(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 2 854 215 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
01.04.2015 Bulletin 2015/14

(51) Int Cl.:
H01Q 1/32 *(2006.01)* ***H01Q 9/36*** *(2006.01)*
H01Q 9/30 *(2006.01)*

(21) Application number: **14186129.4**

(22) Date of filing: **24.09.2014**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

(30) Priority: **26.09.2013 DE 102013219377**

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(54) **Antenna arrangement having an antenna unit and connector unit**

(57) The present invention relates to an antenna arrangement having an antenna unit and a connector unit for electrically connecting the antenna unit to an associated counter-connector unit. The antenna unit has a conductor rod and a folded-top element, wherein the connector unit has a coaxial plug type connector having an inner conductor, an outer conductor and an electrically insulating housing, wherein the conductor rod is connected to the inner conductor of the coaxial plug type connector and the folded-top element is formed by an electrically conductive coating of the electrically insulating housing.

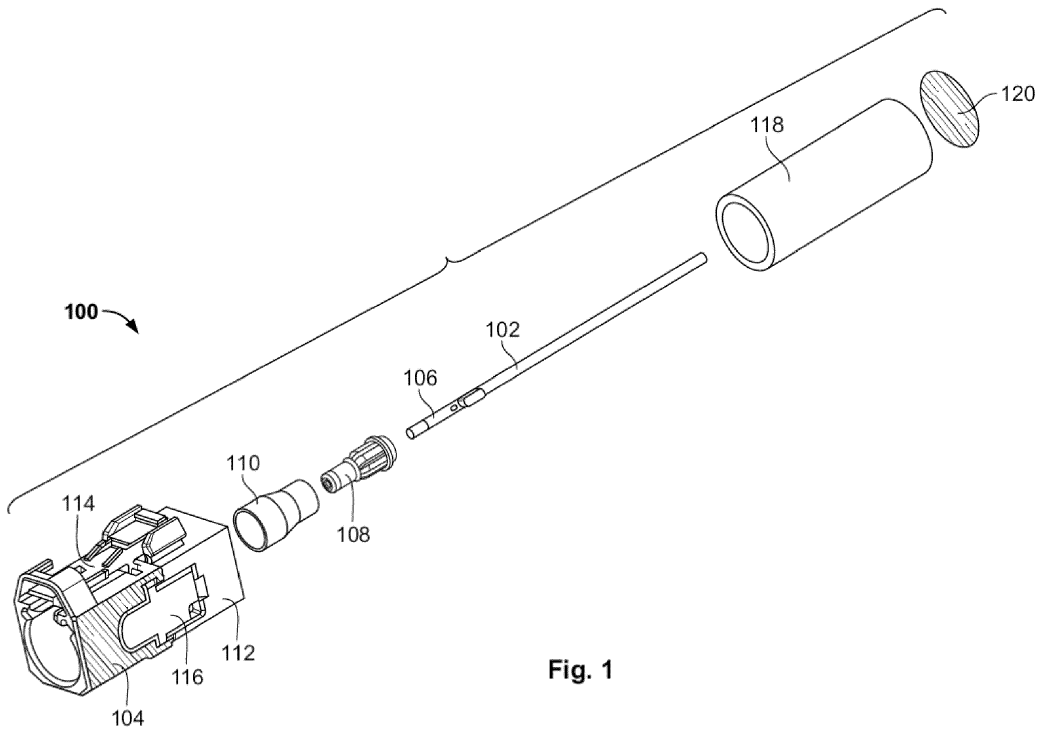

Fig. 1

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Description

[0001] The present invention relates to an antenna arrangement having an antenna unit and a connector unit for electrically connecting the antenna unit to an associated counter-connector unit.

[0002] Such antennae are widespread in particular in the automotive field and serve to transmit an extremely wide range of signals. In particular for multimedia applications having high data rates, monopole antennae are often used nowadays. Such a monopole antenna comprises in its most simple form a straight cylindrical conductor, which is excited at a base location with respect to earth. The electrical properties of such antennae are dependent both on the geometry of the monopole element and on the ground surface. The length of the monopole is approximately a quarter of the wavelength which is intended to be transmitted.

[0003] In general, for example, for communication between vehicles, there are used special antenna elements which enable wireless communication between those vehicles which are provided with so-called on-board units. Such an on-board unit can detect, for example, information relating to current traffic situations (for example, traffic jams, icy roads or construction works) and vehicle-specific parameters (such as the speed, the movement direction, the acceleration, the external temperature or the operating status of the windscreen wipers). This information can then be transmitted via a transmission device to other vehicles in the same geographical region, as long as they are provided with corresponding on-board units. A receiver unit of such an on-board unit can subsequently evaluate the information from more than one vehicle in order to increase the traffic safety and the efficiency of each vehicle. Therefore, antennae as used for communication between vehicles are subject to specific requirements.

[0004] On the one hand, the emission pattern has to have precisely defined properties: in particular it is advantageous for the antenna element to have undirected emission. In this instance, the term "undirected" is intended to be understood to mean that the antenna element has a round beam characteristic in the horizontal plane, that is to say that it emits uniform power in all directions perpendicularly to the line of extent of the antenna element.

[0005] On the other hand, strict requirements are placed on a vehicle antenna in terms of the dimensions and shape of the antenna element and in particular the structural size has to be as small as possible. In particular, it is mostly necessary for the antenna element to be able to be fitted in existing vehicle roof antenna housings.

[0006] Furthermore, with such antenna arrangements, there is in most cases the requirement for them to be connected to an already existing counter-connector, in particular a coaxial plug type connector, via a connector arrangement.

[0007] There is therefore the requirement to provide an antenna arrangement which can be contacted by means of a connector arrangement, which can be produced in the most simple manner possible and which can further be miniaturised to the greatest possible extent.

[0008] This object is achieved with the subject-matter of the independent patent claims. Advantageous developments of the present invention are set out in the dependent patent claims.

[0009] The present invention is based on the notion of constructing a connector unit which is securely connected to the antenna unit in such a manner that components of the antenna unit are carried by the electrically insulating connector housing. The structural length of the entire antenna unit is thereby shortened accordingly.

[0010] In particular, the antenna unit has a conductor rod and a folded-top element and the connector unit has a coaxial plug type connector having an inner conductor, an outer conductor and an electrically insulating housing.

[0011] According to the invention, the conductor rod is connected to the inner conductor of the coaxial plug type connector and the folded-top element is formed by an electrically conductive coating of the electrically insulating housing. According to an advantageous development of the present invention, the antenna arrangement further has a roof capacitor which is connected to the conductor rod in a conductive manner at an end which is remote from the connector unit. This roof capacitor is constructed in an extensive and substantially rotationally symmetrical manner. As is generally known, such a roof capacitor can be used to influence the electrically effective length of the antenna unit. The roof capacitor can in this instance be constructed as a rotationally symmetrical disc, but also as an arrangement comprising a large number of rings about such a disc according to EP 1445828 A2. When the roof capacitor is configured in a corresponding manner, it is possible to achieve, for example, operational ability at different frequencies.

[0012] The roof capacitor can be produced in a particularly simple manner when it is applied as an electrically conductive coating to an electrically insulating protective sheath which at least partially surrounds the conductor rod. Since the protective sheath ensures the mechanical stability, any structures may be selected for the roof capacitor.

[0013] A particularly efficient manner of producing both the housing structure with the electrically conductive coating and the roof capacitor on the electrically insulating protective sheath is the production as a Molded Interconnect Device (MID).

[0014] A Molded Interconnect Device is generally a preferably injection-moulded plastics material component which combines both electrical and mechanical functionalities in a single component. The production of MIDs is a relatively new field with an extremely large potential for industrial applications, in particular in the automotive industry. For example, using single or multi-component injection-moulding methods and subsequent selective metal coating, almost any structures can be pro-

duced. MID techniques in particular afford the advantage of extensive miniaturisation and a substantial reduction of production costs in comparison with many existing methods. Furthermore, the MID technology also affords the possibility of producing completely new types of product designs. For the production of MIDs there are a large number of process sequences and the technology is still developing rapidly.

[0015] One possibility of producing an MID involves processing with laser radiation a thermoplastic cast component which contains metal particles and subsequently carrying out a currentless metal deposition. This process is generally known as Laser Direct Structuring (LDS). Another possibility involves coating the entire plastics material substrate with metal using physical vapour deposition (PVD) and subsequently removing the metal where it is not required by means of a laser processing operation. Furthermore, metal structures can also be pressed directly under the action of heat on the three-dimensional surface of an injection-moulded plastics component. With so-called two-dimensional injection-moulding methods, coatable and non-coatable polymers are combined in an injection-moulding method and the metal coating is bonded only to the coatable polymer. Furthermore, a laser-sensitive polymer can also be combined with a non-coatable polymer and the laser sensitive-polymer is subsequently structured before the metal coating. In this manner, it is possible, for example, to save expensive LDS material when only small portions of the entire MID are intended to be provided with metal. Finally, the desired metal structures can also be inserted into the injection-moulding mould as prefabricated components and be embedded in the plastics material component during the injection-moulding method. In particular, flexible polymer films can also be injected with printed metal coatings as so-called inserts.

[0016] The present invention can be used in a particularly advantageous manner together with WiFi applications and it is, for example, advantageous to size the antenna arrangement for receiving frequencies of 2.4 GHz in this instance.

[0017] Of course, however, it is possible to transmit all other required frequencies and also a plurality of frequencies using the arrangement according to the invention.

[0018] In the field of high-frequency connector arrangements, in particular with coaxial cable connectors, in order to standardise the different connector arrangement types, in particular the interfaces for such connector arrangements, various industry standards are used. One of these standards is known as FAKRA (Fachkreis Automobil). FAKRA is the "Fachkreis Automobil" (Automotive Technical Body) of the German Institute for Standardisation which represents international standardisation interests in the automotive sector. The FAKRA standard provides a system which is based on mechanical coding and colour coding for correct fitting of connectors. In FAKRA connectors, the same socket projections can only be connected to identical connector recesses. Reliable positioning of the locking system of connector housings is facilitated by means of securing according to the FAKRA standard to the socket housing and a lock which cooperates therewith on the connector housing.

[0019] An example of a plug type connector which can be used in an antenna arrangement according to the present invention is described in detail in DE 10 2012 201565 A1, in particular with reference to Figures 1 and 3 and 5. The present invention is based in this instance on the notion of adapting such a known housing, and in particular the connector arrangement, using an appropriate metal coating technology in such a manner that elements of the antenna unit are produced on the connector housing. As already mentioned, this can be carried out in particular using an MID technology during the injection-moulding process.

[0020] In terms of circuit technology, the metal coating which is applied to the plug type connector housing can act, on the one hand, as a reference ground and, on the other hand, balun functions can be carried out therewith.

[0021] For better understanding of the present invention, it is explained in greater detail with reference to the embodiments illustrated in the appended Figures. In this instance, some features or feature combinations from the different embodiments shown and described may constitute independent inventive solutions or solutions according to the invention per se.

[0022] In the drawings:

Figure 1 is an exploded view of the antenna arrangement according to the invention;

Figure 2 is a perspective view of the antenna arrangement according to the invention;

Figure 3 is a schematic illustration of the antenna arrangement according to the invention and an associated electrical equivalent circuit diagram.

[0023] The present invention is explained in detail below with reference to the Figures. Figure 1 shows in the form of an exploded view an antenna arrangement 100 according to an exemplary embodiment of the present invention.

[0024] The antenna arrangement 100 comprises an antenna unit having a conductor rod 102 and a folded-top element 104. The conductor rod 102 is a preferably cylindrical metal component and is connected to the inner conductor 106 of the FAKRA coaxial plug type connector, for example, by means of a crimp connection. The coaxial plug type connector has, as can be seen from DE 10 2012 201565 A1, a dielectric 108 which surrounds the inner conductor 106 and an outer conductor 110 which is electrically insulated from the inner conductor 106 by means of the dielectric 108.

[0025] According to the invention, the connector unit has an electrically insulating housing 112 which is at least partially surrounded by an outer metal coating which acts as a folded-top element 104. In the illustration of Figure 1, the metal coating is indicated with cross-hatching. In

order to simplify the production process, no metal coating is provided, for example, in the region of the locking device 114 and the lock 116. Of course, however, these regions may also be metal-coated should this be necessary.

[0026] In the embodiment shown, the connector unit is a coaxial plug type connector having a connector pin, whilst the plug type counter-connector (not shown) constitutes the corresponding socket element. However, it is clear to a person skilled in the art that the conductor rod 102 could also be connected to a socket element. Furthermore, the present embodiment is based on only one releasable plug type connection. Alternatively, however, other connector housings may also be provided with the metal coating according to the invention, for example, in combination with press-fitting or solder connections.

[0027] In order to ensure adequate mechanical stability, the antenna arrangement further has a preferably electrically insulating protective sheath 118. This may, for example, be produced as an injection-moulded component of plastics material.

[0028] According to an advantageous embodiment of the antenna arrangement 100, there is applied to the electrically insulating protective sheath 118 a metal structure which acts as a roof capacitor 120.

[0029] The additional use of a roof capacitor 120 opens up the possibility of electrically extending the antenna. In this instance, it is known in principle that the resonance frequency of a monopole is indirectly proportional to the length thereof. An electrical extension of the antenna means that the length of the antenna is shorter than would be required by the desired resonance frequency. Owing to a specific arrangement, it is then ensured that the antenna is nonetheless in resonance at the desired frequency. This is understood to be "electrical extension" in an antenna.

[0030] The roof capacitor 120 can, for example, be produced on the protective sheath 118 using an MID method and can be connected to the conductor rod 102 in an electrically conductive manner by means of a solder connection. In Figure 1, the roof capacitor 120 is constructed as a circular continuous conductive disc. However, it is clear to a person skilled in the art that the advantages of the MID method are based on the fact that any metal structures can also be produced on a three-dimensional protective sheath member which is constructed in a more complex manner.

[0031] As already mentioned, the folded-top element 104 and the roof capacitor 120 can be produced according to all known MID metal-coating technologies on the associated plastics material component in each case, that is to say, the housing 112 and the protective sheath 118.

[0032] Figure 2 shows the completely assembled antenna arrangement 100 in a rotated view. Owing to the inclusion of the connector in the construction of the antenna unit, a particularly compact structure can be achieved. For example, the arrangement from Figure 2 has an overall length of only little more than 5 cm.

[0033] Figure 5 is a schematic illustration of an equivalent electrical circuit diagram of the antenna arrangement 100. In this instance, the 50 Ω input location is designated 122. It should be noted that the folded-top element 104 (which is also referred to as a "sleeve") is not connected to the antenna in an electrically conductive manner, but is only coupled in a capacitive manner both to the outer conductor 110 and to the roof capacitor 120. The significant parameters of the antenna circuit are consequently, in addition to the ohmic resistance of the antenna and the inductivity $L_{Antenna}$, the capacitance of the roof capacitor C_{Roof} and the capacitance of the folded-top element C_{Sleeve}.

[0034] R_i and U_i refer to the input voltage and the internal resistance of the connected signal source.

[0035] The solution according to the invention enables an antenna of reduced size to be produced, which antenna brings about no impairment of the advantage or the power, but which can nonetheless be produced in a simple and cost-effective manner. In particular according to the present invention, a plastics material connector housing is provided with a corresponding metal coating, for example, using an MID process. This metal structure is part of the antenna structure and does not take up any additional space.

[0036] In the embodiment shown, both the roof capacitor for the monopole and the required ground reference are produced using an MID method. In particular, the overall length can be reduced by approximately 20% in comparison with a separate construction of the reference ground and plug type connector. In particular in the predetermined antenna construction spaces, therefore, the antenna arrangement according to the invention can be accommodated more readily.

REFERENCE NUMERALS

[0037]

100	Antenna arrangement
102	Conductor rod
104	Folded-top element
106	Inner conductor
108	Dielectric
110	Outer conductor
112	Electrically insulating housing
114	Locking device
116	Lock
118	Electrically insulating protective sheath
120	Roof capacitor

(continued)

122	50 Ω input location

Claims

1. Antenna arrangement having an antenna unit and a connector unit for electrically connecting the antenna unit to an associated counter-connector unit,
wherein the antenna unit has a conductor rod (102) and a folded-top element (104), wherein the connector unit has a coaxial plug type connector having an inner conductor (106), an outer conductor (110) and an electrically insulating housing (112),
wherein the conductor rod (102) is connected to the inner conductor (106) of the coaxial plug type connector and the folded-top element (104) is formed by an electrically conductive coating of the electrically insulating housing (112).

2. Antenna arrangement according to claim 1, which further has a roof capacitor (120) which is connected to the conductor rod (102) in a conductive manner at an end which is remote from the connector unit.

3. Antenna arrangement according to claim 1 or claim 2, wherein the conductor rod (102) is at least partially surrounded by an electrically insulating protective sheath (118).

4. Antenna arrangement according to claim 2 and claim 3, wherein the roof capacitor (120) is formed by an electrically conductive coating of the electrically insulating protective sheath (118).

5. Antenna arrangement according to any one of the preceding claims, wherein the electrically insulating housing (112) and/or the electrically insulating protective sheath (118) is produced with the electrically conductive coating as a Molded Interconnect Device (MID).

6. Antenna arrangement according to claim 5, wherein the electrically conductive coating is produced using a currentless metal deposit operation in a Laser Direct Structuring (LDS) method, using physical vapour deposition (PVD) and subsequent structuring or directly by means of pressing under the action of heat on the three-dimensional surface of the electrically insulating housing (112) and/or the electrically insulating protective sheath (118).

7. Antenna arrangement according to claim 5 or claim 6, wherein the electrically conductive coating is produced by means of injecting a metal insert when the electrically insulating housing (112) is produced and/or when the electrically insulating protective sheath (118) is produced.

8. Antenna arrangement according to any one of the preceding claims, wherein the antenna arrangement is sized to receive frequencies of 2.4 GHz.

9. Antenna arrangement according to any one of the preceding claims, wherein the coaxial plug type connector is an SMBA-(FAKRA) plug type connector according to DIN 72594-1 and USCAR-18.

10. Antenna arrangement according to any one of the preceding claims, wherein the folded-top element (104) forms a reference ground.

11. Antenna arrangement according to any one of the preceding claims, wherein the folded-top element (104) forms a balun.

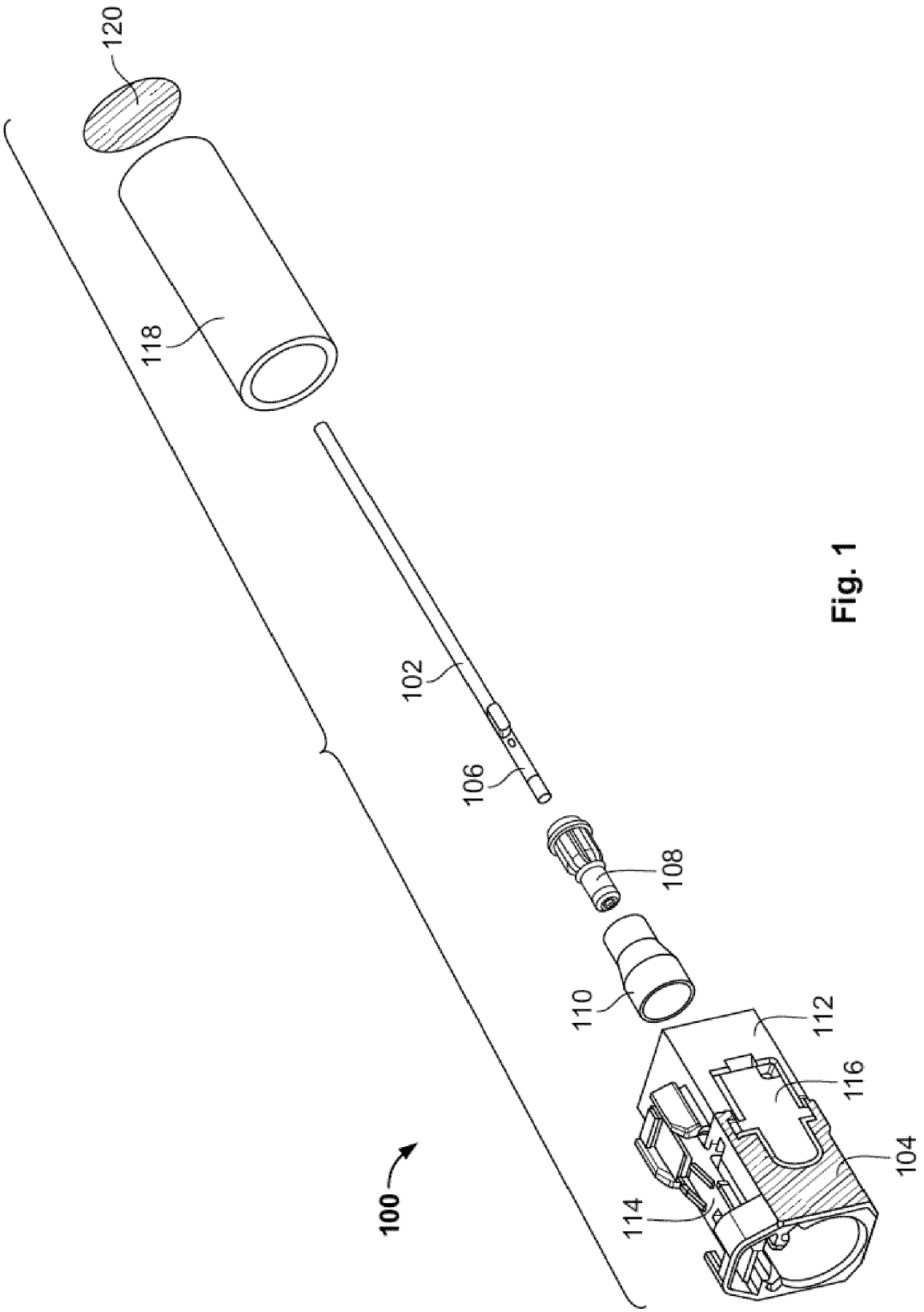

Fig. 1

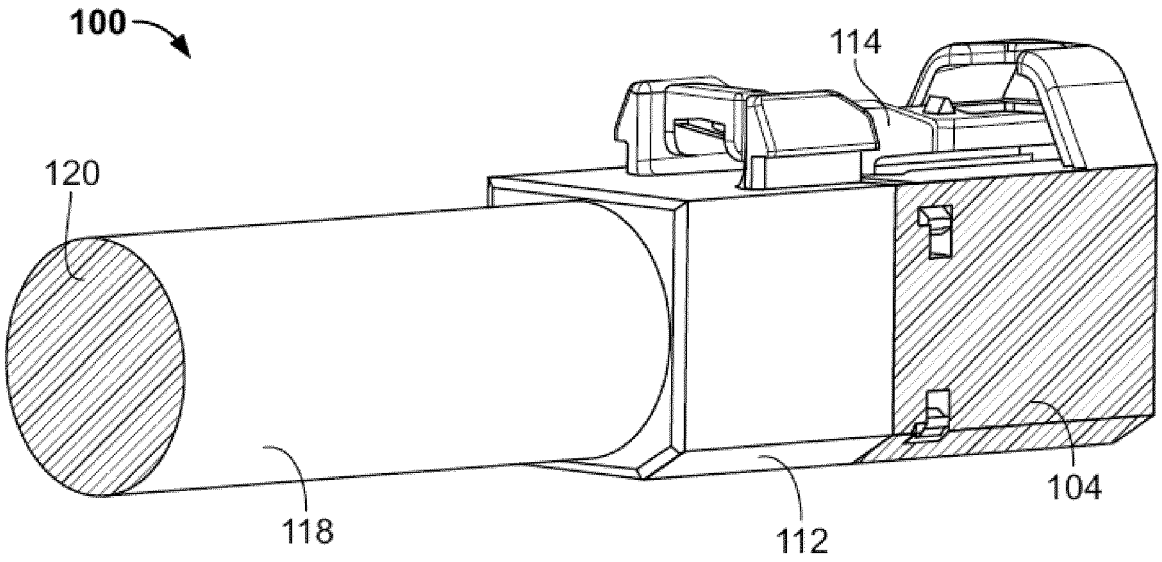

Fig. 2

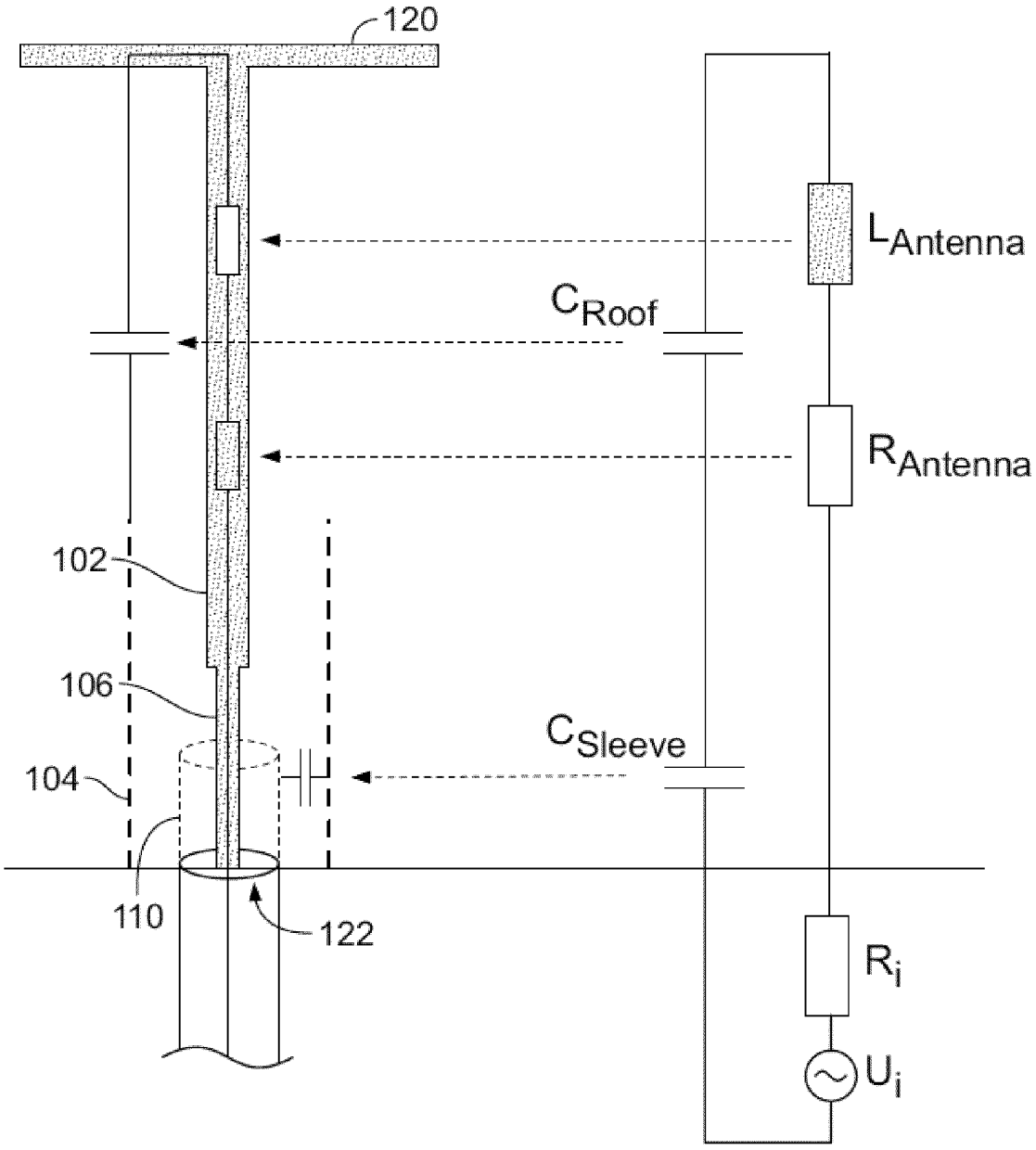
120
$L_{Antenna}$
C_{Roof}
$R_{Antenna}$
102
106
C_{Sleeve}
104
110
122
R_i
U_i

Fig. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 14 18 6129

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	JP 2004 303709 A (HITACHI INT ELECTRIC INC; NOBLE MUSEN KK) 28 October 2004 (2004-10-28)	1,10,11	INV. H01Q1/32 H01Q9/36
Y	* abstract; figures 1-9 *	2-4,8	H01Q9/30
Y	US 2004/160373 A1 (LINDENMEIER HEINZ [DE]) 19 August 2004 (2004-08-19) * abstract; figures 1-5 * * page 2, paragraph 21-23 *	2-4,8	
A	US 2009/098769 A1 (SAKAMOTO NOBUYUKI [JP]) 16 April 2009 (2009-04-16) * abstract; figures 1-6 * * page 2, paragraph 28-31 *	2-11	
A	US 2012/202372 A1 (HARDY DOUGLAS JOHN [US] ET AL) 9 August 2012 (2012-08-09) * abstract; figures 1-13 * * page 1, paragraph 22 - page 2, paragraph 23 * * page 2, paragraph 35 *	1-11	TECHNICAL FIELDS SEARCHED (IPC)
A	US 2010/029132 A1 (PHILLIPS JR WILLIAM THOMAS [US]) 4 February 2010 (2010-02-04) * abstract; figure 1 * * page 1, paragraph 18-19 *	1-11	H01Q

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	29 January 2015	Cordeiro, J

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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29-01-2015

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 2004303709 A	28-10-2004	NONE	
US 2004160373 A1	19-08-2004	DE 10304909 A1	19-08-2004
		EP 1445828 A2	11-08-2004
		US 2004160373 A1	19-08-2004
US 2009098769 A1	16-04-2009	DE 102008050834 A1	23-04-2009
		JP 2009099266 A	07-05-2009
		US 2009098769 A1	16-04-2009
US 2012202372 A1	09-08-2012	DE 102012201565 A1	09-08-2012
		US 2012202372 A1	09-08-2012
US 2010029132 A1	04-02-2010	CN 101640344 A	03-02-2010
		KR 20100013261 A	09-02-2010
		US 2010029132 A1	04-02-2010

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

- EP 1445828 A2 **[0011]**
- DE 102012201565 A1 **[0019] [0024]**