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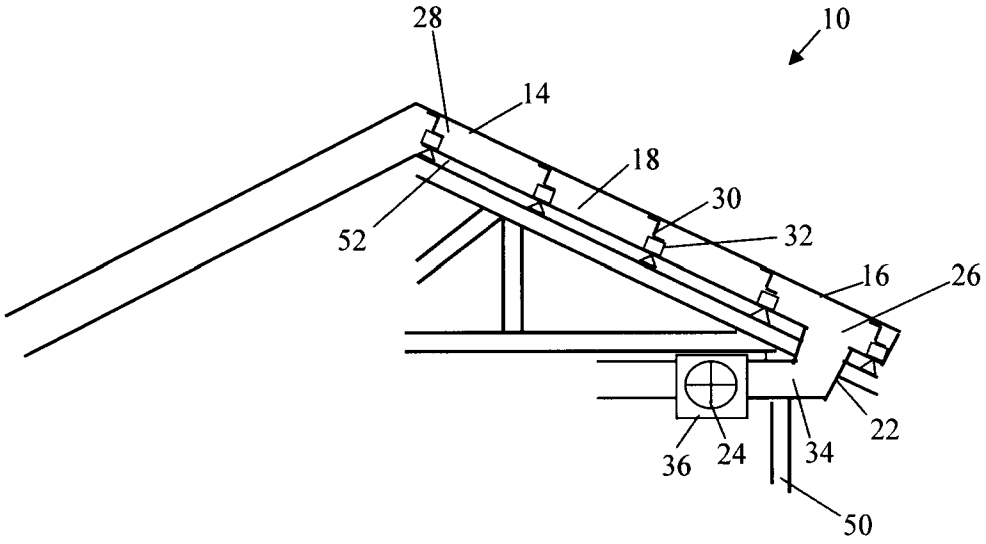
(54) **Title:** METHOD AND APPARATUS FOR COOLING VENTILATION AIR FOR A BUILDING



(57) **Abstract:** An apparatus for cooling ventilation air for a building, includes a radiating panel having an emissive surface for use on the building such that the emissive surface of the panel is directed skyward and exposed to ambient air. The radiating panel defines an air collection space between itself and the building and has a plurality of air openings for the ambient air to pass through the openings to the air collection space. A passageway extends between the air collection space and an interior of the building and is located for passage of cooled ambient air from the air collection space into the interior of the building. A fan is located for moving the cooled ambient air from the air collection space through the passageway to the interior of the building.

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METHOD AND APPARATUS FOR COOLING VENTILATION AIR FOR A BUILDING

FIELD OF THE INVENTION

[0001] The present invention relates to the provision of ventilation air for buildings and to cooling of the ventilation air prior to introduction into a building.

BACKGROUND OF THE INVENTION

[0002] Commercial, industrial, domestic and apartment buildings require ventilation. It is common for natural leakage around doors, wall-ceiling joints, etc. found in standard building construction to allow sufficient air to enter the building. A pressure drop from the exterior to the interior of the building can arise from many factors, such as high winds, exhaust fans and combustion air for fuel-burning furnaces. This tends to draw outside air into the building through cracks or openings.

[0003] The conventional approach to providing ventilation by simply allowing air flow through leaks around doors and joints suffers from the disadvantages that the amount and the temperature of ventilation air is not controlled. This lack of control of ventilation air is typically made up for by providing additional heat during the heating season or by providing additional cooling by way of air conditioning and fans during the warm season or in hot climates.

[0004] United States Patent Nos. 4,899,728 and 4,934,338 issued February 13, 1990 and June 19, 1990, respectively, disclose the use of a solar panel to heat fresh make-up (ventilation) air prior to introduction into a building. These systems are efficient for heating large volumes of air per surface area of solar panel. The systems described in these patents, however, address only heating of ventilation air and fail to address cooling which is desirable during the warm season or in hot climates.

SUMMARY OF THE INVENTION

[0005] According to one aspect of an embodiment, there is provided an apparatus for cooling ventilation air for a building, includes a radiating panel having an emissive surface for use on the building such that the emissive surface of the panel is directed skyward and exposed

to ambient air. The radiating panel defines an air collection space between itself and the building and has a plurality of air openings for the ambient air to pass through the openings to the air collection space. A passageway extends between the air collection space and an interior of the building and is located for passage of cooled ambient air from the air collection space into the interior of the building. A fan is located for moving the cooled ambient air from the air collection space through the passageway to the interior of the building.

[0006] According to another aspect of an embodiment, there is provided a method of cooling ventilation air for a building. The method includes providing on a surface of a building, a radiating panel having an emissive surface such that the emissive surface of the panel is directed skyward and exposed to ambient air. The panel defines an air collection space between itself and the building and includes a plurality of air openings for the ambient air to pass through the openings to the air collection space. The method further includes drawing the ambient air through the air openings and into the air collection space, cooling the ambient air by transferring heat to the panel and radiating heat from the panel to the sky, to provide cooled ventilation air and withdrawing the cooled ventilation air through an air inlet and pushing the cooled ventilation air into the building.

[0007] Advantageously, air that is drawn into the air collection space between the panel and the building, is cooled by heat transfer to the panel and radiation of heat from the panel to the sky. Thus, the ventilation air provided to the building is cooled compared to ambient air temperature. In one embodiment, horizontal Z-bars are used to support the panel on a sloped roof. Some condensation that forms on the backside of the panel runs downwardly to a Z-bar and then drops off and to the roof of the building where the water runs off. Advantageously, less water remains on the backside of the panel, leaving less water to cool down, allowing for cooling of the air.

[0008] In another embodiment, a heating passage is located for passage of heated ambient air from the collection space into the interior of the building. Thus, ambient air heated by solar radiation is directed into the building during the heating months while cooled air is directed into the building during the cooling months.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The present invention will be better understood with reference to the following

drawings and to the description, in which:

[0010] Figure 1 is a perspective view of a portion of an apparatus for cooling ventilation air for a building according to one embodiment of the present invention;

[0011] Figure 2 is a sectional view of the apparatus of Figure 1;

[0012] Figure 3 is a sectional view of an apparatus for cooling ventilation air for a building according to another embodiment of the present invention;

[0013] Figure 4 is a sectional view of an apparatus for cooling ventilation air for a building according to still another embodiment of the present invention;

[0014] Figure 5 is a perspective view of an apparatus for cooling ventilation air for a building according to yet another embodiment of the present invention;

[0015] Figure 6 is a sectional side view of an apparatus for cooling ventilation air for a building according to another embodiment of the present invention;

[0016] Figure 7 is a partial sectional side view of the apparatus of Figure 6, drawn to a larger scale; and

[0017] Figure 8 is a partial top view of the apparatus of Figure 6, drawn to a larger scale.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0018] The Stefan-Boltzmann Law of Radiation provides a calculation of heat loss from a warm surface to a colder surface. Roofs of buildings exposed to the clear night sky experience a temperature drop below that of ambient air temperature due to radiation heat loss from the roof to the cool night sky. The cooling rate in a clear, dry climate is approximately 75 W/m^2 of roof. The cooling rate reduces with higher humidity and cloud cover. The night cooling effect begins when the heat loss exceeds the solar heat gain, typically beginning prior to dusk and lasting until after dawn. Thus, approximately 10 to 12 hours of potential cooling to the night sky, exists each day.

[0019] Reference is made to Figures 1 and 2 to describe an apparatus for cooling ventilation air for a building. The apparatus is indicated generally by the numeral 10 and the building is indicated generally by the numeral 50. The apparatus 10 includes a radiating panel 14 having an emissive surface 16 for use on the building 50 such that the emissive surface 16

of the panel 14 is directed skyward and exposed to ambient air. The radiating panel 14 defines an air collection space 18 between itself and the building 50 and has a plurality of air inlet openings 20 for the ambient air to pass through the openings 20 to the air collection space 18. A passageway 22 extends between the air collection space 18 and an interior of the building 50 and is located for passage of cooled ambient air from the air collection space 18 into the interior of the building 50. A fan 24 is located for moving the cooled ambient air from the air collection space 18 through the passageway 22 to the interior of the building 50.

[0020] One embodiment of the apparatus 10 for cooling ventilation air for a building 50 will now be further described with continued reference to Figures 1 and 2. The apparatus 10 is shown fixed to a roof 52 of the building 50. As shown, the radiating panel 14, referred to herein as the panel 14, is a corrugated metal panel with a highly emissive or radiating surface 16 and an opposing surface 17 with low absorption and emissivity. Thus, one surface has a higher emissivity rate than the other surface. The panel 14 is fixed to the outer surface of the roof 52 with the highly emissive surface 16 facing skyward and the less emissive surface 17 (also referred to herein as the downward facing surface 17) facing the roof 52 of the building 50. The roof 52 in the present embodiment is angled downwardly from an apex near the center of the roof 52 toward the outer edge and portions of the corrugated panel 14 extend generally parallel with the roof 52. Thus, the panel 14 includes a lower portion 26 proximal the outer edge of the roof 52 and an upper portion 28 proximal the apex of the roof 52. In the present embodiment, the panel 14 covers the majority of the roof 50 to provide shade to the roof 50.

[0021] The panel 14 is fixed to the outer surface of the roof 52 by intermediary Z-section bars 30 mounted on hat clips 32. Referring to Figure 2, the hat clips 32 are secured to the outer surface of the roof 52 using suitable fasteners. The clips 32 are located in horizontal rows and are spaced apart so as to permit air flow between the clips. The Z-section of each of the bars 30 is shown in Figure 2. As shown, these bars 30 are fixed to the clips 32 and to the panel 14 such that the central web portion of the Z-section bars further spaces the panel 14 from the roof 52. Thus, one edge of the Z-section bar is seated against the spaced apart clips 32, while the other edge of the bar is seated against the panel 14.

[0022] As indicated above, the panel 14 includes the air inlet openings 20 distributed throughout the surface of the panel 14. The air inlet openings 20 provide a travel path for ambient air to enter the air collection space 18 from the exterior. In the present embodiment, the air inlet openings 20 are distributed generally uniformly over the surface of the panel 14 with

the exception of the immediate surrounding area where the passageway 22 meets the air collection space 18. The air inlet openings are formed by rotary punching slits in the panel 14 such that gaps at the end of the slits provide the air inlet openings 20. The air inlet openings 20 are small to aid in filtering air prior to entry into the apparatus for cooling ventilation air.

[0023] The perimeter of the panel 14 is closed off by a metal frame 33 that surrounds the panel 14. The metal frame 33 is sealed to the roof 52 around the sides and the top of the panel 14, using, for example, silicon caulking. The bottom of the metal frame is not sealed so as to allow rain or moisture to run off of the roof 52.

[0024] An air duct 34 is in communication with the air collection space 18, extending from a lower portion of the air collection space 18 (at a lower portion of the sloped roof 52), passing through an exterior wall of the building 50, and providing the passageway 22 for cooled ambient air from the air collection space 18 to enter the interior of the building 50. The air duct 34 extends into the building 50 to provide cooled outside air to the interior of the building 50, through openings in the air duct 34.

[0025] A fan housing 36 is connected along the air duct 34 and includes the fan 24 for moving air from the air collection space 18 into the interior of the building. In the present embodiment, the fan housing 36 is located on the roof 52, exterior to the building 50. Motorized dampers in the fan housing 36 are adjustable to allow air from the interior of the building to be mixed with cooled air from the air collection space 18. The fan 24 is typically sized to meet ventilation requirements and to inhibit negative air pressure within the building. A positive air pressure can be achieved by introducing the cooled air into the building through the air duct 34. Interior air leaves the building through openings and cracks. In the present embodiment, the fan 24 is a variable speed fan that is controlled by a controller dependent on the temperature of the incoming air. Thus, when the incoming air is above room temperature, the fan 24 runs at low speed. When the temperature of the incoming air is below room temperature, the fan speed increases to provide both ventilation air and cooling.

[0026] In use, the apparatus 10 for cooling ventilation air is located on the roof 52 of the building 50. Ambient air enters the air collection space 18 through the air inlet openings 20 in the panel 14, where the air is cooled. As the air in the air collection space 18 cools, warm air in the air collection space 18 rises while the cool air in the air collection 18 space falls. Thus, the coolest air in the air collection space 18 naturally falls toward the lower portion of the air collection space 18, where the air is withdrawn from the air collection space 18 by the fan 24,

through the passageway 22 provided by the air duct 34 and into the building 50, thereby providing cooled ventilation air to the building 50.

[0027] As cooling of the air occurs in the air collection space 18, any water droplets that form on the downward facing surface of the panel 14, pulled downwardly by the force of gravity and thus travel down the slope of the panel 14. Travel of the water is interrupted by the Z-section bars 30 extending generally horizontally and fixed to the downward facing surface 17 of the panel 14. When the water meets the Z-section bar, the water drops off the panel 14 and down to the roof 52 of the building 50, where the water can then run off. Thus, some of the water that condenses on the downward facing surface 17 of the panel 14 runs off leaving less water to cool down. Further, during the daytime, the sun aids in drying the air collection space.

[0028] Reference is now made to Figure 3 to describe another embodiment. The present embodiment is similar to the first described embodiment and therefore is not described again in detail. Unlike the first embodiment, however, a cooling unit 38 in the form of an air conditioner is provided and the fan 24 is located within the cooling unit. Cooled air that is withdrawn from the air collection space 18 and into the air duct 34 is passed to the cooling unit for further cooling before being introduced to mix with air in the interior of the building, thereby providing further cooling. The cooling unit 38 also includes a dehumidifier for removing some of the moisture from the air entering the building. The dehumidifier is useful in humid climates.

[0029] Reference is now made to Figure 4 to describe yet another embodiment. Again the present embodiment includes many similar features to the first described embodiment and therefore further description of these features is not necessary. In the present embodiment, the emissive surface 16 of the panel 14 is coated with a medium colored paint (between dark and white) to provide a heat absorbent surface. The panel 14 therefore acts as to heat the air in the air collection space 18 during the daylight hours.

[0030] A second air duct 40 is in communication with the air collection space 18, extending from an upper portion of the air collection space 18 (at an upper portion of the sloped roof 52), to the fan 24, and providing a second passageway, this second passageway for heated ambient air from the air collection space 18 to enter the interior of the building 50. The first and second air ducts 34, 40 include dampers to direct air flow to the fan and into the building 50. Thus, air is selectively drawn from the air collection space 18 depending on time of day or heating or cooling needs.

[0031] In use, the apparatus 10 of the present embodiment is used for cooling ventilation air during the cooling (or summer) months. The apparatus 10 of the present embodiment, however, is also used during the heating (or winter) months for heating ventilation. The air in the air collection space 18 is heated by a combination of solar heat transmitted by conduction through the panel 14 and by heat escaping from the inside of the building 50, through the roof 52. As indicated above, warm air in the air collection space 18 rises while the cool air in the air collection 18 space falls. Thus, the second air duct 40 is located to remove air from the upper portion of the air collection space. The heated air is then withdrawn from the air collection space 18 through the second air duct 40 by the fan 24 and is introduced into the building 50. The use of the coating of heat absorbent paint permits daytime heating while still permitting night time cooling when the sun is not up.

[0032] The present invention has been described by way of examples. Modifications and variations to the above-described embodiments are possible. For example, while the first described embodiment refers to a uniform distribution of air inlet openings, air flow openings can be unevenly distributed, for example, by having fewer air flow openings at the lower portion of the panel, close to where the air duct 34 opens into the air collection space. Further, the density of air inlet openings can increase with distance from the air duct 34. Also, the size of the air inlet openings can increase with distance from the air duct 34. While the air duct 34 for providing cooled air to the building, is described as entering through a side wall of the building, it is also contemplated that this air duct can enter through the roof of the building.

[0033] While the apparatus for cooling ventilation air for a building has been shown and described on a sloped roof. The apparatus can also be used on a flat roof, as shown for example in Figure 5 which shows radiating panels 14 with several air openings 20 to permit air flow into the air collection space defined by the radiating panel on the roof 52 of the building 50. In the present embodiment, the radiating panels 14 are sloped in relation to the roof 52 such that the air is drawn off into the passageway 22 at a lower level of the air collection space. Since hot air rises, hot air moves toward the uppermost part of the radiating panels 14 or out the openings 20. The cooler air falls toward the passageway 22 where it is drawn off when in use. As shown, there are no air openings at the point where the air duct 34 meets the air collection space. Also, in the present embodiment, the fan housing 36 (which includes the fan) is located on the roof 52.

[0034] Other alternatives are also possible. For example, the air inlet openings can be

formed in any suitable manner. The openings can be in the form of slits as described, or holes or gaps between adjacent and overlapping roof tiles. Referring to Figures 6 to 8, a radiating panel 14 that is made up of overlapping roof tiles 46 is shown. In this embodiment, ventilation air passes through a gap under each tile, around the tile and then down between vertical supports 47 to which horizontal supports 48 are fixed. The horizontal supports 48 are fixed to the roof 52 of the building 50. It is also contemplated that the overlapping tiles that are used are photovoltaic panels for producing electricity during the day time.

[0035] It will also be appreciated that the heated air in the third-described embodiment can be further heated prior to mixing with air inside the building 50. It will also be appreciated that rather than using a single fan in the third described embodiment in which heating of ventilation air is provided, a second fan housing and second fan can be used for drawing air in. Also, the use of the hat clips and Z bars is described herein for exemplary purposes only. Other attachment means are contemplated. For example, on some roofs, vertical Z bars can be used rather than clips, for example, if a certain distance of the roof is to be spanned or if roof supports are not in line with a clip mounting position. The vertical bars are positioned to allow air to move horizontally towards the passageway. The vertical bar under the horizontal bar stops short of the lower roof line to allow air to move horizontally towards the fan inlet.

[0036] It will be appreciated that the size of the radiating surface of the panel and the flow rate controlled by the fan are related. For example, the flow rate can be determined based on the size of the radiating surface of the panel and the maximum cooling rate for air passing through the openings. Alternatively, the size of the panel can be determined based on the flow rate and the maximum cooling rate for air passing through the openings.

[0037] Still other modifications and variations to the embodiments described herein may occur to those skilled in the art. All such modifications and variations are believed to be within the sphere and scope of the present invention.

CLAIMS

What is claimed is:

1. An apparatus for cooling ventilation air for a building, comprising:

a radiating panel having an emissive surface for use on said building such that said emissive surface of said panel is directed skyward and exposed to ambient air, and said panel defines an air collection space between itself and said building, the panel having a plurality of air openings for the ambient air to pass through the openings to the air collection space;

a passageway between said air collection space and an interior of said building and located for passage of cooled ambient air from said air collection space into said interior of said building; and

a fan located for moving said cooled ambient air from said air collection space through said passageway to said interior of said building.

2. The apparatus according to claim 1, wherein said panel includes a low absorption rate back surface, opposite said emissive surface for inhibiting heat gain from a roof of said building.

3. The apparatus according to claim 1, wherein the emissivity rate of a back surface of said panel is lower than the emissivity rate of said emissive surface.

4. The apparatus according to claim 1, wherein said radiating panel comprises a corrugated panel.

5. The apparatus according to claim 1, wherein said radiating panel is located to cover a roof of said building thereby providing shade for said roof, and said air collection space is disposed between said radiating panel and said roof.

6. The apparatus according to claim 1, wherein said radiating panel is fixed to said building by intermediary, generally horizontal bars.

7. The apparatus according to claim 6, wherein said generally horizontal bars comprise

generally horizontal Z-bars.

8. The apparatus according to claim 7, wherein said Z-bars are fixed to clips which are, in turn, fixed to said building.

9. The apparatus according to claim 1, wherein said fan comprises a cooling unit for further cooling said cooled ventilation air.

10. The apparatus according to claim 9, wherein said cooling unit includes a dehumidifier for removing moisture from said cooled ambient air.

11. The apparatus according to claim 1, further comprising a second passageway between said air collection space and an interior of said building and located for passage of heated ambient air from said air collection space into said interior of said building.

12. The apparatus according to claim 11, further comprising a second fan located for moving said heated ambient air from said air collection space through said second passageway to said interior of said building.

13. The apparatus according to claim 1, wherein said passageway is located at a lower portion of a sloped roof.

14. The apparatus according to claim 13, further comprising:

a second passageway between said air collection space and an interior of said building for passage of heated ambient air from said air collection space into said interior of said building, said second passageway located at an upper portion of said sloped roof.

15. The apparatus according to claim 1, wherein said air openings comprise at least one of slits, holes, and gaps between overlapping panels.

16. The apparatus according to claim 1, wherein said radiating panel comprises a plurality of photovoltaic panels for producing electricity.

17. A method of cooling ventilation air for a building, comprising:

providing on a surface of a building, a radiating panel having an emissive surface such that said emissive surface of said panel is directed skyward and exposed to ambient air, and said panel defines an air collection space between itself and said building, the panel having a plurality of air openings for the ambient air to pass through the openings to the air collection space;

drawing said ambient air through said air openings and into said air collection space;

cooling said ambient air by transferring heat to said panel and radiating heat from said panel to the sky, to provide cooled ventilation air;

withdrawing the cooled ventilation air through an air inlet and pushing said cooled ventilation air into said building.

18. The method according to claim 17, wherein providing said radiating panel comprises providing a low absorption rate back surface, opposite said emissive surface for inhibiting heat gain from a roof of said building.

19. The method according to claim 17, wherein providing said radiating panel comprises providing a panel having a back surface with an emissivity rate that is lower than the emissivity rate of said emissive surface.

20. The method according to claim 17, wherein providing said radiating panel comprises fixing said radiating panel to said building by intermediary, generally horizontal bars.

21. The method according to claim 17, further comprising further cooling said cooled ventilation air in a cooling unit.

22. The method according to claim 23, further comprising dehumidifying said cooled ventilation air.

23. The method according to claim 17, further comprising:

heating said ambient air with solar heat from the panel and with heat from the interior of the building to provide heated ventilation air during a heating season; and

withdrawing the heated ventilation air through a second air inlet and pushing said heated ventilation air into said building during heating periods.

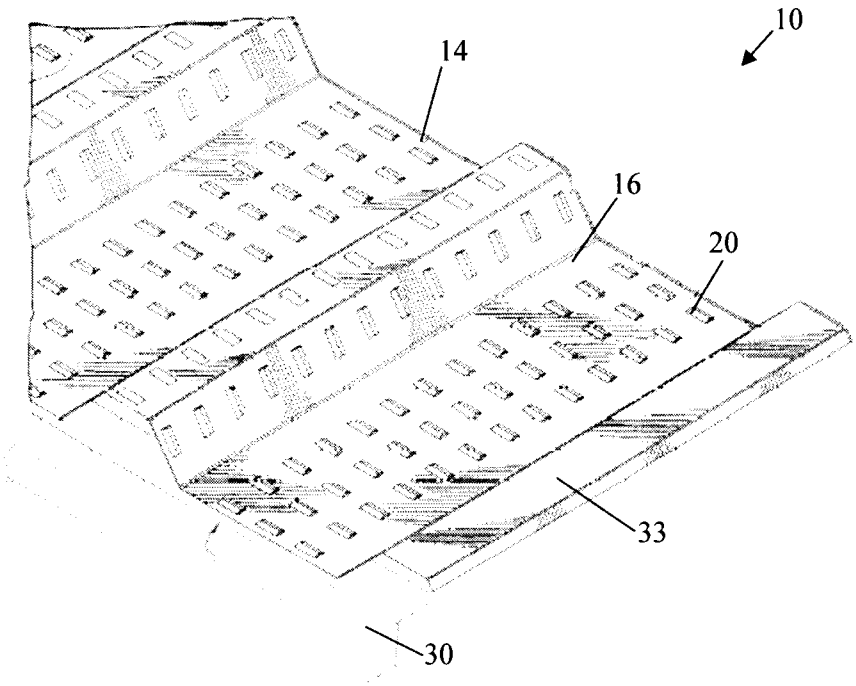

FIG. 1

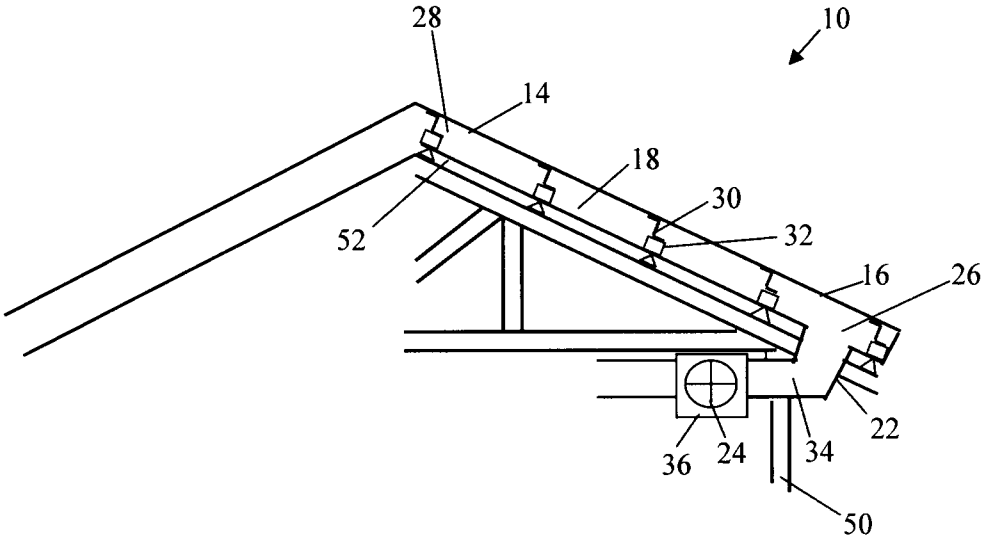

FIG. 2

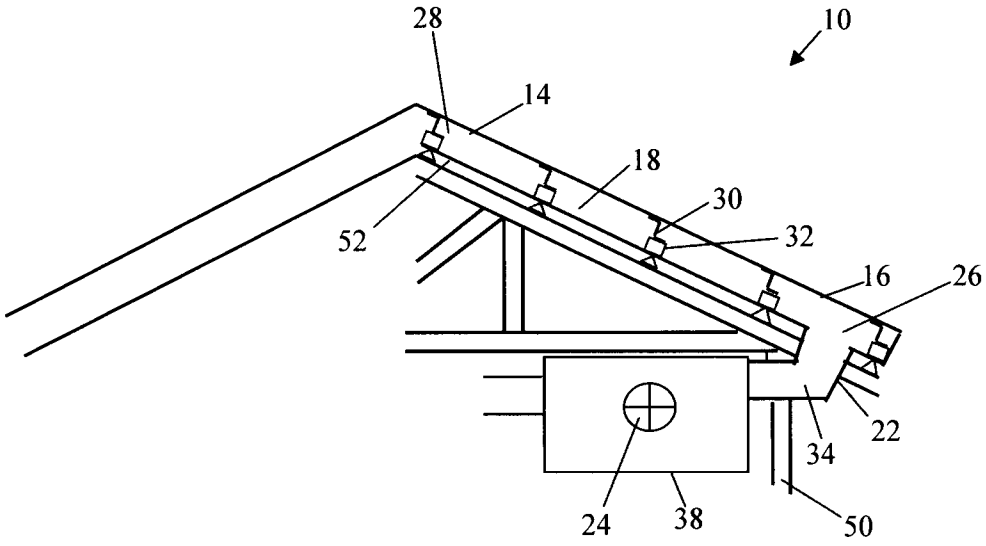

FIG. 3

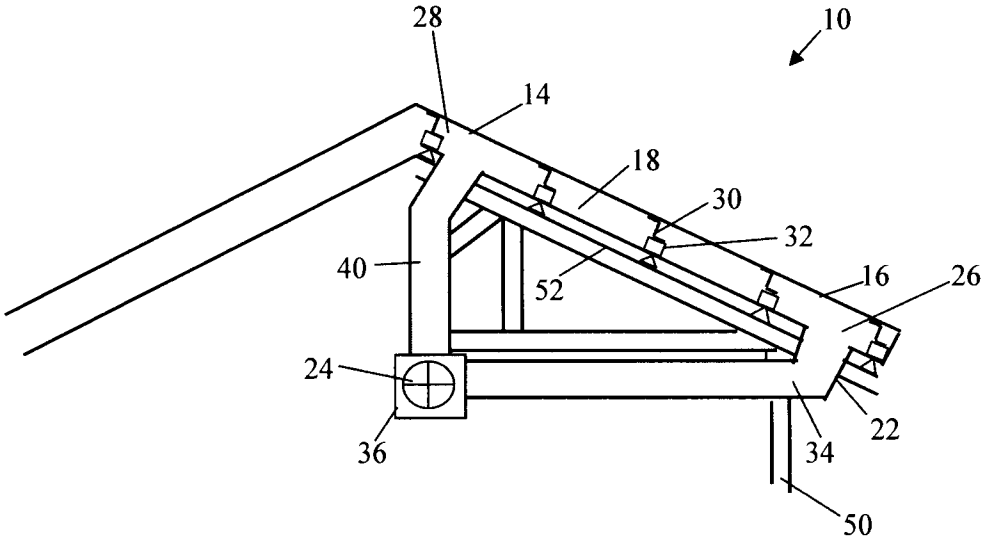

FIG. 4

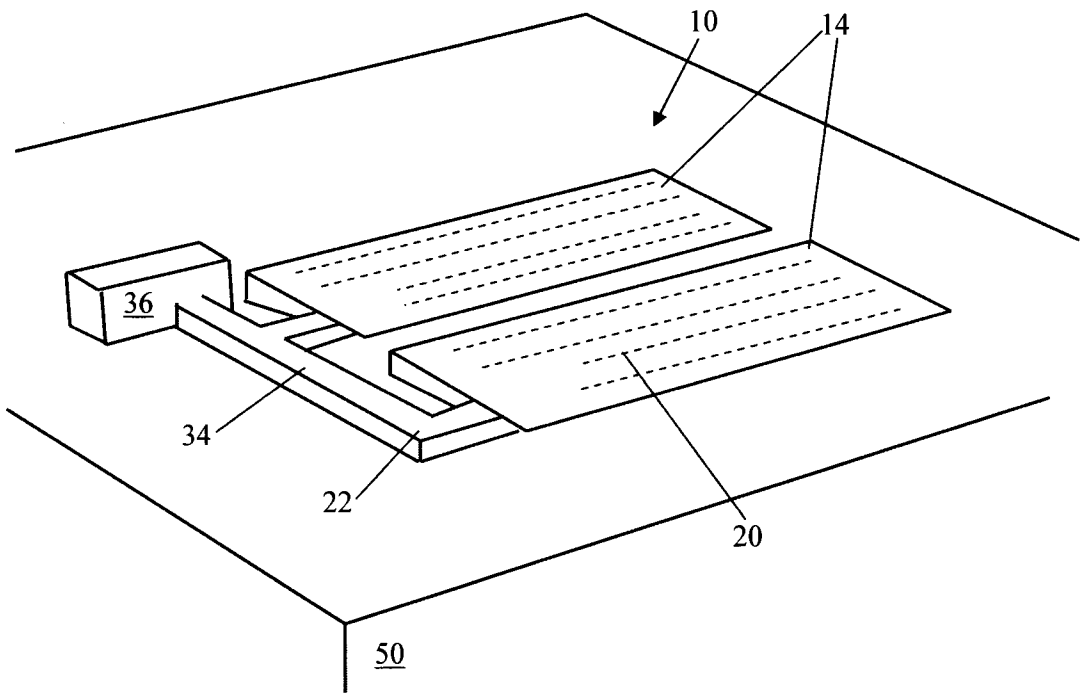

FIG. 5

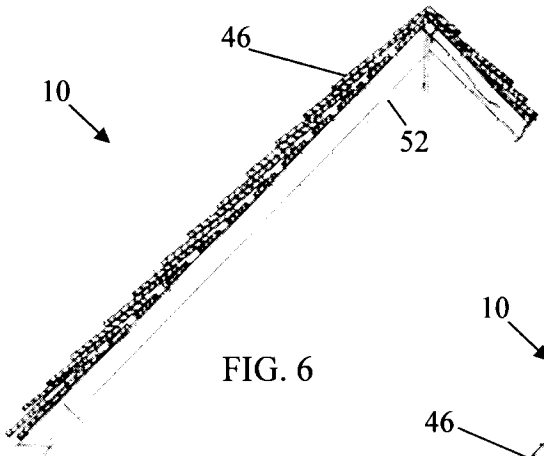

FIG. 6

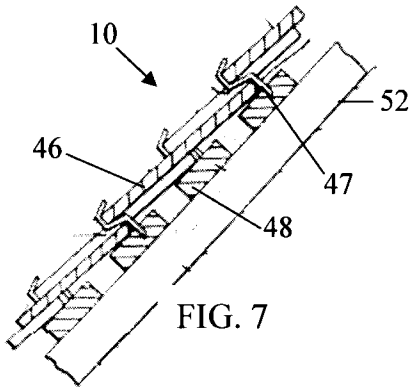

FIG. 7

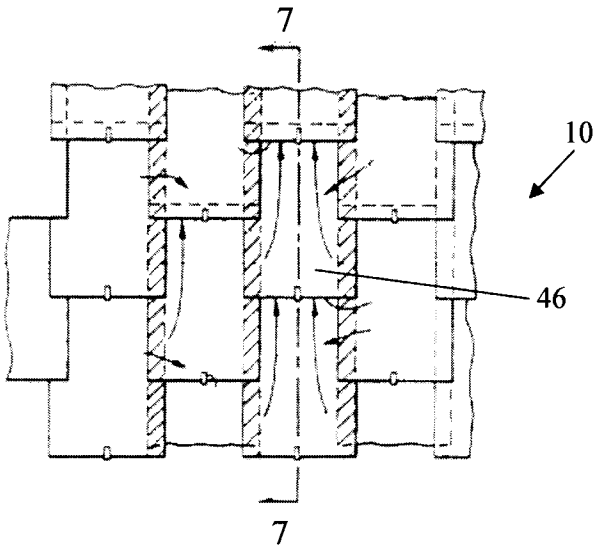

FIG. 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2007/000459

A. CLASSIFICATION OF SUBJECT MATTER
IPC: ***F24F 13/30*** (2006.01) , ***F24F 3/00*** (2006.01) , ***F24F 3/14*** (2006.01) , ***F24J 2/04*** (2006.01)
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC: F24F* (2006.01), F25B* (2006.01), USCL: 62/*, 126/*, 165/*, 98/*

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
none

Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used)
WEST, ESP@CENET, Canadian Patents Database; search terms: solar, panel, battery, ventilat*, cool*, building, roof, heat, radiat*, fan, emission, (ambient air)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2002088994 A (MISAWA HOMES CO); 27 March 2002 (27-03-2002); abstract	1-23
A	DE 10039556 A1 (ALLIGATOR SUNSHINE TECHNOLOGIE); 28 February 2002 (28-02-2002); abstract	1-23
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A	GB 1441456 A (LAING); 30 June 1976 (30-06-1976); abstract	1-23
A	US 3,949,732 A (REINES) ; 13 April 1976 (13-04-1976); abstract	1-23

[ ] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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Date of the actual completion of the international search	Date of mailing of the international search report
27 June 2007 (27-06-2007)	27 July 2007 (27-07-2007)

Name and mailing address of the ISA/CA	Authorized officer
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
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