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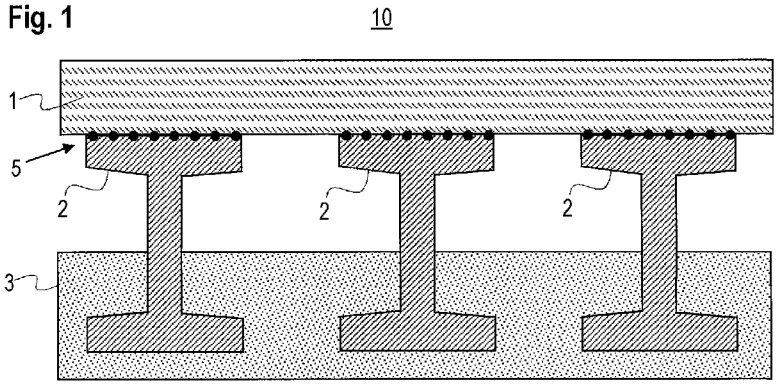
(54) Title: WATERTIGHT BUILDING CONSTRUCTION SURFACE ELEMENT WITH PHOTOVOLTAIC MODULE

Fig. 1



(57) Abstract: Building construction surface element comprising at least one photovoltaic module (1) a watertight barrier layer (3) comprising a sealant mechanical fixation means (2) attached to the at least one photovoltaic module wherein the mechanical fixation means (2) define the distance between the photovoltaic module (1) and the watertight barrier layer (3) and at least an end portion of the mechanical fixation means is sealingly embedded in the sealant. Further in the scope of the invention are a roof built according the principle of the inventive building construction surface element, and methods of manufacturing the building construction surface element and the roof.

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Watertight building construction surface element with photovoltaic module

The invention addressed herein refers to a building construction surface element. Under a further aspect, the invention relates to a method of manufacturing such a building construction surface element. More specifically, the invention refers to a building construction surface element including at least one photovoltaic module.

Instead of mounting photovoltaic modules on top of existing structures of a building, it is efficient to integrate photovoltaic modules into building elements intended to cover the outer surface of a building and being exposed to solar light, as e.g. building elements for walls and roofs. Building construction surface elements incorporating solar converters are known e.g. from the document WO 2015/055714. For most applications, such building construction surface elements need to be watertight. In combination with all the other requirements for building construction surface elements, as e.g. mechanical and thermal requirements, the requirement of water tightness leads to structures that are complicated and expensive to fabricate. Failing to fulfill the requirement of water tightness can lead to substantial damage to the structure of a building. This is particularly critical in the case building elements used to construct flat roofs.

The object of the present invention is to provide an improved watertight building construction surface element, which is able to harvest solar energy and which is easy to fabricate, highly fail-save and durable.

This object is achieved by a building construction surface element according to claim 1. Such an inventive building construction surface element comprises

- at least one photovoltaic module
- a watertight barrier layer comprising a sealant
- mechanical fixation means attached to the at least one photovoltaic module

wherein

- the mechanical fixation means define the distance between the photovoltaic module and the watertight barrier layer and
- at least an end portion of the mechanical fixation means is sealingly embedded in the sealant. The term 'sealingly embedded' here comprises the aspects of surrounding, holding in position and forming a watertight contact at the common surface.

In one embodiment of the building construction surface element according to the invention, which may be combined with any of the embodiments still to be addressed, unless in contradiction, the watertight barrier layer is spaced from the at least one photovoltaic module.

This way, a gap exists between the photovoltaic module and the watertight barrier layer, in which air or water can circulate. This provides a way of cooling the photovoltaic module as well as a possibility for drainage of rainwater.

In one embodiment of the building construction surface element according to the invention, which may be combined with any of the embodiments still to be addressed, unless in contradiction, it comprises several photovoltaic modules attached to a common watertight barrier layer.

In one embodiment of the building construction surface element according to the invention, which may be combined with any of the preaddressed embodiments and with any of the embodiments still to be addressed, unless in contradiction,

- the mechanical fixation means are multi-part mechanical fixation means,
- a first part of the multi-part mechanical fixation means is attached to the photovoltaic module,
- a second part of the multi-part mechanical fixation means having said end portion, and
- a detachable connection is established between said first and second part.

The second part of the multi-part mechanical fixation means is in contact with the sealant. The detachable connection, which e.g. can be established by nuts and bolts, allows

mounting and removal of the photovoltaic module separate from the mounting and removal of the watertight barrier layer. In particular, this configuration allows repair or revision of the photovoltaic modules while the watertight barrier layer stays in place. The end portion referred to in the definition of the second part of the multi-part mechanical fixation means is the end portion of the mechanical fixation means that is sealingly embedded in the sealant.

In one embodiment of the building construction surface element according to the invention, which may be combined with any of the preaddressed embodiments and with any of the embodiments still to be addressed, unless in contradiction, it comprises a support structure to which the mechanical fixation means are attached, and wherein the watertight barrier layer extends between the support structure and the photovoltaic module.

The support structure may e.g. be a flat structure, it may be continuous or it may consist of a grid of support elements.

In one embodiment of the building construction surface element according to the invention, which may be combined with any of the preaddressed embodiments and with any of the embodiments still to be addressed, unless in contradiction, the sealant is a polymer, in particular one of epoxy, butyl rubber, silicone rubber, polyurea or polyurethane, in particular polyurea foam or polyurethane

foam, wherein preferably the watertight barrier layer at least predominantly consists of said sealant.

Polymers are particularly suited to be used as sealants. The polymers listed above have properties, which make them suitable in the context of building construction elements. In the case when a foam, in particular polyurea foam or polyurethane foam, is used, care has to be taken, that a foam with closed porosity results.

The invention is further directed to a roof comprising at least one inventive building construction surface elements.

In an embodiment of the roof according to the invention, the roof comprises a thermal insulation layer.

In an embodiment of the roof according to the invention, the roof is a flat roof consisting of an inventive building construction surface element.

In an embodiment of the flat roof according to the invention, it comprises at least one pair of adjacent photovoltaic modules being horizontally spaced by a gap, wherein an elongated metal strip element with trough holes bridges the gap.

In a further embodiment of the flat roof according to the invention, which may be combined with any of the

preaddressed embodiments and with any of the embodiments still to be addressed, unless in contradiction, it comprises a crossing of elongated metal strip elements formed by one continuous elongated metal strip element and two elongated metal strip elements with ends beneath the one or beside the one.

In a further embodiment of the flat roof according to the invention, which may be combined with any of the preaddressed embodiments and with any of the embodiments still to be addressed, unless in contradiction, it comprises a drainage system.

In the scope of the invention is a method of manufacturing an inventive building construction surface element, involving the following steps in any desired and meaningful sequence:

- providing mechanical fixation means on a horizontal surface
- filling the space between the mechanical fixation means by a polymerisable substance and thereby embedding at least a part of said mechanical fixation means therein
- inducing polymerization of the polymerisable substance
- connecting the at least one photovoltaic module to the fixation means.

Polymerisation can be induced by irradiating ultraviolet light, increasing temperature or adding a catalyst

depending on the polymerisable substance actually used. In the case of adding a catalyst, the catalyst can already be mixed into the polymerisable substance before the filling step as long as the polymerization reaction occurs slowly enough that a significant hardening of the polymerisable substance only takes place after the filling of the space between the mechanical fixation means. In addition, substances that induce the formation of a foam can be mixed into the polymerisable substance, as e.g. a small amount of water in case of polyurethane.

For the filling step, the polymerisable substance can be provided in liquid form; it can as well have a higher paste like viscosity and in can be a foam. During the filling step, the polymerisable substance can be deformed and shaped.

The steps of the method can be carried out in the sequence as listed above. Alternatively, the step of connecting the at least one photovoltaic module to the mechanical fixation means can be the first step carried out when applying the method. If multi-part mechanical fixation means are used, the steps that lead to the embedding of an end portion of the second part of the mechanical fixation means in the sealant and the step of connecting the at least one photovoltaic module to the first part of the mechanical fixation means can be carried out completely independent from each other. In the latter case, in an additional final step, the building construction surface element is assembled by establishing the detachable connection between said first and second part.

Further in the scope of the invention is a method of manufacturing a flat roof, the method applying the steps of the previously described method, wherein the horizontal surface is part of the building to be covered by the flat roof.

Further in the scope of the invention is a method of manufacturing an inventive building construction surface element, the method involving the following steps in any desired and meaningful sequence:

- providing mechanical fixation means in a basin with horizontal bottom
- filling the space between the mechanical fixation means by a polymerisable substance and thereby embedding at least a part of said mechanical fixation means therein
- inducing polymerization of the polymerisable substance
- separating the basin from the resulting polymerized substance
- connecting the at least one photovoltaic module to the fixation means.

For the filling step, the polymerisable substance can be provided in liquid form; it can as well have a higher paste like viscosity and it can be a foam. During the filling step, the polymerisable substance can be deformed and shaped.

The resulting polymerized substance forms a more or less solid block that is stable and self-supporting, such that the basin is not needed anymore to stabilize the form. The building construction surface element thus can be pre-fabricated by this manufacturing method and later be transported to the building site.

The building construction surface element or the roof according to the present invention can be produced in several steps and combining different materials to build up the watertight barrier layer. E.g. a watertight foil can be used as a basic barrier for water. Attaching mechanical fixation means to a support structure can be performed in a way, that weakens the watertight foil or creates holes through it, e.g. by drilling screws through the foil. The watertight barrier can be re-established in a second step of covering or sealing locally by applying a sealant at those places. The number of places needing a second sealing step can be kept low, if e.g. small blocks as a part of the mechanical fixation means are used to be fixed at the underlying support structure. A grid of beams as a further part of the mechanical fixation means can rest on these small blocks and provide a more distributed support for the photovoltaic modules. In a preferred embodiment the water tight barrier or foil is made of an onsite polymerizable material instead of an already industrially pre-polymerized membrane to be rolled on the roof needing additional glueing or thermal welding steps between one roll and the next one. Polymerizable materials as for example listed in

the present invention allow to achieve very quickly a complete watertight surface throughout the roof's lifetime and on top of that they present better mechanical properties than said pre-polymerized foils.

The fact that the photovoltaic modules on the top layer avoid UV light irradiation directly on the watertight barrier further adds to the lifetime expectance of this system over state of the art ones.

The photovoltaic modules can be glued to mechanical fixation means that provide relatively large contact areas for gluing. This way building construction elements are achieved, that can be used to produce walkable roofs.

The invention shall now be further exemplified with the help of figures. The figures show:

Fig. 1 cross-section through an inventive building construction surface element;

Fig. 2. cross-section through an embodiment combining more than one photovoltaic modules with a single watertight barrier layer;

Fig. 3 cross-section through a part of an embodiment with a support structure;

Fig. 4 cross-section through an embodiment with multi-part mechanical fixation means;

Fig. 5 cross-section (Fig. 5a) and top-view (Fig. 5b) of a part of a building construction surface element without the photovoltaic module;

Fig. 6 cross-section through a roof built as building construction surface element according to the invention;

Fig. 7 perspective view (with magnified detail) onto the upper surface of a portion of a building construction surface element, where four corners of photovoltaic modules meet, and metal strip elements with through holes bridge the gaps between adjacent photovoltaic modules;

Fig. 8 cross-section through details of a way of fixing a metal strip element covering the gap between adjacent photovoltaic modules.

Fig. 1 shows in a cross-sectional view, schematically and simplified, an inventive building construction surface element 10. A photovoltaic panel 1 is attaced to mechanical fixation means 2. An end portions of the mechanical fixation means is embedded in a sealant. The sealant builds a watertight barrier layer 3. The photovoltaic module 1 is held at a distance from the watertight barrier layer 3 by the mechanical fixation means 2 forming a gap where air and water can circulate. Connection means 5 fix the photovoltaic module to the fixation means 2. The connection means 5, here indicated by black dots, can e.g. be glue, welding points or screws. Several mechanical fixations

means 2 are distributed such that the photovoltaic module is supported in a way to keep bending stress minimal.

Fig. 2 shows a cross-section through an embodiment combining more than one photovoltaic modules 1 with a single watertight barrier layer 3. Two photovoltaic modules 1 are shown in this figure, but any number of photovoltaic modules can be positioned side by side. End portions of the mechanical fixation means 2 are sealingly embedded in a watertight barrier layer 3 common to several photovoltaic modules 1. This principle can also be extended into the second dimension parallel to the plane of the photovoltaic module. In the current figure, this second dimension runs perpendicular to the paper.

Fig. 3 shows a cross-section through a part of an embodiment with a flat support structure 4 below the watertight barrier layer 3. The mechanical fixation means 2 are fixed to the flat support structure by screws. The sealant of the watertight barrier layer 3 covers the screws on the side facing to the photovoltaic modules, such that the screws are on the protected side of the watertight barrier layer 3. The part of the building construction surface element shown in this figure can be repeated several times to form a single building construction surface element 10. All photovoltaic modules of the building construction surface element 10 share a common watertight barrier layer 3 and a common flat support

structure 4. A photovoltaic module 1 can be attached and be supported by several mechanical fixation means 2.

Fig. 4 shows a cross-section through an embodiment of an inventive building construction surface element with multi-part mechanical fixation means. The mechanical fixation means have a first part 2′ that is attached to the photovoltaic module 1 and a second part 2′′ having the end portion that is embedded sealingly in the watertight barrier layer 3. The two part 2′ and 2′′ are connected by nuts and bolts. The connection by nuts and bolts is one of several possibilities to establish a detachable connection. The first part 2′ of the multi-part mechanical fixation means can – together with the photovoltaic module 3 – be removed and attached to the second part without touching or manipulating the watertight barrier layer 3.

Fig. 5a shows a cross-section through a part of a building construction surface element. The watertight barrier layer 3 and the part of the mechanical fixation means 2, 2′′ that has an end portion embedded in the sealant of the watertight barrier layer 3 is shown. The cross section runs along the line A-A that is marked as dash-dotted line in Fig. 5b. A variant of mechanical fixation means 2, 2′′ having a profile in "Omega" form is shown in this figure.

Fig. 5b shows the top-view of the same part of a building construction surface element as in Fig. 5a. The photovoltaic module is not shown in order to make the arrangement of the mechanical fixation means 2, 2′′

visible. One of the profiles that form the mechanical fixation means 2, 2'' is interrupted. Such interruptions in the profiles allows air and water to circulate and give the possibility to install electrical conductors to connect different photovoltaic modules. With the arrangement of mechanical fixation means shown here a large support area for the photovoltaic modules is provided. This allows photovoltaic modules to be built as sandwich structures having a photovoltaic layer between two glass layers.

Fig. 6 shows a cross-section through a roof 11 built as building construction surface element according to the invention. A flat horizontal support structure 4 supports mechanical fixation means 2. The mechanical fixations means support photovoltaic modules 1 which form the upper surface of the roof. A watertight barrier layer 3 comprises a sealant that covers the flat support structure 4 and sealingly embeds the lower part of the mechanical fixation means 2. An open space between the watertight barrier layer 3 and the photovoltaic modules allows the circulation of air and water. Hot air can escape from this space through holes in metal strip elements that cover the gaps between neighboring photovoltaic modules. This way, overheating of the photovoltaic modules can be prevented. The metal strip elements with through holes also allow run-off of rain water 21 into the space below the photovoltaic modules. This helps to avoid stagnation of water on the roof. The watertight barrier layer 3 is formed to have a channel and a slight slope on its upper surface. These elements provide

a drainage system 8 that is able to collect rain water and guide it to a sink. The through holes in the metal strip element 7 are dimensioned as to prevent larger objects - as e.g. leaves 22 - to fall into the space below the photovoltaic modules. Figure 7 shows a possible way of arranging the metal strip elements in the plane. A beam 24 locally reinforces the support structure 4. The roof 11 comprises a thermal insulation layer 6. A small portion of a wall 23 is shown in the figure to illustrate the situation of the roof 11 and its elements in the environment of a complete building.

Fig. 7 shows a perspective view onto the upper surface of a portion of a building construction surface element, where four corners of photovoltaic modules 1a, 1b, 1c, 1d meet, and elongated metal strip elements 7 with through holes bridge the gaps between adjacent (e.g. 1a and 1b) photovoltaic modules. At the crossing point of the gaps between the photovoltaic modules, a crossing of elongated metal strip elements is formed by one continuous elongated metal strip element 7a and two elongated metal strip elements 7b, 7c with ends beneath the one 7a. The positions of the invisible end parts of 7b and 7c beneath 7a are marked with dotted lines (see also the magnified detail). With this arrangement, all the gaps between the photovoltaic modules are covered in a way that allows securely walking on the surface, that prevents dirt from falling into the gaps and at the same time lets air and rain pass through the cover of the gap.

Fig. 8 shows a cross-section through details of a way of fixing a metal strip element 7 covering the gap between adjacent photovoltaic modules 1. A counterpart element 25 for fixing the metal strip element 7 extends behind the photovoltaic modules 1. A screw fixes the metal strip element 7 and the counterpart element 25 to each other. This way, the elements are secured against being blown away by wind. The detachable connection still allows easy access to space below the photovoltaic modules.

List of reference signs

1 Photovoltaic module
1a, 1b, 1c, 1d Photovoltaic modules
2 mechanical fixation means
2' first part of multi-part mechanical fixation means
2'' second part of multi-part mechanical fixation means
3 watertight barrier layer
4 support structure
5 connection means
6 thermal insulation layer
7 metal strip element with trough holes
7a, 7b, 7c metal strip elements with trough holes
8 drainage system
10 building construction surface element
11 roof
21 rain
22 leave
23 wall
24 beam
25 counterpart element for fixing 7
A marks the line of the cross-section in Fig. 5

Claims

1. Building construction surface element (10) comprising

- at least one photovoltaic module (1)
- a watertight barrier layer (3) comprising a sealant
- mechanical fixation means (2) attached to the at least one photovoltaic module (1)

wherein

- the mechanical fixation means (2) define the distance between the photovoltaic module (1) and the watertight barrier layer (3) and
- at least an end portion of the mechanical fixation means (2) is sealingly embedded in the sealant.

2. Building construction surface element (10) according to claim 1, wherein the watertight barrier layer (3) is spaced from the at least one photovoltaic module (1).

3. Building construction surface element (10) according to claim 1 or claim 2 comprising several photovoltaic modules (1a, 1b) attached to a common watertight barrier layer (3).

4. Building construction surface element (10) according to any one of the claims 1 to 3, wherein

- the mechanical fixation means are multi-part mechanical fixation means,
- a first part (2') of the multi-part mechanical fixation means is attached to the photovoltaic module (1),
- a second part (2'') of the multi-part mechanical fixation means having said end portion, and
- a detachable connection is established between said first and second part.

5. Building construction surface element (10) according to any one of the claims 1 to 4 comprising a support structure (4) to which the mechanical fixation means are attached, and wherein the watertight barrier layer (3) extends between the support structure (4) and the photovoltaic module (1).

6. Building construction surface element (10) according to any one of the claims 1 to 5, wherein the sealant is a polymer, in particular one of epoxy, butyl rubber, silicone rubber, polyurea or polyurethane, in particular polyurea foam or polyurethane foam, wherein preferably the watertight barrier layer (3) at least predominantly consists of said sealant.

7. Roof (11) comprising at least one building construction surface element according to any one of the claims 1 to 6.

8. Roof (11) according to claim 7 comprising a thermal insulation layer (6).

9. Flat roof (11) according to claim 7 or claim 8 consisting of a building construction surface element according to any one of the claims 1 to 5.

10. Flat roof (11) according to claim 9 comprising at least one pair of adjacent photovoltaic modules (1a, 1b) being horizontally spaced by a gap, wherein an elongated metal strip element (7) with trough holes bridges the gap.

11. Flat roof (11) according to claim 10 comprising a crossing of elongated metal strip elements formed by one continuous elongated metal strip element (7a) and two elongated metal strip elements (7b, 7c) with ends beneath the one or beside the one.

12. Flat roof (11) according to any of the claims 9 to 11 comprising a drainage system (8).

13. A method of manufacturing a building construction surface element (10) according to any one of the claims 1 to 6, involving the following steps in any desired meaningful sequence:

- providing mechanical fixation means (2, 2'') on a horizontal surface
- filling the space between the mechanical fixation means (2, 2'') by a polymerisable substance and thereby embedding at least a part of said mechanical fixation means therein
- inducing polymerization of the polymerisable substance
- connecting the at least one photovoltaic module (1) to the mechanical fixation means (2, 2').

14. The method of manufacturing a flat roof applying the steps of the method according to claim 13, wherein the horizontal surface is part of the building to be covered by the flat roof.

15. A method of manufacturing a building construction surface element according to any one of the claims 1 to 6 involving the following steps in any desired meaningful sequence:

- providing mechanical fixation means (2, 2'') in a basin with horizontal bottom
- filling the space between the mechanical fixation means (2, 2'') by a polymerisable substance and thereby

embedding at least a part of said mechanical fixation means therein

- inducing polymerization of the polymerisable substance
- separating the basin from the resulting polymerized substance
- connecting the at least one photovoltaic module (1) to the mechanical fixation means (2, 2').

Fig. 1

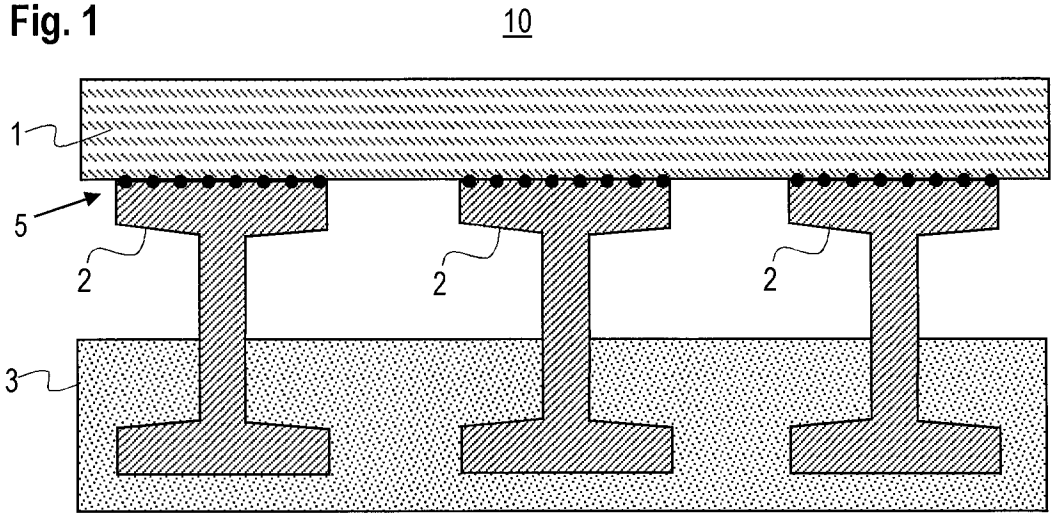


Fig. 2

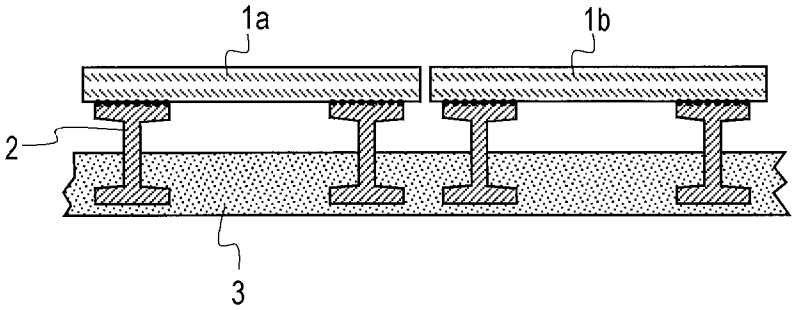


Fig. 3

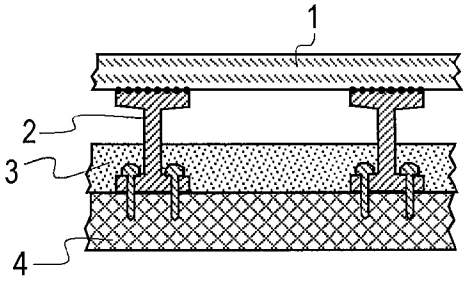


Fig. 4

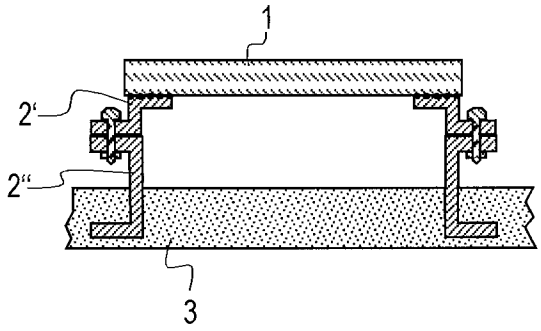


Fig. 5a

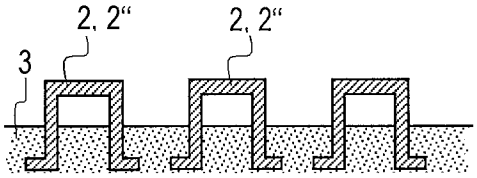


Fig. 5b

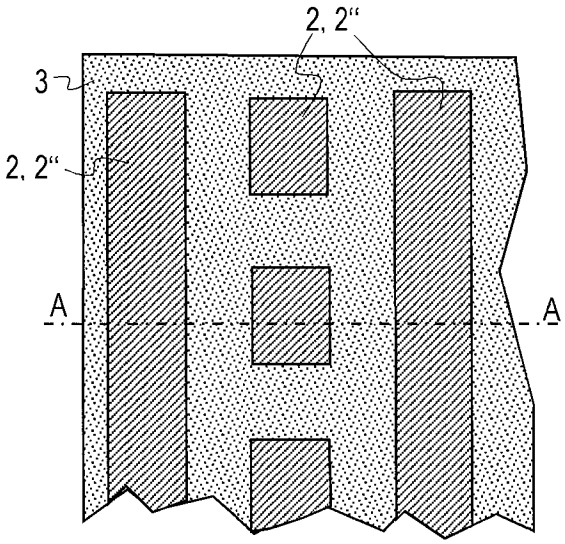


Fig. 6

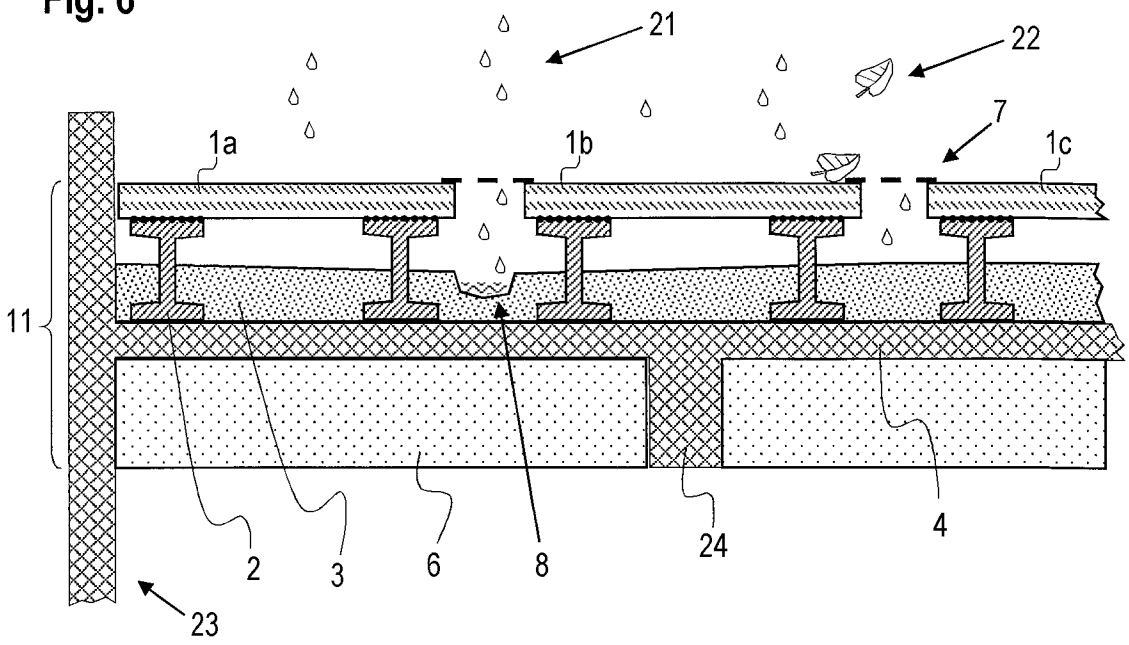


Fig. 7

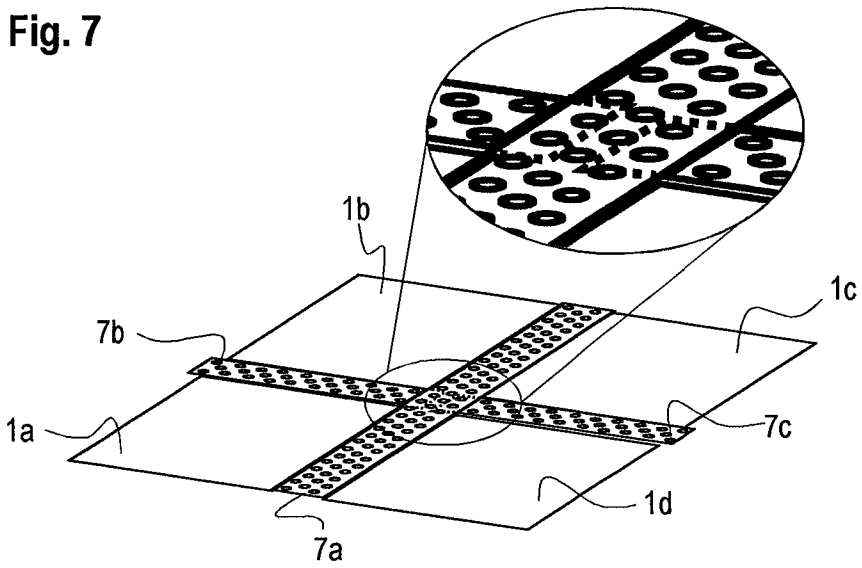
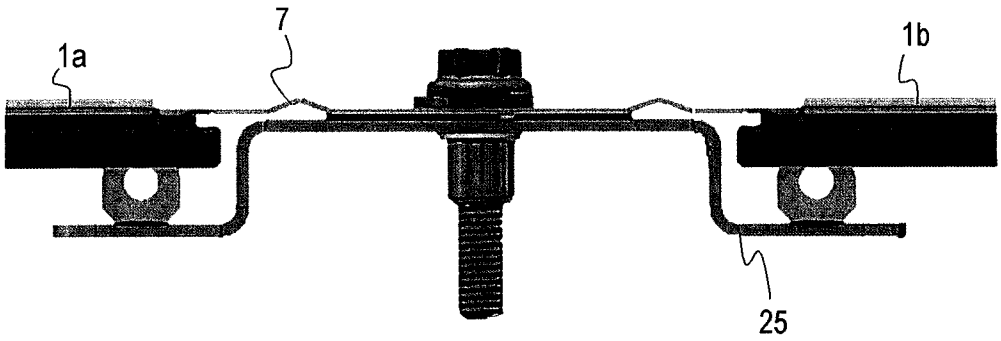


Fig. 8



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/060578

A. CLASSIFICATION OF SUBJECT MATTER
INV. H02S20/26 H02S20/24
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H02S

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2014/041321 A1 (POIVET ALAIN [US]) 13 February 2014 (2014-02-13) figure 20	1-15
A	EP 2 246 902 A1 (PIRONT VINCENT [BE]) 3 November 2010 (2010-11-03) figures	1
A	US 2012/110931 A1 (EIFFERT PATRINA [US] ET AL) 10 May 2012 (2012-05-10) figures	1
A	US 4 707 961 A (NUNLEY C LYNN [US] ET AL) 24 November 1987 (1987-11-24) figures	1

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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6 July 2016	15/07/2016

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/060578

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2015/055714 A1 (DESIGNERGY SA [CH]) 23 April 2015 (2015-04-23) cited in the application figures -----	1

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2016/060578

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