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(54) **CABLE SHIELD CLAMP**

(57) Cable shield clamp (1) for contacting a metal layer cable shield (230) arranged under an outer jacket (240) of a medium-voltage or high-voltage power cable. The clamp comprises a top panel (10) and a conductive bottom panel (20), which are attached to each other such that they face each other and are spaced from each other in a thickness direction (40) of the panels such as to receive the metal layer cable shield (230) between them, and to electrically and mechanically contact the metal layer cable shield.

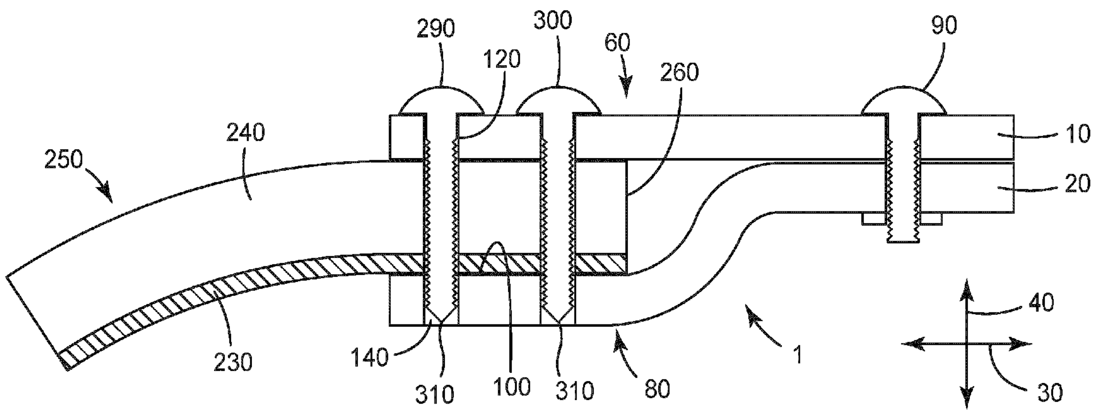

FIG. 3

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Description

[0001] The invention relates to devices and methods for establishing a mechanical and electrical connection to conductive shield layers of medium-voltage and high-voltage insulated power cables in power distribution networks.

[0002] Power cables distribute electrical energy at medium and high voltages and at currents of tens or hundreds of amps over larger geographic areas in power distribution networks, such as in national grids. Traditional power cables are electrically shielded or screened by braids of metal wires, arranged underneath the cable jacket around the main insulation layer and the central conductor.

[0003] More recently, such braids have been replaced by metal films or metal foils, e.g. aluminium films, or metallic tapes, arranged between the outer cable jacket and the main insulation layer of the cable. In some power cables the metal foil cable shield is attached to the inner surface of the cable jacket for better mechanical stability. The contacting of the metal foil, however, may be a challenge due to the native oxide layer on certain metals like aluminium. A low contact resistance is required at the contact point of the metal foil in order to survive short circuits with high currents and high temperatures. The traditional contacting of such metal foil shields is often laborious or not long-term stable. A possible approach to contacting the metal foil shield layer is to heat the cable jacket with a torch and manually remove the liquid jacket material to expose the metal layer shield. The metal film shield can then be contacted from the outside using clamps. However, when the cable becomes hot, the main insulation layer can soften and the clamps can deform and damage the main cable insulation.

[0004] An alternative approach is to insert a contact piece of conductive sheet metal with sharp protrusions, a so-called "cheese grater" contact, under the metal film shield and use cable ties to compress the metal layer cable shield and the cable jacket onto this contact piece. French patent application published as FR 2 271 688 describes a "cheese grater" suitable for this approach. However, the electrical resistance of such a contact increases over time, so that it is often not long-term stable.

[0005] While existing methods and devices for contacting a metal layer cable shield have their advantages, there is still a need for improved contact methods and devices, in particular there is a need for contacting devices that provide long-term stable contacts, and for more flexibility in designing such devices.

[0006] The present invention provides a cable shield clamp for electrically and mechanically contacting a metal layer cable shield arranged under an outer jacket of a medium-voltage or high-voltage power cable, the clamp comprising

a) a top panel of flat and elongated shape forming a connection end portion and an opposed top receiving end portion having a top major surface,

b) a conductive bottom panel, of elongated shape forming a connection end portion and a bottom receiving end portion, arranged opposite and parallel to the top receiving end portion and having a bottom major surface,

wherein the top panel and the bottom panel are attached to each other at their respective connection end portions such that the top major surface and the bottom major surface face each other and are spaced from each other in a thickness direction of the panels such as to receive a portion of the metal layer cable shield between the top major surface and the bottom major surface, and to electrically and mechanically contact the metal layer cable shield.

[0007] The clamping of the metal foil cable shield between the receiving end portions provides a long-lasting electrical and mechanical contact to the metal foil cable shield due to the high clamping forces that can be obtained between the receiving end portions.

[0008] With the top panel and the bottom panel being separate components that are attached to each other at their respective connection end portions, the panels can be made of different materials with different mechanical and/or electrical properties. This provides a degree of flexibility in the design of the cable shield clamp and can help provide advantages in production cost and in performance.

[0009] In certain embodiments of the cable shield clamp according to the present disclosure, the top panel and the bottom panel are made from different materials, different alloys, or different compositions.

[0010] The present disclosure relates to power cables for use in medium-voltage ("MV") or high-voltage ("HV") power distribution networks in which electrical power is distributed via HV/MV power cables, transformers, switchgears, substations etc. with currents of tens or hundreds of amperes and voltages of tens of kilovolts. The term "medium voltage" or "MV" as used herein refers to AC voltages in the range of 1 kilovolt (kV) to 72 kV, whereas the term "high voltage" or "HV" refers to AC voltages of more than 72 kV. Medium voltage and high voltage are collectively referred to herein as "elevated voltage".

[0011] The metal layer cable shield comprises a layer of conductive metal, arranged radially outward from the cable main conductor, so that it can shield electrical fields emanating from the main conductor. A metal layer cable shield as referred to herein may be a separate element that can be handled, moved, or contacted independently from other elements. It may have a "body". An example of such a kind of metal layer cable shield is a thin copper foil.

[0012] Alternatively, the metal layer cable shield may be a layer of conductive metal coated onto a substrate, e.g. a layer of conductive metal coated on the inner surface of the cable jacket or layer of conductive metal coated onto a nonconductive polymeric film. In these cases, the metal layer cable shield has no "body" of its own.

[0013] A metal layer cable shield as referred to herein may be suitable for being held on electrical ground. Grounded metal layer cable shields can shield electrical fields of the cable conductor effectively.

[0014] The long extension of the cable defines an axial or length direction. Radial directions are directions orthogonal thereto. A direction from the central conductor of the cable radially outwards towards the cable jacket is a radial direction. Layers radially further away from the cable conductor are also referred to as outer layers, while a layer "under" another layer is a layer arranged radially inward from that other layer.

[0015] A metal layer cable shield arranged under an outer jacket of a power cable refers to a cable shield arranged radially between the outer jacket of the cable as the outermost layer of the cable, and the main cable insulation layer, i.e. the insulating layer that provides the major insulation of the cable main conductor.

[0016] The top panel is of a flat and elongated shape. In its length direction the top panel comprises a connection end portion and a receiving end portion. The top panel may have a central portion, arranged in length direction between the connection end portion and the receiving end portion.

[0017] The top panel is generally flat. Its lateral extension is considerably larger than its thickness. In a specific embodiment, the top panel has a length of about 5 centimeters (cm), a width of about 2 cm, and a thickness of about 2 millimeters (mm).

[0018] In certain embodiments the top panel of the cable shield clamp is adapted to be arranged radially outward of the metal layer cable shield. It may be adapted to be arranged radially outward of the outer jacket.

[0019] The top panel may be electrically conductive. In certain embodiments in which the cable shield clamp is adapted to clamp the metal layer cable shield, but not the cable outer jacket, it may be advantageous for the top panel to be conductive. As this may improve the electrical contact between the cable shield clamp and the cable shield.

[0020] Alternatively, the top panel may be electrically insulating. In certain embodiments in which the cable shield clamp is adapted to clamp the metal layer cable shield and cable outer jacket, it may be advantageous for the top panel to be electrically insulating, e.g. to reduce the risk of electrical discharges. In these embodiments the top panel may be in mechanical and electrical contact with the outer cable jacket.

[0021] The top receiving end portion of the top panel comprises a major surface, the "top major surface". The top major surface faces a corresponding major surface (the "bottom major surface") of the bottom panel such that between these top and bottom major surfaces the metal layer cable shield can be received and clamped.

[0022] In certain embodiments in which the cable shield clamp is adapted to clamp the metal layer cable shield, but not the cable outer jacket, the top major surface is adapted to be in surface contact with the metal layer cable shield. In certain other embodiments in which the cable shield clamp is adapted to clamp the metal layer cable shield and cable outer jacket, the top major surface is adapted to be in surface contact with the outer cable jacket.

[0023] It may comprise a second major surface, opposed to the top major surface.

[0024] The bottom panel is of a flat and elongated shape. In its length direction the bottom panel comprises a connection end portion and a receiving end portion. The bottom panel may have a central portion, arranged in length direction between the connection end portion and the receiving end portion.

[0025] The bottom panel is generally flat. Its lateral extension is considerably larger than its thickness. The bottom panel comprises a major surface, also referred to herein as the "bottom major surface". It may comprise a second major surface, opposed to the bottom major surface. In a specific embodiment, the bottom panel has a length of about 5 centimeters (cm), a width of about 8 mm, and a thickness of about 4 mm.

[0026] A thickness of the top receiving end portion and a thickness of the bottom receiving end portion is the extension of the respective receiving end portion in the thickness direction of the panels. In certain embodiments the thickness of the bottom receiving end portion is greater than the thickness of the top receiving end portion. A greater thickness of the bottom receiving end portion can provide sufficient space for the tip of a screw pulling the receiving end portions towards each other to be safely accommodated within a bore in the bottom receiving end portion without protruding. The top receiving end portion, however, may not need this additional thickness and its reduced thickness, compared to the thickness of the bottom receiving end portion, may keep it more flexible and helps save space in the thickness direction.

[0027] In certain embodiments the bottom panel of the cable shield clamp is adapted to be arranged radially inward of the metal layer cable shield. It may be adapted to be arranged radially outward of the main insulation layer of the power cable.

[0028] In order to better contact metal layer cable shields of various inner diameters, the bottom receiving end portion may be narrower than the top receiving end portion. "Narrow" refers to extension in a width direction, which is a direction orthogonal to both the thickness direction and the length direction of the panels. Hence in certain embodiments, a width of the bottom receiving end portion is greater than a width of the top receiving end portion.

[0029] The bottom panel is electrically conductive. This facilitates electrical contact between the cable shield clamp and the cable shield.

[0030] The bottom receiving end portion of the bottom panel comprises a major surface, the "bottom major surface". The bottom major surface faces the corresponding major surface (the "top major surface") of the top panel such that between these top and bottom major surfaces the metal layer cable shield can be received and clamped.

[0031] In certain embodiments in which the cable shield clamp is adapted to clamp the metal layer cable shield, but not the cable outer jacket, the bottom major surface is adapted to be in surface contact with the metal layer cable shield. Also, in embodiments in which the cable shield clamp is adapted to clamp the metal layer cable shield and the cable outer jacket, the bottom major surface is adapted to be in surface contact with the metal layer cable shield.

[0032] In certain embodiments of the cable shield clamp according to the present disclosure, and independent from other features, the top receiving end portion comprises a screw hole, extending through the top receiving end portion in a thickness direction of the top panel, and the bottom receiving end portion comprises an opposed bore extending from the second major surface in a thickness direction of the bottom panel. This allows a screw to extend through the screw hole and to be threaded into the bore to pull the receiving end portion of the top panel and the receiving end portion of the bottom panel towards each other and thereby to clamp the metal layer cable shield between the receiving end portions.

[0033] The screw hole and the bore facilitate the use of a screw to clamp the cable shield. In certain embodiments the bore in the bottom panel is a threaded bore into which a tip portion of a threaded screw can be threaded, whereby the screw engages with the bottom receiving end portion. In alternative embodiments the bore in the bottom panel is a non-threaded bore into which a tip of a self-tapping screw can be threaded, whereby the self-tapping screw engages with the bottom receiving end portion. In these latter embodiments the material of the bottom receiving end portion or of the entire bottom panel is advantageously chosen such that it is soft enough to be used with self-tapping screws. Screws can exert considerable forces, which can ensure a reliable clamping and a permanent mechanical connection, as well as a permanently-reliable electrical contact. Also, screws can be tightened easily in the field, and are available at moderate cost.

[0034] In certain of these embodiments, and independent from other features, the top receiving end portion comprises a further, second screw hole, extending through the top receiving end portion in a thickness direction of the top panel, and the bottom receiving end portion comprises a further, second opposed bore extending from the second major surface in a thickness direction of the bottom panel. This allows a further, second screw to extend through the second screw hole and to be threaded into the second bore. The first and the second screw can pull the receiving end portion of the top panel and the receiving end portion of the bottom panel towards each other with even greater force (resulting potentially in better electrical contact with the metal layer cable shield) and thereby clamp the metal layer cable shield between the receiving end portions with an even greater reliability. Also, a second screw hole and a second bore create redundancy for cases where the first screw hole or the first bore becomes unusable.

[0035] In certain of the embodiments in which the cable shield clamp comprises a screw hole and a bore, the cable shield clamp further comprises an adhesive film, adhered to a surface of the top panel such as to cover the screw hole, for holding a screw before the screw is threaded into the bore. The film may help keep a screw in place that has been pushed - through the film - into the screw hole but has not yet been tightened by threaded into the bore. Without the film, the screw might fall out of the screw hole and be lost. Adhesive film is a cost-effective measure to help prevent loss of a screw during installation of the cable shield clamp.

[0036] In certain embodiments, and independent from other features, the cable shield clamp according to the present disclosure further comprises a screw having a screw tip. The screw extends through the screw hole in the top receiving end portion, and the screw tip is threaded into the bore in the bottom receiving end portion for pulling the top receiving end portion of the top panel and the bottom receiving end portion of the bottom panel towards each other, thereby clamping the metal layer cable shield between the receiving end portions of the cable shield clamp.

[0037] As stated above, screws can exert considerable forces, which can ensure a reliable clamping and a permanent mechanical connection, as long as a permanently-reliable electrical contact. Also, screws can be tightened easily in the field, and are available at moderate cost.

[0038] In certain embodiments, and independent from other features, the screw is a shear bolt or a self-tapping screw. In a shear bolt, the screw head is sheared off when the shear bolt is tightened by turning the screw head with a torque that exceeds a threshold torque. The removal of the screw head from the shear bolt is an unambiguous indication that an adequate torque has been used to tighten the screw, making the installation of the cable shield clamp more reliable. Also, the removal of the screw head saves space in the vicinity of the cable shield clamp.

[0039] A self-tapping screw requires no thread in the bore of the bottom receiving end portion, making the design of the cable shield clamp simpler and thereby providing cost advantages.

[0040] Generally, the spacing in thickness direction between the top major surface and the bottom major surface is adapted to the thickness of the element that is to be clamped between the surfaces. In certain scenarios, only the metal layer cable shield is received between the major surfaces (and not any other layer of the power cable, e. g. the cable jacket). In these scenarios the top major surface and the bottom major surface will be arranged closer to each other before clamping, because only this relatively thin metal layer cable shield is to be received between the major surfaces.

[0041] In other scenarios, both the metal layer cable shield and the cable outer jacket are received between the major surfaces. In these other scenarios the top major surface and the bottom major surface will be arranged further from each other before clamping, because also the relatively thick outer jacket is to be received between the major surfaces, in addition to the metal layer cable shield layer. Hence a different cable shield clamp may be used that has a larger spacing between the major surfaces than a cable shield clamp that might be used in the scenario described in the previous paragraph.

[0042] In certain embodiments, and independent from other features, the length of the screw, the spacing between the top major surface and the bottom major surface, and the thickness of the bottom panel are adapted such that the screw tip does not protrude from the bottom panel when the metal layer cable shield is clamped between the receiving end portions. Where - after tightening the screw - the screw tip does not protrude out of the bottom receiving end portion, there is less risk that the screw tip might indent or even puncture the main insulation layer of the power cable, resulting in a more reliable cable.

[0043] In certain embodiments, and independent from other features, the bottom major surface comprises a convex surface portion for enhancing a surface contact with a curved surface of a metal layer cable shield.

[0044] Due to the concentric geometry of layers in most power cables, the metal layer cable shield is curved, and its radially inner surface is concavely curved. As the bottom receiving end portion of the cable shield clamp according to the present disclosure is arranged underneath (i.e. radially inward of) the metal layer cable shield, and as the bottom major surface makes the surface contact with the radially inner surface of the metal layer cable shield, a convex surface portion of the bottom major surface helps keep more of the bottom major surface closer to the metal layer cable shield. This generally provides more contact points and more contact surface between the two elements and thereby increases conductivity between them. Preferably, the convex curvature of the bottom major surface has the same or a similar curvature radius as the concave radially inner surface of the metal layer cable shield which it contacts.

[0045] In certain preferred embodiments of a cable shield clamp according to the present disclosure, the bottom panel is electrically conductive. The entire bottom panel being conductive facilitates the electrical connection of an external wire or cable, e.g. a ground cable, to the metal layer cable shield, as the external wire or cable can be electrically connected to the connection end portion of the bottom panel. The conductivity of the entire bottom panel provides for electrical connection between the external wire or cable and the metal layer cable shield through the bottom panel and its bottom major surface. A conductive bottom panel generally makes the provision of other means to connect the external wire or cable to the bottom major surface obsolete.

[0046] Different from the bottom major surface, the top major surface is not necessarily in direct surface contact with the metal layer cable shield. Instead, where the metal layer cable shield and the cable jacket are clamped, it is designed to be in surface contact with the outer surface of the cable jacket. Hence the top major surface and the top panel may be conductive or insulating.

[0047] In certain embodiments, the top panel is electrically conductive, or the top major surface is electrically conductive. A conductive top panel may facilitate conduction of electricity through the clamping screw(s) to provide a further current path towards the connection end portion of the bottom panel, thereby reducing resistance of the current path and creating redundancy in case of a failure of the bottom panel. Where only the top major surface is conductive, this may provide for a better surface contact and lower resistivity in scenarios in which only the metal layer cable shield is clamped.

[0048] In certain other embodiments the top panel is electrically insulating, or the top major surface is electrically insulating. This may be advantageous, and even provide an additional degree of safety, in scenarios in which the cable shield clamp receives both the metal layer cable shield and the outer cable jacket between the receiving end portions of the panels, since a voltage that may be present on the bottom panel may not be present on the top panel. Also, an insulating top panel can be made from polymeric material at low cost, reducing the production cost of the cable shield clamp according to the present disclosure.

[0049] For the mechanical stability of the cable shield clamp, and for the capability to clamp permanently with high forces, it is important that the top panel and the bottom panel are reliably and securely attached to each other at their respective connection end portions. Therefore, in certain embodiments, the top panel and the bottom panel are attached to each other at their respective connection end portions by a connection screw, or by a rivet, or by a clamp, or by welding, or by soldering, or adhesively. Screws, rivets, and clamps are mechanical elements that can provide strong attachment over long times. Welding and soldering are known to provide strong attachments over extended periods of time. Adhesives can provide strong attachment, too, and certain adhesives provide very strong bonds for years, such as 3M™ VHB™ Tape 4943, available from 3M Company, St. Paul, Minnesota, U.S.A.

[0050] The receiving end portion of the top panel and/or the receiving end portion of the bottom panel may be resilient. A resilient receiving end portion of the top panel, of the bottom panel, or of both the top and the bottom panel, may facilitate insertion of the metal layer cable shield between the receiving end portions before clamping the metal layer cable shield between the receiving end portions. Also, the resilience may facilitate tightening of a screw to pull the receiving end portions towards each other, but also removal of the metal layer cable shield from the space between receiving end portions when the screw is loosened or removed, e.g. for correcting an installation error.

[0051] At a cable end, at a cable termination, or at a cable splice, the metal layer cable shield may be contacted and clamped by more than one cable shield clamp according to the present disclosure. It may be advantageous to connect these cable shield clamps electrically with each other to reduce residual resistance and create failure-mitigating redundancy in contacting the cable shield. It may also be advantageous to connect these cable shield clamps mechanically with each other, for example by bringing the clamps into positions which make clamping of the circular metal layer cable shield easier and quicker. For example, it may speed up installation of several cable shield clamps if they are arranged on a circle that has the radius of the metal layer cable shield layer of the cable.

[0052] In combining the desire for electrical connection and for mechanical connection of a plurality of cable shield clamps, the clamps may be mounted on a conductive support that has the circular shape of the cable shield or can be manually brought into that shape. With the cable shield clamps mechanically mounted on such a support and held in a fixed spatial orientation (e.g. the length directions of all cable shield clamps being oriented parallel to each other) and position (e.g. three clamps, arranged on a circular support and circumferentially spaced by 120° angles) with respect to each other, the bottom major surfaces of these cable shield clamps may be electrically connected with each other through the conductive support.

[0053] The conductive support may be a conformable support which can be manually brought into a circular shape and then keeps that shape. During installation of the cable shield clamps to the metal layer cable shield, a conformable support prevents the twisting of the cable shield clamp when the first screw is threaded into the bottom receiving end portion.

[0054] To provide the installer with freedom to assembly a support and a number of cable shield clamps as he/she requires at each time, a plurality of cable shield clamps and a conductive support may be provided as a kit of parts. The parts can be assembled to form an assembly of cable shield clamps mechanically and electrically connected to a conductive support.

[0055] Hence the present disclosure also provides a kit of parts comprising i) a plurality of cable shield clamps as described herein, and ii) an electrically conductive support, e.g. a ring-shaped support or a bendable support, to which the plurality of cable shield clamps can be mechanically attached and electrically connected such that the respective bottom major surfaces of the attached cable shield clamps are electrically connected with each other through the support, and such that the cable shield clamps are held in a fixed spatial orientation and position with respect to each other.

[0056] he present disclosure also provides a shield-contacted medium-voltage or high-voltage power cable comprising a central conductor, a main insulation layer, a metal layer cable shield surrounding the main insulation layer, an outer cable jacket surrounding the metal layer cable shield. The cable also comprises a cable shield clamp as described herein, wherein the cable shield clamp receives, between its top receiving end portion and its bottom receiving end portion, a portion of the metal layer cable shield, and wherein the bottom major surface contacts the metal layer cable shield.

[0057] Such a power cable provides a particularly reliable contacting of its cable shield by way of the clamping between the top receiving end portion and the bottom receiving end portion of the cable shield clamp according to the present disclosure.

[0058] The cable shield clamp according to the present disclosure is put into use by receiving a portion of the metal layer cable shield between its top receiving end portion and its bottom receiving end portion. This can be achieved by pushing the cable shield clamp over the metal layer cable shield in a particular manner, namely by pushing, in a length direction of the cable shield clamp and in a length direction of the cable, the connection end portion of the bottom panel underneath the metal layer cable shield such that the bottom major surface contacts the metal layer cable shield.

[0059] Hence the present disclosure also provides a process for contacting a metal layer cable shield arranged under an outer jacket of a medium-voltage or high-voltage power cable, the process comprising the steps of

a) providing a medium-voltage or high-voltage power cable comprising an outer jacket, a main insulation layer and a metal layer cable shield arranged under the outer jacket and radially outward from the main insulation layer;

b) providing a cable shield clamp as described herein;

c) pushing, in a length direction of the cable shield clamp and in a length direction of the cable, the connection end portion of the bottom panel underneath the metal layer cable shield such that the bottom major surface contacts the metal layer cable shield.

[0060] Where the cable shield clamp further comprises a screw having a screw tip, the screw extending through the screw hole and the screw tip threaded into the bore for pulling the receiving end portion of the top panel and the receiving end portion of the bottom panel towards each other and thereby clamping the metal layer cable shield between the receiving end portions, after step c) a step d) may follow of tightening the screw and thereby pulling the top receiving end portion and the bottom receiving end portion towards each other to clamp the metal layer cable shield (and potentially the cable outer jacket) between the top receiving end portion and the bottom receiving end portion.

[0061] Embodiments of this disclosure will now be described in more detail with reference to the following Figures in which like elements are indicated with like numbers:

- Fig. 1 Perspective view of a first cable shield clamp according to the disclosure;
- Fig. 2 Perspective view of a shielded power cable on which the first cable shield clamp can be used; and
- Fig. 3 Sectional view of the first cable shield clamp and of an outer jacket and a metal layer cable shield of the power cable of Fig. 2.

[0062] **Figure 1** is a perspective view of a first cable shield clamp 1 according to the disclosure. It comprises a top panel 10 and a bottom panel 20, both of elongated shape, and oriented parallel to each other. Arrow 30 indicates the length direction of the panels 10, 20, while arrow 40 indicates the thickness direction of the panels 10, 20. Both panels 10, 20 are electrically conductive and formed from copper. Alternatively, they might be formed from aluminium or another conductive metal.

[0063] The top panel 10 comprises two longitudinally-opposed end portions: a connection end portion 50 for connection to the bottom panel 20, and a top receiving end portion 60. Similarly, the bottom panel 20 has two longitudinally-opposed end portions: a connection end portion 70 for connection to the top panel 10, and a bottom receiving end portion 80.

[0064] The panels 10, 20 are firmly attached to each other at their respective connection end portions 50, 70 by a connection screw 90. In embodiments not shown here, the panels 10, 20 may be attached to each other by soldering or welding or via an adhesive.

[0065] The bottom receiving end portion 80 comprises a major surface 100 (the "bottom major surface" 100) which faces a corresponding opposed major surface 110 (the "top major surface" 110, not visible in Figure 1) of the top receiving end portion 60. The top major surface 110 and the bottom major surface 100 face each other, and they are spaced from each other in a thickness direction 40 of the panels 10, 20.

[0066] Due to the spacing between the top major surface 110 and the bottom major surface 100, the cable shield clamp 1 can receive a portion of a metal layer cable shield 230 (shown in Figure 2) between the top major surface 110 and the bottom major surface 100. The major surfaces 100, 110 are electrically conductive for establishing an electrical contact with the metal layer cable shield 230 (see Figure 2).

[0067] The top receiving end portion 60 comprises first and second top screw holes 120, 130, spaced in length direction 30 from each other, that are aligned with corresponding first and second bottom screw holes 140, 150 in the bottom receiving end portion 80. The bottom screw holes 140, 150 comprise threads to facilitate using two screws 290, 300 (see Figure 3) that can be tightened to pull the top receiving end portion 60 and the bottom receiving end portion 80 towards each other and thereby to clamp the metal layer cable shield 230 between them.

[0068] In alternative embodiments, not shown here, the bottom screw holes 140, 150 are not threaded. In these embodiments the screws 290, 300 are self-tapping screws 290, 300 which can be threaded into the bottom screw holes 140, 150 and thereby engage with the bottom receiving end portion 80. In yet other embodiments not illustrated here, the screws 290, 300 are regular threaded screws which protrude from the bottom screw holes 140, 150 and can be tightened with respective screw nuts.

[0069] For clamping the metal layer cable shield 230 between the top receiving end portion 60 and the bottom receiving end portion 80, the bottom receiving end portion 80 is adapted to be pushed under the metal layer cable shield 230 in a length direction of the cable 200, so that the bottom major surface 100 is in surface contact with the radially inner surface of the metal layer cable shield 230. In performing that pushing, the top receiving end portion 60 is pushed over the outer surface of the outer cable jacket 240, so that eventually a portion of the metal layer cable shield 230 and a portion of the outer cable jacket 240 are received in the slot formed between the top receiving end portion 60 and the bottom receiving end portion 80 of the shield clamp 1.

[0070] As explained in more detail below, a screw 290, 300 can then be pushed, from the top, through the first top screw hole 120, forced through the outer cable jacket 240 and through the metal layer cable shield 230 into the first bottom screw hole 140. The first bottom screw hole 140 is threaded suitably for engaging the threaded tip 310 of the screw 290, so that the screw can be tightened. By tightening the screw 290, the top receiving end portion 60 and the bottom receiving end portion 80 are pulled towards each other, which clamps the metal layer cable shield 230 and the outer cable jacket 240 between them and provides for a reliable and permanent conductive surface contact between the bottom major surface 100 and the metal layer cable shield 230.

[0071] The bottom major surface 100 is concavely curved in width direction of the bottom panel 20. The curvature mirrors the curvature of the metal layer cable shield 230 of cables 200 of certain diameters. A suitably convexly curved bottom major surface 100 will result in a larger contact area of the surface contact between the bottom major surface 100 and the radially inner surface of the metal layer cable shield 230.

[0072] **Figure 2** illustrates, in a perspective view, an insulated shielded medium-voltage power cable 200 on which the first cable shield clamp 1 can be used. The cable 200 comprises a central conductor 210 which is surrounded by a main insulation layer 220. The main insulation layer 220 is surrounded by a metal layer cable shield 230 which in turn is attached to the radially inner surface of an outer cable jacket 240. The outer cable jacket 240 is the outermost layer of the cable 200.

[0073] The metal layer cable shield 230 is an aluminium foil, adhered to the inner surface of the cable jacket 240.

[0074] The cable 200 is shown partially stripped, so that the central conductor 210 and the main insulation layer 220 are exposed. The metal layer cable shield 230 and the cable jacket 240 have been incised lengthwise for some centimetres, and the resulting three flaps 250 between incisions 280 are shown pulled away from the main insulation layer 220, so that their open edges 260 are removed from the outer surface 270 of the main insulation layer 220. The cable shield clamp 1 of Figure 1 is adapted to clamp an open edge 260 of one flap 250 between its top receiving end portion 60 and its bottom receiving end portion 80.

[0075] **Figure 3** illustrates, in a sectional view, the first cable shield clamp 1 of Figure 1 according to the present disclosure and the outer jacket 240 and the metal layer cable shield 230 attached to the lower surface of the jacket 240 of the power cable 200. As shown, the clamping of a flap 250 of the outer jacket 240 and the metal layer cable shield 230 attached to it involves receiving a portion of the flap 250 between the top receiving end portion 60 and the bottom receiving end portion 80 of the cable shield clamp 1, inserting a first screw 290 from the top, through the first top screw hole 120, forcing the first screw 290 through the outer cable jacket 240 of the flap 250 and through the metal layer cable shield 230 into the first bottom screw hole 140, tightening the first screw 290 and thereby pulling the top receiving end portion 60 and the bottom receiving end portion 80 towards each other sufficiently for creating pressure on the outer jacket 240 and on the metal layer cable shield 230, the pressure resulting in mechanical and electrical contact between the metal layer cable shield 230 and the bottom panel 20 as well as between the cable jacket 240 and the top panel 10. The pressure also results in friction between the cable shield clamp 1 and the flap 250 of the cable 200 to which it is clamped, and this friction provides for a reliable mechanical connection between the cable shield clamp 1 on the one side and the cable jacket 240 and the metal layer cable shield 230 on the other side.

[0076] The length of the screw 290 is selected such that a tip 310 of the screw 290 remains within the bottom screw hole 140 after tightening the screw 290, so that the tip 310 does not protrude from the screw hole 140 and from the bottom panel 20. This may help avoid a risk of a protruding screw tip 310 damaging the main insulation layer 220 of the cable 200.

[0077] A second screw 300 is arranged through the second top screw hole 130, through the flap 250 and into the second bottom screw hole 150. This second bottom screw hole 150 is threaded to allow tightening the second screw 300. Clamping by two screws 290, 300 instead of by a single screw generally provides a higher pressure and a more even pressure distribution for clamping the flap 250 in the cable shield clamp 1, besides some redundancy, should one of the screws fail.

[0078] Once clamped, the bottom major surface 100 of the cable shield clamp 1 is in reliable and permanent surface contact with the metal layer cable shield 230 of the power cable 200.

[0079] For an even more permanently-reliable electrical contact to the metal layer cable shield 230 it will be appreciated that each of the three flaps 250 can be clamped by a respective cable shield clamp 1. In such a scenario the three cable shield clamps 1 may be mechanically and electrically connected with each other by a conductive braid or a resilient conductive sheet (not shown). This braid or sheet may have a certain rigidity. The cable shield clamps 1 may be mechanically attached to the braid or sheet of a certain rigidity, which can provide a fixed spatial relationship between the three cable shield clamps 1 and may thereby facilitate attachment of the plurality of cable shield clamps 1 to a plurality of flaps 250. In that case the braid or sheet, together with the cable shield clamps 1 attached to the braid or sheet, may form a shield clamp assembly.

[0080] The number of flaps 250 created by lengthwise incisions 280 or otherwise is not important, and any reasonable number of flaps 250 can be created on the power cable 200, such as one, two, three, four, five, six, or more flaps. Considering the width of the cable shield clamps 1, i.e. their extension in circumferential direction of the power cable 200, less than ten flaps 250 would typically be created. It is noted that one, two or more cable shield clamps 1 may be clamped to a single flap 250.

[0081] It is not necessary that the cable outer jacket 240 form flaps 250. The cable shield clamp 1 may clamp a metal layer cable shield 230 and an outer jacket layer 240 to which the metal layer cable shield 230 is attached of a cable 200 that has no incisions 280 and forms no flaps 250. The bottom receiving end portion 80 of the bottom panel 20 may be pushed underneath the metal layer cable shield 230, with the top receiving end portion 60 contacting the outer surface of the outer jacket 240.

Claims

1. Cable shield clamp (1) for electrically and mechanically contacting a metal layer cable shield (230) arranged under an outer jacket (240) of a medium-voltage or high-voltage power cable (200), the clamp comprising

    a) a top panel (10) of flat and elongated shape forming a connection end portion (50) and an opposed top receiving end portion (60) having a top major surface (110),
    b) a conductive bottom panel (20), of elongated shape forming a connection end portion (70) and a bottom receiving end portion (80), arranged opposite and parallel to the top receiving end portion (60) and having a bottom major surface (100),

wherein the top panel (10) and the bottom panel (20) are attached to each other at their respective connection end portions (50, 70) such that the top major surface (110) and the bottom major surface (100) face each other and are spaced from each other in a thickness direction (40) of the panels (10) such as to receive a portion of the metal layer cable shield (230) between the top major surface (110) and the bottom major surface (100), and to electrically and mechanically contact the metal layer cable shield (230).

2. Cable shield clamp (1) according to claim 1, wherein the top receiving end portion (60) comprises a screw hole (120, 130), extending through the top receiving end portion in a thickness direction (40) of the top panel (10), and wherein the bottom receiving end portion (80) comprises an opposed bore (140, 150) extending from the second major surface (100) in a thickness direction (40) of the bottom panel (20), so that a screw (290, 300) can extend through the screw hole (120, 130) and be threaded into the bore (140, 150) to pull the receiving end portion (60) of the top panel (10) and the receiving end portion (80) of the bottom panel (20) towards each other and thereby to clamp the metal layer cable shield (230) between the receiving end portions (60, 80).

3. Cable shield clamp (1) according to claim 2, further comprising an adhesive film, adhered to a surface of the top panel (10) such as to cover the screw hole (120, 130), for holding a screw (290, 300) before the screw (290, 300) is threaded into the bore (140, 150).

4. Cable shield clamp (1) according to claim 2 or claim 3, further comprising a screw (290, 300) having a screw tip (310), the screw extending through the screw hole (120, 130) and the screw tip (310) threaded into the bore (140, 150) for pulling the receiving end portion (60) of the top panel (10) and the receiving end portion (80) of the bottom panel (20) towards each other and thereby clamping the metal layer cable shield (230) between the receiving end portions (60, 80).

5. Cable shield clamp (1) according to claim 4, wherein the screw (290, 300) is a shear bolt or a self-tapping screw.

6. Cable shield clamp (1) according claim 4 or claim 5, wherein the length of the screw (290, 300), the spacing between the top major surface (110) and the bottom major surface (100), and the thickness of the bottom panel (20) are adapted such that the screw tip (310) does not protrude from the bottom panel (20) when the metal layer cable shield (230) is clamped between the receiving end portions (60, 80).

7. Cable shield clamp (1) according to any of the preceding claims, wherein in the bottom major surface (100) comprises a convex surface portion for enhancing a surface contact with a curved surface of a metal layer cable shield (230).

8. Cable shield clamp (1) according to any of the preceding claims, wherein a thickness (40) of the bottom receiving end portion (80) is greater than a thickness (40) of the top receiving end portion (60).

9. Cable shield clamp (1) according to any of the preceding claims, wherein a width of the bottom receiving end portion (80) is greater than a width of the top receiving end portion (60).

10. Cable shield clamp (1) according to any of the preceding claims, wherein the top panel (10) is electrically insulating or wherein the top major surface (110) is electrically insulating.

11. Cable shield clamp (1) according to any of the preceding claims, wherein the top panel (10) and the bottom panel (20) are attached to each other at their respective connection end portions (50, 70) by a connection screw (90), or by a rivet, or by a clamp, or by welding, or by soldering, or adhesively.

12. Cable shield clamp (1) according to any of the preceding claims, wherein the top panel (10) and the bottom panel (20) are made from different materials, different alloys, or different compositions.

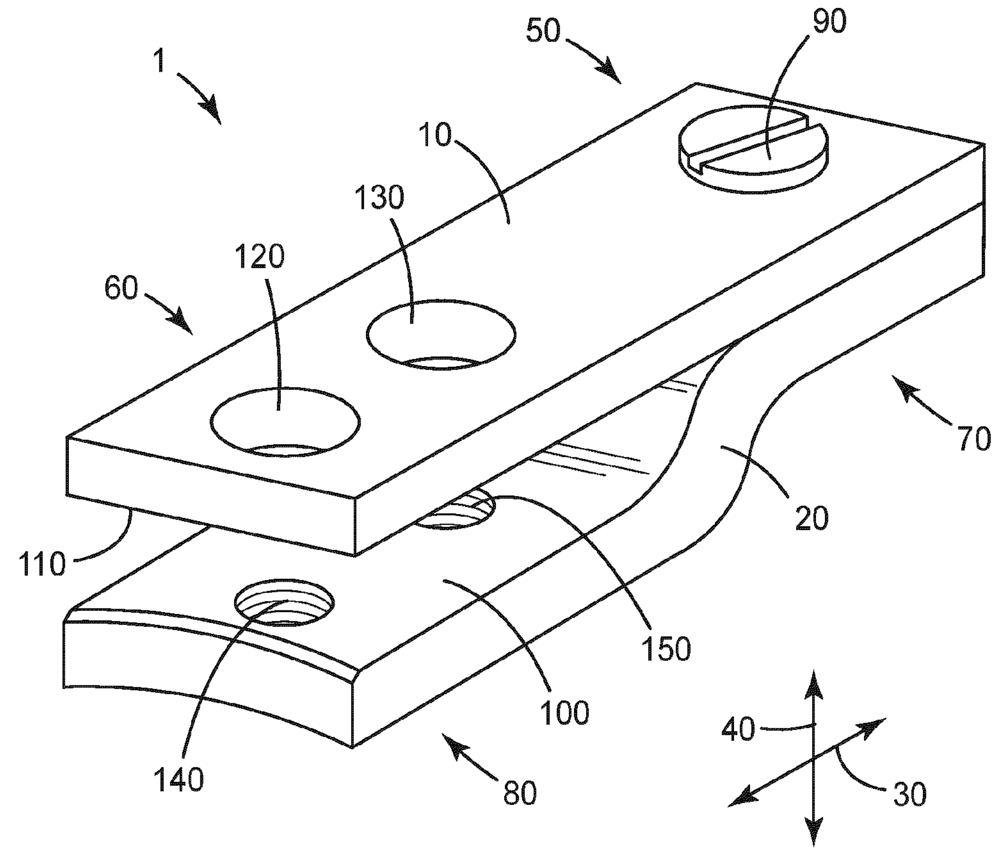
13. Kit of parts comprising

i) a plurality of cable shield clamps (1) according to any of the preceding claims, and
ii) an electrically conductive support, e.g. a ring-shaped support or a bendable support, to which the plurality of cable shield clamps (1) can be mechanically attached and electrically connected such that the respective bottom major surfaces (100) of the attached cable shield clamps (1) are electrically connected with each other through the support, and such that the cable shield clamps (1) are held in a fixed spatial orientation and position with respect to each other.

14. Shield-contacted medium-voltage or high-voltage power cable (200) comprising a central conductor (210), a main insulation layer (220), a metal layer cable shield (230) surrounding the main insulation layer (220), an outer cable jacket (240) surrounding the metal layer cable shield (230), and a cable shield clamp (1) according to any one of claims 1 to 12, wherein the cable shield clamp (1) receives, between its top receiving end portion (60) and its bottom receiving end portion (80), a portion of the metal layer cable shield (230), and wherein the bottom major surface (100) contacts the metal layer cable shield (230).

15. Process for contacting a metal layer cable shield (230) arranged under an outer jacket (240) of a medium-voltage or high-voltage power cable (200), the process comprising the steps of

a) providing a medium-voltage or high-voltage power cable (200) comprising an outer jacket (240), a main insulation layer (220) and a metal layer cable shield (230) arranged under the outer jacket (240) and radially outward from the main insulation layer (220);
b) providing a cable shield clamp (1) according to any one of claims 1 through 12;
c) pushing, in a length direction (30) of the cable shield clamp (1) and in a length direction of the cable (200), the connection end portion (80) of the bottom panel (20) underneath the metal layer cable shield (230) such that the bottom major surface (100) contacts the metal layer cable shield (230).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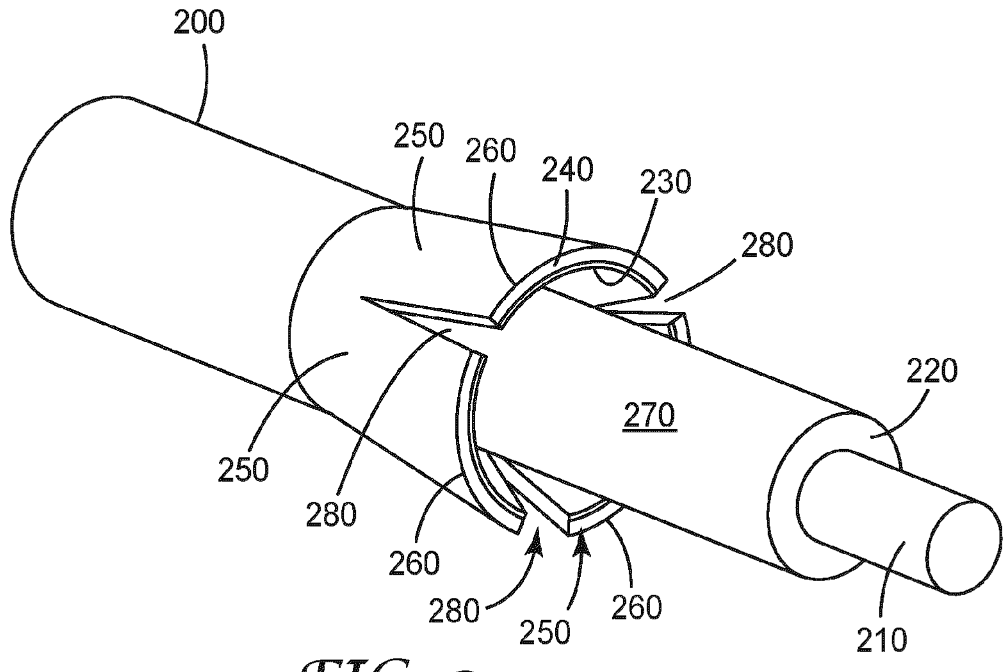
30

FIG. 1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210

FIG. 2

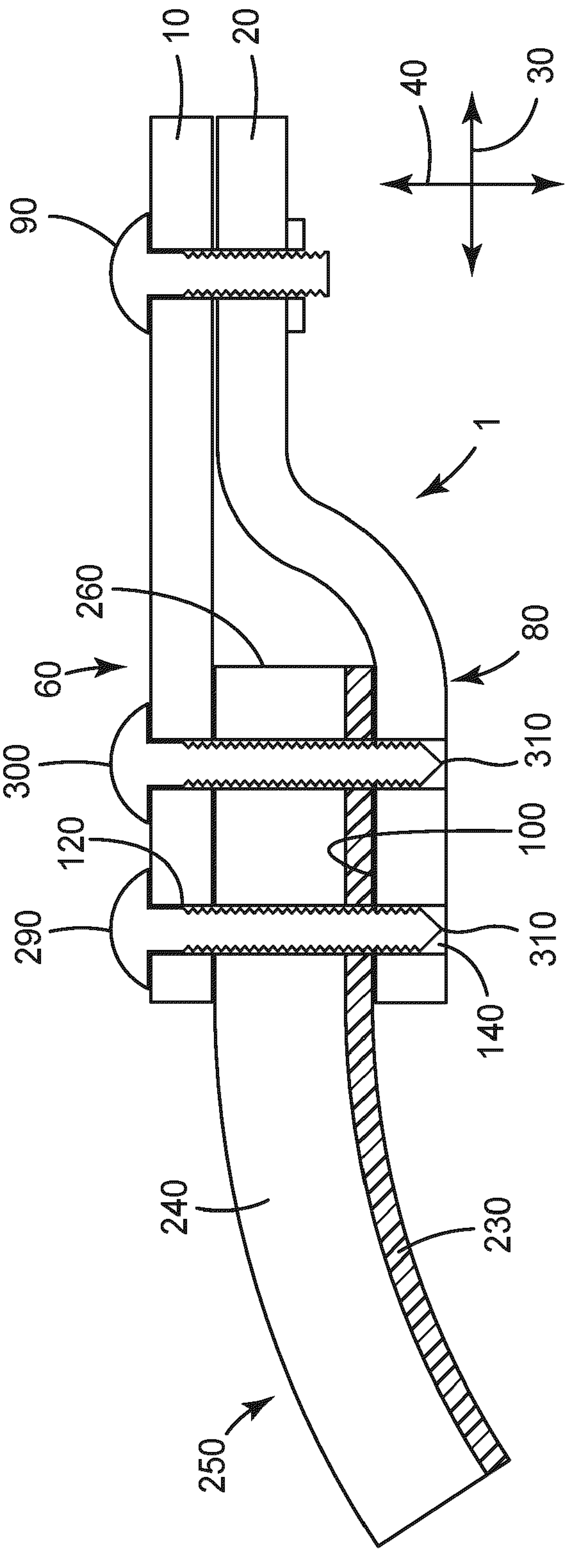

FIG. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 21 17 1815

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	US 3 864 009 A (WICKENBERG RALPH F) 4 February 1975 (1975-02-04) * the whole document *	1,9,10, 12,14,15 2-8,11, 13	INV. H01R4/64 H01R9/05 H01R103/00
Y	US 4 353 612 A (MEYERS RICHARD G) 12 October 1982 (1982-10-12) * the whole document *	2-7	
Y	DE 33 24 722 A1 (COMMUNICATIONS TECH CORP [US]) 3 May 1984 (1984-05-03) * the whole document *	8,11	
Y	EP 0 196 942 A1 (GORO SA [FR]) 8 October 1986 (1986-10-08) * column 5, line 57 - column 6, line 13 * * figure 9 *	13	

TECHNICAL FIELDS SEARCHED (IPC)

H01R

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	21 October 2021	Henrich, Jean-Pascal

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CATEGORY OF CITED DOCUMENTS

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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21-10-2021

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
US 3864009	A	04-02-1975	DE	2417579 A1	24-10-1974
			JP	S5415178 Y2	20-06-1979
			JP	S49150386 U	26-12-1974
			US	3864009 A	04-02-1975
US 4353612	A	12-10-1982	NONE		
DE 3324722	A1	03-05-1984	NONE		
EP 0196942	A1	08-10-1986	EP	0196942 A1	08-10-1986
			FR	2578694 A1	12-09-1986
			JP	S61266004 A	25-11-1986

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- FR 2271688 **[0004]**