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(56) Related Art
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ABSTRACT

This invention relates to a solar sheeting assembly for roofing or walling of a building. The solar sheeting assembly comprises a sheet having a corrugated cross-sectional profile comprised of alternating crest and valley portions, wherein at least a pair of crest portions have plateaus which are substantially flat and coplanar, the sheet assembly further comprising a photovoltaic solar module secured to both of the first and second flat portions of the sheet.

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SOLAR SHEETING FOR ROOFING OR WALLING

FIELD OF THE INVENTION

The present invention relates to sheeting or cladding for the roofing and walling of buildings. In particular the invention concerns the integration of solar photovoltaic modules with the sheeting or cladding.

PRIORITY DOCUMENT

The present application is a divisional application of Australian Patent Application No. 2016259319. The content of this application is hereby incorporated by reference in its entirety.

BACKGROUND OF THE INVENTION

As the world seeks to harness renewable forms of energy such as solar, the large catchment area for solar radiation offered by building cladding makes such cladding an ideal location for photovoltaic (PV) modules.

Solar photovoltaic panels are often rigid modules that are framed and glass encapsulated. These panels are typically roof mounted by attaching the panels to dedicated mounting structures installed onto the roof. The panels may be flush mounted to align with the roof surface or installed at an angle of tilt. Solar panels installed onto roofs in this manner are known as Building Attached Photovoltaic (BAPV) modules.

An emerging market is developing for photovoltaic modules that are integrated as part of the roofing or walling material itself. Solar modules installed in this manner are known as Building Integrated Photovoltaic (BIPV) modules. BIPV modules are attractive from an aesthetic standpoint and enable solar energy generation to be embodied seamlessly as part of the building envelope. BIPV modules are currently far less common than BAPV modules because they present significantly greater design challenges. For example, photovoltaic modules generally need to be mounted on a flat or nearly flat surface in order for the cells of which they are made to be exposed to similar levels of incident solar radiation and for the modules to perform optimally. However, roof sheeting with spanning capability is generally not flat as it must have sufficient strength to achieve an acceptable level of foot traffic loading and wind uplift resistance.

There are known BIPV modules that use photovoltaic film adhered to single wide flat pans bounded by standing seam type lap joints. The problem with this design is that the sheeting generally requires the support of a continuous underlayer of plywood sarking or similar to provide strength and spanning capability. These sheets can be self-supporting if the gauge of the metal is high enough and there is adequate batten support but in colder climates such as Northern Europe they normally form the exterior layer of a multi-skinned roofing system.

Industrial, commercial, residential and agricultural buildings clad with roofing and walling made of corrugated steel sheets are a ubiquitous part of the Australasian landscape and common in many other regions around the world. Corrugated roofing or walling profiles are characterised by a number of crest and valley sections which function to provide the profiles with strength and spanning capability. Typically, corrugated steel roofing requires only the support of intermittent metal or timber battens to achieve sufficient strength for foot traffic loading and to prevent wind uplift.

It is against this background that the present invention has been developed.

Certain objects and advantages of the present invention will become apparent from the following description, taken in connection with the accompanying drawings, wherein, by way of illustration and example, several embodiments of the present invention are disclosed.

SUMMARY OF THE INVENTION

The invention provides a sheet (or panel) for supporting a photovoltaic solar module, the sheet comprising: a cross-sectional profile comprising alternating crest and valley portions, with at least a pair of crest portions having plateaus which are substantially flat and coplanar so as to provide a supporting and bonding surface for the photovoltaic solar module, with the pair of flat crest portions being wider than other crest portions (also referred to herein as standard crest portions), with at least one of the other crest portions separating the pair of flat crest portions, and with at least one of the other crest portions being to an outside of each of the pair of flat crest portions.

The invention also provides a solar sheeting assembly comprising:

a) a sheet (or panel), the sheet comprising a cross-sectional profile comprising alternating crest and valley portions, with at least a pair of crest portions having plateaus which are substantially flat and coplanar, so as to provide a supporting and bonding surface for the photovoltaic solar module, with the pair of flat crest portions being wider than other crest portions (also referred to herein as standard crest portions), with at least one of the other crest portions separating the pair of flat crest portions, and with at least one of the other crest portions being to an outside of each of the pair of flat crest portions, and

b) a photovoltaic solar module secured to both of the pair of flat crest portions of the sheet.

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In one form, the cross-sectional profile shape for the sheet further comprises at least one further standard crest portion to an outside of each of said pair of flat crest portions.

In one form, the cross-sectional profile comprises crests and valleys which are substantially sinusoidal in shape.

In one form, the cross-sectional profile comprises crests and valleys which are substantially trapezoidal in shape.

In one form, said pair of flat crest portions are separated by a further standard crest portion of the sheet. Alternatively, the flat crest portions may be separated by a valley portion.

In one form, the subject sheet is nestable over a further corrugated sheet having a cross-sectional profile comprised only of crest and valley portions identical to the conventional crest and valley portions of the subject sheet.

In one form the subject sheet can be end lapped over corrugated or trapezoidal sheets without flat crest portions.

In one form, the sheet is produced from a ferrous alloy such as steel.

In one form, the sheet is produced by roll forming sheet metal.

In one form, in an alternative, the sheet is produced from a non-ferrous material.

In one form, the photovoltaic solar module is flexible.

In one form, the photovoltaic solar module is a thin film. The thin film module may be comprised of copper indium gallium selenide (CIGS) solar cells or other suitable semi-conductor such as amorphous-silicon.

The invention also provides a solar sheeting assembly comprising a sheet having a corrugated cross-sectional profile comprised of alternating crest and valley portions, wherein at least a pair of crest portions have plateaus which are substantially flat and coplanar, and a solar module is secured to both the first and second flat portions of the corrugated sheet such that the photovoltaic solar module spans across the at least one crest or valley portion between the first and second flat portions.

The invention also provides a solar sheeting assembly for roofing or walling of a building, including a corrugated sheet having a contiguous profile including a plurality of crest and valley portions, a first flat portion; and a second flat portion, the first and second flat portions coplanar and separated by at least one crest or valley portion; and a first photovoltaic solar module securable to the corrugated sheet, wherein, the first photovoltaic solar module is securable to both the first and second flat portions of the corrugated sheet such that the first photovoltaic solar module spans across the at least one crest or valley portion between the first and second flat portions.

In one form, a section along a longitudinal edge of the photovoltaic solar module is secured to the first flat portion of the corrugated sheet prior to installation of the sheet on the building while a section of the photovoltaic solar module securable to the second flat portion remains unbonded so that the unbonded section of the solar module can be bent upward to allow access to the at least one crest or valley portion between the first and second flat portions.

In one form, there is a second photovoltaic solar module attached to the corrugated sheet, the corrugated sheet further including a third flat portion and a fourth flat portion, the third and fourth flat portions coplanar and separated by at least one crest or valley portion, wherein the second photovoltaic solar module is attached to both the third and fourth flat portions of the corrugated sheet such that the second photovoltaic solar module spans across the at least one crest or valley portion between the third and fourth flat portions.

It is also feasible to have a third or even fourth photovoltaic module attached to the corrugated sheet in the same way providing the corrugated sheet employed is wide enough.

A detailed description of several embodiments of the invention is provided below along with accompanying figures that illustrate by way of example the principles of the invention. While the invention is described in connection with such embodiments, it should be understood that the invention is not limited to any embodiment. On the contrary, the scope of the invention is limited only by the appended claims and the invention encompasses numerous alternatives, modifications and equivalents. For the purpose of example, numerous specific details are set forth in the following description in order to provide a thorough understanding of the present invention.

The present invention may be practiced according to the claims without some or all of these specific details. For the purpose of clarity, technical material that is known in the technical fields related to the invention has not been described in detail so that the present invention is not unnecessarily obscured.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of this disclosure it will now be described with respect to several embodiments which shall be described herein with the assistance of drawings wherein:

Figure 1 is a perspective view of a solar sheeting assembly according to a first embodiment of the invention;
Figure 2 is an end view of the solar sheeting assembly of Figure 1;
Figure 3 is an end view showing the solar sheeting assembly of Figure 1 side-lapped to an adjacent assembly;
Figure 4 is an end view of a standard corrugated sheet;
Figure 5 is a perspective view showing the partial lamination of a thin film solar module to the corrugated sheet;
Figure 6 is an end view showing a first method of centre fixing the corrugated sheet under the thin film solar module;
Figure 7 is an end view showing a second method of centre fixing the corrugated sheet under the thin film solar module;
Figure 8 is an end view of a solar sheeting assembly showing wiring routing along a valley region under the thin film solar module;
Figure 9 is a top view showing two thin film solar modules connected in series;
Figure 10 is a perspective view of a plurality of solar sheeting assemblies installed on a roof of a building;
Figure 11 is a plan view showing a layout of different length solar modules series connected on a roof to maximise electrical generation area;
Figure 12A is an end view of a solar sheeting assembly according to a second embodiment of the invention;
Figure 12B is a perspective view of the solar sheeting assembly of Figure 12A;
Figure 13A is an end view of a solar sheeting assembly according to a third embodiment of the invention;
Figure 13B is a perspective view of the solar sheeting assembly of Figure 13A;
Figure 14A is an end view of a solar sheeting assembly according to a fourth embodiment of the invention;
Figure 14B is a perspective view of the solar sheeting assembly of Figure 14A;
Figure 15 is an end view of the solar sheeting assembly of Figure 14A showing a channel for centre fixing the corrugated sheet to the underlying roof support structure (now shown);
Figure 16 is an end view of the solar sheeting assembly of Figure 14A showing it end lapped to a standard trapezoidal sheet; and
Figure 17 is an end view of the solar sheeting assembly of Figure 1 showing it end lapped to a standard corrugated sheet.

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DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS OF THE INVENTION

Referring now to Figures 1 and 2 there is shown a solar sheeting assembly 10 according to a first embodiment of the invention. The solar sheeting assembly 10 includes a sheet (or panel) 20 which is roll formed from sheet metal (or other material suitable for roll forming) so as have a corrugated cross-sectional profile which is constant throughout a length of the sheet, and which is comprised of alternating crest and valley portions 22, 24 and 26 respectively. A pair of flat crest portions 26 differ from other crest portions (hereinafter standard crest portions) 22 in that crest portions 26 have peaks comprising substantially flat and coplanar portions (or plateaus) , so that the pair of flat crest portions 26 is wider than the standard crest portions 22, which have a generally sinusoidal shape.

The corrugations increase the bending strength of the sheet 20 in the direction perpendicular to the corrugations, so each sheet 20 is manufactured in lengths which extend in this direction.

Accordingly, the cross-sectional profile of the sheet 20 further comprises a standard crest portion 22 (i.e. a corrugation) between said pair of flat crest portions 26, and a further standard crest portion 22 to the outside of each of said pair of flat crest portions 26.

The sheet 20 is designed to be nestable over a further corrugated sheet of cladding material 50 (such as that illustrated in Figure 4) having a cross-sectional profile comprised only of crest and valley portions 52 and 54 identical to the standard crest and valley portions 22 and 24 of the sheet or panel 20. In this way, the sheets 20 and 50 may be overlapped along their edges to create a join.

In order to achieve this, the pitch (the distance between two crests 22) and depth (the height from the top of a crest 22 to the bottom of a valley 24) of the standard crest and valley portions 22 and 24 match those of the further panel 50.

The solar sheeting assembly 10 further includes a photovoltaic solar module 30 secured to both of the first and second flat portions of the sheet (i.e. the flat crest portions 26). The solar module 30 is bonded directly to the flat crest portions 26 by a suitable adhesive or tape. The solar module 30 spans across the central corrugation between the flat crest portions 26. In this way, the solar module 30 is supported by and extends between the flat crest portions 26 of the sheet 20, and over the standard crest portion 22 that lies between said pair of flat crest portions 26.

The solar module 30 is a thin film solar module. The preferred photovoltaic module to be used is one based upon Copper, Indium, Gallium, Selenide (CIGS) semiconductor technology. An example of a

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CIGS module, is the SoloPanel SF1 manufactured by Solopower, Inc. This module is flexible, thin and lightweight. In addition, CIGS solar cell technology is more efficient than traditional amorphous-silicon technology in converting sunlight to electricity.

The solar sheeting assembly 10 as illustrated in Figures 1 and 2 provides a building integrated photovoltaic (BIPV) solution and is suitable for roofing or walling of a building or like structure such as a carport, verandah, shed etc.

Referring now to Figure 3, there is shown a mechanical fastening arrangement of the solar sheeting assembly 10 to an adjacent assembly and to underlying roof support structure (e.g. metal or timber battens or purlins) which are not shown. The sheet 20 is secured to support battens by fasteners 4 through crest portions 26 located at respective ends of the sheet 20 (and which are overlapped to adjacent sheets). A fastener 6 also extends through a valley portion located beneath the thin film solar module 30. Further detail of the centre valley fixing arrangement is provided later. By way of example, fasteners 4 may comprise hex head screws typically used for this application. For valley fastener 6, an EPDM dome washer may be used to achieve a secure and watertight seal in the valley. For fixing to walls, the sheeting assemblies 10 may be secured to supporting structures such as wall studs where a wall is being clad.

In one form, the cover width (CW) of the sheet 20 (distance between end crests) is approximately 457mm. A sheet of this size allows ease of handling and provides for extra overlap upon installation to facilitate foot traffic for installation and maintenance.

Referring now to Figure 5, there is shown a method of applying the thin film solar module 30 to the sheet 20. The method involves a partial lamination process whereby the module 30 is partially bonded to the sheet 20 in the factory and completely bonded to the sheet 20 upon installation of the assembly 10 to a roof or wall. As shown in Figure 5, the side of the module 30 near the overlap is bonded along its longitudinal edge to a first of the flat crest portions 26. Double sided adhesive tape 38 is applied to the bonding surface of the other side of the module 30 that is not bonded to the sheet 20 in the factory. The reason why the module 30 is only partially laminated is so that access to the central valley portion 24 between the flat crest portions 26 is not obstructed during installation. As fasteners cannot be driven through the solar module 30 and it is desirable to mechanically fix the sheet 20 to support battens in the centre of the profile (for wind uplift resistance), access to this region of the sheet 20 is required during installation. As the thin film solar module 30 is flexible enough to bend upward in its longitudinal direction, installers can secure fasteners 6 through the central valley region beneath the module 30. After fasteners 6 are in place, release paper is removed from the adhesive tape 38 on the unbonded section of the module 30 and this section is bonded to the sheet 20.

Figures 6 and 7 show different options of fixing the sheet 20 in the centre valley region to underlying support battens (not shown). In Figure 6, fastener 6 penetrates the centre of the valley and this is suitable for fixing to both timber and metal battens. Figure 7 shows an alternative suitable only for timber battens where fastener 6 is affixed along the centre valley wall at an angle as depicted.

The thin film solar modules 30 may have single pole electrical junction boxes 35 located at the top and bottom of each module 30 which makes them suitable for end to end series connection. Figures 8 and 9 illustrate how wiring could be routed between junction boxes of two modules 30 series connected end to end. In the example illustrated in these figures, the positive return wiring 36 from the bottommost junction box is routed along the cavity 5 formed between one of the centre valleys 24 and the module 30. In this way, the wiring or cabling is not exposed when the installation is complete. The concealed wiring provides for improved aesthetic appearance. Wiring 36 traverses along the centre valley up the sheet 20, and to the ridge cap of a roof (not shown) where it is concealed. Wiring 36B series connects intermediate junction boxes between the two end to end solar modules 30. Wiring 36A runs from the topmost junction box to the roof cap. In practice, the wiring 36 that runs along the centre valley will be laid prior to completion of the lamination of the thin film solar module 30 to the sheet 20. The main wiring conduit at the ridge cap which routes all the electricity to an inverter would have a number of plug-in points which enables series connection of the modules on each sheet to modules on all other sheets.

Figures 10 and 11 illustrate a roof 80 having a plurality of solar sheeting assemblies installed. Figure 10 shows a roof 80 having single sheets 20 that span from top to bottom of the roof 80 and supported by intermittent timber or metal battens 2. The thin film solar modules 30 also span the full length of the roof 80. Figure 11 shows a more conventional profile of roof 80 that does not have a rectangular geometry. Figure 11 illustrates how different length solar modules 30 may be used to maximise the use of available roof space for solar power generation. Solar modules 30 and 30A differ in length to minimise wastage of area which could be used to generate electricity.

Although the invention has been described with reference to an exemplary embodiment of a corrugated sheeting profile 20, other forms of corrugated sheeting 20 may alternatively be used to integrate with thin film solar modules. Figures 12A-12B, 13A-13B illustrate alternative embodiments of sinusoidal corrugated sheeting 100, 200. These sheets have a wider cover width than the sheet 20 illustrated in Figures 1 and 2. Sheets 100 and 200 may have a cover width of close to 760mm. The sheet 100 shown in Figures 12A-12B provides further corrugations either side of the flat crest portions 106. The sheet shown in Figures 13A-13B is an alternative arrangement wherein the sheet 200 has four flat crest portions 206 as shown. Multiples solar modules 30 may be bonded to this sheet in a side by side configuration as shown.

Figures 14A-14B show a trapezoidal equivalent of the sinusoidal sheeting shown in previous embodiments. The sheet 300 includes crest and valley portions 302 and 304 respectively, each having a trapezoidal cross-sectional profile. The sheet 300 further includes a pair of flat crest portions 306 having peaks comprising substantially flat and coplanar portions (or plateaus). The flat crest portions 306 are wider than the crest portions 302. In this embodiment, there is no crest portion (i.e. corrugation) between the pair of flat crest portions 306, only a single valley 304. This is a result of the properties of the sheet 300 being such that this is not required. As in the previously described embodiment, a thin film solar module 30 is supported by and extends between the flat crest portions 306 of the sheet 300. The module 30 spans across the single valley 304 between the flat crest portions 306.

Referring again to the problem associated with securing the centre of a sheet to underlying support structure, an alternative solution to the partial lamination discussed previously is shown in Figure 15. An alternative solution resides in the provision of a concealed fixing channel 80 which is securable to the support structure, and to which the sheet 300 is securable without fasteners. In this embodiment, the fixing channel 80 comprises a base portion 82 and a pair of upwardly extending wings 84 which depend from the base portion 82. In use, the base portion 82 is secured to supporting structure using fasteners 7, and the wings 84 capture the valley portion 304 disposed beneath the solar module 30 without need for fasteners. In this embodiment, this capture is effected by punching upwardly and outwardly opening tongues 86 into opposing sides of the valley portion 304, which will be aligned with and then caught on hooked ends 88 of the wings 84 when the valley portion 304 is forced between the wings 84. The sinusoidal sheet profile described in previous embodiments may also be centrally secured by use of a concealed clip arrangement.

Figure 16 shows how the trapezoidal sheeting 300 may be lapped to adjacent trapezoidal profiles. Whereas the sinusoidal profile may end overlap directly with a standard sinusoidal profile (e.g. as shown in Figure 17), the trapezoidal profile may be required to be offset one corrugation as shown in Figure 16 when end-lapping to a standard trapezoidal parent profile 60. The side lapping fastening arrangement is similar to as described for the exemplary sinusoidal sheeting embodiment.

Advantageously, the present invention integrates photovoltaic modules with corrugated roof or wall sheeting without compromising the integrity of the corrugated profile, and whilst minimising material costs associated with the roofing and solar installation. The light gauge single skin corrugated profiles disclosed herein have spanning capability (at least for temperate climates) without insulation or other necessary support such as plywood sarking. Another advantage of the flat crest portions of the profiles is that they provide raised sections which enable airflow and cooling beneath the solar modules to optimise electrical output. The solar sheeting profiles disclosed resemble in appearance, spanning capability and lapping regimes light gauge steel profiles commonly used on single skin buildings in temperate climates. The sheeting may be available in standard sizes or in cut to length sizes customized to suit the application.

Throughout the specification and the claims that follow, unless the context requires otherwise, the words “comprise” and “include” and variations such as “comprising” and “including” will be understood to imply the inclusion of a stated integer or group of integers, but not the exclusion of any other integer or group of integers.

The reference to any prior art in this specification is not, and should not be taken as, an acknowledgement of any form of suggestion that such prior art forms part of the common general knowledge.

It will be appreciated by those skilled in the art that the invention is not restricted in its use to the particular application described. Neither is the present invention restricted in its preferred embodiment with regard to the particular elements and/or features described or depicted herein. It will be appreciated that various modifications can be made without departing from the principles of the invention. Therefore, the invention should be understood to include all such modifications in its scope.

CLAIMS:

1. A solar sheeting assembly comprising:
   (a) a sheet (or panel), the sheet comprising a cross-sectional profile comprising alternating crest and valley portions, with at least a pair of crest portions having plateaus which are substantially flat and coplanar so as to provide a supporting and bonding surface for the photovoltaic solar module, with the pair of flat crest portions being wider than other crest portions, with at least one of the other crest portions separating the pair of flat crest portions, and with at least one of the other crest portions being to an outside of each of the pair of flat crest portions, and
   (b) a photovoltaic solar module secured to both of the flat crest portions of the sheet.

2. The solar sheeting assembly as claimed in claim 1 wherein a section along a longitudinal edge of the photovoltaic solar module is secured to one of the pair of flat crest portions of the corrugated sheet prior to installation of the sheet on the building while a section of the photovoltaic solar module securable to the other one of the pair of flat crest portions remains unbonded so that the unbonded section of the solar module can be bent upward to allow access to the at least one crest or valley portion between the pair of flat crest portions.

3. The solar sheeting assembly as claimed in claim 1 or 2 wherein the crest and valley portions of the corrugated sheet are sinusoidal.

4. The solar sheeting assembly as claimed in claim 1 or 2 wherein the crest and valley portions of the corrugated sheet are trapezoidal.

5. The solar sheeting assembly as claimed in any of the preceding claims wherein the photovoltaic solar module is flexible.

6. The solar sheeting assembly as claimed in any of the preceding claims wherein the photovoltaic solar module is a thin film.

7. The solar sheeting assembly as claimed in claim 5 wherein the photovoltaic solar module is comprised of copper indium gallium selenide (CIGS) solar cells.

8. The solar sheeting assembly of any of the preceding claims wherein the photovoltaic solar module has a width of less than 300mm.

9. A sheet (or panel) for supporting a photovoltaic solar module, the sheet comprising a cross-sectional profile comprising alternating crest and valley portions, with at least a pair of crest portions having plateaus which are substantially flat and coplanar so as to provide a supporting and bonding surface for the photovoltaic solar module, with the pair of flat crest portions being wider than other crest portions, with at least one of the other crest portions separating the pair of flat crest portions, and with at least one of the other crest portions being to an outside of each of the pair of flat crest portions.

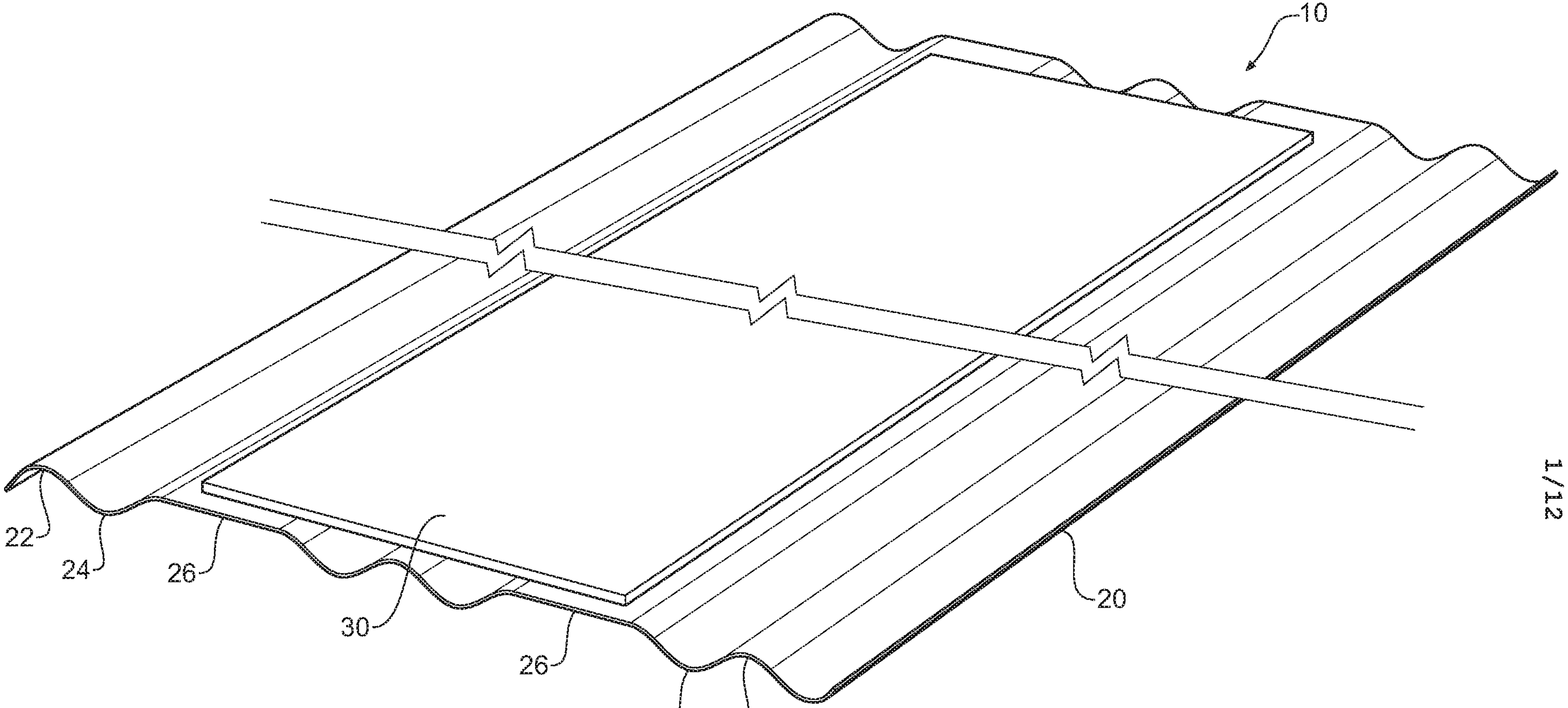

Figure 1

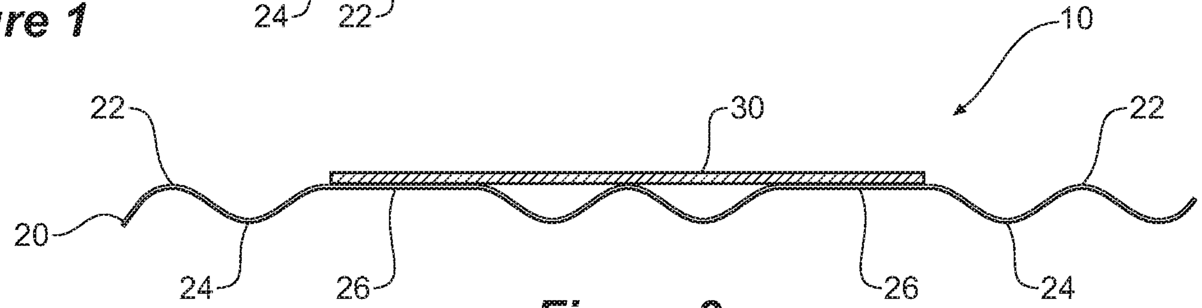

Figure 2

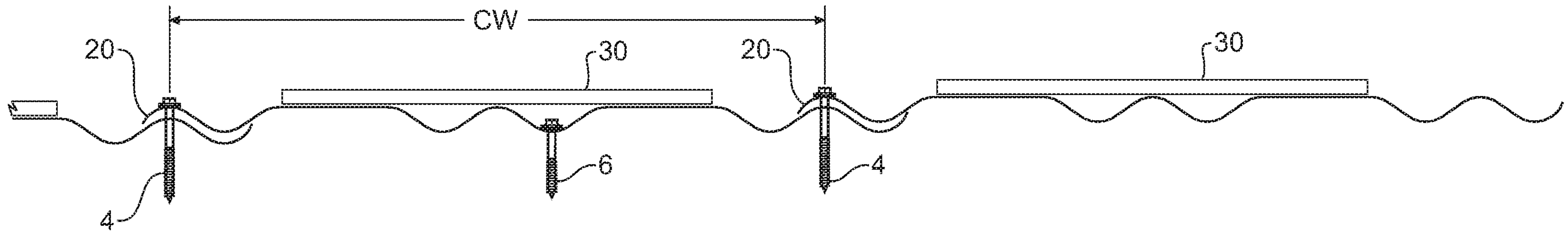

Figure 3

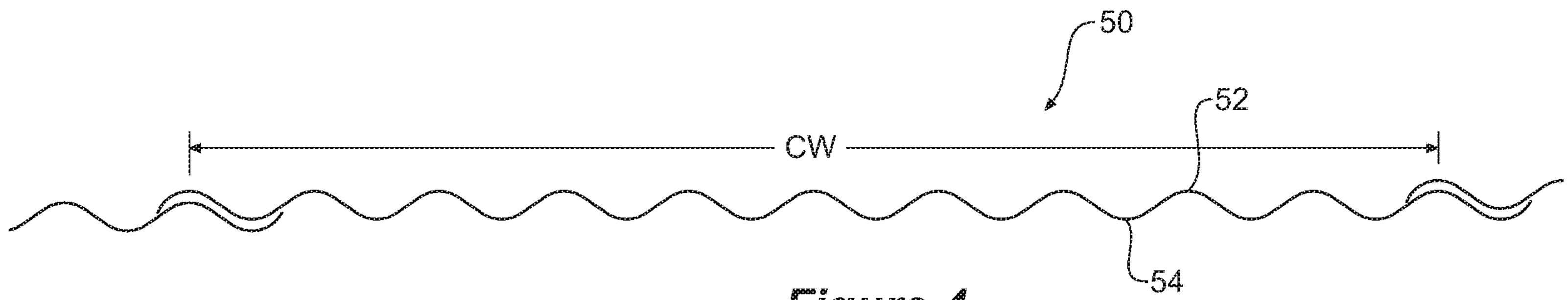

Figure 4

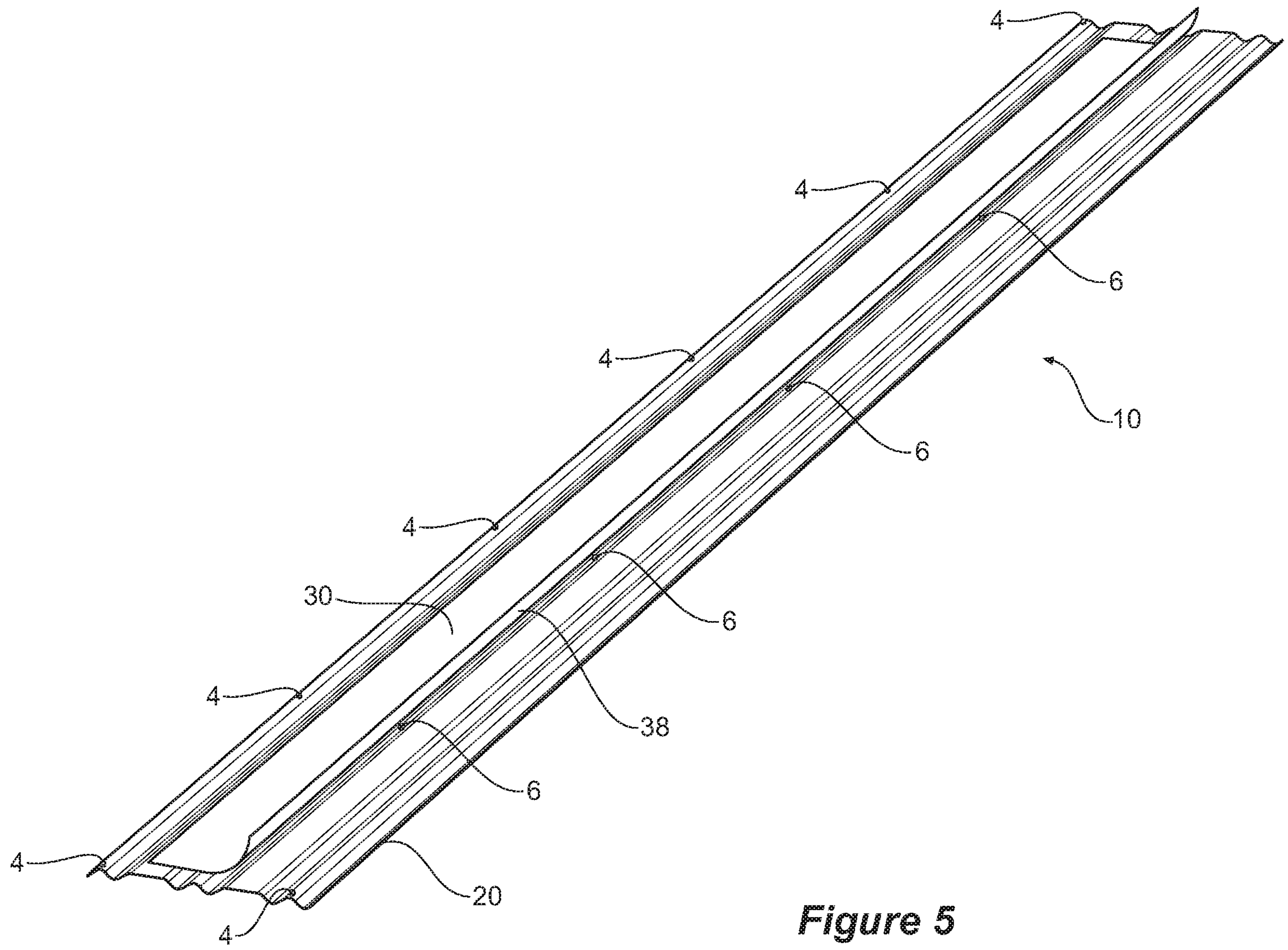

Figure 5

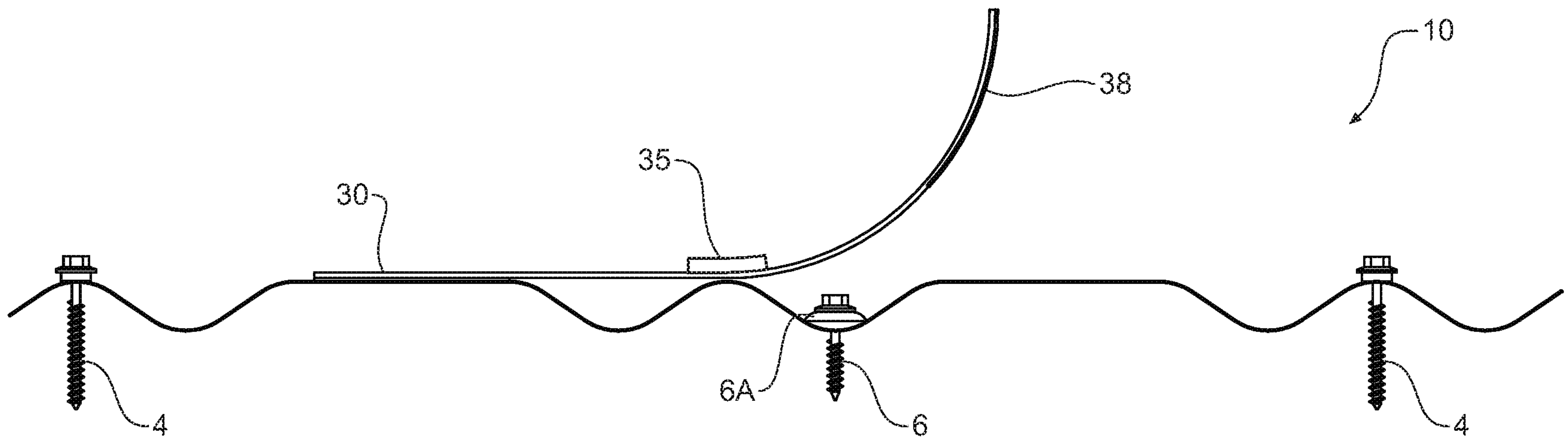

Figure 6

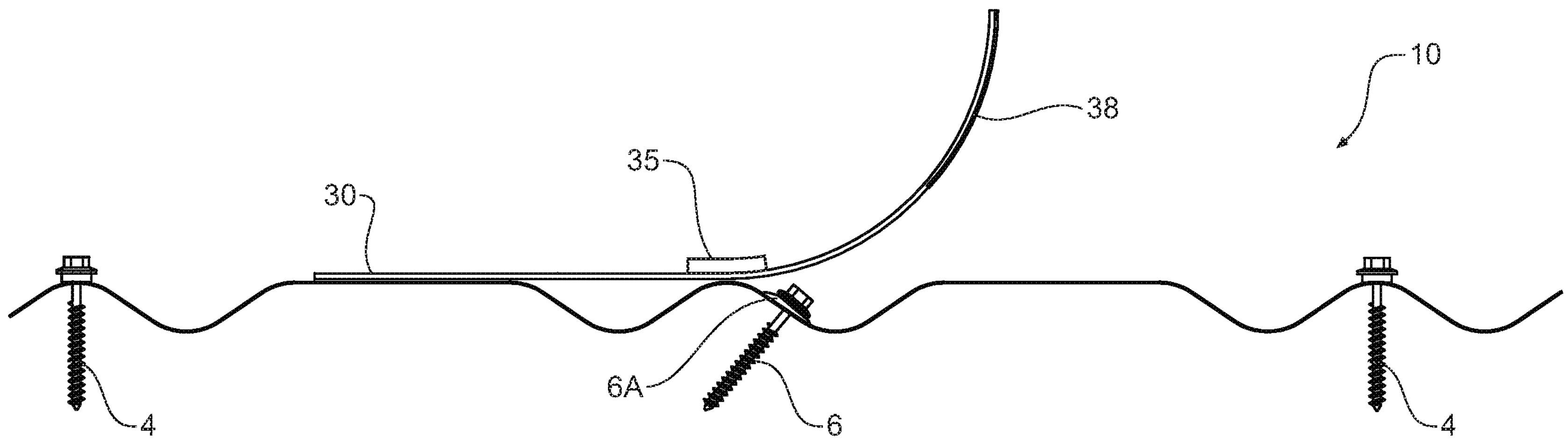

Figure 7

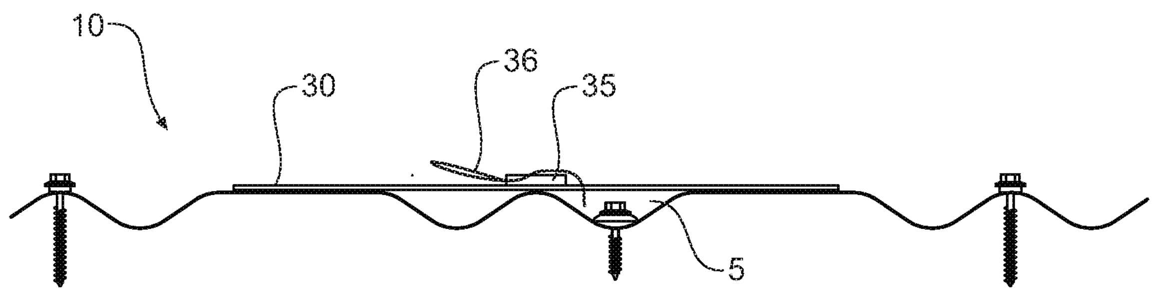

Figure 8

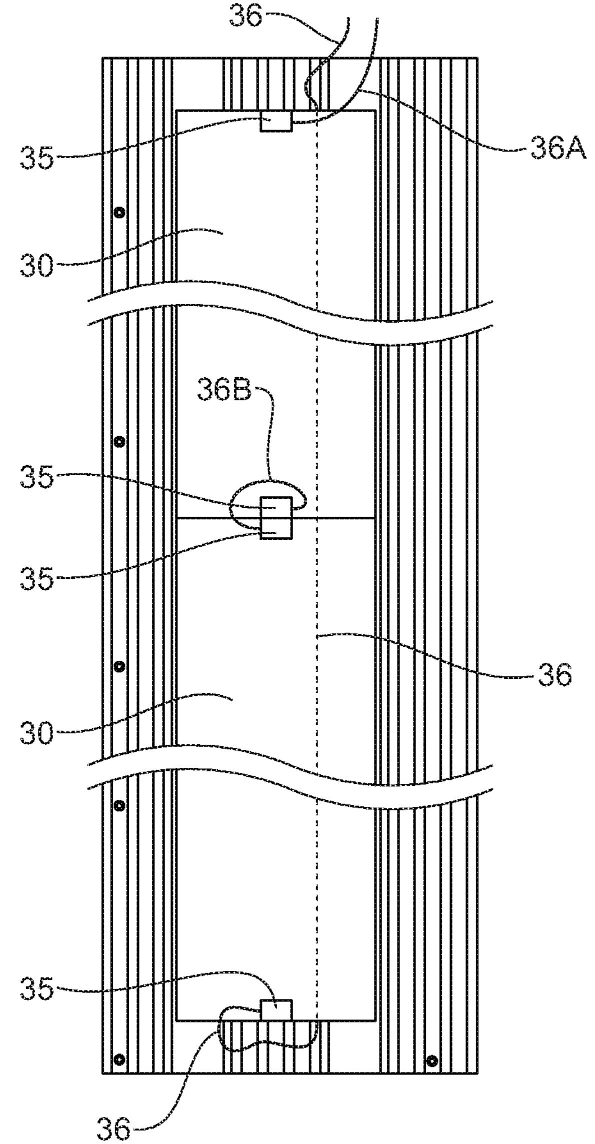

Figure 9

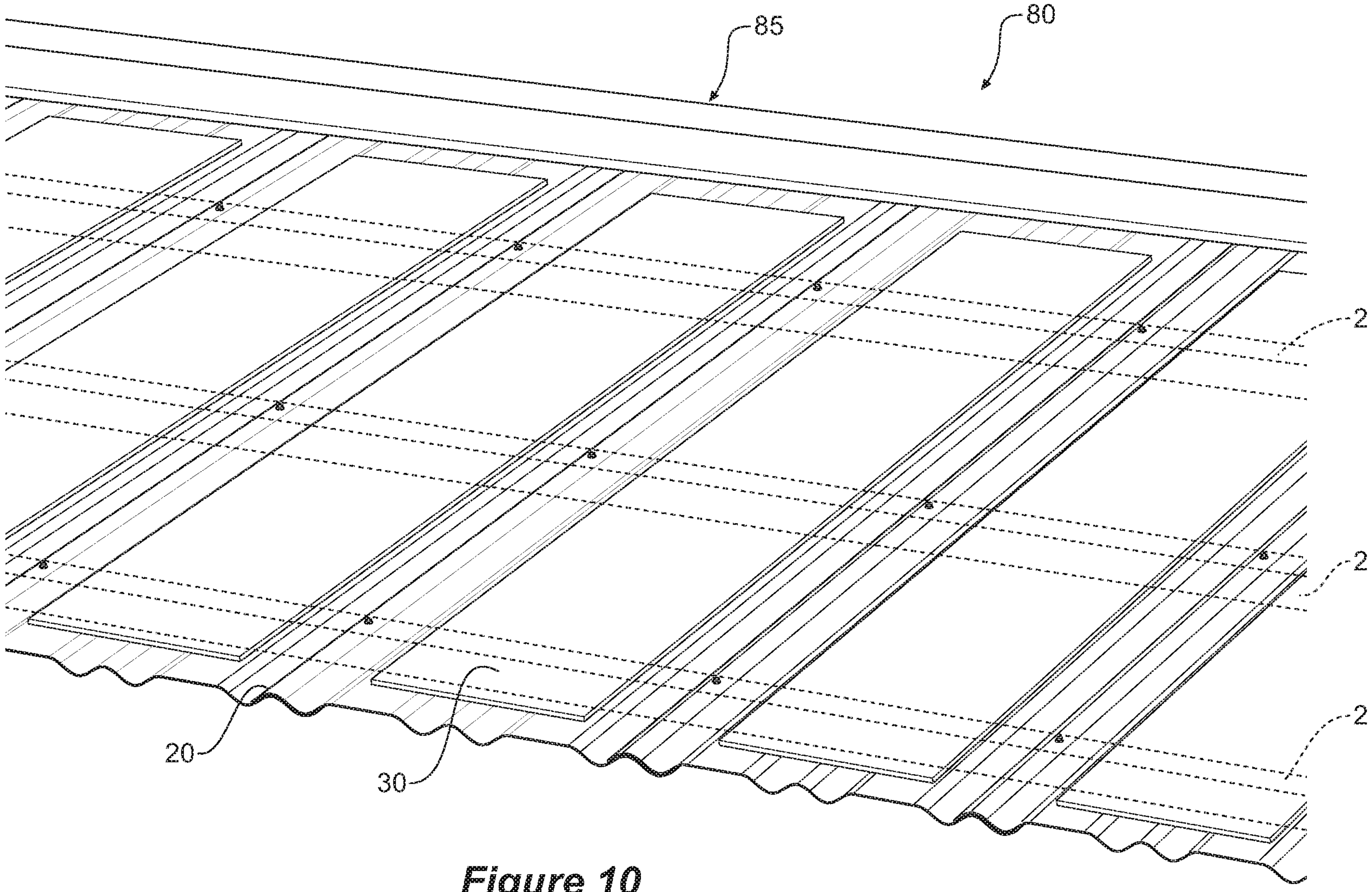

Figure 10

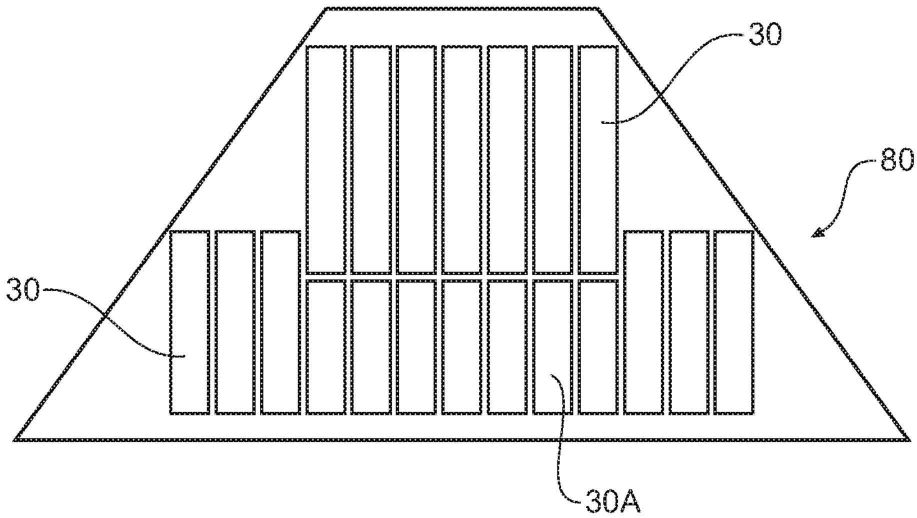

Figure 11

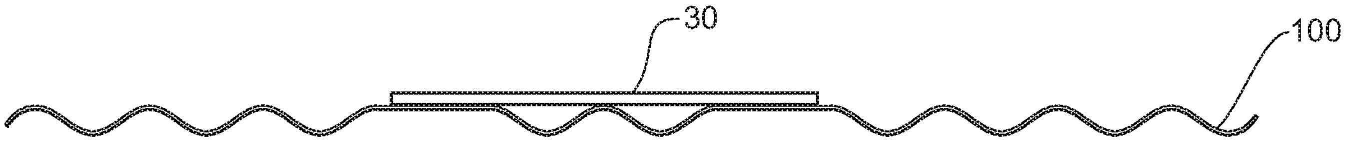

Figure 12A

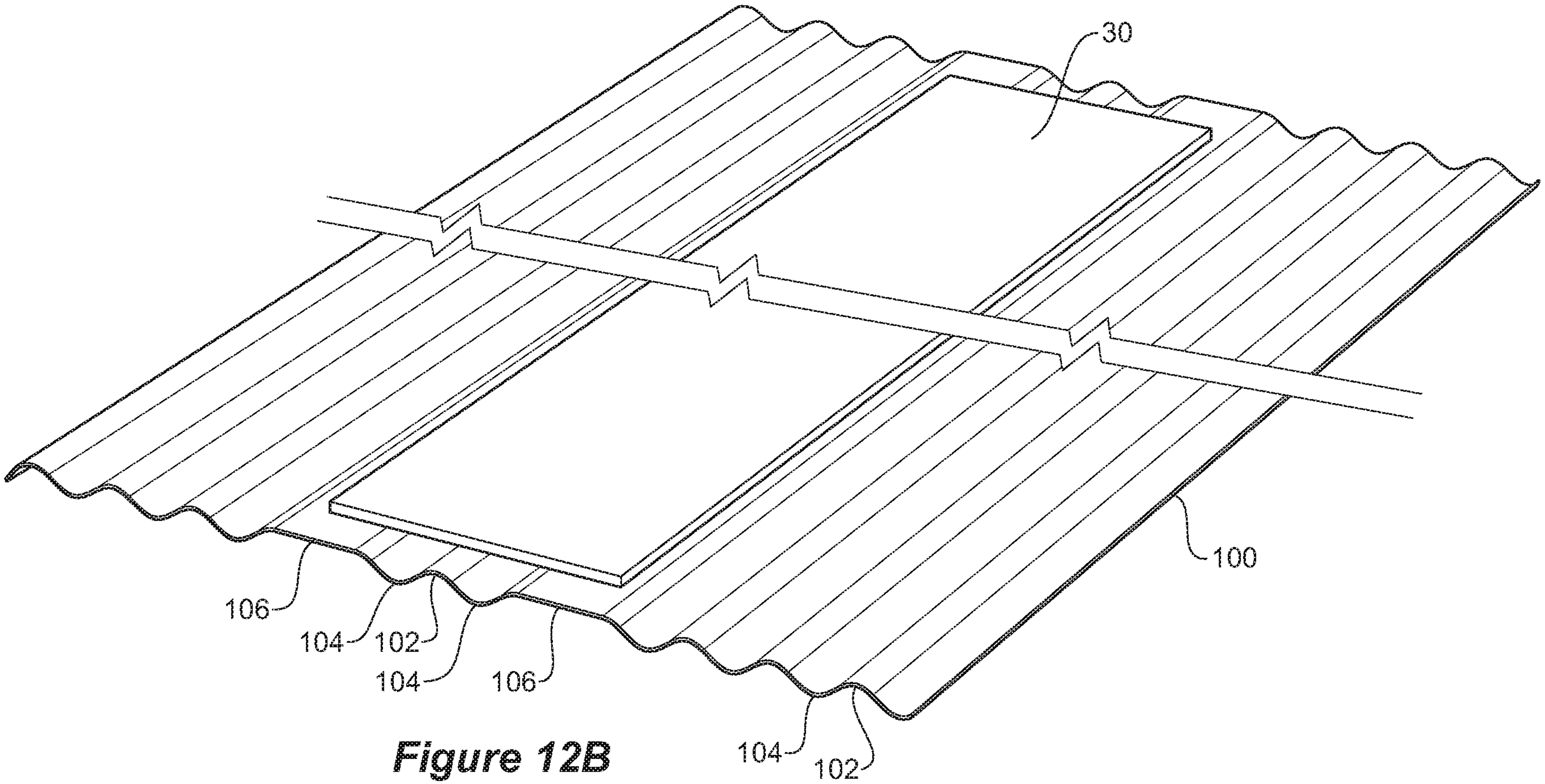

Figure 12B

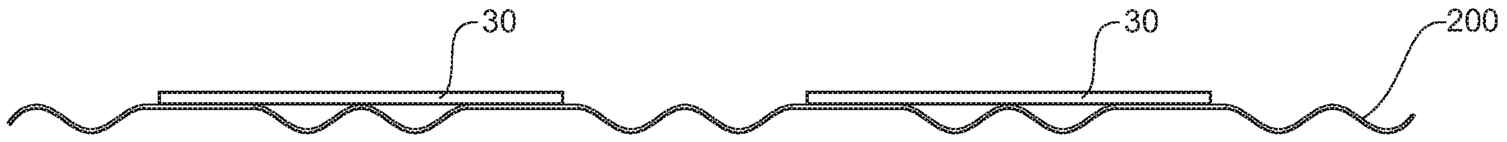

Figure 13A

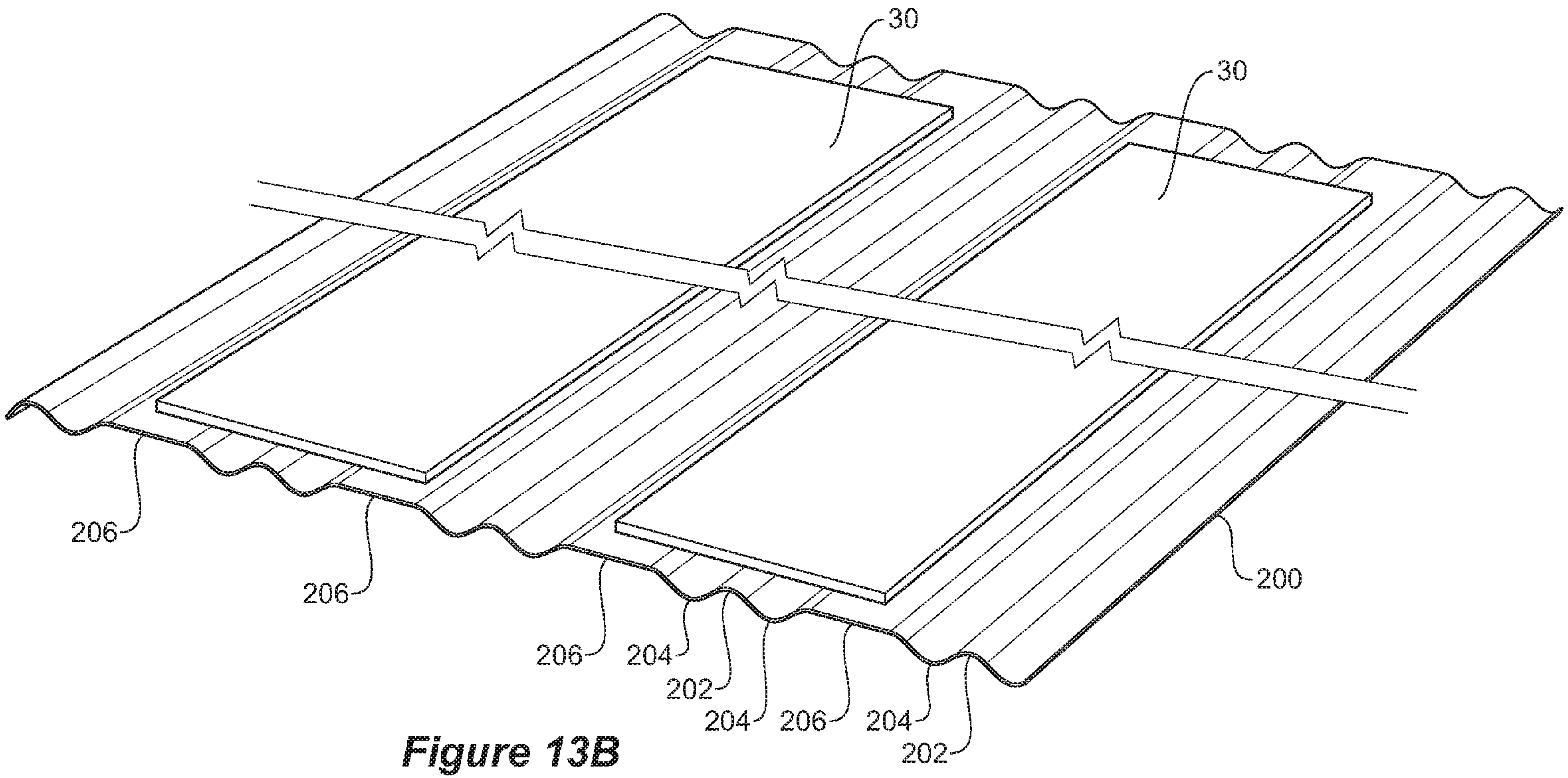

Figure 13B

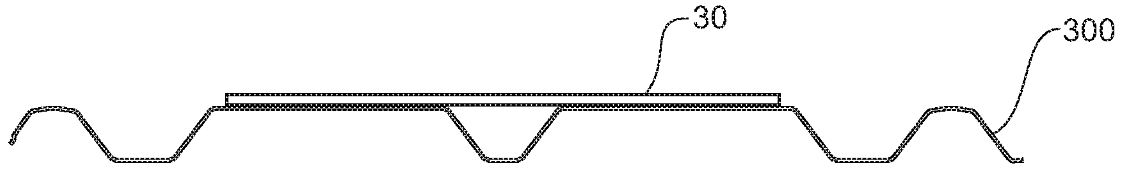

Figure 14A

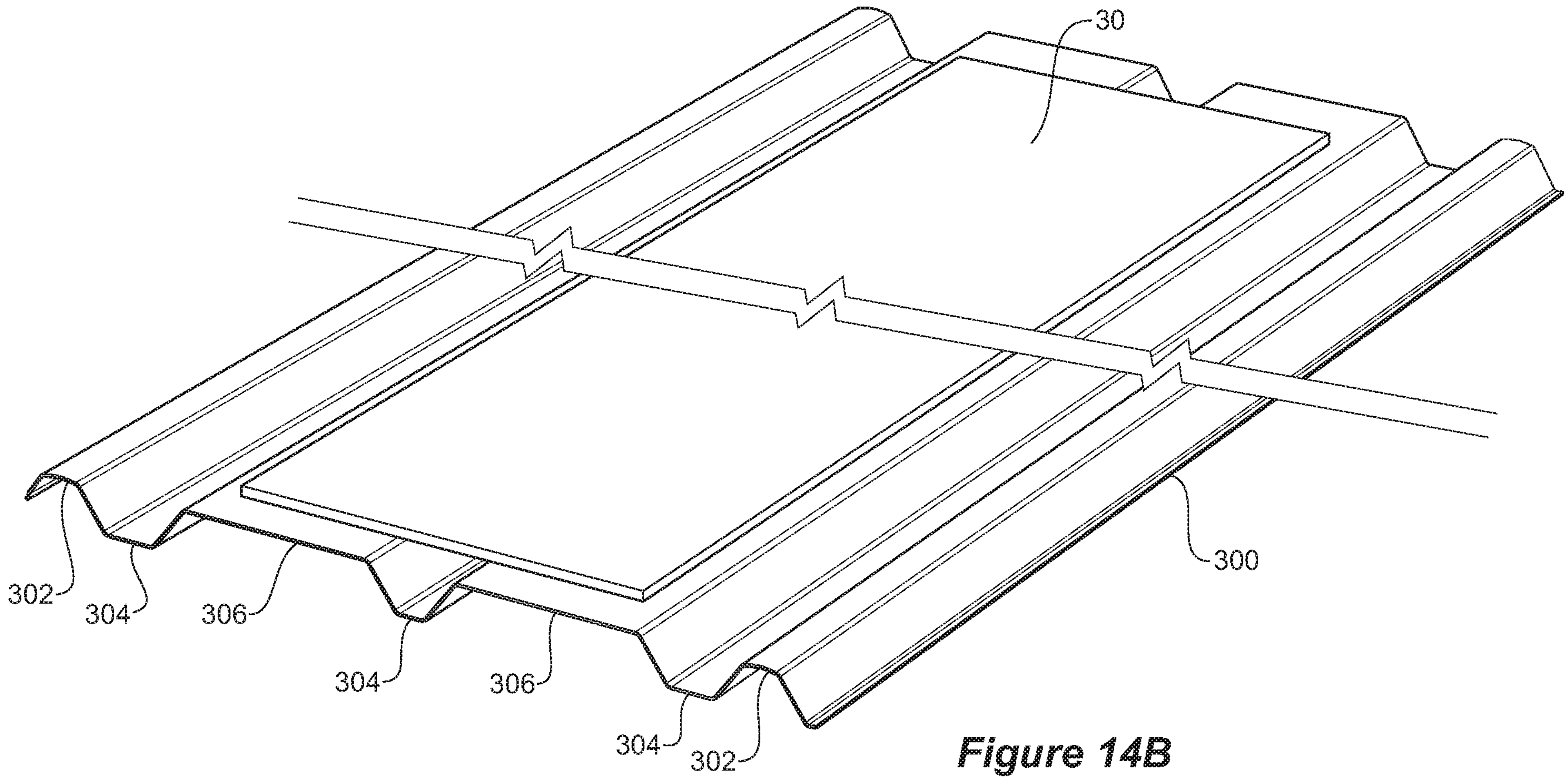

Figure 14B

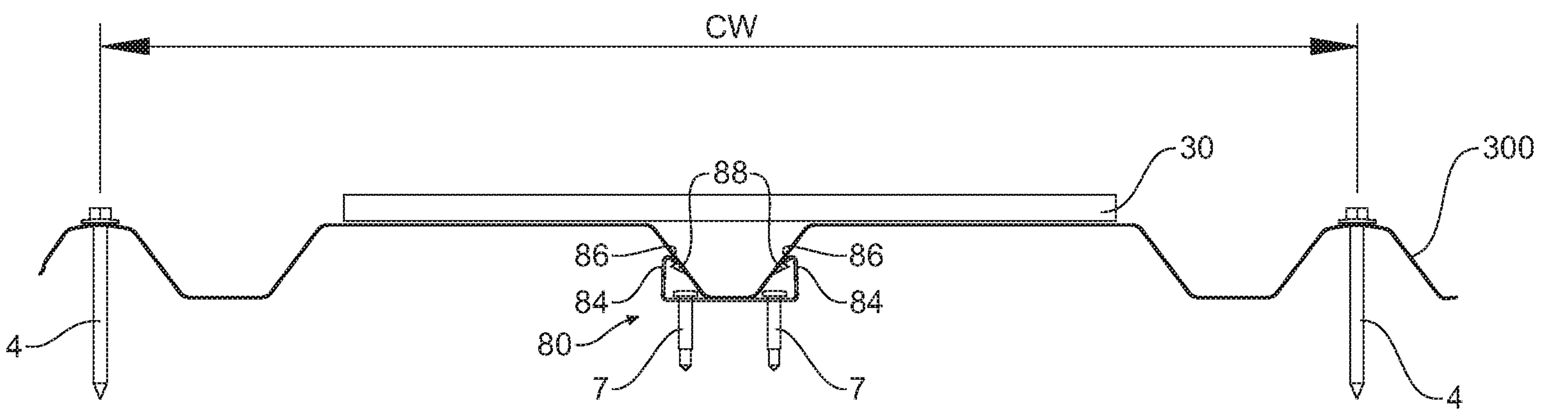

Figure 15

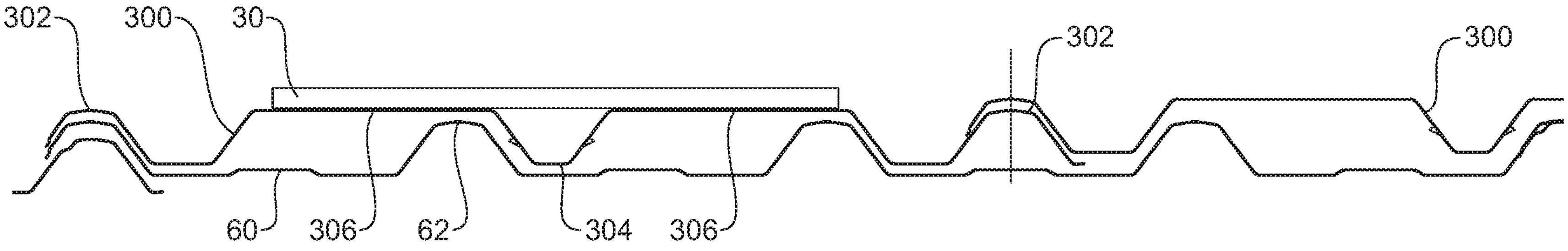

Figure 16

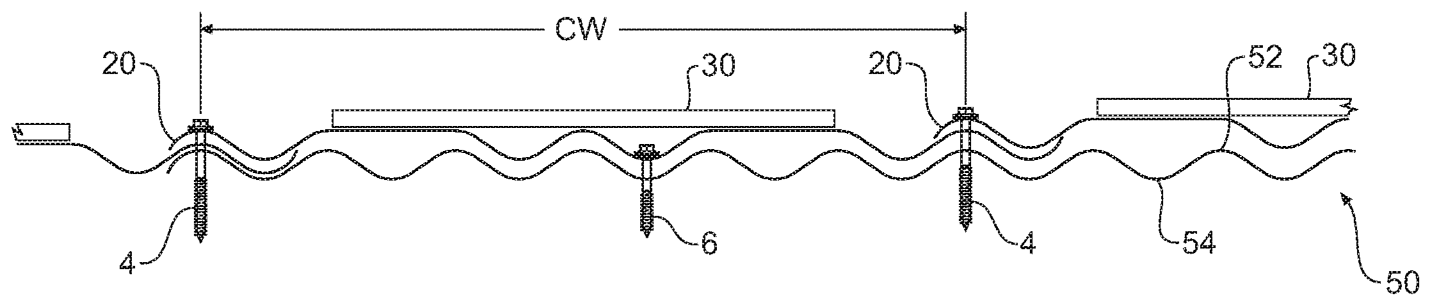

Figure 17