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(54) METHOD FOR MANUFACTURING A LIGHTING UNIT & LIGHTING UNIT

(57) A method for manufacturing a lighting unit (501), including: providing a lighting device (503), an electrical cable (1) including at least one multi-stranded electrical wire (7a,7b) having an insulation sheath (11a,11b) and a casing (509) for housing the lighting device (103) and at least a part of the electrical cable (1); forming a cable assembly by exposing a section of the multi-stranded electrical wire (7a,7b); bonding the exposed strands together with a bonding agent, thereby forming a substantially solid wire section which substantially blocks the flow of fluids along the multi-stranded wire; placing at least part of the electrical cable into a mould; and moulding at least one sealing member (523) onto the electrical cable over at least a part of the exposed wire (7a,7b) and at least a part of the insulating sheath (11a,11b), thereby sealing the substantially solid wire section to the insulation sheath (11a,11b); removing the cable assembly from the mould and assembling together the cable assembly and casing (509).

A lighting unit (101) manufactured according to the manufacturing process is also disclosed.

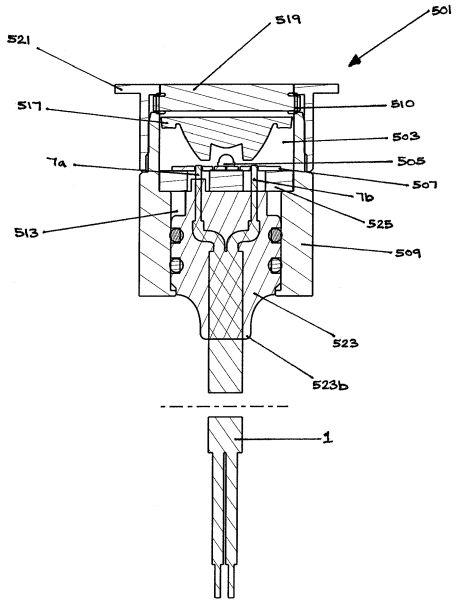

Fig. 16

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Description

[0001] The present invention relates to a method for manufacturing a lighting unit and a lighting unit. The lighting unit includes means for preventing the ingress of moisture into the appliance via an electrical cable.

[0002] Lighting units frequently use multi-stranded electrical cables to connect the appliance to a power source since multi-stranded cables are very flexible and robust. The flexibility enables the cables to follow non-linear paths and enables frequent repositioning and bending of the cable without appreciably work hardening the cable. However when a lighting unit, such as a sealed lighting unit, is turned on heat given off by the light source, and sometimes other electrical components, causes the air inside the lighting unit to expand, thereby increasing the pressure within the unit. The increased pressure causes air to be forced out of the unit via the multi-stranded electrical cable. The air flows through gaps located between strands of copper wire within an inner insulation sheath and via gaps between the inner insulation sheath and an outer sheath.

[0003] When the light is turned off the air inside the unit cools and contracts causing a reduction in pressure within the unit. This causes air to be drawn into the unit through the same gaps.

[0004] Frequently lighting units are used in damp environments such as outdoor applications, and also in submersed conditions such as swimming pools and ponds. When air is drawn along cables in moist or wet conditions, moisture is also drawn into the lighting unit. This can be fatal to the lighting unit, for example by corroding electrical contacts or short circuiting the device. At best, moisture drawn into the unit causes water droplets to form inside the casing, which can reduce the operating effectiveness of the light and also look unsightly.

[0005] This problem is illustrated in Figures 1 to 3. Figures 1 to 3 show a known flexible electrical cable 1 and a prior art lighting unit 3 including the cable.

[0006] The flexible electrical cable 1 includes a flexible outer sheath 5, two multi-stranded wires 7, each wire 7 having multiple strands of copper wire 9 and a flexible insulating sheath 11. It can be seen from Figure 1, in an exaggerated fashion, that there are gaps 13 between the strands of copper wire 9 and gaps 15 between the insulating sheaths 11.

[0007] Figures 2 and 3 show the lighting unit 3 including the multi-stranded electrical cable 1 connected to a light bulb 17 housed in a casing 19 in a substantially sealed compartment 21. When the light bulb 17 is illuminated, it heats up the air inside the compartment 21 causing it to expand and thereby increasing the air pressure in the compartment 21. The increased air pressure causes the air 21 to exit the compartment 21 through the gaps 13,15 in the electrical cable. The air movement is indicated by arrows referenced 23 in Figure 2.

[0008] When the light bulb 17 is switched off, the air in the compartment 21 cools and contracts thereby reducing the air pressure in the compartment 21. This causes air to be sucked into the compartment 21 via the gaps 13,15 in the electrical cable 1. This is illustrated in Figure 3, wherein in the movement of air is referenced by numeral 23. Air drawn into the casing 19 can contain moisture, particularly when the lighting unit is located in damp or wet environment. The moisture can damage electrical components within the casing 19, for example it may corrode some of the electrical contacts. It also can form water droplets on an inner surface of a glass frontage 25.

[0009] Similar problems can occur in other types of lighting units.

[0010] WO2010/052449 teaches a method of addressing this problem, which includes tinning the electrical wires in an exposed section to fill the gaps there between, connecting the wires to light source located in a front compartment, such that the tinned part of the wires is located in a rear compartment, and then pouring liquid sealant (a so called "potting" compound) into the rear compartment. When the liquid sealant sets, it provides a moisture resistant barrier. While this solution is generally satisfactory, there are problems with its implementation. Firstly, it is necessary to mix two liquid parts together to produce the liquid sealant at the point of assembly. This is a messy process and can lead to soiling of some lighting units in the assembly line. Secondly it can be difficult to accurately deliver liquid sealant into the rear of the lighting unit. For example, if the lighting unit is not correctly oriented when receiving the liquid sealant, it can lead to spillages. Also, liquid sealant sometimes splashes out of the lighting unit as it is delivered causing further mess and soiling of units. A messy process requires additional cleaning of the manufacturing facility and equipment and either cleaning or disposal of soiled units, which adds to manufacturing and assembly costs. A third issue is that air bubbles can be trapped within the lighting unit as the liquid sealant is poured in. This can be a problem if the depth of the seal is relatively shallow, for example if the lighting unit is small. Furthermore sealing the lighting unit in the manner described is also a relatively slow, skilled and expensive process.

[0011] A further issue to consider is the thermal management of LED type light sources in the context of sealed lighting units. In order for the LEDs to have good performance and useful life, it is necessary to remove heat from the LEDs effectively. This can be difficult to achieve when the lighting unit is sealed.

[0012] Accordingly the invention seeks to provide a method for manufacturing a lighting unit, and a lighting unit, that mitigates at least one of the above-mentioned problems or provides an alternative solution thereto.

[0013] According to one aspect of the invention, there is provided a method for manufacturing a lighting unit. The method includes: providing a lighting device, an electrical cable including at least one multi-stranded electrical wire having an insulation sheath and a casing for housing the lighting device and at least a part of the electrical cable. The method includes forming a cable assembly

by exposing a section of the multi-stranded electrical wire; bonding the exposed strands together with a bonding agent, thereby forming a substantially solid wire section which substantially blocks the flow of fluids along the multi-stranded wire. The method includes placing at least part of the electrical cable into a mould; and moulding at least one sealing member onto the electrical cable over at least a part of the exposed wire and at least a part of the insulating sheath, thereby sealing the substantially solid wire section to the insulation sheath. The cable assembly is removed from the mould.

[0014] Advantageous features of preferred embodiments are recited in the dependent claims and are further described below.

[0015] Since the mould is separate from the casing, the sealing member is formed on the electrical cable as a separate step, that is, no liquid sealant is poured into the rear of the lighting unit. Forming the sealing member onto the electrical cable, provides a much better controlled sealing process, and allows the sealing member to have a shape that is not limited to the interior shape of the casing. Since no liquid is poured into the casing the process is much cleaner at the place of assembling the lighting unit.

[0016] The invention enables the cable assembly and casing to be assembled together. The sealing member comprises a solid body, for example in the form of a bung, when it is assembled together with the casing. Since the multi-stranded wire includes a solid part, fluids are blocked from flowing into, and out of, the casing via the gaps between the strands in the wire.

[0017] Advantageously the method includes inserting at least part of the sealing member into the casing. For example, the sealing member can be pushed and/or pulled into the casing.

[0018] In preferred embodiments the sealing member is formed on the electrical cable before the electrical cable is electrically connected with the lighting device and/or part of the electrical cable is housed in the casing.

[0019] Advantageously the method includes attaching a heat sink member to the cable assembly. Preferably the heat sink member is attached to the cable assembly prior to assembling the cable assembly with the casing. The heat sink member can comprise a plate, and the method includes inserting the plate into the casing. The plate is arranged transversely to a central axis of the lighting unit.

[0020] Advantageously the method includes fixing the position of the heat sink member with respect to the casing. For example, the heat sink member can be deformed by mechanical means to form a tight fit with the casing, or can be oversized to provide an interference fit.

[0021] Advantageously the method includes mounting the lighting device on the heat sink member. Preferably the lighting device is mounted on the heat sink member prior to assembling the cable assembly with the casing.

[0022] Advantageously the casing includes a first opening. In preferred embodiments the first opening is a front opening.

[0023] The method includes inserting the sealing member into the casing through the first opening.

[0024] The method includes inserting the heat sink member into the casing through the first opening.

[0025] Advantageously the method includes inserting the cable assembly and heat sink member into the casing as a unit. The method can include inserting the cable assembly, heat sink member and lighting device into the casing as a unit.

[0026] The casing includes a first part, such as a first compartment, for housing the lighting device. The casing includes a second part, such as a second compartment, for housing at least part of the cable. The first part is located in a front part of the lighting unit. The second part is located in a rear part of the lighting unit.

[0027] In some embodiments, the casing includes a tubular body. The heat sink plate, when located in-situ within the tubular body, separates the tubular body into the first and second compartments. In other embodiments, the casing includes an integral partition, which separates the casing into first and second compartments.

[0028] Advantageously the casing includes a second opening. In preferred embodiments the second opening is a rear opening. The second opening provides access to the second part of the casing.

[0029] In some embodiments the sealing member is inserted into the casing via the second opening.

[0030] The method includes using sealing means to form a seal with the casing. In preferred embodiments the sealing means prevents moisture, which seeks entry into the casing via the second opening, from reaching the lighting device. The method includes using the sealing means to form a seal with an internal surface of the casing.

[0031] Advantageously the sealing means includes the sealing member. For example, the method can include using the sealing member to form a seal with the casing. The method can include using the sealing member to form a seal with an internal surface of the casing.

[0032] The sealing member can be sealed to the casing directly, for example by means of a tight fit, and/or indirectly, for example by means of at least one intermediate sealing element.

[0033] Advantageously the method includes forming at least one deformable ridge in a wall of the sealing member that engages the casing. The or each deformable ridge is arranged to deform in order to provide a good seal between the sealing member and the casing, and preferably resiliently deform. Each deformable ridge extends around the periphery of the sealing member, for example in a circumferential fashion. For sealing members including a plurality of deformable ridges, preferably each ridge is arranged substantially co-axially, and the ridges are spaced apart along the axis. Advantageously an inner surface of the casing includes at least one peripheral, and preferably circumferential, groove for receiving the deformable ridge. In preferred embodiments,

the inner wall includes a plurality of peripheral, and preferably circumferential, grooves. Each groove is arranged to receive a respective ridge.

[0034] The method can include providing at least one intermediate sealing element, such as an O-ring, and using the or each intermediate sealing element to form a seal between the sealing member and the casing. A plurality of intermediate sealing elements can be provided.

[0035] The method can include forming a recess, such as a circumferential groove, in at least one of the casing and the sealing member, and locating the intermediate sealing element in the recess. The recess can be formed in an outer surface of the sealing member. The recess can be formed in an inner surface of the casing.

[0036] A plurality of recesses can be provided. Typically, each intermediate sealing element is located in an individual recess. The intermediate sealing elements are spaced axially along the sealing member.

[0037] Advantageously the sealing member is sized and shaped to at least partly fit within the second part of the casing. Often the best effect is achieved when the sealing member is sized and shaped to fill at least a substantial part of the second compartment.

[0038] Advantageously the electrical cable includes a second multi-stranded electrical wire having a second insulation sheath, and the method includes exposing a second section of the second multi-stranded wire; bonding the exposed strands together with a bonding agent, thereby forming a second substantially solid wire section which substantially blocks the flow of fluids along the second multi-stranded wire. Thus fluids are blocked from flowing into, and out of, the first part of the casing via the gaps between the strands in the second wire. The method further includes moulding the sealing member onto the electrical cable to seal the second substantially solid wire section to the second insulating sheath. For example, the sealing member can be moulded over at least part of the second solid wire section and over at least part of the second insulating sheath.

[0039] Advantageously the electrical cable includes an outer sheath, and the method includes the sealing member sealing the outer sheath to at least one of: the first solid wire section; the second solid wire section; the first insulation sheath; and the second insulation sheath. For example, the sealing member can be moulded over at least part of the first and second solid wire sections, at least part of the first and second insulating sheaths and at least part of the outer sheath.

[0040] For the or each multi-stranded wire, the strands are preferably bonded together using a metallic material such as a solder. Molten solder has a low viscosity and therefore effectively fills the gaps between the strands. The solder solidifies to bond the wires together to form a substantially solid wire section. Of course other low viscosity materials can be used. It is not necessary for the material to be metallic or electrically conducting.

[0041] Advantageously the sealing member includes a plastics material. The plastics material can include thermoplastic such as a polyamide. The plastics material can include silicone. Other suitable materials, including suitable mixtures, can be used, such as natural rubber and synthetic materials having rubber like-properties, such as resiliency.

[0042] In preferred embodiments the method includes forming the sealing member from heated material. For example, the method can include forming the sealing member from melted material. This can be achieved, for example by melting solid material in the mould, or by inserting material into the mould in a liquid state. The melted material is allowed to solidify. The solidified material conforms to the shape of the mould.

[0043] The sealing member can be formed by an injection moulding process.

[0044] In some embodiments moulding the sealing member onto the electrical cable includes at least first and second moulding processes. The first moulding process produces a first sealing member. The second moulding process produces a second sealing member. The first sealing member is typically smaller than the second sealing member, however this is not a strict requirement. The first sealing member seals the substantially solid wire sections to at least one of the first and second insulating sheaths and the outer sheath. This provides a more effective seal in some applications.

[0045] The part of the electrical cable that receives the first sealing member is placed into a first mould. The first part is moulded onto the cable, for example by melting a first solid material in the mould, or by an injecting the first material into the mould when in a liquid state, such as an injection moulding process, and allowing the liquid first material to cool.

[0046] The part of the electrical cable that receives the second sealing member is placed into a second mould. The second part is moulded onto the cable, for example by melting a second solid material in the mould, or by an injecting the second material into the mould when in a liquid state, such as an injection moulding process, and allowing the liquid second material to cool.

[0047] The first and second materials can be similar, or dissimilar.

[0048] In preferred embodiments the first sealing member is formed from a different material from the second sealing member. For example, the first sealing member includes nylon. The second sealing member includes silicone.

[0049] Advantageously the second sealing member is moulded at least partly over the first sealing member. The second sealing member seals the bonded wire sections to the first sealing member. For this embodiment, it is the second sealing member that is typically sized and shaped to seal against the casing. It has been found in some applications that the second sealing member forms a better bond with the first sealing member than with the outer sheath of the electrical cable.

[0050] Advantageously the method includes the step of treating at least some of the surfaces to be over mould-

ed with a primer. This improves the bond between the sealing member and the surfaces on which the sealing member is moulded. The primer is selected according to the moulding material.

[0051] Advantageously the method includes providing a formation in the sealing member which indicates the electrical polarity of at least one of the wires. This helps a worker in the assembly process to wire the light source to a power supply with the correct polarity.

[0052] Advantageously the method includes inserting a lens device into the first part of the casing. The lens device can be mounted on a PCB.

[0053] Advantageously the method includes sealing the first opening using at least one of an annular seal, trim element and transparent panel.

[0054] According to another aspect of the invention there is provided a method for manufacturing a lighting unit, said method including: providing at least one solid state lighting device, an electrical cable for electrically connecting the or each solid state lighting device to a power source, and a casing including a first part for housing the solid state lighting device and a second part for housing at least a part of the electrical cable, wherein the electrical cable includes an outer sheath and at least one multi-stranded electrical wire having an insulation sheath.

[0055] The method can include exposing a section of the multi-stranded wire; bonding the exposed strands together with a bonding agent, thereby forming a substantially solid wire section which substantially blocks the flow of fluids along the multi-stranded wire.

[0056] The method can include moulding at least one sealing member onto the electrical cable, said moulding step taking place outside of the casing and/or prior to the multi-stranded wire being electrically connected to the solid state lighting device.

[0057] The sealing member preferably forms a seal over at least part of the substantially solid wire section.

[0058] The sealing member preferably forms a seal over at least part of the insulating sheath.

[0059] The sealing member preferably forms a seal over at least part of the outer sheath.

[0060] The sealing member is arranged to substantially block the flow of fluids along gaps between the outer sheath and insulating sheath, and the insulating sheath and wire.

[0061] The method can include using the sealing member to form a seal with the second part of the casing.

[0062] According to another aspect of the invention there is provided a lighting unit. The lighting unit includes: a lighting device; a cable assembly including an electrical cable for electrically connecting the lighting device to a power source, the electrical cable including at least one multi-stranded electrical wire having an insulation sheath, wherein an exposed section of the multi-stranded wire includes strands that are bonded together with a bonding agent, thereby forming a substantially solid wire section which substantially blocks the flow of fluids along the multi-stranded wire, and a sealing member preformed onto the electrical cable, said sealing member overlying at least part of the substantially solid wire section and at least part of the insulating sheath, and is arranged to substantially block the flow of fluids along gaps between the insulating sheath and wire; and a casing for housing the lighting device and at least a part of the cable assembly.

[0063] Advantageously the sealing member may have a shape that is different from the interior shape of the second part of the second part of the casing. This is because the sealing member is pre-formed in a mould that is separate from the casing which provides flexibility to determine the shape of the sealing member. For example, the sealing member has first and second ends, wherein at least one of the first and second ends is profiled. In preferred embodiments, the first end is an innermost end, and the first end is profiled to support the cable.

[0064] Advantageously the lighting unit includes a second multi-stranded electrical wire having a second insulation sheath, the second electrical wire having a second exposed section of wire including strands that are bonded together with a bonding agent, thereby forming a substantially solid second wire section which substantially blocks the flow of fluids along the second multi-stranded wire. The sealing member overlies at least part of the substantially solid second wire section, and is arranged to substantially block the flow of fluids along gaps between the outer sheath and second insulating sheath, and the second insulating sheath and second wire.

[0065] Advantageously the electrical cable includes an outer sheath, wherein the sealing member overlies at least part of the outer sheath. The sealing member is arranged to substantially block the flow of fluids along gaps between any of: the first solid wire section; the second solid wire section; the first insulation sheath; the second insulation sheath; and the outer sheath.

[0066] Advantageously the wire bonding material comprises a metallic material, such as a solder.

[0067] Advantageously the sealing member includes at least one plastics material. The plastics material can include a thermoplastics material. The plastics material can include a polyamide such as nylon. The plastics material can include silicone. Other suitable materials can be used.

[0068] Advantageously the casing includes a first opening. In preferred embodiments the first opening is a front opening.

[0069] Advantageously the casing includes a second opening. In preferred embodiments the second opening is a rear opening.

[0070] Advantageously the lighting unit includes a heat sink member, arranged to dissipate heat from the lighting device. The heat sink member can comprise a plate. The lighting device is mounted on the heat sink plate. Heat generated by the lighting device is conducted into the heat sink plate. The plate is arranged transversely to a central axis of the lighting unit, and is in thermal connec-

tion with the casing. Heat is conducted from the heat sink plate to the casing.

[0071] Advantageously the cable assembly and heat sink member form a unit. In preferred embodiments, the cable assembly, heat sink member and lighting device form a unit. The unit can be inserted into the casing.

[0072] The casing includes a first part, such as a first compartment, for housing the lighting device. The casing includes a second part, such as a second compartment, for housing at least part of the cable. The first part is located in a front part of the lighting unit. The second part is located in a rear part of the lighting unit.

[0073] The first opening provides access to the first part. The second opening provides access to the second part.

[0074] Advantageously the sealing member is removably mounted to the casing. The sealing member is arranged to slide into and/or out of the casing.

[0075] Advantageously the lighting unit includes sealing means.

[0076] The sealing means can be arranged to prevent moisture from reaching the lighting device from the second opening.

[0077] Advantageously the sealing means forms a seal with the casing, and preferably with an internal surface of the casing.

[0078] Advantageously the sealing means includes the sealing member. Advantageously the sealing member forms a seal with the casing, and preferably with an internal surface of the casing.

[0079] Advantageously the sealing member includes at least one deformable ridge that engages the casing. The or each deformable ridge provides a good seal between the sealing member and the casing.

[0080] Advantageously the sealing means includes at least one intermediate sealing element, such as an O-ring, for sealing the sealing member to the casing.

[0081] Advantageously the intermediate sealing element is seated in a recess, such as a circumferential groove, formed in at least one of the casing and the sealing member.

[0082] Advantageously the sealing member is in the form of a bung. The bung can be at least partly located with the second part of the casing.

[0083] Advantageously the sealing member substantially fills the second part of the casing, or at least fills a substantial part thereof.

[0084] Advantageously the sealing member includes first and second parts. In preferred embodiments the second part is moulded over at least a section of the first part. The first part of the sealing member can be formed from a different material from the second part of the sealing member.

[0085] Advantageously the sealing member includes a formation which indicates the electrical polarity of at least one of the wires.

[0086] Advantageously the sealing member includes a tail portion that protrudes from the casing. This provides mechanical strength between the cable, the seal and the casing.

[0087] Advantageously the sealing member is resilient, or at least includes a resilient part.

[0088] Advantageously the lighting device includes a solid state lighting device. In preferred embodiments the solid state lighting device includes a plurality of LEDs and a PCB.

[0089] The solid state lighting device is mounted in thermal contact with the casing, and the casing acts as a heat sink for the solid state lighting device. For example, the solid state lighting device can be mounted in thermal contact with the heat sink plate, which itself is in thermal contact with the casing. The arrangement is such that heat generated by the LEDs is conducted into the casing, and is then transferred to the environment by conduction and/or convection. The casing typically includes a material that is thermally conductive, such as aluminium or copper. This helps to dissipate heat from the solid state lighting device quickly and efficiently. Alternatively the casing can be made from steel, which has good fire resistance qualities, and preferably stainless steel, which resists corrosion.

[0090] Advantageously the casing includes a partition and the first and second parts of the casing are separated by the partition. In some embodiments, the casing includes a tubular body, and the heat sink plate, when located in-situ, partitions the tubular body into front and rear compartments. In other embodiments, the casing includes an integral member, which partitions the casing into first and second compartments.

[0091] The partition includes at least one through hole, and the or each electrical wire protrudes through the hole(s), and is electrically connected to the lighting device. The sealing member seals the or each hole in the partition by sealing against the second part of the casing.

[0092] Advantageously the solid state lighting device is mounted on the partition. This provides a thermally conductive pathway between the LEDs and at least one side wall of the casing.

[0093] Advantageously the lighting unit includes a lens device located in the first part of the casing.

[0094] The first opening is sealed by at least one of an annular seal, trim element and transparent panel.

[0095] In some embodiments the second part of the casing includes an internal housing, and the sealing member is at least partly located within the internal housing. Using an internal housing reduces the size of the sealing member and increasing the surface area of the casing, which improves its ability to dissipate heat to the environment. The internal housing is aligned with the hole(s) formed in the partition. The sealing member forms a seal with the internal housing, and preferably with at least one internal surface of the internal housing. In preferred embodiments the internal housing is substantially cylindrical, or substantially frusto-conical. The internal housing is aligned substantially coaxially with a central axis of the lightning unit. The sealing member substan-

tially fills the internal housing. The internal housing has a smaller diameter, or width for non-cylindrical internal housings, than the second part of the casing. The internal housing is open at both ends.

[0096] According to another aspect of the invention there is provided a method for manufacturing a lighting unit, including: providing a lighting device, an electrical cable including at least one electrical wire having an insulation sheath, and a casing for housing the lighting device and at least a part of the electrical cable; and forming at least one sealing member onto the electrical cable. Advantageously the sealing member is arranged to form a seal with the casing.

[0097] Embodiments of the invention will now be described by way of example only with reference to the drawings, wherein:

Figure 1 is a diagrammatic end view of a known an electric cable including two multi-stranded copper wires;

Figure 2 is a diagrammatic sectional view of a prior art lighting unit illustrating air being forced out of the unit along the cable of Figure 1 when the light is operated;

Figure 3 is a diagrammatic sectional view of the prior art lighting unit of Figure 2 illustrating air being sucked into the unit along the cable when the light is switched off;

Figure 4 is a sectional view of a lighting unit in accordance with a first embodiment of the invention;

Figure 5 is a sectional view of part of an electrical cable having a bung mounted thereon, which is used in the first embodiment of the invention;

Figure 6 is an end view of the arrangement shown in Figure 5;

Figure 7 is a sectional view of part of an electrical cable, having part of a bung mounted thereon, which is used in a second embodiment of the invention;

Figure 8 is an end view of the arrangement shown in Figure 7;

Figure 9 is a sectional view of the part of the electrical cable shown in Figure 7, having a fully formed bung mounted thereon, which is used in the second embodiment of the invention;

Figure 10 is an end view of the arrangement shown in Figure 9;

Figure 11 is a sectional view of a third embodiment of the invention;

Figure 12 is an isometric view of a bung used in the third embodiment;

Figure 13 is a simplified sectional view of the bung of Figure 12;

Figure 14 is a sectional view of a fourth embodiment of the invention;

Figure 15 is an enlarged sectional view of the bung of Figure 14;

Figure 16 is a sectional view of a fifth embodiment of the invention; and

Figure 17 is an enlarged sectional view of the bung of Figure 146.

[0098] A first embodiment of the invention is shown in Figures 4 to 6. Figure 4 shows a lighting unit 101, including: a solid state lighting unit 103, which includes a plurality of Light Emitting Diodes (LEDs) 105 and a Printed Circuit Board (PCB) 107; a casing 109 having a light source compartment 111 for housing the solid state lighting unit 103 and a cable receiving compartment 113 for housing part of an electrical the cable 1; a lens device 117; a transparent panel 119; a trim element 121; and a sealing member in the form of a bung 123 for sealing the cable receiving compartment 113.

[0099] The light source compartment 111 is defined by the side wall(s) 109a of the casing, the transparent panel 119, which is typically glass or a plastics material, and a partition 125, which is preferably formed integrally with the casing 109. The trim element 121 and transparent panel 119 substantially seal the front part of the casing 109. Typically, an annular seal 110 is provided between at least one of the trim element 121 and the transparent panel 119; the trim element 121 and the side wall 109a of the casing; and the transparent panel 119 and the side wall of the casing 109a.

[0100] The solid state lighting unit 103 and lens device 117 are located within the light source compartment 111. The solid state lighting unit 103 is mounted on the partition 125, and the lens device 117 is mounted on the solid state lighting unit.

[0101] The casing 109, is preferably made from a material that has good thermal conductivity properties, such as aluminium, thereby enabling the casing 109 to act as a heat sink for the solid state lighting unit 103. Thus heat generated, in use, by the solid state lighting device 103 is transferred by conduction through the partition 125 into the side wall(s) of the casing 109a.

[0102] The cable receiving compartment 113 is located on the other side of the partition 125. A short section of the cable 1 is housed within the cable receiving compartment 113. The bung 123 seals an opening at the rear end 113b of the cable receiving compartment 113.

[0103] The electrical cable 1 is similar to the prior art

cable shown in Figure 1. It includes a flexible outer sheath 5, two multi-stranded wires 7a,7b, each wire 7a,7b having multiple strands 9 of copper wire and a flexible insulating sheath 11a,11b. It can be seen from Figure 1 that there are gaps 13 between the strands 9 of copper wire, and gaps 15 between the insulating sheaths 11a,11b and the flexible outer sheath 5. Each wire 7a,7b has been treated by removing a section of the insulating sheath 11a,11b at one end and applying a filling material, such as a solder 129 (a so called "tinning process"), to the multiple strands 9 in a molten state. The solder 129 flows into the gaps 13 between the strands 9 and solidifies, thereby bonding the strands 9 together to produce a substantially solid wire along at least part of the exposed section of the wire. The purpose of soldering the strands 9 together is to block the flow of air and moisture along the gaps 13 between the strands 9 of wire. Thus overall the electrical cable 101 retains its flexibility, while at the same times includes means for blocking the flow of moisture into the lighting unit 101.

[0104] At least one hole 127 is formed through the partition 125. The wires 7a,7b protrude through the hole 127 in the partition and are electrically connected to the solid state lighting unit 103, typically to the PCB 107. Preferably, the hole 127 is formed through a central region of the partition 125.

[0105] The bung 123 is resilient. It is made from a mouldable material that is capable of forming a seal with the casing 109 when the bung 123 is located at least partly within the cable receiving compartment 113. For example, the bung 123 can be made from a plastics material such as silicone.

[0106] The bung 123 is formed on the cable 1 via a moulding process such that it overlies at least part of each bonded wire 7a,7b section and part of at least one of the insulating sheaths 11a,11b and the outer sheath 5. For example, Figures 4 and 5 show the bung 123 moulded over each of the bonded wire 7a,7b sections, insulating sheaths 11a,11b and outer sheath 5. The bung 123 prevents air from entering the light source compartment 111 since it blocks air from travelling along the gaps 13,15 in the cable 1. Providing the bung 123 is this manner provides better control of the wires 7a,7b, which helps to ensure separation of the wires 7a,7b so that no short circuits can occur.

[0107] The bung 123 comprises a body at least a part of which is arranged to substantially conform with at least part of the of the cable receiving compartment 113. The bung 123 is pushed into the cable receiving compartment 113 with cable 1, since the bung 123 is formed outside of the casing 109. The bung is pushed in through an opening 109a at a rear end 109b of the casing.

[0108] The bung 123 substantially fills the cable receiving compartment 113. In the embodiment shown in the Figures, the body includes a substantially cylindrical portion 123a which substantially fills the cable receiving compartment 113. The cylindrical part 123a includes peripheral ridges 131, such as circumferential ridges, that extend around a side wall of the bung 123. The ridges 131 are arranged to resiliently deform when the bung 123 is inserted into the cable receiving compartment 113, thereby providing a tight fit and effective seal with the casing. The ridges 131 are arranged substantially coaxially. The ridges 131 are axially spaced from one another.

[0109] The bung 123 also includes a tail portion 123b, which overlies a portion of the cable 1 that protrudes from the cable receiving compartment 113. The tail portion 123b is provided for mechanical purposes.

[0110] Optionally the bung 123 can include three portions 133 of black silicone material (see Figures 5 and 6). Each portion 133 is located in a respective slot, which is formed in the bung 123. The black silicone helps to retain the bung 123 in the casing.

[0111] The bung 123 includes a protrusion 135 around the cable 7a, which indicates that that cable 7a is the electrically "live" cable.

[0112] Two mounting wings 136 are attached to an outer surface of the casing 109. The wings 136 are used to fix the lighting unit to a body, such as a wall, ceiling or floor.

[0113] The process for manufacturing the lighting unit 101, includes at least some of the following steps:

A. Removing a section of the outer sheath 5 of the electrical cable 1 to expose sections of the two multi-stranded wires 7a,7b;

B. For each multi-stranded wire 7a,7b, removing a section of insulating sheath 11a,11b to expose the copper strands 9;

C. For each multi-stranded wire 7a,7b, over a relatively short length of wire, filling the gaps between the strands 9 by bonding the exposed strands together to form a substantially solid section of wire. The filler material is typically a low viscosity material that can easily flow into the gaps 13 between the strands and solidifies in-situ. For example, a solder can be used;

D. Optionally, applying a primer 137, such as a silicone primer, to part of electrical cable 1 which is to be over moulded, which typically includes parts of the wires 7a,7b, insulating sheaths 11a,11b and outer sheath 5;

E. Inserting a part of the cable 1, which is to be over moulded into a mould, this typically includes parts of the: bonded sections of the wires 7a,7b; insulating sheaths 11a,11b; and outer sheath 5. Inserting a material into the mould, such as silicone, in solid form and heating the mould to melt the material. Alternatively the material can be inserted into the mould in liquid form, for example by using an injection moulding process. Allowing the material to solidify by nat-

ural cooling, or by actively cooling the mould, to form the bung 123 around that part of the cable 1. The bung 123 forms a seal to prevent moisture ingress into the gaps 13,15. This provides a controlled and neat way of sealing around the cable 1. It is to be noted that the mould is separate from the casing 109. Thus the bung 123 is formed outside of the casing 109 prior to sealing the opening 113a;

F. Inserting at least part of the bung 123 into the opening 113a at the rear of the cable receiving compartment 113, thereby sealing the compartment 113. The arrangement is such that exposed parts of the wires 7a,7b protrude through the hole 127;

G. Inserting the solid state lighting unit 103 into the light source compartment 111.

H. Electrically connecting the wires 7a,7b to the PCB 107, trimming the wires 7a,7b as required;

I. Inserting the lens device 117 into light source compartment 111; and

J. Attaching the seal 110, trim element 121 and transparent panel 119 to the casing 109, to seal the front of the lighting unit.

[0114] It will be appreciated by the skilled person that strict adherence to the order of these steps is not required for some lighting units.

[0115] A second embodiment of the invention is shown in Figures 7 to 10. In the second embodiment is similar to the first embodiment except that the bung 223 is formed by a plurality of moulding processes, which produces a bung 223 having at least first and second parts 225,227.

[0116] The first part 225 of the bung is preferably moulded from nylon. The first part 225 seals the solid sections of wire 7a,7b to the insulation sheaths 11a,11b and outer sheath 5.

[0117] The second part 227 of the bung is preferably moulded from silicone, and is formed such that it lies over at least a section of the first part 225 of the bung, and parts of the multi-stranded wires 7a,7b. The inventor has discovered that for some applications a better bung 223 is formed by the two step moulding process. In particular, a better bond is made with the cable 1, thereby producing a more effective seal. It has been found that the silicone second part 227 can form a better bond with the nylon first part 225 than the outer sheath 5.

[0118] Typically, the first part 225 of the bung, is smaller than the second part of the bung 227. The first part 225 part of the bung typically includes a formation 235 on the electrically "live" wire 7a to help identify that wire when undertaking the second moulding process.

[0119] The method of manufacturing the lighting device outlined with reference to the first embodiment is also applicable to the second embodiment except that:

method step D above is replaced by the following:

optionally, applying a primer 236, such as a nylon primer, to part of electrical cable 1 which is to be over moulded, which typically includes parts of the wires 7a,7b, insulating sheaths 11a,11b and outer sheath 5; and

method step E above is replaced by the following:

1) Inserting a part of the cable 1, which is to be over moulded, into a first mould, this typically includes parts of the: bonded sections of the wires 7a,7b; insulating sheaths 11a,11b; and outer sheath 5. Inserting a first material into the first mould, such as nylon, in solid form and heating the mould to melt the first material. Alternatively the first material can be inserted into the mould in liquid form, for example by using an injection moulding process. Allowing the first material to solidify by natural cooling, or by actively cooling the first mould to form the first part 225 of the bung around that part of the cable 1 (see Figures 7 and 8). The first part of the bung 225 forms an initial seal to prevent moisture ingress into the gaps 13,15. This provides a controlled and neat way of sealing around the cable 1. It is to be noted that the first mould is separate from the casing 109. Thus the first part 225 of the bung is formed outside of the casing 109 prior to sealing the opening 113a.

2) Optionally, applying a primer 237, such as a silicone primer, to part of electrical cable 1 and/or the first part 225 of the bung, which is to be over moulded in the second moulding process;

3) Inserting the part of the cable 1 which is to be over moulded into a second mould, this typically includes parts of the: wires 7a,7b (bonded sections); insulating sheaths 11a,11b; outer sheath 5; and first part of the bung 225. Inserting a second material into the second mould, such as silicone, in solid form and heating the mould to melt the second material. Alternatively the second material can be inserted into the second mould in liquid form, for example by using an injection moulding process. Allowing the second material to solidify by natural cooling, or by actively cooling the second mould to form the second part 225 of the bung. The second part 227 of the bung overlies at least part of the first part 225 of the bung. It is to be noted that the second mould is separate from the casing 109. Thus the second part of the sealing member is formed

outside of the casing 109 prior to sealing the opening 113a.

[0120] A third embodiment is shown in Figures 11 to 13. Figure 11 shows a lighting unit 301, including: a solid state lighting unit 303, which includes a plurality of LEDs 305 and a PCB 307; a casing 309 having a light source compartment 311 for housing the solid state lighting unit 303, a cable receiving compartment 313 for housing part of an electrical the cable 1, and a partition 325 which separates the compartments 311,313; a lens device 317; a transparent panel 319; a trim element 321; annular seal 310; two mounting wings 326; a thermal pad 328 and/or paste between the PCB 307 and partition 325; and a sealing member in the form of a bung 323 for sealing the cable receiving compartment 313.

[0121] In the third embodiment the bung 323 has a different shape from the bung 123, and the cable receiving compartment 313 has a stepped profile, there being a first portion having a diameter D1 and a second portion having a diameter D2, wherein D2 is larger than D1 and is located towards the second opening 313a. The stepped arrangement provides a shoulder which limits movement of the sealing member 323 into the casing 309. Furthermore, the casing 309 is made from a plurality of parts.

[0122] The bung 323 has a first substantially cylindrical portion 323a, which fills approximately half the volume of the cable receiving compartment 313. The first cylindrical portion 323a has a diameter that is approximately equal to, typically slightly larger, than diameter D2. The bung 323 includes an inner end 323b, which is profiled. The inner end 323b includes a second cylindrical portion 323c that protrudes substantially perpendicularly from an end face 323d of the first cylindrical portion 323a. The second cylindrical portion 323c overlies exposed parts of the cables, forming a seal therewith, and supports the cables. There is typically a small gap between an end face 323e of the second cylindrical portion 323 and the partition 325. Four webs 323f support the second cylindrical portion 323c. The profiled arrangement provides a space within the cable receiving compartment 513. The space provides a larger volume in which heated air can expand. It also reduces the weight of the lighting unit.

[0123] The first cylindrical part 223a includes peripheral ridges 331 (circumferential ridges, in this case) that extend around a side wall of the bung 323. The ridges 331 are arranged to resiliently deform when the bung 323 is inserted into the cable receiving compartment 313, thereby providing a tight fit and effective seal with the casing. The ridges 331 are arranged substantially co-axially. The ridges 331 are axially spaced from one another.

[0124] The bung 323 includes a protrusion 335 around the cable 7a, which indicates that that cable 7a is the electrically "live" cable.

[0125] A lighting unit according to the third embodiment is manufactured by a similar method described above in relation to the first embodiment.

[0126] A lighting unit 401 in accordance with a fourth embodiment of the invention is shown if Figures 14 and 15. The lighting unit 401, including: a solid state lighting unit 403, which includes a plurality of LEDs 405 and a PCB 407; a casing 409 having a light source compartment 411 for housing the solid state lighting unit 403 and a cable receiving compartment 413 for housing part of an electrical the cable 1; a lens device 417; a transparent panel 419; a trim element 421; and a sealing member in the form of a bung 423 for sealing the cable receiving compartment 413.

[0127] The bung 423 has a different shape from the bung 123, and is arranged to fit within a housing 424 located within the cable receiving compartment 413. The housing 424 is located centrally within the cable receiving compartment 413, and is arranged substantially co-axially with a central axis of the lighting unit. The housing 424 can be of any suitable shape, for example can have a polygonal cross-section, however it is preferred to have a substantially hollow cylindrical, or frusto-conical, form, which is open at each end. The housing 424 includes a shoulder portion 426 on which a shoulder portion 423a of the bung is seated. The internal diameter, or width, of the housing 424 adjacent the solid state lighting unit 403 is smaller than the internal diameter, or width of the housing 424 adjacent outer end of the casing.

[0128] Since the bung 423 is arranged to seal with the housing 424 rather than the side walls of the casing, the bung 423 is much smaller than in the other embodiments. The bung 423 has a tail portion 423b which protrudes out of the housing 423.

[0129] The outer surface(s) of the side wall(s) 424a of the housing taper from a broader base 424b, to a narrower outer end 424c.

[0130] An advantage of the housing 424 is that it improves the ability of the casing 409 to act as a heat sink for the solid state lighting unit 403, since it increases the surface area of casing 409 available to transfer heat to the environment.

[0131] A lighting unit according to the fourth embodiment is manufactured by a similar method described above in relation to the first embodiment.

[0132] A lighting unit 501 in accordance with a fifth embodiment of the invention is shown in Figures 16 and 17. The lighting unit 501, includes: a solid state lighting unit 503, which includes a plurality of LEDs 505 and a PCB 507; a casing 509; a lens device 517; a transparent panel 519; a trim element 521; a sealing member in the form of a bung 523 and a heat sink plate 525.

[0133] The casing 509 comprises a tubular body. The casing 509 includes a front part having a first internal diameter θ_1, or internal width, and a rear part having a second internal diameter θ_2, or internal width. The first internal diameter θ_1, or internal width, is larger than the second internal diameter θ_2, or internal width. A shoulder 512, or step, is located at the boundary between the front and rear parts.

[0134] The casing 509 has a front, light emitting, opening 509a at a first end 509b. The casing 509 has a rear opening 509c at a second end 509d. The casing 509 includes a lip 509e at the rear opening 509c.

[0135] A heat sink plate 525 is seated on the shoulder 512 and is arranged transversely to the longitudinal axis of the casing. The heat sink plate 525 forms the front part of the casing into a light source compartment 511 and the rear part of the casing into a cable receiving compartment 513. The heat sink plate 525, is typically made from a thermally conductive material, for example may include at least one of aluminium and copper.

[0136] The solid state lighting unit 503 is mounted on the heat sink plate 525. The solid state lighting unit 503 is mounted to a surface of the plate 525, which faces towards the front opening 509a. In use, heat generated by the LEDs 505 is conducted through the PCB 507, into the heat sink plate 525, and into the casing 509.

[0137] The heat sink plate 525 includes first and second holes 527a,527b formed through the plate. The wires 7a,7b protrude through the holes 527a,527b respectively and are electrically connected to the PCB 507.

[0138] The bung 523 is located in the cable receiving compartment 513. The bung 523 has a similar shape to the bung 423 in the fourth embodiment, however the bung 523 is sized and shaped to fill a substantial part of the cable receiving compartment 513. The outer diameter, or outer width, of the bung is substantially equal to the internal diameter θ_2, or internal width, of the cable receiving compartment, and has a tight fit therewith.

[0139] First and second circumferential grooves 539a,539b are formed in an outer surface of the bung 523. A first O-ring 541a is seated in the first groove 539a. A second O-ring 541b is seated in the second groove 539b. The O-rings 541a,541b sealingly engage with an internal surface of the casing 509 to seal the cable receiving compartment 513. Preferably each O-ring 541a,541b is made from Nitrile Butadiene Rubber (NBR).

[0140] The bung 523 has a narrow front end 523c, which engages a face of the heat sink plate 525 that faces towards the rear opening 509c. A space is provided between the narrow front end 523c and an internal surface of the casing. The space provides a volume for heated air to expand in, when the lighting unit is in use. It also reduces the weight of the lighting unit.

[0141] The bung 523 has a tail portion 523b which protrudes out of the housing 523.A rear portion 523c of the bung is recessed to accommodate the lip 509e.

[0142] The bung 523 is made from a thermoplastic, and preferably includes a polyamide.

[0143] The lens device 517 is mounted in the light source compartment 513. The trim element 521, which includes the transparent panel 519, is sealing attached to the casing 509 at the front of the lighting unit.

[0144] A lighting unit according to the fifth embodiment is manufactured in the following way:

A. Removing a section of the outer sheath 5 of the electrical cable 1 to expose sections of the two multi-stranded wires 7a,7b;

B. For each multi-stranded wire 7a,7b, removing a section of insulating sheath 11a,11b to expose the copper strands 9;

C. For each multi-stranded wire 7a,7b, over a relatively short length of wire, filling the gaps between the strands 9 by bonding the exposed strands together to form a substantially solid section of wire. The filler material is typically a low viscosity material that can easily flow into the gaps 13 between the strands and solidifies in-situ. For example, a solder flux can be used (so-called tinning process). Preferably the ends of the cable are dipped into solder flux to tin the ends;

D. Inserting a part of the cable 1, which is to be over moulded into a mould, this typically includes parts of the wires 7a,7b having the bonded sections; insulating sheaths 11a,11b; and outer sheath 5. Inserting a material into the mould, for example a thermoplastic such as a polyamide. The material can be inserted into the mould in solid form and the mould is heated to melt the material. Alternatively, the material can be inserted into the mould in liquid form, for example by using an injection moulding process. The material is allowed to solidify by natural cooling, or by actively cooling the mould, to form the bung 523 around that part of the cable 1. The bung 523 forms a seal to prevent moisture ingress into the gaps 13,15. The bung 523 and cable 1 form a cable assembly. This provides a controlled and neat way of sealing around the cable 1. It is to be noted that the mould is separate from the casing 509. Thus the bung 523 is formed outside of the casing 509 prior to sealing the opening 513a;

E. Removing the bung 523 and cable 1 from the mould;

F. Placing the O-rings 541a,541b into their respective grooves 539a,593b. The O-rings 541a,541b snap-fit into place.

G. The heat sink plate 525, is placed on the front end of the bung 523.

H. A thermal pad and/or thermal grease is applied to the front surface of the heat sink plate 525.

I. The solid state lighting unit 503, which includes the PCB 507 and LEDs 505 is mounted on the plate 525 over the thermal pad and/or thermal grease.

J. The tinned wires 7a,7b are trimmed, if necessary, threaded through their respective holes 527a,527b

and are soldered to the PCB 507. This forms a unit 550 including the solid state lighting unit 503, heat sink plate 525, cable 1, bung 523 and O-rings 541a,541b.

K. The unit 550 is then inserted into the casing 509. Insertion takes place from front to rear (see Figure 17). The bung 523 is inserted through the front opening 509a and is pushed and/or pulled through the first part of the casing into the second part of the casing, until the heat sink plate 525 engages the shoulder 512.

L. The heat sink plate 525 is punched into its seated position on the shoulder 512. The punching operation forces plate material outwards into tight engagement with the casing 509. This fixes the position of the plate 525 with respect to the casing 509;

M. The lens device 517 is inserted into light source compartment 511 via the front opening 509a; and

N. The trim element 521 having a seal 510 and transparent panel 519 is applied to the casing 509, to seal the front of the lighting unit 501.

[0145] It will be appreciated by the skilled person that modifications can be made to the above embodiments that fall within the scope of the invention, for example the transparent panel is not strictly necessary. The lens device can be arranged in a manner that enables a front part of the lens device to form a seal with the trim element.

[0146] The bung can be moulded to any required shape. For example, the bung may include a substantially cuboid portion, or any other polygonal form required. The bung can also be moulded to fit irregular shapes, according to the form of cable receiving compartment.

[0147] The cable can include any suitable number of wires required for the application. The electrical cable 1 may not include an outer sheath 5, in which case seals are formed between the exposed section of wire and the insulating sheath 11a,11b.

[0148] Light sources other than LED type lights can be used in the invention. However LEDs are used in preferred embodiments.

[0149] The casing is shown as having a circular cross-section and therefore being substantially cylindrical in shape, however the casing may comprise any other practicable shape, for example substantially cuboid. The shape of the bung is moulded accordingly.

[0150] Other materials can be used to manufacture the bung. The main characteristic is that an effective seal has to be made with the cable and the casing. Mouldable materials having rubber like properties are most preferable. These can be natural materials such as natural rubber or synthetic materials such as an elastomer.

[0151] An inner surface of the casing can include circumferential grooves to receive the circumferential ridges formed in the sealing member. If a non-cylindrical casing is provided, for example one having a square cross-section, the inner walls of the casing includes peripheral grooves that extend around the four walls.

[0152] In some embodiments, the sealing member is releasably attachable to the casing so that the sealing member can be removed.

[0153] Additionally, or alternatively, grooves can be formed in the casing to receive the O-rings, and preferably an inner face of the casing.

Claims

1. A method for manufacturing a lighting unit (501), including: providing a lighting device (503), an electrical cable (1) including at least one multi-stranded electrical wire (7a,7b) having an insulation sheath (11a,11b) and a casing (509) for housing the lighting device (503) and at least a part of the electrical cable (1); forming a cable assembly by exposing a section of the multi-stranded electrical wire (7a,7b); bonding the exposed strands (9) together with a bonding agent (529), thereby forming a substantially solid wire section which substantially blocks the flow of fluids along the multi-stranded wire (7a,7b); placing at least part of the electrical cable (1) into a mould; and moulding at least one sealing member (523) onto the electrical cable (1) over at least a part of the exposed wire and at least a part of the insulating sheath (11a,11b), thereby sealing the substantially solid wire section to the insulation sheath (11a,11b); removing the cable assembly from the mould and assembling together the cable assembly and casing (509).

2. A method according to claim 1, including inserting at least part of the sealing member (523) into the casing (509).

3. A method according to claim 1 or 2, including attaching a heat sink member (525) to the cable assembly; and preferably the heat sink member (525) is attached to the cable assembly prior to assembling the sealing member (523) with the casing (509).

4. A method according to claim 3, wherein the heat sink member (525) comprises a plate, and inserting the plate into the casing (509) such that the plate is arranged transversely to a central axis of the lighting unit.

5. A method according to claim 4, including mounting the lighting device (503) on the heat sink plate (525); and preferably the lighting device (503) is mounted on the heat sink plate (525) prior to assembly the sealing member (523) with the casing.

6. A method according to any one of the preceding claims, wherein the casing (509) includes a first opening (509a) and inserting at least one of the sealing member (523) and the heat sink member (525) into the casing (509) through the first opening (509c); and preferably inserting the sealing member (523) and heat sink member (525) into the casing (509) as a unit (550).

7. A method according to any one of the preceding claims, wherein the casing (509) includes a second opening (509c).

8. A method according to any one of the preceding claims, wherein the casing (509) includes a first part for housing the lighting device (503) and a second part for housing at least part of the cable assembly; and preferably the sealing member (523) is sized and shaped to fill a substantial part of the second part of the casing.

9. A method according to any one of the preceding claims, including using the sealing member (523) to form a seal with the casing (509); and preferably the sealing member (523) is in the form of a bung.

10. A method according to any one of the preceding claims, including forming at least one deformable ridge (131) in a wall of the sealing member that is arranged to engage the casing (103).

11. A method according to any one of the preceding claims, including providing at least one intermediate sealing element (541a,541b), and using the or each intermediate sealing element (541a,541b) to form a seal between the sealing member (523) and the casing (509); and the intermediate sealing element (541a,541b) comprises an O-ring.

12. A method according to claim 10 or 11, including forming a recess (539a,539b) in at least one of the casing (509) and the sealing member (523), and locating the intermediate sealing element (541a,541b) in the recess (539a,539b); and preferably the recess comprises a circumferential groove.

13. A method according to any one of the preceding claims, wherein the electrical cable (1) includes a second multi-stranded electrical wire (7a,7b) having a second insulation sheath (11a,11b), and the method includes exposing a second section of the second multi-stranded wire (7a,7b); bonding the exposed strands together with a bonding agent (529), thereby forming a second substantially solid wire section which substantially blocks the flow of fluids along the second multi-stranded wire (7a,7b); and moulding the sealing member (523) onto the electrical cable (1) to seal the second substantially solid wire section to the second insulating sheath (11a,11b); and preferably the electrical cable (1) includes an outer sheath (5), and the method includes the sealing member sealing the outer sheath (5) to at least one of: the first substantially solid wire section; the second substantially solid wire section; the first insulation sheath (11a,11b); and the second insulation sheath (11a,11b).

14. A method according to any one of the preceding claims, wherein the bonding agent (529) includes a metallic material; and preferably the bonding agent (529) includes solder.

15. A method according to any one of the preceding claims, wherein the sealing member (523) is moulded from: a plastics material, natural rubber or synthetic materials having rubber like-properties.

16. A method according to any one of the preceding claims, wherein moulding the sealing member (223) onto the electrical cable (1) includes at least first and second moulding processes; and preferably the first moulding process produces a first sealing member (225) and the second moulding process produces a second sealing member (227).

17. A method according to any one of the preceding claims, including providing a formation (135) in the sealing member which indicates the electrical polarity of at least one of the wires.

18. A lighting unit (501), including: a lighting device (503); a cable assembly including an electrical cable (1) for electrically connecting the lighting device (503) to a power source, the electrical cable (1) including at least one multi-stranded electrical wire (7a,7b) having an insulation sheath (11a,11b), wherein an exposed section of the multi-stranded wire (7a,7b) includes strands (9) that are bonded together with a bonding agent (529), thereby forming a substantially solid wire section which substantially blocks the flow of fluids along the multi-stranded wire (7a,7b), and a sealing member (523) pre-formed onto the electrical cable (1), said sealing member (523) overlying at least part of the substantially solid wire section and at least part of the insulating sheath (11a,11b), and is arranged to substantially block the flow of fluids along gaps (13) between the insulating sheath (11a,11b) and wire (7a,7b); and a casing (509) for housing the lighting device (503) and at least a part of the cable assembly.

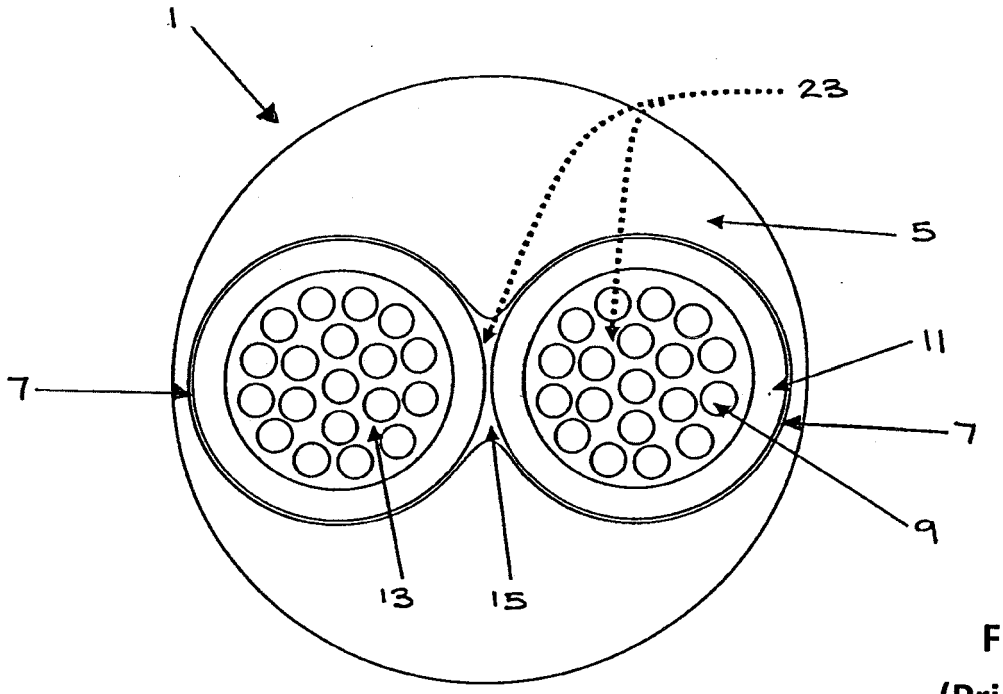

Fig. 1
(Prior Art)

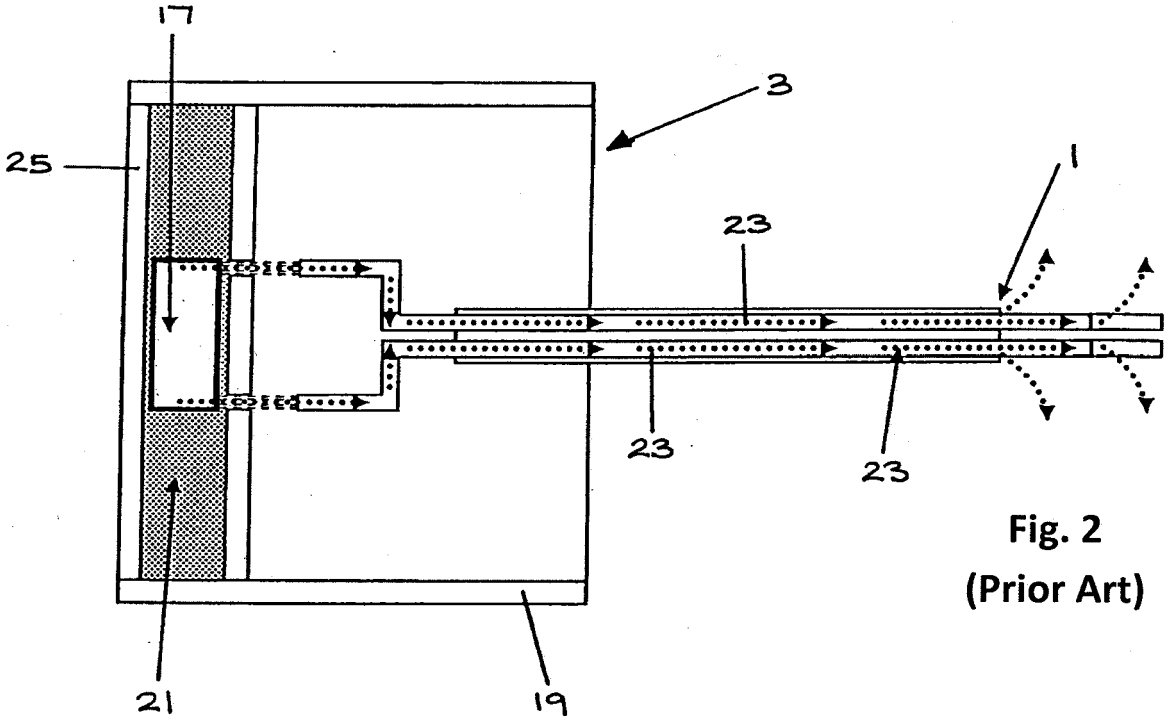

Fig. 2
(Prior Art)

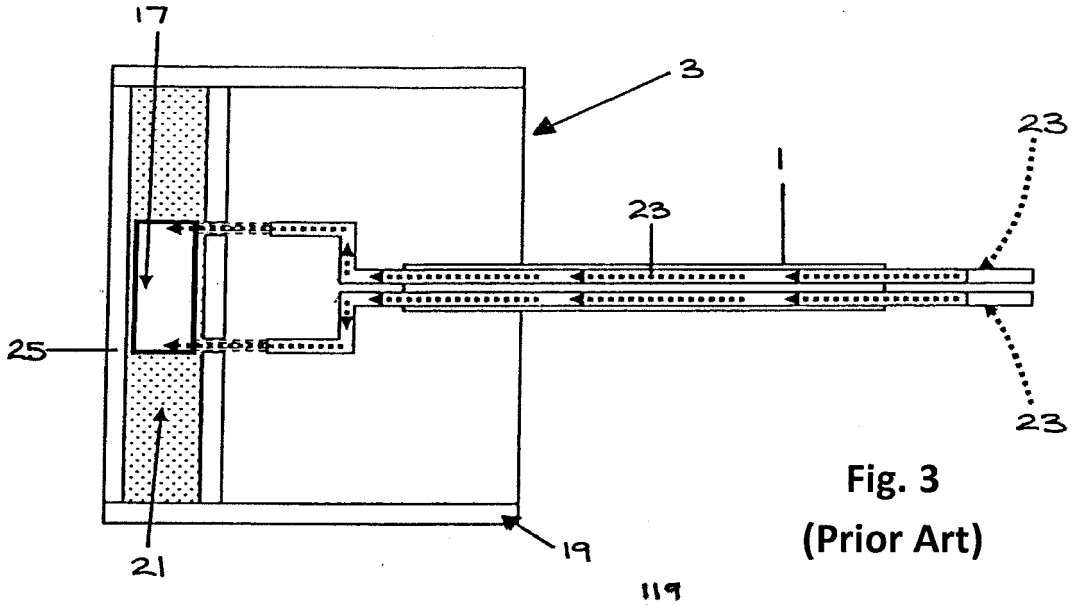

Fig. 3
(Prior Art)

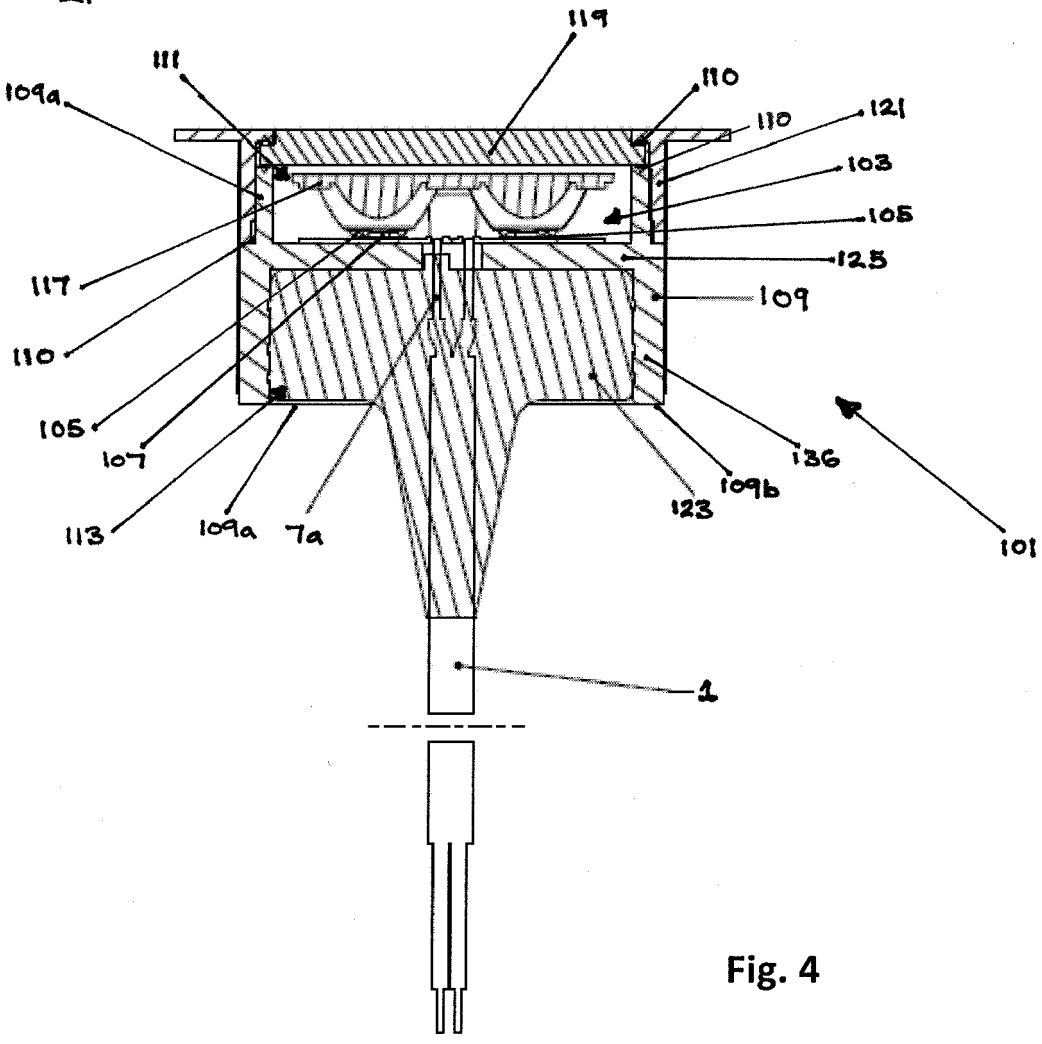

Fig. 4

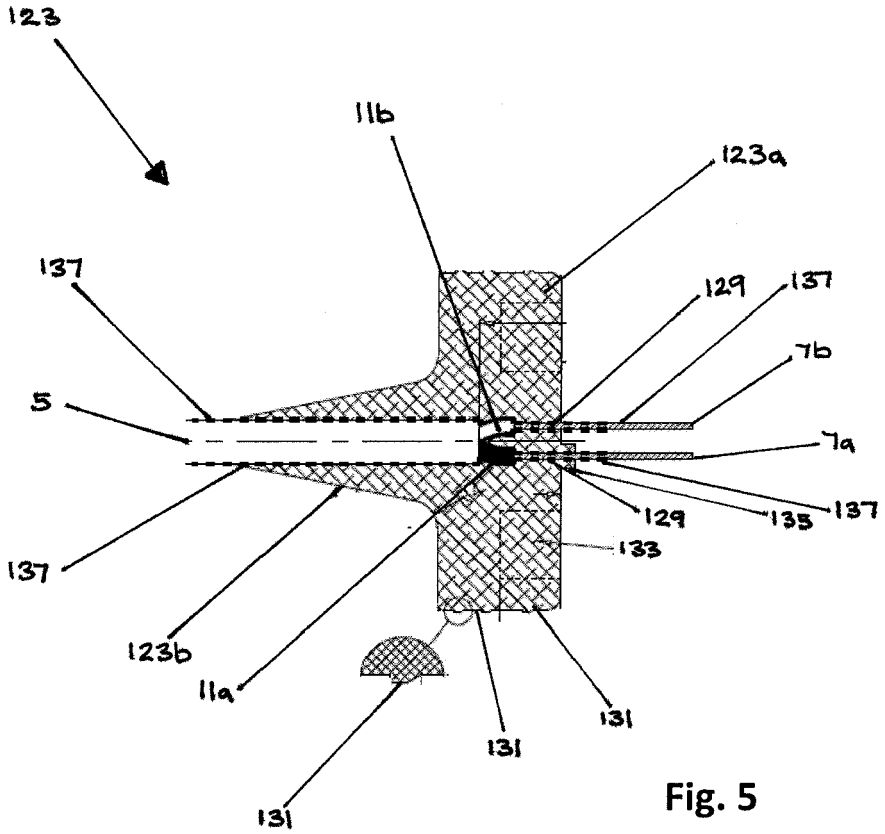
123
11b
123a
137
129
137
7b
5
7a
137
129
135
137
133
123b
11a
131
131
131

Fig. 5

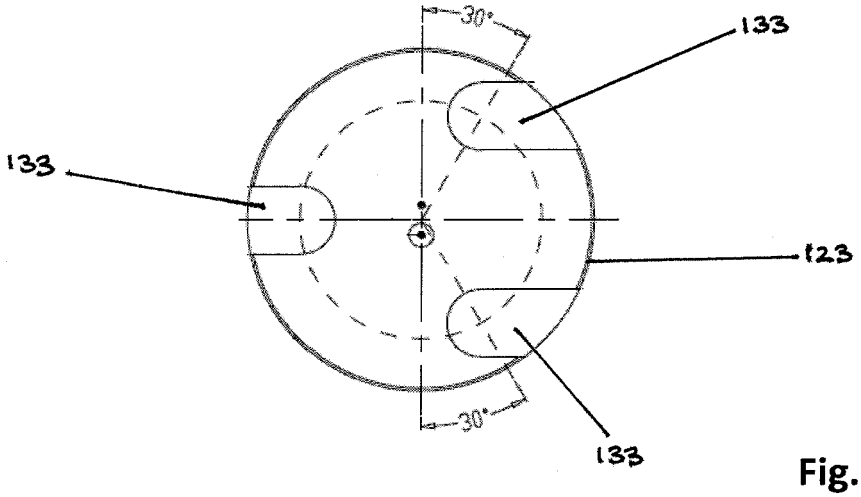
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Fig. 6

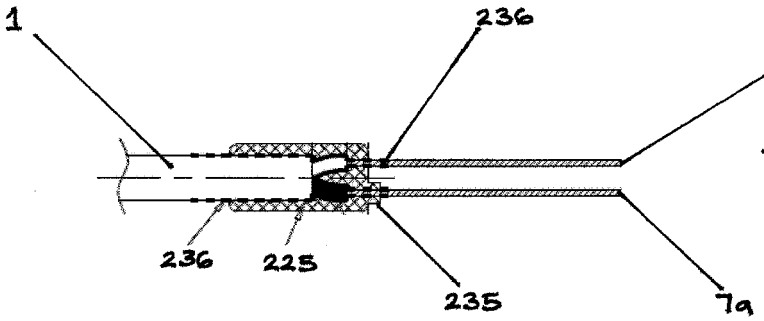


Fig. 7

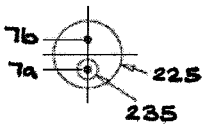


Fig. 8

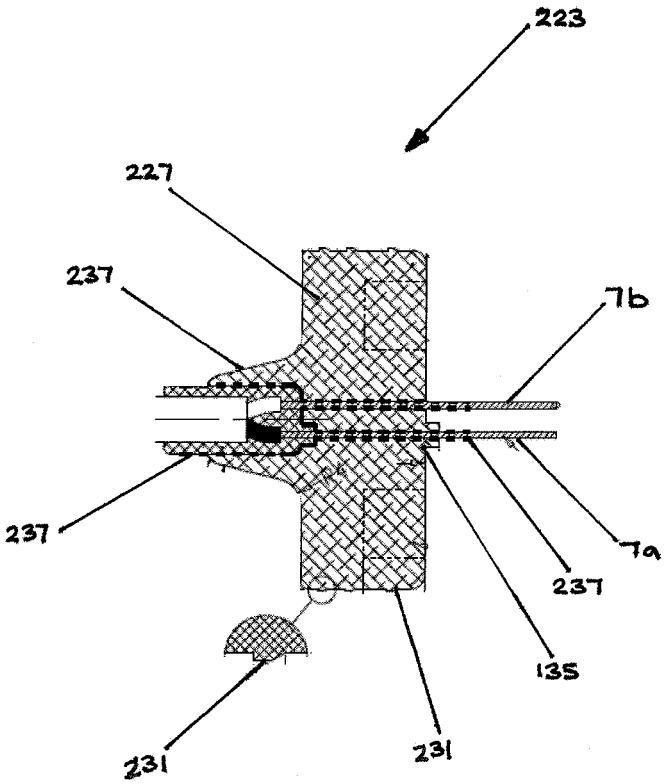


Fig. 9

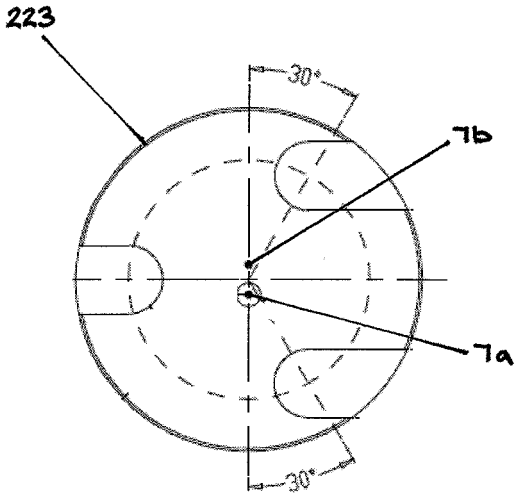


Fig. 10

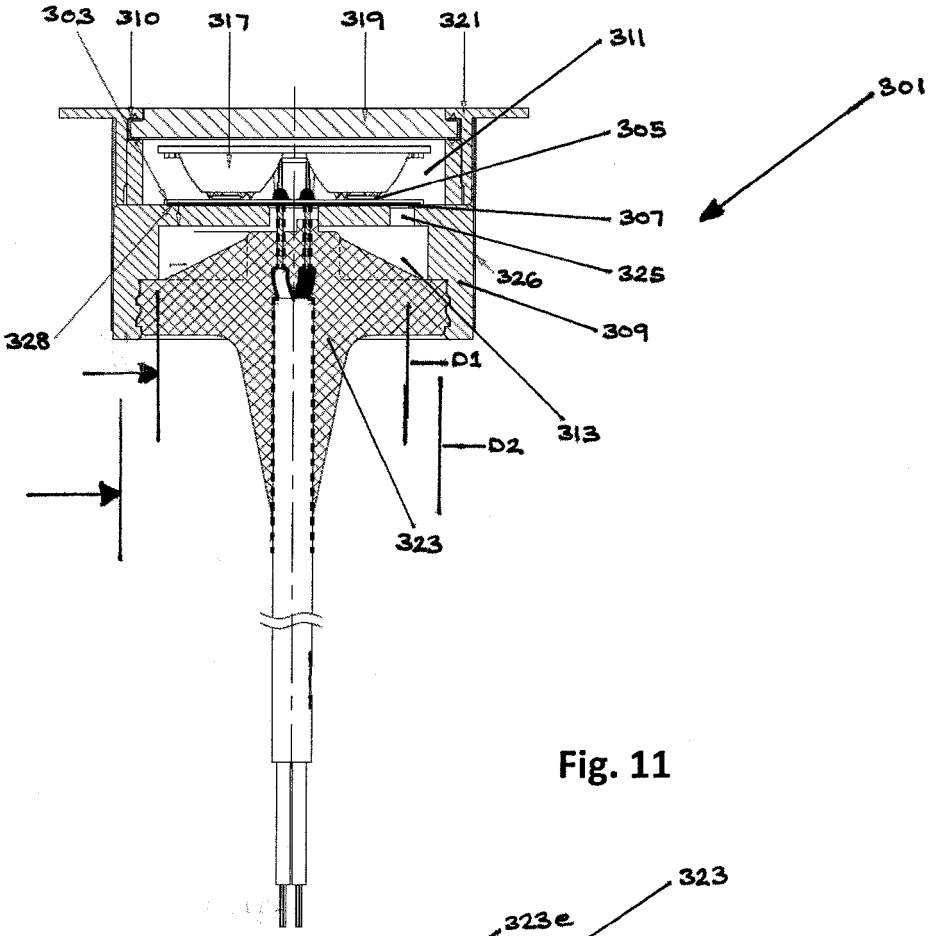


Fig. 11

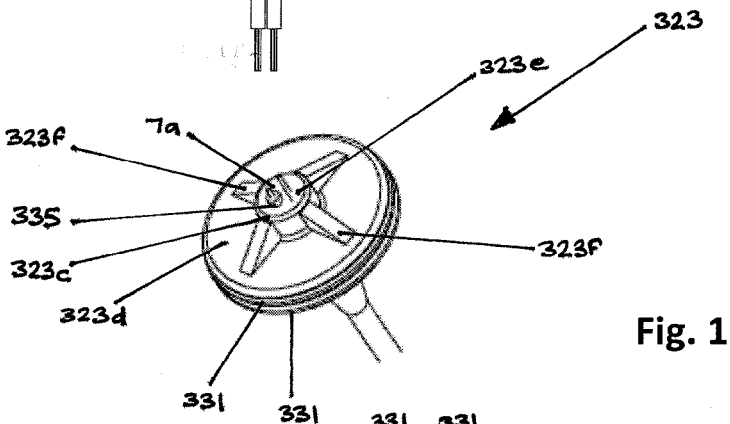


Fig. 12

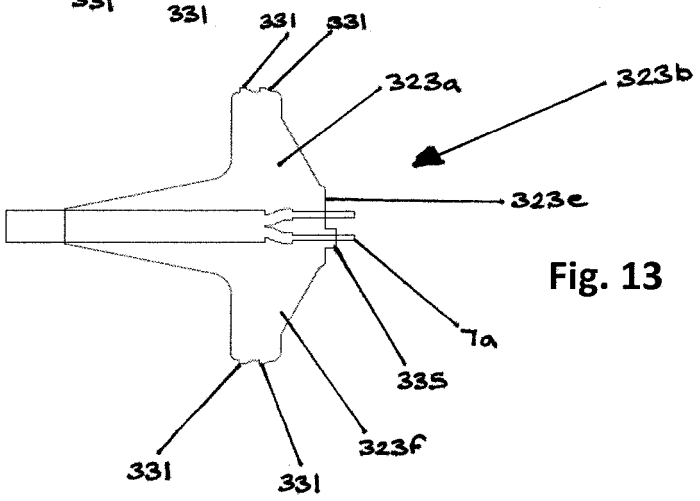


Fig. 13

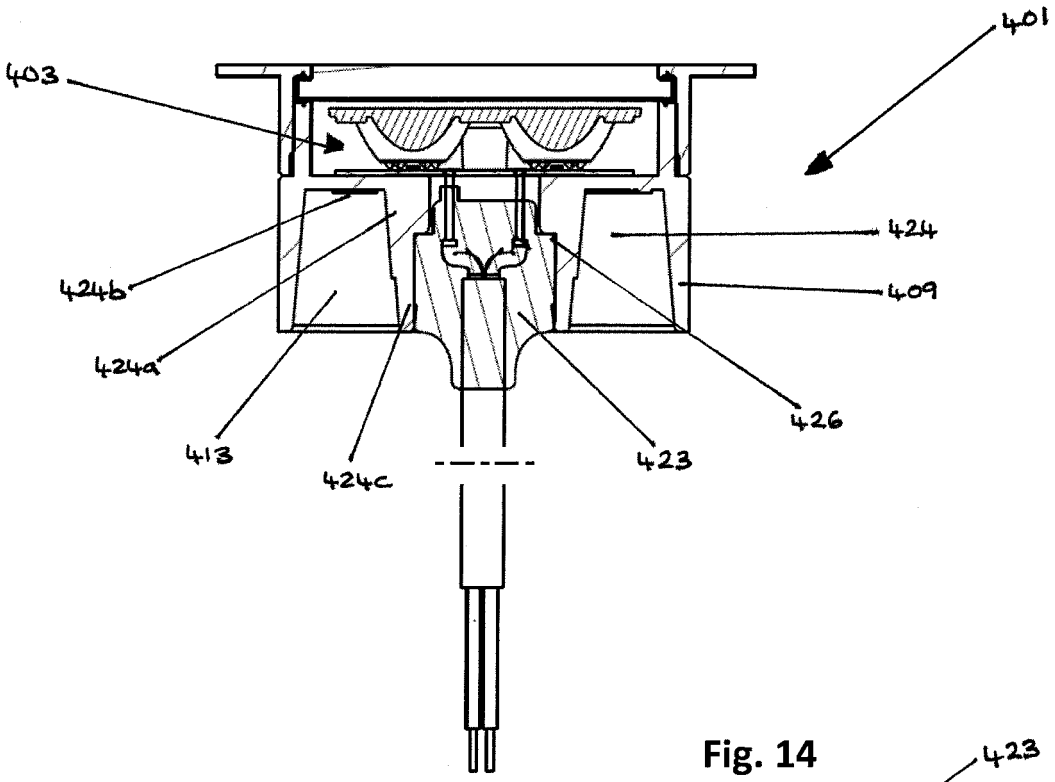


Fig. 14

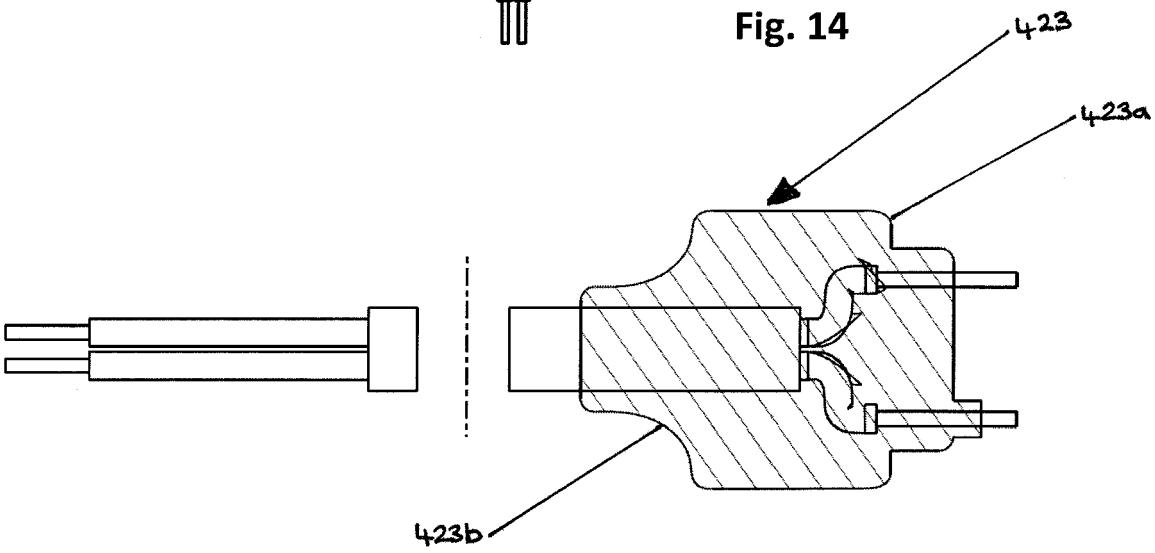


Fig. 15

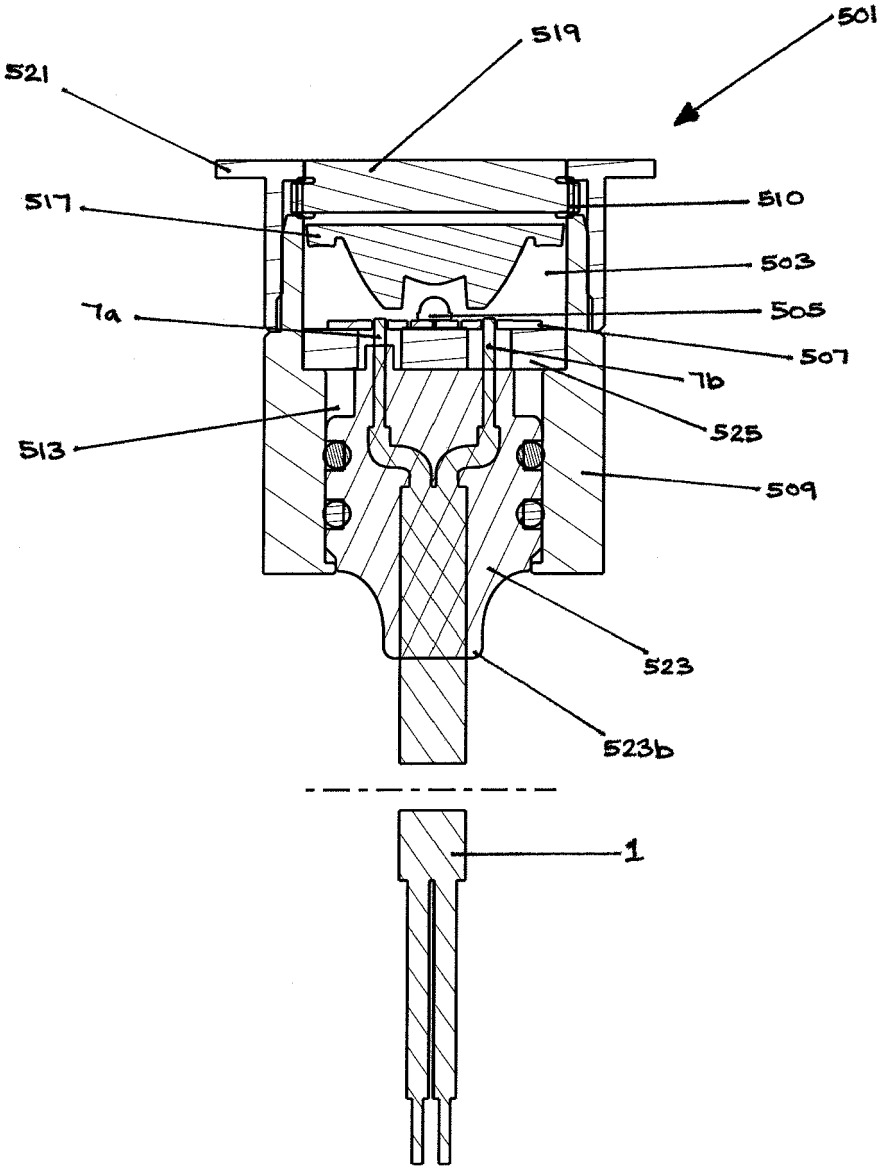
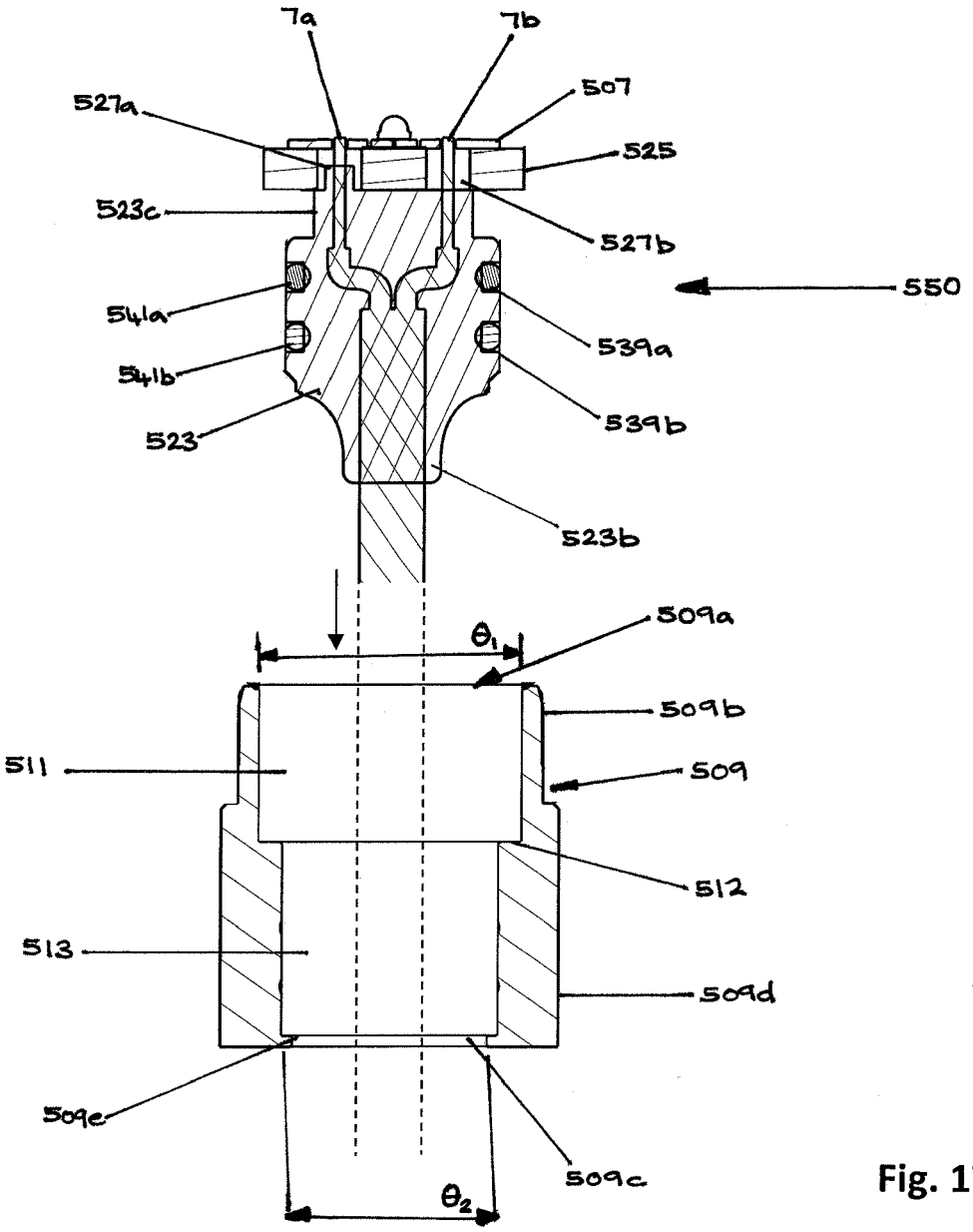


Fig. 16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509d
509e
509c
θ2

Fig. 17

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EUROPEAN SEARCH REPORT

Application Number
EP 16 19 9862

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	WO 2010/052449 A1 (COLLINGWOOD LIGHTING LTD [GB]; MAEERS JUSTIN [GB]) 14 May 2010 (2010-05-14) * the whole document *	1-18	INV. F21V27/02 F21V31/00 ADD. F21V23/00 F21Y115/10
A	WO 2010/134880 A1 (NORDHYDRAULIC AB [SE]; HAKARYD AB [SE]; JANSON GUNNAR [SE]) 25 November 2010 (2010-11-25) * the whole document *	1-18	
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TECHNICAL FIELDS SEARCHED (IPC)

F21V
F21S
H01B
F21Y

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	23 December 2016	Demirel, Mehmet

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