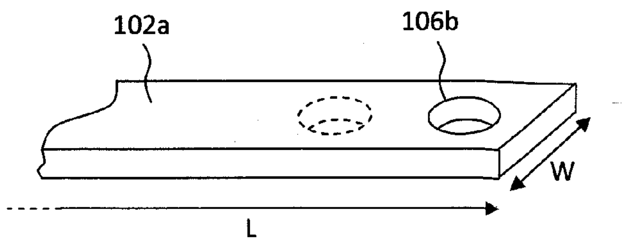


Fig. 2c

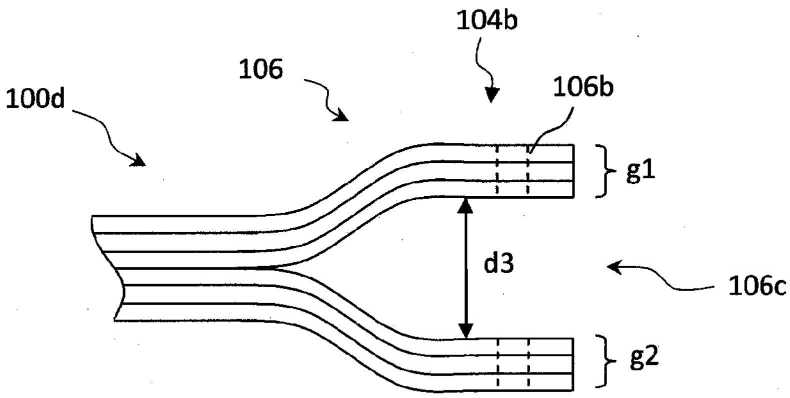


Fig. 3a

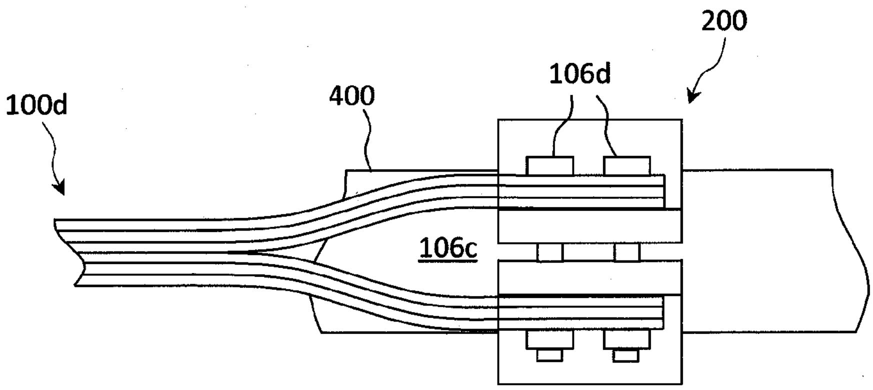


Fig. 3b

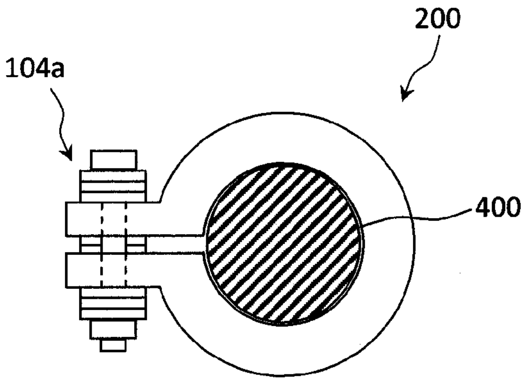
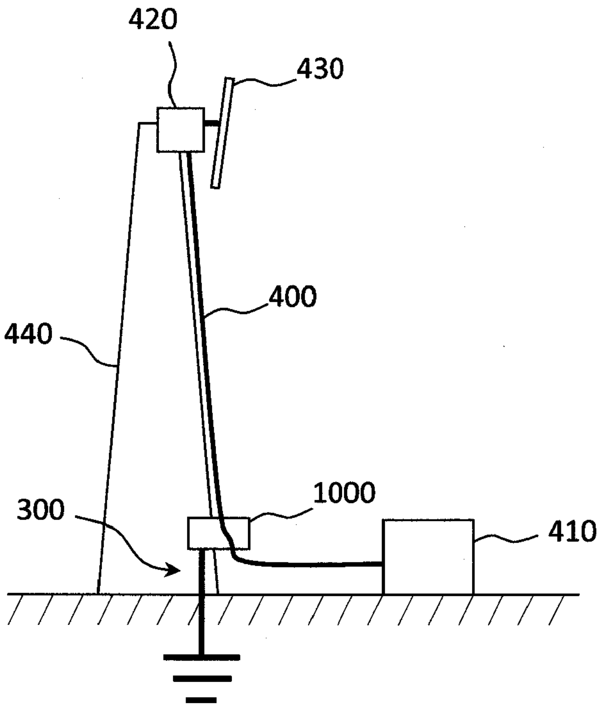


Fig. 4



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EUROPEAN SEARCH REPORT

Application Number
EP 13 15 3250

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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	5 June 2013	Salojärvi, Kristiina

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