

Description

This invention relates to a device for collecting solar energy and more particularly to a device operatively associated with a roofing of a building for selectively collecting electric energy and thermal energy at the same time from solar energy.

Extensive research and development efforts have been paid in the realization of a technology of making effective use of solar energy, i.e. to derive therefrom electric energy in a manner as disclosed for instance in Japanese Utility Model Laid-Open Publication No. 60-170433 and thermal energy as is known from Japanese Utility Model Laid-Open Publication No. 55-32911. To the best knowledge of the present applicant however, no useful technology has yet been made available in successfully deriving both electric and thermal energies at the same time from solar energy. This is mainly due to the following reasons.

Solar batteries in common use mostly rely on the use of silicone elements, and the output of such silicone batteries disadvantageously declines with an increase in the ambient temperature. Therefore, in the case where the solar batteries are installed in the roof tiles as proposed in the aforesaid prior publication, it would become necessary to provide thermal insulation for the roofing. On the other hand, when converting the solar energy into the heat energy, it would be literally a great advantage to form the roofing with highly heat-conductive material in which instance however it would still be necessary to provide proper heat-insulating means so as to prevent a possible adverse effect of heat upon the interior of the building or housing. There is thus a technological contradiction in the attempt of deriving electrical and thermal energies both at a time efficiently from the same source of solar energy.

Patent specification DE-A-3314 637 describes a roofing tile having a solar battery on a surface of said tile exposed to sun rays for producing electrical current, and a passage-way underlying the region of said tile where said solar battery is located for an air flow adapted to cool the solar battery device. The heated air flow can also be used as a source of heat.

The present invention seeks to provide a solar energy collecting device associated with building component materials and capable of converting the solar energy into both electrical and thermal energies both at a time with increased efficiency while eliminating or alleviating adverse effects of heat generation upon the building interiors.

As claimed, the solar energy collector device of the invention comprises a body in the form of a roofing tile or an exterior wall member. A plurality of solar batteries is each disposed on an outer

surface of the tile or wall member exposed to sun rays. A heating medium passageway underlies at least the region of the tile or wall member, where the solar batteries are located. According to the invention, the body of the device is made of particulate inorganic granular or fibrous material and a heat-conductive metal.

According to a preferred embodiment, the heating medium passageway consists of a forward path extending underneath the solar batteries and a return path extending through the areas of the tile or wall member devoid of the batteries. The term inorganic granular or fibrous material preferably includes white porous, volcanic ash precipitates produced typically in the Kyushu Island of Japan (Shirasu balloon), tuff loam, diatomaceous earth, glass fibers and other granular or fibrous materials. By the term metal as used herein is preferably meant aluminum, copper, their alloys and other heat-conductive metals.

Preferably, the density of distribution of the inorganic substance is low (namely coarse) at the outer surface of the roof or wall exposed to sun rays and high (namely fine) at the inner surface which underlies the heating medium passageway, i.e. it is higher at the portion of the tile or wall member underlying the passageway than at the respective overlying portion.

Further, the density of distribution of the inorganic substance is preferably high (or fine) at the forward path portion of the heating medium passageway and low (or coarse) at the return path portion, i.e. it is higher at the forward path than at the return path.

A roofing member or tile formed from the aforesaid composite compound according to the invention may comprise upper and lower notches or cut-away recesses at diagonally opposed corner portions of the tile and a connecting port at an end face of each of the cut-away recesses communicating with the heating medium passageway.

The above and other objects and features of the present invention will be apparent from the following description taken in connection with the accompanying drawings. Like reference numerals refer to like or corresponding parts throughout the several views.

Figure 1 is a plan view of a roofing tile assembly constituting a solar energy collector according to the invention;

Figure 2 is a cross-sectional view taken on the line II - II of Figure 1;

Figure 3 is a side elevational view of an individual roof tile;

Figure 4 is a cross-sectional view taken on the line IV - IV of Figure 1;

Figure 5 is a view similar to Figure 4 but showing a modified tile;

Figure 6 is a perspective view of a tile assembly as mounted in a typical oriental type of house;

Figure 7 is a fragmentary perspective view on enlarged scale of Figure 6;

Figure 8 is a plan view of a modified tile assembly;

Figure 9 is a side elevational view of an individual tile of the assembly shown in Figure 8;

Figure 10 is a cross-sectional view taken on the line X - X of Figure 8;

Figure 11 is a plan view of a further modified tile;

Figure 12 is a cross-sectional view taken on the line XII - XII of Figure 11;

Figure 13 is a perspective view of an assembly of wall-forming members embodying the invention;

Figure 14 is a front elevational view of a curtain wall; and

Figure 15 is a cross-sectional view taken on the line XV - XV of Figure 14.

Referring now to the drawings and firstly to Figure 1 through Figure 4, there is shown a roofing tile assembly 10 which constitutes a solar energy collector according to the invention and which is made from a composite compound comprising a granular or fibrous inorganic substance I of the class defined as above and a metal M of the class also defined as above. Each individual tile 10a is formed for instance by injection-molding from a metal hot melt and granular or fibrous mix into a generally square block as is better shown in Figures 6 and 7. Each tile 10a has a hook member 11 extending downwardly from one of its ends and held in hooked engagement with a lug 12 anchored to a sloped support base or batten 13. A plurality of tiles 10a are partly superimposed at adjacent end portions and interconnected in a cascade fashion as is better shown in Figure 2. At diagonally opposed corners of the tile 10a are formed an upper cut-away recess 14 and a lower cut-away recess 15.

A solar battery 16 rimmed with a square plastic heat insulator 17 is mounted centrally on and flush with the outer surface of each tile 10a which is directly exposed to the sun rays.

A heating medium passageway 18 formed by a conduit 19 extends through the tiles 10a along a meandering path and is preferably concentrated underneath the region of the solar batteries 16. The conduit 19 has its inlet end 19a vertically projecting from the lower cut-away recess 15 of an upstream tile 10a and its outlet end 19b horizontally projecting from the end face of the recess 15 of a downstream tile 10a as shown in Figures 1, 2 and 7. The inlet ends 19a of the conduits 19 located at upstream tiles 10a are connected successively by coupling pipes 20 with the outlet ends 19b of the

conduits 19 located at the downstream tiles 10a.

As shown in Figure 2, the lower cut-away recess 15 in the uppermost tile 10a adjacent to the apex ridge 21 of the roof (Figure 6) is larger than the rest of the corresponding recesses elsewhere to provide space accommodating a larger coupling pipe 22 for connecting a heating medium supply tube 23 in flow communication with the terminal inlet 19a of the conduit 19 via sealing member 24. The outlet 19b of the conduit 19 is connected in flow communication with a heat medium withdrawal tube 25. Lead wires 26 of adjacent solar batteries 16 extend through the lower recesses 15 and are interconnected with one another as is shown in Figures 1 and 7.

The particulate inorganic substance I is substantially uniformly distributed in the metal M in the case of the tiles 10a shown in Figure 4.

In the embodiment shown in Figure 5, the density of distribution of the inorganic substance I is relatively low at the portion of the tile 10b which overlies the passageway 18 and relatively high at the tile portion which underlies the passageway 18, the remaining details of the tile 10b being identical with those of the tile 10a.

The construction of a tile 10c shown in Figures 8 - 10 is quite similar to that of the tile 10a except that the passageway 18 for a heating medium (not shown) consists of a forward path 18a and a return path 18b. The forward path 18a extends in a meander form alike the tile 10a and underlies the solar battery 16 on each tile 10c. The return path 18b is formed in the transverse portion of each tile 10c which is superposed on a neighboring tile 10c and which is devoid of the solar battery 16. An inlet end 18b' of the return path 18b in a downstream tile 10c is disposed in a portion corresponding to the upper recess 14 and directed downwardly toward thereto, while an outlet end 18b'' of the path 18b projects above the upper recess 14. The inlet 18b' in an upstream tile 10c and the outlet 18b'' in a downstream tile 10c are joined together by a flexible coupling pipe 20' so that the heating medium flows in the direction of the arrow as shown in Figure 8. The density of distribution of the inorganic substance I, as shown in Figure 10, is high at the region of the tile 10c surrounding the forward path 18a and low at the region surrounding the return path 18b. This varied density can be achieved by initially placing a predetermined amount of inorganic substance I in a mold cavity where its density is to be increased and thereafter molding a hot melt of metal M containing less proportions of inorganic substance I.

A modified tile 10d shown in Figures 11 and 12 is characterized by the provision of a heating medium passageway 18 in the form of an elongated channel 18' whose upper surface is exposed to the

atmosphere when the tile 10d is formed. The majority of the elongate channel 18' is covered by the solar battery 16 and has an inlet 18'a and an outlet end 18'b covered by an extension of the material of the solar battery 16 and connected to plugs 27 and 28, respectively.

Figure 13 shows an exterior wall-forming member 10e to which the principles of the invention are applied. Each wall-forming member 10e is a flat square or rectangular plate having a refractive ridge 10e', a plurality of such members 10e being superimposed one upon another along the refractive ridge 10e' so that when assembled, they are angularly displaced with respect to the plane of the ground to permit effective reception of sun rays.

Figure 14 shows a curtain-wall 29, to the interior side of which is installed a wall-forming member 10f as shown in Figure 15. The physical characteristics and performance of the wall-forming member 10f are substantially the same as the various embodiments already described. The member 10f is supported in place by brackets 30 disposed interiorly of the curtain-wall 27, and it has a heating medium passageway 18 embedded therein whose inlet and outlet are connected to a heat medium supply tube 23 and a withdrawal tube 25, respectively.

Claims

1. A solar energy collector device comprising a body in the form of a roofing tile (10a, 10b) or an exterior wall member (10e, 10f), a plurality of solar batteries (16) each disposed on an outer surface of said tile or wall member exposed to sun rays, and a heating medium passageway (18) underlying at least the region of said tile or wall member where said solar batteries (16) are located, characterized in that the body is made of a composite of particulate inorganic granular or fibrous material (I) and a heat-conductive metal (M).
2. A solar energy collector device as claimed in claim 1, characterized in that said particulate inorganic granular or fibrous material (I) is selected from the group consisting of white porous volcanic ash precipitates, tuff loam, diatomaceous earth and glass fiber, and said heat-conductive metal (M) is aluminum, copper and their alloys.
3. A solar energy collector device as claimed in claim 1 or 2, characterized in that the density of distribution of said particulate inorganic substance (I) in said composite compound is higher at the portion of said tile or wall member which underlies said passageway (18) than at the

portion which overlies said passageway (18).

4. A solar energy collector device as claimed in claim 1 or 2, characterized in that said heating medium passageway (18) is comprised of a forward path (18a) extending underneath said solar batteries (16) and a return path (18b) extending through the areas of said tile or wall member which are devoid of said batteries (16), the density of distribution of said inorganic substance (I) being higher at said forward path (18a) than at said return path (18b).
5. A solar energy collector device as claimed in any claims 1 to 4, characterized in that said tile or wall member have an upper cut-away recess (14) and a lower cut-away recess (15) formed in diagonally opposed corners of said tile or wall member and a connecting port (19a, 19b) at an end face of each of said cut-away recesses (14, 15) communicating with said passageway (18).
6. A solar energy collector device as claimed in any claims 1 to 5, characterized in that said passageway (18) is in the form of a conduit (19).
7. A solar energy collector device as claimed in any claims 1 to 5, characterized in that said passageway (18) is in the form of an open channel.

Patentansprüche

1. Sonnenenergiesammelvorrichtung mit einem Körper in der Form eines Dachziegels (10a, 10b) oder eines äußeren Wandbestandteils (10e, 10f), einer Mehrzahl von Sonnenzellen (16), von denen jede an einer äußeren, Sonnenstrahlen ausgesetzten Oberfläche des Ziegels oder Wandbestandteils angeordnet ist, und einem Heizmitteldurchgangsweg (18), der zumindest unter demjenigen Gebiet des Ziegels oder Wandbestandteils liegt, an dem die Sonnenzellen (16) lokalisiert sind, dadurch gekennzeichnet, daß der Körper aus einem Verbundstoff eines teilchenförmigen, anorganischen, körnigen oder faserigen Materials (I) und eines wärmeleitenden Metalls (M) hergestellt ist.
2. Sonnenenergiesammelvorrichtung nach Anspruch 1, dadurch gekennzeichnet, daß das teilchenförmige, anorganische, körnige oder faserige Material (I) aus der aus weißen, porösen Vulkanascheniederschlägen, Tufflehm, Diatomeenerde und Glasfaser bestehenden



atmosphere when the tile 10d is formed. The majority of the elongate channel 18' is covered by the solar battery 16 and has an inlet 18'a and an outlet end 18'b covered by an extension of the material of the solar battery 16 and connected to plugs 27 and 28, respectively.

Figure 13 shows an exterior wall-forming member 10e to which the principles of the invention are applied. Each wall-forming member 10e is a flat square or rectangular plate having a refractive ridge 10e', a plurality of such members 10e being superimposed one upon another along the refractive ridge 10e' so that when assembled, they are angularly displaced with respect to the plane of the ground to permit effective reception of sun rays.

Figure 14 shows a curtain-wall 29, to the interior side of which is installed a wall-forming member 10f as shown in Figure 15. The physical characteristics and performance of the wall-forming member 10f are substantially the same as the various embodiments already described. The member 10f is supported in place by brackets 30 disposed interiorly of the curtain-wall 27, and it has a heating medium passageway 18 embedded therein whose inlet and outlet are connected to a heat medium supply tube 23 and a withdrawal tube 25, respectively.

Claims

1. A solar energy collector device comprising a body in the form of a roofing tile (10a, 10b) or an exterior wall member (10e, 10f), a plurality of solar batteries (16) each disposed on an outer surface of said tile or wall member exposed to sun rays, and a heating medium passageway (18) underlying at least the region of said tile or wall member where said solar batteries (16) are located, characterized in that the body is made of a composite of particulate inorganic granular or fibrous material (I) and a heat-conductive metal (M).
2. A solar energy collector device as claimed in claim 1, characterized in that said particulate inorganic granular or fibrous material (I) is selected from the group consisting of white porous volcanic ash precipitates, tuff loam, diatomaceous earth and glass fiber, and said heat-conductive metal (M) is aluminum, copper and their alloys.
3. A solar energy collector device as claimed in claim 1 or 2, characterized in that the density of distribution of said particulate inorganic substance (I) in said composite compound is higher at the portion of said tile or wall member which underlies said passageway (18) than at the

portion which overlies said passageway (18).

4. A solar energy collector device as claimed in claim 1 or 2, characterized in that said heating medium passageway (18) is comprised of a forward path (18a) extending underneath said solar batteries (16) and a return path (18b) extending through the areas of said tile or wall member which are devoid of said batteries (16), the density of distribution of said inorganic substance (I) being higher at said forward path (18a) than at said return path (18b).
5. A solar energy collector device as claimed in any claims 1 to 4, characterized in that said tile or wall member have an upper cut-away recess (14) and a lower cut-away recess (15) formed in diagonally opposed corners of said tile or wall member and a connecting port (19a, 19b) at an end face of each of said cut-away recesses (14, 15) communicating with said passageway (18).
6. A solar energy collector device as claimed in any claims 1 to 5, characterized in that said passageway (18) is in the form of a conduit (19).
7. A solar energy collector device as claimed in any claims 1 to 5, characterized in that said passageway (18) is in the form of an open channel.

Patentansprüche

1. Sonnenenergiesammelvorrichtung mit einem Körper in der Form eines Dachziegels (10a, 10b) oder eines äußeren Wandbestandteils (10e, 10f), einer Mehrzahl von Sonnenzellen (16), von denen jede an einer äußeren, Sonnenstrahlen ausgesetzten Oberfläche des Ziegels oder Wandbestandteils angeordnet ist, und einem Heizmitteldurchgangsweg (18), der zumindest unter demjenigen Gebiet des Ziegels oder Wandbestandteils liegt, an dem die Sonnenzellen (16) lokalisiert sind, dadurch gekennzeichnet, daß der Körper aus einem Verbundstoff eines teilchenförmigen, anorganischen, körnigen oder fasrigen Materials (I) und eines wärmeleitenden Metalls (M) hergestellt ist.
2. Sonnenenergiesammelvorrichtung nach Anspruch 1, dadurch gekennzeichnet, daß das teilchenförmige, anorganische, körnige oder fasrige Material (I) aus der aus weißen, porösen Vulkanascheniederschlägen, Tufflehm, Diatomeenerde und Glasfaser bestehenden



Gruppe, und das wärmeleitende Metall (M) aus Aluminium, Kupfer und deren Legierungen ausgewählt ist.

3. Sonnenenergiesammelvorrichtung nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß die Verteilungsdichte der teilchenförmigen, anorganischen Substanz (I) in der Verbundstoff-Verbindung an dem Bereich des Ziegels oder Wandbestandteils, der unter dem Durchgangsweg (18) liegt, höher ist, als an dem Bereich, der über dem Durchgangsweg (18) liegt. 5
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4. Sonnenenergiesammelvorrichtung nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß der Heizmitteldurchgangsweg (18) umfaßt einen sich unter den Sonnenzellen (16) erstreckenden Vorlaufweg (18a) und einen sich durch die Gebiete des Ziegels oder Wandbestandteils, in denen keine der Zellen (16) vorliegt, erstreckenden Rücklaufweg (18b), wobei die Verteilungsdichte der anorganischen Substanz (I) an dem Vorlaufweg (18a) höher ist, als an dem Rücklaufweg (18b). 15
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5. Sonnenenergiesammelvorrichtung nach einem der Ansprüche 1 bis 4, dadurch gekennzeichnet, daß der Ziegel oder Wandbestandteil aufweist eine obere ausgeschnittene Ausnehmung (14) und eine untere ausgeschnittene Ausnehmung (15), die in diagonal gegenüberliegenden Ecken des Ziegels oder Wandbestandteils gebildet sind, und eine mit dem Durchgangsweg (18) in Verbindung stehende Verbindungsöffnung (19a, 19b) an einer Endfläche von jeder der ausgeschnittenen Ausnehmungen (14, 15). 25
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6. Sonnenenergiesammelvorrichtung nach einem der Ansprüche 1 bis 5, dadurch gekennzeichnet, daß der Durchgangsweg (18) in der Form einer Rohrleitung (19) vorliegt. 35
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7. Sonnenenergiesammelvorrichtung nach einem der Ansprüche 1 bis 5, dadurch gekennzeichnet, daß der Durchgangsweg (18) in der Form eines offenen Kanals vorliegt. 45

Revendications

1. Dispositif capteur d'énergie solaire comprenant un corps ayant la forme d'une tuile (10a, 10b) de toiture ou d'un panneau (10e, 10f) de paroi extérieure, une pluralité de piles solaires (16) placées chacune sur la surface extérieure de ladite tuile ou dudit panneau de paroi exposée aux rayons du soleil, et un passage (18) pour caloporteur situé au moins en-dessous de la région de ladite tuile ou dudit panneau de 50
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paroi où sont placées lesdites piles solaires (16), caractérisé en ce que le corps est fait d'un composite de matériau minéral particulier (I), granuleux ou fibreux, et d'un métal (M) thermoconducteur.

2. Dispositif capteur d'énergie solaire selon la revendication 1, caractérisé en ce que ledit matériau minéral (I) particulier, granuleux ou fibreux, est choisi dans le groupe formé par les précipités blancs de cendres volcaniques poreuses, le limon volcanique, la terre à diatomées et les fibres de verre, et ledit métal (M) thermoconducteur est de l'aluminium, du cuivre ou leurs alliages.
3. Dispositif capteur d'énergie solaire selon la revendication 1 ou 2, caractérisé en ce que la densité de répartition de ladite substance minérale (I) particulière dans ledit composé composite est plus élevée au niveau de la partie de ladite tuile ou dudit panneau de paroi placée en-dessous dudit passage (18) qu'au niveau de la partie qui est au-dessus dudit passage (18).
4. Dispositif capteur d'énergie solaire selon la revendication 1 ou 2, caractérisé en ce que ledit passage (18) pour le caloporteur comprend un trajet aller (18a) s'étendant en-dessous desdites piles solaires (16) et un trajet retour (18b) s'étendant dans les régions de ladite tuile ou dudit panneau de paroi qui sont exemptes de piles (16), la densité de répartition de ladite substance minérale (I) étant plus élevée au niveau dudit trajet aller (18a) qu'au niveau dudit trajet retour (18b).
5. Dispositif capteur d'énergie solaire selon l'une quelconque des revendications 1 à 4, caractérisé en ce que ladite tuile ou ledit panneau de paroi comprend une découpe supérieure (14) et une découpe inférieure (15) formées dans les coins diagonalement opposés de ladite tuile ou dudit panneau de paroi, ainsi qu'un orifice de liaison (19a, 19b) au niveau de la face d'extrémité de chacune desdites découpes (14, 15) qui communique avec ledit passage (18).
6. Dispositif capteur d'énergie solaire selon l'une quelconque des revendications 1 à 5, caractérisé en ce que ledit passage (18) a la forme d'un conduit (19).
7. Dispositif capteur d'énergie solaire selon l'une quelconque des revendications 1 à 5, caractérisé en ce que ledit passage (18) a la forme



d'un canal ouvert.

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