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(54) **Coaxial connector for terminating a coaxial cable, coaxial cable and base station thereof**

(57) The invention relates to a coaxial connector (COAX_CON) for terminating a coaxial cable (COAX_CAB), wherein the coaxial connector (COAX_CON) comprises means for connecting an inner conductor (IC_COAX_CAB) and an outer conductor (OC_COAX_CAB) of the coaxial cable (COAX_CAB) and wherein an outer conductor (OC_COAX_CON) of

the coaxial connector (COAX_CON) comprises means for connecting a grounding cable (G_CAB). The invention further relates to a coaxial cable (COAX_CAB) with a grounding cable (G_CAB) and a coaxial connector (COAX_CON) and to base station for use in a radio communication system comprising the coaxial cable (COAX_CAB) with the grounding cable (G_CAB) and the coaxial connector (COAX_CON).

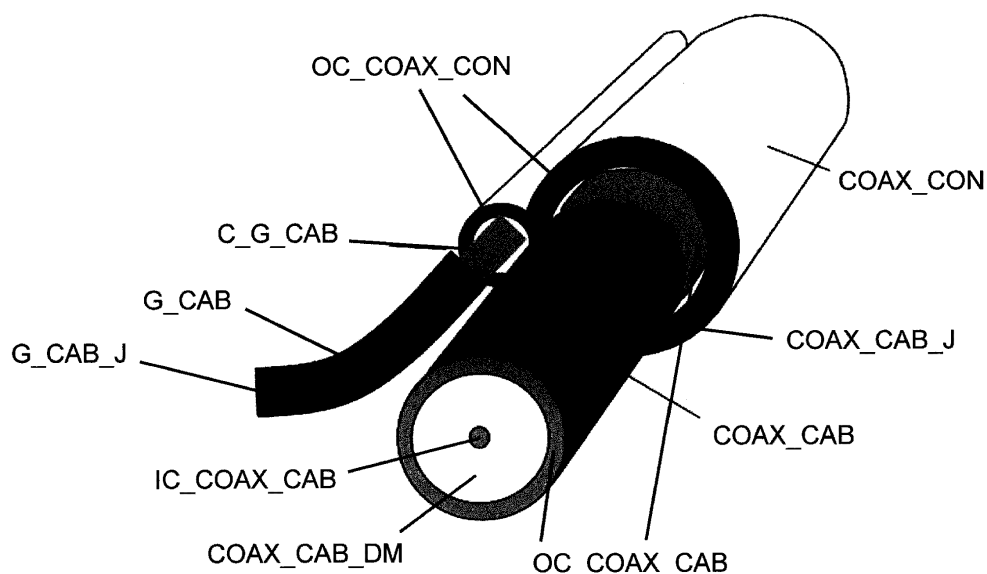


FIG. 3

Description

FIELD OF THE INVENTION

[0001] The invention relates to a coaxial connector for terminating a coaxial cable, and, more particularly but not exclusively, to lightning protection in wireless communications.

BACKGROUND OF THE INVENTION

[0002] A base station of a cellular radio communication system usually comprises one or several transceiver units located in a rack and one or several external antenna systems. The rack is normally located on a bottom of a tower or in a shelter on a roof. The one or several antenna systems are usually located at an upper area of an antenna mast. The one or several transceiver units of the base station are connected to the one or several antenna systems via one or several coaxial transmission lines.

[0003] A coaxial transmission line usually comprises a highly flexible jumper cable connected to an interface of the antenna system. The coaxial transmission line further comprises a feeder cable between the jumper cable and the rack, which bridges most part of a distance between the antenna system and the rack. Due to its weight and inflexibility and strong mechanical forces on its coaxial connectors, the feeder cable cannot not directly connected to the antenna system.

[0004] Usually, connectors adapted for the feeder cable are attached to the feeder cable during installation of the base station and connectors adapted for the jumper cable are attached to the jumper cable during assembly at a factory.

[0005] For lightning protection reasons, the feeder cable is preferably grounded at three sections of the feeder cable by using grounding kits:

A first grounding kit is installed at the feeder cable close to a connection between the feeder cable and the jumper cable. A second grounding kit is usually installed above a bow, where the feeder cable changes from a vertical orientation to a horizontal orientation. A third grounding kit may be installed close to a connection between the rack and the feeder cable.

An installation of the grounding kits is performed during installation of the coaxial transmission line between the rack and the antenna system. This needs to be done by a technician by removing a section of a cable jacket of the feeder cable, by applying the grounding kit to an outer conductor of the feeder cable and by sealing a connection between the outer conductor of the feeder cable and the grounding kit. Preferably, the grounding kit comprises integrated sealing means.

[0006] Such a manual installation requires a significant period of time, requires dry conditions for avoiding an ingress of moisture, has a risk of the ingress of the moisture, if a sealing is not applied properly and has a further risk of cable damages, if a removal of the section of the cable jacket is not applied properly. Furthermore, during the manual installation a not perfectly fitting grounding kit might result in a deformation of the outer conductor of the feeder cable. Such deformation could lead to a local impedance change impacting an overall system performance of the base station.

[0007] For avoiding the manual installation of the grounding kits during setting up the coaxial transmission line it has been proposed to connect a grounding cable already during manufacture of a device comprising a coaxial cable, a coaxial connector and the grounding cable. Thereby, an exposed part of an outer conductor of the coaxial cable is electrically connected to one end of a conductor of the grounding cable close to an interface between the coaxial cable and the coaxial connector.

SUMMARY OF THE INVENTION

[0008] The way of connecting a grounding cable to a connection between a coaxial cable and a coaxial connector affects electrical, mechanical and sealing characteristics of the connection.

[0009] Therefore, it is an object of the invention to provide an alternative solution for connection the grounding cable to the connection between the coaxial cable and the coaxial connector.

[0010] This object is achieved by a coaxial connector for terminating a coaxial cable, wherein the coaxial connector comprises means for connecting an inner conductor of the coaxial cable and an outer conductor of the coaxial cable and wherein an outer conductor of the coaxial connector comprises means for connecting a grounding cable.

[0011] The coaxial connector according to the present invention offers a first benefit of avoiding a direct contact between a conductor of the grounding cable and the outer conductor of the coaxial cable. Thereby, any mechanical forces appearing on the grounding cable may not damage the outer conductor of the coaxial cable, which comprises a much less mechanical stability than the outer conductor of the coaxial connector.

[0012] The coaxial connector offers a second benefit of not requiring sealing an exposed outer conductor of the coaxial cable for example by a heat shrink tube.

[0013] The coaxial connector offers a third benefit of not deforming the outer conductor of the coaxial cable during connecting the grounding cable to the outer conductor of the coaxial cable. If for example a soldering process or a welding process is applied to the outer conductor of the coaxial cable an impact of heat of such processes may result in a slight deformation of the outer conductor of the coaxial cable and thereby may cause local impedance changes at a section of the coaxial ca-

ble.

[0014] The coaxial connector offers a fourth benefit of allowing connecting the grounding cable to the coaxial connector prior to connecting the coaxial cable to the coaxial connector. This reduces a risk of cable damages for the coaxial cable during the connecting process for the grounding cable. According to a first embodiment of the invention, the outer conductor comprises a central body for connecting the inner conductor of the coaxial cable and the outer conductor of the coaxial cable and a peripheral body for connecting the grounding cable.

[0015] The first embodiment of the invention provides an advantage of maintaining a rotational symmetry for the outer conductor of the central body. The rotationally symmetry is only disturbed by the peripheral body outside a largest distance of material of the outer conductor of the central body from a centre point of the central body. Thereby, any local impedance changes can be kept very low.

[0016] In a first alternative, a single part of an electrical conductive material comprises the central body and the peripheral body. In a second alternative, the central body is a first part of an electrical conductive material, the peripheral body is a second part of the electrical conductive material or of a further electrical conductive material and the peripheral body is mechanically and electrically connected to the central body.

[0017] The first alternative allows fabricating the coaxial connector without a further fabrication step for connecting the peripheral body to the central body.

[0018] The second alternative allows adapting electrical and mechanical properties of the central body and the peripheral body to electrical and mechanical properties of the outer conductor of the coaxial cable and the conductor of the grounding cable. The second alternative further allows connecting the grounding cable to the peripheral body and the coaxial cable to the central body prior to connecting the peripheral body to the central body of the coaxial connector.

[0019] According to a second embodiment of the invention, a radial thickness of the outer conductor of the coaxial connector is adapted to a diameter of a cross sectional area of a conductor of the grounding cable and wherein the outer conductor of the coaxial connector comprises an opening for fixing the grounding cable. The second embodiment of the invention provides a first advantage of a mechanical robust outer conductor of the coaxial connector. It provides a second advantage of a possibility to apply the grounding cable in a vertical direction to a longitudinal axis of the coaxial connector and the coaxial cable.

[0020] The invention further relates to a coaxial cable with a grounding cable and a coaxial connector according to the embodiments given above and wherein the coaxial connector terminates the coaxial cable and terminates the grounding cable. The further embodiment of the invention provides an alternative for assembling coaxial connectors with coaxial cables and grounding cables al-

ready in a factory under dry conditions.

[0021] According to two alternatives, the coaxial cable and the grounding cable are connected to the coaxial connector in an equal direction or in opposite directions. Depending on an upper or lower position of the coaxial connector, when installed in a vertical direction with respect to the Earth's surface, this allows applying the grounding cable always in a direction of a lightning current for a best lightning protection of an electronic system. According to a further alternative, the grounding cable is connected in a vertical direction to a longitudinal axis of the coaxial connector. The further alternative also provides a benefit of applying the grounding cable in the vertical direction with respect to the Earth's surface, if the coaxial cable may be installed in a horizontal direction with respect to the Earth's surface. This allows for a shortest way of guiding the lightning current to the Earth's surface.

[0022] According to preferred embodiments of the invention, a first interface between the coaxial cable and the coaxial connector is sealed with a plastic material and a second interface between the grounding cable and the coaxial connector is sealed with the plastic material or a further plastic material. The preferred embodiments provide the advantage of avoiding an ingress of moisture, which could lead to a mechanical and/or electrical degradation of the performance of the interface between the coaxial cable and the coaxial connector. An application of different plastic materials to the first and the second interface allows adapting mechanical properties of the different plastic materials to different mechanical properties of the coaxial cable and the grounding cable or to different mechanical stresses acting on the coaxial cable and the grounding cable.

[0023] In further preferred embodiments of the invention, the plastic material is moulded to the first interface and to the second interface or the plastic material is moulded to the first interface and/or the further plastic material is moulded to the second interface. A moulded plastic material provides better sealing conditions by adapting a form of the plastic material to a geometrical form of the first and/or second interface than a sealing or a plastic material, which may be only pressed on the first and/or second interface or which may be only slightly deformed by heating up.

[0024] According to even further embodiments of the invention, the grounding cable is connected to the coaxial connector by either of the following: soldering, crimping, screwing, welding. These embodiments allow to flexibly adapt a mechanical strength or durability of the connection between the coaxial connector and the grounding cable to operating conditions or to maintenance conditions (e.g. if it would be required to exchange the grounding cable after a certain period of time).

[0025] In even preferred embodiments of the invention, the grounding cable comprises a single wire or a group of at least two wires. Thereby, a wire structure of the grounding cable may be adapted to safety require-

ments (e.g. minimum required cross sectional area of the conductor(s) of the grounding cable) or to mechanical stress under operating conditions.

[0026] In two further embodiments of the invention, the coaxial cable is a jumper cable or a feeder cable for use between a receiver and/or a transmitter of a base station and an external antenna system of the base station.

[0027] The invention even further relates to a base station for use in a radio communication system, wherein the base station comprises at least one receiver and/or at least one transmitter, at least one external antenna system and at least one coaxial cable according to the embodiments given above connecting the at least one receiver and/or the at least one transmitter to the at least one antenna system by the coaxial cable and connecting the coaxial connector to an earth contact by the grounding cable.

[0028] This allows accelerating an installation of a coaxial transmission line between the receiver and/or transmitter of the base station and the antenna system. The overall receiver and/or transmitter system of the base station comprising the receiver and/or transmitter, the coaxial transmission line and the external antenna system gets more reliable, because the coaxial cable with the grounding cable and the coaxial connector can be manufactured under well defined and controlled conditions in the factory. No further treatment of the coaxial cable is required at a place of installation of the base station. Furthermore, a quality of the connection between the coaxial connector and the grounding cable does not depend on whether conditions and work experience of a technician installing the coaxial cable and the grounding cable.

[0029] Further advantageous features of the invention are defined by further dependent claims for the coaxial cable with the grounding cable and the coaxial connector and by following detailed description of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030] The embodiments of the invention will become apparent in the following detailed description and will be illustrated by accompanying drawings given by way of non-limiting illustrations.

Figure 1 shows cross-sectional views along a longitudinal axis of coaxial connectors in accordance to embodiments of the invention.

Figure 2 shows cross-sectional views along a longitudinal axis of a coaxial connector in accordance to further embodiments of the invention.

Figure 3 shows a perspective view of an interface area between a coaxial cable, a grounding cable and a coaxial connector in accordance to a preferred embodiment of the invention.

Figure 4 shows side views of cable systems comprising a coaxial cable with a grounding cable and coaxial connectors in accordance to further pre-

ferred embodiments of the invention.

Figure 5 shows schematic views of base stations in accordance to even further embodiments of the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0031] Figure 1 shows cross-sectional views along a longitudinal axis of coaxial connectors COAX_CON1, COAX_CON2 in accordance to embodiments of the invention near end faces of the coaxial connectors COAX_CON1, COAX_CON2 adapted for connecting a coaxial cable and a grounding cable.

[0032] The coaxial connector COAX_CON1 of Figure 1 a) comprises a central body CB1 with a circular outer conductor OC_COAX_CON1 for connecting an outer conductor of the coaxial cable and a central circular inner conductor IC_COAX_CON1 for connecting an inner conductor of the coaxial cable.

[0033] The inner conductor IC_COAX_CON1 may preferably comprise a circular opening for inclusion of the inner conductor of the coaxial cable. In an alternative, the inner conductor IC_COAX_CON1 may have a form different to the circular opening and adapted to a geometrical form and length of the inner conductor of the coaxial cable.

[0034] The inner conductor IC_COAX_CON1 may comprise a solid pin, allocating the coaxial connector COAX_CON1 to a group of male connectors. In an alternative, the inner conductor IC_COAX_CON1 may comprise a hollow cylinder, allocating the coaxial connector COAX_CON1 to a group of female connectors. In a further alternative, the coaxial connector COAX_CON1 may be a neutral connector such as an APC7 coaxial connector.

[0035] An area of a cross section of the coaxial connector COAX_CON1 between the outer conductor OC_COAX_CON1 and the inner conductor IC_COAX_CON1 comprises a dielectric material DM1 such as air or a solid material such as polyethylene, PTFE (PTFE = polytetrafluoroethylene) or a ceramic such as steatite or aluminium oxide.

[0036] The outer conductor OC_COAX_CON1 of the coaxial connector COAX_CON1 of Figure 1 a) further comprises a peripheral body PB1 located laterally to the central body CB1 of the outer conductor OC_COAX_CON1 with an end face at a same longitudinal position of the coaxial connector COAX_CON1 as an end face of the central body CB1. Alternatively, the end face of the peripheral body PB1 may be offset to the end face of the central body CB1 and may be located in a longitudinal position between the end face of the central body CB1 and an opposite end face of the central body CB1.

[0037] In a further alternative, the outer conductor OC_COAX_CON1 of the coaxial connector COAX_CON1 further comprises a peripheral body located laterally to the central body CB1 of the outer conductor OC_COAX_CON1 near a screwing joint or a plug connection unit of

the coaxial connector COAX_CON1 at the opposite end face of the central body CB1.

[0038] Preferably, a radial thickness of the outer conductor OC_COAX_CON1 of the peripheral body PB1 is adapted to a fixing method to be applied for fixing the conductor of the grounding cable.

[0039] A geometrical form of the peripheral body PB1 may be for example a circular tube with a circular opening PB1-OP for connecting a conductor of the grounding cable. In an alternative, the geometrical form of the peripheral body PB1 may be a tube with a quadratic outer form and with the circular opening PB1-OP. In a further alternative, the geometrical form of the peripheral body PB1 may be a cuboid or a solid cylinder with a blind hole for insertion of the conductor of the grounding cable without breaking through to an opposite end face of the peripheral body PB1. A diameter of the opening PB1-OP or the blind hole may be adapted to an outer diameter of a cross section of the conductor of the grounding cable and is preferably of equal size or slightly larger than the diameter of the cross section of the conductor of the grounding cable.

[0040] The outer conductor OC_COAX_CON1 of the central body CB1 and the peripheral body PB1 may be in direct electrical and mechanical contact as shown in Figure 1 a) or may be not in direct contact. If the outer conductor OC_COAX_CON1 of the central body CB1 and the peripheral body PB1 may be not in direct contact, an electrical and mechanical contact between the central body CB1 and the peripheral body PB1 may be provided by a mounting material for fixing the peripheral body PB1 to the central body CB1 or by a further part of the coaxial connector COAX_CON1 in between the peripheral body PB1 to the central body CB1 with an electric conductive material.

[0041] The peripheral body PB1 may be mechanically and electrically connected to the central body CB1. The connection may be established by soldering, welding, crimping or screwing. A type of connection may depend on operation conditions during use of the coaxial connector COAX_CON1. Exemplarily, Figure 1 a) is shown with a welded joint WJ between the peripheral body PB1 and the central body CB1 of the outer conductor OC_COAX_CON1.

[0042] The coaxial connector COAX_CON2 of Figure 1 b) also comprises a central body CB2 with a circular outer conductor OC_COAX_CON2 for connecting the outer conductor of the coaxial cable and a central circular inner conductor IC_COAX_CON2 for connecting the inner conductor of the coaxial cable.

[0043] The inner conductor IC_COAX_CON2 may be identical to the inner conductor IC_COAX_CON1 of the coaxial connector COAX_CON1.

[0044] A dielectric material DM2 between the outer conductor OC_COAX_CON2 and the inner conductor IC_COAX_CON2 may be identical to the dielectric material DM1 of the coaxial connector COAX_CON1.

[0045] The outer conductor OC_COAX_CON2 of the

coaxial connector COAX_CON2 of Figure 1 b) further comprises a peripheral body PB2 located laterally to the central body CB2 of the outer conductor OC_COAX_CON2.

[0046] A position of an end face of the peripheral body PB2 adapted for connecting a grounding cable in a longitudinal direction of the coaxial connector COAX_CON2 may be identical to the position of the end face of the peripheral body PB1 of the coaxial connector COAX_CON1.

[0047] A geometrical form of the peripheral body PB2 may be identical to the geometrical form of the peripheral body PB1 of the coaxial connector COAX_CON1.

[0048] An opening PB2-OP of the peripheral body PB2 may be identical to the opening PB1-OP of the peripheral body PB1 of the coaxial connector COAX_CON1.

[0049] A conductor material of the central body CB2 and the peripheral body PB2 of the outer conductor OC_COAX_CON2 may be identical to the conductor material of the central body CB1 or the peripheral body PB1 of the coaxial connector COAX_CON1.

[0050] A main difference between the coaxial connector COAX_CON1 and the coaxial connector COAX_CON2 is based on the fact, that the central body CB2 and the peripheral body PB2 of the outer conductor OC_COAX_CON2 may be formed from a single part of an electric conductive material. A geometrical form of the single part may be generated by machining, milling or casting.

[0051] Figure 2 shows cross-sectional views along a longitudinal axis of coaxial connectors COAX_CON3, COAX_CON4 in accordance to further embodiments of the invention.

[0052] The coaxial connector COAX_CON3 of Figure 2 a) comprises a circular outer conductor OC_COAX_CON3 for connecting an outer conductor of the coaxial cable and a central circular inner conductor IC_COAX_CON3 for connecting an inner conductor of the coaxial cable.

[0053] The inner conductor IC_COAX_CON3 may be identical to the inner conductor IC_COAX_CON1 of the coaxial connector COAX_CON1.

[0054] A dielectric material DM3 between the outer conductor OC_COAX_CON3 and the inner conductor IC_COAX_CON3 may be identical to the dielectric material DM1 of the coaxial connector COAX_CON1.

[0055] A radial thickness of the outer conductor OC_COAX_CON3 of the coaxial connector COAX_CON3 of Figure 2 a) may be extended near a first end face towards the coaxial cable in comparison to a geometrical form of standard coaxial connectors such as N coaxial connectors or 7/16 DIN coaxial connectors preferably used for transmission lines between transceivers of a base station and external antenna systems or in comparison to a geometrical form of standard coaxial connectors such as BNC coaxial connectors, TNC coaxial connectors, F coaxial connectors or SMA coaxial connectors.

[0056] In further alternatives, a radial thickness of the

outer conductor OC_COAX_CON3 of the coaxial connector COAX_CON3 may be extended near a second end face opposite to the first end face comprising for example a screwing joint or a plug connection unit or may be extended along a whole longitudinal axis of the coaxial connector COAX_CON3 from the first end face to the second end face in comparison to the geometrical form of the standard coaxial connectors such as the BNC coaxial connectors, the TNC coaxial connectors, the F coaxial connectors, the N coaxial connectors, the 7/16 DIN coaxial connectors, or the SMA coaxial connectors.

[0057] Preferably, the radial thickness of the outer conductor OC_COAX_CON3 is adapted to the diameter of the cross sectional area of the conductor of the grounding cable to be applied and exceeds the diameter of the cross sectional area of the conductor of the grounding cable by a predefined amount (e.g. 0.5 mm or 1 mm). In case of using the invention for example for jumper cables between the transmitter and/or receiver of a base station and an external antenna system, a cross section of a circular conductor of the grounding cable is typically around 16 mm². This means, that the radial thickness of the outer conductor OC_COAX_CON3 may be for example equal to or above 2.5 mm.

[0058] Preferably, the first and/or the second end face of the outer conductor OC_COAX_CON3 comprises an opening OP-GC1 in a central radial position between an inner radius IR_OC1 of the outer conductor OC_COAX_CON3 and an outer radius OR_OC1 of the outer conductor OC_COAX_CON3. In an alternative, the radial position of the opening OP-GC1 may be shifted towards the outer radius OR_OC1 of the outer conductor OC_COAX_CON3.

[0059] The opening OP-GC1 may be identical to the opening PB1-OP of the peripheral body PB1 of the coaxial connector COAX_CON1.

[0060] The coaxial connector COAX_CON4 of Figure 2 b) comprises a circular outer conductor OC_COAX_CON4 for connecting an outer conductor of the coaxial cable and a central circular inner conductor IC_COAX_CON4 for connecting an inner conductor of the coaxial cable.

[0061] The inner conductor IC_COAX_CON4 may be identical to the inner conductor IC_COAX_CON1 of the coaxial connector COAX_CON1.

[0062] A dielectric material DM4 between the outer conductor OC_COAX_CON4 and the inner conductor IC_COAX_CON4 may be identical to the dielectric material DM1 of the coaxial connector COAX_CON1.

[0063] A radial thickness of the outer conductor OC_COAX_CON4 of the coaxial connector COAX_CON4 of Figure 2 b) may be extended similarly as the outer conductor OC_COAX_CON3 of the coaxial connector COAX_CON3. An outer surface of the outer conductor OC_COAX_CON4 comprises an opening OP-GC2 in a vertical direction to the longitudinal axis of the coaxial connector COAX_CON4 between a first end face and a second end face of the outer conductor OC_COAX_

CON4.

[0064] The opening OP-GC2 is preferably circular and has a diameter preferably adapted to a diameter of the cross sectional area of the conductor of the grounding cable. A depth of the opening OP-GC2 may be adapted to a fixing method to be applied for fixing the conductor of the grounding cable (e.g. 5 mm depth for welding or soldering) and/or may be adapted to materials of the outer conductor OC_COAX_CON4 and the conductor of the grounding cable.

[0065] The opening OP-GC2 may be an end-to-end opening from the outer surface of the outer conductor OC_COAX_CON4 at an outer radius OR_OC2 to an inner surface of the outer conductor OC_COAX_CON4 at an inner radius IR_OC2 and or may have a form of a blind hole without breaking through to the inner surface of the outer conductor OC_COAX_CON4.

[0066] A material of the outer conductors OC_COAX_CON1, OC_COAX_CON2, OC_COAX_CON3, OC_COAX_CON4 may be aluminium.

[0067] Using aluminium provides the advantages of reducing total weight of the coaxial connectors COAX_CON1, COAX_CON2, COAX_CON3, COAX_CON4. Furthermore, the utilization of aluminium reduces the manufacturing costs.

[0068] In further alternatives, metals such as copper alloy, gold plated copper alloy, copper, gold, or silver may be used for the material of the outer conductors OC_COAX_CON1, OC_COAX_CON2, OC_COAX_CON3, OC_COAX_CON4.

[0069] A material of the inner conductors IC_COAX_CON1, IC_COAX_CON2, IC_COAX_CON3, IC_COAX_CON4 may be copper, aluminium, gold or silver.

[0070] The inner and outer conductors IC_COAX_CON1, IC_COAX_CON2, IC_COAX_CON3, IC_COAX_CON4, OC_COAX_CON1, OC_COAX_CON2, OC_COAX_CON3, OC_COAX_CON4 may comprise a single metal, a bi-metal with two metals joined together or a plastic material covered with a metal.

[0071] The usage of metal-metal combinations or plastic-metal combinations for the conductors of the coaxial connectors COAX_CON1, COAX_CON2, COAX_CON3, COAX_CON4 increases the flexibility in the selection of adequate conductor materials to achieve the required electrical and mechanical properties for the coaxial cable terminated by the coaxial connectors COAX_CON1, COAX_CON2, COAX_CON3, COAX_CON4. The coaxial connectors COAX_CON1, COAX_CON2, COAX_CON3, COAX_CON4 may be based for example on N coaxial connectors (N = Neill) or 7/16 DIN coaxial connectors preferably used for transmission lines between receivers of a base station and external antenna systems or may be based for example on BNC coaxial connectors (BNC = Bayonet Neill Concelman), TNC coaxial connectors (TNC = Threaded Neill Concelman), F coaxial connectors or SMA coaxial connectors (SMA = Sub-Miniature-A).

[0072] Figure 3 shows a perspective view of an interface area between a coaxial cable COAX_CAB, a grounding cable G_CAB and a coaxial connector COAX_CON in accordance to a preferred embodiment of the invention. A sealing such as a plastic mould preferably covering the interface area between the coaxial cable COAX_CAB, the grounding cable G_CAB and the coaxial connector COAX_CON is not shown for simplification. Also the coaxial cable COAX_CAB as a whole, the grounding cable G_CAB as a whole and the coaxial connector COAX_CON as a whole are not shown for simplification.

[0073] The coaxial connector COAX_CON comprising an outer conductor OC_COAX_CON may be for example the coaxial connector COAX_CON2, if the grounding cable G_CAB and the coaxial cable COAX_CAB are connected in an equal direction (as shown in Figure 3) or opposite directions with respect to the coaxial connector COAX_CON. In further alternatives, the coaxial connector COAX_CON may be one of the coaxial connectors COAX_CON1, COAX_CON3, if the grounding cable G_CAB and the coaxial cable COAX_CAB are connected in an equal direction or opposite directions with respect to the coaxial connector COAX_CON.

[0074] If the grounding cable G_CAB may be connected in a vertical direction to a longitudinal axis of the coaxial connector COAX_CON and the coaxial cable COAX_CAB, the coaxial connector COAX_CON may be preferably identical to the coaxial connector COAX_CON4.

[0075] The coaxial cable COAX_CAB may be preferably of a hard line type using round copper, silver or gold tubing or a combination of such metals as an outer conductor OC_COAX_CAB. In an alternative, aluminium may be used for the outer conductor OC_COAX_CAB.

[0076] The outer conductor OC_COAX_CAB may be helically corrugated. In an alternative, the outer conductor OC_COAX_CAB may be annularly corrugated with rings of equal spacing. In a further alternative, the outer conductor OC_COAX_CAB may comprise a cylindrical tube with a flat surface. In an even further alternative, the outer conductor OC_COAX_CAB may comprise thin wires, which are twisted or not twisted.

[0077] An inner conductor IC_COAX_CAB of the coaxial cable COAX_CAB may consist of solid copper or copper plated aluminium. The inner conductor IC_COAX_CAB may comprise a solid or hollow cylinder. In further alternatives, the inner conductor IC_COAX_CAB may comprise thin wires, which are twisted or not twisted.

[0078] A dielectric material COAX_CAB_DM between the inner conductor IC_COAX_CAB and the outer conductor OC_COAX_CAB may comprise a polyethylene foam, PTFE (PTFE = polytetrafluorethylene), ceramic (such as steatite or aluminium oxide), mica or air.

[0079] The outer conductor OC_COAX_CAB and the dielectric material COAX_CAB_DM of the coaxial cable COAX_CAB may be removed for a predefined length at

an end piece of the coaxial cable COAX_CAB for connecting the coaxial cable COAX_CAB to the coaxial connector COAX_CON.

[0080] In an alternative, the outer conductor OC_COAX_CAB and the dielectric material COAX_CAB_DM of the coaxial cable COAX_CAB may be not removed at the end piece of the coaxial cable COAX_CAB, if an electrical and mechanical connection between the inner conductors of the coaxial cable COAX_CAB and the coaxial connector COAX_CON can be generated via an access provided by a specific geometrical construction of the coaxial connector COAX_CON.

[0081] A cable jacket COAX_CAB_J of the coaxial cable COAX_CAB may comprise an isolating, corrosion-resistant, and waterproof material such as PE (PE = polyethylene), PVC (PVC = polyvinyl chloride) or vulcanised rubber.

[0082] In an alternative, the coaxial cable COAX_CAB may comprise no cable jacket COAX_CAB_J, if the coaxial cable COAX_CAB is used in an environment, where the outer conductor OC_COAX_CAB of the coaxial cable COAX_CAB has no contact to other conductive materials or humidity during operation.

[0083] The coaxial cable COAX_CAB may be in a first alternative an RF cable for radio frequency applications in telecommunication such as a jumper cable or feeder cable used for a transmission line for radio frequency signals between radio a transmitter and/or a radio receiver and an antenna system. In a further alternative, the coaxial cable COAX1 may be a cable used for transmitting television or video signals. In an even further alternative, the coaxial cable COAX1 may be used for transmission of data signals in computer networks.

[0084] The coaxial connector COAX_CON terminates one of the end pieces of the coaxial cable COAX_CAB and one of the end pieces of the grounding cable G_CAB.

[0085] The grounding cable G_CAB may comprise a single wire or a group of two or more wires such as 7 individual wires as a conductor C_G_CAB. Preferably, the group of two or more wires may be twisted. In a further preferred alternative, the group of two or more wires may be for example of a 7 x 7 wire type. The 7 x 7 wire type comprises seven twisted wire systems, wherein each twisted wire system comprises seven twisted single wires.

[0086] A cable jacket G_CAB_J of the grounding cable G_CAB may consist of a plastic material such PE (PE = polyethylene), preferably. In an alternative, PVC (PVC = Polyvinyl chloride) may be used.

[0087] The grounding cable G_CAB may be connected to the coaxial connector COAX_CON by removing an end piece of the cable jacket G_CAB_J, by inserting the bared conductor C_G_CAB of the grounding cable G_CAB into the opening PB2-OP of peripheral body PB2 of the coaxial connector COAX_CON2 and by soldering, crimping, screwing or welding the conductor C_G_CAB of the grounding cable G_CAB to the peripheral body PB2 of

the coaxial connector COAX_CON2 (in case of using the coaxial connector COAX_CON2 as the coaxial connector COAX_CON).

[0088] Figure 4 shows side views of cable systems CAB_SYS1, CAB_SYS2 comprising the coaxial cable COAX_CAB with the grounding cable G_CAB and coaxial connectors COAX_CON_D, COAX_CON in accordance to further preferred embodiments of the invention.

[0089] Figure 4 a) shows a first cable system CAB_SYS1 comprising the coaxial cable COAX_CAB with the grounding cable G_CAB connected in an equal direction to the coaxial connector COAX_CON (see also Figure 3).

[0090] A first interface between a first end face of the coaxial cable COAX_CAB and the coaxial connector COAX_CON and a second interface between a first end face of the grounding cable G_CAB and the coaxial connector COAX_CON may be preferably sealed with a first sealing SEAL1. The first sealing SEAL1 may be for example a moulded plastic material such as a polyolefine resin. Thermoplastic polyolefins such as PE, PP (PP = polypropylene, PMP (PMP = polymethylpentene), PB-1 (PB-1 = polybutene-1) or polyolefin elastomers (POE) such as PIB (PIB = polyisobutylene), EPR (EPR = Ethylene propylene rubber) or EPDM rubber (EPDM = ethylene propylene diene monomer) may be used. In an alternative, the first sealing SEAL1 may be a heat-shrink tube.

[0091] A gasket sealing surrounding the outer conductor OC_COAX_CON of the coaxial cable COAX_CAB may be located near an end face of the cable jacket COAX_CAB_J of the coaxial cable COAX_CAB to avoid ingress of any humidity.

[0092] In a further alternative, the first interface between the coaxial cable COAX_CAB and the coaxial connector COAX_CON may be sealed with the first sealing SEAL1 and the second interface between the grounding cable G_CAB and the coaxial connector COAX_CON may be sealed with a further sealing. The further sealing may comprise the same moulded plastic material as used for the first sealing SEAL1, may comprise a further moulded plastic material different to the moulded plastic material of the first sealing SEAL1, or the further sealing may be a heat-shrink tube.

[0093] A material of the first sealing SEAL1 and/or the further sealing may be adapted to mechanical stress acting on the first and the second interface or may be adapted to environment conditions such as temperature range, range of air humidity, indoor or outdoor use, exposure to sun light or UV light or exposure to rain.

[0094] A second end face of the grounding cable G_CAB may comprise preferably a cable lug CAB_LUG. In further alternatives, the second end face of the grounding cable G_CAB may comprise a bared or non-bared end piece, a plug connector, a female connector.

[0095] A second end face of the coaxial cable COAX_CAB may be preferably connected to a further coaxial connector COAX_CON_D. The further coaxial

connector COAX_CON_D may be for example a BNC coaxial connector (BNC = Bayonet Neill Concelman), a TNC coaxial connector (TNC = Threaded Neill Concelman), an F coaxial connector, an N coaxial connector (N = Neill), a 7/16 DIN coaxial connector, or an SMA coaxial connector (SMA = Sub-Miniature-A).

[0096] Preferably an interface between the second end face of the coaxial cable COAX_CAB and the further coaxial connector COAX_CON_D may be sealed with a second sealing SEAL2. The second sealing SEAL2 may be for example a moulded plastic material such as a polyolefine resin (see examples above for the first sealing SEAL1) or may be a heat-shrink tube.

[0097] Figure 4 b) shows a second cable system CAB_SYS2 comprising the coaxial cable COAX_CAB with the grounding cable G_CAB connected in opposite directions with respect to the coaxial connector COAX_CON. Comparing with Figure 3 and Figure 1 b), this means for example in case of the coaxial connector COAX_CON2, that the coaxial cable COAX_CAB is connected to a first end face of the central body CB2 of the coaxial connector

[0098] COAX_CON2 and that the grounding cable G_CAB is connected to an end face of the peripheral body PB2 directed to a second end face of the central body CB2 (e.g. comprising for example a plug unit or screwing unit), which is opposite to the first end face of the central body CB2. A position of the end face of the peripheral body PB2 depends on an axial length of the peripheral body PB2, which may be smaller of equal to an axial length of the central body CB2.

[0099] A third interface between the first end face of the coaxial cable COAX_CAB and the coaxial connector COAX_CON and a fourth interface between the first end face of the grounding cable G_CAB and the coaxial connector COAX_CON may be preferably sealed with a third sealing SEAL3. The third sealing SEAL3 may be for example a moulded plastic material such as a polyolefine resin (see examples above for the first sealing SEAL1) or may be a heat-shrink tube.

[0100] In a further alternative, the third interface between the coaxial cable COAX_CAB and the coaxial connector COAX_CON may be sealed with the third sealing SEAL3 and the fourth interface between the grounding cable G_CAB and the coaxial connector COAX_CON may be sealed with a further sealing. The further sealing may comprise the same moulded plastic material as used for the third sealing SEAL3, may comprise a further moulded plastic material different to the moulded plastic material of the third sealing SEAL3, or the further sealing may be a heat-shrink tubing.

[0101] A material of the third sealing SEAL3 and/or the further sealing may be adapted to mechanical stress acting on the first and the second interface or may be adapted to environment conditions such as temperature range, range of air humidity, indoor or outdoor use, exposure to sun light or UV light or exposure to rain.

[0102] The second end face of the grounding cable

G_CAB may comprise preferably the cable lug CAB_LUG. In further alternatives the second end face of the grounding cable G_CAB may comprise the bared or not-bared end piece, the plug connector, the female connector.

[0103] The second end face of the coaxial cable COAX_CAB may be connected to the further coaxial connector COAX_CON_D.

[0104] Preferably the interface between the second end face of the coaxial cable COAX_CAB and the further coaxial connector COAX_CON_D may be sealed with the second sealing SEAL2.

[0105] In an alternative, a further cable system may comprise the coaxial cable COAX_CAB with the grounding cable G_CAB connected in a vertical direction to the longitudinal axes of the coaxial connector COAX_CON and the coaxial cable COAX_CAB using for example the coaxial connector COAX_CON4 (not shown in Figure 4).

[0106] Figure 5 shows schematic views of base stations BS1, BS2 in accordance to even further embodiments of the invention.

[0107] Figure 5 a) shows a first base station BS1 comprising a housing HOUS, an antenna system ANT and a first transmission line TL1 between the housing HOUS and the antenna system ANT.

[0108] The housing HOUS may be for example a rack comprising one or several receivers RC and/or one or several transmitters TR. In an alternative, the housing HOUS may comprise one or several transceivers.

[0109] The antenna system ANT may comprise one or more antenna elements. The first transmission line TL1 may comprise a feeder cable F_CAB and the first cable system CAB_SYS1 shown in Figure 4 a).

[0110] A first end piece of the feeder cable F_CAB is connected to the one or several transmitters TR and/or the one or several receivers RC and a second end piece of the feeder cable F_CAB is connected to the further coaxial connector COAX_CON_D of the first cable system CAB_SYS1.

[0111] The coaxial connector COAX_CON of the first cable system CAB_SYS1 is connected to the antenna system ANT. The grounding cable G_CAB of the first cable system CAB_SYS1 is connected with the cable lug CAB_LUG to a first earth contact EC1. This allows for grounding the first transmission line TL1 at an antenna port of the antenna system ANT.

[0112] The coaxial cable COAX_CAB of the first cable system CAB_SYS1 is a jumper cable J_CAB.

[0113] The feeder cable F_CAB preferably comprises a first grounding kit GK1 at a cable position, where a routing of the feeder cable F_CAB changes from a vertical direction to a horizontal direction with respect to the Earth's surface. A first end of a grounding cable of the first grounding kit GK1 is connected to an outer conductor of the feeder cable F_CAB and a second end of the grounding cable of the first grounding kit GK1 is connected to a second earth contact EC2.

[0114] The feeder cable F_CAB preferably comprises

a second grounding kit GK2 at a cable position near the housing HOUS. A first end of a grounding cable of the second grounding kit GK2 is connected to the outer conductor of the feeder cable F_CAB and a second end of the grounding cable of the second grounding kit GK2 is connected to a third earth contact EC3.

[0115] Figure 5 b) shows a second base station BS2 comprising the housing HOUS, the antenna system ANT and a second transmission line TL2 between the housing HOUS and the antenna system ANT.

[0116] The second transmission line TL2 comprises the second cable system CAB_SYS2 instead of the first cable system CAB_SYS1 used for the first transmission line TL1 of the first base station BS1. This allows for grounding the second transmission line TL2 at an interface between the second cable system CAB_SYS2 and the feeder cable F_CAB.

[0117] In an alternative, the first and the second transmission line TL1, TL2 may comprise a further cable system with a further jumper cable between the housing HOUS and the first end piece of the feeder cable F_CAB, wherein the grounding cable G_CAB of the further cable system is preferably connected in a vertical direction with respect to the longitudinal axes of the coaxial connector and the coaxial cable (see Figure 2 b)).

[0118] For an optimal lightning protection, the grounding wire G_CAB is preferably routed in a direction of a lightning current, which means vertically with respect to the Earth's surface. This means, both embodiments shown in Figure 5 a) and b) require a different one of the cable systems CAB_SYS1, CAB_SYS2. Likewise, in case of using the further jumper cable between the housing HOUS and the first end piece of the feeder cable F_CAB the further cable system is required (not shown in Figure 4).

Claims

1. A coaxial connector (COAX_CON, COAX_CON1, COAX_CON2, COAX_CON3, COAX_CON4) for terminating a coaxial cable (COAX_CAB), said coaxial connector (COAX_CON, COAX_CON1, COAX_CON2, COAX_CON3, COAX_CON4) comprising means for connecting an inner conductor (IC_COAX_CAB) and an outer conductor (OC_COAX_CAB) of said coaxial cable (COAX_CAB) and wherein an outer conductor (OC_COAX_CON1, OC_COAX_CON2, OC_COAX_CON3, OC_COAX_CON4) of said coaxial connector (COAX_CON, COAX_CON1, COAX_CON2, COAX_CON3, COAX_CON4) comprises means for connecting a grounding cable (G_CAB).
2. Coaxial connector (COAX_CON, COAX_CON1, COAX_CON2) according to claim 1, wherein said outer conductor (OC_COAX_CON1, OC_COAX_CON2) comprises a central body (CB1, CB2) for

- connecting said inner conductor (IC_COAX_CAB) and said outer conductor (OC_COAX_CAB) of said coaxial cable (COAX_CAB) and a peripheral body (PB1, PB2) for connecting said grounding cable (G_CAB).
3. Coaxial connector (COAX_CON, COAX_CON1, COAX_CON2) according to claim 2, wherein a single part of an electrical conductive material comprises said central body (CB1, CB2) and said peripheral body (PB1, PB2).
 4. Coaxial connector (COAX_CON, COAX_CON1, COAX_CON2) according to claim 2, wherein said central body (CB1, CB2) is a first part of an electrical conductive material, wherein said peripheral body (PB1, PB2) is a second part of said electrical conductive material or of a further electrical conductive material and wherein said peripheral body (PB1, PB2) is mechanically and electrically connected to said central body (CB1, CB2).
 5. Coaxial connector (COAX_CON, COAX_CON3, COAX_CON4) according to claim 1, wherein a radial thickness of said outer conductor (OC_COAX_CON3, OC_COAX_CON4) of said coaxial connector (COAX_CON, COAX_CON3, COAX_CON4) is adapted to a diameter of a cross sectional area of a conductor of said grounding cable (G_CAB) and wherein said outer conductor (OC_COAX_CON3, OC_COAX_CON4) of said coaxial connector (COAX_CON, COAX_CON3, COAX_CON4) comprises an opening (OP_GC1, OP_GC2) for fixing said grounding cable (G_CAB).
 6. A coaxial cable (COAX_CAB) with a grounding cable (G_CAB) and a coaxial connector (COAX_CON, COAX_CON1, COAX_CON2, COAX_CON3, COAX_CON4) according to any of the preceding claims and wherein said coaxial connector (COAX_CON, COAX_CON1, COAX_CON2, COAX_CON3, COAX_CON4) terminates said coaxial cable (COAX_CAB) and terminates said grounding cable (G_CAB).
 7. Coaxial cable (COAX_CAB) according to claim 6, wherein said coaxial cable (COAX_CAB) and said grounding cable (G_CAB) are connected to said coaxial connector (COAX_CON, COAX_CON1, COAX_CON2, COAX_CON3) in an equal direction or in opposite directions.
 8. Coaxial cable (COAX_CAB) according to claim 6, wherein said grounding cable (G_CAB) is connected in a vertical direction to a longitudinal axis of said coaxial connector (COAX_CON, COAX_CON4).
 9. Coaxial cable (COAX_CAB) according to any of the preceding claims 6, 7, 8, wherein a first interface
- between said coaxial cable (COAX_CAB) and said coaxial connector (COAX_CON, COAX_CON1, COAX_CON2, COAX_CON3, COAX_CON4) is sealed with a plastic material and a second interface between said grounding cable (G_CAB) and said coaxial connector (COAX_CON, COAX_CON1, COAX_CON2, COAX_CON3, COAX_CON4) is sealed with said plastic material or a further plastic material.
10. Coaxial cable (COAX_CAB) according to claim 9, wherein said plastic material is moulded to said first interface and to said second interface or wherein said plastic material is moulded to said first interface and/or said further plastic material is moulded to said second interface.
 11. Coaxial cable (COAX_CAB) according to any of the preceding claims 6-10, wherein said grounding cable (G_CAB) is connected to said coaxial connector (COAX_CON, COAX_CON1, COAX_CON2, COAX_CON3, COAX_CON4) by either of the following: soldering, crimping, screwing, welding.
 12. Coaxial cable (COAX_CAB) according to any of the preceding claims 6-11, wherein said grounding cable (G_CAB) comprises a single wire or a group of at least two wires.
 13. Coaxial cable (COAX_CAB) according to claim 12, wherein said at least two wires of said group are twisted.
 14. Coaxial cable (COAX_CAB) according to any of the preceding claims 6-13, wherein said coaxial cable (COAX_CAB) is a jumper cable (J_CAB) or a feeder cable (F_CAB).
 15. A base station (BS1, BS2) for use in a radio communication system, said base station (BS1, BS2) comprising at least one receiver (RC) and/or at least one transmitter (TR), at least one external antenna system (ANT) and at least one coaxial cable (COAX_CAB) according to any of the preceding claims 6-13 connecting said at least one receiver (RC) and/or said at least one transmitter (TR) to said at least one antenna system (ANT) by said coaxial cable (COAX_CAB) and connecting said coaxial connector (COAX_CON, COAX_CON1, COAX_CON2, COAX_CON3, COAX_CON4) to an earth contact (EC1) by said grounding cable (G_CAB).

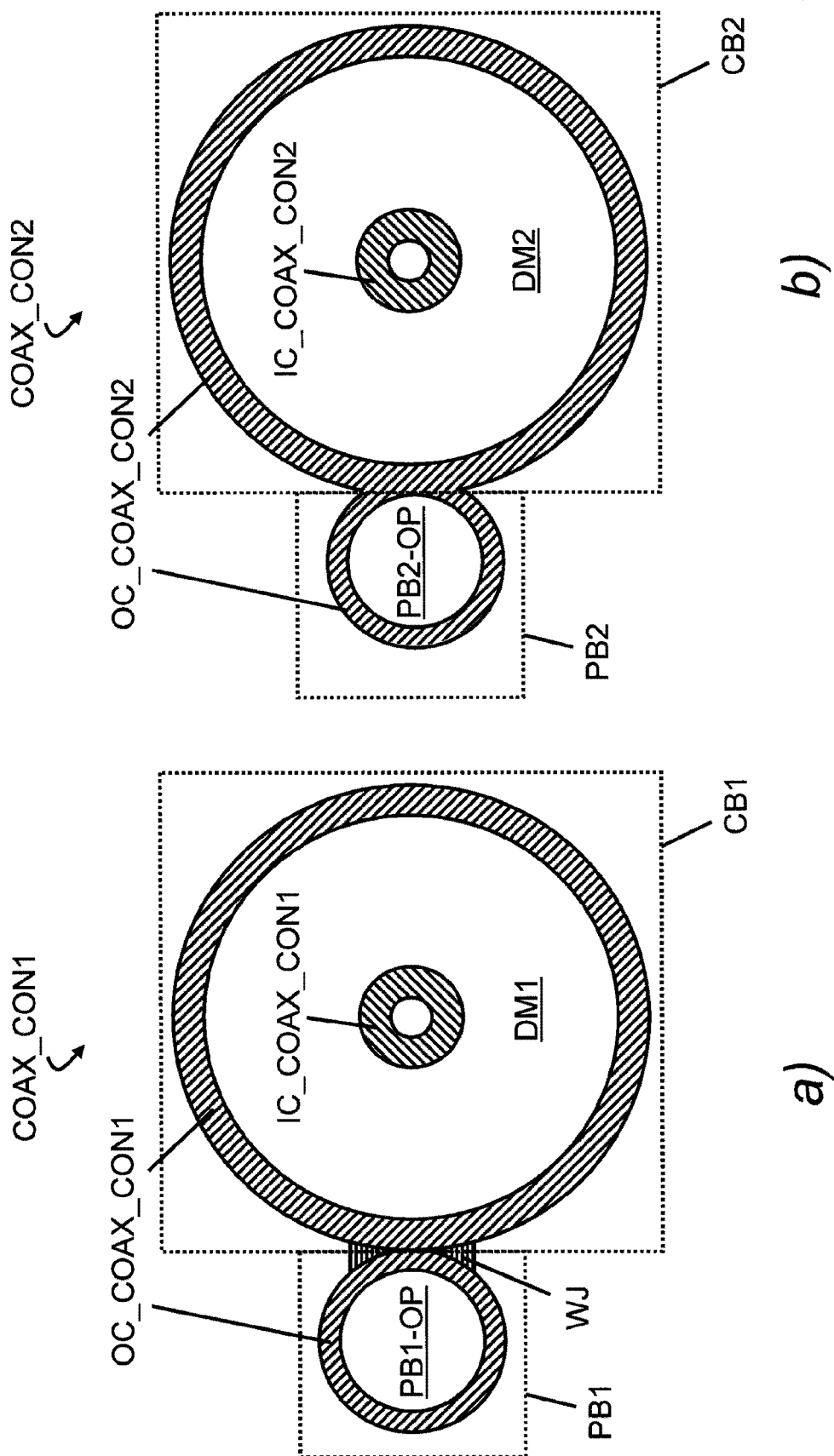


FIG. 1

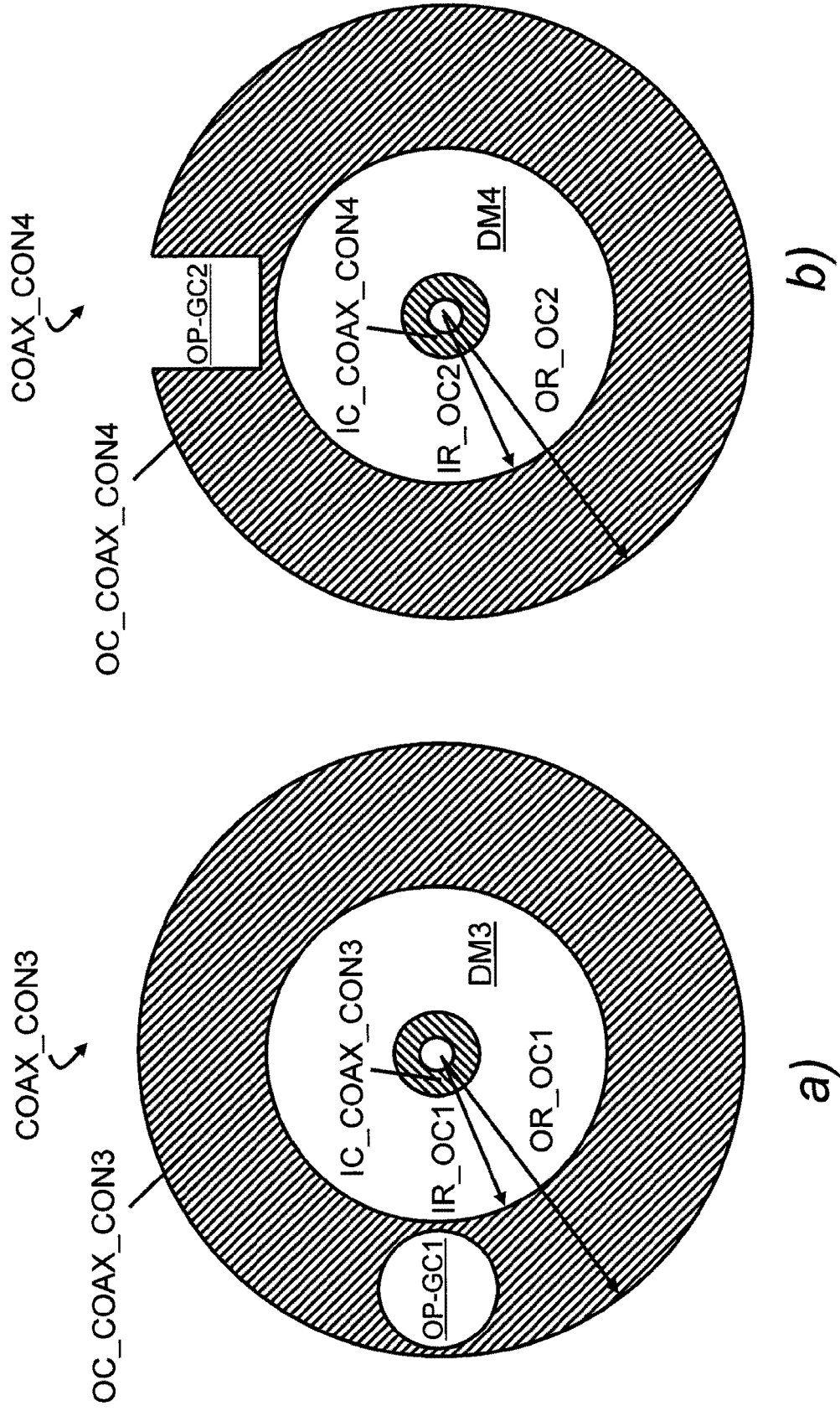


FIG. 2

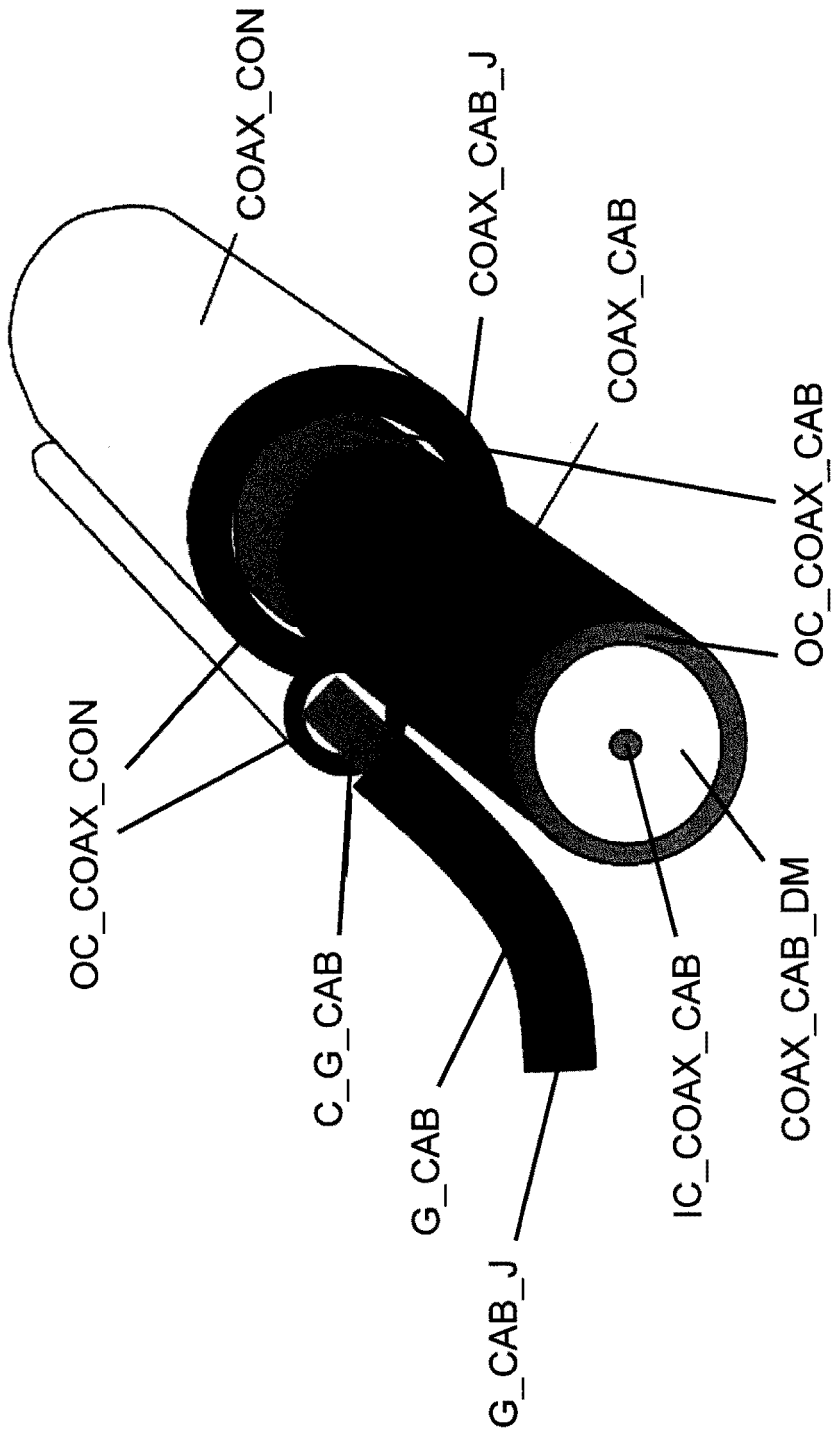


FIG. 3

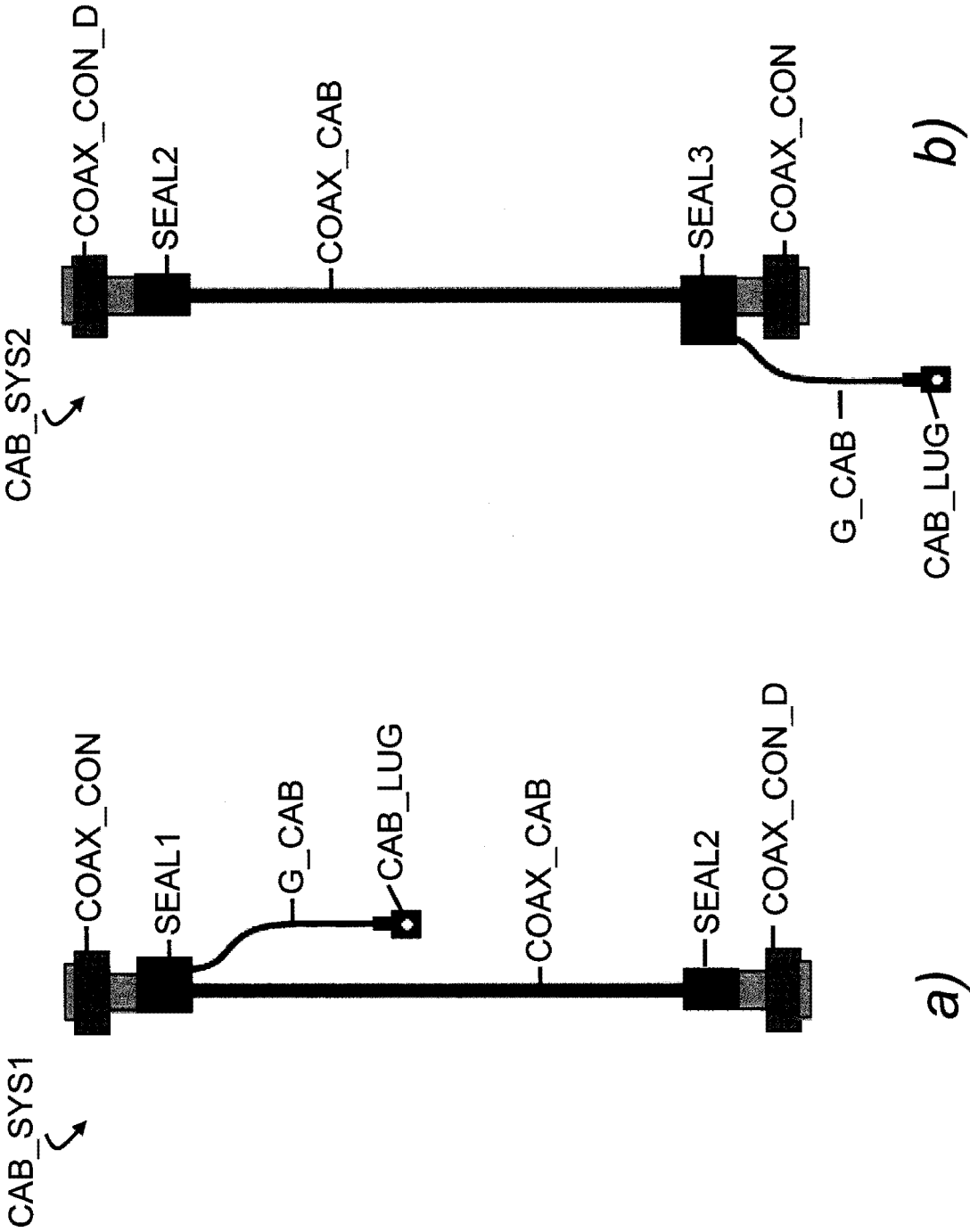


FIG. 4

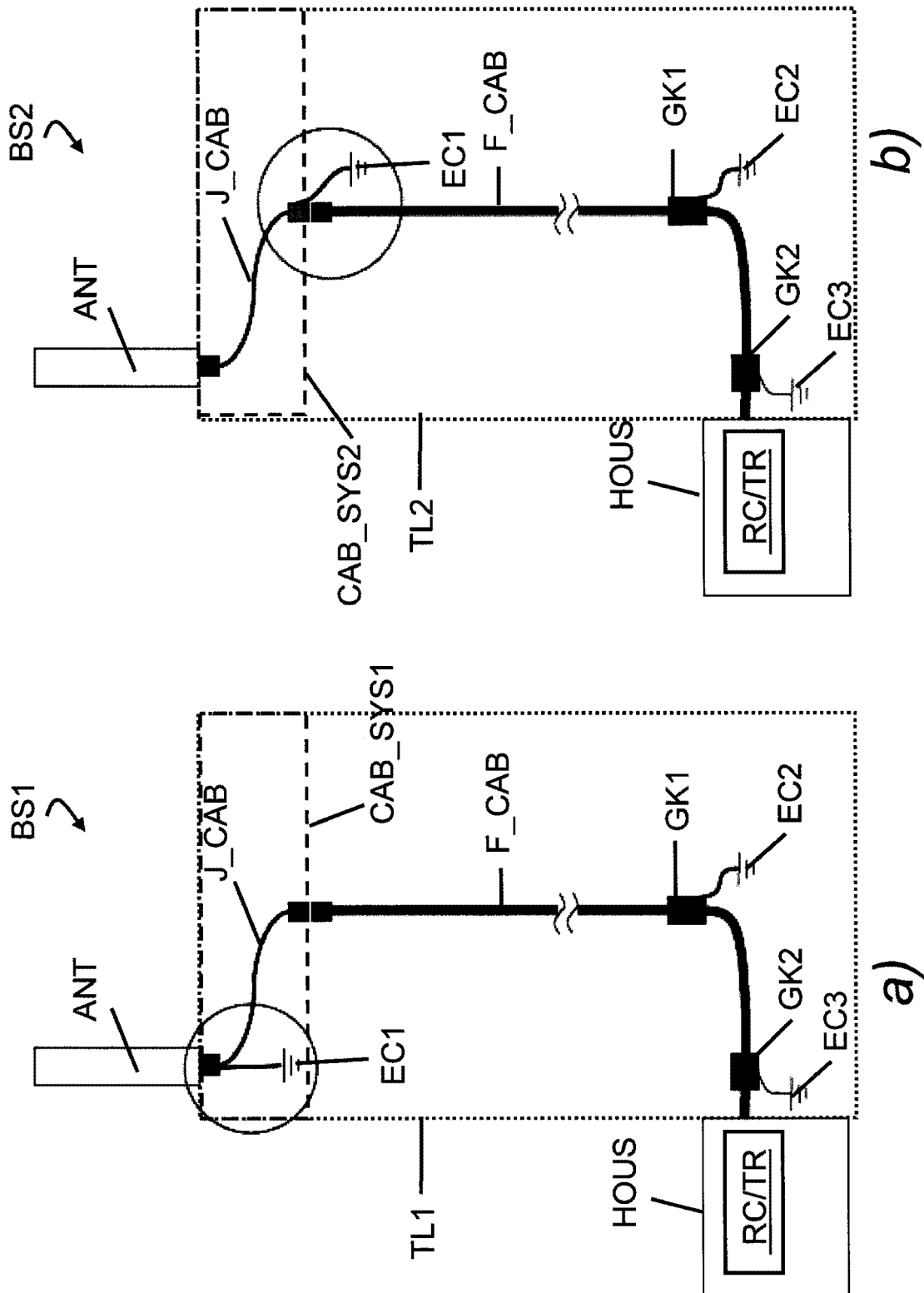


FIG. 5



EUROPEAN SEARCH REPORT

Application Number
EP 10 30 5646

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 27 September 2010	Examiner Knack, Steffen
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