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(54) Method of providing a wire connector contact to a piece of foil and assembly of foil and connector contact

(57) A method of providing a connector contact to a piece of foil, includes providing a piece of foil (4) provided in an active area of its plane with at least one cell (2) with active elements for interaction with the environment through a surface on at least one side of the piece of foil (4) and having embedded therein at least one electrically conductive lead (3) lying at least partially in the active area and in electrical connection with at least one of the cells (2),and providing a connector contact (8) having a first section (9) including at least one protruding contact element (11) and a second section (12) including a terminal (13) for forming a connection to a wire. At least the first section (9) is placed adjacent to the piece of foil (4) such that at least one of the contact elements (11) penetrates into the piece of foil to contact an electrically conductive lead (3).

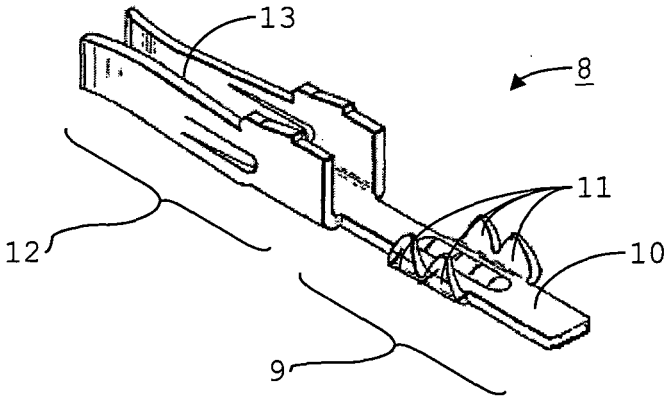

Fig. 3

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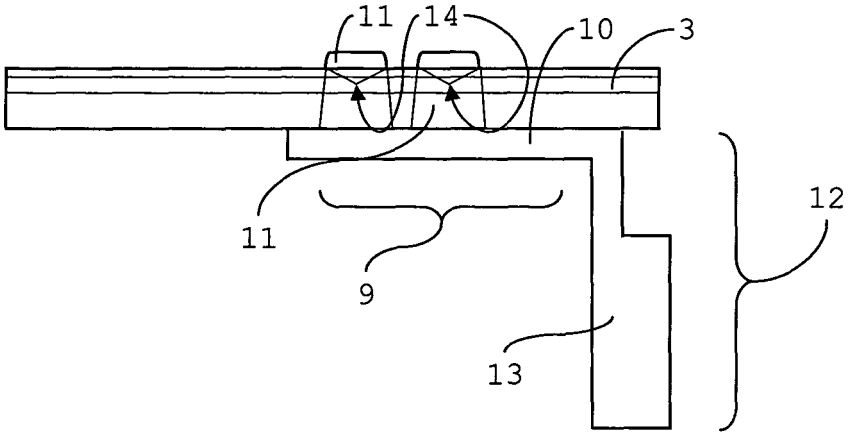

Fig. 4

Description

[0001] The invention relates to a method of providing a connector contact to a piece of foil, including providing a piece of foil provided in an active area of its plane with at least one cell with active elements for interaction with the environment through a surface on at least one side of the piece of foil and having embedded therein at least one electrically conductive lead lying at least partially in the active area and in electrical connection with at least one of the cells, and providing a connector contact having a first section including at least one protruding contact element and a second section including a terminal for forming a connection to a wire.

[0002] The invention also relates to an assembly including a piece of foil provided in an active area of its plane with at least one cell with active elements for interaction with the environment through a surface on at least one side of the piece of foil and having embedded therein at least one electrically conductive lead lying at least partially in the active area and in electrical connection with at least one of the cells, and a connector contact having a first section including at least one protruding contact element and a second section including a terminal for forming a connection to a wire.

[0003] Examples of such a method and assembly are known. EP-A2-1 102 354 discloses an apparatus for contacting foil conductors, in particular of a solar module. The apparatus has a housing. A first connecting region is provided in the housing base for making contact with the solar module. The first connecting region has an opening in the housing base within a centring ring. The foil conductors are inserted into the housing through this opening. Two conductor rails are located in the housing. The conductor rails each have a contact region for detachable connection to a foil conductor. The contact regions consist of metallic clamping springs that allow clamping of the foil conductors between the clamping springs and conductor rails. The foil conductors are contacted by means of the clamping springs of the contact regions with the conductor rails.

[0004] A problem of the known arrangement is that the point of connection of the connector contact to the foil is fixed relative to the foil. In principle, the foil can only be contacted at an edge of its plane, since a section of foil at the edge has to be inserted into the opening. The edge of the section of foil has to be adapted to go into the arrangement, or else parts of active cells are inserted into the arrangement without their surface being exposed. This would make the interaction with the environment difficult to control or predict. If the edge of the section of foil has to be adapted, this requires manufacturing discrete pieces of foil, which is more expensive than forming the sections from pieces cut to a desired size from a roll of the foil.

[0005] It is an object of the present invention to provide a method and assembly of the types mentioned above, which allow for more flexibility in placement of the connector contacts.

[0006] This object is achieved by the method according to the invention, which is characterised in that at least the first section is placed adjacent to the piece of foil such that at least one of the contact elements penetrates into the piece of foil to contact an electrically conductive lead.

[0007] Because the contact element(s) penetrate into the piece of foil, placement is not limited to a region near the perimeter of the piece of foil in its plane. Adaptation of the edge of the piece of foil is not necessary, since it can remain in the plane of the major part of the piece of foil. This makes the method suitable for use with rolls of foil that are manufactured relatively easily and efficiently. Because the foil is penetrated, the foil can be positioned flat over substantially the entire extent of its plane, resulting in better controlled interaction with its environment.

[0008] A preferred embodiment includes providing a piece of a foil comprising a laminate bearing an electrically insulating layer at a surface on at least one side and piercing through at least one electrically insulating layer to provide respective passages for the contact elements.

[0009] Thus, the method allows placement of the connector contact at any position along the length of the electrically conductive lead. The electrically insulating layer prevents short-circuiting at the other positions, which remain covered. This embodiment has the additional advantage that the piece of foil can be adhered to a support surface without much regard to the electrical properties of the support surface.

[0010] Preferably, the method includes providing a connector contact with the second section attached to the first section at an opposite end along a longitudinal axis to the terminal, and configuring the connector contact such that the second section is positioned with its longitudinal axis at an angle to the plane of the piece of foil, preferably substantially perpendicularly to its plane.

[0011] Thus, the second section including the terminal directs a connected wire away from the surface of the piece of foil. This embodiment has the advantage that that surface can be adhered to a support surface with only a minimal interruption of the support surface to accommodate a recess or hole for the connector and connected wire. Thus, mechanical support of the piece of foil is better.

[0012] Preferably, the method includes providing a connector contact with a first section including a substantially planar base, wherein the contact elements include at least one tine protruding from the base, and placing the base against a surface of the piece of foil in parallel to its plane with the tines protruding at an angle to the plane.

[0013] This embodiment ensures a firmer, more rigid, connection between the connector contact and the piece of foil, in particular where the assembly of foil and connector contact is not directly backed up by a support surface.

[0014] A preferred variant includes bending the con-

tact terminal such that the second section assumes an orientation at an angle to the base.

[0015] Thus, the connector contact can be manufactured in one piece, for example stamped and formed. A firm connection to the piece of foil is assured, whilst the wire to which a connection is provided is lead away from the surface of the foil.

[0016] Preferably, the method includes providing a connector contact wherein the first section includes a base and at least one protruding tine, wherein at least one of the tines is pressed into the foil and subsequently bent into an arcuate shape, such that at least a tip of a bent tine is brought into contact with the electrically conductive lead.

[0017] This ensures a connection with better resistance to pulling forces at an angle to the plane of the piece of foil. A shape-locked connection is provided, rather than a purely frictional connection.

[0018] According to another aspect, the assembly according to the invention is characterised in that at least the first section of the connector contact is positioned adjacent to the piece of foil such that at least one of the contact elements penetrates into the piece of foil to contact an electrically conductive lead.

[0019] The assembly has the advantage of being more versatile, since the connector contact need not necessarily occupy the edge of the piece of foil. This increases the number of configurations in which the piece of foil can be placed to expose it to the environment.

[0020] Preferred embodiments of the assembly are defined in the dependent claims.

[0021] The invention will now be explained in further detail with reference to the accompanying drawings, in which:

Fig. 1 is a schematic illustration of a roll of solar foil from which a piece may be cut to form an assembly with connector contacts for attachment to wires;

Fig. 2 shows in schematic fashion a cross-section of the foil to illustrate various layers that are present;

Fig. 3 is a schematic perspective view of one example of a connector contact that is suitable for attachment to the piece of foil; and

Fig. 4 is a very schematic side view of an assembly formed by attaching one connector contact to a piece of foil.

[0022] In Fig. 1 a roll 1 of photovoltaic (PV) foil comprises a plurality of solar cells 2, arranged in an array. Each row comprises a number of solar cells 2 connected in series by means of interconnects (not detailed separately in Fig. 1). Two bus bars 3 are embedded in the foil. An example of a method of manufacturing the roll 1 of foil is set out in more detail in WO 01/78156. An example of a roll 1 of foil that is currently manufactured has a width of about 1.2 m.

[0023] Thin film solar cell foils, also known as photovoltaic foils, generally comprise a carrier and a photovoltaic layer composed of a semiconductor material provided between a front electrode comprising a transparent conductive oxide (TCO) at the front of the foil and a back electrode at the back of the foil. The front electrode is transparent, enabling incident light to reach the semiconductor material, where the incident radiation is converted into electric energy. In this way, light is usable to generate electric current.

[0024] Manufacturing the solar foil on the roll 1 has the advantage that pieces, or strips, can be cut off to provide a unit for generating a desired voltage or power. It is preferred to allow pieces of any length to be cut off to form a unit. To make this possible, the roll 1 preferably has no pre-defined division into units. This means that it should be possible to provide a point of connection to the wires that are to be attached to conduct the generated electric current at substantially any position along the length of the roll 1 of foil.

[0025] In the shown configuration, the solar cells 2 are series-connected between the bus bars 3. The length of the piece of foil that is cut off from the roll 1 determines the length of each bus bar 3 in the foil. The width of a bus bar 3 (in the plane of the foil) is preferably a value in the range of 0.5-1 cm. The height is preferably a value in the range of 80-100 μm. A suitable material for the bus bars 3 is aluminium, although another electrically conductive material, e.g. a metal or metal alloy is usable in alternative embodiments.

[0026] Referring to Fig. 2, a piece of laminated foil 4 comprises a laminate of a PV foil 5 sandwiched between an upper electrically insulating layer 6 and a lower electrically insulating layer 7. Both electrically insulating layers 6,7 are made of plastic. The upper layer 6 is thicker than the lower layer 7 in the illustrated embodiment, since it is exposed to the environment. The opposite is true in other variants, depending on the need to stabilise the foil, for instance. In principle, the piece of laminated foil 4 comprising the laminate of the PV foil 5, and electrically insulating layers 6,7 need not be sandwiched between glass plates. The lower layer 7 is preferably adhered directly onto a supporting surface (not shown), in order to provide stability.

[0027] At least the upper electrically insulating layer 6 includes a Fluorine component and, optionally, a fibreglass mat or fleece with a thickness in the range of 30-80 μm. Photodiodes in the solar cells 2 interact with the environment through the surface formed by the upper layer 6. Interaction takes place in the form of exchange of electromagnetic radiation.

[0028] The upper and lower electrically insulating layers 6,7 extend beyond the perimeter of the PV foil 5, which has a width W_1, over a width W_2 on either side. This is to comply with common regulatory requirements. A similar region is provided at the other edges of the piece of laminated foil 4. Where a surface is clad with a

plurality of such pieces of laminated foil 4 in an array, the pieces are preferably arranged on a support surface with their edges in overlapping relationship. This provides a larger total active area. To ensure that the height of the overlapping edge regions is kept within bounds, connectors are preferably attached to the piece of laminated foil 4 in the active area in which the solar cells 2 and at least part of the bus bars 3 are situated, rather than at an edge.

[0029] To allow electrical connection to a wire, a connector contact 8, for example the one shown in Fig. 3, is attached to each bus bar 3. The connector contact 8 is known as such from applications in the automotive field. It is obtainable by stamping and subsequent shaping steps. Thus, the connector contact 8 is preferably an integral part. Embodiments made of copper, aluminium and alloys thereof are usable. Such embodiments are optionally coated, for example galvanised. Preferably, the connector contact is made of galvanised phosphor bronze, to facilitate its being crimp connected to the piece of laminated foil 4.

[0030] The connector contact 8 includes a first section 9, including a substantially planar base 10, from which four tines 11 protrude. These tines 11 form contact elements for establishing an electrically conductive connection to a bus bar 3 at a desired point along its length. The first section 9 is of a somewhat elongated shape, and is attached to a second section 12 at one longitudinal end. The opposite longitudinal end terminates the connector contact 8. The second section 12 includes a female terminal 13, suitable for mating with a male terminal (not shown) of a wire connector. In an alternative embodiment, the second section 12 includes a terminal for direct attachment to a wire, for example by soldering or crimping onto the wire.

[0031] Suitable wires have a diameter with a value in the range of 2-3 mm, and are included in a single-wire cable. The wire is preferably made of between thirty and sixty strands of copper, aluminium, or an alloy thereof, and may be galvanised. Insulating cladding is used, with an outer diameter having a value in the range of 5-6 mm. Suitable insulating materials include Polyolefins and PTFE. Such cables generally have a rated voltage of 1000 V DC, and a rated current of 60 A.

[0032] In the illustrated embodiment, the connector contact 8 is attached to the piece of laminated foil 4 by pressing the tines 11 into the laminated foil 4, such that they penetrate the laminated foil. The base 10 is thus brought into contact with the lower surface of the lower electrically insulating layer 7. In that position, the base 10 is parallel to the plane of the laminated foil, so as to provide extra support. The connection is thus stiffened, and the area of connection need not necessarily be adhered to a supporting surface, allowing provision of a recess or hole for accommodating the connector contact and a connector housing (not shown). The tines 11 protrude into the piece of laminated foil 4 at an angle to the base 10. Subsequently, the tines 11 are bent back on themselves to bring their tips 15 into contact with the bus bar 3. The upper surface of the piece of laminated foil 4, formed by the outer surface of the upper electrically insulating layer 6, is raised only to a minimal extent. This helps prevent shadow-forming, because a housing with a lower profile can be used to shield the protruding tines 11 from the environment.

[0033] The connector contact 8 is then bent, assuming the configuration shown very schematically in Fig. 4. The second section 12 is oriented at an angle to the first section 9, preferably substantially perpendicularly to it. Thus, the longitudinal axis of the second section 12 is at substantially the same angle to the plane of the piece of laminated foil 4. When connected, the wire is substantially aligned with the longitudinal axis of the terminal 13, so that the wire is lead away from the lower surface of the piece of laminated foil 4. This allows as much as possible of the area surrounding the point of connection to be adhered directly onto a support surface, without being raised by wires situated in between. A relatively high level of stability is achieved in this way. In alternative embodiment, the connector contact 8 is bent before being pressed into the piece of laminated foil 4.

[0034] It is observed that the connector contact 8 shown in Fig. 3 is but one suitable embodiment. Other embodiments include a first section with a base from which pyramid-shaped structures with sharp tips protrude. Such tips pierce through the lower electrically insulating layer to contact a bus bar from below. Friction keeps the connector contact attached to the piece of laminated foil 4. A soldered connector contact may be used instead of a crimp connector contact or piercing connector contact, but is least preferred because the solder causes a local elevation of the laminated foil when the latter is applied to a supporting surface.

[0035] The invention is not limited to the above-described embodiments, which may be varied within the scope of the claims. For example, instead of being applied to pieces of laminated_foil with solar cells as active elements, the invention can also be implemented using other types of foils in which exchange of radiation energy occurs, for example those comprising cells with luminescent Light Emitting Diodes, window foils, foils for a flexible display. Indeed, other types of interaction with the environment may take place through the surface, as in the case of battery foils, for example.

Claims

1. Method of providing a connector contact to a piece of foil, including providing a piece of foil (4) provided in an active area of its plane with at least one cell (2) with active elements for interaction with the environment through a surface on at least one side of the piece of foil (4) and having embedded therein at least one electrically conductive lead (3) lying at least partially in the active area and in electrical connection with at least one of the cells (2), and providing a

connector contact (8) having a first section (9) including at least one protruding contact element (11) and a second section (12) including a terminal (13) for forming a connection to a ire, **characterised in that** at least the first section (9) is placed adjacent to the piece of foil (4) such that at least one of the contact elements (11) penetrates into the piece of foil to contact an electrically conductive lead (3).

2. Method according to claim 1, including providing a piece of a foil comprising a laminate bearing an electrically insulating layer (6,7) at a surface on at least one side and piercing through at least one electrically insulating layer (7) to provide respective passages for the contact elements (11).

3. Method according to any one of the preceding claims, including providing a connector contact (8) with the second section (12) attached to the first section (9) at an opposite end along a longitudinal axis to the terminal (13), and configuring the connector contact (8) such that the second section (12) is positioned with its longitudinal axis at an angle to the plane of the piece of foil (4), preferably substantially perpendicularly to its plane.

4. Method according to any one of the preceding claims, including providing a connector contact (8) with a first section (9) including a substantially planar base (10), wherein the contact elements (11) include at least one tine protruding from the base (10), and placing the base (10) against a surface of the piece of foil (4) in parallel to its plane with the tines protruding at an angle to the plane.

5. Method according to claim 4, including bending the contact terminal (8) such that the second section (12) assumes an orientation at an angle to the base (10).

6. Method according to any one of the preceding claims, including providing a connector contact (8) wherein the first section (9) includes a base (10) and at least one protruding tine (11), wherein at least one of the tines (11) is pressed into the foil and subsequently bent into an arcuate shape, such that at least a tip (14) of a bent tine (11) is brought into contact with the electrically conductive lead (3).

7. Assembly including a piece of foil (4) provided in an active area of its plane with at least one cell (2) with active elements for interaction with the environment through a surface on at least one side of the piece of foil (4) and having embedded therein at least one electrically conductive lead (3) lying at least partially in the active area and in electrical connection with at least one of the cells (2), and a connector contact (8) having a first section (9) including at least one protruding contact element (11) and a second section (12) including a terminal (13) for forming a connection to a wire, **characterised in that** at least the first section (9) of the connector contact (8) is positioned adjacent to the piece of foil (4) such that at least one of the contact elements (11) penetrates into the piece of foil (4) to contact an electrically conductive lead (3).

8. Assembly according to claim 7, wherein the piece of foil (4) comprises a laminate bearing an electrically insulating layer (6,7) at a surface on at least one side and wherein at least one of the contact elements (11) protrudes through at least one electrically insulating layer (7) to contact the electrically conductive lead (3).

9. Assembly according to claim 7 or 8, wherein the second section (12) of the connector contact (8) is attached to the first section (9) at an opposite end along a longitudinal axis to the terminal (13), and wherein the second section (12) is positioned with its longitudinal axis at an angle to the plane of the piece of foil (4), preferably substantially perpendicularly to the plane.

10. Assembly according to any one of claims 7-9, wherein the first section (9) of the connector contact (8) includes a substantially planar base (10), wherein the contact elements (11) include at least one tine protruding from the base (10), and wherein the base (10) is positioned against a surface of the piece of foil (4) in parallel to its plane with the tines protruding at an angle to the plane.

11. Assembly according to claim 10, wherein the connector contact (8) is bent such that the second section (12) is oriented at an angle to the base (10).

12. Assembly according to any one of claims 7-11, wherein the first section (9) of the connector contact (8) includes a base (10) and at least one protruding tine (11), wherein at least one of the tines (11) protrudes into the foil and is bent back on itself into an arcuate shape, such that at least a tip (14) of a bent tine (11) contacts the electrically conductive lead (3).

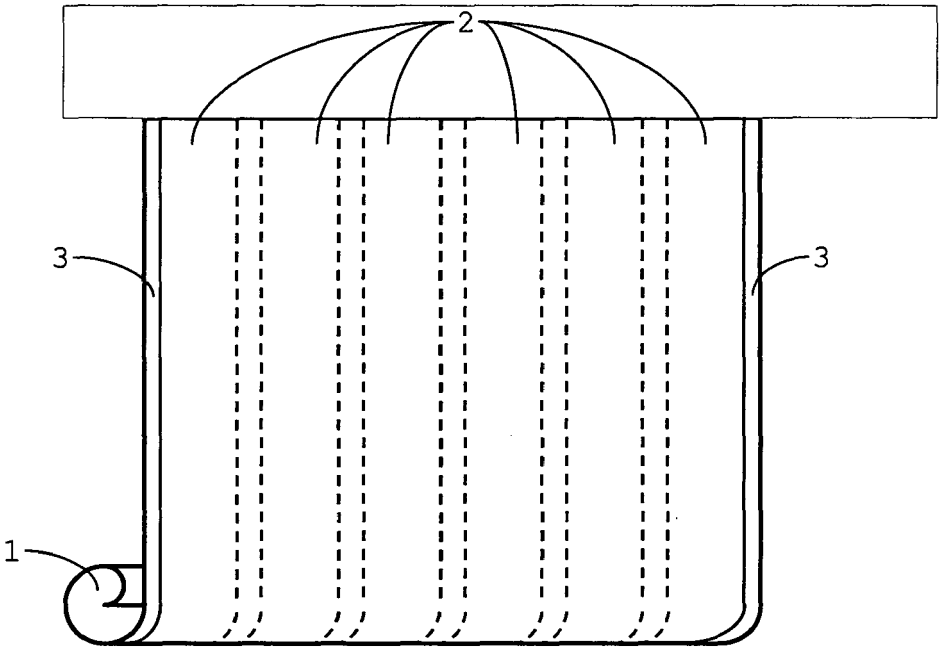

Fig. 1

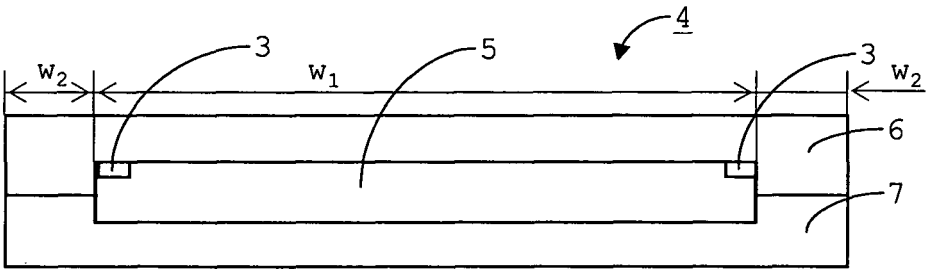

Fig. 2

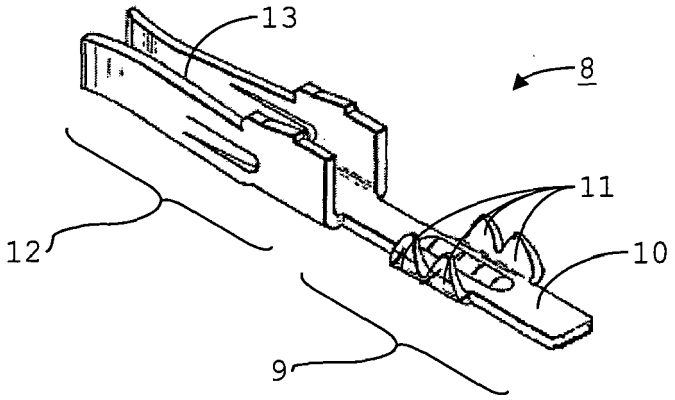

Fig. 3

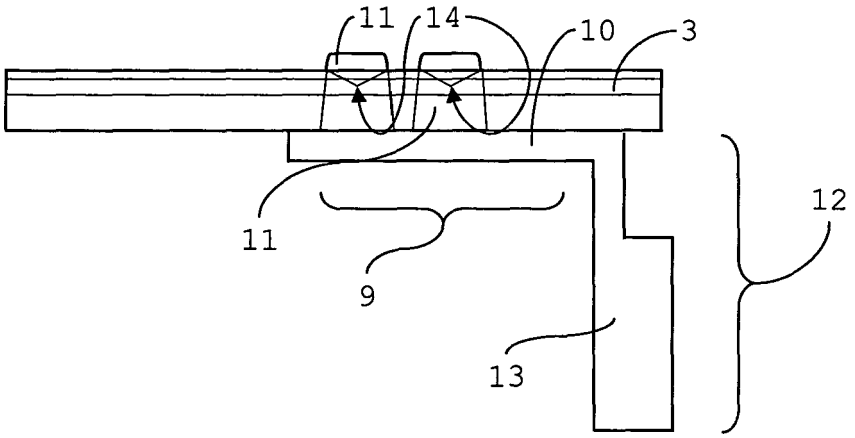

Fig. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 05 07 5734

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	10 October 2005	Jiménez, J

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