

SEALED ELECTRICAL PLUG

TECHNICAL FIELD

[1] The present disclosure relates to an electrical connector, and more particularly to a sealed electrical plug including one or more temperature sensors.

BACKGROUND

[2] Electrical plugs are commonly used to supply power to electrical appliances, such as electric toasters and kettles, and electrical vehicle charging devices, some of which draw more current than other devices. Conventional electrical plugs typically do not include protective mechanisms for higher current drawing applications and may be subject to overheating, melting, or burning. As a result, the conventional electrical plugs may become damaged and may cause unsafe conditions. Furthermore, in certain environments, the electrical plugs may be exposed to air and moisture that can enter the plugs and result in additional damage and unsafe conditions. There is thus a need for improvements to the conventional electrical plugs.

SUMMARY

[3] In accordance with an aspect of the present disclosure, there is provided an electrical plug which comprises at least one temperature sensor embedded in the plug. The temperature sensor is configured to detect an internal temperature of the plug. The electrical plug further comprises data cables wrapped by a shield for screening electric noises so as to accurately acquire and transmit temperature data from the at least one temperature sensor. The electrical plug further comprises a housing for accommodating the at least one temperature sensor.

[4] The electrical plug may comprise two thermistors, one thermistor may be disposed adjacent to a live pin of the plug and the other thermistor may be disposed adjacent to a neutral pin of the plug. The housing for accommodating the thermistors may include at least one snap joint for removably locking a cover portion and a base portion of the housing together. The electrical plug may further comprise a snap-fit mechanism for removably attaching the housing to a pin bridge of the plug.

[5] Alternatively, the housing for accommodating the thermistors may include a ceramic housing which may comprise two pin receptacles and two thermistor receptacles. The two pin receptacles and the two thermistor receptacles may be arranged in a line and the two thermistor receptacles may be disposed between the pair of pin receptacles. A thermally conductive adhesive may be filled into gaps between the thermistor receptacles and their respective thermistors so as to maintain a tight contact and to reduce thermal resistivity, thereby ensuring stable performances of the thermistors during a predicted life time. In addition, the pins (also referred to as terminals and prongs) of the electrical plug may be sealed within the pin bridge of an inner mold of the electrical plug to prevent air and moisture from entering the electrical plug, thereby preventing damage to the interior of the electrical plug, preventing shorts, and protecting the thermistors.

[6] In accordance with a second aspect of the present disclosure, there may be provided a method of assembling an electrical plug, including the following steps of inserting at least one temperature sensor into a housing and embedding the housing accommodating the at least one temperature sensor in the plug. The method further includes the following steps of forming an inner mold around the housing accommodating the at least one temperature sensor, sealing pins within the inner mold, and forming a coating mold over the inner mold.

BRIEF DESCRIPTION OF THE DRAWINGS

[7] Embodiments of the present disclosure will be described more fully hereinafter with reference to the accompanying drawings, in which:

[8] Fig. 1 illustrates a partially translucent electrical plug including thermistors in accordance with the present disclosure;

[9] Fig. 2 is an exploded perspective view of an electrical plug including thermistors in accordance with the present disclosure;

[10] Fig. 3 is a cross-sectional view of a cable in accordance with the present disclosure;

[11] Fig. 4A and 4B are perspective views of a housing accommodating thermistors according to an embodiment of the present disclosure;

[12] Fig. 5A and 5B are perspective views showing a snap-fit mechanism for removably attaching a housing to a pin bridge according to an embodiment of the present disclosure;

[13] Fig. 6A, 6B, 6C and 6D illustrate a process of assembling an electrical plug including thermistors in accordance with an embodiment of the present disclosure;

[14] Fig. 7 is a perspective view of a thermally conductive housing such as a ceramic for accommodating thermistors according to another embodiment of the present disclosure;

[15] Fig. 8 illustrates an electrical plug including thermistors in accordance with another embodiment of the present disclosure;

[16] Fig. 9 illustrates a sealed electrical plug including thermistors in accordance with another embodiment of the present disclosure;

[17] Fig. 9A further illustrates a pin seal as illustrated in Fig. 9;

[18] Fig. 10 illustrates a sealed electrical plug including a single thermistor in accordance with another embodiment of the present disclosure;

[19] Fig. 10A further illustrates a pin seal as illustrated in Fig. 10;

[20] Fig. 11 illustrates a sealed electrical plug including thermistors in accordance with another embodiment of the present disclosure;

[21] Fig. 11A further illustrates a pin seal as illustrated in Fig. 11;

[22] Fig. 12 illustrates a sealed electrical plug including thermistors in accordance with another embodiment of the present disclosure;

[23] Fig. 12A further illustrates a pin seal as illustrated in Fig. 12;

[24] Fig. 13 illustrates various embodiments for forming a seal around one or among more of elements of an electrical plug, in accordance with the present disclosure;

[25] Fig. 13A further illustrates a first embodiment of a pin seal for the embodiments illustrated in Fig. 13;

[26] Fig. 13B further illustrates a second embodiment of a pin seal for the embodiments illustrated in Fig. 13;

[27] Fig. 13C further illustrates a third embodiment of a pin seal for the embodiments illustrated in Fig. 13;

[28] Fig. 14 illustrates additional embodiments for forming a seal around one or among more of elements of an electrical plug-in accordance with the present disclosure;

[29] Fig. 14A further illustrates a seal between cable tubes and wire insulators as illustrated in Fig. 14;

[30] Fig. 14B further illustrates a first embodiment of a pin seal for the embodiments illustrated in Fig. 14; and

[31] Fig. 14C further illustrates a second embodiment of a pin seal for the embodiments illustrated in Fig. 14.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

[32] The present disclosure describes an improved electrical plug that is capable of accurately monitoring temperature of the electrical plug and transmitting temperature data to a controller. Once the temperature of the electrical plug exceeds a predetermined threshold, the plug is configured to automatically cut off an electric circuit, so that damage to the electrical plug and unsafe conditions are avoided.

[33] While embodiments of type B plugs used in North America are illustrated in the drawings and described herein, it is to be understood that the present disclosure is not limited to type B plugs. As noted, the electrical plug in the present disclosure can be a plug of any voltage standard as well as a plug supporting two or more voltage standards. The electrical plug can be in any shape, size, and type, such as type A and C-N.

[34] Fig. 1 illustrates an embodiment of a fully assembled electrical plug 100 according to the present disclosure, with a translucent inner mold 170 and a coating mold 180 (as shown in Fig. 2) so internal components are visible. As shown more particularly in Fig. 2, the electrical plug 100 may include a live pin 102, a neutral pin 104, and an earth pin 106, which as noted above are also referred to in the art as terminals and prongs. The pins 102, 104 and 106 may be assembled in a pin bridge 110. The electrical plug 100 may also include thermistors 120a and 120b (collectively 120), fastening members 126a, 126b, and 126c (collectively 126), a housing 130, a cable 150, an inner mold 170, and a coating mold 180. The pins 102, 104, 106 may be made of any suitable electrically conductive materials, such as copper or brass. The pins 102, 104, and 106 may be electrically coupled to their respective conductors in the cable 150. The pins 102, 104, and 106 may be fixed in the pin bridge 110. The pin bridge 110 may be made of any suitable insulation materials, such as plastics.

[35] The thermistors 120a and 120b may be coupled to a data part 160 of the cable 150 (as shown in Fig. 3) so as to accurately transmit temperature data to a temperature controller installed in an electrical appliance (not shown). The fastening members 126 may be used to fasten electrodes of the thermistors 120 to corresponding data cables of the data part 160. The

thermistors 120 may be of any type of thermistors, such as bead thermistors and disc thermistors. The thermistors 120 may be received in the housing 130 which can be embedded in the plug 100. The housing 130 may be removably attached to the pin bridge 110. The features of the housing 130 will be further described below.

[36] While the thermistors 120 are illustrated in the drawings and described herein, it is to be understood that the illustrated thermistors 120 are not limited in any way. The present disclosure is not limited to the use of thermistors and other suitable temperature sensors may be used, such as integrated circuit chips on a printed circuit board assembly, or any electrical and/or electronic components with certain precision. Likewise, it is to be understood that the number of the thermistors 120 is not limited to two and may be any other number, such as one and three.

[37] Fig. 3 is a cross-sectional view of a cable 150 according to an exemplary embodiment of the present disclosure. The cable 150 may include a jacket 151, a first sheath 152, a power part including three wires 153 with conductors 154, 156 and 158, and a data part 160. The wires 153 of the power part and the data part 160 may be enclosed within the first sheath 152. The jacket 151 may be wrapped around the first sheath 152. The jacket 151 and the first sheath 152 may be made of any suitable insulating materials, such as plastics. The conductors 154, 156, and 158 may be coupled to the pins 102, 104, and 106, respectively, so as to transmit electrical power. Each of the conductors 154, 156, or 158 may be surrounded by a layer of insulating material. Fillers 155 may be disposed within the cable 150 so as to fill gaps between the insulating layers of the conductors 154, 156, 158, and the data part 160, thereby maintaining their respective positions relative to each other and increasing a strength of the cable 150. The fillers 155 may be of any type, such as a plastic filler or a paper filler.

[38] It is to be noted that the wires 153 of the power part described herein are not limited in any way. The wires 153 of the power part may have any suitable structures and arrangements corresponding to a specific type of electrical plug. For example, when the plug 100 is a type A plug which is an ungrounded plug with two flat parallel pins, the wires 153 of the power part of the cable 150 may include only two conductors for being electrically coupled to the two pins of the type A plug, respectively.

[39] As illustrated in Fig. 3, the data part 160 may include a shield 162, a second sheath 164, a first data cable 166a, a second data cable 166b, and a third data cable 166c (collectively data cables 166). The data cables 166a, 166b, and 166c may comprise conductors 167a, 167b, and 167c, respectively. The conductors 167a, 167b, and 167c may be surrounded by

corresponding insulation layers 168a, 168b, and 168c, respectively. The data cables 166 may be coupled to electrodes of the thermistors 120 so as to transmit temperature data from the thermistors 120 to a temperature controller. By way of example rather than limitation, the temperature controller may be installed in an electrical appliance (not shown). It is to be understood that the number of the data conductors described herein is not limited in any way. The number of the data conductors may vary corresponding to the number of temperature sensors embedded in the electrical plug 100.

[40] The data cables 166 may be enclosed within the second sheath 164. The shield 162 may be wrapped outside the second sheath 164. The shield 162 may be made of copper or other electrically conductive materials. The shield 162 may screen electrical noises from the wires 153 of the power part and prevent the electrical noises from interfering with a temperature data signal, thereby allowing the data part 160 to accurately transmit the temperature data. The shield 162 may be composed of braided strands of copper or other metal, a non-braided spiral winding of copper tape, or a layer of a conducting polymer.

[41] Fig. 4A and 4B illustrate an embodiment of the housing 130 for accommodating the thermistors 120. The housing 130 may be made of any insulating materials with a given level of flexibility, such as plastics. By way of example rather than limitation, the housing 130 may be manufactured by using a plastic injection molding process. The housing 130 includes a cover portion 132, a hinge portion 133, and a base portion 134. The cover portion 132 and the base portion 134 may rotate around the hinge portion 133 so as to close or open the housing 130. The cover portion 132 includes four side walls and a central recess. Likewise, the base portion 134 includes four side walls and a central recess. The central recesses of the cover portion 132 and the base portion 134 may be used to receive the thermistors 120 and the data cables 166.

[42] A first snap joint 136 and a second snap joint 138 may be formed on a side wall 135 of the cover portion 132 and a side wall 137 of the base portion 134. The first snap joint 136 includes a first protruding part 136a and a first receptacle 136b. The second snap joint 138 includes a second protruding part 138a and a second receptacle 138b. The first and second protruding parts 136a and 138a are positioned and configured to be fastened in the first and second receptacles 136b and 138b, respectively, thereby latching the cover portion 132 and the base portion 134 together when the housing 130 is closed. When the housing 130 is desired to be opened, a user may apply a force to the snap joints 136 and 138 which cause the protruding parts 136a and 138a to separate from the receptacles 136b and 138b, respectively.

[43] In the embodiment illustrated in Fig. 4A and 4B, the protruding parts 136a and 138a are arranged on the side wall 137 of the base portion 134 and their corresponding receptacles 136b and 138b are formed on the side wall 135 of the cover portion 132. In another embodiment, the protruding parts 136a and 138a may be formed on the cover portion 132, and the corresponding receptacle 136b and 138b may be arranged on the base portion 134.

[44] While the snap joints 136 and 138 are described herein, the illustrated embodiments are not limited in any way. It is to be understood that the number of snap joints is not limited to two, and the numbers may vary, such as one or three. Also, it is to be understood that the snap joints are merely illustrative and that any other suitable fixing structure may be used for joining the cover portion 132 and the base portion 134 together in accordance with the present disclosure.

[45] As illustrated in Fig. 4A, the cover portion 132 includes three channels 140a, 140b, and 140c which may be formed on a back side wall 141 of the cover portion 132. The base portion 134 includes three channels 142a, 142b and 142c which may be formed on a back side wall 143 of the base portion 134. The channels 140a, 140b, and 140c of the cover portion 132 and the channels 142a, 142b and 142c of the base portion 134 may be symmetrically arranged on the back side walls 141 and 143 such that three approximately round channels can be formed so as to receive the data cables 166 when the housing 130 is closed.

[46] Two partition walls 144a and 144b (collectively 144) may be formed in a central recess of the base portion 134 between the channels 142a and 142b and between the channels 142b and 142c, and extend upward, being perpendicular to the inner bottom surface of the central recess of the base portion 134. The height of the partition walls 144 may be equal to or less than a total of the depth of the central recesses of the cover portion 132 and the base portion 134 so that the cover portion 132 and the base portion 134 can fit together to completely close the housing 130. The back ends of the partition walls 144 may be perpendicularly attached to the inner surface of the back side wall 143. The partition walls 144 may be positioned and configured to approximately evenly divide the back region of the central recess of the base portion 134 into three subregions so as to receive the three data cables 166a, 166b, and 166c, respectively.

[47] A first cantilever 146 and a second cantilever 148 may be symmetrically formed on the outside surface of the front end of the housing 130 around vertical and horizontal centerlines of the outside surface of the front end of the housing 130. Two halves 146a and 146b

of the first cantilevers 146 may extend outward and be perpendicular to the outside surface of the front side wall 145 of the cover portion 132 and the outside surface of the front side wall 147 of the base portion 134, respectively. Likewise, two halves 148a and 148b of the second cantilevers 148 may extend outward and be perpendicular to the outside surface of the front side wall 145 of the cover portion 132 and the outside surface of the front side wall 147 of the base portion 134, respectively.

[48] The first cantilever 146 may include a first arm 118a and a first hook 118b which may be formed at the distal end of the first arm 118a. Likewise, the second cantilever 148 may include a second arm 116a and a second hook 116b which is formed at the distal end of the second arm 116a. The pair of cantilevers 146 and 148 may be configured to fit into a third receptacle 112 (as shown in Fig. 5A and 5B) formed in the pin bridge 110, thereby removably attaching the housing 130 to the pin bridge 110. When the housing 130 is desired to be detached from the pin bridge 110, a user may apply an inwardly directed force to the hooks 116b and 118b which can cause the cantilevers 148 and 146 to disengage from the third receptacle 112.

[49] Although Fig. 4A and 4B depict the exemplary embodiment of the housing for accommodating temperature sensors embedded in the electrical plug 100, those of ordinary skill in the art will understand that in other embodiments the depicted examples may be modified. For example, it is to be understood that the use of the cantilevers 146 and 148 for connecting the housing 130 to the pin bridge 110 is merely illustrative and that any other suitable arrangements may be used to attach the housing 130 to the pin bridge 110, such as use of an adhesive, which may have the additional benefit of omitting the cantilevers 146 and 148 and the third receptacle 112. It is also to be understood that the housing is not limited to two thermistors, and that the housing may be modified to accommodate one, three, four, or more thermistors.

[50] As shown more particularly in Fig. 5A and 5B, the third receptacle 112 may be configured to allow the housing 130 to be positioned among the three pins 102, 104, and 106 when the housing 130 is attached to the pin bridge 110. Preferably, the third receptacle 112 may be disposed approximately at the center of the pin bridge 110. In another embodiment in which the plug 100 is a type A plug that has only two pins, the third receptacle 112 may be configured to allow the housing 130 to be slightly below or above the two pins in a vertical direction and approximately centrally between the two pins in a horizontal direction. As illustrated more particularly in Fig. 5A, the third receptacle 112 may be a stepped slit and include a narrow portion 113 and a broad portion 114. The narrow portion 113 may be configured to receive the

first and second arms 118a and 116a. The broad portion 114 may be configured to receive the first and second hooks 118b and 116b. A width of the broad portion 114 may be greater than a width of the narrow portion 113. As the third receptacle 112 will be covered with the coating mold 180, any remaining opening, where the pin bridge 110 passes through, at the third receptacle 112 will be sealed by the material of the coating mold 180.

[51] Fig. 6A and 6D illustrate a process of assembling the electrical plug 100 according to an exemplary embodiment of the present disclosure. The assembling process may include a first step 210 of connecting electrodes of the thermistors 120 to corresponding data cables of the data part 160 by using the fastening members 126, and connecting the pins 102, 104, and 106 to corresponding conductors of the power part 153. The assembling process may include a second step 220 of installing the thermistors 120 into the housing 130, and removably attaching the housing 130 to the pin bridge 110 by fitting the pair of cantilevers 146 and 148 into the third receptacle 112. The assembling process may include a third step 230 of forming an inner mold 170 over a portion of pins 102, 104, and 106 connected to the cable 150; the portion includes the housing 130 that accommodates the thermistors 120 connected to the data part 160 of the cable 150 and mate with the pin bridge 110. The assembling process may further include a fourth step 240 of forming a coating mold 180 over the inner mold 170, the pin bridge 110 and part of the cable 150. Those of ordinary skill in the art will understand that any suitable means may be used to form the inner mold 170 over the connecting portion and forming the coating mold 180 over the inner mold 170.

[52] Fig. 7 illustrates a second exemplary embodiment of a housing 130A for accommodating thermistors. Preferably, the housing 130A may be made of ceramics. The ceramics may be highly thermally conductive ceramics, such as aluminum nitride, silicon carbon, and aluminum oxide. Other thermally conductive ceramics include beryllium oxide and boron nitride, among others. In an embodiment, the highly thermally conductive ceramic housing 130A is positioned near pins 102 and 104 to assist in heat sensing by the thermistors. For example, a closely positioned thermistor, as discussed herein, may sense heat and send a data signal to a control system external to the electrical plug, such that power consumed from an electrical appliance will be cut off when the sensed temperature reaches a pre-set temperature.

[53] Alternatively, the housing 130A may be made of any other suitable electrically insulating materials with high thermal conductivity. The housing 130A may have an elongated shape, such as an oblong oval and an oblong rectangle. The housing 130A has a certain thickness

140A (shown in Fig. 8), a certain length 142A, and a certain width 144A so as to provide receptacles for receiving the pins 102 and 104 and one or more thermistors 120 and so as to be capable of being embedded in the electrical plug 100.

[54] As shown in Fig. 7, the housing 130A includes a pair of pin receptacles 132A and 134A and a pair of thermistor receptacles 136A and 138A. The pair of pin receptacles 132A and 134A and the pair of thermistor receptacles 136A and 138A may be arranged in a line. The pair of pin receptacles 132A and 134A may be positioned and configured to receive back ends of the live pin 102 and the neutral pin 104, respectively. The pair of pin receptacles 132A and 134A may be disposed adjacent to two ends of the housing 130A. The pair of pin receptacles 132A and 134A may have the shape of a cylinder or any other suitable shape so as to receive the back ends of the live pin 102 and the neutral pin 104.

[55] The pair of thermistor receptacles 136A and 138A may be positioned and configured to receive two thermistors 120, respectively. The pair of thermistor receptacles 136A and 138A may be positioned at the central portion of the housing 130A and between the pair of pin receptacles 132A and 134A. The pair of thermistor receptacles 136A and 138A may have the shape of a cube or any other suitable shape so as to receive the thermistors 120. Although Fig. 7 depicts an exemplary embodiment, those of ordinary skill in the art will understand that various embodiments may modify the depicted example. For example, the number of thermistor receptacles is not limited to two, and it may be any other number, such as one or three.

[56] Fig. 8 illustrates an assembling relationship of the housing 130A, the live pin 102, the neutral pin 104, the pin bridge 110, and the cable 150. The housing 130A may be attached to the back (inward facing) surface of the pin bridge 110 by fitting the live pin 102, the neutral pin 104, and the thermistors 120 into their corresponding receptacles 132A, 134A, 136A, and 138A. The electrodes 122 of the thermistors 120 may be connected to the corresponding data cables of the cable 150 by using the fastening members 126. The pins 102, 104, and 106 may be connected to the corresponding conductors of the cable 150.

[57] After fitting the thermistors 120 into their corresponding receptacles 136A and 138A and connecting the electrodes 122 of the thermistors 120 to the corresponding data cables of the cable 150, a user can use any suitable thermally conductive adhesive or other material to fill in the thermistor receptacles 136A and 138A so as to maintain a tight contact between the thermistors 120 and their corresponding receptacles 136A or 138A, thereby effectively reducing thermal resistivity and ensuring stable performances of the thermistors 120 during a predicted

life time. By way of example rather than limitation, the thermally conductive adhesive may be Dow Corning TC-2035 heat-resistance adhesive. It is to be understood that the use of thermally conductive adhesive is merely illustrative, and the any other suitable materials and means may be used to achieve a tight thermally conductive contact between the thermistors 120 and the corresponding receptacles 136A or 138A.

[58] After fitting the live pin 102 and the neutral pin 104 into the corresponding receptacles 132A and 134A and connecting the pins 102 to the corresponding conductors of the cable 150, a user can solder the contact area between the pins and their respective receptacles so as to ensure a tight connection between the housing 130A and the pins 102 and 104 and significantly reduce the thermal resistivity. It is to be understood that soldering the contact area between the pins and the receptacles is merely illustrative, and that any other suitable means may be used to ensure a tight connection between the housing 130A and the pins 102 and 104. The subsequent assembling steps of forming an inner mold 170 and a coating mold 180 may be the same as the ones described above with respect to the first exemplary embodiment of the housing 130.

[59] Fig. 9 illustrates an embodiment, in which two thermistors are positioned in a single holder or housing 130. The thermistors 120 are disposed in a receptacle between the receptacles for the live pin and neutral pin and are positioned within the holder 130. The holder 130 secures the position of each thermistor and may attach to the bridge 110 and each of the metal pins. In the illustrated embodiment, the thermistors each are placed at the same or different positions relative to their respective pins. The thermistors 120 may also be disposed in a particular configuration on the bridge 110 to, for example, individually determine the temperature of each pin.

[60] Data cables 166 are coupled to the electrodes of the thermistors 120 to transmit the temperature to a controller. In an embodiment, tubes 920 respectively surround the data cables 166 to provide insulation and protection. The tubes 920 may include heat-shrinkable tubes or any of a plurality of designs and compositions adaptable to particular plug configurations, uses, and embodiments. The cable 150, as discussed above, houses the data cables 166 and conductors, and electrically connects various components of the electrical plug. In an embodiment, the inner mold 170 encases the inner portion of the electrical plug, including the thermistors 120, the housing, terminal ends of the data cables and the cable, and the tubes 920.

The coating mold 180 surrounds the inner mold 170, in accordance with various embodiments, and seals any open joint between the inner mold 170 and the bridge 110.

[61] In Fig. 9 and 9A, a portion of the pins further comprise a plurality of grooves 910 to further assist in sealing the electrical plug. The combination of the pin grooves 910 and a holder 130 may form a tight, complementary seal against the passage of air, water, and/or other particles into the electrical plug. In an embodiment, the housing comprises a receptacle to receive the at least one pin, and may be molded around the pin, such that the seal is formed by filling the pin grooves 910. In an embodiment, molding may be carried out during the formation of the electrical plug. In one example, the housing may be positioned on the bridge and heated such that the holder material (e.g., plastics) melts into the pin grooves 910 to form a waterproof and/or airtight seal.

[62] In another embodiment, the pins comprise a plurality of grooves, and the grooves are positioned to mate with the bridge 110 and consequently form a tight seal between the external and internal sides of the plug. The bridge may be configured to receive the pins, and may be positioned such that when heated, the bridge material surrounding the pins melts into the pin grooves 910. During cooling, the various components form a secure connection between the bridge 110 and metal pins. Additional embodiments for securing the pins to the bridge 110 and forming a tight seal between the external and internal portions of the electrical plug are described below with respect to Fig. 13 and 14.

[63] It is to be understood that the connection between the pin grooves and plug components may include any of a variety of designs to form a secure attachment and tight seal. Molding and/or mating of the pin grooves with the housing and/or bridge are not limited to the examples discussed above. Particular physical, chemical, and structural properties of the housing, pin, bridge, and plug materials may be taken into account in the various designs, including but not limited to a material's thermal conductivity, electrical conductivity, magnetic properties, corrosivity, strength, and durability. The designs may further vary based on economic and/or manufacturing considerations regarding the materials of the plug components.

[64] The depicted pin grooves 910 may include three evenly-spaced, distinct grooves surrounding the circumference of each pin, however the pin grooves are not limited to the depicted embodiments. The pins grooves 910 may include any number of grooves, e.g., one, two, four or more, and any combination of groove shapes, sizes, and spacing to securely mate with the

housing and/or bridge and form a tight seal. In addition, each pin may have the same or different pin groove 910 design.

[65] Fig. 10 illustrates positioning a single thermistor between the live pin and neutral pin according to an embodiment of the present invention. The holder 130 holds the thermistor in its position between the pins. This arrangement provides the ability to concurrently sense pin temperature. In an example, the sensed temperature indicates an overall temperature of the electrical plug, and/or provides a general estimated temperature of one or both pins. Such an arrangement can be particularly useful in applications that do not require a temperature for individual pins. The use of a single thermistor may also reduce production costs, compared to embodiments having a plurality of thermistors.

[66] Similar to the embodiment of Fig. 9 and 9A, Fig. 10 and 10A illustrate at least one pin having a plurality of pin grooves 910. As discussed above, the pins grooves 910 assist in securing the pin to the holder 130 and/or bridge 110. The pins grooves 910 work with either the holder 130 may form a waterproof and airtight seal and the like to prevent moisture and other particles from entering the interior of the plug. Significantly reducing and/or eliminating water and other particulates in the plug may prolong the service life of the plug and its components, reduce any potential electrical interference, and provide more accurate thermistor data and temperature readings.

[67] Fig. 11 illustrates an embodiment comprising two thermistors 120 installed within a single holder 130, with each thermistor adjacent to a pin. The thermistors 120 do not need to be placed between the pins, as in the embodiment of Fig. 9, but may instead be placed at any position adjacent to the pin. This arrangement allows for a greater variety of temperature determinations. For example, a single thermistor may be placed adjacent to each of the live pin and the neutral pin, thus allowing each pin's temperature to be individually sensed. Thermistor data can also be utilized to determine an overall temperature of the plug and/or an estimated temperature of both pins. Thus, the present embodiment provides additional flexibilities and possibilities for temperature determinations and may be particular useful in electrical plug applications requiring both individual and collective temperature sensing.

[68] In addition, the single holder accommodating both thermistors may have unique advantages. The use of a single holder may reduce manufacturing costs compared to embodiments which require a plurality of separate holder units to hold each thermistor. In addition, the single holder unit can provide additional stability in maintaining thermistor

positioning. For example, a single holder reduces the number of individually attached components on the bridge 110, and accordingly reduces the number the components that may become unsecured. Moreover, the holder 130 may attach to each pin via mating with the plurality of pin grooves 910, as discussed above and illustrated in Fig. 11A, to provide greater stability. Even if a portion of the holder becomes unsecured due to, for example, a damaged attachment and/or a defective adhesive, the design of the pin grooves 910 will stabilize the holder through the attachment on one or both pins.

[69] In addition to the single holder unit 130, Fig. 11 further depicts, for example, spliced heat-shrinkable tubes 920, surrounding each of the thermistor data cables and each of the pin conduction elements, consistent with the embodiments discussed above. An inner mold 170 surrounds the internal components for additional insulation and protection, and a coating mold 180 surrounds the inner mold.

[70] Fig. 12 and 12A depict another embodiment of the present invention, having two thermistors disposed in completely separate holder units 130a and 130b, and each holder unit connected to a pin via one or more pin grooves 910 on each pin. Similar to the embodiment of Fig. 11, multiple thermistors provide greater flexibility in temperature determinations. The temperature of one or both pins may be determined, and thermistor data for each pin may be taken together or separately.

[71] The individual holder unit for each thermistor also increases flexibility with respect to the thermistor positioning. Since each thermistor is in a separate holder, its position relative to the pin may be at any desired position on the bridge 110. That is, the thermistor positions are not limited to a particular configuration. For example, each thermistor may be placed at a position between the live pin and neutral pin of the electrical plug. In another example, only one thermistor is placed between the pins. Alternatively, each thermistor may be placed at a position adjacent to each pin and not between the pins. Such flexibility may be desired for electrical plug applications requiring individual pin temperature determinations and/or temperature sensing at a particular position on the bridge 110.

[72] Each holder 130 may attach to a pin via pin grooves 910 to stabilize positioning and to seal against moisture and particles from the outside of the electrical plug. The pin grooves 910 may also be formed to secure the electrical plug with the bridge 110, and further prevent any potential moisture and particles from entering. In additional embodiments, a surface, adjacent to the bridge, of each holder may have an adhesive to improve holder attachment and stability.

[73] Fig. 13, 13A, 13B, 13C, 14, 14A and 14B depict various methods and embodiments for forming complementary seals between the pins and the bridge. As discussed above, the seals may assist in securing the pins to the bridge and preventing the passage of air, water, and/or other particles between the external and internal portions of the electrical plug.

[74] In one embodiment 1310, illustrated in Fig. 13A, an adhesive tape may be used to secure a pin to the bridge. The adhesive tape may be positioned around the circumference of the pin, similar to the pin groove embodiments, and assist in both sealing the external and internal bridge portions from air, moisture and particles, and securing the pin to the bridge. In another embodiment 1320, illustrated in Fig. 13B, a sealing ring, such as an O-ring, may be placed around a pin such that a seal is formed when the pin is positioned within the bridge. The depicted and described embodiments may be used individually and/or in combination with other sealing options, such as pin grooves or an adhesive tape. For example, in a further embodiment 1330, illustrated in Fig. 13C, the pin grooves may be used with or without the adhesive and/or sealing ring features. In a further embodiment, an embedded injection material may be used to mate with and seal the pins grooves and bridge, such as LSR (liquid silicon rubber), or TPE.

[75] Fig. 14 depicts additional embodiments for sealing the electrical plug, with respect to pins and other elements, such as cables, from air, moisture and particles. As previously described and depicted, one or more cables, e.g., data cables and pin conductors, may be coupled to the pins, electrodes, and other elements within the electrical plug. The tubes may surround the cables to provide insulation and protection, and may include a variety of designs and compositions, depending on the purpose of the cables. In the embodiments of Fig. 14, various embodiments for sealing the internal elements of the electrical plug are depicted. Similar to the sealing options discussed above with respect to Fig. 13, the present embodiments may be configured to prevent the passage of moisture, air, dust, and other particles.

[76] In a first embodiment 1410, illustrated in Fig. 14A, an adhesive may be applied to cable tubes to form an attachment and seal between the cable tubes and wire insulators. An epoxy molding may be alternatively used. The adhesive and sealing mechanism may be similar to the sealing method discussed above between the pin and the bridge 1310. In another embodiment 1420, illustrated in Fig. 14B, a wire conductor and an insulator may be crimped together to form a seal. An adhesive may then be applied to the crimped portion between the conductor and the insulator to form a stronger seal. Similarly, an adhesive may be applied to the root of the pin at the junction with the bridge for achieving additional stability and security. In

yet another embodiment 1430, illustrated in Fig. 14C, tin may be soldered onto a wire conductor after a wire insulator and a cable tube are crimped together. In a further embodiment, a small portion (i.e., a window) may be cut from an insulator around a wire core of a wire conductor and an adhesive or epoxy or molding may be applied around the wire conductor so as to wrap the wire conductor and a cable jack and flow into the window and any gap between the insulation core and the jacket to form a seal between the cable tube and the wire insulator.

[77] It is to be understood that the sealing methods discussed in Fig. 13 and 14 are not limited to the depicted embodiments, and any such sealing methods may be applied to form a seal and/or attachment among various elements of the plug, e.g., pins, a bridge, cables, cable tubes, wire insulators, a housing, and thermistors. While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the disclosure of the invention. For example, depending on various plug types, the number of temperature sensors, such as thermistors, embedded in the electrical plug, the configurations of the housing accommodating the temperature sensors, and the process for assembling the electrical plug may have variations without departing from the spirit of the present disclosure. Indeed, the present disclosure described herein may be embodied in a variety of other forms; furthermore, various omissions, substitutions, and changes in the form of the embodiments described herein may be made without departing from the spirit of the disclosure of the invention. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope and spirit of the disclosure of the invention.

CLAIMS

1. A sealed electrical plug, comprising:
 - two or more pins comprising a live pin including a first plurality of grooves formed around the live pin and a neutral pin including a second plurality of grooves formed around the neutral pin;
 - a bridge through which the two or more pins extend;
 - a first temperature sensor for monitoring a temperature of the live pin, wherein the first temperature sensor is positioned on the bridge adjacent to the live pin, and a second temperature sensor for monitoring a temperature of the neutral pin, wherein the second temperature sensor is positioned on the bridge adjacent to the neutral pin;
 - a first housing for holding the first temperature sensor in a first position on an inward facing surface of the bridge and configured to receive the live pin;
 - a second housing for holding the second temperature sensor in a second position on the inward facing surface of the bridge and configured to receive the neutral pin;
 - a first groove seal formed between the first plurality of grooves and the bridge, and/or between the first plurality of grooves and the first housing,
 - wherein, for the first groove seal formed between the first plurality of grooves and the bridge, the first groove seal is formed by molding materials of the bridge to fill the first plurality of grooves;
 - wherein, for the first groove seal formed between the first plurality of grooves and the first housing, the first groove seal is formed by molding materials of the first housing to fill the first plurality of grooves; and
 - wherein the first groove seal seals a passage between the live pin and the bridge to at least one of air and water;
 - a second groove seal of the neutral pin formed between the second plurality of grooves and the bridge, and/or between the second plurality of grooves and the second housing,
 - wherein, for the second groove seal formed between the second plurality of grooves and the bridge, the second groove seal is formed by molding materials of the bridge to fill the second plurality of grooves;
 - wherein, for the second groove seal formed between the second plurality of grooves and the second housing, the second groove seal is formed by molding materials of the the second housing to fill the second plurality of grooves; and

wherein the second groove seal seals a passage between the neutral pin and the bridge to at least one of air and water;

a cable including:

a first conductor and first insulation crimped together to form a first crimped seal at a first crimped portion where the first conductor is connected with the live pin;

a second conductor and second insulation crimped together to form a second crimped seal at a second crimped portion where the second conductor is connected with the neutral pin;

a first data cable for conveying data from the first temperature sensor; and

a second data cable for conveying data from the second temperature sensor;

a first adhesive seal between the first conductor and the first insulation formed by adhesive at the first crimped portion;

a second adhesive seal between the second conductor and the second insulation formed by adhesive at the second crimped portion;

an inner-mold covering the first and second temperature sensors, the inward facing surface of the bridge and the first and second adhesive seals, and the first and second housing; and

an outer-mold covering the inner-mold.

2. The sealed electrical plug of claim 1, wherein the first housing comprises a first pin receptacle for receiving an end of the live pin and a first temperature sensor receptacle for receiving the first temperature sensor, and the second housing comprises a second pin receptacle for receiving an end of the neutral pin and a second temperature sensor receptacle for receiving the second temperature sensor.

3. The sealed electrical plug of claim 2, further comprising a thermally conductive adhesive filled into a gap between the first temperature sensor receptacle and the first temperature sensor, and a gap between the second temperature sensor receptacle and the second temperature sensor.

4. The sealed electrical plug of claim 1, further comprising a third seal formed between the cable and the inner-mold.

5. The sealed electrical plug of claim 1, wherein the first temperature sensor and the second temperature sensor are a thermistor or an integrated circuit chip.

6. The sealed electrical plug of claim 1, wherein the first and second housing are formed of a thermally conductive material.
7. The sealed electrical plug of claim 6, wherein the thermally conductive material is a thermally conductive ceramic.
8. The sealed electrical plug of claim 1, wherein first tubing surrounds the first data cable and second tubing surrounds the second data cable for insulation and protection.
9. The sealed electrical plug of claim 1, wherein the first housing is separate from the second housing.
10. A method of assembling a sealed electrical plug having two or more pins, comprising:
 - positioning a first temperature sensor on an inward facing surface of a bridge adjacent to a live pin among the two or more pins and placing a second temperature sensor on the inward facing surface of the bridge adjacent a neutral pin among the two or more pins, the live pin extending through the bridge and including a first plurality of grooves formed around the live pin, the neutral pin extending through the bridge and including a second plurality of grooves formed around the neutral pin, the first temperature sensor configured to monitor a temperature of the live pin and the second temperature sensor configured to monitor a temperature of the neutral pin;
 - holding the first temperature sensor in a first position on the bridge using a first housing configured to receive the live pin and holding the second temperature sensor in a second position on the bridge using a second housing configured to receive the neutral pin;
 - forming a first groove seal between the first plurality of grooves and the bridge, and/or between the first plurality of grooves and the first housing,
 - wherein, for the first groove seal formed between the first plurality of grooves and the bridge, the first groove seal is formed by molding the material of the bridge to fill the first plurality of grooves; and
 - wherein, for the first groove seal formed between the first plurality of grooves and the first housing, the first groove seal is formed by molding the material of the first housing to fill the first plurality of grooves;

forming a second groove seal between the second plurality of grooves and the bridge,
and/or between the second plurality of grooves and the second housing,

wherein, for the second groove seal formed between the second plurality of grooves
and the bridge, the second groove seal is formed by molding the material of the bridge to
fill the second plurality of grooves; and

wherein, for the second groove seal formed between the second plurality of grooves
and the second housing, the second groove seal is formed by molding the material of the
second housing to fill the second plurality of grooves;

connecting the live pin to a first conductor;

connecting the neutral pin to a second conductor;

forming a first crimped seal between the first conductor and the first insulation by crimping
the first conductor and the first insulation together at a first crimped portion;

forming a first adhesive seal between the first conductor and the first insulation by
applying adhesive at the first crimped portion;

forming a second crimped seal between the second conductor and a second insulation by
crimping the second conductor and the second insulation together at a second crimped portion;

forming a second adhesive seal between the second conductor and the second insulation by
applying adhesive at the second crimped portion;

connecting the first temperature sensor to a first data cable and connecting the second
temperature sensor to a second data cable;

forming an inner-mold covering the first and second temperature sensors, the inward facing
surface of the bridge and the first and second adhesive seals, and the first and second housing;
and

an outer-mold covering the inner-mold.

11. The method of claim 10, wherein the first temperature sensor and the second temperature
sensor are a thermistor or an integrated circuit chip.

12. The method of claim 10, wherein the first and second housing are formed of a thermally
conductive material.

13. The method of claim 12, wherein the thermally conductive material is a thermally
conductive ceramic.

14. The method of claim 10, wherein first tubing surrounds the first data cable and second tubing surrounds the second data cable for insulation and protection.
15. The method of claim 10, wherein the first housing is separate from the second housing.