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(54) ROOF STRUCTURE FOR A SOLAR SYSTEM

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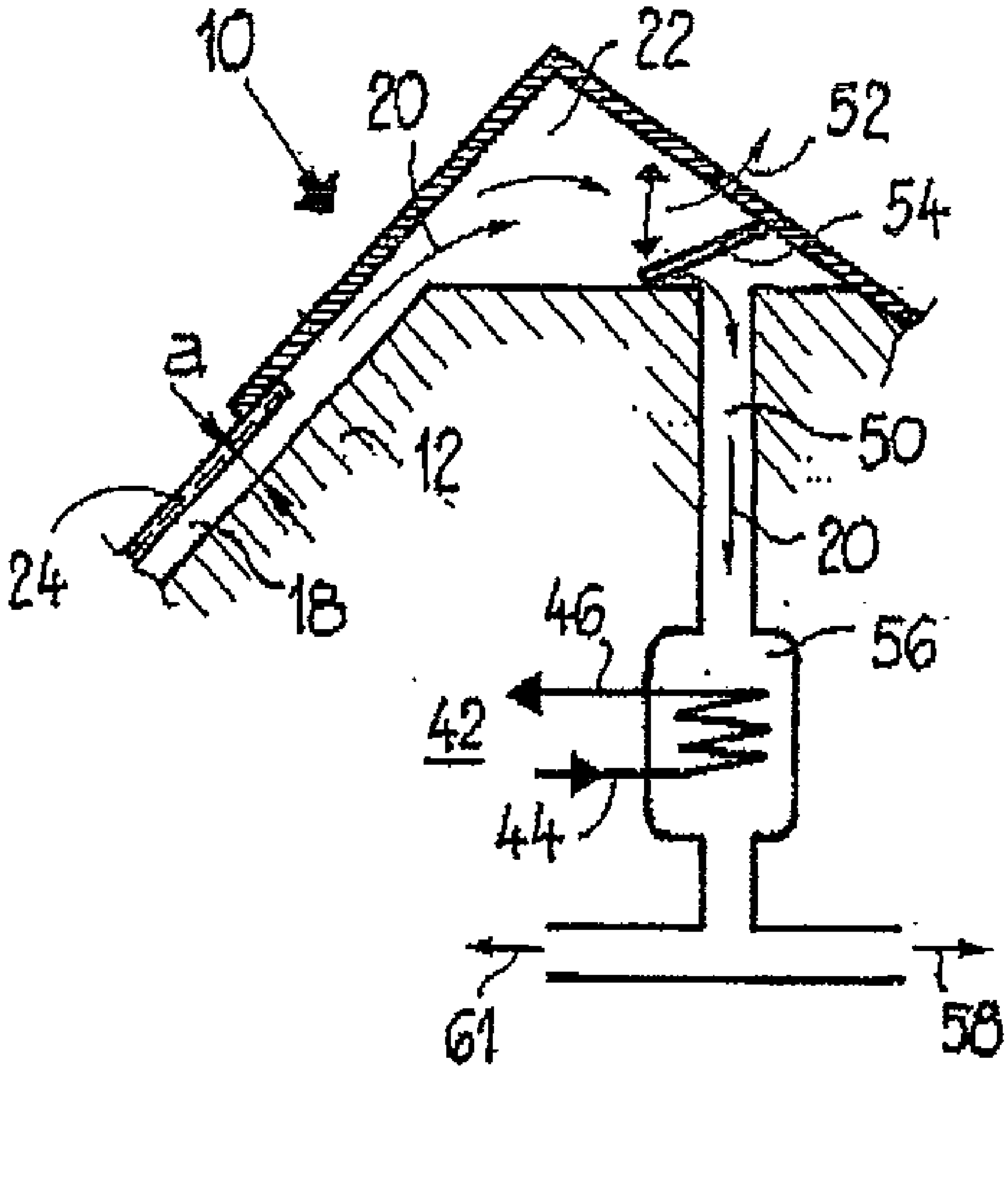
(57) **ABSTRACT**

A roof structure (**10**) for photovoltaic generation of electric current and/or for heating a flowing medium, in particular an airflow (**14**, **20**), comprises glass roof panels (**24**) that are flat, transparent or equipped at least partially with solar cells (**60**) of flat design. Said panels are laid at a spacing (a) from a subroof (**12**) with formation of an airtight flat gap (**18**) that is largely free of obstructions in the flow direction, and are preferably of square or rectangular design.



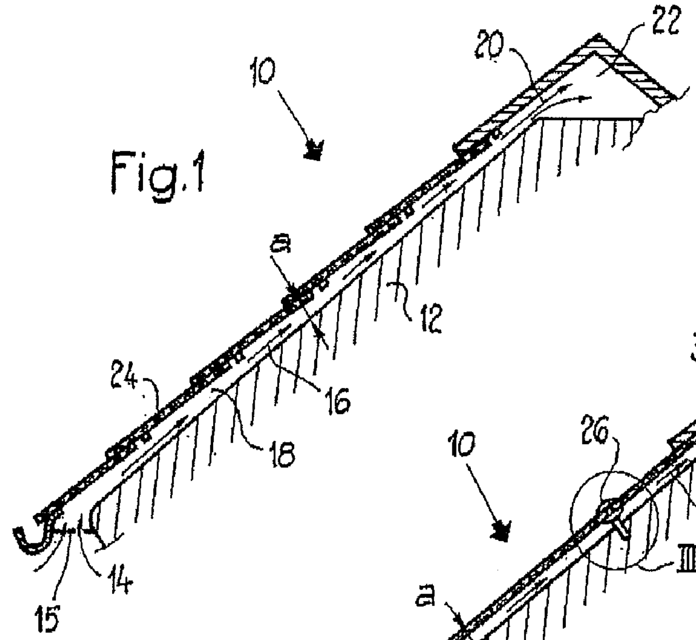


Fig.1

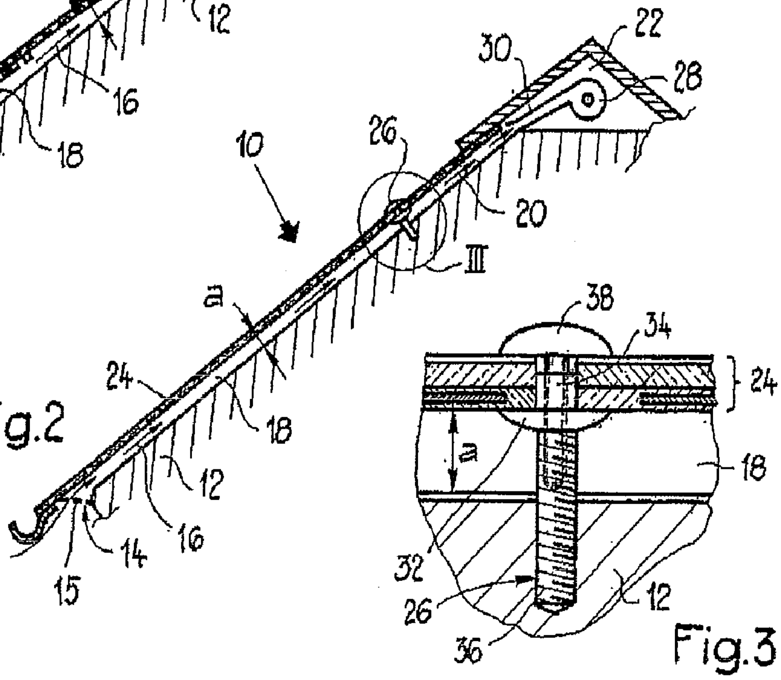


Fig.2

Fig.3

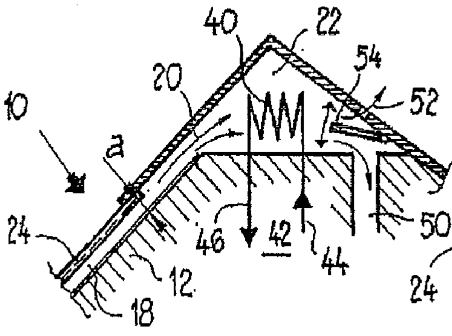


Fig.4

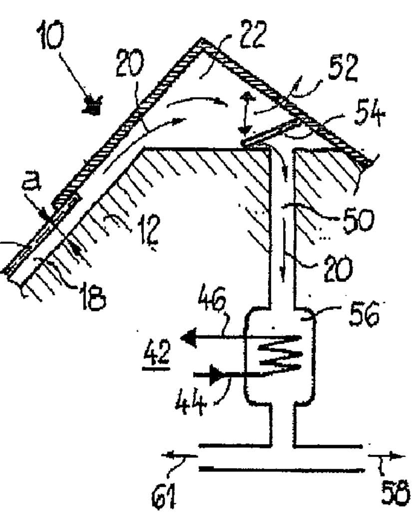


Fig.5

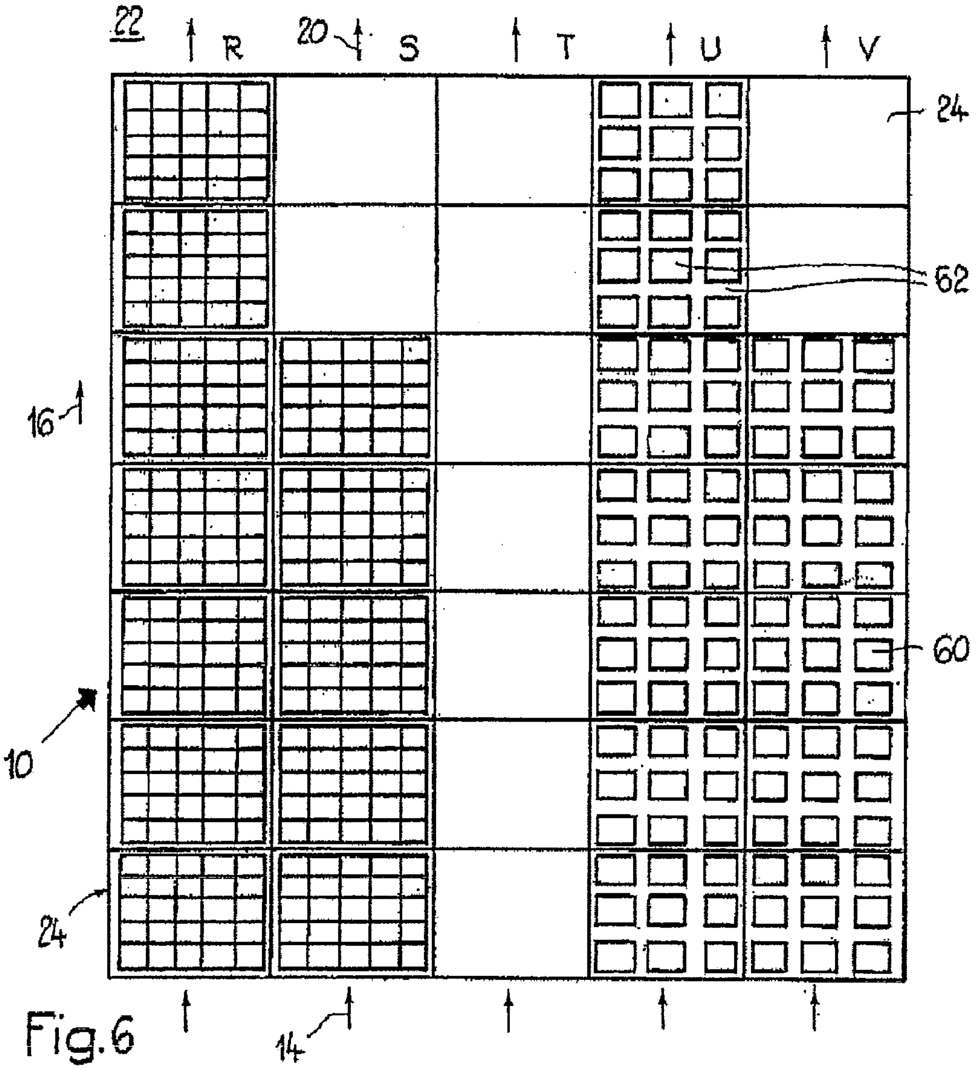


Fig.6

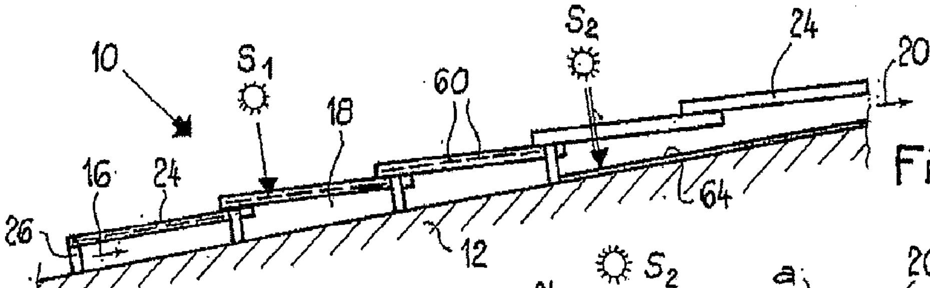


Fig.7

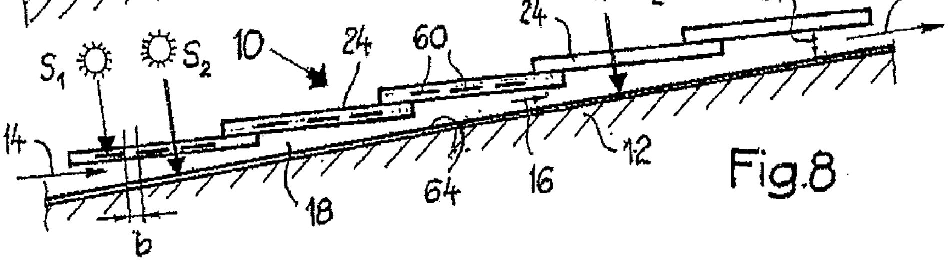


Fig.8

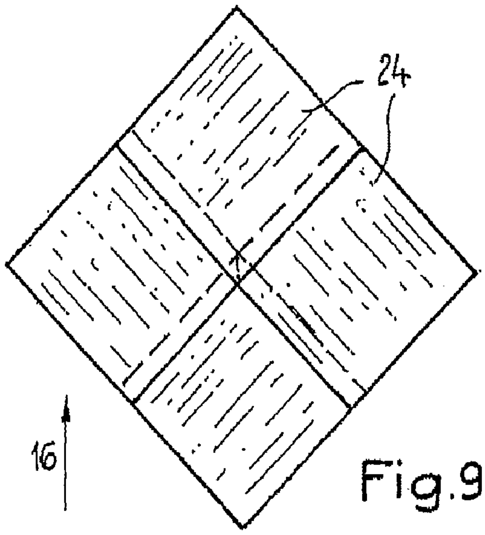


Fig.9

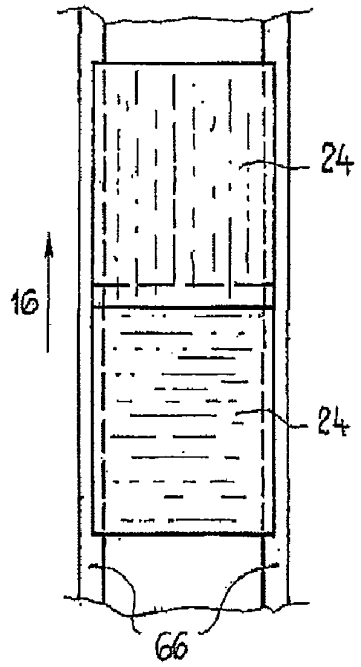


Fig. 10

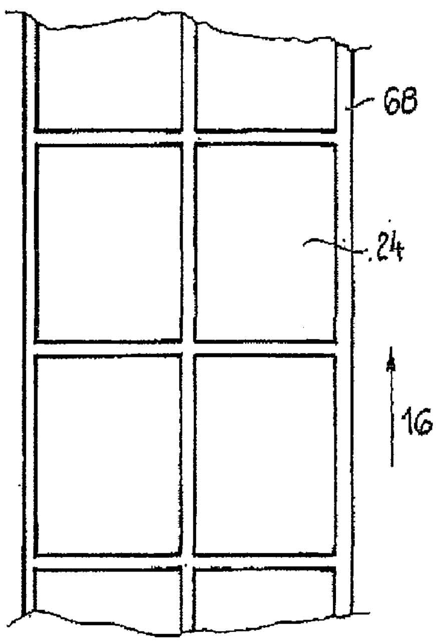


Fig.11

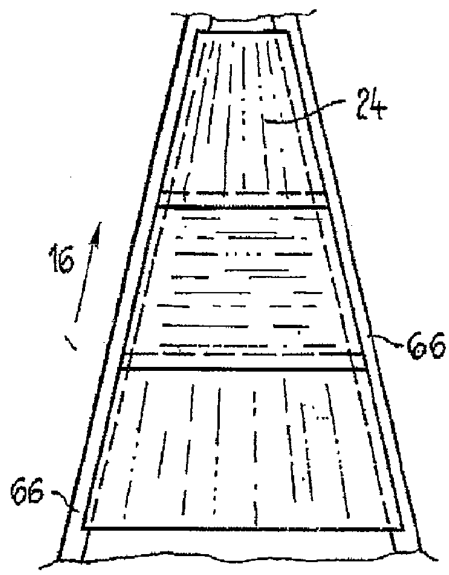


Fig.12

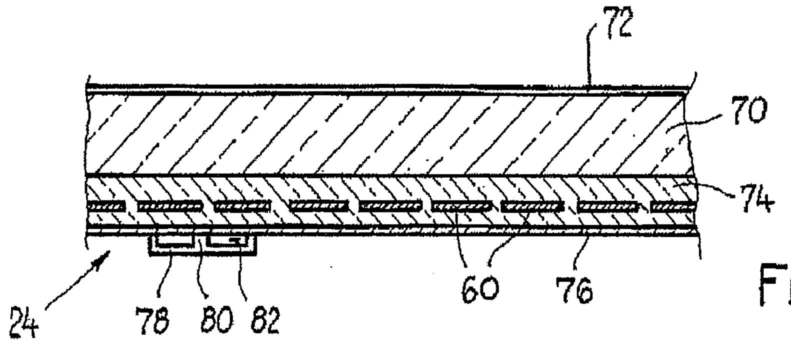


Fig.13

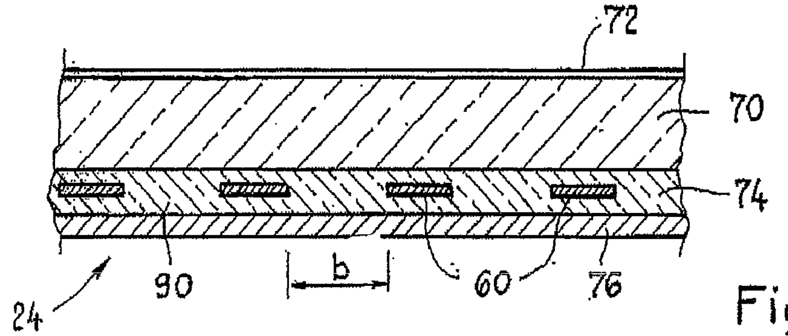


Fig.14

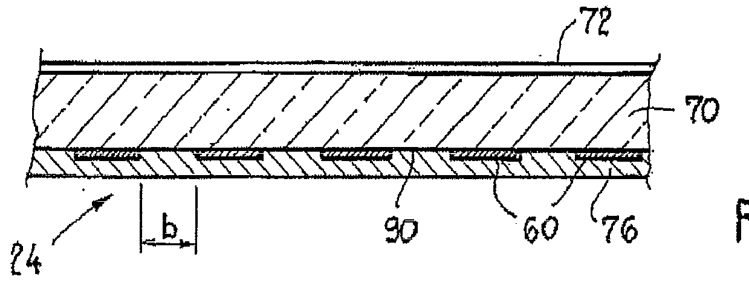


Fig. 15

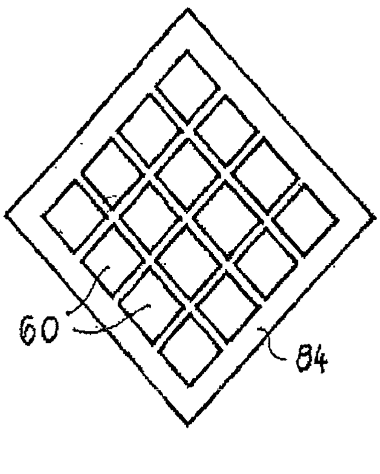


Fig.16

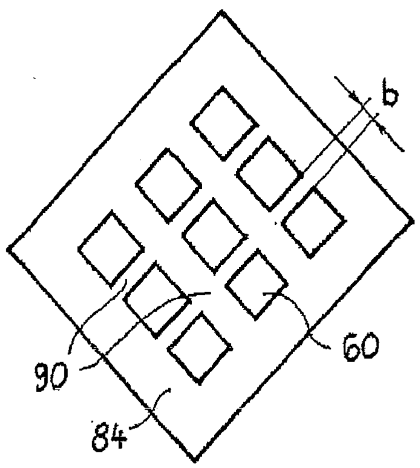


Fig.17

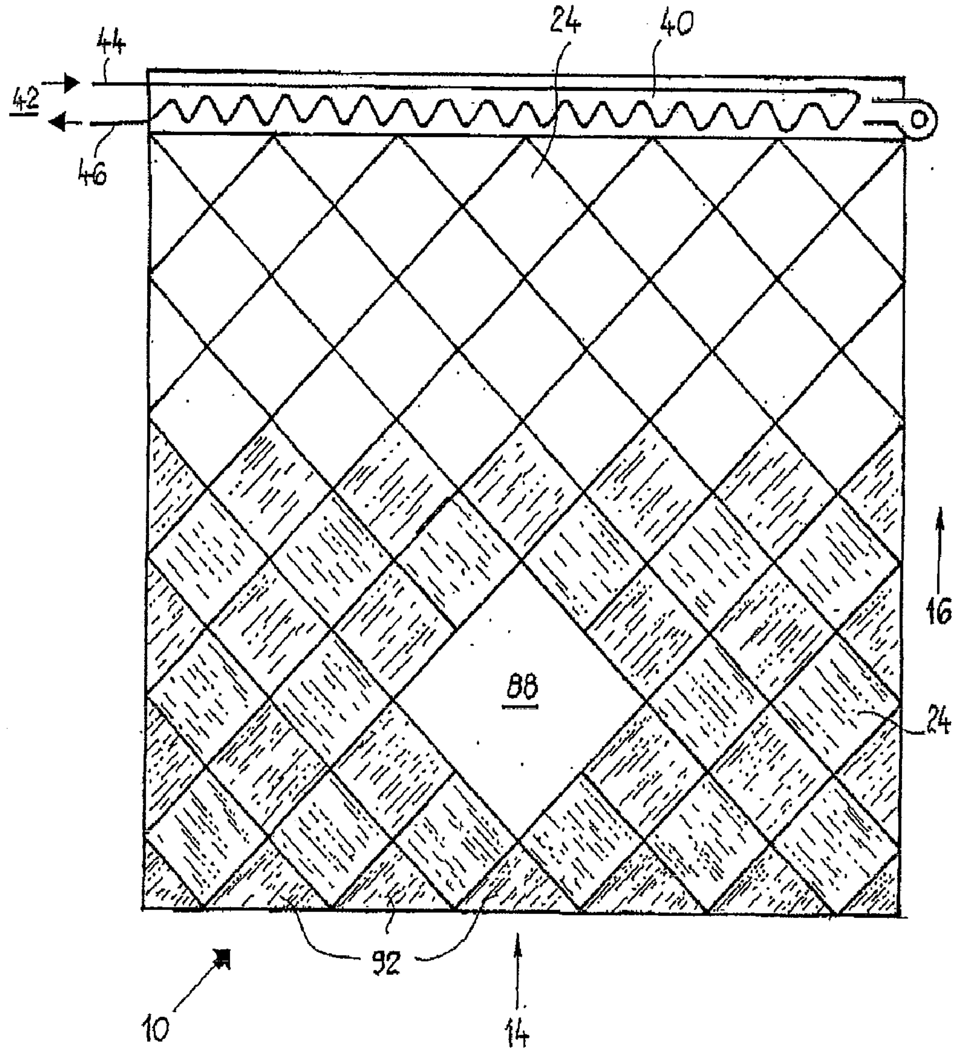


Fig. 18

ROOF STRUCTURE FOR A SOLAR SYSTEM

[0001] The invention relates to a roof structure for photovoltaic generation of electric current and/or for heating a flowing medium, in particular an airflow. The roof structure also serves as a whole for all the general functions of a roof.

[0002] The use of the daily incident solar radiation of roofs and facades of inhabited and uninhabited buildings for the purpose of obtaining energy in the form of electric current and heat has already acquired great significance.

[0003] Because of the finite nature of fossil energy sources and of uranium, the exploitation of inexhaustible energy sources such as those of the sun is of great importance for our future power supply.

[0004] The reduction of combustion and/or increased use of fossil energy sources is also necessary on ecological grounds.

[0005] Developments of recent years have shown that solar current and heat can be obtained on a large scale. Even today the annular production of solar cells for power generation is over 1400 MW, corresponding to an area of approximately 14 km^2. The present annual growth rate is approximately 40%. By 2004 nearly 6 million m^2 of collector area had been installed on roofs in Germany alone for the purpose of obtaining heat. This area is to be doubled by 2012.

[0006] While photovoltaic modules are now being mounted in larger numbers on roofs, it has become normal to cover roof segments with thermal collectors by laying water carrying absorbers. However, for reasons of cost and esthetics the technical development is leading increasingly to the integration of the solar systems in the roof skin, facades and skylights and shading devices. In addition, the photovoltaic modules and thermal collectors are also taking over the usual function of roofs and facades.

[0007] Increasing use is being made of large area photovoltaic roof elements as a "solar roof" for the roof structure. The German company SUNWORLD AG is marketing an appropriate solar roof. It is necessary to take specific, complicated measures for fastening, but above all for attaining waterproofness (side and transverse profiles, rubber seals etc.). Separately therefrom, thermal, mostly water carrying solar collectors are being installed on or in the roofs. Also known are so called air correctors that are used as roof structures chiefly for drying hay with the aid of the warm air generated. A very esthetic design of overlapping roofing shingles for photovoltaic current generation is known from U.S. Pat. No. 5,990,414 A.

[0008] The photovoltaic modules or roof elements themselves consist essentially of thin, fragile silicon solar cells of flat design in the form of strips or plates. For the purpose of protection against mechanical and chemical damage, the cells are embedded in an elastic transparent material, usually EVA (ethyl vinyl acetate) between the front, transparent front side of hardened glass or plastic, and a rear sheet or glass. The solar cells are interconnected electrically such that the module voltage generated can be tapped via an appliance outlet, mostly arranged at the rear. A multiplicity of such modules or roof elements are connected in series and in parallel, in order to obtain the respectively desired system voltage/DC power. The current is mostly fed into a public grid via an inverter, or buffered in batteries in the case of small island systems.

[0009] Thin layers are known that are made from amorphous silicon, CuIS2, or other semiconducting materials or chemical compounds that are likewise used to construct modules or roof and facade elements. These layers are applied to glass or transparent plastic, plastic sheets being used on the front and/or rear for protection against mechanical or chemical influences.

[0010] Solar systems, in which insulation is used for the purpose of heating flows of water or air carried in pipeline systems and current is simultaneously generated by means of photovoltaics are known, though scarcely used to date. The total cost of such roofs fitted with solar systems is very high, and casts doubt on an important advantage of multifunctionality. The functionality and heat yield are unsatisfactory, just as are the esthetic factors and suitability for construction of standard roofs. Again, the known systems are not suitable for the mass production that is required to lower the costs of power generation. They mostly also have complicated structures for integration in the roof. The roof elements that obtain power, which can replace conventional roof elements (tiles, shingles etc.) would need to be able to be designed and installed cost effectively. All the factors mentioned impair the cost effectiveness of obtaining power and heat in combination.

[0011] The object of the present invention is therefore to provide a roof structure of the type mentioned at the beginning that enables decisive cost reductions in conjunction with high operational reliability, and includes the advantages of multifunctional power generation without neglecting the esthetic requirements of the roofs built. Furthermore, it is the object of the invention also to provide cost effective solutions for the roof elements that obtain energy.

[0012] The object is achieved in accordance with the invention by virtue of the fact that glass roof panels that are transparent or equipped at least partially with solar cells of flat design and form an airtight flat gap which is largely free of obstructions in the flow direction laid and sealed at a spacing from a subroof. Specific and developing embodiments are the subject matter of dependent patent claims.

[0013] The flat gap preferably has at least one entrance opening for the cold air, at least one exit opening for the warm air and an airtight outer roof edge surround or airtight lateral boundaries of the flat gap.

[0014] Guided through the flat gap is an airflow that is cold when introduced and heated and outlet again into the atmosphere when used. In certain instances, it is also possible to install closed circuits that are operated with air or another gaseous medium.

[0015] The expression, generally used here, "glass roof panels", fully having the function of roof elements—for example for substitution of roof tiles, roof shingles etc.—also covers panels made from all other suitable transparent materials.

[0016] The spacing between the subroof of flat design (without the usual roof ribs) and the glass roof panels is preferably in the range of 15-30 mm. The spacing is determined on the basis of design parameters such as, for example, the desired temperature rise, height of the roof, expected thermal efficiency and the air speed determined.

[0017] According to one variant, the flat gap can widen upward. This is the case, in particular, when the glass roof panels, and thus the roof or the roof part itself narrow upward (pitched roof).

[0018] The glass roof panels of rectangular or square design fulfill the function of roofing materials, in particular of tiles.

[0019] In the case of glass roof panels of rectangular design, these are laid in an overlapping fashion and sealed with known means such that an airtight flat gap is ensured. Longitudinal profiles are constructed at the side and ensure tightness, maintenance of the spacing, and fastening. In the case of rectangular, nonoverlapping glass roof panels that abut one another, the sealing is with rubber profiles and longitudinal profiles that prescribe the abovementioned spacing of 15-30 mm and enable the panels to be fastened.

[0020] A particular refinement of the inventive roof structure comprises specially designed square glass roof panels that are laid with their diagonals in a vertical direction and in a fashion overlapping on both sides. Cost savings result, in particular, from the fact that rain water is certain to flow off without further measures, that is to say profiles and the like for the lateral sealing of the panels can be eliminated. This design is particularly suitable for mass production and is exceptionally cost effective to lay.

[0021] The square glass roof panels are esthetically attractive as roof elements and are used for covering the entire roof including possible adjacent roofs (also without power being obtained). In addition to functions that obtain current and heat, they are also configured according to the invention for the incidence of light (skylight function), including in combination with the power generation as translucent roof elements.

[0022] According to a further laying variant, the glass roof panels can, however, always be sealed, laid and supported on a plane or in the form of a shingle roof while being held with a frame. For its part, the frame comprises fastening feet that are not allowed to impede the throughflow of air.

[0023] Since the glass roof panels laid in accordance with the invention replace a conventional roof, these are always watertight in the case of storm gusts and fulfill the snow load regulations. It is also possible to walk on the glass roof panels.

[0024] According to the invention, these glass roof panels can be used as follows for the roof structure:

- [0025] as conventional glass roof panels—transparent or opaque—for covering roof parts without use for power. This holds, in particular, for the square roof panels that are esthetic and easy to install. The preferably doubly overlapping glass roof panels are fastened at the four corners on the subroof and simultaneously pressed onto one another in order to attain tightness.
- [0026] As thermal glass roof panels for thermal use by heating the airflow in the air gap thereunder. In this case, the glass roof panels are transparent for full solar radiation. The radiation is absorbed by a selectively coated absorber that serves for directly efficient heating of the air to high useful temperatures (up to 100° C.)
- [0027] As photovoltaic glass roof panels with and without simultaneous thermal use. If no heat is obtained with the aid of the airflow in the gap therebehind, this is suitable for performance enhancing cooling of the cells. The air is heated at the rear side of the glass roof panels, useful temperatures of up to approximately 55° C. being attainable.
- [0028] As transparent glass roof panels with a skylight function.
- [0029] As partially transparent glass roof panels for photovoltaic power generation (skylight shaded by the cells), subroof transparent, or only with the roof girders.
- [0030] As partially transparent glass roof panels for photovoltaic and thermal power use.

[0031] The roof structure can be installed in the form of roof sections with only a thermal function, only an electrical function, only a skylight function with an electrothermal function (air temperatures of up to 55° C.), and in the form of downstream, purely thermal glass roof panels for obtaining high temperatures at the output. The thermal roof panels therefore act as a "booster". Further combinations for the use of the glass roof panels are likewise possible in conjunction with the transparent or partially transparent properties.

[0032] Particularly with the preferred roof structure consisting of the square, esthetic glass roof panels, there is the possibility of building ultramodern multifunctional roofs in the case of which power is produced simultaneously and fossil fuels are replaced for obtaining heat. Given the installation of dozens of square kilometers, interesting prerequisites for large scale economic use of solar energy can be attained worldwide by the mass production of these roof elements in combination with thermal use. In Switzerland alone it is possible to switch fully to inexhaustible environmentally friendly energy sources if as little as 10% of the areas of roofs and facades of the presently existing total area of 700 km^2 is used. Currently, 12 km^2 of roofs are built or renovated annually in Switzerland. In Germany the abovementioned numbers are tenfold.

[0033] The embodiments of the various glass roof panels are described below with reference to the example of the square doubly overlapping glass roof panels.

[0034] Glass roof panel with simple roof function. This consists of a front hardened glass roof panel with a sheet, laminated on the rear, for coloring, as well as the fastening elements and pressure elements at the four corners. However, other materials can also be used for this function with the same geometric structure and fastening technique.

- [0035] If the glass remains transparent, the glass roof panel can be used with skylight function.
- [0036] Glass roof panel with purely thermal function. This consists of hardened glass with the same geometric structure and fastening technique.
- [0037] Glass roof panel with photovoltaic function. This consists of a photovoltaic cell laminate in accordance with the layer assembly (silicon cells or thin-layer cells) described at the beginning.
- [0038] Glass roof panel with photovoltaic function and passage of light, as well as the same geometric structure and fastening technique. These consist of a photovoltaic laminate in accordance with the layer assembly described at the beginning, the solar cells being interconnected electrically with the maintenance of a spacing between the cells for the purpose of transmitting light. The geometric structure and fastening technique once again remain the same.

[0039] Conventional thermal collectors for producing hot water and for assisting heating with necessary installation of metallic absorbers with the associated water carrying tubes, or even vacuum collectors for "gathering in" sunbeams over an entire area are more expensive by a multiple than the inventive absorbers of solar radiation over the same area with an airflow and downstream heat exchanger for transferring the heat to the fluid medium. In the case of the photovoltaic roof panels, the investments for the simultaneous heating of the airflow have, in addition, already been made, the costs for a conventional roof element having been deducted.

[0040] However, good heat transmission is a prerequisite for an effective transfer of heat from the photovoltaic roof panels to the air circulating therebehind. For the inventive roof structure, the gap width between panel and subroof is preferably, as mentioned, 15-30 mm, depending on the definition of the decisive design parameters.

[0041] In order to maintain the air temperature at the exit, the air speed or flow rate is preferably regulated with the aid of a ventilator that is controlled by a solar sensor or driven with solar cells.

[0042] According to one variant, for the purpose of further temperature increase, for example above the photovoltaic roof panels, it is expedient to dispense with the installation of solar cells and to arrange the transparent thermal glass roof panels. In this case, the radiation passes through the glass roof panel directly onto a selective absorber sheet thereunder past which the air flows and is heated. A selective absorber has the property that the solar radiation (shortwave) is virtually completely absorbed (black body), while the thermal emission of the hot absorber is avoided as far as possible. This is achieved by virtue of the fact that the absorber sheet has a low emission factor for the emission at longer wavelengths.

[0043] The selective sheet is, for example, a solid sheet of ceramic and metal termed CERMET. The coated absorber sheet is long lived and heat resistant. It can be touched, cleaned, shaped, welded and riveted. The absorption factor is 95%, the emission factor only 5%. These requirements are fulfilled, for example, by the product Sunselect from Interpane Solar GmbH & Co. in Germany.

[0044] If the selective absorber sheet is fastened on the subroof, the air flows between it and the transparent glass roof panel. The thermal efficiency, and thus the attainable air temperature are less than when the air flows through behind the selective absorber sheet. The absorber sheet is preferably fitted at a spacing of approximately 10 mm below the transparent glass roof panel.

[0045] In a preferred variant, the heated air flows in the gable region directly through an elongated air/water heat exchanger running along the gable. Air, for the most part cooled, is caught by collecting channels downstream of the exchanger and, for example, guided by means of a ventilator operated by solar cells directly into the ambient air or—if still being used for heating purposes—into the interiors. In certain applications, an airflow supported and regulated by a ventilator is not required, since the uplift resulting from the heating of the air is sufficient to guide the hot air through the heat exchanger arranged along the gable.

[0046] According to a further variant, the exiting hot air is guided via a pipeline system to an air manifold heat exchanger outside the roof region, where a water circuit is expediently heated, in turn. The residual heat can be used for further useful purposes before it is outlet into the atmosphere as expulsion air.

[0047] The advantages of the inventive roof structure are evident, reference has already been made above to the applications for using the heat and to the cost advantages, in particular there is no need for expensive pipeline systems to be laid in the entire roof region, and the continuously open flat gap requires far lower investment costs and makes no demand on maintenance.

[0048] The invention is explained in more detail with the aid of exemplary embodiments that are illustrated in the drawing and are also the subject matter of dependent patent claims. In the drawing,

[0049] FIG. **1** shows a vertical section through half a solar roof with overlapping glass roof panels,

[0050] FIG. **2** shows a variant in accordance with FIG. **1**, with glass roof panels laid in a flat fashion and a ventilator,

[0051] FIG. **3** shows a detail III of FIG. **2** with a standard type support,

[0052] FIG. **4** shows a roof gable with a heat exchanger,

[0053] FIG. **5** shows a variant in accordance with FIG. **4** with an air manifold heat exchanger,

[0054] FIG. **6** shows a view of a specimen roof with five laying variants R-V,

[0055] FIG. **7** shows a partial vertical section through the laying variant S,

[0056] FIG. **8** shows a partial vertical section through the laying variant V,

[0057] FIG. **9** shows a laying variant with square glass roof panels set on end,

[0058] FIG. **10** shows a laying variant of the glass roof panels in the form of a shingle roof,

[0059] FIG. **11** shows a flat laying of the glass roof panels in accordance with FIG. **2**,

[0060] FIG. **12** shows a laying variant of tapering glass roof panels for a pitched roof,

[0061] FIG. **13** shows a partial section through a glass roof panel,

[0062] FIG. **14** shows a variant in accordance with FIG. **13**,

[0063] FIG. **15** shows a further variant of a glass roof panel,

[0064] FIG. **16** shows a plan view of a roof glass panel with tightly arranged solar cells,

[0065] FIG. **17** shows a plan view of a translucent glass roof panel, and

[0066] FIG. **18** shows a view of a solar roof with glass roof panels set on end.

[0067] FIG. **1** shows a roof structure **10** for a solar system for the photovoltaic production of electric current and/or for heating a cold airflow **14**. The roof structure **10** is arranged removed in a parallel fashion by a spacing a from a subroof **14**. The spacing a is approximately 20 mm here.

[0068] The subroof **12** and the roof structure **10** form a flat gap **18** that is virtually free from obstructions in the flow direction **16** and in which the cold air **14** is continuously heated, exits as a hot airflow **20** into a gable space **22** and is fed from there directly to a further use.

[0069] It is of substantial importance that the flat gap **18** extends over the entire roof structure (saving of roof ribs), and that there are no substantial obstructions in the flow direction **16**. The flat gap **18** is sealed in the outermost region of the roof structure with the entire circumference or a part thereof. It is thus possible for a natural flow to build up in the direction **16** and heat the cold air **14**, which expands and rises in the flow direction **16** because of the lower density.

[0070] A filter **15** is also expediently arranged at the entrance opening for the cold air **14**. The hot airflow **20** exiting in the gable space **22** can be used directly for drying.

[0071] FIG. **2** differs from FIG. **1** particularly in that the glass roof panels **24** are not arranged in an overlapping fashion, but on a plane, again at the spacing a from the subroof **12**. The glass roof panels **24** are held by standard-type supports **26** of small flow cross section at the spacing a. The airflow in the direction **16** is assisted by at least one ventilator **28** in the gable space **22**. This ventilator **28** is connected to at least one exit opening of the hot airflow **20** via a suction tube **30**. A variant that is not illustrated serves for regulating the ventilator performance. The ventilator can also be driven directly by solar cells, as a result of which a sensor is eliminated. Both variants serve to maintain the temperature level under varying radiation conditions.

[0072] FIG. **3** illustrates in detail a standard-type support anchored in the subroof **12**. A screw **36** with a peripheral bearing flange **32** and a guide arbor **34** ensures the setting of a flat gap **18** in the abovementioned region of, expediently, approximately 15 mm. The mounted glass panels **24** are secured with a head screw. The laminate structure of the glass roof panels **24** is shown in FIGS. **13** to **15**.

[0073] The gable space **22** illustrated in FIG. **4** and that can also be configured as a manifold, includes a heat exchanger **40** that is connected upstream of the ventilator **28** (FIG. **2**), in the hot airflow **20**. The heat exchanger absorbs a substantial fraction of the heat content of the air and feeds the latter to a water circuit **42** in a way known per se. Said circuit comprises a supply lead **44** and a down lead **46**, for example in a hot water or heating circuit. Opening into the gable space **22**, which is sealed in an airtight fashion, is an exhaust-air line **50** through which the still hot air can be fed to a further use. According to one variant, the still hot air exits as expulsion air into the external atmosphere via an exit opening indicated by an arrow **52**. The airflow can be deflected or split up with a baffle **54**.

[0074] FIG. **5** shows the further course of the exhaust-air line **50**. After the baffle **54** is opened, the entire hot airflow **20** flows to an air manifold heat exchanger **56** where the heat content of the air is, once again, absorbed for the most part by a water circuit **42**. The hot airflow **20** exiting from the air manifold heat exchanger **56**, which has been cooled but is still hot, passes into the atmosphere as expulsion air **58**, or is fed to a further use **60**.

[0075] FIG. **6** shows a view of a virtual roof structure **10**. In other words, FIG. **6** corresponds not to a roof that is customary in practice, but to a specimen roof with as many variants as possible. Each of the variants R, S, T, U and V would correspond in practice to a roof or a roof segment.

[0076] Variant R. Here, the glass roof panels **24** are arranged with a photovoltaic function over the entire roof height. The heating of the air in the rear gap is performed by the heat transfer of the glass roof panels **24**, which have a temperature of up to 70° C. when the sun is shining. The useful heat thereby obtained comes in at a temperature level of 45-60° C.

[0077] Variant S. Here, the roof consists in the lower part of glass roof panels **24** with a photovoltaic function. In the upper part, the air flows under glass roof panels **24** with a purely thermal function. The solar radiation strikes selective absorber sheets such that the airflow is further heated depending on whether it is guided past the front or rear side of the selective sheet up to a temperature of 60-80° C.

[0078] Variant T. In the case of this roof structure, glass roof panels **24** with a purely thermal function are used over the entire roof height such that high temperatures of up to 100° C. are attained.

[0079] Variant U. Here, use is made of glass roof panels **24** with a photovoltaic function and translucent properties. Sunlight enters between the solar cells **60**, which are electrically connected at a certain spacing. In this roof area, electric current is generated and the translucent glass roof panels **24** also take over the function of shaded sky lights. If the selective sheet is used in the air gap, the skylight function is dropped in favor of the generation of heat. The temperature level attained in this case for the useful heat is somewhat higher, owing to the additional incidence of light, than for the glass roof panels **24** with only power generation.

[0080] Variant V. Here, glass roof panels **24** with a purely thermal function are used in the upper roof region for the production of heat.

[0081] Of course, yet further variants are possible, and individual variants can be combined with one another.

[0082] In particular, glass roof panels **24** with a skylight function (roof window) can be installed, or the glass roof panels **24** can be coated black without solar cells being installed.

[0083] FIG. **7** shows a partial longitudinal section through variant S in accordance with FIG. **6**. Glass roof panels **24** in the lower region contain solar cells **60** that abut one another on all sides, and the sunlight S_1 is completely absorbed thereby. The uppermost two glass roof panels **24** contain no solar cells **60**, and the sunlight S_2 can pass through completely and is completely absorbed by a black absorber layer **64** applied to the subroof **12**, and this leads to intense heating of the air **20** flowing through. The absorber layer **64** is applied only in the region of the completely transparent glass roof panels **24**.

[0084] In the embodiment in accordance with FIG. **8**, the solar cells **60** are applied with an all-round spacing b corresponding to the variant V of FIG. **7**. Respectively approximately half the sunlight strikes the solar cells (S_1), or the other half of the sunlight passes through the glass roof panels **24** and strikes the selective absorber layer **64** (S_2), which covers the entire subroof **12**. By comparison with FIG. **7**, the photovoltaic generation of electric current is reduced while the heating of the airflow **20** is increased, by contrast.

[0085] Evidently, in accordance with FIG. **8**, and to a lesser extent in accordance with FIG. **7**, the flat gap **18** is increased in the flow direction **16**, and this even further improves the effect of the two completely transparent glass roof panels **24**.

[0086] FIG. **9** indicates the preferred laying variant of square glass roof panels **24**. The glass roof panels **24** are set on end, the diagonals running in the fall line of the roof. The glass roof panels **24** are arranged in a fashion doubly overlapping downward, and they are held by standard-type supports **26**.

[0087] According to FIG. **10**, the glass roof panels **24** are laid conventionally, that is to say in the form of a shingle roof overlapping downward on one side. Sealing and collecting channels **66** are laid on both sides and run in a vertical direction, that is to say in the flow direction **16** of the air guided through. Below the glass roof panels **24**, the sealing and collecting tracks **66** both provide support and keep the spacing, and have longitudinal openings (not depicted) for the passage of the air and the cabling. However, it is not these openings that are important, but the fact that the tracks **66** run in the direction of the airflow **16** and are therefore virtually no obstruction.

[0088] In accordance with FIG. **11**, square or rectangular glass roof panels **24** are held like a window in frames **68** which both provide a seal and support at a spacing a (FIG. **1**).

[0089] A variant in accordance with FIG. **10** is illustrated in FIG. **12**. The glass roof panels **24** taper rearward, and this is required in particular for a pitched roof.

[0090] Embodiments in accordance with FIGS. **13** to **15** show a laminate structure of the glass roof panels **24**. Common to all the embodiments is a panel **70** made from hardened glass. It is generally possible to walk on this. An antireflection layer **72** that prevents undesired mirror effects is optional. Visible on the other side of the plate **70** made from hardened glass is a cell embedding made from ethyl vinyl acetate EVA for the solar cells **60** of flat design. As in FIG. **13**, these solar cells **60** are arranged in an abutting fashion, and they pass no sunlight. The EVA layer **74** is protected by a rear wall sheet **76**, for example made from a Tedlar sheet or an aluminum sheet.

[0091] Arranged on the rear wall sheet **76** is a flat box **78** for cable outlets and a bridging diode **60**. The current conduction takes place in a way known per se, although it is ensured that the cable **82** is flat and therefore poses little obstruction to the airflow.

[0092] The laminate structure of the glass roof panel **24** in accordance with FIG. **14** corresponds substantially to that of FIG. **13**. The flat solar cells **60** are, however, embedded in a transparent EVA layer **74** at a spacing b from one another, the width b of the transparent strips **90** being greater than the corresponding linear dimension of the solar cells **60**. The rear sheet or panel **76** must likewise be of transparent design. A translucent glass roof panel **24** in accordance with FIG. **14** has transparent and opaque regions by definition.

[0093] FIG. **15** shows a further variant of a laminar glass roof panel **24** in accordance with which the solar cells are deposited directly onto the underside of the panel **70** made from hardened glass at a spacing b from one another (thin-layer cell technology). Also in accordance with FIG. **15**, what is involved is a translucent glass roof panel **24**, but with a smaller area fraction of the transparent strips **90** than in FIG. **14**. Depending on the process, the thin layer that is applied to glass or transparent plastics lies between two glass or plastic panels.

[0094] FIG. **16** shows in plan view a glass roof panel **24** corresponding to FIG. **13**. Solar cells **60**, which are of substantially square design, are laid in a fashion abutting one another and leave no gap open for the sunlight S_2 to slip through (FIG. **8**). The edge zones **84** serve for the formation of overlaps. The laid glass roof panels **24** form a roof structure **10** that is opaque to the sun's rays raised (FIG. **6**, variant R).

[0095] FIG. **17** shows a translucent glass roof panel **24** with solar cells **60** arranged at a spacing b in accordance with FIG. **15**. The laid glass roof panels **24** also have substantial transparent strips **90**.

[0096] FIG. **18** shows a roof structure **10** for a solar system for the photovoltaic generation of electric current and for strong heating of air in the flow direction **16**. Use is made in principle of the laying pattern S of FIG. **6**, but with glass roof panels **24**, standing on end, of square shape with diagonals in the direction of fall. In the lower region, glass roof panels **24** are arranged with square solar cells **60**, in an abutting arrangement, in an overlapping fashion on two sides and sealed. Also inserted in this region is a transparent or (not illustrated) translucent glass roof panel **24** that takes over the function of a roof window **88**, and this is sensible chiefly when the roof consists only of opaque glass roof panels **24**.

[0097] Purely thermal glass roof panels **24** without solar cells are arranged in the uppermost, so called "booster region". Here, the already preheated air is heated to a temperature of about 100° C. The air passes directly into a heat exchanger **40** with a water circuit **42** for the production of hot water. As already indicated in FIG. **4**, this heat exchanger **40** is arranged in the gable region.

[0098] Arranged in the lowermost roof region are so called "dummies" **90**, black coated glass roof panels **24** without a photovoltaic effect, in the case of which "solar cells" are printed on by screen printing.

List of reference numerals
Case: FID-A6/01-CH

No.	Designation
10	Roof structure
12	Subroof
14	Cold airflow
15	Filter
16	Flow direction
18	Flat gap
20	Warm airflow
22	Gable space
24	Glass roof panels
26	Standard-type supports
28	Ventilator
30	Suction tube
32	Bearing flange
34	Guide arbor
36	Screw
38	Head screw
40	Heat exchanger
42	Water circuit
44	Supply lead
46	Down lead
48	Baffle
50	Exhaust-air line
52	Arrow
54	Baffle
56	Air manifold heat exchanger
58	Expulsion air
60	Solar cells
62	Transparent strips
64	Absorber layer
66	Sealing and collecting channel
68	Frame
70	Hardened front glass
72	Antireflection layer
74	EVA embedding
76	Rear wall sheet
78	Flat box
80	Bridging diode
82	Flat cables
84	Edge zones
86	Roof window
88	Dummies
90	Transparent strips
92	
94	
96	
98	
100	
102	
104	
106	
108	
110	
112	
114	
116	
118	
120	
122	
124	
126	
128	
130	

-continued

List of reference numerals
Case: FID-A6/01-CH

No.	
132	
134	
136	
	Special numerals
a	Wide flat gap 18
S_1	Sunlight on 60
S_2	Sunlight on 64
b	Spacing between 60, wider 90

1. A roof structure (**10**) for photovoltaic generation of electric current and/or for heating a flowing medium, in particular an airflow (**14**, **20**),

characterized in that

glass roof panels (**24**) that are transparent or equipped at least partially with solar cells (**60**) of flat design and form an airtight flat gap (**18**) which is largely free of obstructions in the flow direction (**16**) are laid and sealed at a spacing (a) from a subroof (**12**).

2. The roof structure (**10**) as claimed in claim **1**, characterized in that the solar cells (**60**) consist of a photosensitive semiconductor material that converts photons into electric voltage, in particular of high purity amorphous silicon.

3. The roof structure (**10**) as claimed in claim **1**, characterized in that at least a portion of the laid glass roof panels (**24**) is constructed as a laminate that comprises a hardened front glass (**70**) also having an antireflection layer (**72**), thereunder a layer of a plastic embedding compound (**74**) with the solar cells (**60**), accessible uncovered for the sunlight (S_1), and a rear wall sheet (**76**) protecting the glass roof panels (**24**) from below.

4. The roof structure (**10**) as claimed in claim **1**, characterized in that the glass roof panels (**24**) are constructed at least partially as a laminate that comprises a hardened front glass (**70**), also with an antireflection layer (**72**), thereunder a layer of a transparent plastic embedding compound (**74**) with the solar cells (**60**), and a transparent protective panel or protective sheet (**76**) protecting the translucent glass roof panels (**24**) from below.

5. The roof structure (**10**) as claimed in claim **1**, characterized in that the glass roof panels (**24**) are constructed at least partially as a laminate that comprises a hardened front panel (**70**), also with an antireflection layer (**72**), thereunder thin-layer solar cells (**60**), deposited directly onto the glass roof panel (**24**) with a chemical or physical deposition method, and a rear wall sheet (**76**) protecting the glass roof panels (**24**) from below, or a corresponding transparent protective layer or sheet for translucent glass roof panels (**24**).

6. The roof structure (**10**) as claimed in claim **3**, characterized in that the glass roof panels (**24**) have a grid of flat solar cells (**60**) that are arranged abutting or have an all round spacing (b) in the case of translucent glass roof panels (**24**), preferably up to the largest linear dimension of the solar cell.

7. The roof structure (**10**) as claimed in claim **3**, characterized in that the embedding (**74**) of the solar cells (**60**) consists of plastic, preferably also of transparent ethyl vinyl acetate (EVA).

8. A solar roof (**10**) as claimed in claim **1**, characterized in that the flat gap (**18**) has at least one entrance opening for the cold airflow (**14**), at least one exit opening for the warm airflow (**20**), and an airtight outer roof edge surround.

9. The roof structure (**10**) as claimed in claim **1**, characterized in that the spacing (a) between the subroof (**12**) and the glass roof panels (**24**) is in the range of 10-30 mm, preferably approximately 20 mm.

10. The roof structure (**10**) as claimed in claim **1**, characterized in that the subroof (**12**) and the glass roof panels (**24**) run parallel or, particularly given glass roof panels (**24**) narrowering in the flow direction (**16**) of the air, form a widening flat gap (**18**) in this direction.

11. The roof structure (**10**) as claimed in claim **1**, characterized in that the square or rectangular glass roof panels (**24**) are laid in overlapping sealed fashion and preferably with a diagonal approximately in the flow direction (**16**) of the air.

12. The roof structure (**10**) as claimed in claim **1**, characterized in that the glass roof panels (**24**) are supported in the corner region or with sealing and collecting tracks (**66**) running in the flow direction (**16**) of the air.

13. The roof structure (**10**) as claimed in claim **12**, characterized in that the tracks (**66**) have through openings for the airflow (**14**, **20**) and the electrical cabling, which is preferably of flat design.

14. The roof structure (**10**) as claimed in claim **1**, characterized in that the individual glass roof panels (**24**) are sealed with a frame (**68**) and are laid and supported on a plane or in the form of a shingle roof.

15. The roof structure (**10**) as claimed in claim **1**, characterized in that the subroof (**12**) is covered with a black, preferably selective absorber layer (**64**) for sunlight (S_2), in particular in the region of transparent and translucent glass roof panels (**24**).

16. The roof structure (**10**) as claimed in claim **1**, characterized in that, in the case of sloping roofs, glass roof panels (**24**) covered completely or to a high degree by solar cells (**60**) are arranged in the lower region, while glass roof panels (**24**) with a low degree of cover or complete transparency are arranged in the upper region.

17. The roof structure (**10**) as claimed in claim **1**, characterized in that a pipeline system (**30**) for transporting the warm airflow (**20**) away is connected to the exit openings.

18. The roof structure (**10**) as claimed in claim **1**, characterized in that a ventilator (**28**) which is preferably sensor controlled in accordance with the intensity of the sunlight (S_1, S_2) is arranged, particularly in the region of the exit openings for the warm air (**20**) from the flat gap (**18**), for the purpose of regulating and supporting the natural airflow (**14**, **20**).

19. The roof structure (**10**) as claimed in claim **17**, characterized in that a heat exchanger (**40**), preferably an air/water one, with a water circuit (**42**) is installed next to the exit openings for the warm air (**20**).

20. The roof structure (**10**) as claimed in claim **1**, characterized in that a closed circuit with a ventilator (**28**) and a heat exchanger (**40**) is constructed for the airflow (**14**, **20**) through the flat gap (**18**).

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