



- (51) International Patent Classification:  
*H01R 11/09* (2006.01)
- (21) International Application Number:  
PCT/US2015/058065
- (22) International Filing Date:  
29 October 2015 (29.10.2015)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:  
62/157,578 6 May 2015 (06.05.2015) US
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- (81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.
- (84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

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(54) Title: POWER DISTRIBUTION MODULE

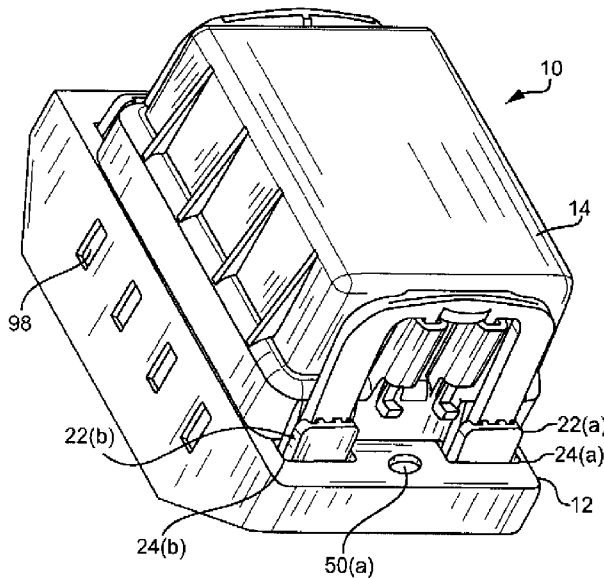


FIG. 1

(57) Abstract: A compact power distribution module includes a cover and a base. The cover includes a shielded hydrophobic breather to reduce breather hole clogging. The cover further includes a second locking mechanism that prevents a first locking mechanism from disengaging; thereby double locking the cover to the base. The base includes a mounting nut between snap-fit receptacles. Because the power distribution module is compact, the cover may be removed from the base using only one hand to unlock the first and second locking mechanisms.

WO 2016/178708 A1

**Declarations under Rule 4.17:**

- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
- *of inventorship (Rule 4.17(iv))*

**Published:**

- *with international search report (Art. 21(3))*
- *with amended claims and statement (Art. 19(1))*

**POWER DISTRIBUTION MODULE****CROSS-REFERENCE TO RELATED APPLICATION**

**[0001]** The present application claims priority to U.S. Provisional Patent Application No. 62/157,578, filed on May 6, 2015, entitled Power Distribution Module, the entirety of which is hereby incorporated herein by reference.

**FIELD OF THE INVENTION**

**[0002]** The present disclosure relates generally to power distribution modules and, more particularly, to power distribution modules for transportation applications.

**BACKGROUND**

**[0003]** Power distribution modules (PDMs) house terminal electrical components such as fuses, relays, circuit breakers, diodes, and other components. PDMs are configured for plug-in connection to circuitry to avoid labor intensive hard-wired connections and generally consist of a base and an enclosure. PDMs accommodate the terminal electrical components in a single package, and thus may provide both overcurrent protection and convenient switching of power in a single package, as examples.

**[0004]** In general, PDMs include a base and an enclosure. In use, wire leads with terminals and single wire seals are inserted into receptacles located on one side of the base. Electrical components are mated to the terminals in receptacles located at the opposite side of the base. The enclosure, which may be a cover, houses the electrical components. Some PDMs are provided with a breather hole located on one of the PDM's surfaces. The breather hole helps relieve pressure within the enclosure by dissipating the heat generated by the functioning internal electrical hardware. However, specialty vehicles, construction and agricultural equipment, and marine, truck, bus, and RV applications, as examples, often entail high degrees of moisture, vibration, and contaminant issues in use. The contaminants, which likely include

dust and debris, settle on the PDM's surfaces and, consequently, clog the breather. PDMs having clogged breathers may have a shorter life span due to component wear that results from heat accumulation and lack of heat dissipation outside the PDM enclosure. Moreover, if the breather hole is clogged pressure internal to the PDM will not be relieved. As pressure increases within the PDM its sealing system may be compromised. A compromised sealing system will likely only get worse over time as moisture and dust pass through the breach, and impair the PDM's components.

**[0005]** A PDM's sealing system usually includes a gasket that is laterally compressed between vertical surfaces of the base and enclosure/cover. The gasket is provided to prevent containments, including water and other liquids, from entering the PDM enclosed chamber. With increases in the amount of heat that accumulates within a PDM, internal pressure increases. As the internal pressure increases, the integrity of the seal between the base and cover becomes jeopardized, which oftentimes results in moisture and/or other contaminants entering the PDM, corroding its components and causing other damage.

**[0006]** Because the electrical components within a PDM generate a lot of heat, PDMs are constructed of high temperature resilient materials that can withstand heat stress. Because PDMs are constructed of high temperature resilient materials they are not very resistant to damage resulting from, as an example, the force of impact when accidentally dropped. Thus, due to the need to use high temperature resilient materials, PDMs are relatively fragile.

**[0007]** For vehicle mounting, PDMs are fitted with snap-type connectors for connection to support structures. The snap-type connectors have proven to be satisfactory strong enough for vehicle mounting.

**[0008]** Thus, PDMs of the related art have design requirements and limitations that are consequential to the functionality that PDMs provide as well as the environment in which they operate. The design requirements and limitations have resulted in PDMs having inherent shortcomings, such as fragility and potential water/dust breach. PDMs of the related art are thus poorly suited for certain applications. Additionally, related art PDMs tend to be large and therefore difficult to work with.

## BRIEF SUMMARY

**[0009]** The present disclosure relates to a compact power distribution module having a base and a cover attachable to the base. The cover and the base are attachable by way of a first locking mechanism integral to the cover and the base. The cover further includes a second locking mechanism that, when engaged, prevents the first locking mechanism from disengaging.

**[0010]** The cover includes a strategically located breather hole covered with a hydrophobic material. As fully disclosed below, the strategic location provides an inherent shield that significantly reduces the amount of contaminants (e.g., water, dust, debris) that can come in contact with the breather hole and hydrophobic material. The inherent shield significantly reduces breather hole clogging. Advantageously, additional tooling and materials are not needed to procure the breather hole shield because the shield is inherently present in the structure of the preferred embodiment of the cover.

**[0011]** The base includes snap-fit receptacles for receiving the cover's snap-fits. The base also includes a mounting nut situated between the snap-fit receptacles. The overall footprint of the PDM is condensed because the mounting nut is located between, and not significantly offset from, the snap-fit receptacles. Because the power distribution module is compact, the cover may be removed from the base using only one hand to unlock the first and second locking mechanisms and lift the cover off the base. Many vehicles have compartments that house electrical and/or mechanical components. In many cases, these compartments are relatively small and therefore the components within them are "crammed" together. Many a mechanic can attest that it can be painfully difficult to access and work with components that are cramped together within a confined compartment. It is less difficult to access the PDM of the present disclosure within a confined compartment because the PDM has a compact footprint. It is also easier to access the PDM's internal components because the cover can be removed with only one hand. Even in cases in which the PDM is mounted outside of a compartment, the convenience of requiring only one hand to remove the cover cannot be overlooked or underappreciated.

**[0012]** Disclosed herein is a power distribution module that includes a base and a cover. The cover has a guide channel and a breather hole, which is shielded by the guide channel. The cover may include a chamber and a hydrophobic material adhered to a surface within the chamber. In an embodiment, a guide within the guide channel also shields the breather hole. The power distribution module may include a locking clip that includes the guide. However, it is to be understood that the locking clip is not a required component of the PDM. In such a case the guide channel alone shields the breather hole.

**[0013]** In another version, a power distribution module includes a base and a cover. A compression seal is axially compressed between a raised edge surrounding component receptacles of the base and a surface within a groove that surrounds the interior of the cover. By securing the cover to the base, the compressed seal seals off the interior of the PDM (which may now be referred to as a chamber). Compared to PDMs having laterally compressed seals, a PDM having an axially compressed seal has a smaller footprint.

**[0014]** In an embodiment, the surface within the seal groove is orthogonal to both an inner lip and an outer lip of the cover. The inner and outer lips surround the component receptacles of the base when the cover is secured thereto. The cover may include a plurality of snap-fits and the base may include a plurality of snap-fit receptacles. The snap-fits and snap-fit receptacles engage to secure the cover onto the base to maintain compression of the compression seal. The compression seal is preferably a silicone seal.

**[0015]** In yet another version, a power distribution module includes a cover and a base. The base has no more than two mounting structures, one on each side thereof. Further, the mounting structures each have no more than one mounting nut. On each side, at least a portion of the mounting nut is seated between two snap-fit receptacles. The pairs of snap-fit receptacles are formed within their respective mounting structures (as apertures) on each side of the base and directly abut a rectangular cube that houses an array of cavities within the base. Preferably, on each side of the base there is no intervening structure between the rectangular cube and the snap-fit receptacle apertures. The cover may include at least one snap-fit directly abutting a cover casing, wherein the cover casing defines a cover chamber. The at least one snap-fit is preferably U-shaped and slightly flexible and includes a catch that, when

the snap-fit is inserted into the snap-fit receptacle, engages an underside of the snap-fit receptacle to secure the cover onto the base. In a version, the base material comprises glass reinforced semi-crystalline polybutylene terephthalate and the cover material comprises a blend of polyphenylene ether, polystyrene, and polyamide.

**[0016]** According to another aspect of the disclosure, a power distribution module cover comprises at least one snap-fit and a guide channel. The snap-fit directly abuts a cover casing and is preferably U-shaped, wherein an inverted leg of the "U" directly abuts the cover casing with no intervening structure. The guide channel supports a locking clip, wherein the locking clip is slide-able within the guide channel. The locking clip includes at least one guide that is slide-able within the guide channel. The locking clip is preferably formed as an arch with extended ends and has guides (at least one guide) that protrude in a downward direction from an upper portion (proximate the crown) of the arch. The locking clip includes at least one hitch at the distal end (relative to the upper portion of the arch) of the guide. The hitch(es) prevents the guide(s) from slipping out of the guide channel(s). The guide may include a slanted hitch between the crown of the arch and the at least one hitch. The slanted hitch engages a terminal end of the guide channel to secure the locking clip in a first position, whereby the first position corresponds to the locking clip preventing the snap-fit catch from disengaging the underside of the snap-fit receptacle.

**[0017]** In use, the locking clip includes a wedge that maintains a release tab of a power distribution base in a first position and prevents the release tab from disengaging from the base.

**[0018]** Also disclosed is a power distribution module having a first locking mechanism that locks a power distribution module cover to a power distribution module base, and a second locking mechanism that prevents the first locking mechanism from unlocking. The power distribution module includes a first array of cavities that receives wire leads with terminals and a second array of cavities that receives at least one electrical component selected from a group of electrical components consisting of a fuse, a relay, a circuit breaker, and a diode.

## DESCRIPTION OF THE DRAWINGS

**[0019]** The present invention may be better understood, and its numerous objects, features, and advantages made apparent to those skilled in the art by referencing the accompanying drawings.

**[0020]** FIG. 1 is a perspective view of an embodiment of a power distribution module according to the present invention;

**[0021]** FIG. 2 is a perspective view of the top of the base of the power distribution module of FIG. 1;

**[0022]** FIG. 3 is a perspective view of the cover of the power distribution module of FIG. 1;

**[0023]** FIG. 4 is a bottom view of the cover of FIG. 3;

**[0024]** FIG. 5 is a side view of the base of FIG. 2;

**[0025]** FIG. 6 is a perspective view of the underside of the base of the power distribution module of FIG. 1;

**[0026]** FIG. 7 is a top view of the cover of FIG. 3;

**[0027]** FIG. 8 is a view taken along section line B-B of FIG. 7;

**[0028]** FIG. 9 is a perspective view of the locking clip shown in FIG. 1;

**[0029]** FIG. 10 is a view taken along section line A-A of FIG. 7; and

**[0030]** FIG. 11 is a perspective view of a terminal lock for securing wire terminals to receptacles of a power distribution module.

## DETAILED DESCRIPTION

**[0031]** The power distribution module (PDM) of the present disclosure houses plug-in terminal electrical components such as one or more of: fuse(s), mini fuse(s), relays circuit breaker(s), diode(s), and/or other components in a sealed chamber. In an embodiment, a PDM of the present disclosure may be utilized in any of a number of vehicle types and applications, including, as examples, construction, agriculture, and heavy duty transportation applications where ruggedness is required. The present application discloses new and improved structural features for PDMs. The new and improved structural features disclosed herein improve at least one or more of PDM performance, durability, workability, and longevity that has/have not

heretofore existed in the art of PDMs. The PDM of the present disclosure also features ease of access and use through a compact PDM footprint (i.e., outermost dimensions) that facilitates user access to the PDM when secured to a vehicle, as well as user access to internal PDM components. Because the footprint is relatively compact, the PDM body is more readily accessible within a crowded vehicle compartment (because the compact PDM body utilizes less free space). Also, due to the relatively compact footprint a user may readily remove a PDM cover with only one hand to access its internal components, in contrast to PDMs of the related art which are relatively larger and require two hands for removing the cover.

**[0032]** Referring to Figs. 1, 2, and 3, a power distribution module 10 of the present disclosure includes a base 12 and a cover 14. Wire leads with terminals and single wire seals are inserted in what may be referred to as the base underside 16. Unused cavities of the base underside 16 are plugged to prevent ingress of contaminants such as moisture and dust/debris. Electrical components are mated to the terminals at what may be referred to as the base topside 18. The cover 14 includes an integrated compression seal 20 (best seen in Fig. 4) that prevents ingress of dust, debris, and moisture into the PDM interior. In an embodiment, the cover is secured to the base with snap-fits 22a-22d (best seen in Figs. 3 and 4) that mate with respective snap-fit receptacles 24(a)-24(d) (best seen in Fig. 2.) As an additional feature, a second locking mechanism, discussed below, may be provided. The second locking mechanism ensures that the snap-fits 22a-22d remain locked within the snap-fit receptacles 24(a)-24(d).

**[0033]** In an embodiment, the cover 14 may include a hydrophobic vent. As discussed in more detail below, unlike PDMs of the related art, the PDM of the present disclosure includes an integrated shield that obstructs movement of external dust and debris toward the hydrophobic vent. However, the shield allows the flow of air in/out of the sealed PDM chamber. This air flow relieves pressure differentials that are caused by internal electrical component heating. It is noted that, as an example, the vent may not be needed in transportation applications with low heat generation and minimal water exposure. For more demanding applications, the vent relieves internal pressure to prevent gasket blow-by and, due to its hydrophobic properties, prevents the intrusion of water into the sealed chamber.

**[0034]** The PDM 10 of the present disclosure may be wired before or after it is mounted to a vehicle. The PDM 10 includes two mounting structures integrated with the base and preferably located at opposing base sides. Each mounting structure includes its respective mounting nut, discussed below, integrated within the mounting structures at each side of the base. In a version, the PDM 10 includes no more than one mounting structure, including no more than one mounting nut on each respective opposing side of the PDM 10 (i.e., the PDM 10 has no more than a total of two mounting structures for mounting the PDM 10 to a vehicle, and each mounting structure includes no more than one mounting nut).

**[0035]** Referring to Figs. 1, 2, and 5, in a version the base 12, from front and rear views (Fig. 5 is a front view, the rear view is identical), is fairly isosceles trapezoidal shaped, with the base underside 16 and base topside 18 generally planar and parallel to one another. The base sides are substantially the same length, both having angled portions 26(a), 26(b) and parallel side portions 28(a), 28(b). As explained in detail below, the parallel side portions 28(a), 28(b) partially delineate and form elements of mounting structures 30(a) and 30(b), as best seen in Fig. 2.

**[0036]** Referring to Fig. 6, the base underside 16 includes an array of receptacles 32 that, as shown, are configured to receive wire leads with terminals, single wire seals, and/or plugs (not shown). The base topside 18 includes an array of receptacles 34. The base topside receptacles receive plug-in terminal electrical components such as one or more of: fuse(s), mini fuse(s), relays circuit breaker(s), diode(s), and/or other components. Via the arrays of receptacles 32, 34, electrical connections are established between user selected leads and wire terminals inserted at user selected receptacles at the base underside 16 and user selected components inserted into user selected receptacles at the base topside 18.

**[0037]** It is to be understood that the terms “base underside 16” and “base topside 18” are being used herein to aid the reader in understanding the invention when referencing the base 12 and other components as presented in the drawings. However, the base 12, the cover 14, and the PDM 10 of the present disclosure are not limited to any particular orientation. Rather, the terms “underside” and “topside” are intended to be interpreted as describing that those respective sides are opposed sides of the base 12. The base 12 may be mounted within or on a

vehicle (typically, within an engine compartment) in any user preferred orientation, which may in fact be dictated by the available space for mounting the PDM 10. Accordingly, the “underside” may also be referred to as the terminal side and the “topside” may also be referred to as the component side or covered chamber side. In other words, “underside” and “topside” pertain to the orientations of the base as presented in the set of drawings and are in no way to be interpreted as orientation or structural limitations. The PDM 10 may be mounted in any orientation.

**[0038]** Several features disclosed in the present application are significantly advantageous departures from customary designs of PDMs that exist in the related art. As an example, PDMs of the related art that include a gasket intended to prevent moisture and debris from entering the chamber inside of the PDM body position the gasket between abutting, vertical side surfaces of a cover and a base, respectively, such that the gasket is compressed between said vertical side surfaces. Such placement has, in general, proven to be adequate for preventing substantial amounts of moisture and/or debris from entering the PDM and, as such, there exists no motivation to modify the placement of the seal for the purpose of protecting the PDM from debris, moisture, and other contaminants. As another example, PDMs of the related art include snap-type connectors to mount the PDM to a support structure. PDMs of the related art include four connectors: two located at the outer edges of one side of the PDM, and the other two located at the outer edges of the opposite side of the PDM. The four snap-type connectors have proven to provide a satisfactorily rigid mount to the support structure.

**[0039]** The minimum number of receptacles required on either side of a PDM is determined by its intended application (e.g., truck, bus, marine or RV application, etc.). For the most part, the size of a PDM is directly related to the number of its receptacles. For example, an eighty-four way PDM is larger than a forty-eight way PDM. The size of a PDM is a considerable factor when determining where the PDM is to be mounted. Due to the number and size of other mechanical and electrical components that are installed in a vehicle (e.g., within its engine compartment and component box) space is limited. The available space must be large enough to accommodate the PDM and allow user access thereto.

**[0040]** PDM covers must be removed to access the electrical components within the sealed chamber to, as an example, replace a blown fuse. Thus, vacant space proximate a mounted PDM must be sufficient to allow a user to access the PDM cover and unsecure and remove it; a process that, in the related art, requires two hands. Consequently, space restrictions often dictate where a PDM can be mounted. Thus, it is more difficult to find a mounting space for larger PDMs than it would be for compact PDMs.

**[0041]** In accordance with a preferred embodiment of the present invention, the cover 14 includes an integrated compression seal 20 (best seen in Fig. 4). The integrated compression seal 20 provides a barrier between the cover 14 and the base 12 when the PDM 10 is assembled and the cover 14 is locked onto the base 12 by way of mating the snap-fits 22a-22d with the snap-fit receptacles 24(a)-24(d). This sealed barrier ensures that the PDM chamber 48 is sealed off from its exterior at the fitting point between the cover 14 and the base 12, thereby preventing debris and moisture from entering the PDM chamber 48. Referring to Figs. 7 and 8, the compression seal 20 is preferably inset to a bottom surface 44 within the seal groove 36 formed in the cover casing 38. The seal groove 36 formed in the cover casing 38 is defined by an inner lip boarder 42 and an outer lip boarder 40 and has a depth defined by a bottom surface 44 formed in the cover casing 38.

**[0042]** Referring back to Fig. 2, the base 12 includes a raised flange 46 forming a raised perimeter around the array of receptacles 34. When the PDM 10 is assembled and the cover 14 is locked onto the base 12 by way of mating the snap-fits 22a-22d with the snap-fit receptacles 24(a)-24(d), the raised flange 46 mates with the seal groove 36. The depth of the seal groove 36 corresponds to the dimensions of the compression seal 20 such that the compression seal 20 forms a tight seal between the terminal edge 100 of the raised flange 46 and the bottom surface 44 formed in the cover casing 38.

**[0043]** In an embodiment, the raised flange 46 defines a rectangular perimeter around the topside array of receptacles 34. The rectangular perimeter defines the sides of a rectangle, and the rectangle defines one side of a rectangular cube. The rectangular cube is defined by a first plane coplanar with a first surface 52 at the base topside 18, a second plane coplaner with a second surface 54 at the underside array of receptacles 32, and third, fourth, fifth, and sixth

planes coplanar with third, fourth, fifth, and sixth sides 56, 58, 60, and 62, respectively, of the rectangular cube. The rectangular cube, which may be referred to as the receptacle cube or PDM body, houses an array of cavities, wherein the array of cavities are defined by the underside array of receptacles 32 and the topside array of receptacles 34.

**[0044]** As discussed above, PDMs of the related art include radial (i.e., side compressed), not axial (i.e., bottom compressed), seals. To accommodate radial seals, PDMs of the related art include a wider groove to provide lateral room for the seal, which is compressed between lateral (side) surfaces of the cover and the base. The wider grooves of PDMs of the related art contribute to an increase in the overall width, length, and perimeter of the PDM, consequently contributing to an increase in the overall size of the PDM. In contrast and in accord with the present disclosure, the compression seal 20 and seal groove 36 provide an axial-type seal. In contrast with and relative to radial seals of the related art, the axial seal disclosed herein does not require a broad groove sufficiently wide enough to accommodate the entire seal in a radial position. Thus, the axial seal of the presently disclosed PDM 10 does not contribute to an increase in the width, length, and perimeter of the PDM, and therefore does not dictate an increase in the overall size of the PDM.

**[0045]** Referring now to Figs. 1 and 2, in a preferred version the snap-fit receptacles 24(a) – 24(d) are apertures formed within the mounting structures 30(a) and 30(b). The mounting structures 30(a) and 30(b) extend laterally outside the perimeter of the raised flange 46 at opposite sides of the PDM 10. However, the snap-fit receptacles (apertures) 24(a) - 24(d) directly abut the rectangular cube that houses the arrays of cavities. The rectangular cube as defined hereinabove may be referred to as the body of the PDM 10, wherein the body is completely confined within a boundary commensurate with the raised flange 46. In other words, in a version there exists no intervening structure between the PDM body (rectangular cube) and the snap-fit receptacle apertures 24(a)-24(d).

**[0046]** Mounting structures 30(a) and 30(b) include respective snap-fit receptacles 24(a)-24(b) and 24(c)-24(d) and respective mounting nuts 50(a) and 50(b). In a preferred version, mounting nut 50(a) is located in a central portion of mounting structure 30(a). The snap fit receptacles 24(a)-24(b) are located outside of the central portion at side (end) regions of the mounting

structure 30(a). In this version, at least a portion of the mounting nut 50(a) is in between snap-fit receptacle apertures 24(a) and 24(b), and at least a portion of the mounting nut 50(b) is in between snap-fit receptacle apertures 24(c) and 24(d).

**[0047]** In a preferred version, mounting nut 50(b) is located at a central portion of mounting structure 30(b). The snap fit receptacles 24(c) and 24(d) are located outside of the central portion at side (end) regions of the mounting structure 30(b). In this version, at least a portion of mounting nut 50(b) is in between snap-fit receptacle apertures 24(c) and 24(d).

**[0048]** As illustrated, in a preferred version the PDM 10 has no more than two connection components configured to connect the PDM 10 to a mounting structure (i.e., no more than one connection component at each of opposed sides of the base 12). The first of the two connection components (mounting nut 50(a)) is located at a first side of the PDM 10, and the second of the two connection components (mounting nut 50(b)) is located at a second side of the PDM 10, opposite the first side. Thus, both of opposite sides of the PDM 10 have only one connection component configured to connect the PDM 10 to a structure. A connection component may be, as examples, a nut, a snap-type connector, a pin, a latch, a hook, etc. that may be integrated in respective PDM mounting structures 30(a), 30(b).

**[0049]** As illustrated in Fig. 2, the snap-fit receptacles 24(a) and 24(b) abutt the side 56 of the rectangular cube that houses the array of cavities, and the mounting nut 50(a) is within an area that is between the snap-fit receptacles 24(a) and 24(b). Similarly, on the opposite side of the PDM, the snap-fit receptacles 24(c) and 24(d) abutt the side 60 of the rectangular cube that houses the array of cavities and the mounting nut 50(b) is within an area that is between the snap-fit receptacles 24(c) and 24(d).

**[0050]** In the related art, many PDM connection and cover lock elements extend in a sequential arrangement outward along a plane orthogonal to the side of the rectangular cube. Consequently, PDM covers of the related art are generally too long to dislodge from the base using only one hand. Also, due to their size in certain applications it may be challenging to find a location to mount PDMs of the related art.

**[0051]** Because of the location of the snap-fit receptacles 24(a)-24(d) with respect to the mounting nuts 50(a) and 50(b), the cover 14 of the PDM of the present disclosure is relatively

compact and for that reason it is possible to unsecure and remove it from the base using only one hand, as opposed to requiring two hands as is required to remove PDMs of the related art. Because of its compact size, it is also less challenging to locate an area to mount the PDM of the present disclosure, compared to PDMs of the related art.

**[0052]** Referring to Figs. 3 and 8, the snap-fits 22(a)-22(d) are generally U-shaped and extend perpendicularly away from a plane coplanar with the opening of the cover 14. A U-shaped snap-fit includes an attachment arm 64 (one arm of the "U") attached to the body of the cover 14, a flexible arched curvature 66 (semi-circle portion of the "U"), and a locking arm 68 (a second arm of the "U") that includes a catch 70 and a release tab 72. In a version, the attachment arm 64 is directly attached to the body (i.e. cover casing 38) of the cover 14 with no intervening parts or extensions between the attachment arm 64 and the cover casing 38. The attachment arm 64 may be either directly attached to the cover casing 38, or may form part of the cover casing 38 and extend (in relation to the orientation of Fig. 3) downward (perpendicular to a plane coplanar with the opening of the cover 14).

**[0053]** In a version, the cover 14 is secured to the base by inserting the snap-fits 22(a)-22(d) into their respective snap-fit receptacles 24(a)-24(d) via the respective flexible arched curvatures of each snap-fit, and compressing the cover 14 onto the base 12, thereby tightly axially compressing the compression seal 20 between the raised flange 46 and the bottom of the seal groove 36. With adequate compression force, the snap-fits narrow as they are further inserted into their respective snap-fit receptacles. Once the catch 70 surpasses the distal edge of the snap-fit receptacle it engages the underside thereof to secure the cover 14 to the base 12. To remove the cover, a user compresses opposed release tabs 72(a), 72(b) toward the cover 14, and lifts the cover away from the base 12. For example, referring to Fig. 3, a user may use one hand to simultaneously compress the release tabs of opposed snap-fits 22(b) and 22(d) and lift the cover to release the catches 70 from the undersides of the respective snap-fit receptacles, and then, subsequently, simultaneously compress the release tabs of opposed snap-fits 22(a) and 22(c) and lift the cover 14 and remove it from the base 12.

**[0054]** Referring to Fig. 9, in an embodiment the PDM 10 includes a second locking mechanism (referred to herein as a locking clip 74) that, when in place, retains the snap-fits in the locked

position when the cover 14 is secured to the base 12. The locking clip 74 includes a pair of guides 76(a), 76(b) bounded by guide channels 78(a), 78(b). The locking clip 74 includes a pair of hitches 80(a), 80(b) that prevent the locking clip 74 from sliding out of the guide channels 78(a), 78(b) when the locking clip 74 is disengaged from the snap-fits 22(a), 22(b) and/or the cover 14 is removed from the base 12.

**[0055]** The locking clip 74 includes wedges 82(a), 82(b) that retain the snap-fits in position when the cover 14 is locked onto the base 12. In other words, the wedges 82(a), 82(b) maintain a separation distance between the cover casing 38 and the snap fits 22(a), 22(b) such that the catch cannot disengage from its locked position, regardless of whether pressure is applied to the release tabs 72(a), 72(b).

**[0056]** The locking clip 74 further includes lock hitches 84(a), 84(b) that engage the lower edges of the guide channels 78(a), 78(b) when the locking clip is pressed down into its locked state. The locking clip 74 may be disengaged by pressing the hitches 80(a), 80(b) inward and upward in relation to the cover casing 38.

**[0057]** Thus, the cover 14 of the PDM 10 is locked onto the base 12 by pressing the cover 14 onto the base 12 until the latch 70 surpasses the distal edge of the snap-fit receptacle. Downward pressure is then applied to the locking clip 74 until the hitches 84(a), 84(b) engage the lower edges of the guide channels 78(a), 78(b). In this state, the cover 14 is securely locked onto the base 12.

**[0058]** The cover 14 of the PDM 10 is removed from the base 12 by pressing the hitches 80(a), 80(b) inward and upward towards the cover casing 38 to disengage the locking clip 74 from the lower edges of the guide channels 78(a), 78(b). First and second pairs of opposed release tabs are then compressed (an action that may be performed sequentially with the use of only one hand) as the cover 14 is lifted away from the base 12.

**[0059]** As referenced above, PDMs of the related art are provided with breathers located on the top surface of the cover. Although these breathers relieve pressure within the PDM chamber, they eventually become clogged which results in an accumulation of heat and an increase in pressure within the PDM chamber.

**[0060]** As discussed above, in a preferred version of the PDM 10, the seal groove 36 is formed in the cover casing 38 and is defined by the inner lip boarder 42 and the outer lip boarder 40 and has a depth defined by the bottom surface 44 formed in the cover casing 38. The inner lip boarder 42 is an extension of the inner chamber wall. The outer lip boarder 40 is parallel to the inner lip boarder 42 and is spaced from the inner lip boarder 42 in a direction away from the inner chamber. The spacing between the inner lip boarder 42 and the outer lip boarder is commensurate with the width of the bottom surface 44 of the seal groove 36.

**[0061]** In a preferred version, the cover 14 is molded plastic. The cover 14 includes an aperture 90 traversing the width of the cover casing 38. The aperture 90 is shielded outside the chamber 48 by one of the guide channels, for example guide channel 78(a), as well as the respective guide 76 within the guide channel 78(a) (if a locking clip is in place). A hydrophobic material 92 is adhered to a section of the inner wall 86 over and around the aperture 90. Thus, the hydrophobic material 92 and the aperture 90 provide a breather hole that is sheltered at the outside by the guide channel 78(a) and its respective guide 76. This distinctive location of the breather hole is a vast improvement over PDMs of the related art which directly expose the hydrophobic material to outside elements, which eventually leads to clogging issues. In the disclosed embodiment, the hydrophobic material 92 is located within the chamber 48. Because the hydrophobic material 92 is located within the chamber 48 it is much less susceptible to clogging and dirt accumulation because it is not directly exposed to outside elements. Therefore, pressure dissipation through the hydrophobic material 92 and the aperture 90 to the outside remains unimpeded despite long periods of use. Because internal chamber pressure is released via the breather hole, there is a significantly reduced occurrence of seal breach, which in turn significantly extends the lifespan of the PDM 10 over that of PDMs either having no breather hole, or unshielded breather holes that are susceptible to clogging.

**[0062]** The PDM 10 of the present disclosure may optionally include a terminal lock 94, an embodiment of which is illustrated in Fig. 11. A terminal lock 94 includes tabs 96(a), 96(b) for locking engagement with base apertures, an example of which is illustrated in Fig. 1 at 98. The terminal lock 94 prevents wire terminals from disengaging from the base receptacles 32 and

preferably includes semi-circular apertures that do not impede the wires that are connected to the wire terminals.

**[0063]** According to another aspect of the present disclosure, the preferred material for the PDM cover is a blend of polyphenylene ether, polystyrene, and polyamide. This material provides exceptional stiffness and flexural modulus, excellent chemical resistance, and good processability and flow. Meanwhile, the preferred material for the PDM base is glass reinforced semi-crystalline polybutylene terephthalate, which shows low moisture and thermal expansion and offers outstanding wear and friction properties. With good strength at high temperatures, it has good electrical properties and is flame resistant. Unlike PDMs of the related art which use the same material for the base and the cover, the PDM of the present disclosure utilizes a first material that withstands the temperature demands of a base that supports electrically active components, and a second material that has properties suitable for a protective structure, such as the cover. Silicone is the preferred material for the compression seal 20.

**[0064]** A PDM prototype according to the present disclosure has been built, tested, and rated and found to be compliant with the Restriction of Hazardous Substances (RoHS) directive. The prototype cover is a blend of polyphenylene ether, polystyrene, and polyamide. The prototype base is glass reinforced semi-crystalline polybutylene terephthalate. And the material for the compression seal is silicone.

**[0065]** The prototype constructed in accordance with the present disclosure is a forty-eight way PDM that measures approximately 108.5 millimeters in length and 62 millimeters in width, thereby providing forty-eight receptacles within a PDM having an area of only 6,727 square millimeters.

**[0066]** Water and dust ingress protection was rated at Ingress Protection (IP) 67, which corresponds to no ingress of dust and complete protection against contact, and protection from liquid immersion up to 1 meter in depth. The prototype was rated as follows: cover: UL 94 HB flammability rating, base: UL 94V-0 flammability rating, and compression seal: UL 94HB flammability rating. A prototype having a vent as disclosed herein withstood a maximum continuous current of 300 Amps. A prototype without a vent withstood a maximum continuous current of 150 Amps.

**[0067]** A prototype was highly accelerated life test (HALT) tested and was rated as follows:

**[0068]** Combined temperature vibration HALT: -40 to 125 °C

**[0069]** High temperature soak: 125 °C (operational)

**[0070]** Low temperature soak: -40 °C (operational)

**[0071]** Temperature cycle: -40 to 125 °C, 10 cycles (operational)

**[0072]** Temperature shock: -40 to 90 °C, 100 cycles (operational)

**[0073]** Drop test: 1 meter onto hardwood, all sides passed

**[0074]** Vibration: random 100 hours (operational)

**[0075]** Particle impact: simulated gravel

**[0076]** Water and dust ingress: IP67

**[0077]** Combined temperature and humidity: 100 hours (operational)

**[0078]** Salt spray: sustained 96 hour testing

**[0079]** Chemical resistance: tested against and resisted oils, fertilizer, urea, and NPK

**[0080]** Ozone: sustained 70 hour test

**[0081]** Accelerated weathering (ultraviolet): sustained 240 hours

**[0082]** The foregoing is illustrative of the present invention and is not to be construed as limiting thereof. Although exemplary embodiments of this invention have been described, those skilled in the art will readily appreciate that many modifications are possible in the exemplary embodiments without materially departing from the novel teachings and advantages of this invention. Accordingly, all such modifications are intended to be included within the scope of this invention as defined in the claims. The invention is defined by the following claims, with equivalents of the claims to be included therein.

CLAIMS

I claim:

1. A power distribution module comprising:

a base;

a cover, the cover comprising:

a guide channel and a breather hole, wherein the breather hole is shielded by the guide channel,

a chamber,

a hydrophobic material within the chamber, and

a guide within the guide channel;

a locking clip, wherein the locking clip comprises the guide and includes a wedge that maintains a release tab of the cover in a first position and prevents the release tab from disengaging from the base; and

a compression seal axially compressed between a terminal edge of the base and a surface within a seal groove of the cover, wherein the surface within the seal groove is orthogonal to both an inner lip and an outer lip of the cover, and

wherein the cover further comprises a plurality of snap-fits and the base comprises a plurality of snap-fit receptacles, and wherein the snap-fits and snap-fit receptacles engage to lock the cover onto the base and maintain compression of the compression seal.

2. A power distribution module comprising:

a base; and

a cover attached to the base, wherein the cover comprises a guide channel and a breather hole, and wherein the breather hole is shielded by the guide channel.

3. The power distribution module of claim 2 wherein the cover comprises:

a chamber; and

a hydrophobic material covering the breather hole from within the chamber.

4. The power distribution module of claim 3 wherein the hydrophobic material is adhered to a surface within the chamber.

5. The power distribution module of claim 2 further comprising a guide within the guide channel, wherein the guide shields the breather hole.

6. The power distribution module of claim 5 further comprising a locking clip, wherein the locking clip comprises the guide.

7. A power distribution module comprising:

a base;

a cover; and

a compression seal axially compressed between a terminal edge of the base and a surface within a seal groove, wherein the surface within the seal groove is orthogonal to both an inner lip and an outer lip of the cover.

8. The power distribution module of claim 7 wherein the cover comprises a plurality of snap-fits and the base comprises a plurality of snap-fit receptacles, and wherein the snap-fits and snap-fit receptacles engage to secure the cover onto the base and maintain compression of the compression seal.
9. The power distribution module of claim 7 wherein the compression seal is a silicone seal.
10. A power distribution module comprising:
- a cover; and
- a base attached to the cover, wherein the base comprises opposing mounting structures, and wherein each mounting structure has no more than one mounting nut.
11. The power distribution module of claim 10, wherein at least a portion of the mounting nut is between first and second snap-fit receptacles.
12. The power distribution module of claim 11 wherein the first and second snap-fit receptacles directly abut a rectangular cube that houses an array of cavities within the base.
13. The power distribution module of claim 12 wherein there is no intervening structure between the rectangular cube and the first and second snap-fit receptacles.
14. The power distribution module of claim 10 wherein the cover comprises at least one snap-fit directly abutting a cover casing, wherein the cover casing defines a cover chamber.
15. The power distribution module of claim 14 wherein the at least one snap-fit is U-shaped and comprises a catch that engages an underside of the snap-fit receptacle to secure the cover onto the base.

16. The power distribution module of claim 10 wherein the base material comprises glass reinforced semi-crystalline polybutylene terephthalate, and the cover material comprises a blend of polyphenylene ether, polystyrene, and polyamide.

17. A power distribution module cover comprising:

at least one snap-fit directly abutting a cover casing, wherein the cover casing defines boundaries of an inner chamber; and

a locking clip that retains the snap-fit in a locked position when the cover is locked onto a power distribution module base.

18. The power distribution module cover of claim 17 wherein the locking clip includes a wedge that maintains a release tab in a first position and prevents the release tab from disengaging from a power distribution module base.

19. The power distribution module cover of claim 18 further comprising at least one guide channel that retains a guide of the locking clip.

20. A base for a power distribution module, the base comprising:

a base body; and

opposed mounting structures connected to the base body, wherein each mounting structure has no more than one mounting nut, and

wherein at least a portion of the mounting nut is between first and second snap-fit receptacles,

and

wherein the first and second snap-fit receptacles directly abut the base body.

21. The power distribution module of claim 20 further comprising:

a first array of cavities integral with the base body, wherein the first array of cavities receive wire leads with terminals; and

a second array of cavities that receive at least one electrical component selected from a group of electrical component consisting of: a fuse, a relay, a circuit breaker, and a diode.

## AMENDED CLAIMS

received by the International Bureau on 01.Apr.2016 (01.04.2016)

1. A power distribution module comprising:
  - a base;
  - a cover, the cover comprising:
    - a guide channel and a breather hole, wherein the breather hole is shielded by the guide channel,
    - a chamber,
    - a hydrophobic material within the chamber, and
    - a guide within the guide channel;
    - a locking clip, wherein the locking clip comprises the guide and includes a wedge that maintains a release tab of the cover in a first position and prevents the release tab from disengaging from the base; and
    - a compression seal axially compressed between a terminal edge of the base and a surface within a seal groove of the cover, wherein the surface within the seal groove is orthogonal to both an inner lip and an outer lip of the cover, and
  - wherein the cover further comprises a plurality of snap-fits and the base comprises a plurality of snap-fit receptacles, and wherein the snap-fits and snap-fit receptacles engage to lock the cover onto the base and maintain compression of the compression seal.
2. A power distribution module comprising:
  - a base;
  - a cover attached to the base, wherein the cover comprises a guide channel and a breather hole, and wherein the breather hole is shielded by the guide channel; and
  - a guide within the guide channel, wherein the guide shields the breather hole.
3. The power distribution module of claim 2 wherein the cover comprises:

a chamber; and

a hydrophobic material covering the breather hole from within the chamber.

4. The power distribution module of claim 3 wherein the hydrophobic material is adhered to a surface within the chamber.

5. The power distribution module of claim 2 wherein the guide channel is externally mounted to the cover.

6. The power distribution module of claim 5 further comprising a locking clip, wherein the locking clip comprises the guide.

7. A power distribution module comprising:

a base;

a cover; and

a compression seal axially compressed between a terminal edge of the base and a surface within a seal groove, wherein the surface within the seal groove is orthogonal to both an inner lip and an outer lip of the cover.

8. The power distribution module of claim 7 wherein the cover comprises a plurality of snap-fits and the base comprises a plurality of snap-fit receptacles, and wherein the snap-fits and snap-fit receptacles engage to secure the cover onto the base and maintain compression of the compression seal.

9. The power distribution module of claim 7 wherein the compression seal is a silicone seal.

10. A power distribution module comprising:

a cover; and

a base attached to the cover, wherein the base comprises opposing mounting structures, and wherein each mounting structure has no more than one mounting nut;

wherein the cover comprises at least one snap-fit directly abutting a cover casing,

wherein the cover casing defines a cover chamber; and

wherein the at least one snap-fit is U-shaped and comprises a catch that engages an underside of the snap-fit receptacle to secure the cover onto the base.

11. The power distribution module of claim 10, wherein at least a portion of the mounting nut is between first and second snap-fit receptacles.

12. The power distribution module of claim 11 wherein the first and second snap-fit receptacles directly abut a rectangular cube that houses an array of cavities within the base.

13. The power distribution module of claim 12 wherein there is no intervening structure between the rectangular cube and the first and second snap-fit receptacles.

14. The power distribution module of claim 10 wherein the at least one snap fit comprises a release tab.

15. The power distribution module of claim 14 further comprising a locking clip capable of retaining the snap-fits in a locked position when the cover is secured to the base

16. The power distribution module of claim 10 wherein the base material comprises glass reinforced semi-crystalline polybutylene terephthalate, and the cover material comprises a blend of polyphenylene ether, polystyrene, and polyamide.

17. A power distribution module cover comprising:

at least one snap-fit directly abutting a cover casing, wherein the cover casing defines boundaries of an inner chamber;

wherein the at least one snap-fit is U-shaped and comprises a catch; and

a locking clip that retains the snap-fit in a locked position when the cover is locked onto a power distribution module base.

18. The power distribution module cover of claim 17 wherein the locking clip includes a wedge that maintains a release tab in a first position and prevents the release tab from disengaging from a power distribution module base.

19. The power distribution module cover of claim 18 further comprising at least one guide channel that retains a guide of the locking clip.

20. A base for a power distribution module, the base comprising:

a base body;

opposed mounting structures connected to the base body, wherein each mounting structure has no more than one mounting nut;

wherein at least a portion of the mounting nut is between first and second snap-fit receptacles;

wherein the first and second snap-fit receptacles directly abut the base body; and

wherein the base body comprises a base underside and a base topside generally planar and parallel to one another.

21. The power distribution module of claim 20 further comprising:

a first array of cavities integral with the base body, wherein the first array of cavities receive wire leads with terminals; and

a second array of cavities that receive at least one electrical component selected from a group of electrical component consisting of: a fuse, a relay, a circuit breaker, and a diode.

STATEMENT UNDER PCT ARTICLE 19.1

This amendment has no impact on the description and the drawings as originally filed. The claims amended herein have been amended to more succinctly and precisely claim the subject matter described in the specification. No new matter has been added.

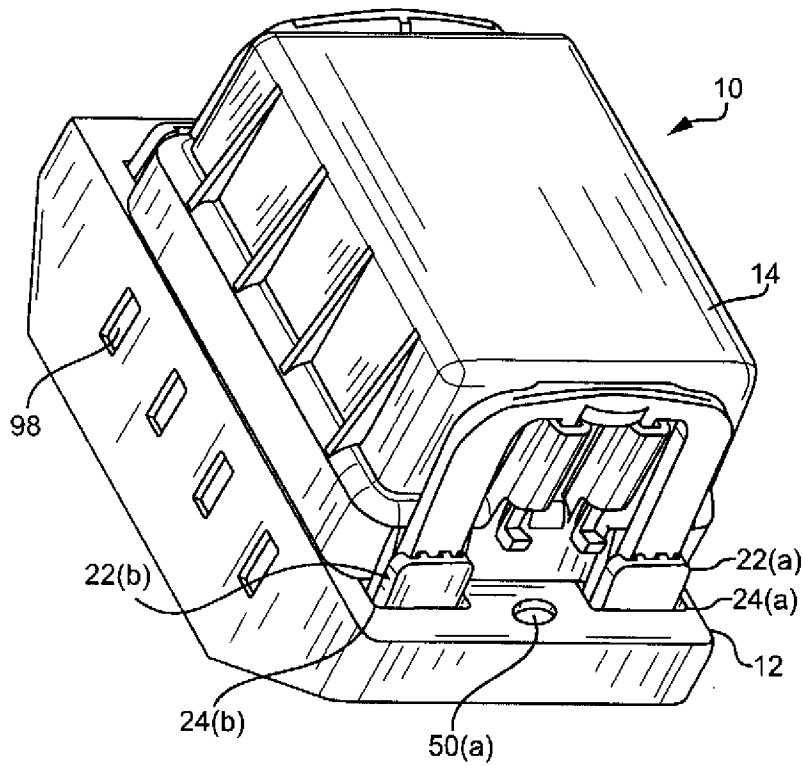


FIG. 1

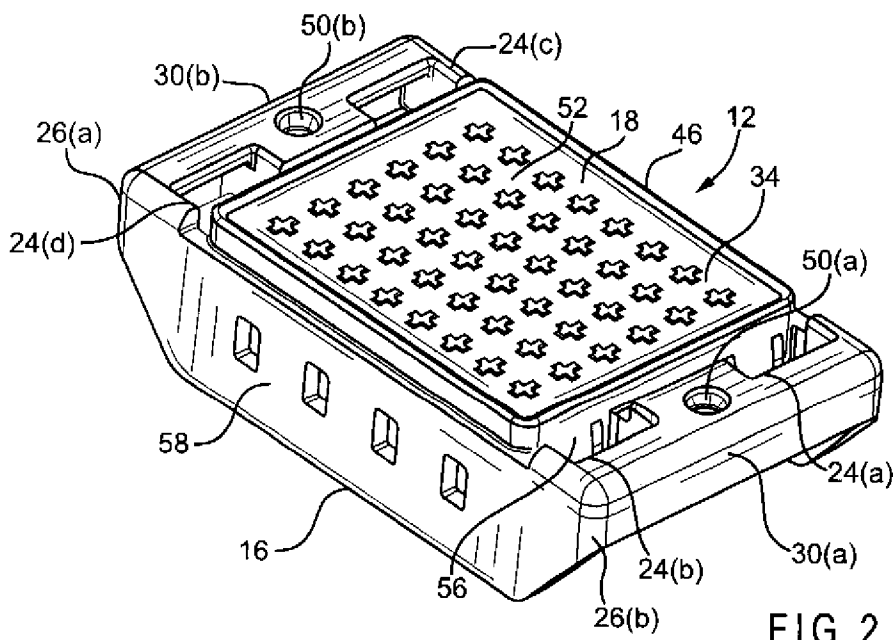


FIG. 2

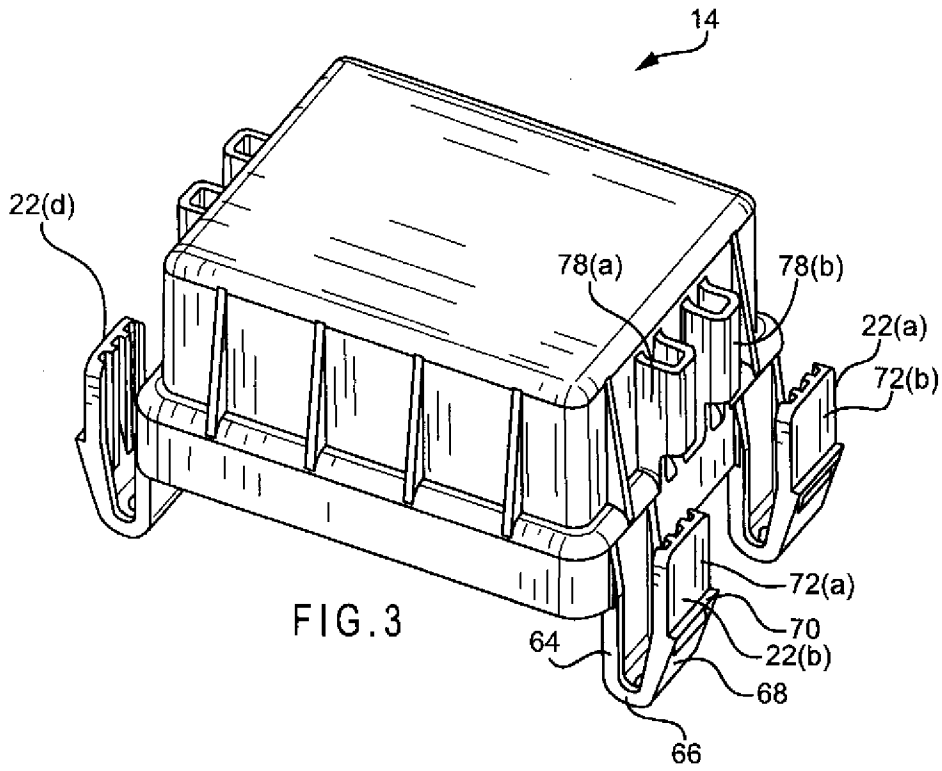


FIG. 3

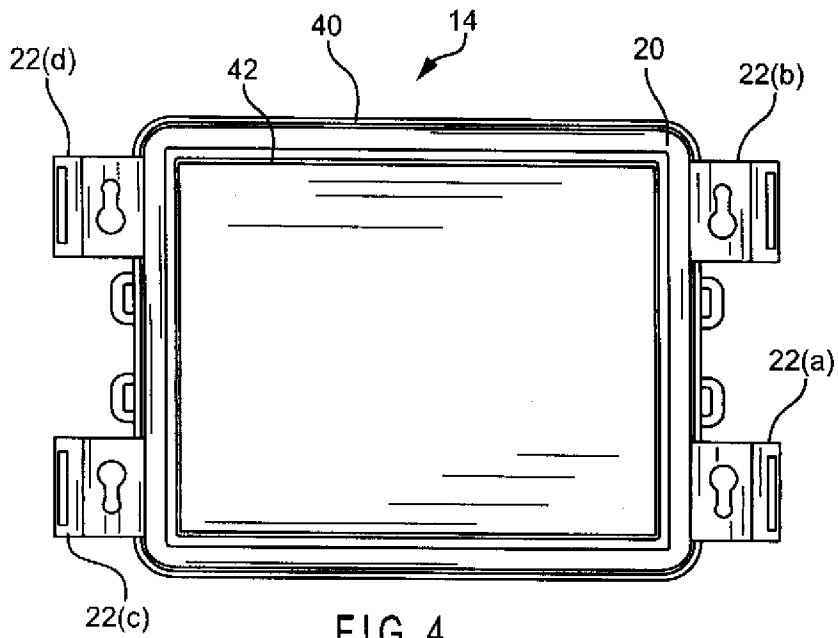
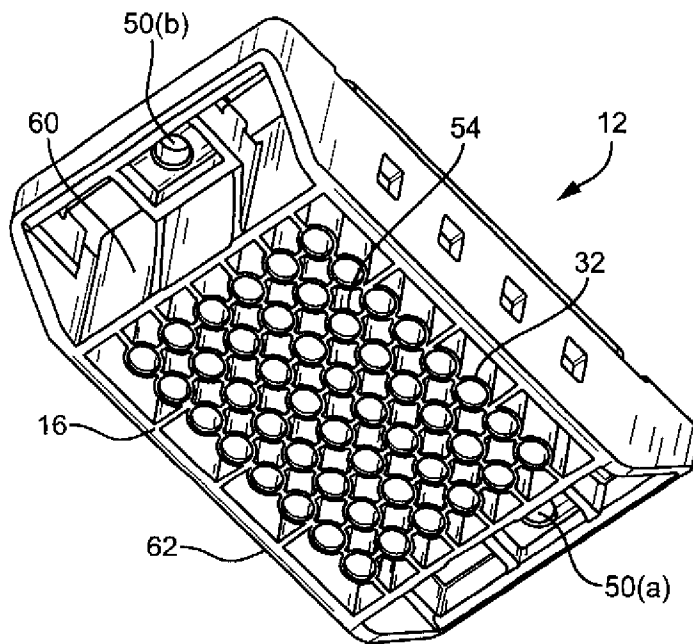
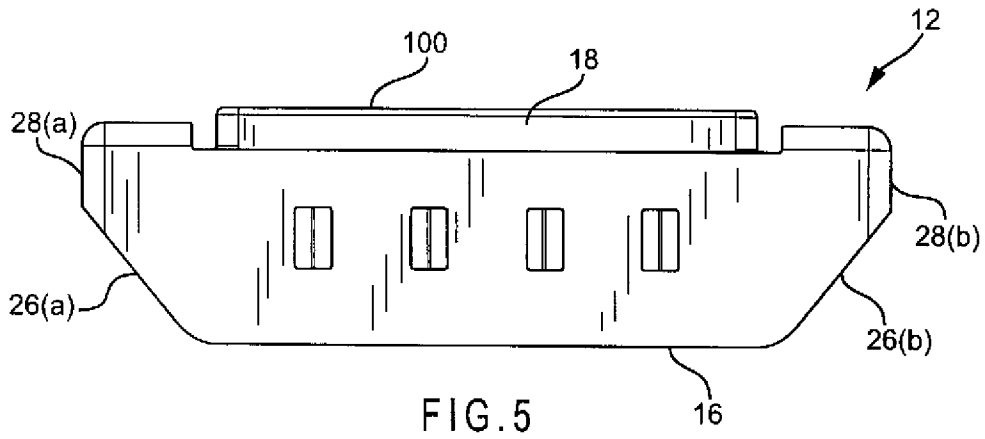
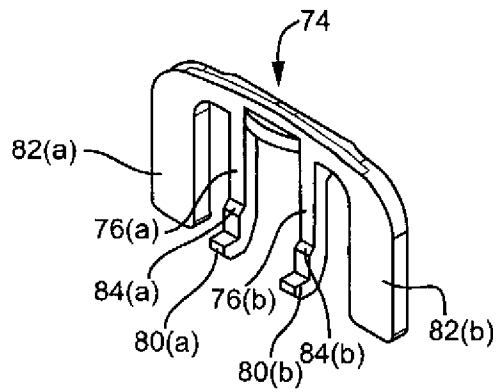
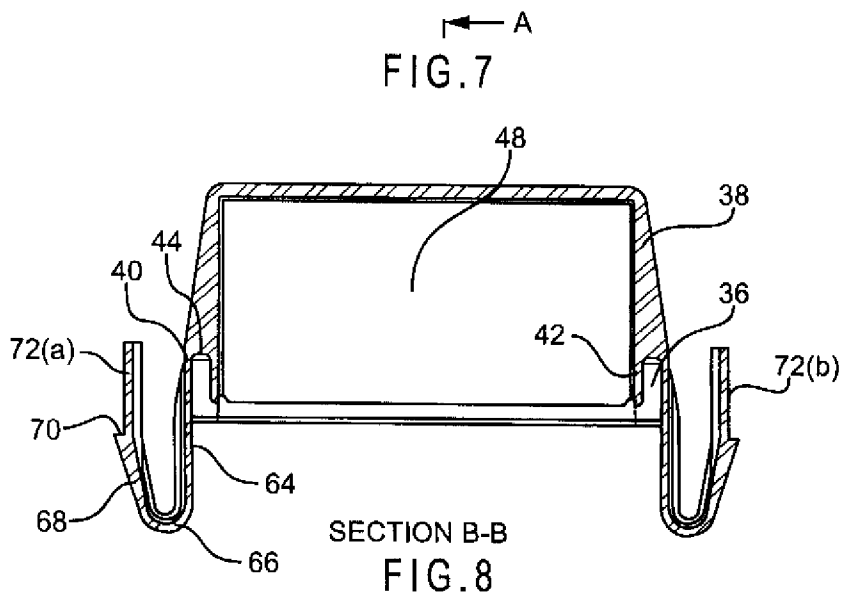
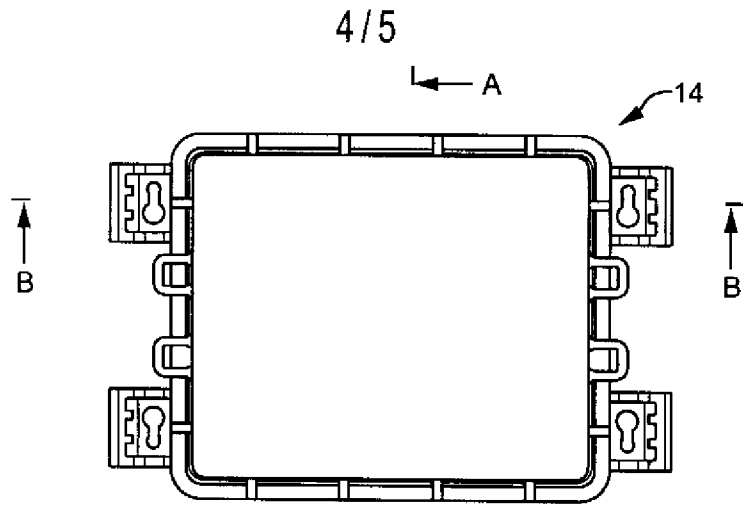
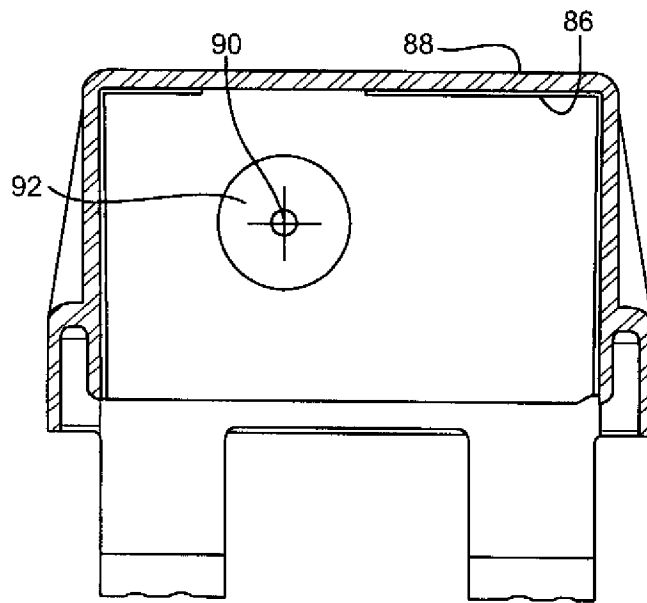


FIG. 4







SECTION A-A

FIG. 10

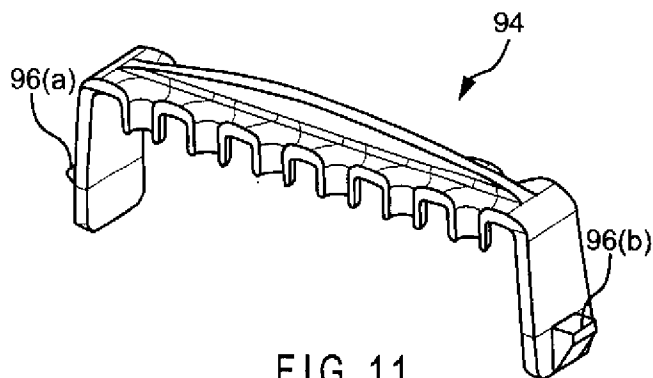


FIG. 11

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US15/58065

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - H01R 11/09 (2015.01)

CPC - H01R 11/09

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC(8) Classification(s): B60L 1/00; B60R 16/02, 16/023; H01R 11/09, 13/00 (2015.01); CPC Classification(s): B60R 16/0238; H01R 9/2491, 11/09, 13/5213; USPC Classification(s): 174/138, 520; 307/9.1; 361/823, 837; 439/76.2, 271, 620.27, 718, 723

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

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

PatSeer (US, EP, WO, JP, DE, GB, CN, FR, KR, ES, AU, IN, CA, INPADOC Data) ProQuest (Derwent, INSPEC, NTIS, PASCAL, Current Contents Search, Dissertation Abstract Online, Inside Conference); IEEE/IEEExplore; Google/Google Scholar; Keywords: power w2 distribution, distribution w2 module, base, cover, guide, channel, breather, hole, breather w2 hole, vent\*, chamber, cavity, enclosure, hydrophobic, waterproof, watertight, repel\* w2 water, lock\* w2 clip, clasp, catch, release w2 tab, flap, strip, seal, compress, gasket, snap

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 5,643,693 A (HILL, MG et al.) July 01, 1997; figures 1, 4, 6, 7, 9, 11; column 2, lines 30-40 column 3, lines 40-45, column 4, lines 65-68, column 5, lines 1-5, lines 15-20 and lines 25-30	10-14, 20, 21 --- 15, 16
X --- Y	US 2008/0293291 A1 (JANISCH, D) November 27, 2008; figures 2, 7, 12, 13; paragraphs [0028]-[0030], [0031]	7, 8, 17-19 --- 9, 15
X Y	US 6,445,568 B1 (BAUR, R et al.) September 03, 2002; figures 1, 2; column 3, lines 15-25; column 5, lines 1-10	2-4 9
Y	US 2008/0233783 A1 (JACOBSON, J) September 25, 2008; paragraphs [0004], [0016]	9
Y	US 20140134884 A1 (OKAMOTO, R) May 15, 2014; figure 1; paragraphs [0045], [0046], [0061]	16
A	US 2008/0111863 A1 (SILVERBROOK, K) May 15, 2008; entire document	1-21
A	US 2007/0270045 A1 (KORCZYNSKI, JM et al.) November 22, 2007; entire document	1-21
A	US 5,531,345 A (NAKAMURA, M et al.) July 02, 1996; entire document	1-21

Further documents are listed in the continuation of Box C.

See patent family annex.

\* Special categories of cited documents:

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

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

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search

29 December 2015 (29.12.2015)

Date of mailing of the international search report

02 FEB 2016

Name and mailing address of the ISA/

Mail Stop PCT, Attn: ISA/US, Commissioner for Patents

P.O. Box 1450, Alexandria, Virginia 22313-1450

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