



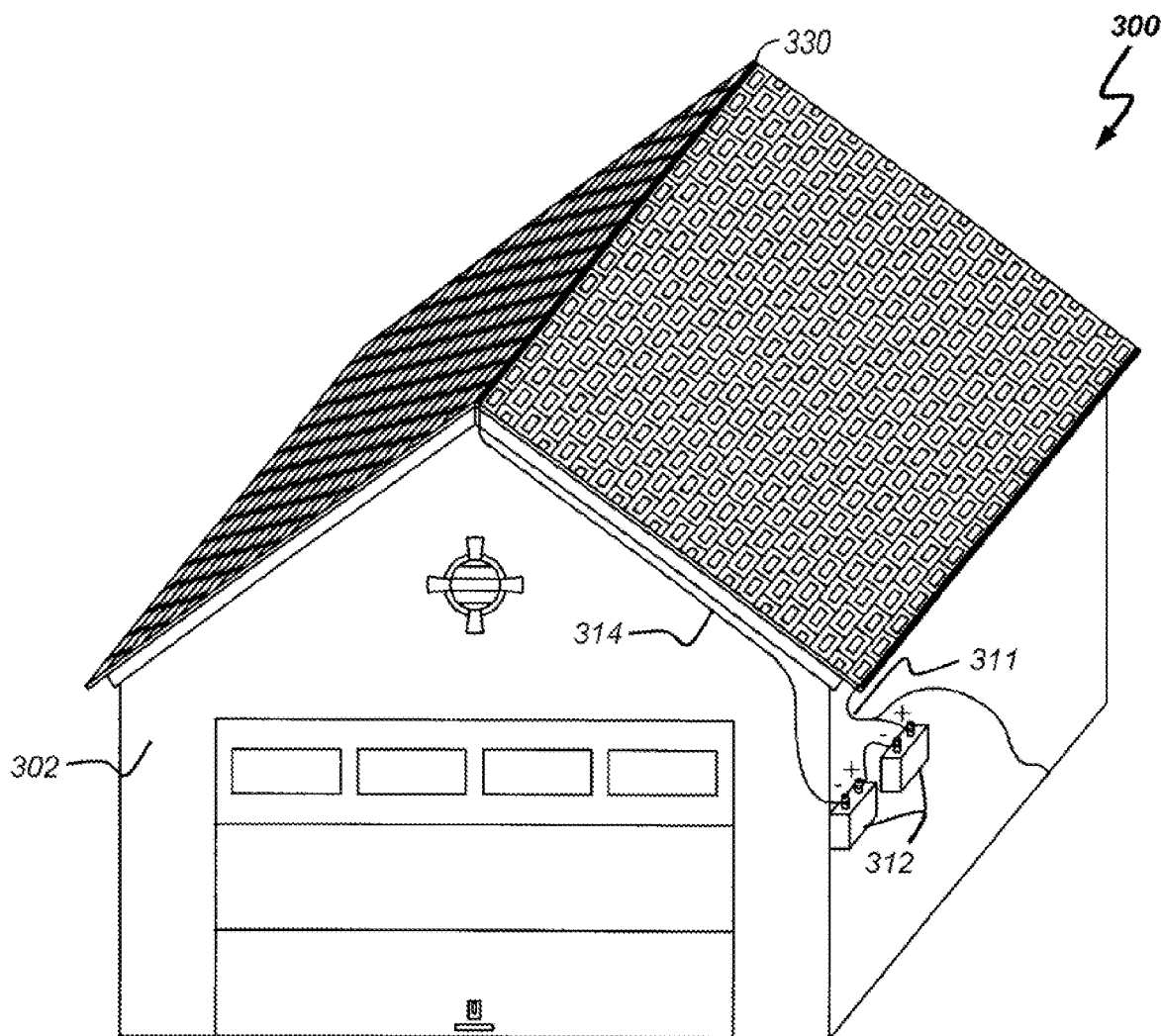
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(19) **United States**(12) **Patent Application Publication**
Degenfelder et al.(10) **Pub. No.: US 2010/0325976 A1**(43) **Pub. Date: Dec. 30, 2010**(54) **SOLAR SHINGLE SYSTEM****Publication Classification**(76) Inventors: **Jeffrey G. Degenfelder**, Coppel,
TX (US); **David W. Carstens**,
Plano, TX (US)(51) **Int. Cl.**
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(52) **U.S. Cl.** **52/173.3; 52/518**Correspondence Address:
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DALLAS, TX 75240 (US)(57) **ABSTRACT**

The present invention comprises an asphalt roofing shingle with integrated thin film solar cells that is easy to install and scalable to each particular application. The system of the present invention comprises a standard asphalt roofing shingle manufactured with an integrated thin film solar cell connected to two electrodes configured on opposing sides of the shingle. The shingle is dimensioned to that of a standard asphalt shingle. Roofing nails, which are used to install the shingle to the roof, physically attach the shingle to the roof, may also establish an electrical connection between the electrodes of the respective shingles creating a unified electrical circuit amongst the attached solar shingles.

(21) Appl. No.: **12/823,006**(22) Filed: **Jun. 24, 2010****Related U.S. Application Data**

(60) Provisional application No. 61/220,539, filed on Jun. 25, 2009.



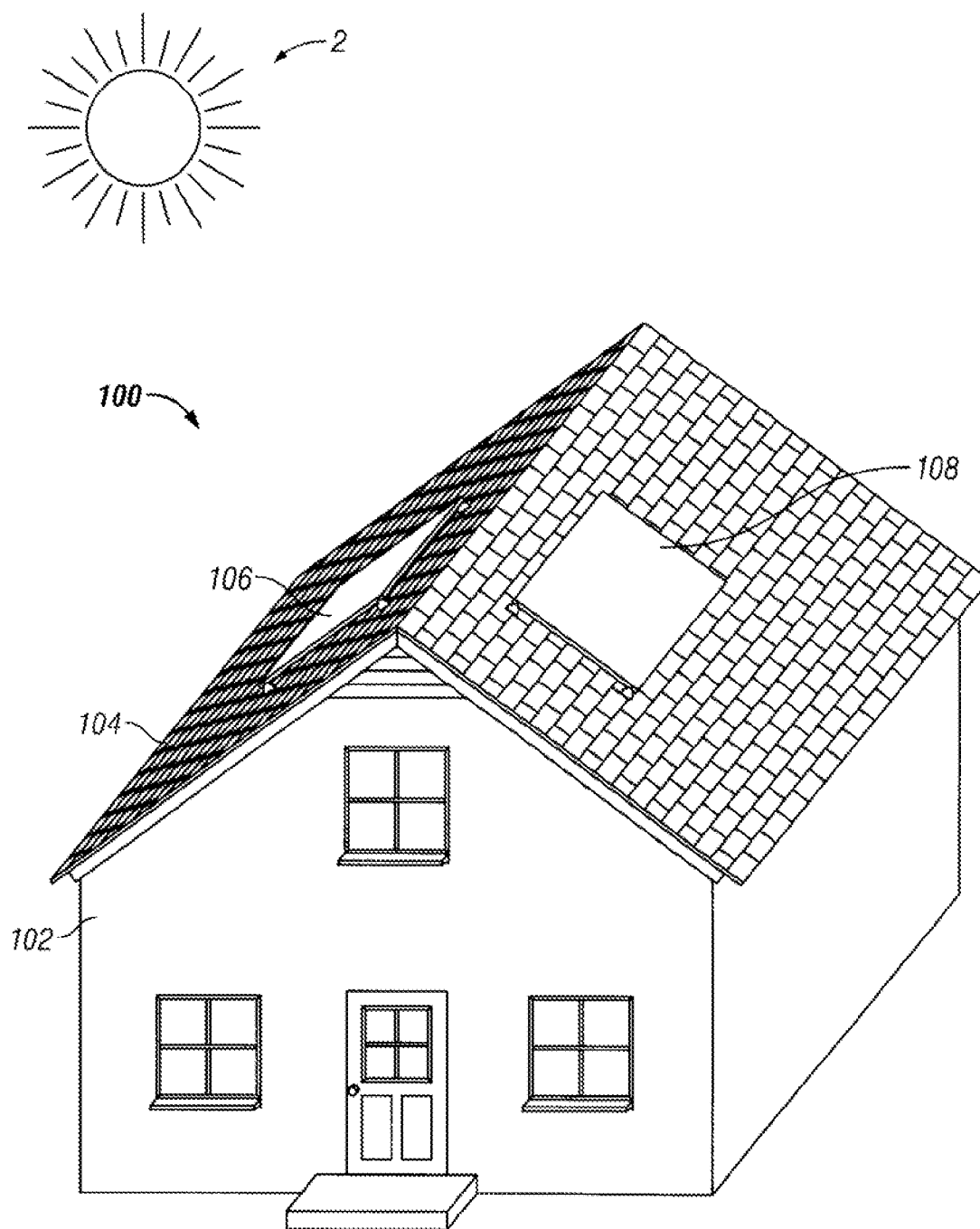


FIG. 1
(Prior Art)

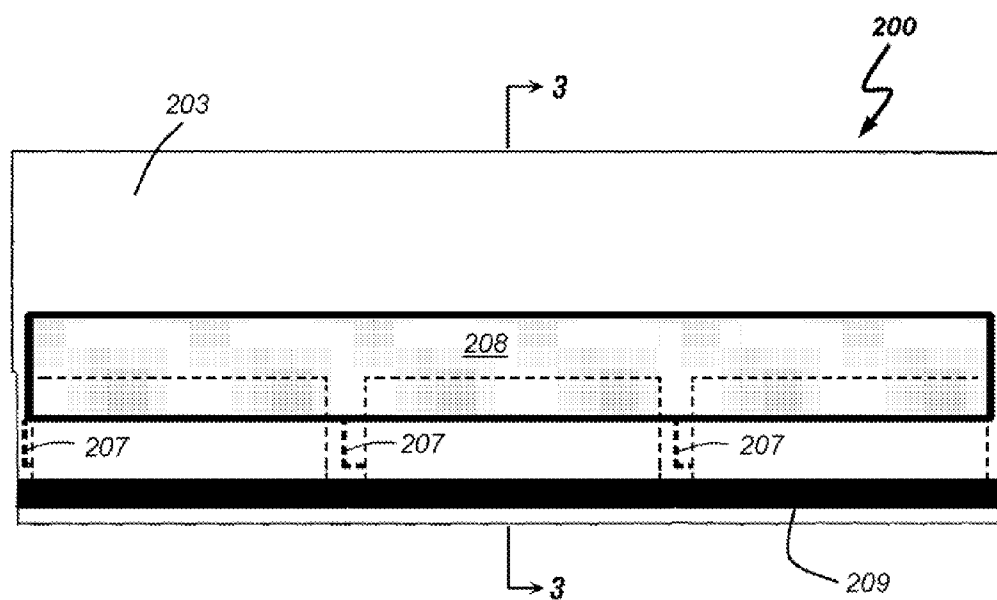
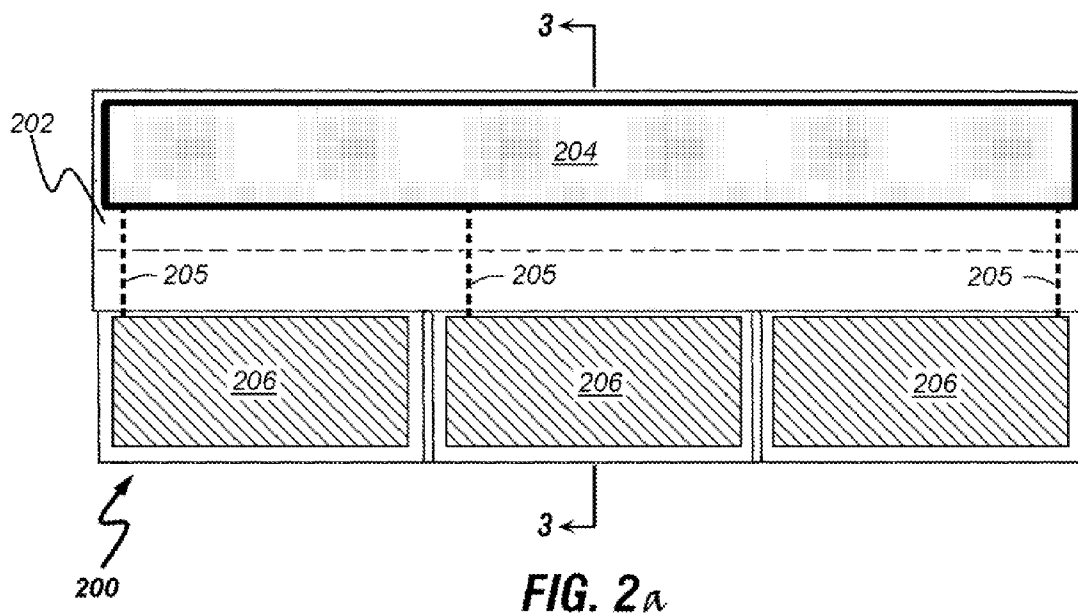


FIG. 5

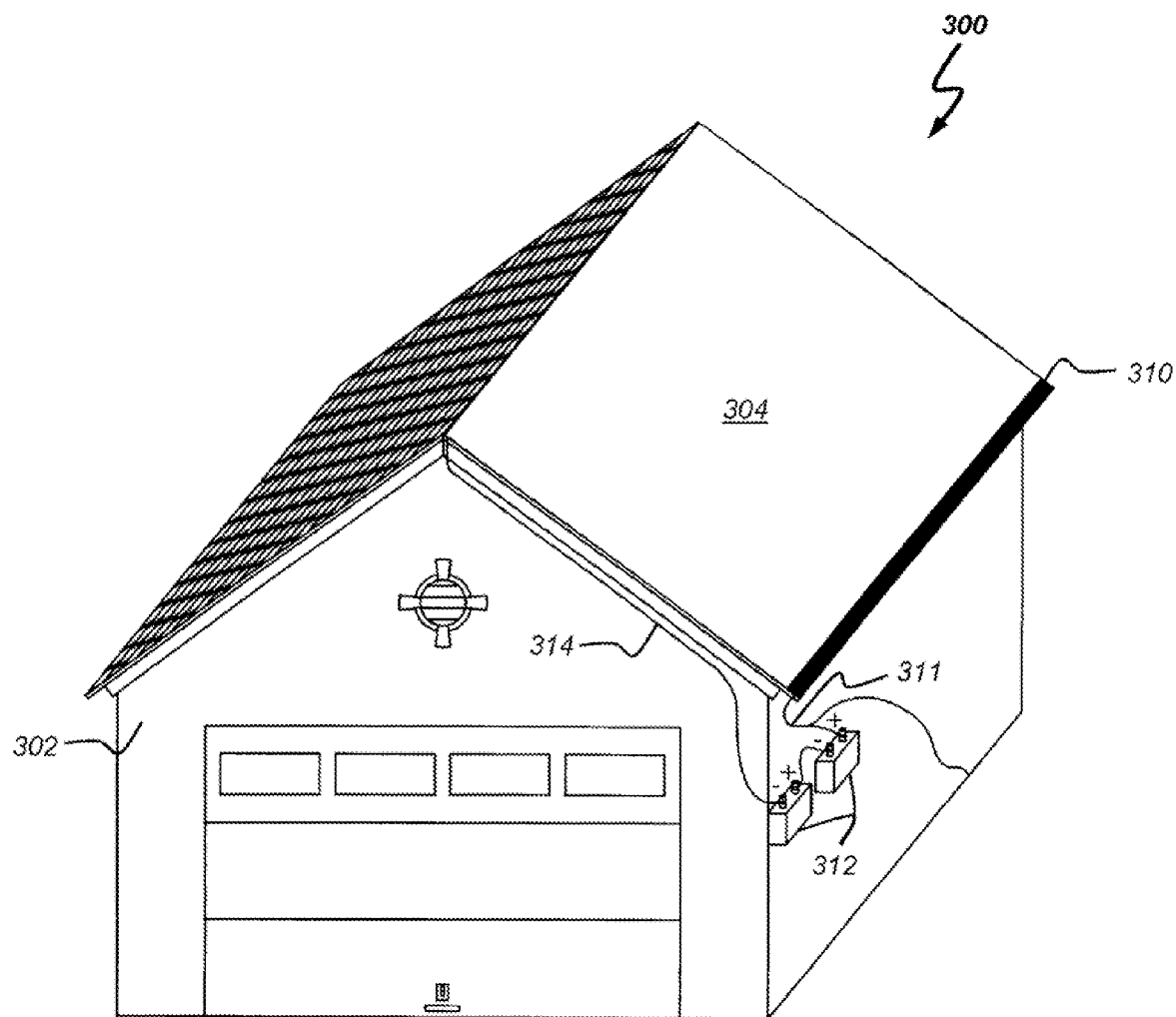


FIG. 6A

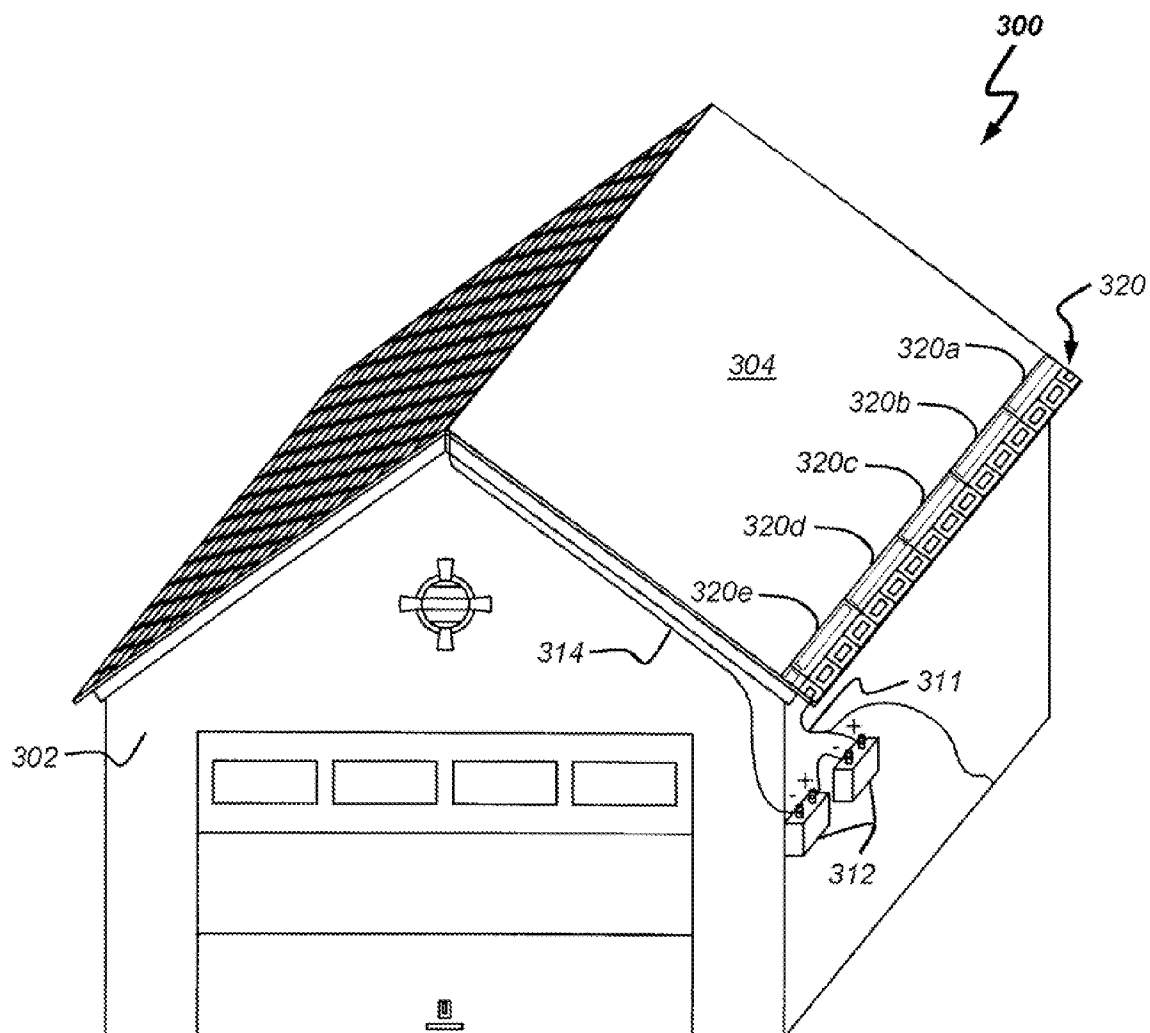


FIG. 6b

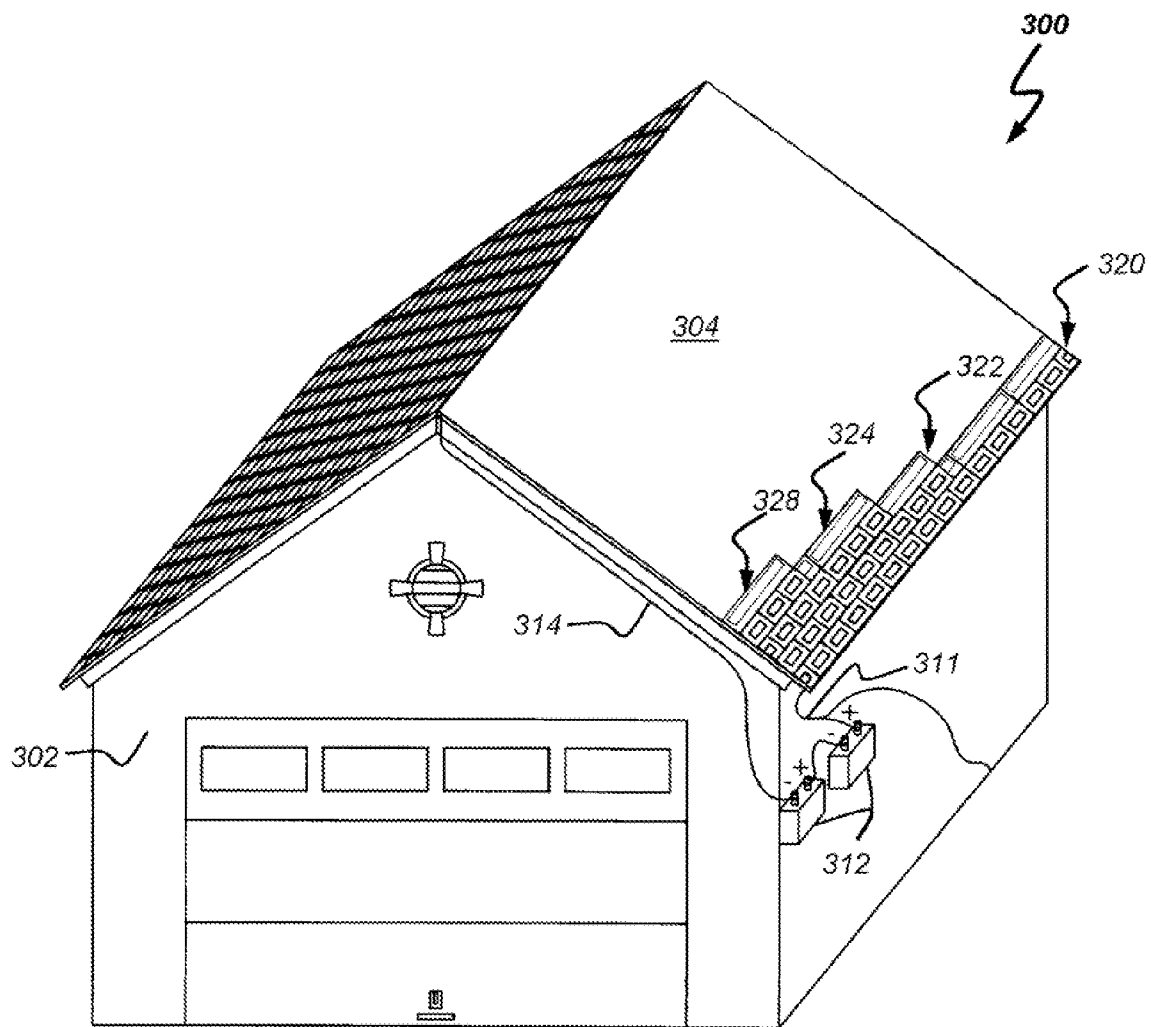


FIG. 6c

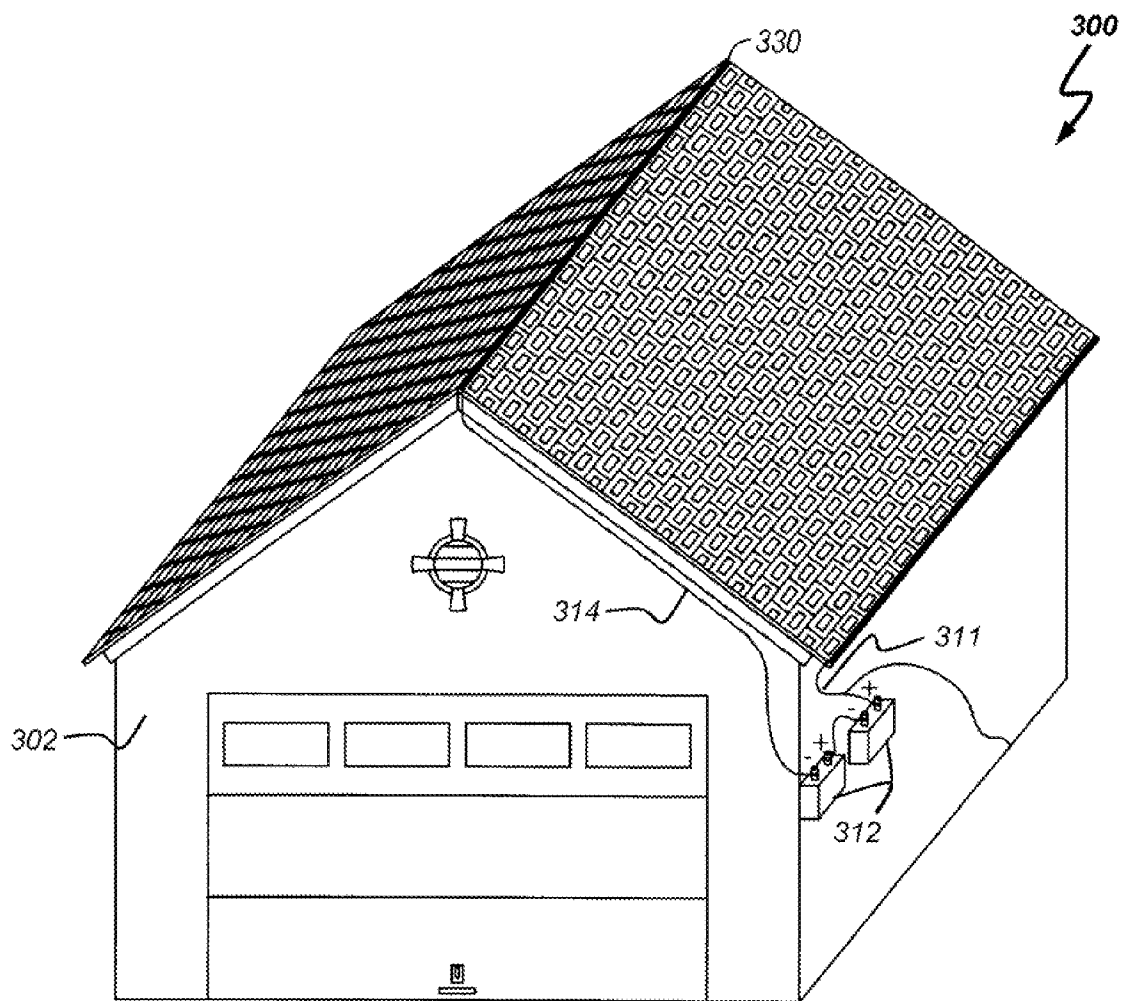


FIG. 6d

SOLAR SHINGLE SYSTEM

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of and priority to a U.S. Provisional Patent Application No. 61/220,539 filed Jun. 25, 2009, the technical disclosure of which is hereby incorporated herein by reference.

BACKGROUND OF THE INVENTION

[0002] 1. Technical Field of the Invention

[0003] The present invention relates generally to photovoltaic roofing systems and more particularly to a roofing material which is capable of generating electrical power. Most specifically, the invention relates to a roofing shingle structure and wiring system which is compatible with conventional shingles and which is capable of generating electrical power.

[0004] 2. Description of the Related Art

[0005] Environmental pollution and energy shortages are now of global concern. More interest is focusing on solar energy, which promises an unlimited source of clean energy. Solar energy is the clean and affordable solution to growing energy needs. Solar energy is a renewable energy source that has gained significant worldwide popularity due to the recognized limitations of fossil fuels and safety concerns of nuclear fuels. There are now available components that convert light energy into electrical energy. Such "photovoltaic cells" are often made from semiconductor-type materials such as doped silicon in either single crystalline, polycrystalline, or amorphous form.

[0006] The power generated by a photovoltaic device is proportional to the illumination incident thereupon and if relatively large amounts of power are to be generated, fairly large collection areas are required. The roof and upper story areas of building structures are well illuminated and are generally not put to productive use. For some time now it has been known to place photo-thermal and photo-voltaic collectors on the top portions of buildings. Roof mounted photovoltaic devices are shown for example in U.S. Pat. Nos. 5,092,939; 5,232,518, and 4,189,881. These particular photovoltaic roofing structures are of the batten and seam type.

[0007] The use of such photovoltaic cells on roofs is becoming increasingly common and a very significant source of electrical power, especially as device performance has improved. Demand for photovoltaic (PV) solar energy has grown at least 25% per annum over the past 15 years. Worldwide photovoltaic installations increased by 1460 MW (Megawatt) in 2005, up from 1,086 MW installed during the previous year (representing a 34% yearly increase) and compared to 21 MW in 1985.

[0008] Photovoltaic (PV) material is well-known by now and readily commercially available in a variety of forms. Recent advances in photovoltaic technology have made possible the large scale manufacture of low cost, light weight, thin film photovoltaic devices. It is now possible to manufacture large scale, thin film silicon and/or germanium alloy materials which manifest electrical and optical properties equivalent, and in many instances superior to, their single crystal counterparts. These alloys can be economically deposited at high speed over relatively large areas and in a variety of device configurations, and as such they readily lend themselves to the manufacture of low cost, large area photovoltaic devices. U.S. Pat. Nos. 4,226,898 and 4,217,364 both

disclose particular thin film alloys having utility in the manufacture of photovoltaic devices of the type which may be employed in the present invention. However, it is to be understood that the present invention is not limited to any particular class of photovoltaic materials and may be practiced with a variety of semiconductor materials including crystalline, polycrystalline, microcrystalline, and non-crystalline materials.

[0009] Growth in the field of solar energy has focused on solar modules fixed on top of an existing roof. Rooftops provide direct exposure of solar radiation to a solar cell and structural support for photovoltaic devices. Despite increased growth, the widespread use of conventional roof-mounted solar modules has been limited by their difficulty and cost of installation, lack of aesthetic appeal, and especially their low conversion efficiency.

[0010] Many conventional roof-mounted solar modules are constructed largely of glass enclosures designed to protect the fragile silicon solar cells. These modules are complex systems comprising separate mechanical and electrical interconnections that are then mounted into existing rooftops, requiring significant installation time and skill. Additionally, because existing modules do not provide weather protection to roof tops, homeowners are subjected to material and labor costs for both the modules and the protective roofing material to which they are mounted. Modules are also invasive in the aesthetics of homes and commercial buildings, resulting in limited use. For example, in FIG. 1, a conventional solar panel electrical generation system 100 typically includes one or more rigid solar panels 106, 108 mounted on the roof 104 of a residential structure 102. In addition to being expensive to install and maintain, the solar panels 106, 108 also tend to detract from the aesthetics of the residential structure 102.

[0011] In many instances shingled roofs are favored, typically for residential construction, and in those instances where fairly complex roof geometries are encountered. For example, asphalt shingles make up roughly 2/3rds of the U.S. residential roofing market. In a typical shingle construction, roofing material is supplied in rolls, or in pre-cut pieces which are subsequently laid in an overlapping configuration. In some instances, roofs are shingled with relatively thick tiles, which may be planar or of a curved cross-section. It will be appreciated that there is a need for integrating photovoltaic power generation with shingled roof constructions.

[0012] Photovoltaic roofing elements are generally difficult to install, as they must not only be physically connected to the roof in a manner that provides weather protection but also be electrically interconnected into a wiring system to be connected to the elements of a larger photovoltaic generation system (e.g., inverters, batteries and meters). Such installation often requires an electrical specialist to perform the electrical interconnections, which can be difficult to time appropriately with the physical installation of the photovoltaic roofing elements. Moreover, relatively large voltage differences (e.g., 100-600 V) are created in many photovoltaic roofing systems. As such, it is desirable to protect the electrical interconnections from the weather so as to avoid arcing and short circuits.

[0013] U.S. Pat. No. 4,040,867 describes a photovoltaic shingle construction comprised of a plurality of individual shingle members, each of which has a number of electrically interconnected single crystal photovoltaic devices thereupon. In order to obtain high power from this type of device, either the individual shingle must be made larger, or several shingles

need to be electrically interconnected. The first approach presents problems of wind-loading; and the second approach results in a construction requiring a large number of weatherproof electrical interconnections; also, leakage can result because of moisture creep between adjacent shingles by capillary action. Another configuration of photovoltaic shingle is described in U.S. Pat. No. 4,321,416. U.S. Pat. No. 3,769,091 depicts yet another photovoltaic roofing system comprised of a number of individual silicon devices mounted in an overlapping relationship.

[0014] More recently, U.S. Pat. Nos. 5,575,861 and 5,437,735 disclose a photovoltaic roofing system which includes a long strip of roofing material having an overlap portion, and a plurality of tab portions depending therefrom and separated by embossed inactive regions. Each of the tab portions includes a photovoltaic generating device affixed thereto. An encapsulating layer covers the top surface of each strip and wraps around the exposed and side edges. The photovoltaic devices are electrically interconnected, and each photovoltaic shingle member includes a pair of electrical terminals for delivering power from said photovoltaic devices. In use, the shingle members are affixed to a roof so that the tab portions of one row of shingles cover the overlap portion of an adjoining row. However, each electrical interconnection is made through the roof to the inside of the building, or to a point atop the roof.

[0015] The prior art has not been able to provide an acceptable shingle type photovoltaic roofing system. While prior art manufacturers have fabricated more aesthetically pleasing and less obstructive solutions, the systems are not price competitive largely due to installation difficulties and poor total area efficiency. Lower module efficiency levels are correlated to higher photovoltaic system costs because a greater module area is required for a given energy demand. Prior art devices are generally thick, inflexible, or of a geometry which makes them incompatible with standard construction techniques. As a result, prior art photovoltaic shingle structures require specialized installation techniques and trained personnel, which increases their cost and limits their utility. Furthermore, such structures cannot be easily integrated into a conventionally constructed roof. In addition, prior art photovoltaic roofing structures present aesthetic problems since the devices are often of a distinctive color, or of a geometry such that they are very obvious when installed.

[0016] Clearly, it would be desirable to have a photovoltaic roofing material which is as much like conventional roofing material as possible. The photovoltaic portion of the roofing material should be self-contained to a large degree and be easily installed by conventional techniques. It should also be relatively lightweight, resistant to wind loading, and stable under harsh atmospheric conditions.

[0017] The present invention, as will be described in further detail herein below, provides a roofing material which incorporates photovoltaic technology into conventionally configured shingle stock. The roofing material of the present invention is simple to install and efficiently converts light to electricity, and may be used in combination with standard, non-photovoltaic shingle stock to cover any desired portion of a roof. The particular configuration of the present invention makes efficient use of roof space for generating electricity and is unobtrusive in use. These and other advantages of the

present invention will be readily apparent from the drawings, discussion and description which follow.

SUMMARY OF THE INVENTION

[0018] The present invention overcomes many of the disadvantages of prior art photovoltaic roofing systems by disclosing a roofing shingle, having integrated thin film solar cells, that is easy to install and scalable to each particular application. While solar energy is the answer, its implementation hinges on whether it may be easily “adopted” by a consumer. As previously noted, the average consumer often-times considers conventional solar panels to be cumbersome, difficult to install, and an unattractive addition to their home. Thus, a solar solution is needed that allows for easier adoption by a consumer.

[0019] The system of the present invention comprises a standard asphalt roofing shingle manufactured with a plurality of integrated thin-film solar cells. The shingle is dimensioned to that of a standard asphalt shingle. Roofing nails, which are used to install the shingle to the roof, physically attach the shingle to the roof, may also establish an electrical connection between the shingles forming a unified electrical circuit.

[0020] In a preferred embodiment, the solar shingle of the present invention incorporates a flexible photovoltaic cell that is visible when properly installed on a roof. Two leads are connected to the photovoltaic cell, but are buried within the layers of the shingle. As shingles are overlapped on a roof, roofing nails are used to connect the shingles to the roof deck. In one embodiment, the nails act as electrical conductors that pass between the shingles and through the electrode leads. The electrode leads are conductive layers within the shingle. The positive (+) electrode lead on a first shingle is connected to the negative (−) electrode leads on two underlying shingles. The shingle needs to be able to withstand harsh conditions. In one embodiment, the exposed PV cells are covered with a translucent material to absorb minor impacts and insulate from rain.

[0021] The system of the present invention also includes a battery system, which is typically placed in the house/garage for storage of electricity. The batteries are preferably lead phosphate. The system also includes an anode and cathode plane are established through an upper and lower electrode band. The use of flexible or thin-film PVs is less efficient than crystalline monolithic PVs, but the shingle of the present invention is easier to install on a wider variety of roof line architectures. Further, the solar shingle design allows installation by a standard roofing crew.

[0022] Power generation at the home is often encouraged by local utilities. The solar shingle system of the present invention will produce the greatest energy on the days and times that have the greatest drain on the energy grid. In the event of an electrical “blackout”, the solar shingles should allow for the powering of essential home needs such as refrigeration and emergency lighting.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] A more complete understanding of the method and apparatus of the present invention may be had by reference to the following detailed description when taken in conjunction with the accompanying drawings, wherein:

[0024] FIG. 1 is an isometric perspective view of a typical prior art electrical generation system featuring a rigid, photovoltaic solar panel array;

[0025] FIG. 2a is a top or exterior exposed view of an embodiment of the solar shingle of the present invention;

[0026] FIG. 2b is a bottom or underside view of the embodiment of the solar shingle of the present invention shown in FIG. 2a;

[0027] FIG. 3 is a cross-sectional view of the embodiment of the solar shingle of the present invention shown in FIG. 2a;

[0028] FIG. 4 is top view of a plurality of solar shingles of the present invention, physically and electrically connected into a photovoltaic array;

[0029] FIG. 5 is a cross-sectional view of the plurality of solar shingles of the present invention shown in FIG. 4;

[0030] FIGS. 6a-6d are isometric perspective views depicting the various stages of construction of a photovoltaic system using the solar shingle of the present invention.

[0031] Where used in the various figures of the drawing, the same numerals designate the same or similar parts. Furthermore, when the terms "top," "bottom," "first," "second," "upper," "lower," "height," "width," "length," "end," "side," "horizontal," "vertical," and similar terms are used herein, it should be understood that these terms have reference only to the structure shown in the drawing and are utilized only to facilitate describing the invention.

[0032] All figures are drawn for ease of explanation of the basic teachings of the present invention only; the extensions of the figures with respect to number, position, relationship, and dimensions of the parts to form the preferred embodiment will be explained or will be within the skill of the art after the following teachings of the present invention have been read and understood. Further, the exact dimensions and dimensional proportions to conform to specific force, weight, strength, and similar requirements will likewise be within the skill of the art after the following teachings of the present invention have been read and understood.

DETAILED DESCRIPTION OF THE INVENTION

[0033] With reference to FIGS. 2a-3, an embodiment of the solar shingle of the present invention 200, which comprises a standard asphalt roofing shingle having an integrated thin film solar cell, is depicted. Asphalt shingles are typically constructed of four basic materials:

[0034] a fiberglass or cellulose backing;

[0035] asphalt cement;

[0036] sand-sized rock called aggregate; and

[0037] mineral filler or stabilizer that includes limestone, dolomite and silica.

[0038] As shown in FIG. 2a, the exterior or outer facing side 202 of each solar shingle 200 further includes a plurality of thin film solar cells 206 formed or attached thereon and electrically connected to an upper electrical connector or electrode lead 204 formed or attached to the upper portion of the exterior or outer facing side 202 of solar shingle 200. Separate electrical conduits 205, such as conductive wires, are used to electrically connect the upper electrode 204 to the plurality of thin film solar cells 206.

[0039] As shown in FIG. 2b, the underside or bottom facing side 203 of each solar shingle 200 further includes a lower electrical connector or electrode lead 208 formed or attached to the middle portion of the underside or bottom facing side 203 of the solar shingle 200. Separate electrical conduits 207, such as conductive wires, are used to electrically connect the

lower electrode 208 to the plurality of thin film solar cells 206. The underside or bottom facing side 203 of each solar shingle 200 may also include an adhesive strip 209 for adhesively adhering the underside or bottom facing side 203 of each solar shingle 200 to the exterior or outer facing side 202 of an adjacent or adjoining solar shingle. It is understood that the upper electrode 204 can be either the cathode or the anode, so long as the lower electrode 208 is the other. And so long as this arrangement is consistent through all of the shingles in a particular system.

[0040] With reference now to FIG. 3 it will be noted that the upper 204 and lower 208 electrodes on each shingle 200 are isolated and insulated from one another. Moreover, the electrical conduits 205, 207 are also isolated and insulated from each other. The asphalt material of the shingle may be used as a non-conductive material. However, it will be observed that the upper 204 and lower 208 electrodes are configured on each shingle 200 so that they will align with the electrode on another solar shingle when properly positioned above or below another shingle. For example, as shown in FIGS. 4 and 5, the upper electrode 204a of a first shingle 200a is configured to align with the lower electrode 208b on a second shingle 200b when the second shingle 200b is properly aligned in an overlapping configuration on the first shingle 200a.

[0041] The solar shingle 200 of the present invention is designed to be installed in much the same manner as standard asphalt shingles are installed. A series of nails 212 are used to affix one shingle to two of the shingles positioned beneath it. In one embodiment, the nails 212 are simply used to ensure that the respective upper and lower electrodes are mechanically bonded to one another and to the underlying roof 304.

[0042] In another embodiment, the nails 212 may be partially-conductive in order to allow the transfer of electricity from the upper electrode of one shingle to the respective lower electrode of an adjoining shingle. The use of partially-conductive nails allows the outer surface of the electrodes to be coated or sealed in a non-conductive material. The nails are said to be partially-conductive because they include only a portion which conducts electricity from the lower electrode of one shingle to the upper electrode of another shingle or vice versa, but does not allow an electrical path to ground into the underlying roof surface 304.

[0043] With reference to the Figures, and in particular FIGS. 6a-6d, a method of installation of the system will be described. As shown in FIG. 6a, a typical system 300 is attached to a structure 302 having a roof 304. The system 300 includes a lower electrode band 310 affixed to the bottom edge of the roof surface 304. As depicted in the drawings, the lower electrode band 310 is connected to the terminal of a collection mechanism 312, such as a battery, by means of an electrical connection 311, such as insulated wire. The collection mechanism 312 will also be connected to an upper electrode band 330 by means of a second electrical connection 314, such as insulated wire. It is understood that the collection mechanism 312 of the system 300 may, in the alternative, comprise a conventional electrical inverter system (not shown) or a mechanism for transferring the generated electricity back to the electrical grid (also not shown).

[0044] As shown in FIG. 6b, a first row of solar shingles 320 is attached to the underlying roof 304 by means of nails 212 hammered through each of the shingles (i.e., 320a, 320b, 320c, 320d, 320e) in a conventional manner. Each of the shingles in the first row 320 is positioned so that its lower

electrode **208** is configured over the lower electrode band **310**. Thus, when each shingle is affixed the underlying roof **304** by means of nails **212**, the lower electrode **208** of each respective shingle is electrically connected to the lower electrode band **320**. When each successive and overlapping row is affixed to the roof, each shingle's lower electrode is positioned over and electrically connected with the upper electrode of two underlying shingles. The adhesive strip **209** on the underside or bottom facing side of each solar shingle further aids in bonding and sealing the adjoining electrodes from wind and rain.

[0045] For example, with reference again to FIGS. **4** and **5**, when the overlapping solar shingle **200b** is properly installed over two underlying solar shingles **200a**, **200c**, the lower electrode **204b** of the overlapping shingle **200b** is positioned over the upper electrode **204a**, **204c** of the underlying solar shingles **200a**, **200c**, such that when affixed to one another by means of nails **212**, a electrical connection is formed between all three shingles. Practitioners in the art will quickly recognize that by following this pattern with successive overlapping rows **320**, **322**, **324**, **328** as shown in FIG. **6c**, all of the shingles may be electrically connected to each other so as to create an electrical circuit that collects the electricity generated by the photovoltaic cells. It will also be observed that the number of solar shingles used is scalable with regard to the desired amount of generated electricity and the physical restraints of the roof area.

[0046] As shown in FIG. **6d**, the final row of solar shingles is capped with an upper electrode band **330** so that the upper electrodes **204** of each respective solar shingle in the final row is electrically connected to the upper electrode band **330**. The upper electrode band **330**, in turn, is electrically connected to the battery **312** by means of a second electrical connection **314** such as wire. The upper electrode band **330** may further comprise a durable exterior layer that allows it to blend into the roof line and protect the roof from intrusion by rain water.

[0047] It will now be evident to those skilled in the art that there has been described herein an improved solar shingle and solar shingle system. Although the invention hereof has been described by way of a preferred embodiment, it will be evident that other adaptations and modifications can be employed without departing from the spirit and scope thereof. For example, all of the component parts of the shingle may be incorporated into a homogeneous shingle base. The terms and expressions employed herein have been used as terms of description and not of limitation; and thus, there is no intent of excluding equivalents, but on the contrary it is intended to cover any and all equivalents that may be employed without departing from the spirit and scope of the invention.

We claim:

1. A solar shingle comprising in combination:
 - a asphalt shingle having an outer and an under side;
 - said outer side including a plurality of solar cells attached thereon and a first electrode, wherein said plurality of solar cells are electrically connected to said first electrode; and
 - said under side including a second electrode which is electrically connected to said plurality of solar cells.
2. The solar shingle of claim **1**, wherein said under side further includes an adhesive strip along the length of said shingle.
3. The solar shingle of claim **1**, wherein said solar cells comprise flexible, thin-film photovoltaic material.

4. The solar shingle of claim **1**, wherein said plurality of solar cells are electrically connected to said electrodes by means of an insulated wire embedded in said shingle.

5. The solar shingle of claim **1**, wherein said electrodes are configured on said shingle so that the first electrode on a first shingle will align with the second electrode on a second shingle when the second shingle positioned over the first shingle in an overlapping manner.

6. A solar shingle, comprising in combination:

- a roofing shingle having an outer surface and an under surface;

- said outer surface including at least one solar cell attached thereon and a first electrode, wherein said at least one solar cell is electrically connected to said first electrode; and

- said under surface including a second electrode which is electrically connected to said at least one solar cell.

7. The solar shingle of claim **6**, wherein said under surface includes an adhesive strip along the length of said shingle.

8. The solar shingle of claim **6**, wherein said at least one solar cell is comprised of flexible, thin-film photovoltaic material.

9. The solar shingle of claim **6**, wherein said at least one solar cell is electrically connected to said electrodes by means of an insulated wire embedded in said shingle.

10. The solar shingle of claim **6**, wherein said electrodes are configured on said shingle so that the first electrode on a first shingle will align with the second electrode on a second shingle when the second shingle positioned over the first shingle in an overlapping manner.

11. A system for generating electrical power, comprising in combination:

- an electrical collection mechanism;

- a first electrode band electrically connected to said collection mechanism, said first electrode band attached to a roof surface;

- a second electrode band electrically connected to said collection mechanism, said second electrode band attached to said roof surface and spaced apart from said first electrode band;

- a plurality of solar shingles configured between said first and second electrode bands in an overlapping manner, wherein each of said plurality of solar shingles comprises:

- a roofing shingle having an outer surface and an under surface; said outer surface including at least one solar cell attached thereon and a first electrode, wherein said at least one solar cell is electrically connected to said first electrode; and said under surface including a second electrode which is electrically connected to said at least one solar cell,

- wherein said electrodes are configured on said shingle so that the first electrode on a first shingle will align with the second electrode on a second shingle when the second shingle positioned over the first shingle in an overlapping manner;

- wherein, said plurality of solar shingles when configured in said overlapping manner form an electrical circuit between said first and second electrode bands.

12. The system for generating electrical power of claim **11**, wherein said electrical collection mechanism comprises a battery.

13. The system for generating electrical power of claim **11**, wherein said electrical collection mechanism comprises an electrical inverter mechanism.

14. The system for generating electrical power of claim **13**, wherein said electrical inverter mechanism is connected to an electrical grid.

15. The system for generating electrical power of claim **11**, wherein the under surface of each solar shingle includes an adhesive strip along the length of said shingle.

16. The system for generating electrical power of claim **11**, wherein said at least one solar cell on each solar shingle is comprised of flexible, thin-film photovoltaic material.

17. The system for generating electrical power of claim **11**, wherein said first electrode band is electrically connected to

said second electrode on the under surface of each of said plurality of solar shingles in a first row.

18. The system for generating electrical power of claim **17**, wherein said second electrode band is electrically connected to said first electrode on the outer surface of each of said plurality of solar shingles in a second row.

19. The system for generating electrical power of claim **11**, wherein each of said plurality of solar shingles are fixably attached to said roof surface by at least one nail fastener.

20. The system for generating electrical power of claim **19**, wherein said at least one nail fastener is partially conductive.

* * * * *