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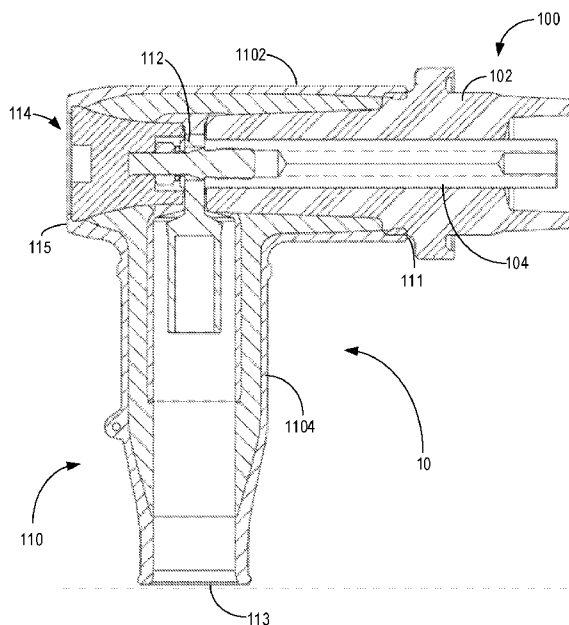


Fig. 1

(57) Abstract: Embodiments of present disclosure relate to a bushing, a cable accessory, a system, a method for assembling bushing and a method for assembling cable accessory. The bushing comprises a housing and a conductor provided within the housing and adapted to couple with a cable lug of the cable accessory. The bushing further comprises a passive wireless measuring apparatus. The passive wireless measuring apparatus comprising a sensor and an antenna, the passive wireless measuring apparatus provided on the bushing such that the sensor is closer to the conductor than the antenna. According to embodiments of the present disclosure, the real time monitoring of the temperature of the cable lug can be obtained accurately and the power failure can be detected in advance.



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**BUSHING, CABLE ACCESSORY, SYSTEM, METHOD FOR ASSEMBLING
BUSHING AND METHOD FOR ASSEMBLING CABLE ACCESSORY**

FIELD

5 [0001] Example embodiments of the present disclosure generally relate to temperature measurement and more particularly, to a bushing for use with a cable accessory, a cable accessory, a system use for a main ring unit, a method for assembling a bushing, and a method for assembling a cable accessory.

10 **BACKGROUND**

[0002] In medium/high voltage power distribution system, the monitoring of the joints between different electrical equipment is a key issue when the system is operating. This is because the incidents always incur at these joints. However, it is difficult to monitor the health statues of these joints as they lies within the electrical equipment and it is not
15 easy to access during operation. How to monitor the health parameter accurately would be a challenge for the designers.

[0003] Conventionally, there is provided a plurality of methods to sense the temperature of the joint within the electrical equipment. For example, CN 102214870B describes an intelligent detachable connector comprising a detachable connector jacket
20 and a high voltage shielding sleeve provided within the jacket. CN 106207940A describes a cable connector which comprises a sensor fixed at some locations.

[0004] However, in these approaches, for example, in CN 106207940A, sensors are pre-installed, or even cast into the component within the cable joint. When it is necessary to replace the sensors, the existing components have to be replaced as a whole,
25 which would significantly increase the operating cost. What's more, in both CN 102214870B and CN 106207940A, the sensor and the antenna of the measuring apparatus are set very close, for example on a same surface. Such an arrangement may adversely influence the communication of the antenna.

30 **SUMMARY**

[0005] Example embodiments of the present disclosure propose a solution for measuring temperature of a conductor in an electrical device such as cable accessory.

[0006] In a first aspect, example embodiments of the present disclosure provide a bushing for use with a cable accessory. The bushing comprises a housing and a conductor provided within the housing and adapted to couple with a cable lug of the cable accessory. The bushing further comprises a passive wireless measuring apparatus. The passive wireless measuring apparatus comprising a sensor and an antenna, the passive wireless measuring apparatus provided on the bushing such that the sensor is closer to the conductor than the antenna.

[0007] According to embodiments of the present disclosure, the communication quality will be improved due to the fact that the antenna is kept away from the conductor. As a result, the on-line temperature of the bushing can be measured accurately and effectively, thereby improving the reliability and safety of the bushing.

[0008] In some embodiments, the antenna is of an elongated rectangular shape, and the sensor is coupled to the antenna to form a "T" shape. In this way, the passive wireless measuring apparatus can be made in a simple manner.

[0009] In some embodiments, the housing comprises an end face adjacent to the cable lug, the sensor is provided on the end face; and a circumferential surface surrounding the conductor, the antenna is provided on the circumferential surface. In this way, the passive wireless measuring apparatus may be securely coupled to the bushing, ensuring robust and stable measurement of the temperature of the conductor.

[0010] In some embodiments, the sensor and antenna are packaged with PET or PI material, and the passive wireless measuring apparatus is formed as a film. In this way, the passive wireless measuring apparatus may be made thin and thus can be used in various situations.

[0011] In some embodiments, the antenna is directly coupled to the circumferential surface of bushing, or the antenna is printed onto the circumferential surface. In this way, the possibility of frequency offset may be reduced.

[0012] In some embodiments, the sensor is directly coupled to the end face of the bushing, or the sensor is coupled to the end face by a thermal conductive material, or the sensor is printed onto the end face. In this way, a precise measurement of the cable lug may be achieved.

[0013] In a second aspect, example embodiments of the present disclosure provide a cable accessory. The cable accessory comprises: a bushing insulating plug comprising a

housing and a conductor, provided within the housing and adapted to couple with a cable lug of the cable accessory; and a passive wireless measuring apparatus comprising a sensor and an antenna, the passive wireless measuring apparatus provided on the bushing insulating plug such that the sensor is closer to the conductor than the antenna. In this way, the on-line temperature of the cable accessory can be measured accurately and effectively, thereby improving the reliability and safety of the cable accessory.

[0014] In some embodiments, the antenna is of an elongated rectangular shape, and the sensor is coupled to the antenna to form a “T” shape.

[0015] In some embodiments, the housing comprises an end face adjacent to the cable lug, the sensor is provided on the end face; and a circumferential surface surrounding the conductor, the antenna is provided on the circumferential surface. In this way, the robust and stable measurement of the temperature of the conductor may be ensured.

[0016] In some embodiments, the cable lug comprises a plate portion and a cylindrical portion, a thickness of the plate portion being less than a diameter of the cylindrical portion to form a shoulder on an end of the cylindrical portion adjacent to the plate portion, wherein the passive wireless measuring apparatus is arranged on the shoulder. In this way, the passive wireless measuring apparatus may be securely coupled to the cable lug to obtain desired measurement of the temperature.

[0017] In some embodiments, the sensor and antenna are packaged with PET or PI material, and the passive wireless measuring apparatus is formed as a film.

[0018] In some embodiments, the sensor is directly coupled to the end face of the bushing insulating plug, or the sensor is coupled to the end face by a thermal conductive material, or the sensor is printed onto the end face.

[0019] In a third aspect, example embodiments of the present disclosure provide a system use for a main ring unit. The system comprises a bushing of the first aspect coupled to the main ring unit. In the system, the cable accessory comprises a first portion comprising a first end adapted to contain the bushing inserted therethrough; and a second portion connected to the first portion and comprising a second end adapted to contain the cable lug inserted therethrough.

[0020] In some embodiments, the system further comprising a bushing insulating plug inserted through a third end of the first portion, the third end located opposite to the first end; and a further passive wireless measuring apparatus with the same specification as the

passive wireless measuring apparatus provided on the bushing insulating plug.

[0021] In some embodiments, the cable accessory comprises an internal surface; and the system further comprises a further passive wireless measuring apparatus with the same specification as the passive wireless measuring apparatus provided on the internal surface.

5 [0022] In a fourth aspect, example embodiments of the present disclosure provide a system use for a main ring unit. The system comprises a cable accessory of the second aspect coupled to the main ring unit and a bushing coupled to the cable accessory. In the system, the cable accessory comprises: a first portion comprising a first end adapted to contain the bushing inserted therethrough; and a second portion connected to the first
10 portion and comprising a second end adapted to contain the cable lug inserted therethrough.

[0023] In a fifth aspect, example embodiments of the present disclosure provide an Internet of Things (IoT) system. The IoT system comprises a bushing of the first aspect.

15 [0024] In a sixth aspect, example embodiments of the present disclosure provide an Internet of Things (IoT) system. The IoT system comprises a cable accessory of the second aspect.

[0025] In a seventh aspect, example embodiments of the present disclosure provide a method for assembling a power cable connector. The method comprises providing a housing; providing a conductor within the housing and the conductor is adapted to couple
20 with a cable lug of the cable accessory; and providing a passive wireless measuring apparatus comprising a sensor and an antenna, the passive wireless measuring apparatus provided on the bushing such that the sensor is located closer to the conductor than the antenna.

25 [0026] In an eighth aspect, example embodiments of the present disclosure provide a method for assembling a cable accessory. The method comprises providing a bushing insulating plug, comprising: providing a housing; and providing a conductor provided within the housing and adapted to couple with a cable lug of the cable accessory. The method also comprises providing a passive wireless measuring apparatus comprising a sensor and an antenna, the passive wireless measuring apparatus provided on the bushing
30 insulating plug such that the sensor is closer to the conductor than the antenna.

[0027] According to embodiments of the present disclosure, the safety of the electrical device such as the bushing for use with the main ring unit may be ensured. Accordingly,

temperature measurement for the conductor can be conducted appropriately in a reliable and efficient way.

BRIEF DESCRIPTION OF THE DRAWINGS

5 [0028] Through the following detailed descriptions with reference to the accompanying drawings, the above and other objectives, features and advantages of the example embodiments disclosed herein will become more comprehensible. In the drawings, several example embodiments disclosed herein will be illustrated in an example and in a non-limiting manner, wherein:

10 [0029] Fig. 1 illustrates a cross section view of an electric system comprising a bushing and a cable accessory in accordance with some example embodiments of the present disclosure;

[0030] Fig. 2 illustrates a cross section view of the bushing of Fig. 1 in accordance with some example embodiments of the present disclosure;

15 [0031] Fig. 3 illustrates an exemplary close-up view of a passive wireless measuring apparatus in accordance with some example embodiments of the present disclosure;

[0032] Fig. 4 illustrates a cross section view of the bushing insulating plug of Fig. 1 in accordance with some example embodiments of the present disclosure;

20 [0033] Fig. 5 illustrates a cross section view of the cable lug of Fig. 1 in accordance with some example embodiments of the present disclosure;

[0034] Fig. 6 illustrates a chart showing the exemplary temperature changes between the point of surface between the bushing and cable accessory and the point at the joint of the conductor; and

25 [0035] Fig. 7 illustrates a method for assembling a bushing in accordance with some example embodiments of the present disclosure.

[0036] Throughout the drawings, the same or corresponding reference symbols refer to the same or corresponding parts.

DETAILED DESCRIPTION

30 [0037] The subject matter described herein will now be discussed with reference to several example embodiments. These embodiments are discussed only for the purpose of enabling those skilled persons in the art to better understand and thus implement the

subject matter described herein, rather than suggesting any limitations on the scope of the subject matter.

[0038] The term “comprises” or “includes” and its variants are to be read as open terms that mean “includes, but is not limited to.” The term “or” is to be read as “and/or” unless
5 the context clearly indicates otherwise. The term “based on” is to be read as “based at least in part on.” The term “being operable to” is to mean a function, an action, a motion or a state can be achieved by an operation induced by a user or an external mechanism. The term “one embodiment” and “an embodiment” are to be read as “at least one embodiment.” The term “another embodiment” is to be read as “at least one other
10 embodiment.”

[0039] Unless specified or limited otherwise, the terms “mounted,” “connected,” “supported,” and “coupled” and variations thereof are used broadly and encompass direct and indirect mountings, connections, supports, and couplings. Furthermore, “connected” and “coupled” are not restricted to physical or mechanical connections or couplings. In
15 the description below, like reference numerals and labels are used to describe the same, similar or corresponding parts in the Figures. Other definitions, explicit and implicit, may be included below.

[0040] As mentioned above, temperature of conductors in an electrical device, such as main ring unit needs to be monitored so as to ensure safety and power quality of the
20 electrical device.

[0041] Some example embodiments of the present disclosure are described below with respect to Figs. 1-3.

[0042] Fig. 1 illustrates a cross section view of an electric system (referred to as “system” hereinafter) 10 in accordance with some example embodiments of the present
25 disclosure. The system 10 is be used with a main ring unit (not shown) and ensures the safe operation of the unit. As shown in Fig. 1, the system 10 comprises, among other components, a bushing 100 and a cable accessory 110 coupled with the bushing 100.

[0043] Fig. 2 illustrates a cross section view of the bushing 100 of Fig. 1 in accordance with some example embodiments of the present disclosure. With reference to Fig. 2, the
30 bushing 100 comprises a housing 102. A conductor 104 is provided within the housing 102. With reference to Fig. 1, the cable accessory 110 comprises a cable lug 112. The conductor 104 within the housing 102 is adapted to couple with the cable lug 112. The

cable lug 112 may be adapted to connect with a cable and usually has the highest temperature inside the system 10. Therefore, the inspection of the temperature of the conductor 104 in real time would be critical to prevent overheat of the whole system 10.

[0044] The bushing 100 also comprises a passive wireless measuring apparatus 106. The passive wireless measuring apparatus 106 can be used for sensing the temperature of the conductor 104.

[0045] Fig. 3 illustrates an exemplary close-up view of a passive wireless measuring apparatus 106 in accordance with some example embodiments of the present disclosure. The passive wireless measuring apparatus 106 comprises a sensor 1062 and an antenna 1064. The passive wireless measuring apparatus 106 may be powered by energy extracted from the wireless signal received by the antenna 1064 and sent by, for example, an RFID reader. Referring also to Fig. 2, the passive wireless measuring apparatus 106 is provided on the bushing 100 and the sensor 1062 is closer to the conductor 104 than the antenna 1064.

[0046] According to embodiments of the present disclosure, the sensor 1062 is more adjacent to the conductor 104 compared to the antenna 1064. In this way, the sensor 1062 of the passive wireless measuring apparatus 106 is provided to be contacted with conductor 104 and the antenna 1064 is kept away from the conductor 104. This makes sure that the sensor 1062 senses the temperature of the conductor 104 more accurately. Moreover, the antenna 1064 may receive/send the signal in stable way. By sensing the real-time temperature of the conductor 104, a fast reactive measurement can be achieved. Therefore, the failure possibility of cable accessories caused by temperature rising can be effectively prevented or reduced.

[0047] Moreover, due to the fact that the passive wireless measuring apparatus 106 requires no external power supply, the need of regular removal and recharging is eliminated. The power quality may be improved.

[0048] In some embodiments, the cable lug 112 may be made of metal material, e.g. aluminum or copper.

[0049] In some embodiments, the passive wireless measuring apparatus 106 may also comprise an integrated circuit (IC). The IC (not shown) is coupled to the sensor 1062 and configured to receive a signal indicative of the parameter e.g. temperature from the sensor 1062. The electrical power can be supplied to the passive wireless measuring

apparatus 106 via the antenna 1064 from an electromagnetic generation device.

[0050] In some embodiments, the antenna 1064 may be of an elongated rectangular shape, and the sensor 1062 may be coupled to the antenna 1064 to form a “T” shape. The “T”-shape passive wireless measuring apparatus 106 may be symmetric, that is, the sensor 1062 may be coupled to the midpoint of the antenna 1064. Of course, the passive wireless measuring apparatus 106 may also be asymmetric, that is, the sensor 1062 may be coupled to a point of the antenna 1064, which is not the midpoint of the antenna 1064.

[0051] In this way, the passive wireless measuring apparatus 106 can be made in a simple manner. Moreover, there is no need to significantly change the structure of the bushing 100. As such, the cost of the bushing 100 could be effectively controlled.

[0052] In some embodiments, as shown in Fig. 2, the housing 102 may comprise an end face 107 adjacent to the cable lug 112, and the sensor 1062 is provided on the end face 107. The housing 102 may also comprise a circumferential surface 108 surrounding the conductor 104, and the antenna 1064 is provided on the circumferential surface 108. In this way, the passive wireless measuring apparatus 106 may be securely coupled to the bushing 100, ensuring robust and stable measurement of the temperature of the conductor 104.

[0053] In some embodiments, the sensor 1062 and antenna 1064 may be packaged with PET (polyethylene terephthalate) or PI (polyimide) material, and the passive wireless measuring apparatus 106 may be formed as a film.

[0054] In this way, the passive wireless measuring apparatus 106 may be made very thin and thus facilitate mounting in desired location, especially the location where the room for the passive wireless measuring apparatus 106 is very limited. Due to this, there is no need to change the existing structure of the electrical equipment for example the bushing 100.

[0055] In some embodiments, the antenna 1064 may be directly coupled to the circumferential surface 108 of bushing 100. In this way, the antenna 1064 of the passive wireless measuring apparatus 106 can be attached the circumferential surface 108 of bushing 100 in an easy and cost-effective manner.

[0056] In some embodiments, the antenna 1064 may be adhered to the circumferential surface 108 by some materials. For example, adhesive may be used to establish well contact between the antenna 1064 and the circumferential surface 108 to avoid undesired

detachment of the antenna 1064 off the circumferential surface 108.

[0057] In some embodiments, the antenna 1064 may be printed onto the circumferential surface 108 using 3D printing technology or spraying technology. In this way, the antenna 1064 can be integrally formed with the circumferential surface 108 and the chance of detachment of the antenna 1064 may be eliminated.

[0058] In some embodiments, the sensor 1062 may be directly coupled to the end face 107 of the bushing 100. In this way, the temperature of the conductor 104 may be obtained by means of the passive wireless measuring apparatus 106 easily.

[0059] In some embodiments, the sensor 1062 may be coupled to the end face 107 by a thermal conductive material. In this way, the thermal conductive material may establish a better thermal contact between the conductor 104 and the sensor 1062 of the passive wireless measuring apparatus 106. Thus, the temperature deviation between the conductor 104 and the passive wireless measuring apparatus 106 may be smaller, and a more accurate measurement of the cable lug 112 can be obtained.

[0060] In some embodiments, the thermal conductive material may be in the form of thermal paste or thermal grease. In some embodiments, the thermal conductive material may be made of silicone rubber, acrylic resin, or the like. It could be understood that the material mentioned herein is only for illustrative purpose. The thermal conductive material may be any material already known or to be developed in the future, e.g. epoxy resin or other suitable materials, as long as the thermal conductive material used to couple the sensor 1062 to the end face 107 of the bushing 100 can reduce the temperature difference between the conductor 104 and the passive wireless measuring apparatus 106 to ensure precise measurement of the conductor 104.

[0061] In some embodiments, the sensor 1062 may be printed onto the end face 107 using 3D printing technology or spraying technology. In this way, the sensor 1062 can be integrally formed with the bushing 100 and a precise measurement of the conductor 104 may be achieved.

[0062] Compared with the conventional method of temperature monitoring, the passive wireless measuring apparatus 106 according to example embodiments of the present invention can be easily attached where necessary and replaced without changing the existing structure of the electrical equipment. Moreover, due to the spatial arrangement of the sensor 1062 and antenna 1064, the measurement of the temperature may be

obtained more accurately and effectively.

[0063] In a second aspect, example embodiments of the present disclosure provide a system 10 use for a main ring unit (not shown). The system 10 comprises a bushing 100 of the first aspect coupled to the main ring unit and a cable accessory 110. As shown in Fig. 1, in the system 10, the cable accessory 110 comprises a first portion 1102 and a second portion 1104. The first portion 1102 comprises a first end 111, which is adapted to contain the bushing 100. The second portion 1104 is connected to the first portion 1102 and comprises a second end 113, which is adapted to contain the cable lug 112. The bushing 100 is inserted through the first end 111. The cable lug 112 is inserted through the second end 113, to form an electrical connection with the conductor 104 of the bushing 100. In this way, the measurement of the temperature of the conductor 104 would reflect the temperature profile of the cable lug 112.

[0064] In some embodiments, the cable accessory 110 may further comprise a third end 115, which is located opposite to the first end 111, as shown in Fig. 1. The system 10 may further comprise a bushing insulating plug (BIP) 114. The BIP 114 is inserted through the third end 115 to form an electrical connection with the bushing 100 and the cable lug 112.

[0065] Although only one passive wireless measuring apparatus 106 is shown in Fig. 2, it is to be understood that this is merely example without suggesting any limitation as to the scope of the present disclosure. Any other numbers of the passive wireless measuring apparatus 106 may be also possible, for example, two, three, and even more, which may depend on the demand of the user and the size of each passive wireless measuring apparatus 106.

[0066] In some embodiments, the system 10 may comprise a further passive wireless measuring apparatus. The further passive wireless measuring apparatus may be located in a different location than the passive wireless measuring apparatus 106 as shown in Fig. 2, as long as the location would not interfere with the normal operation of the system 10. For example, in some embodiments, the system 10 may also comprise a further passive wireless measuring apparatus provided on the BIP 114, which has the same specification as the passive wireless measuring apparatus 106.

[0067] In some embodiments, the cable accessory 110 may comprise an internal surface. The system 10 may also comprise a further passive wireless measuring

apparatus provided on the internal surface which has the same specification as the passive wireless measuring apparatus 106.

[0068] Fig. 4 illustrates a cross section view of the bushing insulating plug 114 of Fig. 1 in accordance with some example embodiments of the present disclosure. As shown in Fig. 4, the bushing insulating plug 114 comprises a housing 122 and a conductor 124. The conductor 124 is provided within the housing 122 and is adapted to couple with the cable lug 112 of the cable accessory 110, as shown in Fig. 1. A passive wireless measuring apparatus 116 is provided on the bushing insulating plug 114. Similar to the passive wireless measuring apparatus 106 discussed above, the passive wireless measuring apparatus 116 also comprises a sensor 1162 and an antenna 1164. The sensor 1162 is closer to the conductor 124 than the antenna 1164.

[0069] According to embodiments of the present disclosure, the temperature of the conductor 104 can be sensed more accurately. Moreover, the signal may be received and sent by the antenna 1164 in stable way.

[0070] In some embodiments, the housing 122 may be made of insulation material, e.g. epoxy resin. In some embodiments, same as the passive wireless measuring apparatus 106 discussed above, the antenna 1164 may be of an elongated rectangular shape, and the sensor 1162 may be coupled to the antenna 1164 to form a “T” shape.

[0071] In some embodiments, as shown in Fig. 1 and 4, the housing 122 comprises an end face 117 adjacent to the cable lug 112 and a circumferential surface 118 surrounding the conductor 124. The sensor 1162 is provided on the end face 117 and antenna 1164 is provided on the circumferential surface 118. In this way, the passive wireless measuring apparatus 116 may be securely coupled to the bushing insulating plug 114, ensuring robust and stable measurement of the temperature of the conductor 124.

[0072] Similar to the passive wireless measuring apparatus 106 discussed above, in some embodiments, the sensor 1162 and antenna 1164 in the passive wireless measuring apparatus 116 may also be packaged with PET or PI material, and the passive wireless measuring apparatus 116 may be formed as a film.

[0073] Similar to the passive wireless measuring apparatus 106 discussed above, as shown in Fig. 4, the sensor 1162 may be directly coupled to the end face 117 of the bushing insulating plug 114. In other embodiments, the sensor 1162 may be coupled to the end face 117 by a thermal conductive material. In yet embodiments, the sensor 1162

may be printed onto the end face 117.

[0074] Fig. 5 illustrates a cross section view of the cable lug 112 of Fig. 1 in accordance with some example embodiments of the present disclosure. The cable lug 112 may comprise a plate portion 1121 and a cylindrical portion 1122 as shown in Fig. 5. The plate portion 1121 has a thickness T and the cylindrical portion 1122 has a diameter D . The thickness T is less than the diameter D , thus a shoulder 1123 is formed on an end of the cylindrical portion 1122 adjacent to the plate portion 1121, wherein the passive wireless measuring apparatus 116 is arranged on the shoulder 1123.

[0075] In this way, by easily placing the passive wireless measuring apparatus 116 on the shoulder 1123, there is no need to significantly change the structure of the cable lug 112. As such, the cost of could be effectively controlled.

[0076] With more than one passive wireless measuring apparatus, a more accurate measurement of the temperature of the conductor 104 may be obtained by processing the measurement from the plurality of passive wireless measuring apparatus. For example, the temperature of the conductor 104 may be calculated by averaging the temperature data obtained from the passive wireless measuring apparatus in different locations.

[0077] In case that the temperature distribution on the conductor 104 is not uniform, some specific portions of the conductor 104 may suffer a different temperature than the other regions of the conductor 104. In such an embodiment, providing a plurality of passive wireless measuring apparatus enables an on-line monitoring of the region of interest on cable lug 112.

[0078] In some embodiments, the passive wireless measuring apparatus 106 may comprise a radio frequency identification (RFID) tag. In this way, the temperature of the conductor 104 can be obtained in a more reliable manner. It is to be understood that the passive wireless measuring apparatus 106 may comprise other suitable apparatus rather than the RFID tag, e.g. a surface acoustic wave (SAW) sensor, depending on individual requirement from the user.

[0079] Referring back to Fig. 1, although only one busing 100 and one cable accessory 110 are shown in the system 10, it could be understood that the system 10 may include a plurality of bushings and a plurality of cable accessories.

[0080] Fig. 6 illustrates a chart showing the exemplary temperature changes between the point of surface between the bushing 100 and cable accessory 110 and the point at the

joint of the conductor 104.

[0081] As shown in Fig. 6, the line plotted by the triangle blocks represents the temperature profile over time by using the passive wireless measuring apparatus 106 according to embodiments of the present disclosure, which is positioned at a surface
5 between the bushing 100 and the cable accessory 110. The line plotted by the square blocks represents the temperature profile over time by using an existing passive wireless measuring apparatus which is contacted by the conductor 104 within the bushing 100.

[0082] The two lines show the same tendency of temperature. That is to say, the passive wireless measuring apparatus 106 according to embodiments of the present
10 disclosure may reflect the tendency of the temperature of the conductor 104 synchronously and obtain good measurements, and also provide various benefits as mentioned above.

[0083] In some embodiments, the system 10 may be deployed as an Internet-of-Things (IoT) system. In the system, the bushing 100 is connected to a system in a wired or
15 wireless way for on-line monitoring of temperature of conductor 104, and transmits temperature data collected by the sensor 1062 of the passive wireless measuring apparatus 106 for on-line monitoring.

[0084] In some embodiments, the system may be deployed as an Internet-of-Things (IoT) system. In the system, the bushing insulating plug 114 is connected to a system in
20 a wired or wireless way for on-line monitoring of temperature of conductor 124, and transmits temperature data collected by the sensor 1162 of the passive wireless measuring apparatus 116 for on-line monitoring.

[0085] Fig. 7 illustrates a method 700 for assembling a bushing 100 in accordance with some example embodiments of the present disclosure. In some embodiments, the
25 method 700 can be executed manually. In some embodiments, the method 700 can be executed automatically. For example, the method 700 can be executed by a robot in a production line.

[0086] At block 702, a housing 102 is provided. At block 704, a conductor 104 is provided within the housing 102 and the conductor 104 is adapted to couple with a cable
30 lug 112 of the cable accessory 110. At block 706, providing a passive wireless measuring apparatus 106 is provided. The passive wireless measuring apparatus 106 comprises a sensor 1062 and an antenna 1064. The passive wireless measuring apparatus

106 is provided on the bushing 100, such that the sensor 1062 is located closer to the conductor 104 than the antenna 1064.

5 [0087] It is to be understood that the apparatus, the structure or the process involved in Fig. 7 have been described above with reference to Figs. 1-5, and the details will not be described hereinafter for the sake of brevity.

10 [0088] Further, while operations are depicted in a particular order, this should not be understood as requiring that such operations be performed in the particular order shown or in sequential order, or that all illustrated operations be performed, to achieve desirable results. In certain circumstances, multitasking and parallel processing may be advantageous. Likewise, while several specific implementation details are contained in the above discussions, these should not be construed as limitations on the scope of the present disclosure, but rather as descriptions of features that may be specific to particular embodiments. Certain features that are described in the context of separate embodiments may also be implemented in combination in a single embodiment. On the other hand, 15 various features that are described in the context of a single embodiment may also be implemented in multiple embodiments separately or in any suitable sub-combination.

20 [0089] Although the subject matter has been described in language specific to structural features and/or methodological acts, it is to be understood that the subject matter defined in the appended claims is not necessarily limited to the specific features or acts described above. Rather, the specific features and acts described above are disclosed as example forms of implementing the claims.

WHAT IS CLAIMED IS:

1. A bushing (100) for use with a cable accessory (110), comprising:
a housing (102);
5 a conductor (104) provided within the housing (102) and adapted to couple with a cable lug (112) of the cable accessory (110); and
a passive wireless measuring apparatus (106) comprising a sensor (1062) and an antenna (1064), the passive wireless measuring apparatus (106) provided on the bushing (100) such that the sensor (1062) is closer to the conductor (104) than the antenna (1064).

2. The bushing (100) of claim 1, wherein the antenna (1064) is of an elongated rectangular shape, and the sensor (1062) is coupled to the antenna (1064) to form a "T" shape.

3. The bushing (100) of claim 1 or 2, wherein the housing (102) comprises:
an end face (107) adjacent to the cable lug (112), the sensor (1062) is provided on the end face (107); and
a circumferential surface (108) surrounding the conductor (104), the antenna (1064) is provided on the circumferential surface (108).

4. The bushing (100) of claim 1 or 2, wherein the sensor (1062) and antenna (1064) are packaged with PET or PI material, and the passive wireless measuring apparatus (106) is formed as a film.

5. The bushing (100) of claim 3, wherein
the antenna (1064) is directly coupled to the circumferential surface (108) of bushing (104), or
the antenna (1064) is printed onto the circumferential surface (108).

6. The bushing (100) of claim 3, wherein
the sensor (1062) is directly coupled to the end face (107) of the bushing (104), or
the sensor (1062) is coupled to the end face (107) by a thermal conductive material,
or

the sensor (1062) is printed onto the end face (107).

7. A cable accessory (110), comprising:

a bushing insulating plug (114), comprising:

5 a housing (122);

a conductor (124) provided within the housing (122) and adapted to couple with a cable lug (112) of the cable accessory (110); and

a passive wireless measuring apparatus (116) comprising a sensor (1162) and an antenna (1164), the passive wireless measuring apparatus (116) provided on the bushing
10 insulating plug (114) such that the sensor (1162) is closer to the conductor (124) than the antenna (1164).

8. The cable accessory (110) of claim 7, wherein the antenna (1164) is of an elongated rectangular shape, and the sensor (1162) is coupled to the antenna (1164) to
15 form a "T" shape.

9. The cable accessory (110) of claim 7 or 8, wherein the housing (122) comprises:

an end face (117) adjacent to the cable lug (112), the sensor (1162) is provided on the end face (117); and

20 a circumferential surface (118) surrounding the conductor (124), the antenna (1164) is provided on the circumferential surface (118).

10. The cable accessory (110) of claim 7, wherein the cable lug (112) comprises a plate portion (1121) and a cylindrical portion (1122), a thickness (T) of the plate portion
25 (1121) being less than a diameter (D) of the cylindrical portion (1122) to form a shoulder (1123) on an end of the cylindrical portion (1122) adjacent to the plate portion (1121),
wherein the passive wireless measuring apparatus (116) is arranged on the shoulder (1123).

30 11. The cable accessory (110) of claim 7 or 8, wherein the sensor (1162) and antenna (1164) are packaged with PET or PI material, and the passive wireless measuring apparatus (116) is formed as a film.

12. The cable accessory (110) of claim 9, wherein
the sensor (1162) is directly coupled to the end face (117) of the bushing insulating
plug (114), or

the sensor (1162) is coupled to the end face (117) by a thermal conductive material,
5 or
the sensor (1162) is printed onto the end face (117).

13. A system (10) use for a main ring unit, comprising:

a bushing (100) of any of claims 1-6 coupled to the main ring unit;

10 wherein the cable accessory (110) comprises:

a first portion (1102) comprising a first end (111) adapted to contain the
bushing (100) inserted therethrough; and

a second portion (1104) connected to the first portion (1102) and comprising
a second end (113) adapted to contain the cable lug (112) inserted therethrough.

14. The system (10) of claim 13, further comprising:

a bushing insulating plug (114) inserted through a third end (115) of the first
portion (1102), the third end (115) located opposite to the first end (111); and

a further passive wireless measuring apparatus with the same specification as the
20 passive wireless measuring apparatus (106) provided on the bushing insulating plug (114).

15. The system (10) of claim 13, wherein the cable accessory (110) comprises an
internal surface; and

wherein the system (10) further comprises a further passive wireless measuring
25 apparatus with the same specification as the passive wireless measuring apparatus (106)
provided on the internal surface.

16. A system use for a main ring unit, comprising:

a cable accessory (110) of any of claims 7-12 coupled to the main ring unit;

30 a bushing (100) coupled to the cable accessory (110).

wherein the cable accessory (110) comprises:

a first portion (1102) comprising a first end (111) adapted to contain the
bushing (100) inserted therethrough; and

a second portion (1104) connected to the first portion (1102) and comprising a second end (113) adapted to contain the cable lug (112) inserted therethrough.

17. An Internet of Things (IoT) system comprising:

5 a bushing (100) of any of claims 1-6.

18. An Internet of Things (IoT) system comprising:

a cable accessory (110) of any of claims 7-12.

10 19. A method for assembling a bushing (100), comprising:

providing a housing (102);

providing a conductor (104) within the housing (102) and the conductor (104) is adapted to couple with a cable lug (112) of the cable accessory (110); and

15 providing a passive wireless measuring apparatus (106) comprising a sensor (1062) and an antenna (1064), the passive wireless measuring apparatus (106) provided on the bushing (100) such that the sensor (1062) is located closer to the conductor (104) than the antenna (1064).

20 20. A method for assembling a cable accessory (110), comprising:

providing a bushing insulating plug (114), comprising:

providing a housing (122); and

providing a conductor (124) provided within the housing (122) and adapted to couple with a cable lug (112) of the cable accessory (110); and

25 providing a passive wireless measuring apparatus (116) comprising a sensor (1162) and an antenna (1164), the passive wireless measuring apparatus (116) provided on the bushing insulating plug (114) such that the sensor (1162) is closer to the conductor (124) than the antenna (1164).

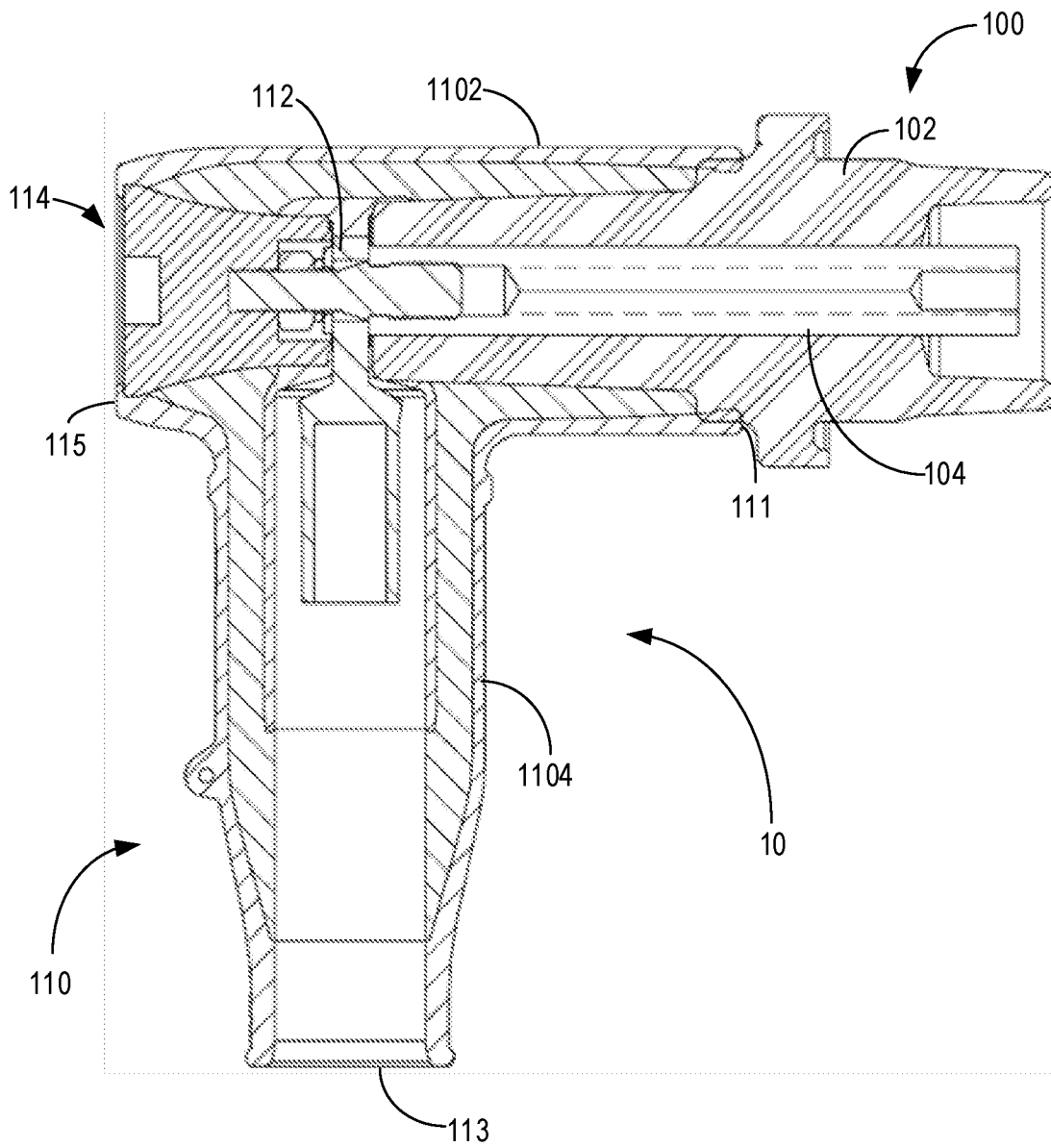


Fig. 1

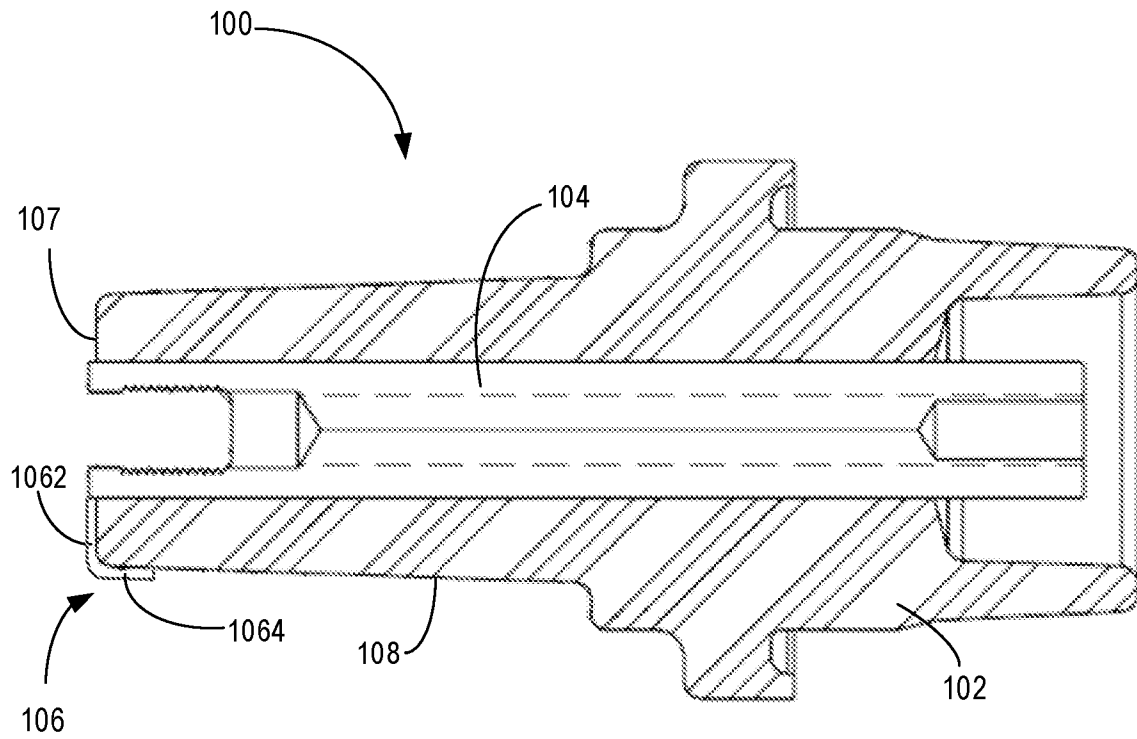


Fig. 2

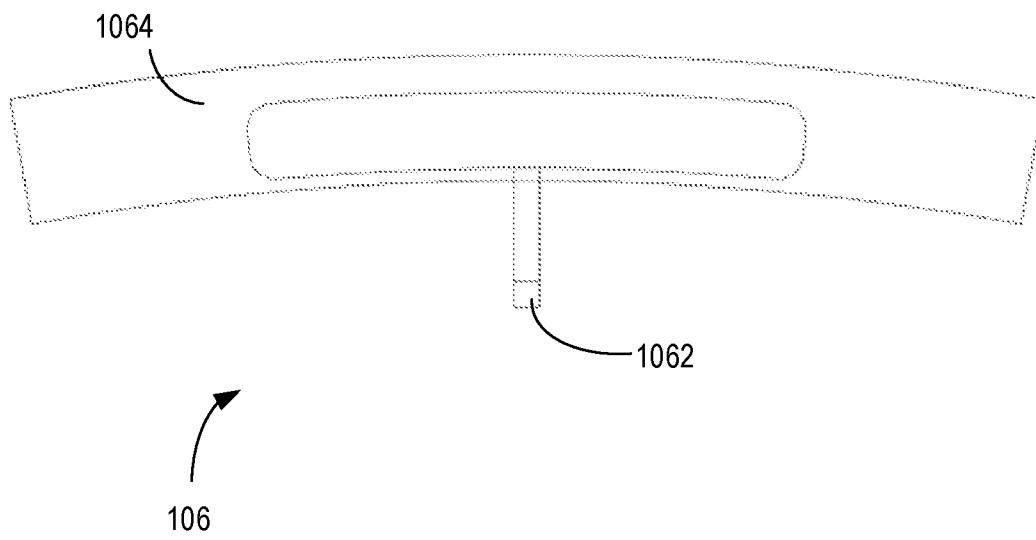


Fig. 3

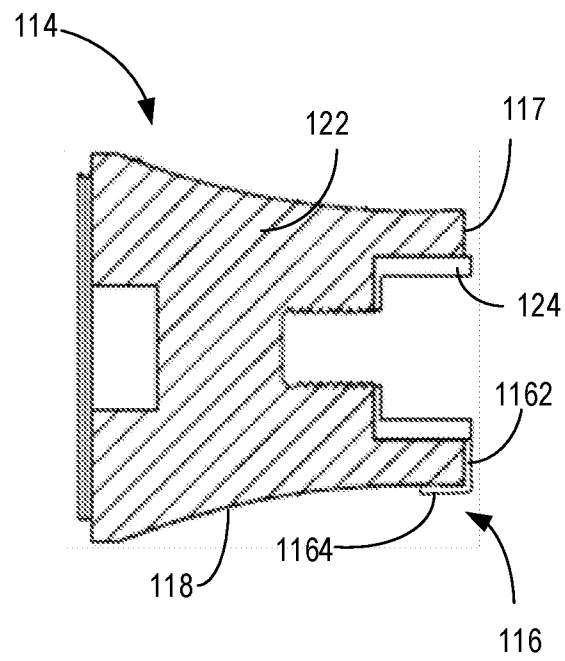


Fig. 4

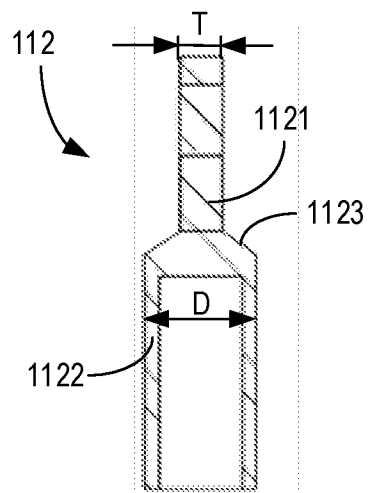


Fig. 5

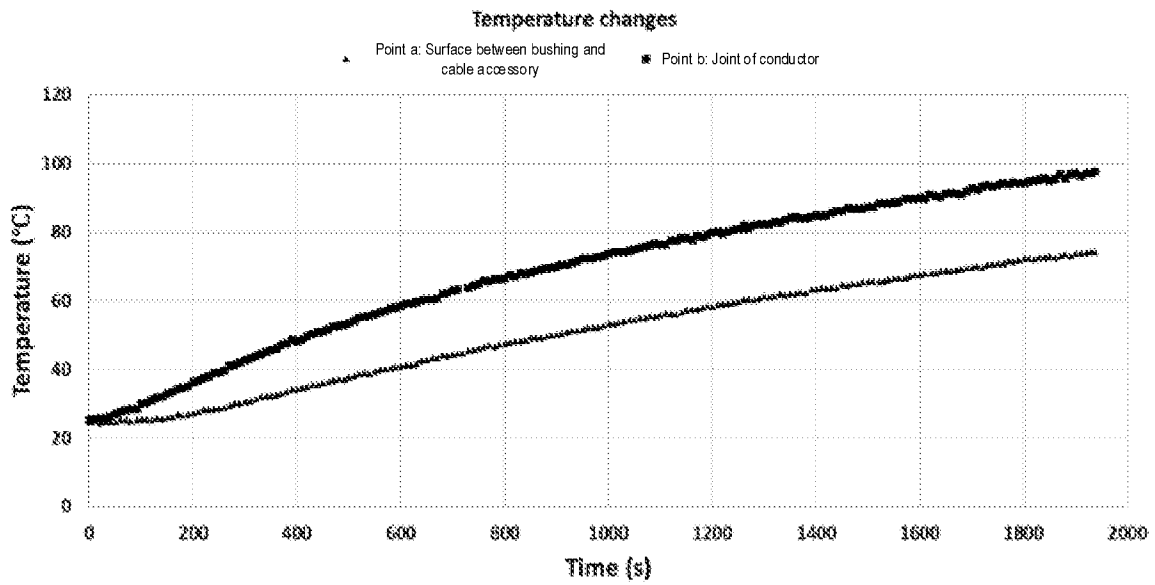


Fig. 6

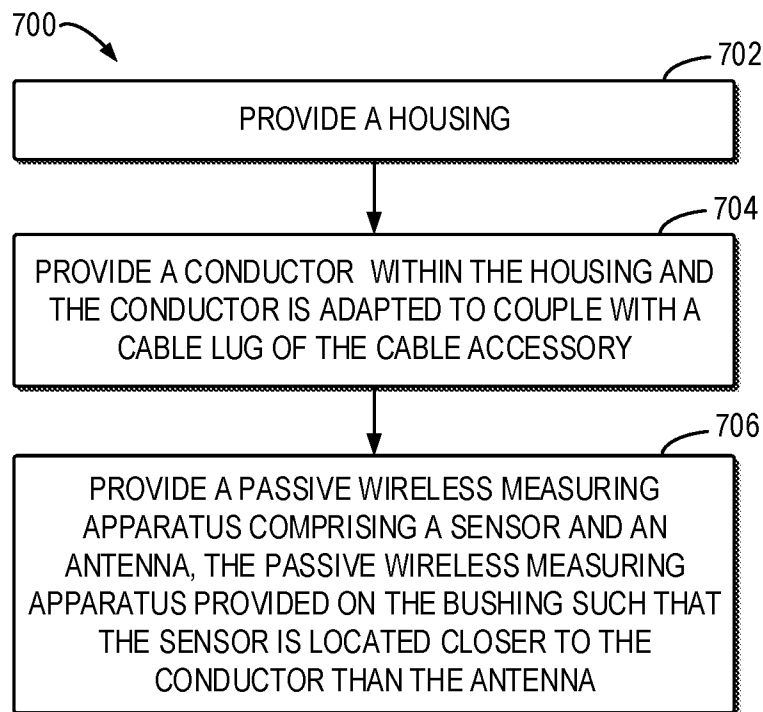


Fig. 7

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2019/073469

A. CLASSIFICATION OF SUBJECT MATTER

G01K 1/00(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

G01K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNABS, DWPI, SIPOABS, CNKI: bushing, cable, accessory, housing, conductor, lug, passive, wireless, measure, sensor, antenna, insulating plug

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	CN 207636199 U (SCHNEIDER ELECTRIC INDUSTRIES SAS) 20 July 2018 (2018-07-20) description, paragraphs [0024]-[0033] and figures 1-3	1-20
Y	CN 206313419 U (SHENZHEN CHUANGYIN TECHNOLOGY CO., LTD.) 07 July 2017 (2017-07-07) description, paragraphs [0019]-[0023] and figures 1-2	1-20
A	CN 108061610 A (MIANYANG RUITAI INTELLIGENT TECHNOLOGY CO., LTD.) 22 May 2018 (2018-05-22) the whole document	1-20
A	CN 206430821 U (NANJING GELPAG ELECTRIC TECHNOLOGY CO., LTD.) 22 August 2017 (2017-08-22) the whole document	1-20

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:

“A” document defining the general state of the art which is not considered to be of particular relevance

“E” earlier application or patent but published on or after the international filing date

“L” document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

“O” document referring to an oral disclosure, use, exhibition or other means

“P” document published prior to the international filing date but later than the priority date claimed

“T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

“X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

“Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

“&” document member of the same patent family

Date of the actual completion of the international search

28 October 2019

Date of mailing of the international search report

06 November 2019

Name and mailing address of the ISA/CN

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2019/073469

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
CN	207636199	U	20 July 2018	None	
CN	206313419	U	07 July 2017	None	
CN	108061610	A	22 May 2018	None	
CN	206430821	U	22 August 2017	None	