

INSULATING WINDOW INCORPORATING PHOTOVOLTAIC CELLS AND A PRESSURE EQUALIZATION SYSTEM

5 FIELD OF THE INVENTION

The present invention relates generally to window structures, and more particularly to window structures comprising photovoltaic panels.

10 BACKGROUND OF THE INVENTION

Windows or glass areas are a significant weakness in the heat insulation schemes for buildings in hot or cold climates. A basic insulating window that is well-known is constructed from two panes of glass within a rigid frame. The air space between the panes provides heat insulation.

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Photovoltaic units, when disposed between the two panes, heat the air entrapped within the insulating glass unit, which causes the seal to fail prematurely. U.S. Patent 4,137,098 to Gillard discloses photovoltaic cells enclosed between two panes of glass of a window housing that is cooled by a forced air system. U.S. Patent 5,128,181 to Kunert discloses photovoltaic cells enclosed between two panes of glass of a window housing in which excess solar radiation is dissipated outwardly by convection. U.S. Patent 5,221,363 to Gillard discloses photovoltaic cells enclosed between two panes of glass of a window housing having valves so that excess heat may be removed by convection. However, if the entrapped air is vented, when the window cools and air reenters the unit, condensation may occur which impairs the transparency of the window unit.

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Therefore there is a need in the art for an insulating glass unit window structure, which includes a photovoltaic cell and mitigates the difficulties posed by the prior art.

SUMMARY OF THE INVENTION

The present invention is directed to a pressure equalized heat insulation window comprising photovoltaic cells. Therefore, in one aspect, the invention comprises a heat insulation window
5 comprising:

- (a) a pair of glass panes defining an air space therebetween;
- (b) a spacing member disposed between said glass panes which maintain the panes in a spaced-apart relationship;
- 10 (c) at least one photovoltaic cell disposed between said glass panes; and
- (d) a frame surrounding a perimeter of the window, wherein the frame comprising a conduit means for providing gas communication through the frame to the air space.

15 In one embodiment the conduit means comprises a desiccant.

In other embodiments the frame encloses an interior space and comprises an access means.

BRIEF DESCRIPTION OF THE DRAWINGS

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The invention will now be described by way of an exemplary embodiment with reference to the accompanying simplified, diagrammatic, not-to-scale drawings. In the drawings:

25 **FIG. 1** is a perspective view of a heat insulation window enclosing photovoltaic cells and a diagrammatic representation of electrical connections;

FIG. 2 is a cross-sectional view of the window of Fig. 1 (photovoltaic cells not shown), showing the interior space enclosed by the window frame and access means; and

30 **FIG. 3** is a cross-section of the embodiment of Fig. 2.

DETAILED DESCRIPTION OF THE INVENTION

The present invention provides for an energy efficient, heat insulating window design. When
5 describing the present invention, all terms not defined herein have their common art-recognized meanings.

Figure 1 shows a perspective view of photovoltaic cells (2) mounted on the inner surface of outer
glass pane (12) and a diagrammatic representation of electrical connections (4).

Figures 2 and 3 show the heat insulation window with a pressure equalization system as
described in co-owned Canadian Patent Application 2,507,108, the contents of which are herein
incorporated by reference.

Figure 2 shows a view of a window unit comprising dual glass panes (10, 12) and a frame (14).

Figure 3 shows cross-sections of the glass panes (10, 12) spaced apart by a spacer (16) and held
together by the frame (14).

The frame comprises an outer channel member (18), an inner channel member (20) and dual
intermediate web members (22) which join the inner and outer channel members. The inner channel
member may include an installation flange (24) which projects outwardly and will abut a window
jamb (not shown) when installed into a wall frame. A removable desiccant concealing member (26)
is attached to the inner channel member (20) opposite the installation flange (24) which serves to
25 retain the glass unit but does not serve any other structural function. The desiccant concealing
member (26) is tube-shaped defining a single elongate channel (28). One edge of the channel
defines a first lip (30) while the other edge of the channel defines a second lip (32). The two lips
(30, 32) mate with corresponding grooves (31, 33) formed in the inner channel member (20).

The glass planes are positioned and retained by resilient seals (34, 36, 38). Seal (34) is attached to
30 the outer channel member (18) while seal (36) is attached to the inner channel member (20). Air

seal (38) is attached to the desiccant concealing member (26). The seals are preferably formed from a material having low thermal conductivity and relatively impervious to moisture, such as neoprene, EPDM or silicone rubber.

- 5 In a preferred embodiment, a dual desiccant system is employed. The spacer (16) is a hollow rectangular member which is filled with a suitable desiccant (40). The spacer defines pores which allow air to circulate between the air space between the glass panes (10, 12) and the interior volume of the spacer (16) which contains the desiccant. As well, a small conduit (42) connects the interior space of the spacer to a sealed tube (44) within the desiccant concealing member (26) which is filled
10 with desiccant (40). The sealed tube (40) has a cap (46) which receives the conduit (42) thereby providing gas communication between the spacer interior volume and the desiccant tube (44).

- As is apparent, the desiccant concealing member (26) may be removed from the frame (14) by disengaging the lips (30, 32) from the inner channel member (20), thereby exposing the desiccant
15 tube (44). The desiccant tube (44) can then be easily disconnected from the conduit (44) and replaced with a fresh desiccant tube if necessary. In one alternative embodiment, the desiccant in the desiccant tube may be different from the desiccant contained in the spacer and has a higher affinity for water than the desiccant in the spacer. As will be appreciated by those skilled in the art, air which is drawn into the air space must pass through the replaceable desiccant tube, thereby
20 preserving the dry atmosphere within the window unit.

Desiccant tubes (44) may be placed in one, two, three or all four desiccant concealing (20) members (26) in any orientation.

- 25 The outer, intermediate and inner channel members which comprise the frame (14) may be formed from a thermoplastic material having low thermal conductivity such as polyvinylchloride or polyamide. Alternatively, the inner and outer channel members may be metallic members such as aluminum while the intermediate member is non-metallic, thereby avoiding a thermal bridge between the two. The desiccant concealing members may be any suitable material such as a metal

or a plastic, and is preferably resilient to facilitate its installation and removal from the inner channel member.

A solar cell, or photovoltaic cell (2), is a semiconductor device consisting of a large-area p-n junction diode, which, in the presence of sunlight is capable of generating usable electrical energy. Any suitable type photovoltaic cell (2) can be used in the window described herein. For example, silicon, calcium sulfide, gallium arsenide and other types of cells are suitable. The cells can be of any desired configuration such as square, circular.

10 The photovoltaic cells may be any suitable cell, such as crystalline wafers, or thin film cells. As an alternative to using crystalline photovoltaic cell wafers, photovoltaic laminated glass can also be produced using thin-film solar photovoltaic (PV) cells. The fabrication of a thin-film solar cell involves depositing very thin, consecutive layers of atoms, molecules, or ions of semiconductor material (such as amorphous silicon, copper indium diselenide, or cadmium telluride) on a low-
15 cost substrate, such as glass, metal, or plastic. Thin-film cells have certain advantages over crystalline solar cell wafer technologies. They use less material and the cell's active area is usually only 1 to 10 microns thick, whereas conventional wafers are as much as 200 to 400 microns thick. Thin-film cells are also usually amenable to large-area fabrication (more than 1 m²) and are suitable for automated, continuous production, arraying, and packaging. They can
20 also be deposited on flexible substrate materials.

In one embodiment, the photovoltaic cells (2) are disposed between the two glass panes of glass (10, 12) as a photovoltaic laminate, with the photovoltaic cells laminated between two glass panels. In conventional laminated glass products a sheet of glass is bonded to a layer of polymer
25 adhesive film, and a further sheet or layer of material is bonded to the other side of the adhesive film layer, so that the adhesive film is sandwiched between two outer layers. A number of methods for producing such laminates are known, for example, see U.S. Patent Nos: 5,268,049; 5,118,371; 4,724,023; 4,234,533; and 4,125,669. Laminated glass has been generally manufactured by a process wherein a stack of at least two sheets of glass having a plastic film
30 called an intermediate film or laminating film, typically a plasticized polyvinyl butylal (PVB)

film, is sandwiched between each pair of adjacent sheets of glass which is subjected to evacuation, pressing and heating.

5 The photovoltaic cells (2) are usually electrically connected (4) together in a series circuit to achieve desired voltage, and a plurality of series circuits of photovoltaic cells can then be connected in parallel, as desired. The electrical energy can then be fed by electric lines (4) from + and - terminals to a power control or other suitable distribution device (6). Such conventional electrical circuitry, would preferably include an isolator, to a main power bus. As well known in the art, an inverter would be used to produce alternating current (AC) from direct current (DC)
10 produced by the photovoltaic cells. Preferably, a plurality of photovoltaic cells are grouped in parallel to raise the voltage and each group is provided with a three pole disconnect DC switch and an inverter, the AC current then passing to a 208 volt distribution panel.

15 As will be apparent to those skilled in the art, various modifications, adaptations and variations of the foregoing specific disclosure can be made without departing from the scope of the invention claimed herein. The various features and elements of the described invention may be combined in a manner different from the combinations described or claimed herein without departing from the scope of the invention.

WHAT IS CLAIMED IS:

1. A heat insulation window comprising:
 - 5 (a) a pair of glass panes defining an interior air space therebetween;
 - (b) a spacing member disposed between said glass panes which maintain the panes in a spaced-apart relationship;
 - (c) at least one photovoltaic cell disposed between said glass panes; and
 - 10 (d) a frame surrounding a perimeter of the window, wherein the frame comprises a conduit means for providing gas communication through the frame to the air space.
2. The heat insulation window of claim 1 wherein said conduit means comprises a desiccant.
- 15 3. The heat insulation window of claims 1 or 2 wherein said at least one photovoltaic cell is laminated to one of said glass panes.
4. The heat insulation window of claims 1-3 wherein said frame encloses an interior space and comprises an access means through said frame to said interior space.
- 20 5. The heat insulation window of claim 1 or 2 wherein the spacing member defines an internal volume in gas communication with the air space between the glass panes, and further comprising a dessicant disposed within the internal volume.
- 25 6. The heat insulation window of claim 5 wherein said at least one photovoltaic cell is electrically connected to a three pole disconnect direct current switch and an inverter.
7. A heat insulation window comprising:
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(a) a pair of glass panes defining an air space therebetween and having a photovoltaic cell disposed within the airspace;

5 (b) a spacing member disposed between the glass panes which maintain the panes in a spaced-apart relationship, the spacing member being hollow and defining openings permitting gas communication between the air space and the interior volume of the spacing member;

10 (c) a desiccant material contained within the spacing member; and

(d) a frame surrounding a perimeter of the window, wherein the frame comprises:

(i) at least one desiccant concealing member which is hollow and detachable from the frame;

15 ii) a desiccant cartridge removably disposed within the desiccant concealing member and

(iii) conduit means for providing gas communication between the air space and the desiccant cartridge.

8. The window of claim 7 wherein the conduit means provides gas communication between
20 the interior volume of the spacing member and the desiccant cartridge.

9. The window of claim 7 wherein the desiccant cartridge comprises an elongated cylindrical tube.

25 10. The window of claim 7 wherein the desiccant concealing member is elongated and has a substantially U-shaped cross-sectional profile.

11. The window of claim 10 wherein the cross-sectional profile comprises two linear segments joining at a substantially right angle.

12. The window of claim 7 wherein the frame comprises an outer channel member, an inner channel member, a web member disposed between the outer and inner channel members, wherein the desiccant concealing member is detachably connected to the inner channel member.
- 5 13. The window of claim 10 wherein the desiccant concealing member is comprised of a resilient material and comprises a first lip and a second lip which each engage an undercut groove in the inner channel member.