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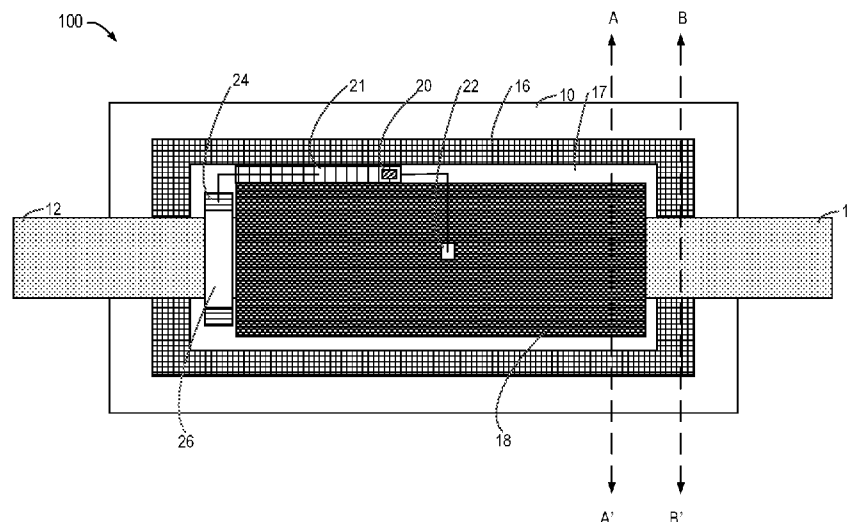


Fig. 2

(57) Abstract: Embodiments of present disclosure relates to a power cable joint device. The power cable joint device comprises a screen cover, a current transformer, a temperature sensor and a wireless transmission device. The screen cover includes a first opening for receiving a first cable and a second opening for receiving a second cable and operable to transmit wireless signal through at least one of the first opening, the second opening and a third opening. The first and second cables are electrically coupled by an electrical connection component inside the screen cover. The current transformer includes a magnetic loop surrounding the first cable and a coil winding the magnetic loop. The temperature sensor is attached to a surface of one of the first and second cables and the electrical connection component inside the screen cover, and senses a temperature of the surface with power supplied from the current transformer. The wireless transmission device is operable to transmit data indicating the sensed temperature with power supplied from the current transformer.

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## POWER CABLE JOINT DEVICE AND ELECTRIC SYSTEM

### TECHNICAL FIELD

5 [0001] Example embodiments of the present disclosure generally relate to temperature measurement and more particularly, to a power cable joint device (PCJD), an electrical system including the PCJD.

### BACKGROUND

10 [0002] A PCJD is widely used for connecting cables in high voltage applications. The PCJDs, together with the cables, are often buried underground, or disposed in the tunnels and trenches.

[0003] Due to various factors including contact resistance at the connection of conductors of the cables, the PCJDs may suffer from a threat of a fire accident, which is often caused by high temperature at connections of conductors of the cables (cable joint).  
15 In this event, it is necessary to monitor the operation status of the PCJDs so as to ensure safety and power quality of the electrical system in which the PCJD is used.

[0004] An approach is proposed to use RFID technology to measure a temperature of the conductors of cables at the connection of the conductors of the cables in the PCJD. A RFID tag is located inside the PCJD to passively transmit temperature signals.  
20 WO201206022A describes such an approach for monitoring the temperature of a device in an electrical system with a RFID tag. However, this approach only transmits temperature signals when it is powered by electric field generated by the readers.

### SUMMARY

25 [0005] Example embodiments of the present disclosure propose a solution for temperature monitoring.

[0006] In a first aspect, example embodiments of the present disclosure provide a power cable joint device. The power cable joint device comprises a screen cover, a current transformer, a temperature sensor and a wireless transmission device. The screen  
30 cover includes a first opening for receiving a first cable and a second opening for receiving a second cable and operable to transmit wireless signal through at least one of the first opening, the second opening and a third opening. The first and second cables

are electrically coupled by an electrical connection component inside the screen cover. The current transformer includes a magnetic loop surrounding the first cable and a coil winding the magnetic loop. The temperature sensor is attached to a surface of one of the first and second cables and the electrical connection component inside the screen cover, and operable to sense a temperature of the surface with power supplied from the current transformer. The wireless transmission device is operable to transmit data indicating the sensed temperature with power supplied from the current transformer.

[0007] In some embodiments, the current transformer and the wireless transmission device are located inside the screen cover.

[0008] In some embodiments, the wireless transmission device and the coil are located at opposite sides of the magnetic loop.

[0009] In some embodiments, the wireless transmission device and the temperature sensor are located at the surface of the electrical connection component.

[0010] In some embodiments, the current transformer is located inside the screen cover, and the wireless transmission device is located outside the screen cover.

[0011] In some embodiments, the wireless transmission device and the coil are located at opposite sides of the magnetic loop.

[0012] In some embodiments, the third opening includes a plurality of windows along a length of the screen cover, such that the wireless transmission device transmits data indicating the sensed temperature through the plurality of windows.

[0013] In some embodiments, the third opening includes a slit along a length of the screen cover, such that the wireless transmission device transmits data indicate the sensed temperature through the slit.

[0014] In some embodiments, the first and second openings are operable to form a gap between the screen cover and the respective cable, such that the wireless transmission device transmits data indicating the sensed temperature through the gap.

[0015] In some embodiments, the screen cover includes metallic mesh layer or metallic layer.

[0016] In some embodiments, the temperature sensor and the wireless transmission device are integrated on a circuit board.

[0017] In some embodiments, the at least one of the first opening, the second opening and a third opening are filled with air, thermoplastic material or thermoset material.

[0018] In a second aspect, example embodiments of the present disclosure provide an electric system. The electric system comprises a power cable joint device of the first aspect, a first antenna and a receiver. The receiver is coupled to the first antenna. The receiver is operable to receive temperature data via the first antenna.

5 [0019] In some embodiments, the electric system further comprises a power cable joint device of the first aspect.

[0020] In a third aspect, example embodiments of the present disclosure provide an Internet of Things (IoT) system. The IoT system comprises a power cable joint device of the first aspect.

10 [0021] In a fourth aspect, example embodiments of the present disclosure provide a method for manufacturing a PCJD. The method comprises providing a screen cover including a first opening for receiving a first cable and a second opening for receiving a second cable and operable to transmit wireless signal through at least one of the first opening, the second opening and a third opening; providing a current transformer including a magnetic loop surrounding the first cable and a coil winding the magnetic loop;  
15 providing a temperature sensor located inside the screen cover to attach to a surface of one of the first and second cables and the electrical connection component, and supplied with power from the current transformer to sense a temperature of the surface; and providing a wireless transmission device supplied with power from the current transformer and  
20 operable to transmit data indicating the sensed temperature. The first and second cables are electrically coupled by an electrical connection component inside the screen cover.

[0022] According to the embodiments of the present disclosure, the temperature of the PCJD can be measured accurately and effectively, thereby improving the reliability and safety of the PCJD and the electrical device in which the PCJD is used. Accordingly,  
25 temperature measurement for the PCJD can be conducted appropriately in a cost-effective and efficient way.

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

30 [0023] 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:

[0024] Fig. 1 illustrates an electric system in accordance with some example embodiments of the present disclosure;

5 [0025] Fig. 2 illustrates a cross section view of a PCJD in a first direction in accordance with some example embodiments of the present disclosure;

[0026] Fig. 3 illustrates a cross section view of a PCJD in a first direction in accordance with some example embodiments of the present disclosure;

[0027] Fig. 4 illustrates a cross section view of a PCJD in a first direction in accordance with some example embodiments of the present disclosure;

10 [0028] Fig. 5 illustrates a cross section view of a PCJD in a first direction in accordance with some example embodiments of the present disclosure;

[0029] Fig. 6 illustrates a cross section view of a PCJD in a first direction in accordance with some example embodiments of the present disclosure;

15 [0030] Fig. 7 illustrates a cross section view of a PCJD in a first direction in accordance with some example embodiments of the present disclosure;

[0031] Fig. 8 illustrates a cross section view of a PCJD in a first direction in accordance with some example embodiments of the present disclosure;

[0032] Fig. 9 illustrates a cross section view of a PCJD in a first direction in accordance with some example embodiments of the present disclosure;

20 [0033] Fig. 10 illustrates a first cross section view of a PCJD in a second direction in accordance with some example embodiments of the present disclosure;

[0034] Fig. 11 illustrates a second cross section view of a PCJD in a second direction in accordance with some example embodiments of the present disclosure;

25 [0035] Fig. 12 illustrates a schematic graph of a screen cover in accordance with some example embodiments of the present disclosure;

[0036] Fig. 13 illustrates a cross section view of a PCJD in a second direction in accordance with some example embodiments of the present disclosure;

[0037] Fig. 14 illustrates a cross section view of a PCJD in a second direction in accordance with some example embodiments of the present disclosure;

30 [0038] Fig. 15 illustrates a cross section view of a PCJD in a first direction in accordance with some other example embodiments of the present disclosure;

[0039] Fig. 16 illustrates a cross section view of a PCJD in a second direction in

accordance with some example embodiments of the present disclosure;

[0040] Fig. 17 illustrates a cross section view of a PCJD in a second direction in accordance with some example embodiments of the present disclosure;

[0041] Fig. 18 illustrates a cross section view of a PCJD in a second direction in accordance with some example embodiments of the present disclosure; and

[0042] Fig. 19 illustrates a method for manufacturing a PCJD in accordance with some example embodiments of the present disclosure.

[0043] Throughout the drawings, the same or corresponding reference symbols refer to the same or corresponding parts.

#### **DETAILED DESCRIPTION**

[0044] 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.

[0045] 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 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 embodiment.”

[0046] Unless specified or limited otherwise, the terms “coupled” and “connected” and variations thereof are used broadly and encompass direct and indirect connections and couplings. Furthermore, “connected” and “coupled” are not restricted to physical or mechanical connections or couplings. In the description below, like reference numerals and labels are used to describe the same, similar or corresponding parts in the drawings. Other definitions, explicit and implicit, may be included below.

[0047] As mentioned above, temperature of conductors in an electrical system, especially temperature at connections of conductors of cables, need to be monitored so as

to ensure safety and power quality of the electrical system.

[0048] Fig. 1 illustrates an electric system 600 in accordance with some example embodiments of the present disclosure. As shown, the system 600 comprises a PCJD 100. The PCJD 100 comprises a temperature sensor operable to measure a temperature at a connection of conductors (conducting joint) of cables and an active wireless communication module operable to transmit the measured temperature. The system 600 further comprises an antenna 620 and a receiver 630 connected to the first antenna 620, and the receiver 630 is operable to receive data, such as temperature data indicating the temperature at the connection of conductors of cables inside the PCJD 100, from the PCJD 100.

[0049] In some embodiments, the system 600 may further comprise PCJDs 200 and 300 and antennas 650 and 670. In some embodiments, the antenna 620 may be arranged towards the PCJD 100 while the antennas 650 and 670 may be arranged towards the PCJDs 200 and 300 respectively.

[0050] Although the antennas 650, 620 and 670 are illustrated outside the PCJDs 100, 200, and 300, this is only for illustration without suggesting any limitations as to the scope of the subject matter described here. In an example, the antennas 650, 620 and 670 can be integrated into the PCJDs 100, 200 and 300, respectively. For example, the antenna may be disposed inside the housing but outside the screen cover. In another example, only one or two of the antennas 650, 620 and 670 are integrated into the PCJDs 100, 200 and 300. Moreover, the system 600 may further comprise an antenna 660, which may be arranged outside the PCJDs 100, 200 and 300. The antenna 660 may be a larger antenna and can receive all the temperature data in the system 600.

[0051] According to embodiments of the present disclosure, the temperature sensors in PCJDs 100 and 200 can obtain the temperatures of the PCJDs. The antennas 620, 650 and 670 are connected to the receiver 630 via the lines 625, 655 and 675, such as a RF cable or a co-axially cable, and are operable to receive the measured temperatures from the PCJDs 100, 200 and 300. Moreover, the antenna 660 may be connected to the receiver 630 via the line 665. For example, the antenna 660 may be arranged near the PCJDs 100, 200 and 300.

[0052] It is to be understood that although three PCJDs 100, 200 and 300 are shown in Fig. 1, the system 600 may include less or more PCJDs. Moreover, to improve the

communication quality in the case of a large amount of temperature sensors, more antennas located at different locations may be provided.

[0053] In some embodiments, the temperature sensors in the PCJDs of the present disclosure can be used to measure temperature at connection of conductors of cables in the PCJDs. Although the temperature sensors in the PCJDs of the present disclosure can  
5 mainly described to measure temperature at connection of conductors of cables in PCJD, the temper sensors may also measure temperature of conductors of cables near the connection of the conductors due to the fact that the conductors have good thermal communication, and thus temperature difference between different locations, which are  
10 sufficiently near to each other, can be neglected.

[0054] In some embodiments, the electric system 600 may be deployed as an Internet-of-Things (IoT) system. In the system 600, the receiver 630 is connected  
15 wiredly or wirelessly to a system for on-line monitoring of temperature of conductors, and transmits temperature data collected by the temperature sensors of the PCJDs to the system for on-line monitoring.

[0055] Fig. 2 illustrates a cross section view of a PCJD 100 in a first direction in accordance with some example embodiments of the present disclosure. The first  
20 direction is along the length direction of the PCJD 100, and a second direction hereinafter refers to a direction traverse to the length direction. The PCJD 100 comprises an insulating housing 10, a screen cover 16 inside the insulating housing 10, a current transformer including a magnetic loop 26 and a coil 24 winding the magnetic loop 26, a  
temperature sensor 22, and a wireless transmission device 20.

[0056] The housing 10 may adopt various structures including a structure of a single  
25 layer and a structure of complex layers to provide insulation effect. The housing 10 is operable to insulate internal components from the outside environment. The housing 10 includes a first opening at a first end to receive a first cable 12, and a second opening at a second end to receive a second cable 14.

[0057] The screen cover 16 is located inside the housing, and includes a first opening at  
30 a first end to receive the first cable 12, and a second opening at the second end to receive a second cable 14. The screen cover 16 is operable to transmit wireless signal through at least one of the first opening, the second opening and a third opening. The at least one of the first opening, the second opening and a third opening may be filled with air or other

insulating materials, such as thermoplastic material and thermoset material.

[0058] The third opening may include a slit or a plurality of windows along the length of the PCJD 100 such that the wireless transmission device 20 transmits data indicating the sensed temperature through the plurality of windows. The window may be regularly disposed in the length direction in the lateral side of the screen cover 16.

[0059] The first and second cables 12 and 14 are electrically coupled by an electrical connection component 18 inside the screen cover 16. The screen cover includes a metallic mesh layer or metallic layer, and operable to cover a part of the first cable 12, a part of the second cable 14 and the electrical connection component 18 such that the electrical field is evenly distributed without causing potential damages. The space between the screen cover 16 and the electrical connection component 18 may be filled with air or other insulating materials, such as thermoplastic material and thermoset material.

[0060] In an example, a smooth metallic layer is used for the screen cover. The smooth metallic layer is more easily inserted into the housing 10 due to less friction force. In contrast, the mesh structure may cause potentially scratch on the housing 10, which may weaken insulation effect or may even cause an accident in some circumstances.

[0061] The current transformer includes a magnetic loop 26 surrounding the first cable 12 and a coil 24 winding the magnetic loop 26, and the current transformer is operable to generate electricity to supply the circuits on the circuit board 21, such as a printed circuit board (PCB). The current transformer may locate inside in the screen cover 16 in an example, and may locate outside the screen cover 16 but inside the housing 10 in another example.

[0062] As compared to conventional PCJDs with RFIDs, the PCJD having a current transformer may actively transmit temperature data on a periodic basis or continuously. Thus, the electrical system may dynamically monitor temperature at connection of conductors of the cables in the PCJDs.

[0063] The circuit board 21 may include the wireless transmission device 20 and other auxiliary circuits, such as an analog-to-digital converter (ADC), a digital signal processor (DSP), a controller and a power management circuit.

[0064] The wireless transmission device 20 is supplied with power from the current transformer directly or via the circuit board, and operable to transmit data indicating the

sensed temperature to the receiver 630 through an opening of the screen cover 16. The wireless communication may be performed according to a protocol of one of ZigBee (2.4GHz), LoRa (433MHz, 868MHz and 915MHz), Bluetooth, NB-IOT and other wireless communication protocol.

5 [0065] In an example, the wireless transmission device 20 and the circuit board 21 are fully inside the screen cover 16. The circuit board 21 may locate on a lateral side of the electrical connection component 18 with an insulation layer therebetween. Although the circuit board 21 is illustrated to locate a lateral side of the electrical connection component 18, this is only for illustration without suggesting any limitations as to the scope of the  
10 subject matter described here. As an example, the circuit board 21 including the wireless transmission device 20 and the coil 24 are located at opposite sides of the magnetic loop.

[0066] In another example, the wireless transmission device 20 and the circuit board 21 may be disposed on lateral surface of the first cable 12 outside the screen cover 16, and are coupled to the temperature sensor 22 via wires. In another example, the temperature  
15 sensor 22 may be integrated into a device on the circuit board 21 or disposed on the circuit board 21, and in this event the circuit board 21 is located inside the screen cover 16.

[0067] The temperature sensor 22 is coupled to the circuit board 21 and supplied power from the circuit board 21 or directly from the current transformer. The temperature sensor 22 is fully located inside the screen cover 16 for measurement accuracy. In an  
20 example, the temperature sensor 22 is attached to a surface of one of the first and second cables 12 and 14 and the electrical connection component 18 inside the screen cover 16, and the temperature sensor 22 is supplied with power from the current transformer to sense a temperature of the surface.

[0068] Generally, due to the fact that the first cable 12 and the second cable 14 are electrically coupled by the electrical connection component 18, the connection position among them may generate more heat than elsewhere. Thus, the temperature at the  
25 conductors of the first cable 12 and the second cable 14, and the electrical connection component 18 needs to be monitored.

[0069] On the hand, the conductors of the cables 12 and 14 and the electrical  
30 connection component 18 are all thermally conductive components, and can transmit heat fluently. Thus, the temperature difference among them can be neglected within the PCJDs. In this case, the measurement can be performed on a surface of any of the

conductors of the cables 12 and 14 and the electrical connection component 18.

[0070] It is more accurate to directly sense the temperature of the conductors or the electrical connection component 18. As such, it can make a timely operation decision in advance based on the accurate temperature of the conductor. In contrast, the conventional approach senses surface temperature of the housing 10, which is generally lower than the temperature of the conductors because the insulating housing 10 is not a good thermal-conductively components. In this conventional approach, it may take time to notice the huge temperature rise, and a failure or damage may be inevitable in this circumstance.

[0071] Although a temperature sensor 22 is illustrated, this is only for illustration without suggesting any limitations as to the scope of the subject matter described here. As an example, three temperature sensors may be set at the surface of the conductors of the cables 12 and 14 and the electrical connection component 18, respectively. As such, even one of the temperature sensors fails or provides an incorrect temperature sensor, the other two may provide a correct temperature data.

[0072] Fig. 3 illustrates a cross section view of a PCJD 110 in a first direction in accordance with some example embodiments of the present disclosure. The PCJD 110 has a configuration similar to that of the PCJD 100 except for the location of the temperature sensor 22. Thus, same or similar configuration and operation of the PCJD 110 is omitted here for brevity.

[0073] The temperature sensor 22 of the PCJD 110 is located at a lateral side of the second cable 14 inside the housing 10 to sense the temperature of the second cable 14, and is supplied with power from the current transformer via the circuit board 21. As described, the temperature sensor 22 of the PCJD 110 may accurately sense temperature of the cables and the electrical connection component 18 since the temperature difference between the second cable 14 and the electrical connection component 18 can be neglected.

[0074] Fig. 4 illustrates a cross section view of a PCJD 120 in a first direction in accordance with some example embodiments of the present disclosure. The PCJD 120 has a configuration similar to that of the PCJD 100 except for the location of the coil 24 and the circuit board 21 including the wireless transmission device 20. Thus, same or similar configuration and operation of the PCJD 120 is omitted here for brevity.

[0075] The PCJD 120 includes the coil 24 and the circuit board 21 on opposite sides of

the magnetic loop 26. In Fig. 2, the coil 24 is illustrated to surround the magnetic loop 26 of the PCJD 100 on the opposite sides of the magnetic loop 26. The coil 24 may not surround the entire loop of the magnetic loop 26. In this case, the coil 24 and the circuit board 21 may be operable to locate on opposite sides of the magnetic loop 26 to save space between the lateral side of the electrical connection component 18 and the screen cover 16 such that a more compact PCJD can be achieved.

[0076] Fig. 5 illustrates a cross section view of a PCJD 130 in a first direction in accordance with some example embodiments of the present disclosure. The PCJD 130 has a configuration similar to that of the PCJD 120 except for the location of the temperature sensor 22. Thus, same or similar configuration and operation of the PCJD 130 is omitted here for brevity.

[0077] The temperature sensor 22 of the PCJD 130 is located at a lateral side of the second cable 14 inside the housing 10 to sense the temperature of the second cable 14, and is supplied with power from the current transformer via the circuit board 21. As described, the temperature sensor 22 of the PCJD 130 may accurately sense temperature of the cables and the electrical connection component 18 since the temperature difference between the second cable 14 and the electrical connection component 18 can be neglected.

[0078] Fig. 6 illustrates a cross section view of a PCJD 140 in a first direction in accordance with some example embodiments of the present disclosure. The PCJD 140 has a configuration similar to that of the PCJD 100 except for the location of the circuit board 21 including the wireless transmission device 20. Thus, same or similar configuration and operation of the PCJD 140 is omitted here for brevity.

[0079] In the example, the circuit board 21 is operable to locate at a lateral surface of the first cable 12 between the housing 10 and the screen cover 16 with the wireless transmission device 20 disposed on the circuit board 21. The circuit board 21 is supplied with power from the current transformer, and the temperature sensor 22 is also supplied with power from the current transformer.

[0080] Although not shown, the temperature sensor 22 is coupled to the circuit board 21 to send the sensed temperature signal to the circuit board 21 for processing. The processed signal is then transmitted by the wireless transmission device 20. By setting the wireless transmission device 20 outside the screen cover 16, better wireless transmission may be achieved.

[0081] Fig. 7 illustrates a cross section view of a PCJD 150 in a first direction in accordance with some example embodiments of the present disclosure. The PCJD 150 has a configuration similar to that of the PCJD 140 except for the location of the temperature sensor 22. Thus, same or similar configuration and operation of the PCJD 150 is omitted here for brevity.

[0082] The temperature sensor 22 is supplied with power from the current transformer and operable to detect surface temperature of a first cable 12 inside the screen cover 16. As described above, the temperature sensor 22 of the PCJD 150 may accurately sense temperature of the cables 12 and 14 and the electrical connection component 18, since the temperature difference between the second cable 12 and the electrical connection component 18 can be neglected.

[0083] Fig. 8 illustrates a cross section view of a PCJD 160 in a first direction in accordance with some example embodiments of the present disclosure. The PCJD 160 includes a current transformer outside the screen cover 16. The magnetic loop 26 surrounds the first cable 12, and the coil 24 winds the magnetic loop 26. Since the coil 24 does not wind the entire magnetic loop 26, the circuit board 21 may be set on the opposite of the magnetic loop 26.

[0084] The temperature sensor 22 is supplied with power from the current transformer and operable to detect surface temperature of the electrical connection component 18 inside the screen cover 16. By setting the circuit board 21 including the wireless transmission device 20 outside of the screen cover 16, better wireless transmission may be achieved.

[0085] Fig. 9 illustrates a cross section view of a PCJD 170 in a first direction in accordance with some example embodiments of the present disclosure. The PCJD 170 has a configuration similar to that of the PCJD 160 except for the location of the temperature sensor 22. Thus, same or similar configuration and operation of the PCJD 170 is omitted here for brevity.

[0086] The temperature sensor 22 is supplied with power from the current transformer and operable to detect surface temperature of a first cable 12 inside the screen cover 16. As described above, the temperature sensor 22 of the PCJD 170 may accurately sense temperature of the cables 12 and 14 and the electrical connection component 18, since the temperature difference between the second cable 12 and the electrical connection

component 18 can be neglected.

[0087] Fig. 10 illustrates a first cross section view of a PCJD 100 along the lines A-A' in a second direction in accordance with some example embodiments of the present disclosure. The screen cover 16 with an opening for wireless transmission is located inside the housing 10. A gap 17 exists between the electrical connection device 18 and the screen cover 16. The gap 17 may be filled with air or other insulating materials, such as thermoplastic material and thermoset material.

[0088] The electrical connection device 18 closely surrounds or is fixed to the second cable 14 such that a current may fluently flows between the electrical connection device 18 and the second cable 14. Analogous situation apply to connection between the electrical connection device 18 and the first cable 12.

[0089] Fig. 11 illustrates a first cross section view of a PCJD 100 along the lines B-B' in a second direction in accordance with some example embodiments of the present disclosure. The screen cover 16 with an opening for wireless transmission is located inside the housing 10. At an end of the screen cover 16, the scree cover 16 abuts the second cable 16. Wireless transmission in this case can be still achieved because the screen cover 16 includes a slit or a window along its length direction for wireless transmission, as will be discussed below. The slit of window may be filled with air or other insulating materials, such as thermoplastic or thermoset materials.

[0090] Fig. 12 illustrates a schematic graph of a screen cover 16 in accordance with some example embodiments of the present disclosure. In an example, the screen cover 16 may include a plurality of windows 15. The plurality of windows 15 are used to transmit wireless signals. The plurality of windows 15 are evenly or regularly disposed along the length direction of the screen cover 16 so as to minimize affection for the evenly distributed electrical field.

[0091] The size and shape of the pluralities of windows 15 may be designed to achieve an optimum transmission effect. For example, a plurality of round window may be structured along the length direction. In addition, the number of the plurality of the windows 15 may be selected as needed to achieve an optimum transmission effect.

[0092] Although the plurality of windows 15 is illustrated along a length direction, this is only for illustration without suggesting any limitations as to the scope of the subject matter described here. As an example, two sets of windows may be structured on

opposite sides of the screen cover 16 along the length direction.

[0093] Fig. 13 illustrates a cross section view of a PCJD 100 in a second direction in accordance with some example embodiments of the present disclosure. In an example, the screen cover 16 may include two slits 19 along the length direction of the screen cover 16. The slits 19 are used to transmit wireless signals, and the wireless transmission device 20 may face at least one of the slits 19. In an example, the slits 19 are disposed on opposite sides of the screen cover 16 so as to minimize affection for the evenly distributed electrical field.

[0094] The size and shape of the slits 19 may be designed to achieve an optimum transmission effect. In addition, the number of the slits 19 may be selected as needed to achieve an optimum transmission effect. Although two slits 19 are illustrated, this is only for illustration without suggesting any limitations as to the scope of the subject matter described here. As an example, four slits may be evenly distributed on the circumference of the screen cover 16 along the length direction.

[0095] Fig. 14 illustrates a cross section view of a PCJD 100 in a second direction in accordance with some example embodiments of the present disclosure. In an example, as an alternative to the slits 19 or the windows 15, a plurality of openings 13 may be provided at an end of the screen cover 16. The openings 13 are evenly distributed on the interior circumference of the screen cover 16 so as to transmit the wireless signal from the wireless transmission device 20.

[0096] The size and shape of the openings 13 may be designed to achieve an optimum transmission effect. In addition, the number of the openings 13 may be selected as needed to achieve an optimum transmission effect. Although eight openings 13 are illustrated, this is only for illustration without suggesting any limitations as to the scope of the subject matter described here. As an example, four openings 13 may be evenly distributed on the interior circumference of the screen cover 16 along the length direction.

[0097] Fig. 15 illustrates a cross section view of a PCJD 180 in a first direction in accordance with some other example embodiments of the present disclosure. The PCJD 180 has a configuration similar to that of the PCJD 100 of Fig. 2 except for the screen cover 16. Thus, same or similar configuration and operation of the PCJD 180 is omitted here for brevity.

[0098] The screen cover 16 has gaps 11 at both ends. The first and second openings

form the gaps 11 between the screen cover 16 and the first and second cables 12 and 14, respectively, such that the wireless transmission device 20 transmits data indicating the sensed temperature through the gaps 11.

5 [0099] Fig. 16 illustrates an example cross section view of a PCJD 180 along the line C-C' in a second direction in accordance with some example embodiments of the present disclosure. The gap 11 is formed between the second cable 14 and the screen cover 16. The gap 11 may be filled with air or other insulating materials, such as thermoplastic material and thermoset material.

10 [00100] Although a circular gap 11 is illustrated in Fig. 16, for illustration without suggesting any limitations as to the scope of the subject matter described here. As an example, Fig. 17 illustrates another example cross section view of a PCJD 180 along the line C-C' in a second direction in accordance with some example embodiments of the present disclosure. The gap 23 may combine the gap 11 of Fig. 15 with the slits 19 of Fig. 13 to achieve a better wireless transmission for the wireless transmission device 20.

15 [00101] As another example, Fig. 18 illustrates another example cross section view of a PCJD 180 in a second direction in accordance with some example embodiments of the present disclosure. The gap 25 may combine the gap 11 of Fig. 15 with the slits 13 of Fig. 13 to achieve a better wireless transmission for the wireless transmission device 20.

20 [00102] Although various configurations of PCJDs have been described above, this is only for illustration without suggesting any limitations as to the scope of the subject matter described here. The above configurations may be recombined as needed.

25 [00103] Fig. 19 illustrates a method 900 for manufacturing a PCJD in accordance with some example embodiments of the present disclosure. At 902, a screen cover is provided. The screen cover includes a first opening for receiving a first cable and a second opening for receiving a second cable and operable to transmit wireless signal through at least one of the first opening, the second opening and a third opening. The first and second cables are electrically coupled by an electrical connection component inside the screen cover.

[00104] At 904, a current transformer is provided. The current transformer includes a magnetic loop surrounding the first cable and a coil winding the magnetic loop.

30 [00105] At 906, a temperature sensor is provided inside the screen cover. The temperature sensor is attached to a surface of one of the first and second cables and the electrical connection component, and supplied with power from the current transformer to

sense a temperature of the surface.

[00106] At 908, a wireless transmission device is provided. The wireless transmission device is supplied with power from the current transformer and operable to transmit data indicating the sensed temperature.

5 [00107] 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  
10 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, various features that are described in the context of a single embodiment may also be  
15 implemented in multiple embodiments separately or in any suitable sub-combination.

[00108] 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  
20 example forms of implementing the claims.

**WHAT IS CLAIMED IS:**

1. A power cable joint device (100), comprising:

5 a screen cover (16) including a first opening for receiving a first cable (12) and a second opening for receiving a second cable (14) and operable to transmit wireless signal through at least one of the first opening, the second opening and a third opening, the first and second cables being electrically coupled by an electrical connection component (18) inside the screen cover;

10 a current transformer including a magnetic loop (26) surrounding the first cable (12) and a coil (24) winding the magnetic loop;

a temperature sensor (22) attached to a surface of one of the first and second cables and the electrical connection component inside the screen cover (16), and operable to sense a temperature of the surface with power supplied from the current transformer; and

15 a wireless transmission device (20) operable to transmit data indicating the sensed temperature with power supplied from the current transformer.

2. The power cable joint device (100) of claim 1, wherein the current transformer and the wireless transmission device are located inside the screen cover (16).

20 3. The power cable joint device (100) of claim 2, wherein the wireless transmission device and the coil are located at opposite sides of the magnetic loop.

25 4. The power cable joint device (100) of claim 2, wherein the wireless transmission device and the temperature sensor are located at the surface of the electrical connection component (18).

30 5. The power cable joint device (100) of claim 1, wherein the current transformer is located inside the screen cover (16), and the wireless transmission device is located outside the screen cover (16).

6. The power cable joint device (100) of claim 5, wherein wireless transmission device and the coil are located at opposite sides of the magnetic loop.

7. The power cable joint device (100) of claim 1, wherein the third opening includes a plurality of windows (15) along a length of the screen cover, such that the wireless transmission device transmits data indicating the sensed temperature through the plurality of windows.

5

8. The power cable joint device (100) of claim 1, wherein the third opening includes a slit (19) along a length of the screen cover, such that the wireless transmission device transmits data indicate the sensed temperature through the slit.

10

9. The power cable joint device (100) of claim 1, wherein the first and second openings are structured to form a gap (11) between the screen cover (16) and the respective cable, such that the wireless transmission device transmits data indicating the sensed temperature through the gap.

15

10. The power cable joint device (100) of claim 1, wherein the screen cover includes metallic mesh layer or metallic layer.

11. The power cable joint device (100) of claim 1, wherein the temperature sensor and the wireless transmission device are integrated on a circuit board (21).

20

12. The power cable joint device (100) of claim 1, wherein the at least one of the first opening, the second opening and a third opening are filled with air, thermoplastic material or thermoset material.

25

13. An electric system (600), comprising:  
a power cable joint device (100) of any of claims 1-12;  
a first antenna (620); and  
a receiver (630) coupled to the first antenna (620), wherein the receiver (630) is operable to receive temperature data via the first antenna (620).

30

14. The electric system (600) according to claim 13, further comprising:  
a further power cable joint device (200) of any of claims 1-12.

15. An Internet of Things (IoT) system comprising:  
a power cable joint device (100) of any of claims 1-12.

16. A method (900) for manufacturing a power cable joint device, comprising:

5 providing (902) a screen cover including a first opening for receiving a first cable and a second opening for receiving a second cable and operable to transmit wireless signal through at least one of the first opening, the second opening and a third opening, the first and second cables electrically coupled by an electrical connection component inside the screen cover;

10 providing (904) a current transformer including a magnetic loop surrounding the first cable and a coil winding the magnetic loop;

providing (906) a temperature sensor inside the screen cover to attach to a surface of one of the first and second cables and the electrical connection component, the temperature sensor operable to sense a temperature of the surface with power supplied  
15 from the current transformer; and

providing (908) a wireless transmission device operable to transmit data indicating the sensed temperature with power supplied from the current transformer.

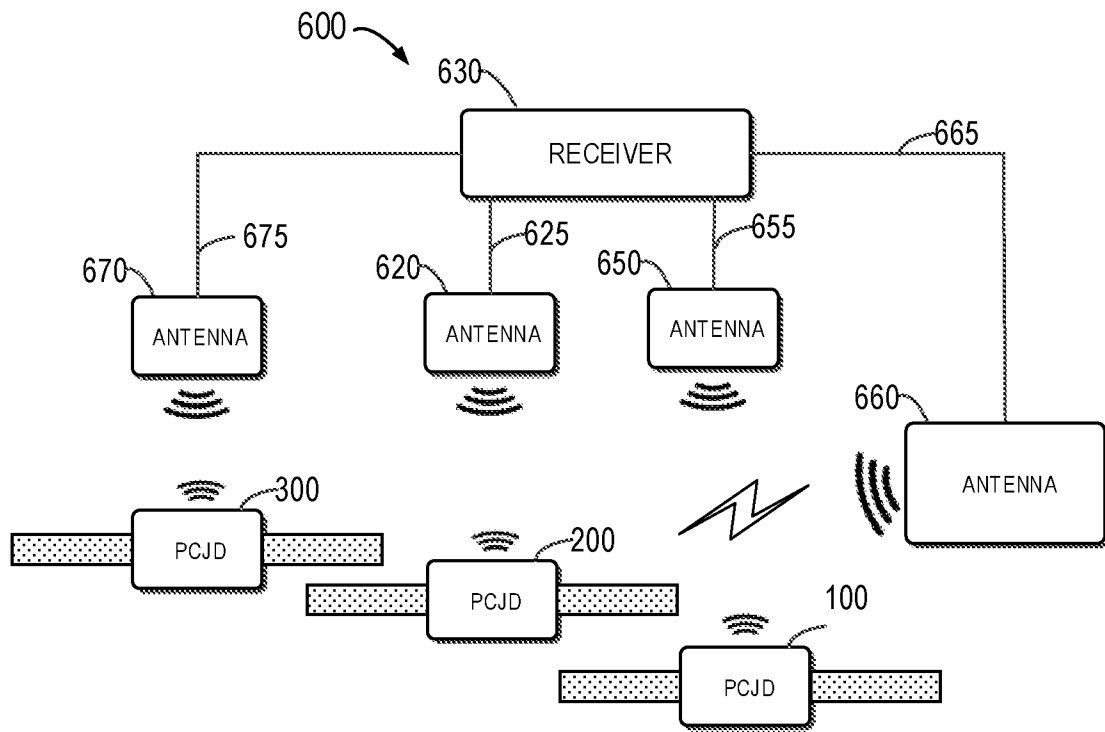


Fig. 1

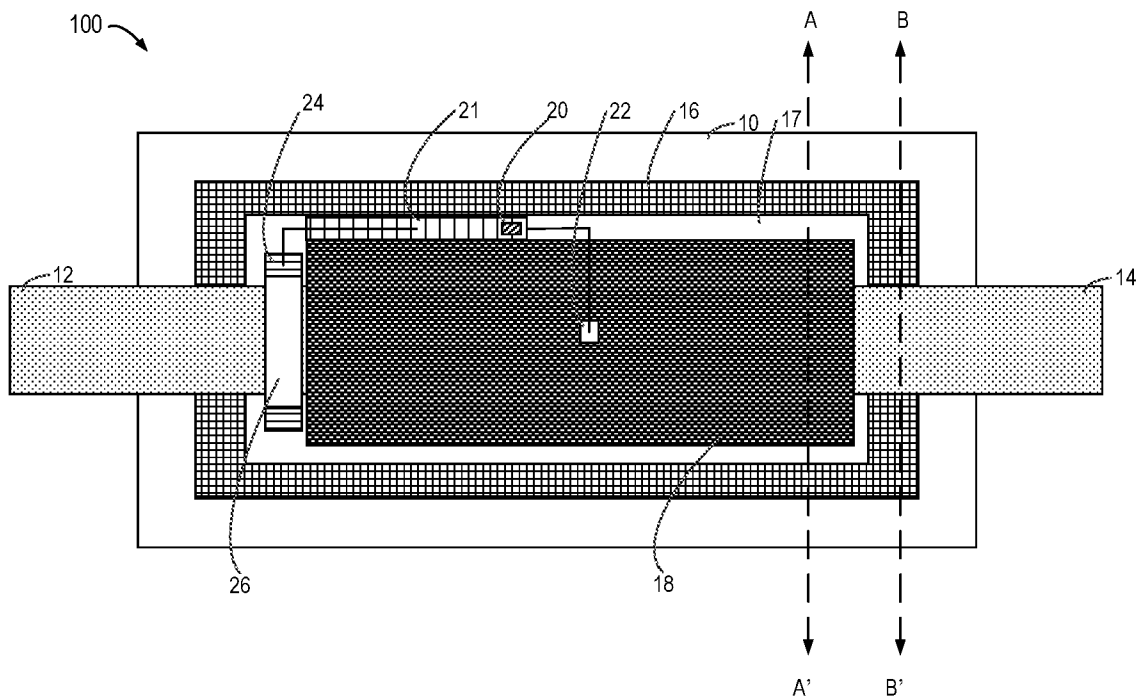


Fig. 2

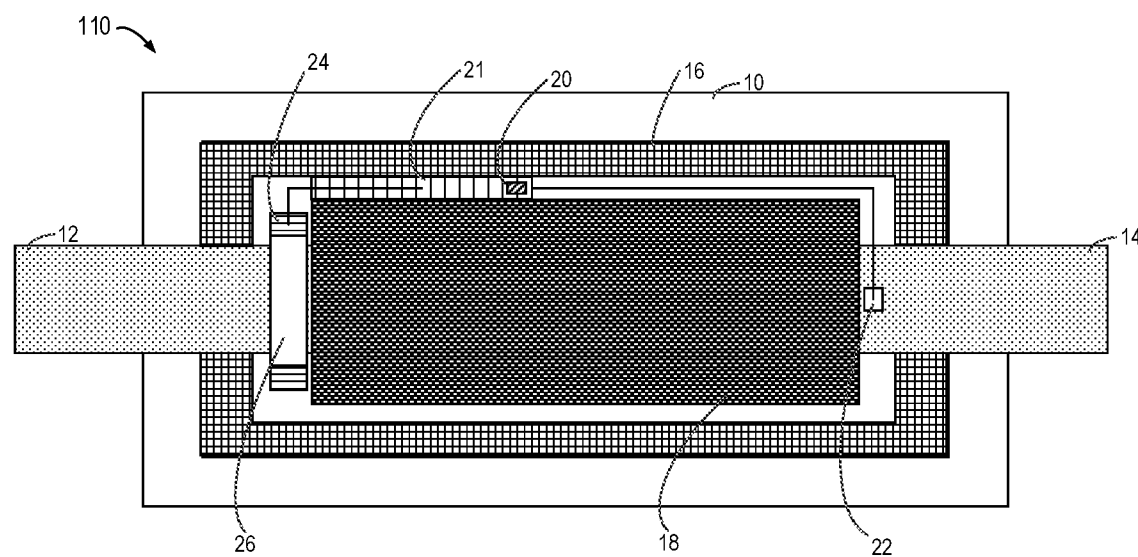


Fig. 3

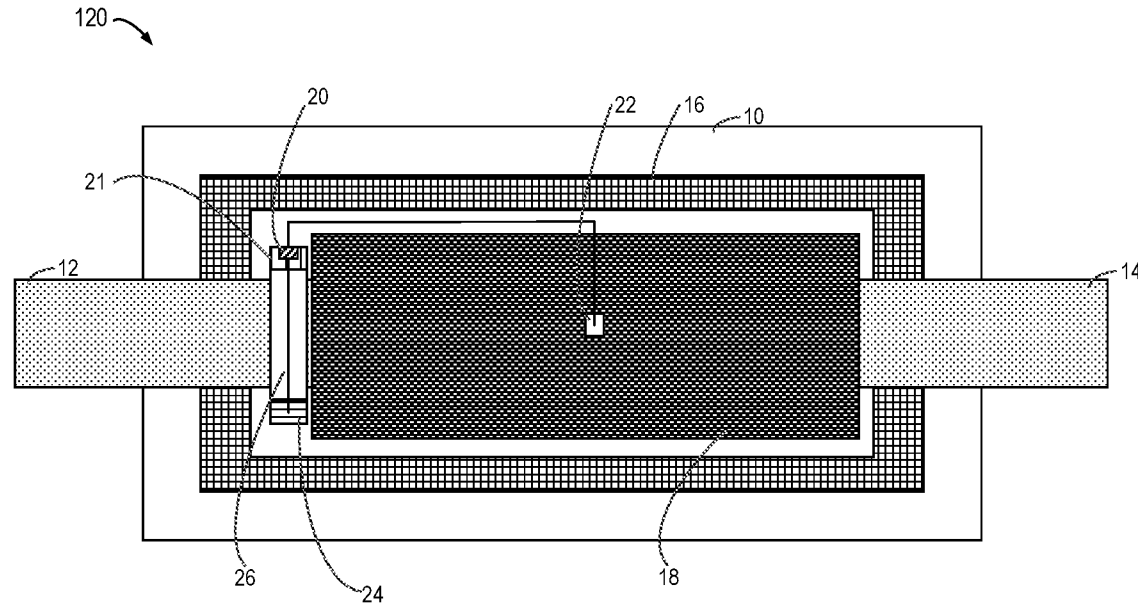


Fig. 4

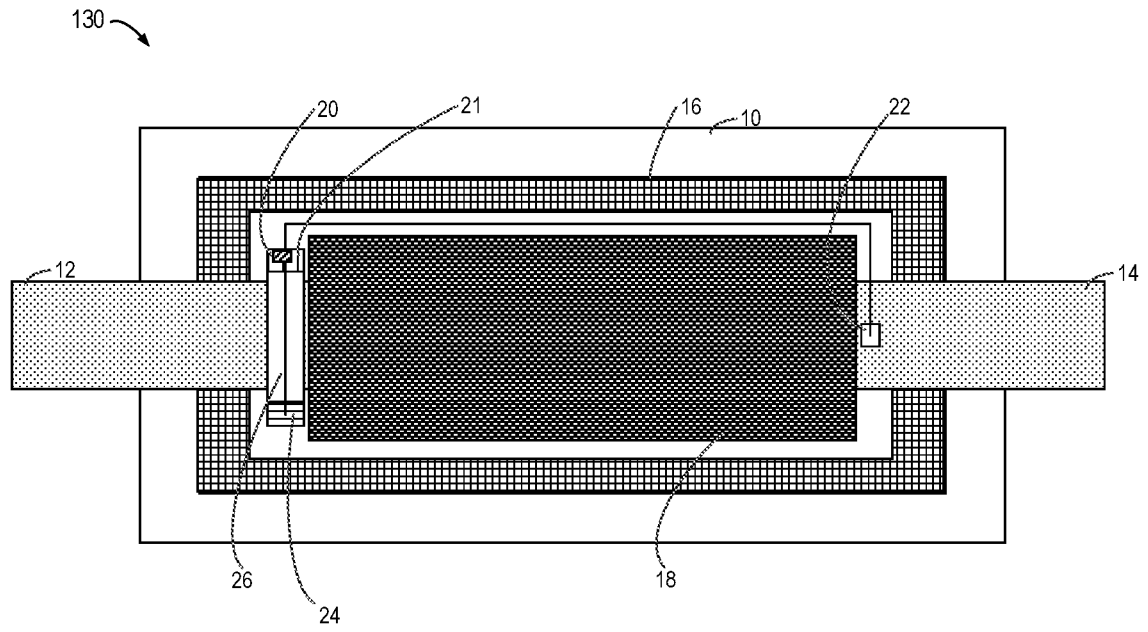


Fig. 5

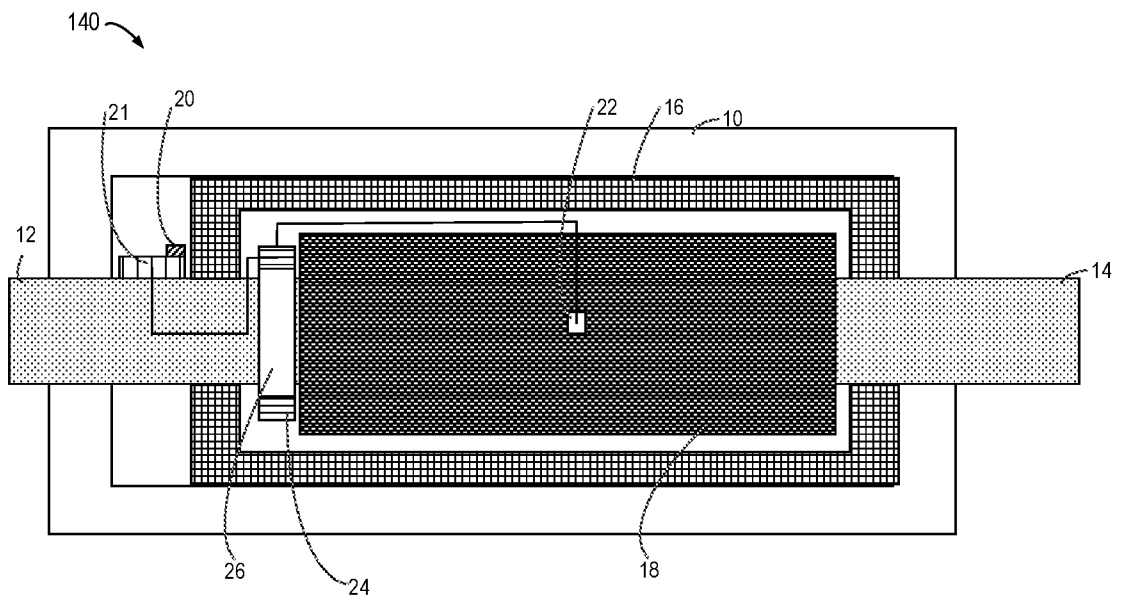


Fig. 6

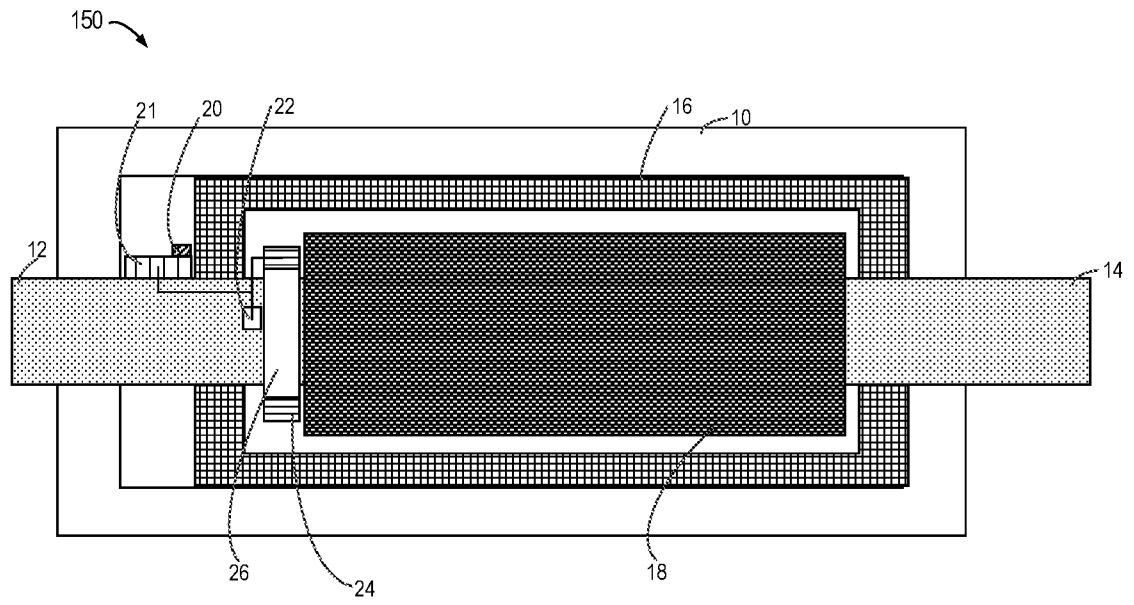


Fig. 7

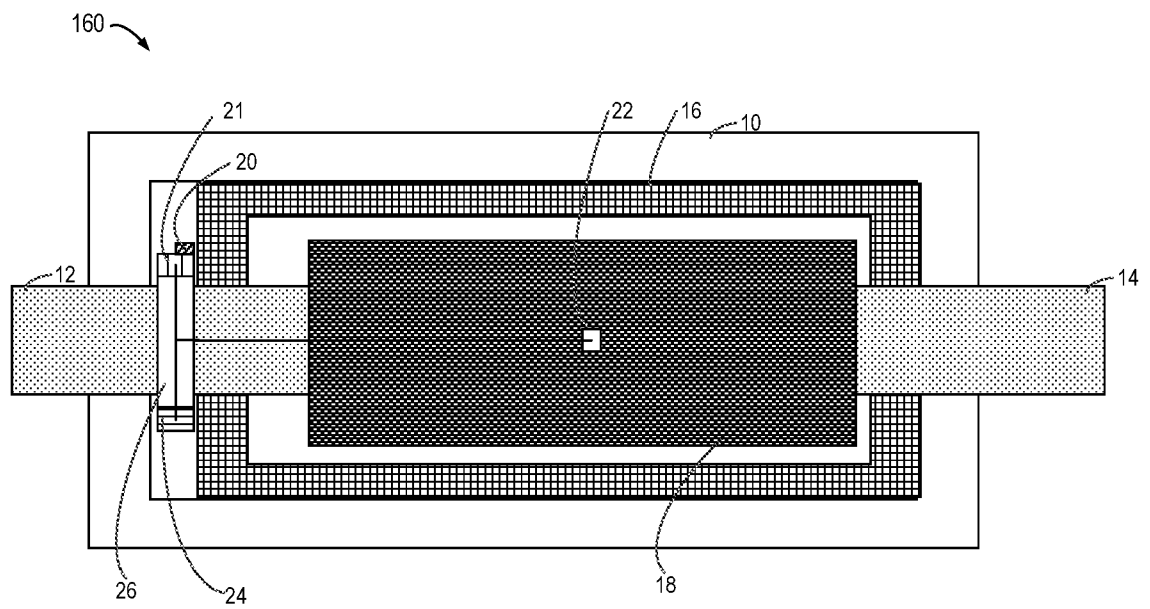


Fig. 8

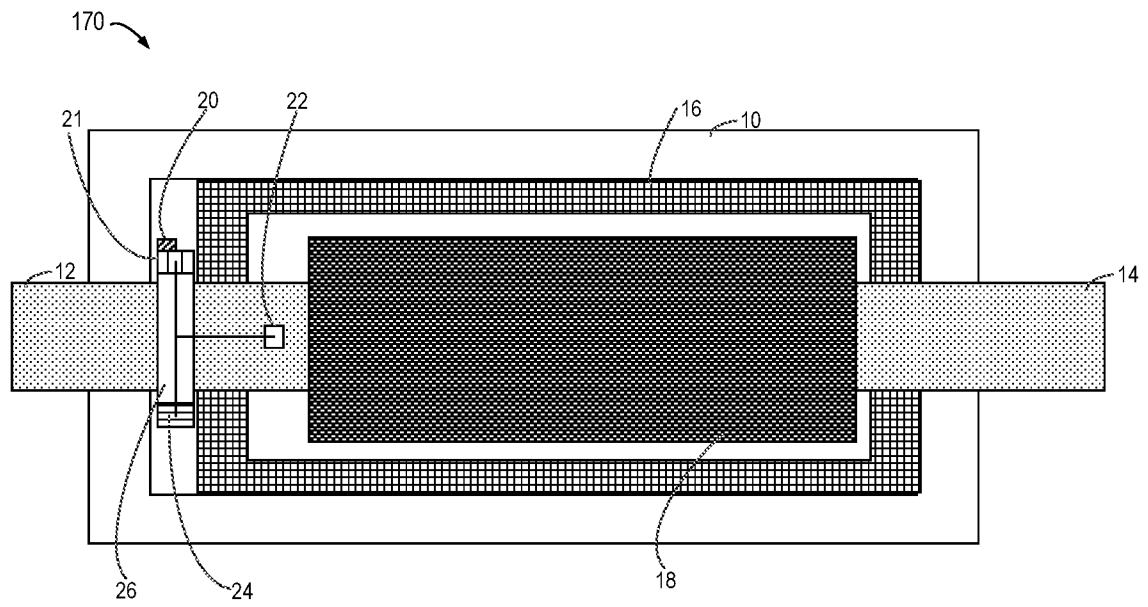


Fig. 9

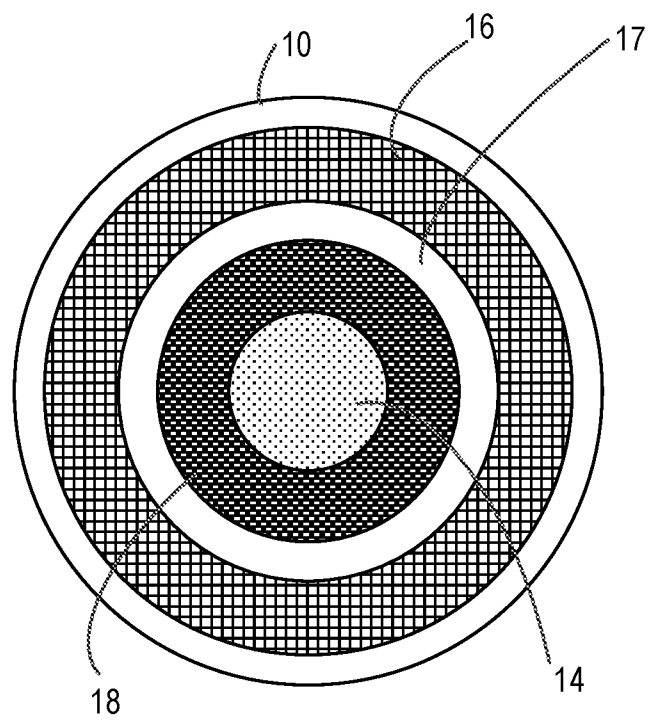


Fig. 10

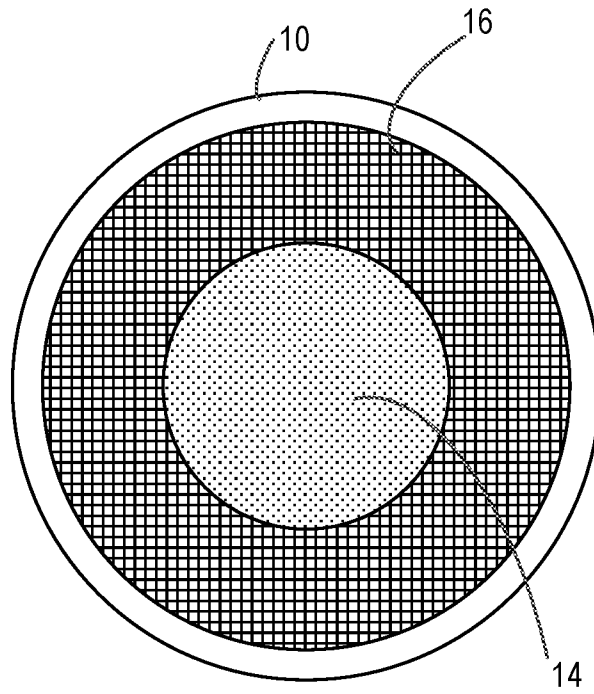


Fig. 11

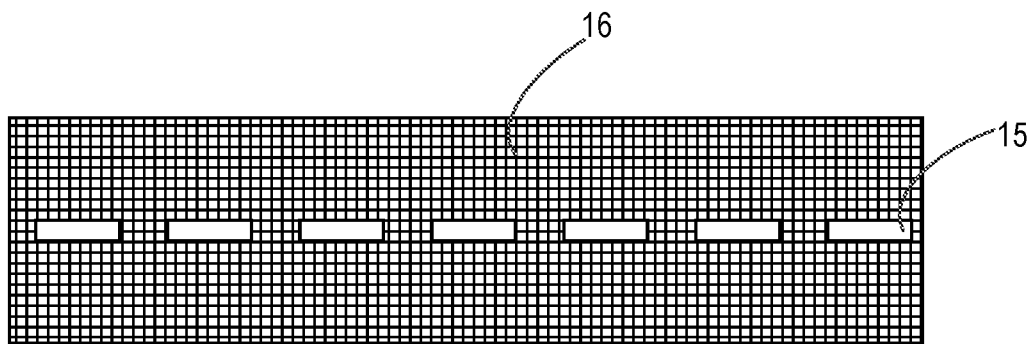


Fig. 12

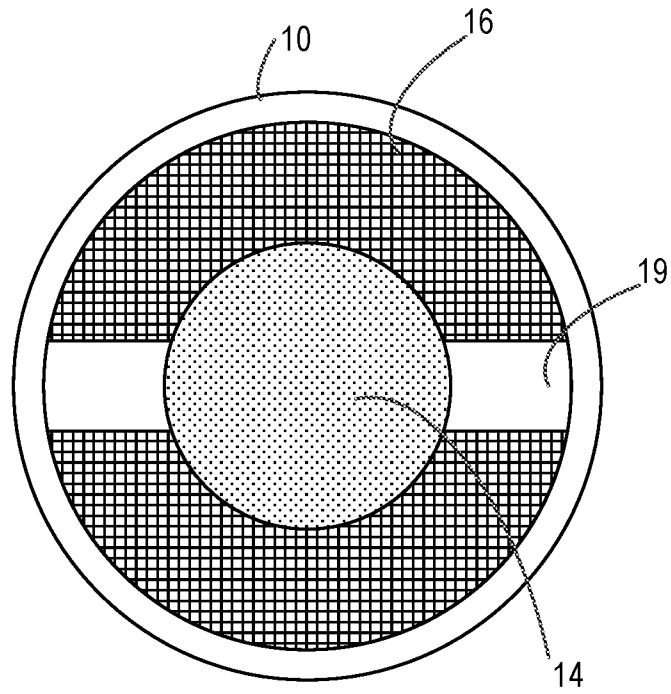


Fig. 13

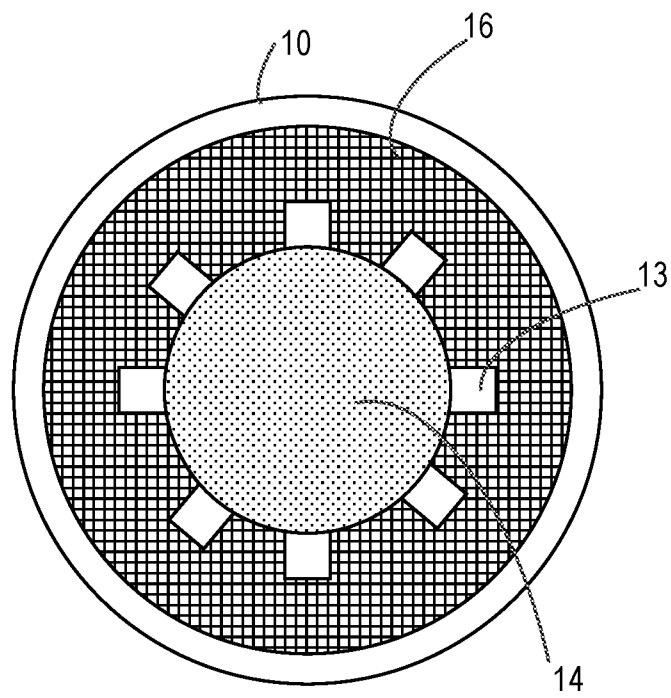


Fig. 14

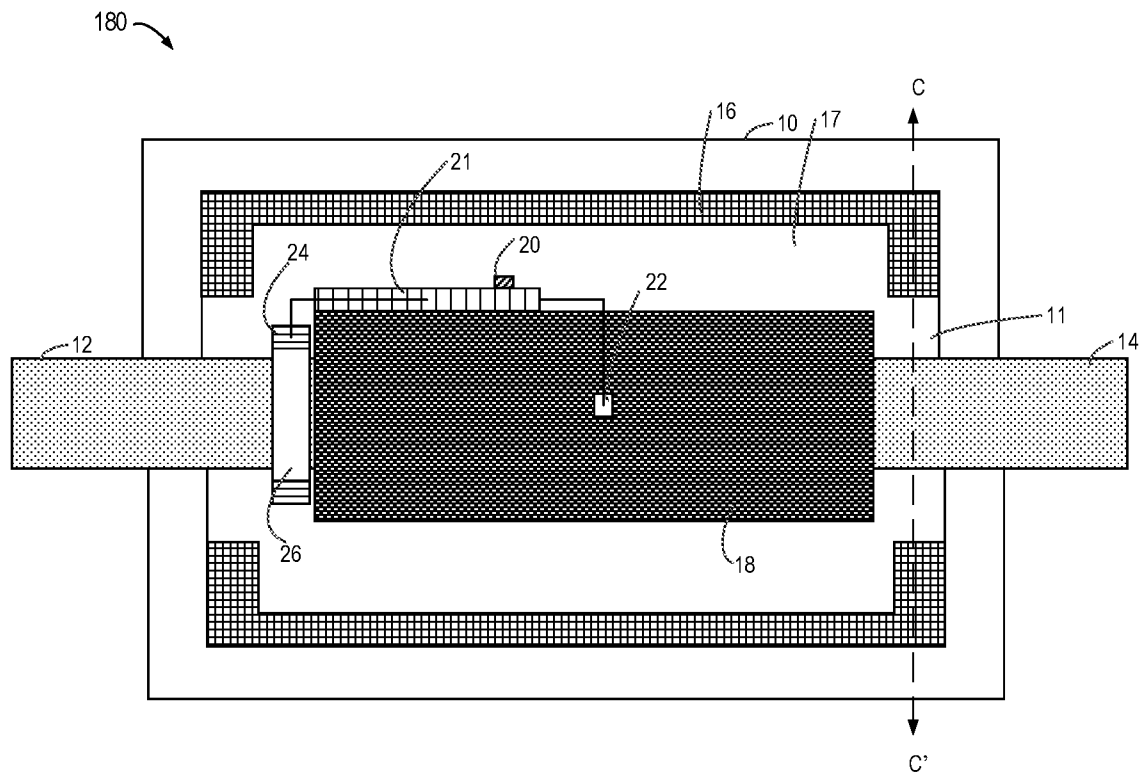


Fig. 15

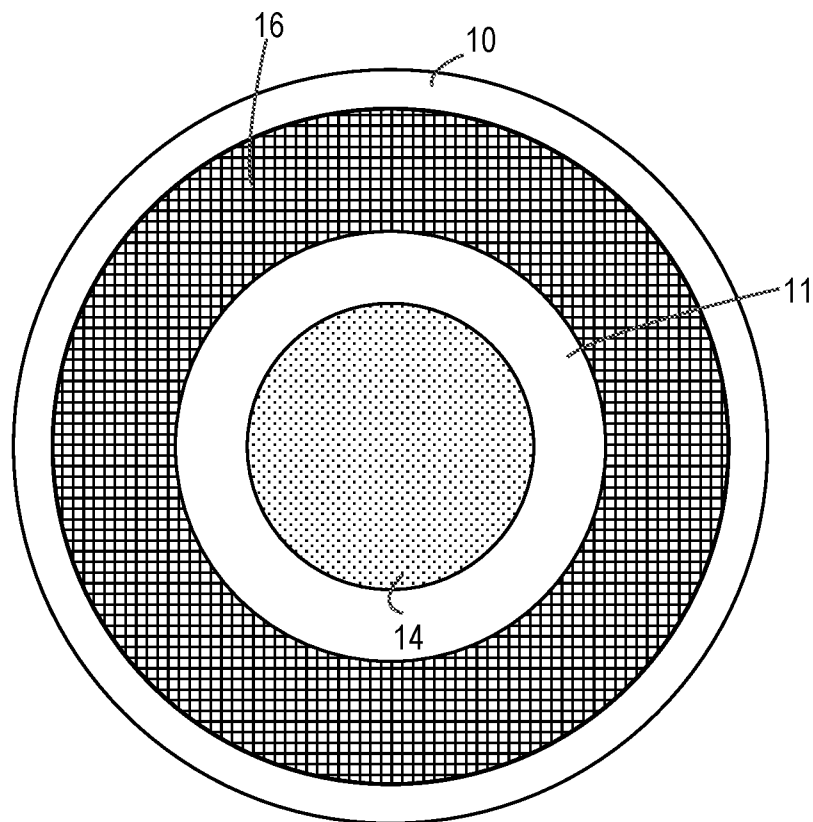


Fig. 16

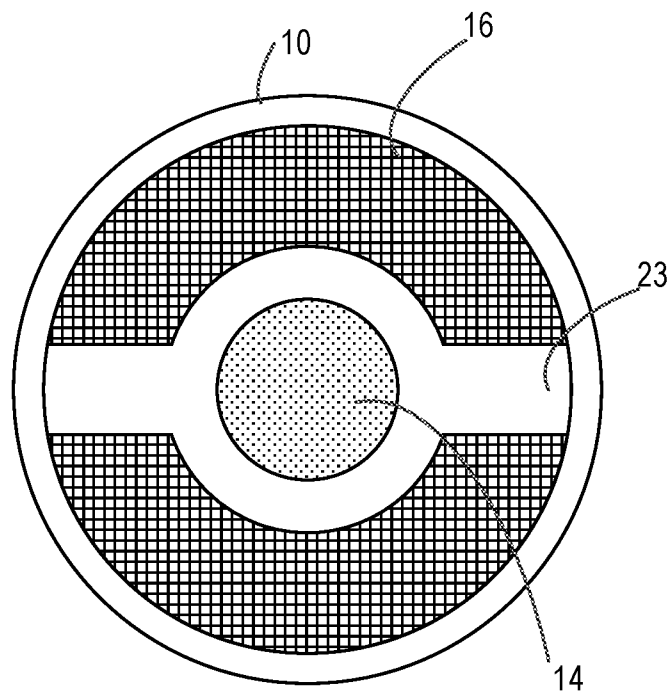


Fig. 17

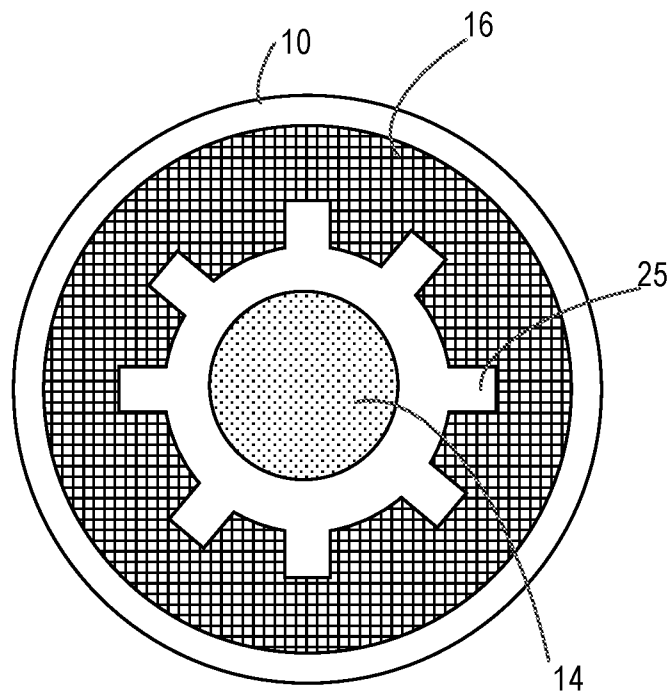


Fig. 18

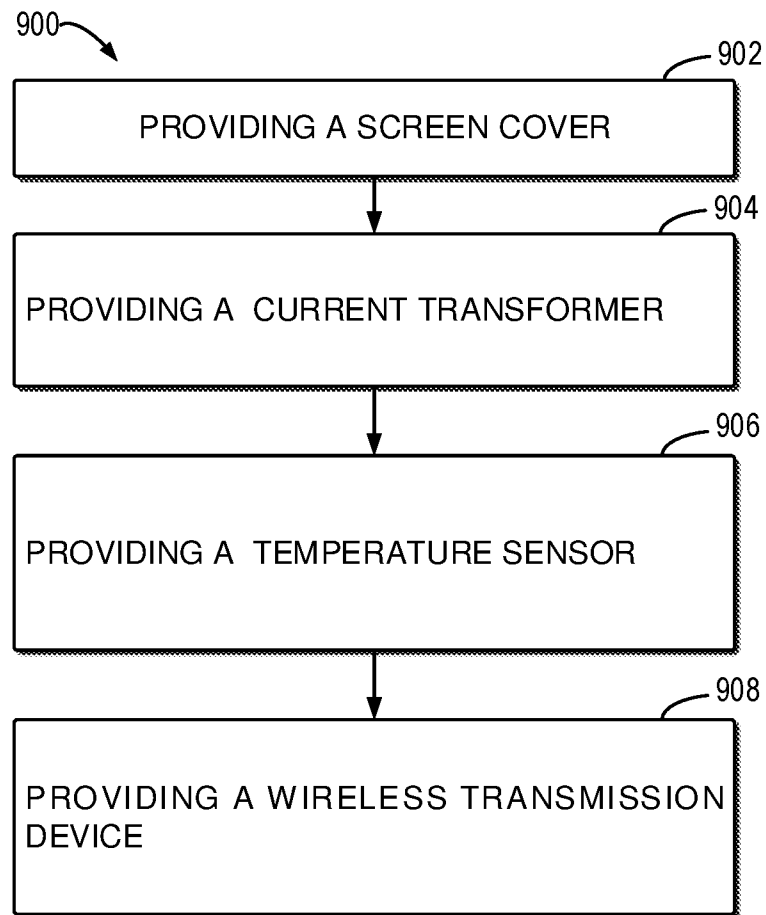


Fig. 19

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2019/085253

| <b>A. CLASSIFICATION OF SUBJECT MATTER</b><br>G01R 31/00(2006.01)i<br><br>According to International Patent Classification (IPC) or to both national classification and IPC                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                       |   |                                                                                                        |      |   |                                                                                                                                                  |      |   |                                                                                                |      |   |                                                                                                          |      |
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| <b>B. FIELDS SEARCHED</b><br>Minimum documentation searched (classification system followed by classification symbols)<br>G01R<br><br>Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched<br><br>Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)<br>CNABS,CNKI,DWPI,SIPOABS: power cable joint device, PCJD, cover, opening, slit, gap, wireless, current transformer, sensor, temperature, transmit, transfer, convey, delivery, cable, connect, connector, joint, adapter, measure+, detect+                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                       |   |                                                                                                        |      |   |                                                                                                                                                  |      |   |                                                                                                |      |   |                                                                                                          |      |
| <b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b> <table border="1" style="width: 100%; border-collapse: collapse; margin-top: 5px;"> <thead> <tr> <th style="width: 10%;">Category*</th> <th style="width: 70%;">Citation of document, with indication, where appropriate, of the relevant passages</th> <th style="width: 20%;">Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">Y</td> <td>CN 108801502 A (GUANGDONG POWER GRID CO., LTD. et al.) 13 November 2018 (2018-11-13)<br/>claims 1 and 4</td> <td style="text-align: center;">1-16</td> </tr> <tr> <td style="text-align: center;">Y</td> <td>CN 206772345 U (SHANDONG ZHONGXIN ELECTRIC POWER TECHNOLOGY CO., LTD.) 19 December 2017 (2017-12-19)<br/>description, paragraph 0037 and figure 5</td> <td style="text-align: center;">1-16</td> </tr> <tr> <td style="text-align: center;">Y</td> <td>CN 103007465 A (WEIHAI BEIYANG ELECTRIC GROUP CO., LTD.) 03 April 2013 (2013-04-03)<br/>claim 4</td> <td style="text-align: center;">1-16</td> </tr> <tr> <td style="text-align: center;">A</td> <td>US 2011210844 A1 (NSTAR ELECTRIC &amp; GAS CORPORATION) 01 September 2011 (2011-09-01)<br/>the whole document</td> <td style="text-align: center;">1-16</td> </tr> </tbody> </table>                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                      | Category*                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Citation of document, with indication, where appropriate, of the relevant passages                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Relevant to claim No. | Y | CN 108801502 A (GUANGDONG POWER GRID CO., LTD. et al.) 13 November 2018 (2018-11-13)<br>claims 1 and 4 | 1-16 | Y | CN 206772345 U (SHANDONG ZHONGXIN ELECTRIC POWER TECHNOLOGY CO., LTD.) 19 December 2017 (2017-12-19)<br>description, paragraph 0037 and figure 5 | 1-16 | Y | CN 103007465 A (WEIHAI BEIYANG ELECTRIC GROUP CO., LTD.) 03 April 2013 (2013-04-03)<br>claim 4 | 1-16 | A | US 2011210844 A1 (NSTAR ELECTRIC & GAS CORPORATION) 01 September 2011 (2011-09-01)<br>the whole document | 1-16 |
| Category*                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Citation of document, with indication, where appropriate, of the relevant passages                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Relevant to claim No.                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                       |   |                                                                                                        |      |   |                                                                                                                                                  |      |   |                                                                                                |      |   |                                                                                                          |      |
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| <input type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> See patent family annex.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                       |   |                                                                                                        |      |   |                                                                                                                                                  |      |   |                                                                                                |      |   |                                                                                                          |      |
| <table style="width: 100%;"> <tr> <td style="width: 50%; vertical-align: top;">           * Special categories of cited documents:<br/>           "A" document defining the general state of the art which is not considered to be of particular relevance<br/>           "E" earlier application or patent but published on or after the international filing date<br/>           "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)<br/>           "O" document referring to an oral disclosure, use, exhibition or other means<br/>           "P" document published prior to the international filing date but later than the priority date claimed         </td> <td style="width: 50%; vertical-align: top;">           "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<br/>           "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<br/>           "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<br/>           "&amp;" document member of the same patent family         </td> </tr> </table> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                      | * Special categories of cited documents:<br>"A" document defining the general state of the art which is not considered to be of particular relevance<br>"E" earlier application or patent but published on or after the international filing date<br>"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)<br>"O" document referring to an oral disclosure, use, exhibition or other means<br>"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<br>"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<br>"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<br>"&" document member of the same patent family |                       |   |                                                                                                        |      |   |                                                                                                                                                  |      |   |                                                                                                |      |   |                                                                                                          |      |
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| Date of the actual completion of the international search<br><div style="text-align: center;"><b>21 January 2020</b></div>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Date of mailing of the international search report<br><div style="text-align: center;"><b>03 February 2020</b></div> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                       |   |                                                                                                        |      |   |                                                                                                                                                  |      |   |                                                                                                |      |   |                                                                                                          |      |
| Name and mailing address of the ISA/CN<br><div style="text-align: center;"> <b>National Intellectual Property Administration, PRC<br/>         6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing<br/>         100088<br/>         China</b> </div> Facsimile No. (86-10)62019451                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Authorized officer<br><div style="text-align: center;"><b>DENG,Jun</b></div> Telephone No. 86-(10)-62411644          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                       |   |                                                                                                        |      |   |                                                                                                                                                  |      |   |                                                                                                |      |   |                                                                                                          |      |

**INTERNATIONAL SEARCH REPORT**  
**Information on patent family members**

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