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The references to figures 9e are deemed to be deleted (Rule 43 EPC 1973).

(54) **Lighting unit**

(57) A solid state lighting unit (100). The lighting unit (100) includes a lens device (104), at least one solid state lighting device (106,108), and a heat sink (112). The lens device (104) and the heat sink (112) are push fit coupled directly together in manner such that the solid state lighting device (106,108) is held in thermal contact with the heat sink (112) thereby enabling, in use, at least some of the heat generated by solid state lighting device (106,108) to be transferred to the heat sink (112) by conduction.

A method of manufacturing a lighting unit (100) is also disclosed.

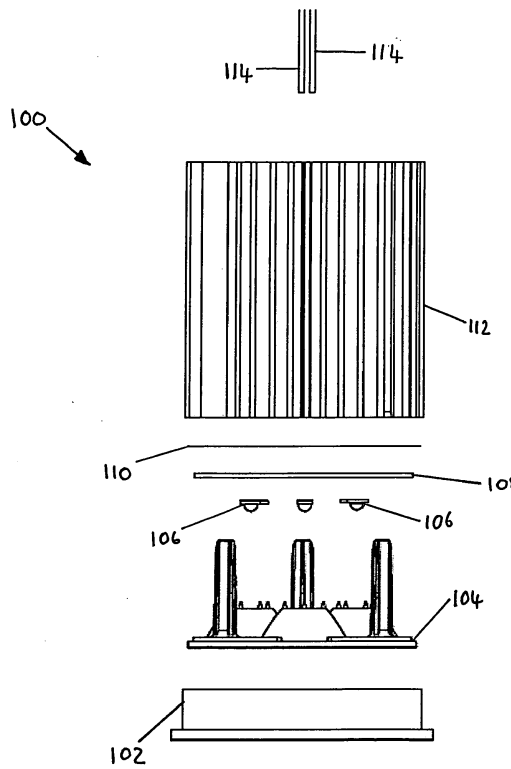

Fig. 3

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Description

[0001] The invention relates to a lighting unit, and in particular, to a solid state lighting unit such as an LED lighting unit, and a method for manufacturing the lighting unit.

[0002] A typical LED lighting unit 1 is shown in Figures 1 and 2.

[0003] The unit 1 includes a trim element 3, a plurality of lenses 5 and three LEDs 7 mounted on a printed circuit board (PCB) 9. The PCB 9 is mounted on a support plate 11, which in turn is mounted on a heat sink 13. Electrical cables 15 connect to the PCB 9 via a hole (not shown) formed through the heat sink 13 and support plate 11. The lighting unit 1 is assembled by securing the support plate 11 to the heat sink 13 using screws 17. This requires holes (not shown) formed through the support plate 11 and tapped holes (not shown) to be formed in the heat sink 13 to receive the screws 17. The support plate 11 and PCB 9 each have holes (not shown) formed through their bodies. The trim element 3 has tapped holes (not shown). The PCB 9, LEDs 7, lenses 5 and trim element 3 are mounted on to the support plate 11. The subassembly is held together by screws 19, which screw into the tapped holes formed in the trim element 3.

[0004] The lighting unit 1 shown includes eighteen components and takes a significant amount of time to manufacture. This consequently leads to a high unit cost.

[0005] Another problem with the arrangement shown in Figure 1 is that sometimes during manufacture the PCB 9 is misaligned when attaching it to the heat sink 13. In this situation, inserting screws 17 can cause damage to the LEDs. Also, the LEDs and PCB are easily damaged during the manufacturing process, for example due to mishandling of the components. Therefore it is desirable to have some way of protecting those items during manufacture of the lighting unit.

[0006] Other known lighting units are disclosed in EP2053666, US2004/0066142 and CN201237095. These all teach the idea of push fit coupling a lens device to a support plate and attaching the support plate to the heat sink by some other means. While this is concept is an improvement on the traditional lighting unit described above, it still does not provide a fully optimised arrangement for manufacture and assembly.

[0007] The invention seeks to mitigate at least one of the afore-mentioned problems, or to at least provide an alternative to the lighting unit described above.

[0008] According to a first aspect of the invention there is provided a lighting unit, including a lens device, at least one solid state lighting device, and a heat sink, wherein the lens device is directly coupled with the heat sink in a push fit manner thereby holding the solid state lighting device in thermal contact with the heat sink such that, in use, at least some of the heat generated by solid state lighting device is transferred to the heat sink by conduction.

[0009] The invention significantly reduces the part count, the manufacturing time and the unit cost when compared with the traditional prior art lighting device mentioned in the introductory paragraphs, and is a more optimised solution to other known push fit coupling arrangements since the lens device is directly coupled to the heat sink. Thus the invention provides a lower cost lighting unit that is easier to manufacture.

[0010] Advantageously the lens device is firmly coupled with the heat sink to fix the relative positions of the heat sink and lens device. For example, the lens device can be coupled to the heat sink by means of an interference press fit. The interference fit prevents the lens device from separating from the heat sink during normal use

[0011] Advantageously at least one of the lens device and the heat sink can be arranged to deform when coupled together, and preferably plastically deform. For example, the lens device can be arranged to plastically deform when inserted into the heat sink. Plastic deformation is preferred since this tends to provide a tighter more permanent fit.

[0012] One of the lens device and the heat sink can include at least one male connector, and preferably a plurality of male connectors, and the other of the lens device and the heat sink can include at least one female connector, and preferably a plurality of female connectors. Having a plurality of male and female connectors allows the lens device to be applied to a lighting unit having only a single LED, which is centrally located. The plurality of male connectors can be distributed on the lens device such that they are substantially uniformly spaced and the plurality of female connectors can be distributed on the heat sink such that they are substantially uniformly spaced. Typically the number of male connectors matches the number of female connectors.

[0013] Advantageously the or each male connector can be deformable, and preferably plastically deformable, and /or includes at least one deformable formation, such as a rib, protrusion, or similar, and preferably a plastically deformable formation. Additionally, or alternatively, each female connector can be deformable.

[0014] Advantageously the solid state lighting device can include at least one alignment formation for correctly positioning the solid state lighting device with respect to the lens device and/or heat sink prior to coupling the lens device to the heat sink. This prevents the heat sink from being damaged when the first and second parts are coupled together.

[0015] Advantageously the alignment formation can be arranged to engage the male and/or female connector (s). In preferred embodiments the solid state lighting device includes at least one female alignment formation, such as a hole or a recess that is arranged to engage the male connector. Preferably the solid state lighting device includes a plurality of female alignment formations that are each arranged to engage one of the male connectors. Advantageously the lens device can include the male connectors and the solid state lighting device is attached to the lens device before the lens device is coupled to the heat sink. This ensures that the solid state lighting device is properly positioned relative to the lens device so that the lens device does not damage the solid state lighting device when the lens device is coupled to the heat sink. The lens device also helps to protect the solid state lighting device throughout the manufacturing process. It also provides an efficient arrangement.

[0016] Advantageously the lens device can comprise a moulded component. The lens device can be made from a plastic material and is preferably made by injection moulding.

[0017] Advantageously the lighting unit can include at least one tolerance element that is arranged to deform when the lens device is coupled to the heat sink, and preferably plastically deform. The or each tolerance element accounts for the variability in size of lighting unit components, the variability being due to manufacturing tolerances. A build up of manufacturing tolerances can be exhibited between the heat sink and at least one of the lens device and a trim element.

[0018] The or each tolerance element can be substantially conical or include a substantially conical portion. This form provides good deformation characteristics.

[0019] Advantageously the lens device can include at least one of the tolerance elements. In an advantageous manufacturing process, the lens device is coupled to the heat sink using a press. The press applies a substantially constant load, or a predetermined loading profile, to the lighting unit and the or each tolerance element deforms under the load. In some lighting units there will be significant deformation of the or each tolerance element, in other lighting units the deformation will be less. The amount of deformation depends on the actual size of the components for individual units.

[0020] In the assembled lighting unit, the or each tolerance element impinges on the solid state lighting device thereby holding the solid state lighting device in firm thermal connection with the heat sink.

[0021] The lens device can include at least one lens member having at least one of the tolerance elements mounted thereon. The lens device can include a plurality of lens members and each lens member can include at least one of the tolerance elements thereon. The or each lens member can include a set of tolerance elements mounted thereon. Preferably there are four tolerance elements in each set arranged in a square or rectangle.

[0022] The solid state lighting device includes at least one LED, and preferably a plurality of LEDs. When the lens device is coupled to the heat sink, the arrangement can be such that the tolerance elements surround each of the LEDs. The solid state lighting device can include a printed circuit board (PCB).

[0023] Advantageously the heat sink can include an extruded body. This gives the component a substantially prismatic form. Advantageously the extruded body can include at least one of the male and/or female connectors formed therein. The lens device is coupled directly with the extruded body via the male and/or female connector (s).

[0024] Advantageously the heat sink can include, when viewed from an end face, a plurality of cores and the solid state lighting device includes a plurality of LEDs, wherein each LED is seated over one of the cores. Thus each LED is seated over a heat sink core which enables heat to be removed effectively from all of the LEDs. This improves the performance and life span of each of the LEDs. The number of cores matches the number of LEDs. The multi-core arrangement provides a lighter unit than an oversized single core heat sink.

[0025] The heat sink includes a central portion and each of the cores is connected to the central portion by a connector portion such as a spoke or web. Preferably each core is substantially cylindrical. Each core can include a plurality of fins that protrude outwards therefrom.

[0026] Advantageously the heat sink can include a plurality of support arms. Each support arm can be arranged to extend radially from one of the cores. Each support arm can be connected to its respective core and spaced apart from the adjacent core. Each support arm can be separated from the adjacent core by a bulbous recess, which undercuts the root of the support arm where it joins to the core.

[0027] Advantageously each support arm can include a female connector such as a bore formed therein for receiving one of the male connectors.

[0028] The heat sink is made from a material having good thermal conduction properties such as aluminium or copper.

[0029] Advantageously each support arm can include a longitudinal slot formed therein that protrudes into the bore. This enables the bores to be easily formed during the extrusion process and does not require the bores to be drilled during a subsequent manufacturing process. The slots also enable the heat sink, in some embodiments, to deform by a small amount when the bores receive their respective male connectors, thereby loading the male connectors.

[0030] The heat sink includes a through bore for receiving electrical cables that are arranged to connect the solid state lighting device to a power source.

[0031] The lighting unit can include thermal interface means, such as a thermal interface pad or paste, for connecting the solid state lighting device to the heat sink. The thermal interface means is located between the solid state lighting device and the heat sink and provides a thermal pathway from the solid state lighting device to the heat sink such that at least some of the heat emitted from the solid state lighting device is transferred to the heat sink via the thermal interfacing means by way of conduction. The thermal interfacing means promotes heat transfer and optionally can be arranged to adhere the solid state lighting device to the heat sink. Alternatively, the solid state lighting device can be held directly in contact with the heat sink in order to provide a thermally conductive pathway between the solid sate lighting device and the heat sink.

[0032] According to another aspect of the invention there is provided a method for manufacturing a lighting unit, said method including providing a solid state lighting device, a lens device, and a heat sink, and directly coupling together the heat sink and lens device such that the solid state lighting device is held in thermal contact with the heat sink, the arrangement being such that, in use, at least some of the heat generated by solid state lighting device is transferred to the heat sink by conduction.

[0033] Advantageously the method can include coupling the lens device and the heat sink together using a press. Advantageously the method can include deforming at least one of the lens device and the heat sink when the first and second parts are coupled together by the press, and preferably plastically deforming the lens device.

[0034] Advantageously one of the lens device and the heat sink includes at least one male connector, and preferably a plurality of male connectors, and the other of the lens device and heat sink includes at least one female connector, and preferably a plurality of female connectors.

[0035] Advantageously the method can include deforming, and preferably plastically deforming, at least one male connector when coupling the lens device and heat sink together.

[0036] Advantageously the method can include coupling the solid state lighting device to the lens device prior to coupling the lens device to the heat sink. This helps to prevent the solid state lighting device from being damaged when the lens device is coupled with the heat sink. Advantageously the method can include providing the lens device having a least one male connector, and preferably a plurality of male connectors, and the solid state lighting device having at least one female alignment formation, and preferably a plurality of female alignment formations, and coupling the male connector to the female alignment formation, thereby correctly aligning the orientations of the lens device and the solid state lighting device.

[0037] Advantageously the method can include providing at least one deformable tolerance element, and deforming the or each tolerance element when the lens device and heat sink are coupled together, and preferably plastically deforming the tolerance element.

[0038] Advantageously the method can include the press applying a predetermined load, or a predetermined loading profile, to the push fit coupling means and the extent of deformation of the or each tolerance element is determined by manufacturing tolerance(s) of at least one of the following: the lens device, the heat sink, the solid state lighting device and a trim element.

[0039] Advantageously the method permanently couples the first and second parts together.

[0040] Advantageously the method can include forming the heat sink by an extrusion process.

[0041] Advantageously the method can include forming the lens device by a moulding process, such as injection moulding.

[0042] Advantageously the lighting unit can be arranged according to any configuration described herein.

[0043] According to another aspect of the invention there is provided a lighting unit, including a lens device, at least one solid state lighting device, a heat sink and push fit coupling means arranged to couple together the heat sink and at least one of the lens device and the solid state lighting device, wherein the solid state lighting device is held in thermal contact with the heat sink such that, in use, at least some of the heat generated by solid state lighting device is transferred to the heat sink by conduction.

[0044] The invention significantly reduces the part count, the manufacturing time and the unit cost when compared with the prior art lighting device mentioned in the introductory paragraphs. Thus the invention provides a lower cost lighting unit that is easier to manufacture.

[0045] Advantageously the coupling means includes first and second parts and the lens device and the heat sink and / or the solid state lighting device and the heat sink are coupled together by coupling the first and second parts. The lens device can include one of the first and second parts of the push fit coupling means. The heat sink can include one of the first and second parts of the push fit coupling means. Advantageously in preferred embodiments the lens device includes one of the first and second parts and the heat sink includes the other of the first and second parts. Thus the solid sate lighting device can be held in thermal contact with the heat sink by the lens device.

[0046] Advantageously the first and second parts of the push fit coupling means can be arranged for an interference press fit.

[0047] Advantageously at least one of the first and second parts of the push fit coupling means can be arranged to deform when the first and second parts are coupled together, and preferably plastically deform. For example, the first part of the push fit coupling means can be arranged to plastically deform when inserted into the second part of the coupling. Plastic deformation is preferred since this tends to provide a tighter more permanent fit.

[0048] The first part of the push fit coupling means can include at least one male connector and the second part of the push fit coupling means can include at least one female connector. Preferably the first part can include a plurality of male connectors and the second part can include at a plurality of female connectors. Having a plurality of male and female connectors allows the lens unit to be applied to a lighting unit having only a single LED, which is centrally located. The plurality of male connectors can be distributed on the lens device such that they are substantially uniformly spaced and the plurality of female connectors can be distributed on the heat sink such that they are substantially uniformly spaced. Typically the number of male connectors matches the number of female connectors.

[0049] Advantageously the or each male connector can be deformable, and preferably plastically deformable, and /or includes at least one deformable formation, such as a rib, protrusion, or similar, and preferably a plastically deformable formation. Additionally, or alternatively, each female connector can be deformable.

[0050] Advantageously the lighting unit can be arranged according to any configuration described herein.

[0051] According to another aspect of the invention there is provided a lighting unit, including a solid state lighting device, a lens device, a heat sink, wherein one of the heat sink and the lens device includes a plurality of deformable male connectors and the other of the heat sink and the lens device includes a plurality of female connectors, the lens device is directly push fit coupled to the heat sink by the male and female connectors, the arrangement being such that the solid state lighting device is held in thermal contact with the heat sink by the lens device such that, in use, at least some of the heat generated by solid state lighting device is transferred to the heat sink by conduction.

[0052] The male connectors are plastically deformable. The lens device includes the plurality of male connectors and the heat sink includes the plurality of female connectors. Each male connector is arranged for an interference fit with one of the female connectors.

[0053] Embodiments of the invention will now be described by way of example, with reference to the accompanying drawings, wherein:

Figure 1 is an exploded side view of a prior art lighting unit;

Figure 2 is a schematic plan view of the prior art lighting unit of Figure 1 showing the relative positions of LEDs in relation to a heat sink core;

Figure 3 is an exploded side view of a first embodiment of the invention;

Figures 4a-e show views of a lens unit included in the first embodiment

Figures 5a-e show views of a heat sink included in the first embodiment;

Figure 6 is a schematic plan view showing how LEDs included in the first embodiment sit in relation to the heat sink cores of Figures 5a-e;

Figure 7 is an exploded side view of a second embodiment of the invention;

Figures 8a-e show views of a lens unit included in the second embodiment of the invention; and

Figures 9a-e show views of a heat sink included in the second embodiment.

[0054] Figures 3 to 6 show a lighting unit 100 in accordance with the first embodiment of the invention. The lighting unit 100 includes a trim element 102, a lens unit 104, three LEDs 106, a PCB 108, optionally a thermal interface pad (or paste) 110, a heat sink 112 and electrical cables 114.

[0055] The lens unit 104 directs light emitted by the LEDs 106 and includes a disc member 116, three lenses 118, three connector members 120, and a lip 122 (see Figures 4a-d). The lens unit 104 comprises a moulded component and therefore the disc member 116, lenses 118, connector members 120 and lip 122 are integrally formed. Preferably the lens unit 104 is made from a plastics material such as acrylic and is formed by injection moulding.

[0056] The disc member 116 provides a protective cover for the lenses 118. The disc member 116 has a planar outer surface 124. The three lenses 118 are located on the inner surface 126 of the disc member. Each lens 118 protrudes out of the plane of the disc member 116 and has a central axial bore 128 and a flattened annular portion 130. The plane of the annular portion 130 is arranged substantially parallel to the plane of the disc member 116. Each annular part 130 includes four crush pins 132 protruding substantially perpendicularly therefrom. Each crush pin 132 has a substantially conical form. When the lighting unit 100 is assembled, the crush pins 132 impinge on the PCB 108 and collapse under load. The purpose of the crush pins 132 is to account for a build up in manufacturing tolerances between the heat sink and the trim element 102. For embodiments not having a trim element 102, the crush pins 132 are not strictly necessary.

[0057] Each of the lenses 118 is axially aligned with one of the LEDs 106.

[0058] The connector members 120 are arranged to hold the lighting unit 100 together when assembled. The connector members 120 effectively replace the screws 17,19 from the prior art arrangement. Each of the connector members 120 protrudes out of the plane of the disc member 116 and is arranged substantially perpendicularly to the inner surface 126. Each connector member 120 is located adjacent two lenses 118 towards a peripheral part of the disc member 116 (adjacent the lip 122).

[0059] Each connector member 120 tapers along its length from a broader proximal end 134 to a narrower distal end 136. Each connector member 120 includes four crush ribs 138 that run longitudinally along the connector member 120 and protrude radially outwards therefrom.

[0060] Each rib 138 tapers towards the distal end 136. At the proximal end 134, each connector member includes a counter sink formation 138.

[0061] The LEDs 106 are mounted on the PCB 108. The PCB 108 is attached to the heat sink 112 by a thermal interface pad (or paste) 110. The thermal interface pad or paste 110 adheres the PCB 108 to the heat sink 112 and aids the thermal transfer of heat generated by the

LEDs 106 to the heat sink 112.

[0062] The heat sink 112 comprises an aluminium extrusion (see Figures 5a-5e). The heat sink 112 includes three bores 140 that are arranged substantially parallel to the longitudinal axis of the heat sink. Each of the bores 140 is arranged to receive one of the connector members 120. Each bore 140 has a counter sunk recess 140a at its entrance that is arranged to receive the counter sink formation 156. Preferably each bore has a substantially circular cross-section, though other cross-sections can be used.

[0063] Since the heat sink is formed by an extrusion process, the heat sink 112 is substantially prismatic in form. The heat sink 112 has a central portion 142. The central portion 142 includes an axial through bore 144 for receiving the electrical cables 114. Three rib-like members 146 protrude radially outwards from the central portion 142. The rib-like members 146 are uniformly distributed about the central portion, the arrangement being such that the separation between the centre lines of each of the rib-like members 146 when viewed in plan is 120°. Each rib-like member 146 includes a solid core 148. Twelve cooling fins 150 of varying lengths protrude radially outwards from each core 148. The lengths of the fins 150 are such that the tips of some of the fins 150 lie on a pitch circle thereby providing the heat sink 112 with a notionally cylindrical form.

[0064] Each core 148 has a support arm 152 protruding substantially radially therefrom. The bores 140 for receiving the connector members 120 are formed in the support arms 152. The bores 140 have longitudinal openings 154 formed through the support arm 152. The bores 140 and openings 154 are formed during the extrusion process. The openings allow the bores to be formed more easily during the extrusion process. Optionally the openings 154 can be arranged to enable the support arms 152 to deform by a small amount when the connector members 120 are inserted into the bores 140.

[0065] The counter sunk recesses 140a are formed in one end face of the heat sink 112 at the mouths of the bores 140.

[0066] The arrangement of the heat sink 112 is such that it provides cores 148 for each of the LEDs and facilitates good air flow around the core. Bulbous recesses 154 are formed between each support arm and adjacent core 148.

[0067] The trim element 102 comprises an annular member. The annular member includes an internal lip (not shown) that is arranged to engage with the lip 122 on the lens unit 104. In its coupled state, the lens unit 104 is seated within the annular trim element 102.

[0068] Manufacture of the lighting unit 100 will now be described with references to Figures 3 and 6. The LEDs 106 and electrical cables 114 are connected to the PCB 108. The PCB 108 is attached to the lens unit 104 by inserting connector members 120 into alignment holes 121 formed in the PCB 108. This ensures that the LEDs 106 are properly aligned with the lens 118, thereby preventing them from being damaged when attached to the heat sink 112. Furthermore, the lens unit 104 also provides some protection to the PCB 108 and LEDs 106 throughout the process since its structure partially surrounds and extends beyond the LEDs and PCB 108. This helps to reduce the number of rejected lighting units due to damage to the solid state lighting device.

[0069] The electrical cables 114 are threaded through the central axial bore 144 formed in the heat sink and the thermal interface pad (or paste) 110 is applied to the heat sink and/or PCB 108.

[0070] The connector members 120 and bores 140 are sized for an interference press fit, that is, the diameter (width and/or depth) of the connector members 120 is slightly larger than the diameter (width and/or depth) of the bore 140.

[0071] The lens unit 104 is attached to the heat sink 112 using a press. The trim element 102 is located over the heat sink 112. The lens unit 104 is then inserted into the trim element 102, with the connector members 120 being pushed into the bores 140. The lens unit 104 is pushed into position via the press, which applies a predetermined load or loading profile to the lens unit. As the lens unit 104 moves into its final position, the crush ribs 138 on the connector members 120 engage side walls of the bores 140 and plastically deform under the load applied by the bores to provide a tight fitting engagement between the lens unit 104 and the heat sink 112. The crush pins 132 impinge upon the LED 106 or PCB 108. Depending on the relative sizes of trim element, lens unit 104 and heat sink 112, the crush pins 132 plastically deform to varying degrees. When the lens unit 104 is seated correctly in the trim element 102 the crush pins 132 force the PCB 108 to hold the PCB 108 tightly against the heat sink 112. This enables heat transfer between the LEDs 106 and the heat sink 112 to take place by conduction. The interaction between the connector members 120 and the heat sink 112 provides sufficient force to hold the lighting unit 100 together in its assembled state during normal usage. The arrangement of the lighting unit 100, the manufacturing process leads to a simplified lighting unit, and one that can be manufactured significantly more quickly and economically..

[0072] When in the assembled state, it is apparent from Figure 6 that each of the LEDs 106 overlies one of the heat sink cores 148. This ensures good heat transfer from each LED into the heat sink and that the heat sink has the capacity to absorb the heat emitted by the LED in the immediate vicinity of the LED. This improves the performance of the LEDs 106 and increases the life of each LED.

[0073] A second embodiment is shown in Figures 7-9d. The lighting unit 200 according to the second embodiment includes a trim element 202, a lens unit 204, an LED 206, a PCB 208, a thermal interface pad (or paste) 110, and a heat sink 212. The second embodiment is similar to the first embodiment except that the lighting unit 200 only includes one LED 206. Accordingly, the lens unit 204 only includes a single lens 218.

[0074] The lens unit 204 includes crush pins 232 and three connector members 220 having crush ribs 238.

[0075] The heat sink 212 is adapted to a lighting unit having a single LED 206. The heat sink 212 includes a single core 248, which is centrally located. Three sets of five fins 250 protrude radially outwards from the core 248. Each set of fins is separated by radial support arms 252, which each include a bore 240 and a longitudinal opening 254. Thus the second embodiment shares a similar simple structure to the first embodiment and is manufactured in a similar manner. Accordingly, the second embodiment also has the same manufacturing and cost benefits as the first embodiment.

[0076] It will be apparent to the skilled person that modifications can be made to the above embodiments that still fall within the scope of the invention, for example the connector members can be formed in the heat sink and the bores formed in the lens unit.

[0077] The number of connectors can be different. For example, there is at least one male connector and at least one female connector. Typically embodiments include y male connectors, where y is in the range 2 to 6, and preferably in the range 3 to 4. The number of female connectors (bores or similar) is equal to the number of male connectors.

[0078] The heat sink can include at least one male connector and the lens device can include at least one female connector, in addition to, or as an alternative to the arrangement described above.

[0079] The lens unit can be attached to the heat sink via an intermediate component.

[0080] The push fit coupling can be provided by other components. For example, the trim element can be arranged to couple with the heat sink, the arrangement being such that when coupled to the heat sink, the trim element urges the lens unit towards the heat sink, and the lens unit urges the PCB against the heat sink. The trim element can include male connectors that are arranged to couple with the female connectors formed in the heat sink. Alternatively the trim element can be in the form of a sleeve that can couple with the outer surface of the heat sink, there being an interference fit between the trim element and the heat sink.

[0081] The heat sink can be made from any other suitable material having a high thermal conductivity such as copper.

[0082] The heat sink can include a different number of cores. Typically the number of cores is matched to the number of LEDs. The number of fins on each core can be different.

[0083] The bores can be formed into a different part of the heat sink from the support arms. In which case, the support arms are not strictly necessary.

[0084] The PCB can be mounted directly onto the heat sink.

[0085] The lens unit can be attached to the heat sink via an intermediate component.

[0086] The connector members can be arranged to elastically deform in addition, or as an alternative, to the plastic deformation.

[0087] The heat sink can be of a different, more conventional construction.

[0088] The lens unit can be of the type known as Total Internal Reflection (TIR) unit, which includes at least one lens and at least one reflector in a combined unit.

Claims

1. A lighting unit, including a lens device (1040, at least one solid state lighting device (106,108), and a heat sink (112), **characterised in that** the lens device (104) is directly coupled with the heat sink (112) in a push fit manner thereby holding the solid state lighting device (106,108) in thermal contact with the heat sink (112) such that, in use, at least some of the heat generated by solid state lighting device (106,108) is transferred to the heat sink (112) by conduction.

2. A lighting unit according to claim 1, wherein the lens device (104) and the heat sink (112) are arranged for an interference press fit.

3. A lighting unit according to claim 1 or 2, wherein at least one of the lens device (104) and the heat sink (112) is arranged to deform when coupled together, and preferably plastically deform.

4. A lighting unit according to any one of the preceding claims, wherein one of the heat sink (112) and the lens device (104) includes at least one male connector (120) and the other of the heat sink (112) and the lens device (104) includes at least one female connector (140).

5. A lighting unit according to claim 4, wherein the or each male connector (120) is deformable, and preferably plastically deformable, and/or includes at least one deformable formation (138), such as a rib, protrusion, or similar, and preferably a plastically deformable formation (138).

6. A lighting unit according to claim 4 or 5, wherein the heat sink (112) includes an extruded body having at least one of the male and/or female connectors (120,140) formed therein.

7. A lighting unit according to any one of the preceding claims, wherein the solid state lighting device (106,108) includes at least one alignment formation (121) for correctly positioning the solid state lighting device (106,108) with respect to the lens device (104) and/or heat sink (112) prior to coupling the lens device (104) to the heat sink (112), and preferably the alignment formation (121) is arranged to engage

the male and/or female connector(s) (120,140).

8. A lighting unit according to any one of the preceding claims, including at least one tolerance element (132) that is arranged to deform when the lens device (104) is coupled to the heat sink (112), and preferably plastically deform.

9. A lighting unit according to claim 8, wherein the or each tolerance element (132) holds the solid state lighting device (106,108) in thermal contact with the heat sink (112).

10. A lighting unit according to claim 8 or 9, wherein the lens device (104) includes at least one of the tolerance elements (132), and preferably heat sink (112) the lens device (104) includes at least one lens member (118) having at least one of the tolerance elements (132) mounted thereon.

11. A lighting unit according to any one of the preceding claims, wherein the heat sink (112) includes, when viewed from an end face, a plurality of cores (148) and the solid state lighting device (106,108) includes a plurality of LEDs (106), wherein each LED (106) is seated over one of the cores (148).

12. A lighting unit according to claim 11, wherein the heat sink (112) includes a plurality of support arms (152) each having a bore (140) formed therein for receiving one of the male connectors (120), and preferably each support arm (152) includes a longitudinal slot (154) formed therein.

13. A lighting unit according to any one of the preceding claims, including thermal interface means (110), such as a thermal interface pad or paste, for connecting the solid state lighting device (106,108) to the heat sink (112).

14. A method for manufacturing a lighting unit, said method including providing a solid state lighting device (106,108), a lens device (104), and a heat sink (112), and **characterised by** directly coupling together the heat sink (112) and lens device (104) such that the solid state lighting device (106,108) is held in thermal contact with the heat sink (112), the arrangement being such that, in use, at least some of the heat generated by solid state lighting device (106,108) is transferred to the heat sink (112) by conduction.

15. A method according to claim 14, including coupling the lens device (104) and heat sink (112) together using a press.

16. A method according to claim 14 or 15, including deforming at least one of the lens device (104) and the heat sink (112) when coupling them together, and preferably plastically deforming the lens device (104).

17. A method according to any one of claims 14 to 16, including coupling the solid state lighting device (106,108) to the lens device (104) prior to coupling the lens device (104) to the heat sink (112).

18. A method according to any one of claims 14 to 17, including providing at least one deformable tolerance element (132), and deforming the or each tolerance element (132) when the lens device (104) and heat sink (112) are coupled together, and preferably plastically deforming the tolerance element (132).

19. A method according to claim 18 when dependent on claim 15, wherein the press applies a predetermined load, or load profile, to at least one of the lens device (104) and the heat sink (112) and the extent of deformation of the or each tolerance element (132) is determined by manufacturing tolerance(s) of at least one of the following: the lens device (104), the heat sink (112), the solid state lighting device (106,108) and a trim element (102).

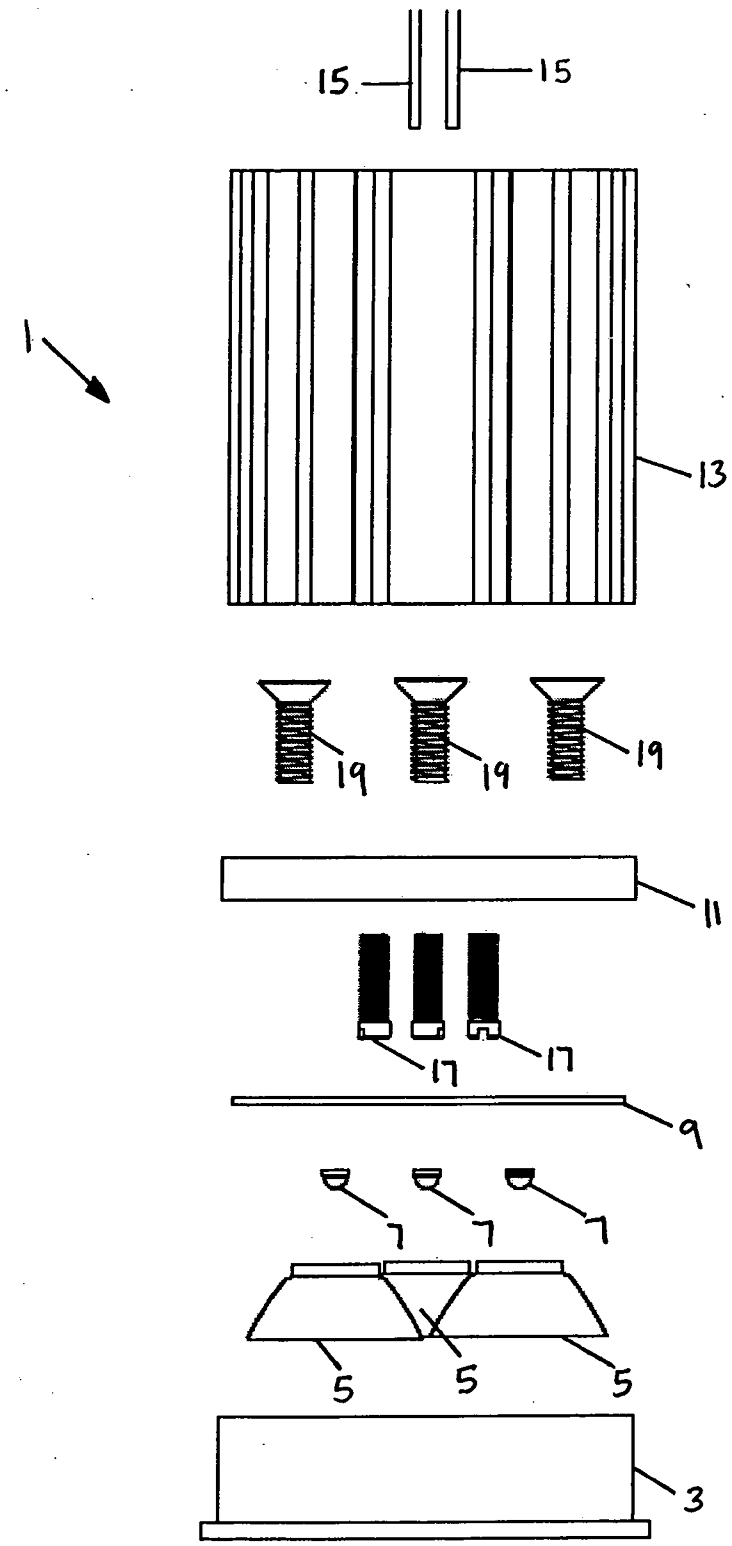

Fig. 1

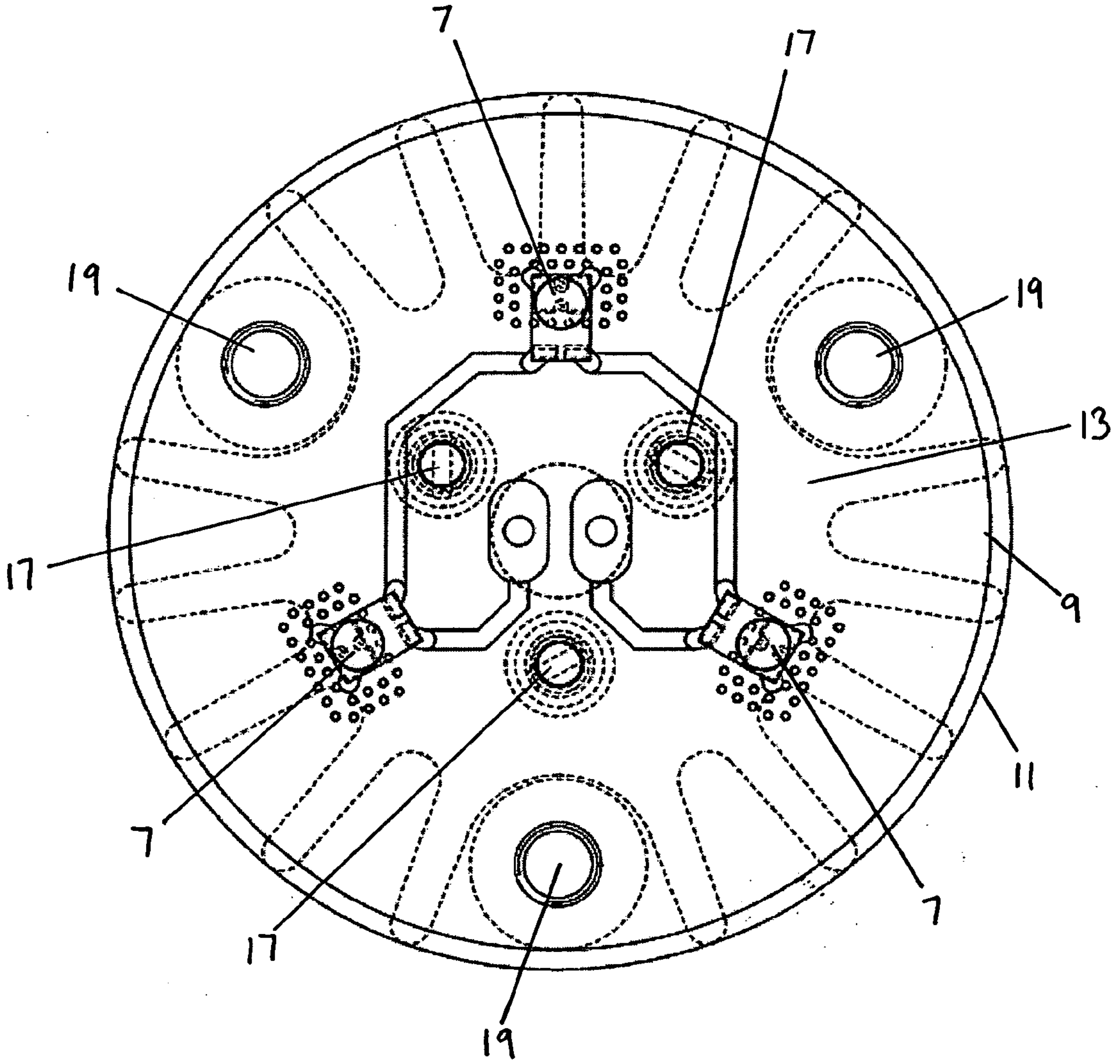

Fig. 2

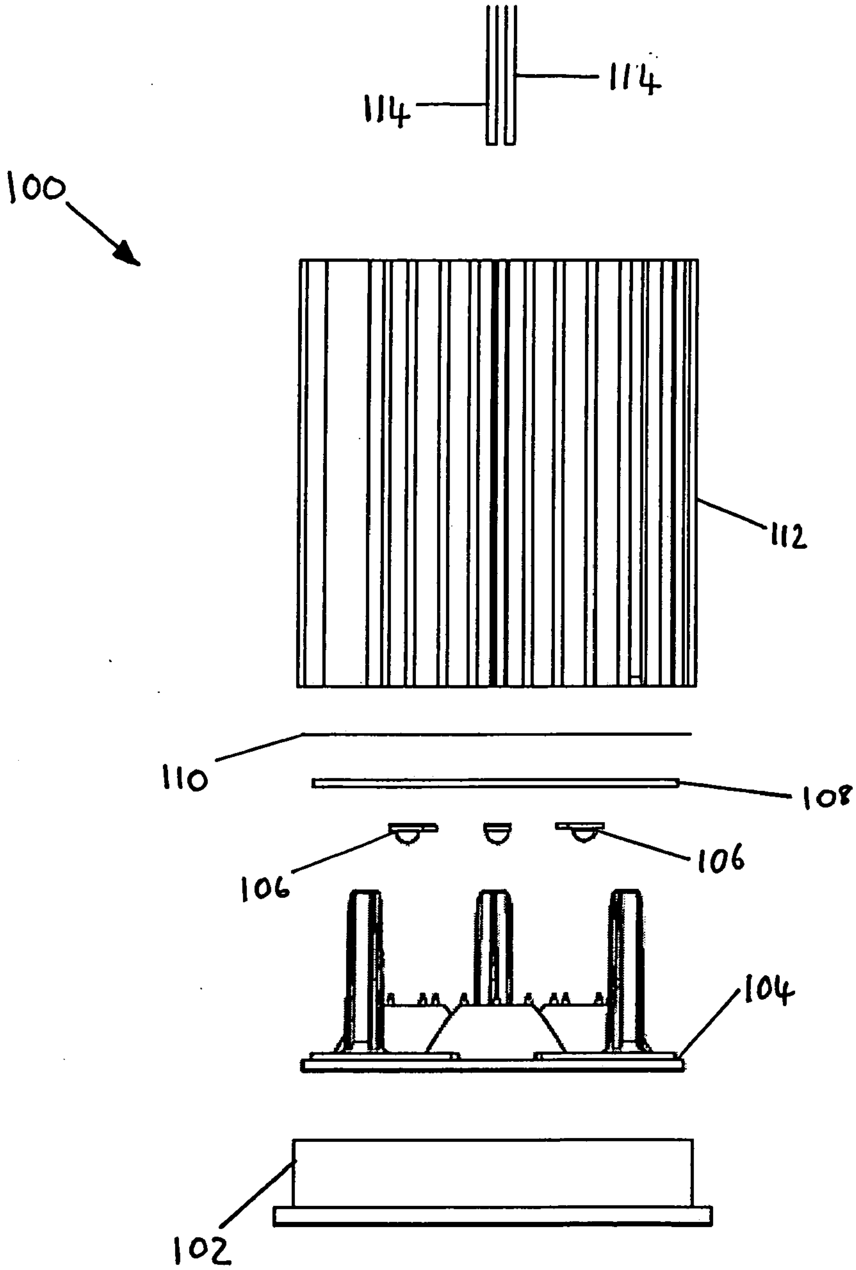

Fig. 3

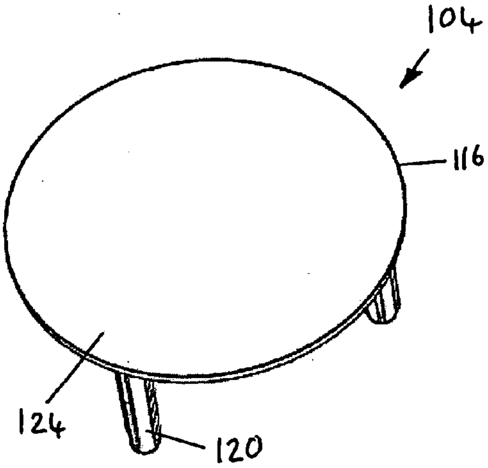

Fig. 4a

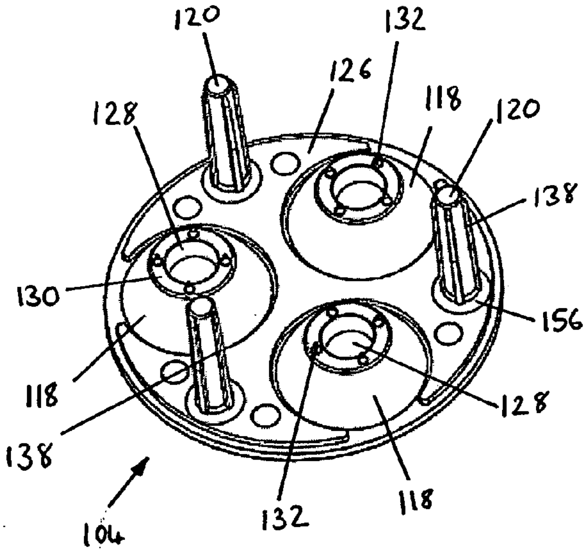

Fig. 4b

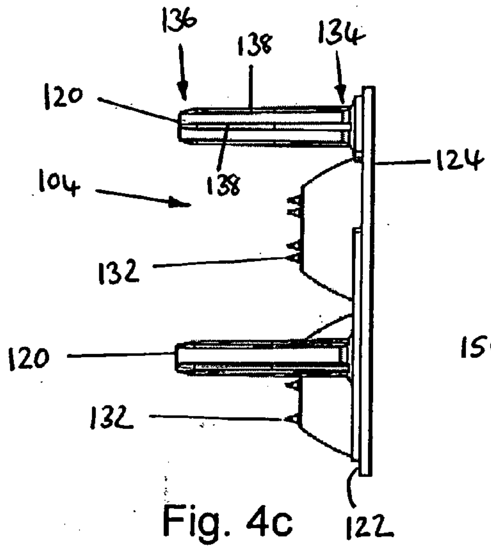

Fig. 4c

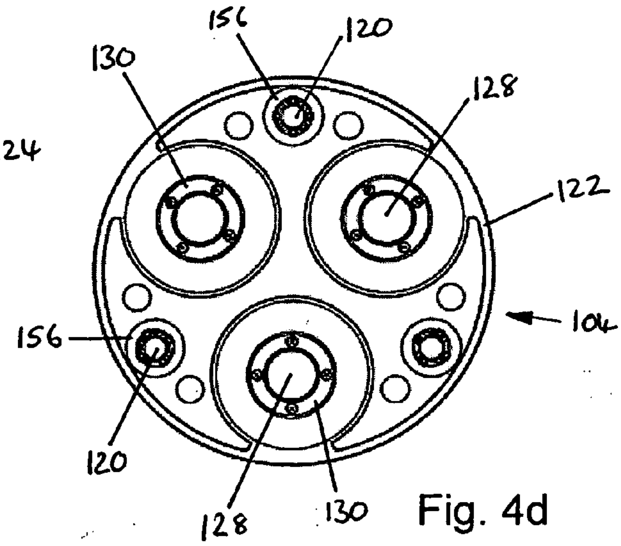

Fig. 4d

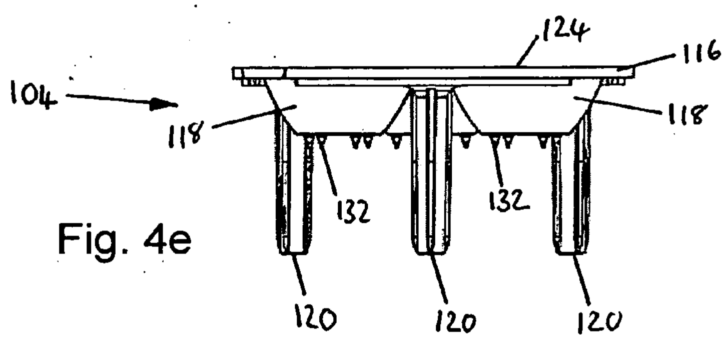

Fig. 4e

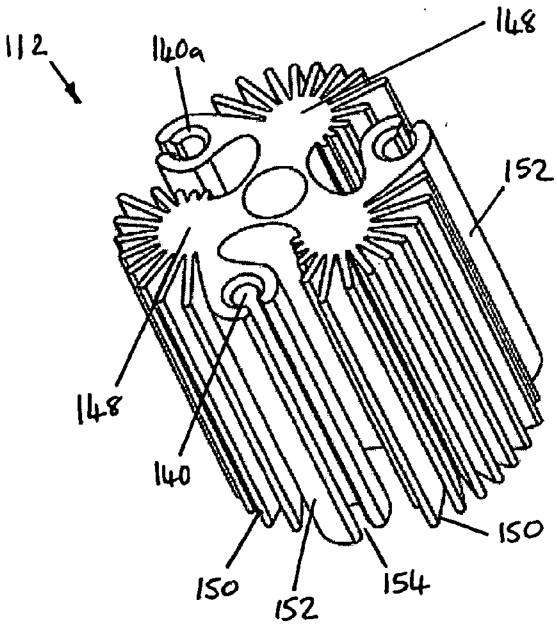

Fig. 5a

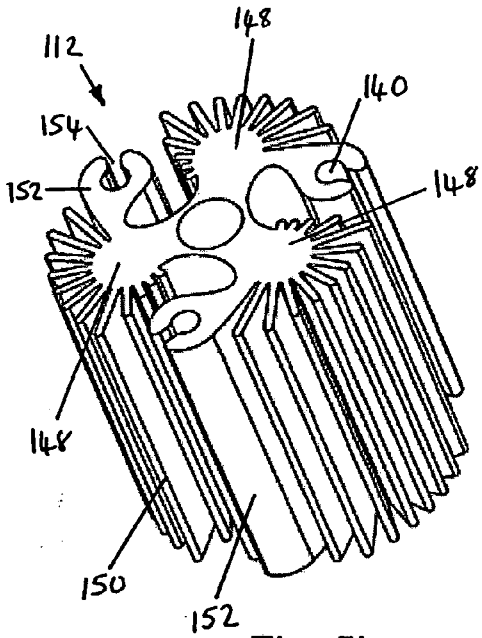

Fig. 5b

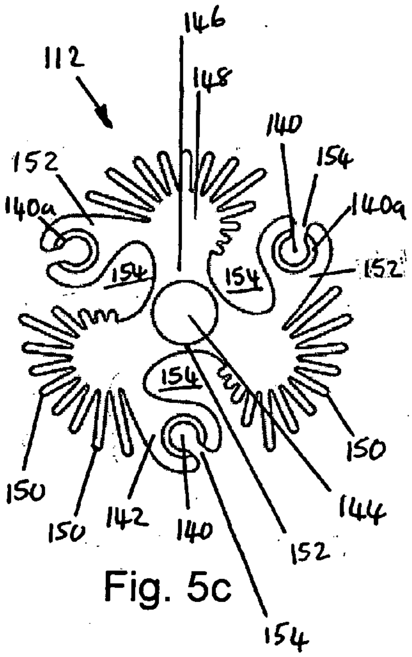

Fig. 5c

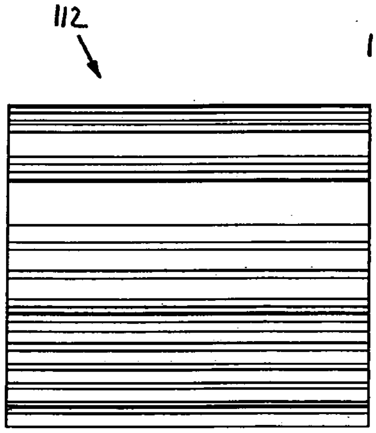

Fig. 5d

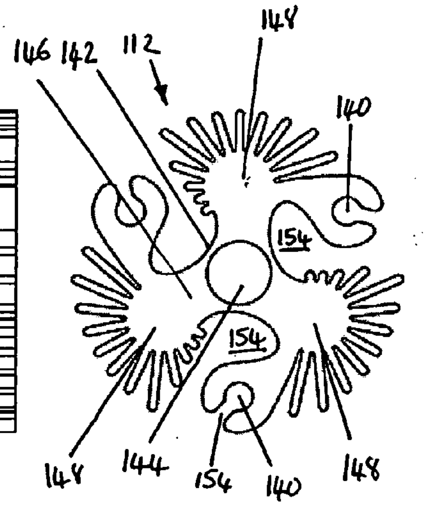

Fig. 5e

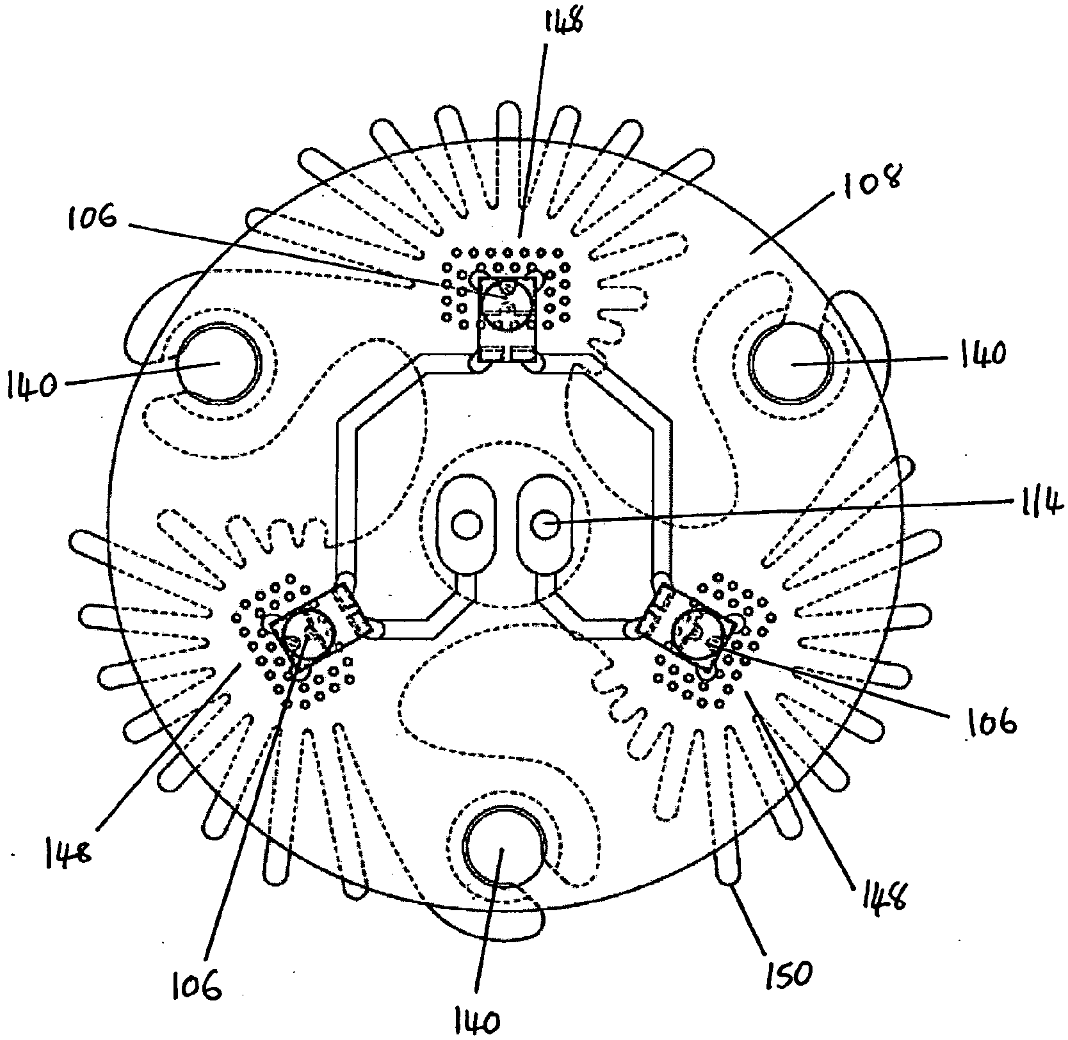

Fig. 6

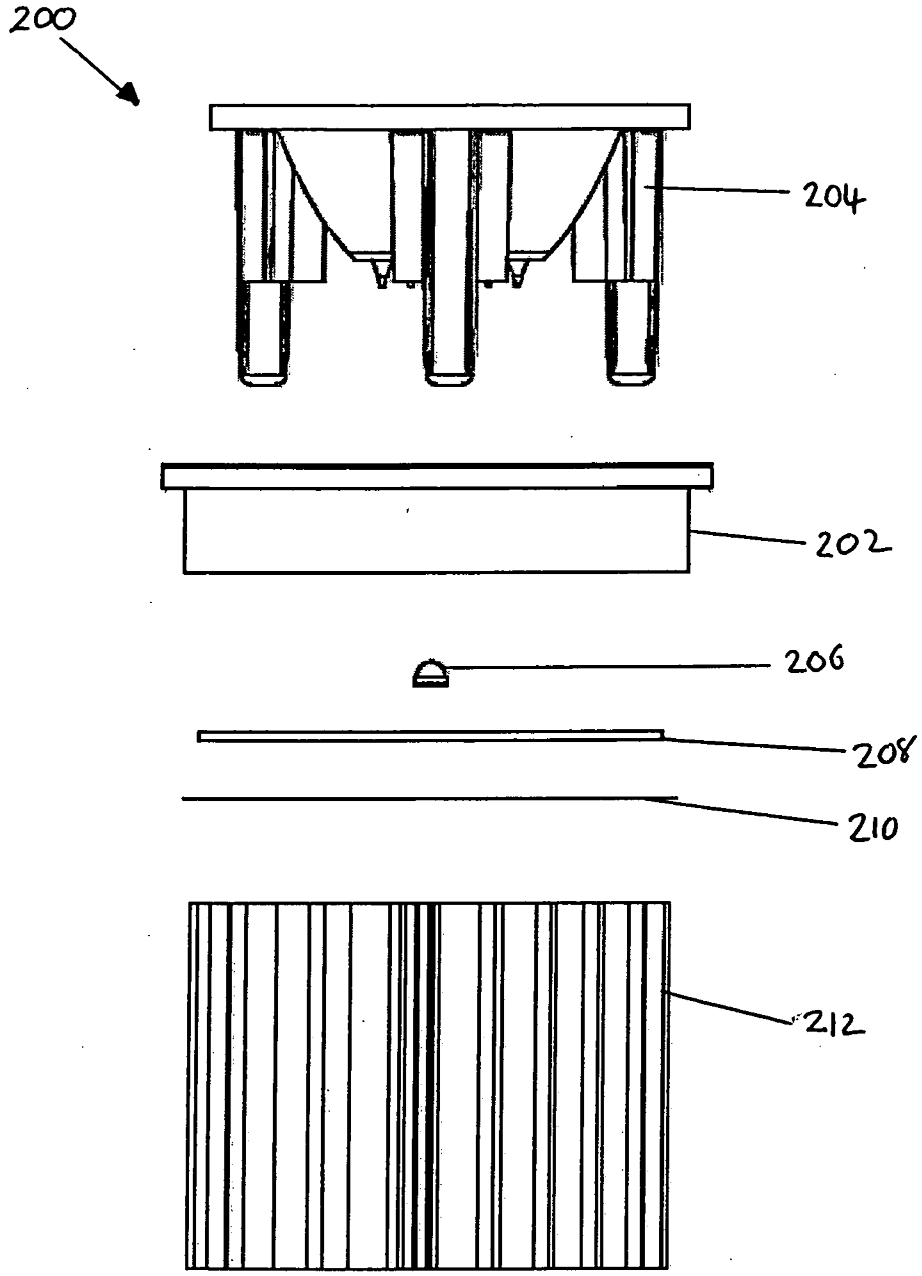

Fig. 7

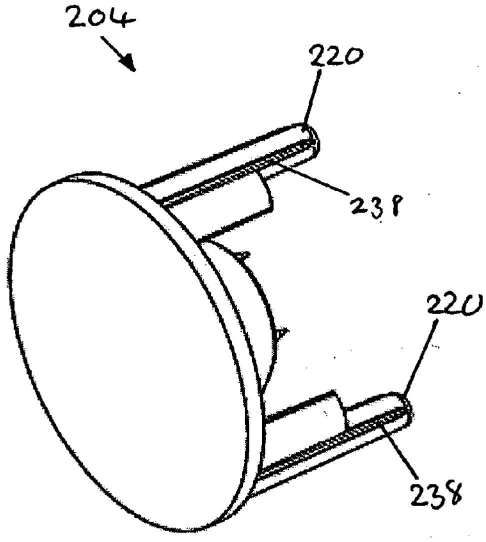

Fig. 8a

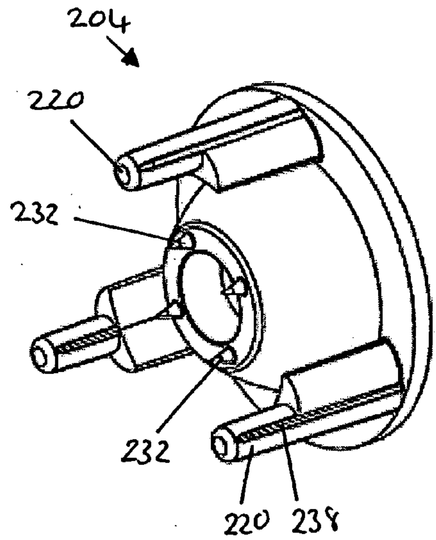

Fig. 8b

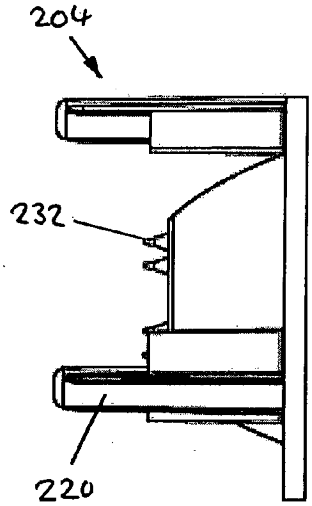

Fig. 8c

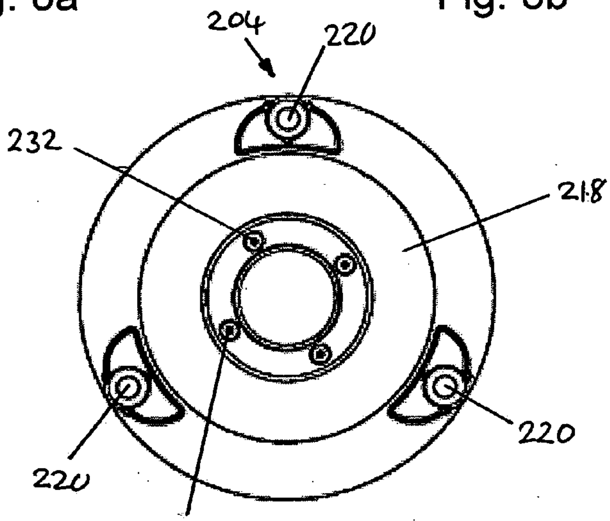

Fig. 8d

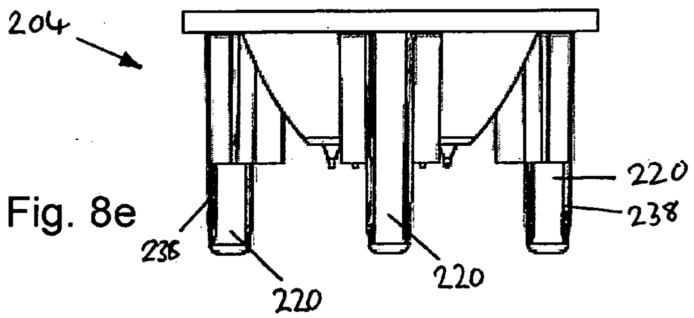

Fig. 8e

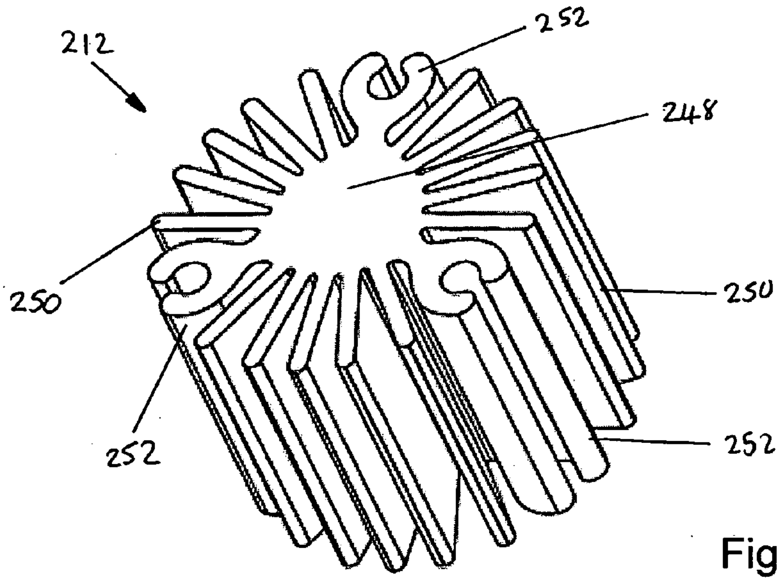

Fig. 9a

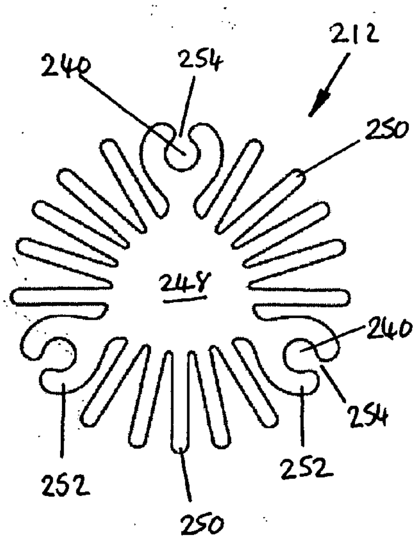

Fig. 9b

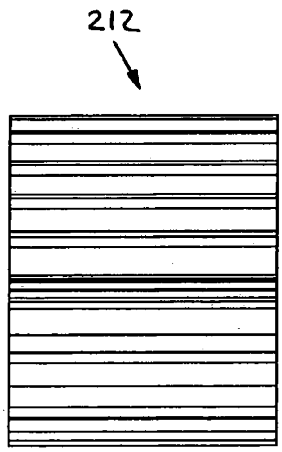

Fig. 9c

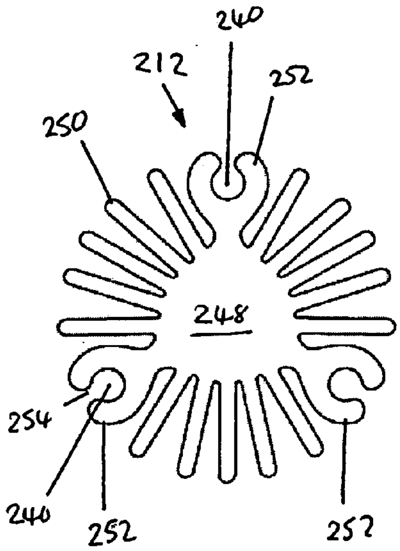

Fig. 9d

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- EP 2053666 A **[0006]**
- US 20040066142 A **[0006]**
- CN 201237095 **[0006]**