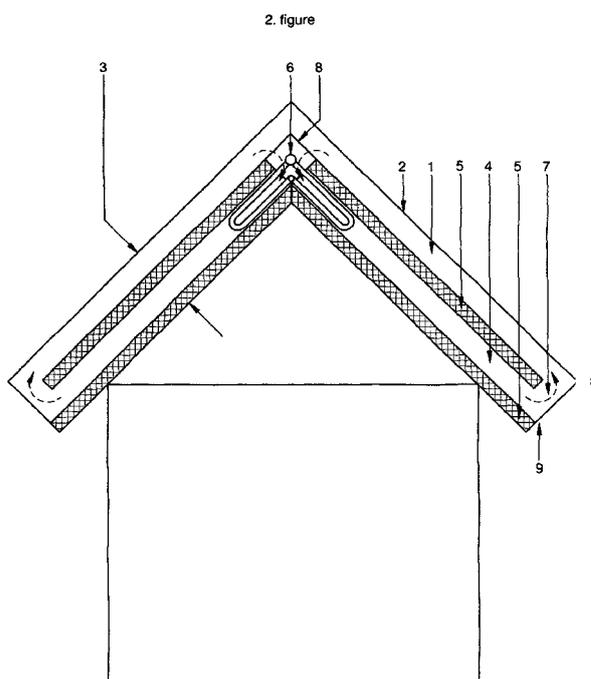




- (51) International Patent Classification:
F24J 2/04 (2006.01) *E04D 13/18* (2014.01)
- (21) International Application Number:
PCT/HU2017/000027
- (22) International Filing Date:
20 April 2017 (20.04.2017)
- (25) Filing Language: Hungarian
- (26) Publication Language: English
- (30) Priority Data:
P1600265 20 April 2016 (20.04.2016) HU
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- (81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.
- (84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ,

(54) Title: SANDWICH ROOF PANELS TO SERVE AS THERMAL COLLECTORS



(57) Abstract: The subject of the present application is an arrangement of sandwich panels already used in buildings in a way that makes them capable of collecting solar radiation and ambient heat and transferring the energy out of the roof. The structural elements of the present invention consist of a heat insulating core sandwiched between external and internal sheets with load-bearing capacity, similar to the make-up of the known load-bearing sandwich panels. Whether the sheet profiles are placed in the direction of the ridge beam or of the rafters, with the appropriate set of them, hollow structure is created on the surface and in the core of the panel in the direction of the rafters, in the entire length of the roof, functioning as pathways for gaseous materials (air ducts (1, 4)). If these air ducts, both external and in the core, are connected at the end facing each other, i.e. at the upper air turn chamber (8), the substance in them will start to flow on its own using solely gravitational forces in reaction to heat reaching the panel's external surface, i.e. the external profiled metal sheet (2). If a given point of the panel is cooled by heat exchanger (6), the spontaneous flow will remain continuous. Cooling transports the heat collected in the air ducts (hot air duct (1) and cold air duct (4)) out of the system, and this heat is utilized to provide for our energy needs. The subject of the application is, therefore a sandwich panel which functions as a thermal collector, hereinafter heat collector sandwich panel (3), which serves as the roof structure of a building, or is an integral part of the roof structure and meets without fail all protection requirements set for roof constructions. Due to its special design it is capable of collecting ambient heat, and transferring this heat to



TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

- *of inventorship (Rule 4.17(iv))*

Published:

- *with international search report (Art. 21(3))*
- *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

SANDWICH ROOF PANELS TO SERVE AS THERMAL COLLECTORS

The subject of the application is an arrangement of sandwich panels already used in buildings in a way that makes them capable of obtaining solar radiation and ambient heat energy and transferring the energy out of the roof.

The structural element in question comprises a heat insulating material arranged between sheets with load-bearing capacity, similar to the known load-bearing sandwich panels. Whether the sheet profiles are placed in the direction of the ridge beam or of the rafters, with appropriate assembling of them hollow structures are formed on the surface and in the core of the panel in the direction of the rafters, along the entire rafter length of the roof, functioning as pathways for aeriform material or air ducts. If these air ducts, both external and in the core, are connected at the end facing each other, the substance in them will start to flow on its own using solely gravitational forces in reaction to heat reaching the panel's external surface. If a given point of the panel is cooled, the spontaneous flow will remain continuous. Cooling transports the heat collected in the air ducts out of the system, and this heat is utilized to provide for our energy needs.

The subject of the application is therefore a sandwich panel which functions as a thermal collector, hereinafter heat collector sandwich panel, forming physically the roof structure of a building and forming an integral part of the roof structure meeting without fail all protection requirements set for roof constructions, resp. Due to its special design it is capable of absorbing ambient heat and transferring this heat to a heat storage by the use of a compatible, known auxiliary appliance.

Since the supply of fossil fuels is finite, it is appropriate to include solar energy as a source for the energy supply of houses and other buildings. Several solutions aiming to do this have already been worked out, such as, for example, in the form of an auxiliary equipment that can be installed onto the outside of the building, or an equipment utilizing energy resources formed and arranged outside of the building.

Utilization of the renewable energy powered by the sun can also be performed in the direct physical vicinity of the buildings, e.g.: solar collectors, solar panels, heat pumps laid down or drilled into the ground surrounding houses, or two-directional atmospheric heat pumps, etc. Electric energy consumption can be reduced by

improving the heat insulation of buildings (passive house), or by using a system that utilizes energy gained from the environment on site, periodically recuperating some of said energy to the grid (active house).

Products of sandwich panel manufacturers like Kingspan in Ireland, Lindab in Sweden, Metalsheet in Hungary, fit into the "passive house" line. Usually their products come with a wide selection of heat insulation values.

There are also several manufacturers serving the "active house" market. Solar collectors as one of the many solutions for harvesting energy on site near the building shall be mentioned.

Solar collectors can be grouped based on two main principles of operation.

a) According to a generally used solution a liquid is circulated in a tubing embedded in various heat absorbing materials, arranged in various frames subsequently installed on a roof, said liquid, when heated carries the heat from the panel to other units utilizing the heat. A known manufacturer: Vaillant in Germany (EP2015000 A2 [2009.01.14.] „Frame with solar absorbent tube and reception means”; DE10258711 A1 [2002.12.12.] „Solar collector unit has several tubular collectors fixed on main collector body which is formed by extruded cast profiled section”).

According to the solution disclosed in the US 4,135,490 entitled „Recirculating natural convection solar energy collector” a heat exchanger is formed comprising spaces separated by plates in a frame covered by a transparent plate on the front side and non-transparent plates on the other sides. A liquid circulation is generated in the so formed heat exchanger and the absorbed heat can be continuously transferred and used. A similar solution is proposed in the US 3,987,782 entitled „Solar heat holder”. Both patent documents comprise the description and training for separately applied heat exchanger units that can be installed on the roofs of residential buildings.

b) Evacuated tube solar collectors show a more efficient solution: a vacuum is generated between two glass tubes, one inserted into the other and sealed at the end. The vacuum between the two tubes provides heat insulating function. The internal closed tube contains a liquid that evaporates when the sun shines on it, then it delivers heat when condensing at the cold end of the tube. Heat transfer is allowed

by the energy of change of the state of condition of the substance. This system is also mounted in a panel. In addition to its many advantages only the radiated energy from the sun is utilized, ambient heat cannot be utilized due to the insulating property of the vacuum. A similar solution is disclosed in EP 0 025 305 A1 [1981.03.18.], entitled „Absorber for electromagnetic energy”.

Solar panels that convert solar energy directly into electric energy shall be mentioned as well, widely used based on the application methods of semiconductors developed in the 20th century. Among others, US 2005081908 A1 [2005.04.21.], entitled „Method and apparatus for generation of electrical power from solar energy” discloses such a solution.

The disadvantage of the above solutions is that they only utilize a small portion of the building's usable surface for gaining energy. Furthermore, it is also disadvantageous that they use primarily the radiated energy of the sun while the ambient energy is not used, or used to a very small extent.

A further disadvantage of the above solutions is that they do not constitute a part of the building, they are made up of units that can be mounted onto an existing building, and of other equipment that can be attached to them. Their use does not allow for reducing the cost of construction.

In order to eliminate the disadvantages mentioned above a new solution is proposed based on the recognition that a roof structure of a building can be designed so that most of the roof surface or the entire roof surface consists of heat exchange sandwich panels, to be described in detail below, functioning as collectors and capable of meeting all structural requirements set for the elements, and at the same time can absorb and utilize ambient heat in addition to radiated heat. Furthermore, there is no need for using any transparent external cover plate; by the use of a profiled metal sheet cover plate serving as a heat absorber or of heat conducting ribbed metal foam, ambient heat can also be utilized.

Radiated energy was already used by the cave man, when he turned his back towards the sun, while the principle of recirculating heat exchanger has been used by humanity for some hundred years. Compared to other known solar panel patents, the essence of my invention is a completely different and new spacial arrangement, in which a roof – in place of traditional roof structures of buildings – is capable of

collecting as well as transmitting radiated and ambient energy by the aid of a new heat collector sandwich panel arrangement.

A loft of a building is covered by the newly developed heat collector sandwich panels. Fitted together along their sides and assembled, the panels form the roof, i.e., structural part of the building. Absorption of heat on large surfaces, by the use of a heat pump, provides a significant amount of heat energy even in cloudy weather, even at moderate temperature differences.

The invention will be described more detailed below:

Disclosure of the Figures:

List of reference signs on the drawings:

- 1 - hot air duct
- 2 – external limiting profiled metal sheet
- 3 – heat collector sandwich panel
- 4 – cold air duct
- 5 – heat insulation
- 6 – cooling device
- 7 - lower air reversing chamber
- 8 - upper air reversing chamber
- 9 - condensate drain hole
- a – distance between cold air ducts
- b, c, e – dimensions of trapezoid sheet
- d – thickness of heat insulated panel
- f – total thickness of the panel structure
- S1 – cross-section of the hot air duct
- S2 – cross-section of cold air duct

Fig. 1 shows the arrangement of the heat collector sandwich panel 3 making up the roof structure of a building.

Fig. 2 shows the operating principle of the heat collector sandwich panel 3 constituting the roof structure of a building.

Figs. 3, 4, and 5 show three different heat collector sandwich panel cross-sections representing advantageous implementations of the invention. Matter-of-course, by the use of the invention further sheet profiles can be formed.

Fig. 6 shows the upper air reversing chamber 8 and its location, partly concealed by the internal heat exchanger and represented by a dotted line in favourable saddle roof arrangements.

Fig. 7 shows the lower air reversing chamber 7 and its location.

Short general description:

In the plane of the heat collector sandwich panel 3, there are two duct rows, preferably air duct rows 1, 4 arranged, running parallel in rafters direction. With a view to the building, outer hot air duct row 1 is covered with an external profiled metal sheet 2 having an external surface made of known structural materials capable of absorbing solar radiation and ambient heat, preferably corrugated metalsheet, even more advantageous trapezoid profiled metalsheet or aluminum foam shape. Between the two duct rows 1, 4 a heat insulation 5 is arranged. There is also a heat insulation 5 on the inner side of the heat collector sandwich panel 3 with a view to the roof (Figures 3, 4 and 5). At each end of the heat collector sandwich panel 3, there are air reversing chambers 7, 8 (Figures 6 and 7).

In the upper air reversing chamber 8 of the heat collector sandwich panel 3 a cooling device 6 is arranged comprising a streaming cooling medium for discharging heat from the system (Figures 2 and 6).

Detailed description of the function of the invention:

One side of the outer hot air duct 1, being an external side with a view to the roof structure of the building serves to absorb solar radiation and ambient heat via the external profiled metal sheet 2. The other cold air duct row 4 is located inside of the heat collector sandwich panel 3, thus separated by a further layer of heat insulation 5 from the interior of the building. The ducts 1, 4 are preferably air ducts running through the panel at rafters direction, from the bottom of the plane of roof to the ridge.

At the lower and upper ends of the heat collector sandwich panel 3, air reversing chambers 7, 8 are formed, which make possible the circulation of the

medium inside of the panel. The circulation of the medium in the air ducts preferably occurs by gravity or by forced-circulation in case of necessity.

The cooling device 6 is located in the upper air reversing chamber 8 (hot point), which serves the purpose of extracting heat, with a known widely used cooling medium circulating in it, and where preferable, the cold side of a heat pump can be connected into.

The medium, which has been heated up, rises in the outer hot air duct 1 while the medium, which has cooled down, descends in the inner cold air duct 4.

The heat collector sandwich panel 3 can be formed using various structural materials such as metals, profiled sheets and thermal insulating materials, suitable for heat insulated delimitation of the outer and inner parts of the building, forming a self-supporting sandwich panel structure and with proper dimensioning, also functioning as roof elements supported by purlin or rafters in accordance with the requirements of statics. Thus installation of further rafters or purlins in the roof structure is not necessary.

The external limiting profiled metal sheet 2 is preferably a metal sheet of proper heat conductivity, warming up at incident radiation and transmitting the external heat to the neighbourhood of the air ducts, furthermore, it is formed as a sectional and/or ribbed profile sheet to withstand against thermal dilation and to increase rigidity. Matter a course, use of profiled sheet increases the heat transferring surface too and radiation non-perpendicular to the plane of the roof can be better utilized with higher efficiency.

Inter-connecting the constituents of the heat collector sandwich panel 3, like external, internal, covers sheets and hot and cold air ducts 1, 4 by mechanical, non-heat-conductive materials like plastic screws or shaped elements, the structural strength of the heat collector sandwich panel 3 is significantly increased, making possible forming a panel structure for optimizing the sheet thickness and enabling larger spans.

In the following two examples for dimensioning of the heat collector sandwich panel 3 according to the invention will be shown. The invention is not restricted by the examples to the given shapes, measures, dimensions and can be re-dimensioned

using simple calculations and experimentations in accordance with given requirements, taking the characteristics of the used materials into consideration.

Example 1 (Figure 3) both the outer and the inner air ducts 1, 4 have hexagonal cross-sections

Distance between cold air ducts	a	23.5	cm
Dimensions of the trapezoid sheet	b	12	cm
	c	6	cm
	e	6	cm
	d	21	cm
Thickness of heat insulated panel	d	21	cm
Total thickness of the panel structure	f	27	cm
Cross-section of the hot air duct	S1	105	cm ²
Cross-section of cold air duct	S2	205	cm ²

Example 2 (Figure 4) the outer air duct row 1 consists of ducts of hexagonal cross-section, the inner air duct row 4 consists of ducts of circular cross-section

Distance between cold air ducts	a	23.5	cm
Dimensions of the trapezoid sheet	b	12	cm
	c	6	cm
	e	6	cm
	d	20	cm
Thickness of heat insulated panel	d	20	cm
Total thickness of the panel structure	f	26	cm
Cross-section of the hot air duct	S1	105	cm ²
Cross-section of cold air duct	S2	53	cm ²

The heat transfer medium in the air ducts 1, 4 is preferably under atmospheric pressure or different one, circulating by gravity or by force. The circulating heat transfer medium can be chosen from different substances. Preferably it should be a gaseous substance, even more preferably atmospheric air is to be used.

Small holes are drilled on the bottom of the lower air reversing chamber 7, to allow condense free to drain from the system.

The operation of the invention, using air as heat transfer medium:

The medium in the hot air duct 1 takes over the temperature of the external limiting profiled metal sheet 2, preferably ribbed metal sheet. As a result of the heat, it expands and its density decreases. The heavier medium in the cold air duct 4 makes an effort to take the place of the hot medium through the lower air chamber 7 and pushes the hot medium up to the upper air chamber 8 of the panel.

In the upper air chamber 8, the hot air passes its heat to the cooling device 6 and while cooling down its volume decreases. Since its density increases it sinks to the cold air duct 4. Thus the continuous heating and cooling results a self-circulation of the medium in the hot and cold air ducts 1, 4. The heat thus taken over as well as the liquid in the cooling device 6 can be used for further known utilizations, preferably at additional storage in a hot water tank, using other technologies for supplying hot water to the household, heating the building, or even to generate electric energy.

Once the utilization within the building does not require further heat absorption, ventilation windows located at the end of the lower and upper air reversing chambers 7, 8 will be opened in a controlled way, resulting in a free flow out of the warm medium, air, from the panel through the upper window. In this way the air flow conveys the heat from the panel into the environment and increase of the thermal loading of the building can be avoided.

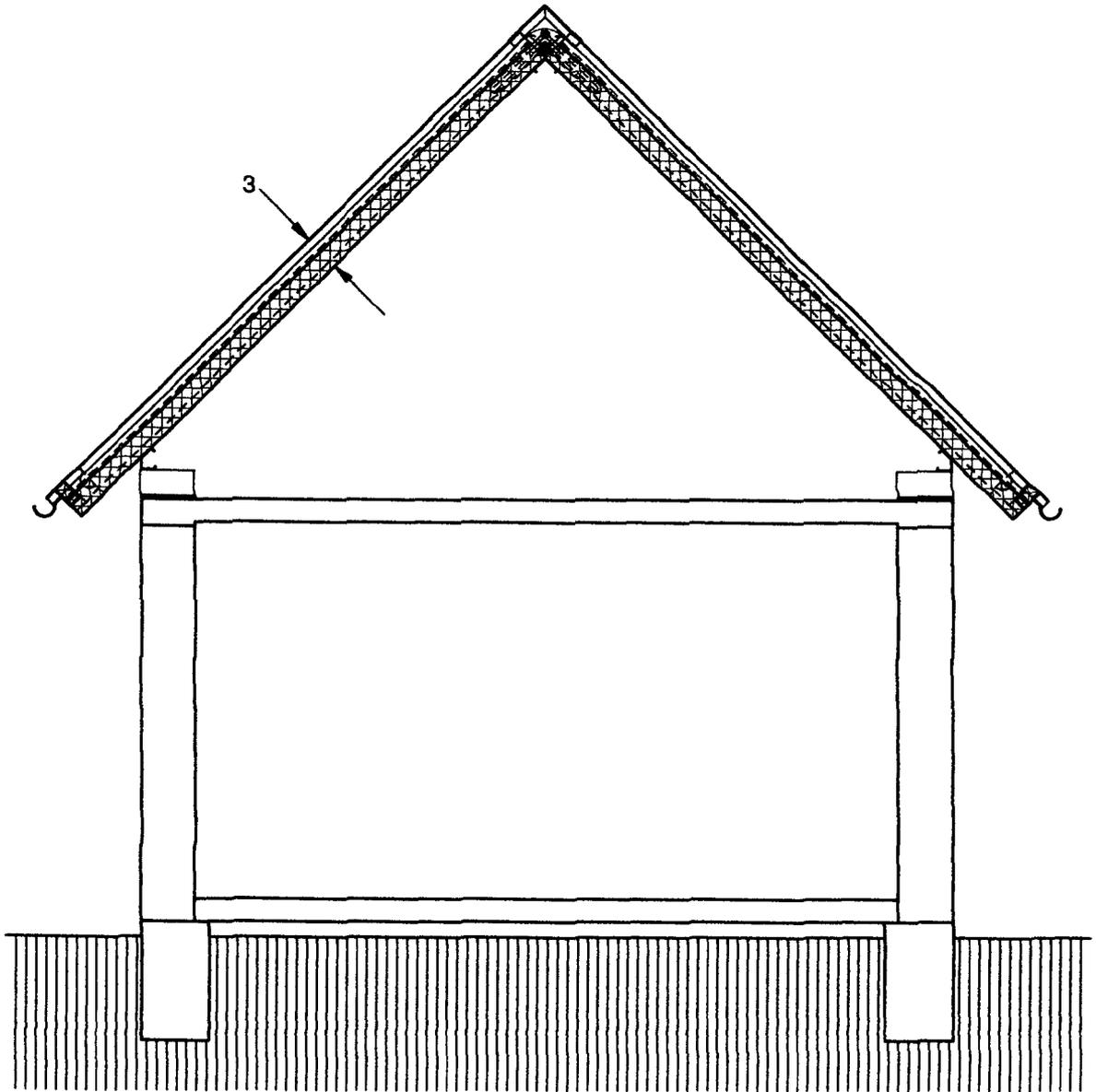
Of course the heat collector sandwich panel 3 can be used in roofs with different slope angles. As it is well-known, slope and orientation of the roof have a great influence on the maximum possible yield.

Claims

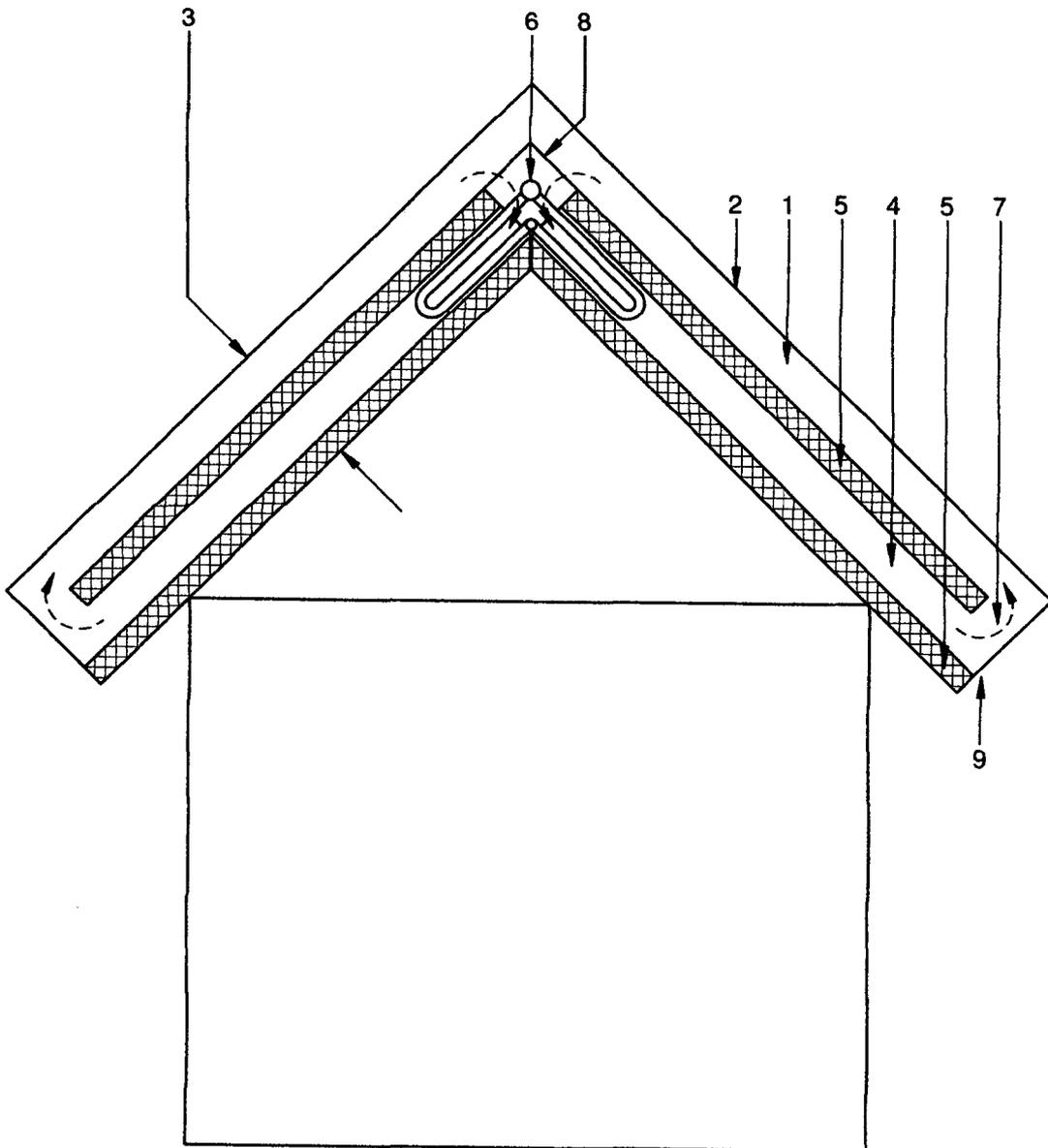
1. Arrangement of sandwich panels used as roof structure of buildings as a thermal collector characterized in that
in the plane of the heat collector sandwich panel (3), there are two duct rows, preferably air duct rows (1, 4) arranged, running parallel in rafters direction;
with a view to the building, the outer hot air duct row (1) is covered with a metal sheet (2) having an external surface made of known structural materials capable of absorbing solar radiation and ambient heat;
a separating heat insulation (5) is arranged between the planes of the duct rows (1, 4);
a further heat insulation (5) is arranged on the inner side of the heat collector sandwich panel (3) with a view to the roof;
reversing chambers (7, 8), preferably air reversing chambers are formed on each end of the heat collector sandwich panel (3);
in the upper air reversing chamber (8) of the heat collector sandwich panel (3) there is a cooling device (6) arranged comprising streaming cooling medium for discharging the heat.
2. The arrangement according to claim 1, characterized in that with the distinction that the chambers in the heat collector sandwich panel (3) are lower and upper air reversing chambers (7, 8) and they commonly connect all the hot and cold air ducts (1, 4) at the lower and upper air reversing chambers (7, 8).
3. The arrangement according to claim 1 or 2, characterized in that the heat insulation (5) on the heat collector sandwich panel (3) facing the inner side of the roof is known heat insulation, composite and/or masonry material.
4. A method for the use of the heat collector sandwich panel roof structure according to any of claims 1-3, characterized in that it serves the purpose of the utilization of radiated solar energy and/or ambient heat energy.
5. The method according to claim 4, characterized by using the heat collector sandwich panel (3) for heating of water or other known heat storing substance.
6. The method according to claim 4 or 5, characterized in that a gaseous medium is used for transferring heat in the ducts (1, 4) of the heat collector sandwich panel (3).

7. The method according to claim 6, characterized in that the gaseous medium is air at atmospheric pressure.
8. The method according to any of claims 4-7, characterized by employing the heat collector sandwich panel (3) at roof planes with different slopes being less than 90 degrees.
9. The method according to claim 8, characterized in that the heat insulation (5) of the heat collector sandwich panel (3) facing the building's interior is of known heat insulating material and/or space delimiting material.
10. The method according to any of claims 4-7, characterized by using the heat collector sandwich panel (3) as a roof structure of the building and/or as an integral part of the roof structure itself.
11. The method according to any of claims 4-10, characterized by installing the heat collector sandwich panels (3) lengthwise into the roof parallel either with the rafter or the ridgepole, with the distinction that the hot and cold air ducts (1, 4) are always by any case parallel with the rafters.

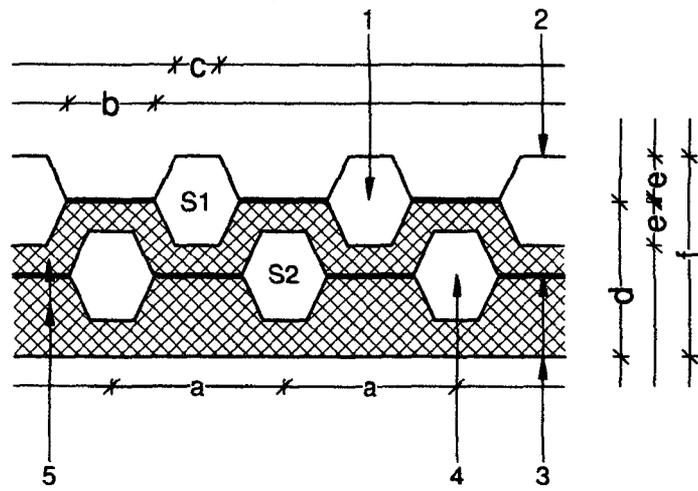
1. figure



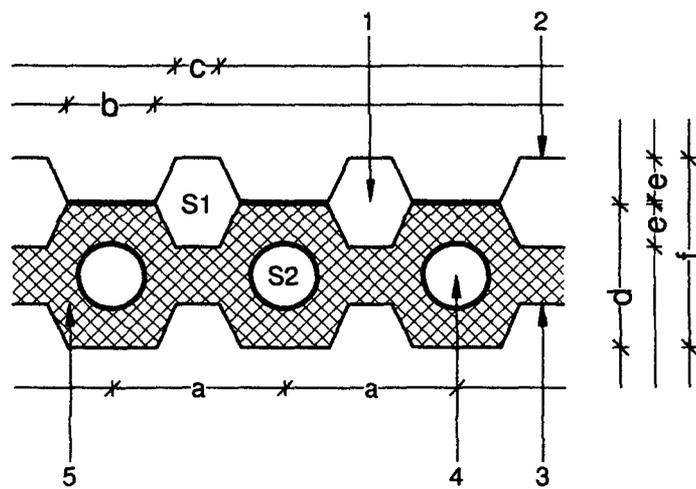
2. figure



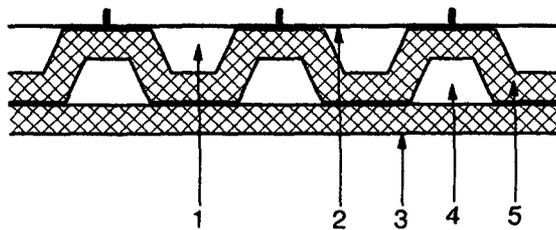
3, figure



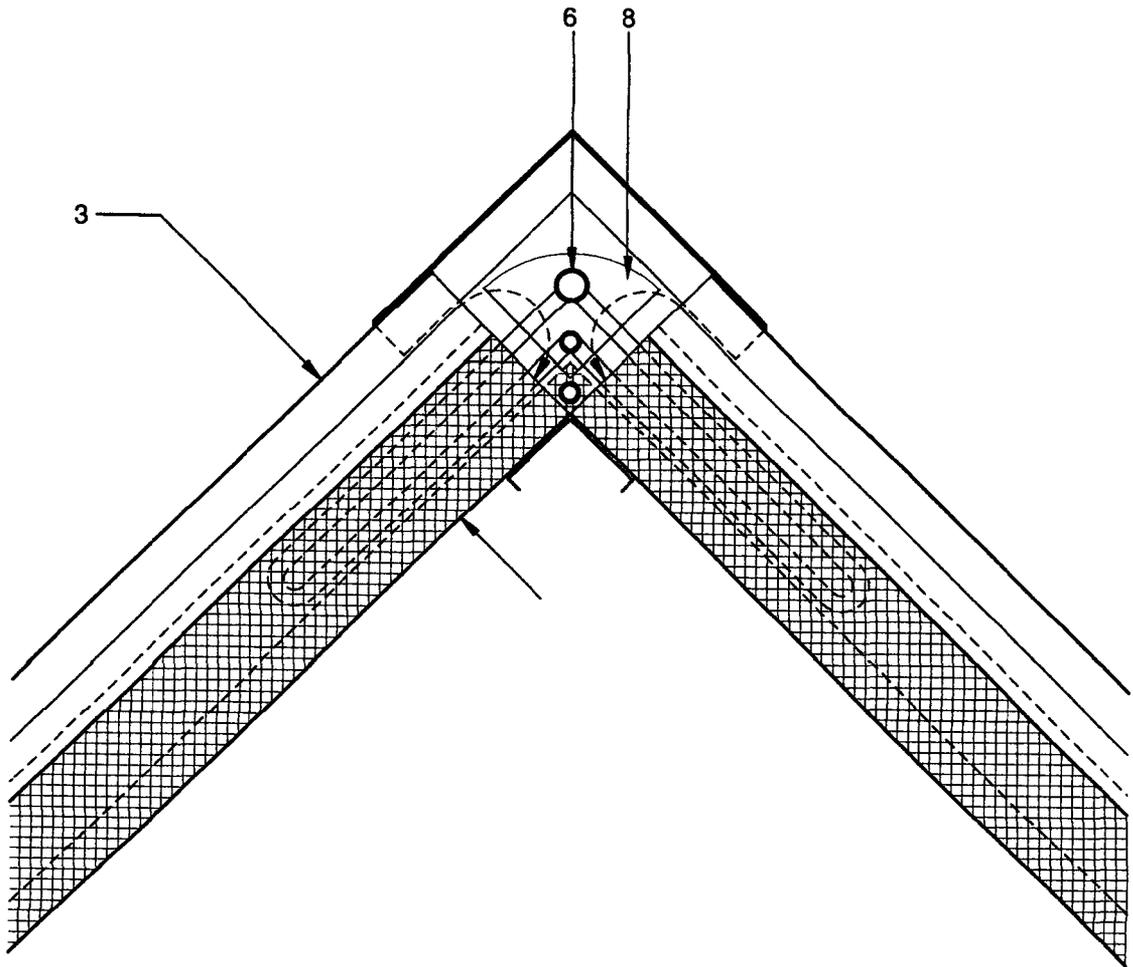
4. figure



5. figure



6. figure



7. figure

