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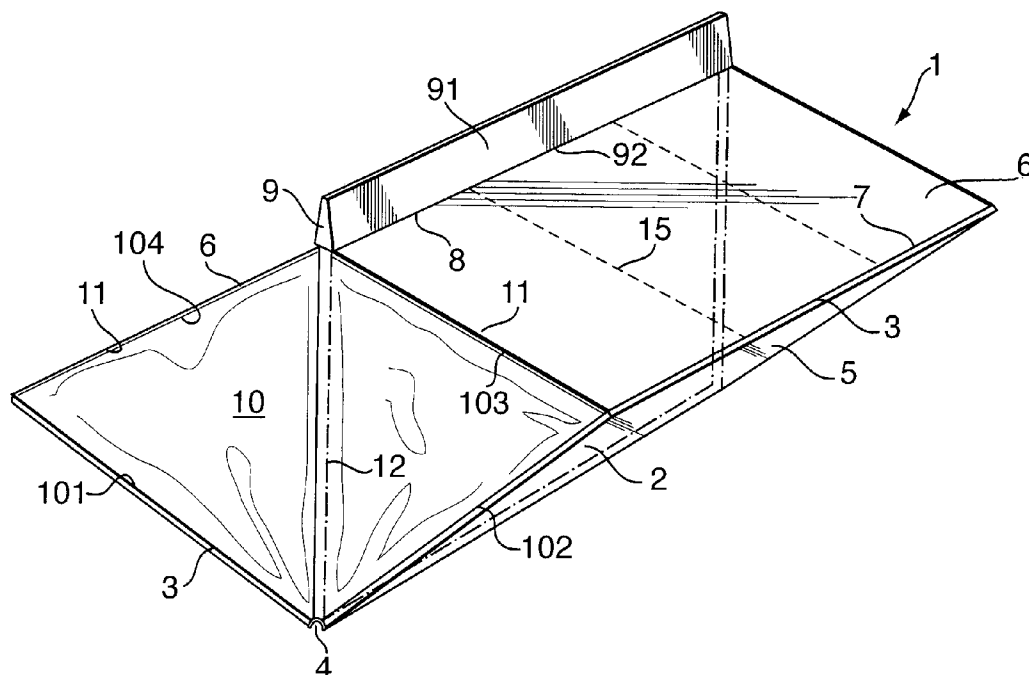
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(54) Title: GREENHOUSE INSULATION SYSTEM



(57) Abstract: An insulation system for use in a greenhouse, comprising at least one insulation panel adapted to be mounted in the ceiling of a greenhouse, and means to move the at least one panel from a closed position to an open position, whereby when the panel or panels are closed, air below the panels remains in the area of the greenhouse below the panels, and when the panel or panels are open, air below the panels can move to a space in the greenhouse above the panels.

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GREENHOUSE INSULATION SYSTEM

The present invention relates to the field of greenhouses and controlled environment agriculture (CEA).

5 Generally speaking, a greenhouse is a building constructed for the practice of indoor horticulture or agriculture. Traditionally, the walls and roofs of greenhouses have been constructed of glass or similar transparent material such as transparent plastic panels. This permits sunlight to directly illuminate plants, and permit them to grow. Systems have been proposed, for instance as shown in US Patent No. 5,655,335 to allow
10 the roof of a traditionally constructed transparent greenhouse to open to permit the plants being grown therein to become hardier, thereby increasing the success rate of transplants from the greenhouse to a natural environment. In US Patent No. 5,655,335, longitudinally extending roof panels are paired together in v-shaped pairs that extend the length or width of a greenhouse. Each arm of the 'V' slantingly abuts the 'V' next to it,
15 to define a series of peaks running the length or width of the greenhouse. Each 'V' shaped pair of panels is hinged together at the base of the 'V' and provided with mechanical means to draw the arms of the 'V' inward. It will be understood, then, that when one or more V shaped pairs is closed up in this way, the roof will be opened, and the natural atmosphere permitted to circulate in the open greenhouse.

20 It is, moreover, known to use a plurality of inflatable tubes, arranged parallel to each other to construct an insulating partition in a greenhouse. In US4290242 (Gregory), inflatable clear polyethylene tubes are arranged in longitudinal lines in a greenhouse to provide an insulating layer. The tubes are inflated to lean against each other and provide a continuous insulating ceiling structure when there is no sunlight, and deflated to hang
25 vertically and provide passages between the tubes when the sun is shining.

 A similar system is shown in US4352259 (Smith et al.), which also provides that the ends of the longitudinally extending tubes are mounted on racks, whereby the tubes may be drawn to the side of the greenhouse. Other patents that show the use of insulating structures made up of parallel inflatable tubes can be seen in US4301626 (Davis et al.),
30 US6000170 (Davis) and US6442903 (Hebert).

The present invention, therefore, provides a greenhouse insulation system that has, at its core, a novel retractable insulation module for use in a greenhouse. Each module has a pair of rectangular light-weight insulating panels that are hinged together along a common lower edge. The panels can be pulled together to permit air flow, and heat flow, between the panels, preferably by means of a bellows created by joining the remaining edges of the panels by means of a gas impermeable membrane, and selectively inflating or deflating the bellows defined by the panels and the membranes.

Alternatively, the panels may be opened or closed by means of cables, wires, a rack and pinion system, or any other mechanical means, as will be obvious to one skilled in the art. An air space is provided in the greenhouse between the insulated ceiling panels of the present invention, and the roof (which may be transparent or translucent), of the greenhouse. It will be understood, moreover, that the present invention is applicable to any building having roof glazing. Therefore, as used herein the word 'greenhouse' should be interpreted to mean any building with areas of roof glazing in which it may be desired to install the system of the present invention.

The downwardly facing surfaces of the insulating panels of the present invention will ideally be coated with a reflective material, which will maximise the efficiency of the natural light reaching the plant canopy in the greenhouse.

In a broad aspect, then, the present invention relates to an insulation system for use in a greenhouse, comprising at least one insulation panel adapted to be mounted in the ceiling of a greenhouse, and means to move said at least one panel from a closed position to an open position, whereby when said panel or panels are closed, air below said panels remains in the area of said greenhouse below said panels, and when said panel or panels are open, air below said panels can move to a space in said greenhouse above said panels.

In another broad aspect, then, the present invention relates to a selectively operable ceiling panel for use in a greenhouse, comprising a bellows defined by a pair of longitudinally extending insulation panels hinged together along a common lower edge, and joined together along their end and upper edges by an air-tight membrane to define a bellows the evacuation of which will cause said panels to move together. The panels will

remain in this vertical position until the air is no longer being evacuated, at which time the panels will spread apart.

In drawings that illustrate the present invention by way of example:

5 Figure 1 is a perspective view partly in phantom of a collapsible insulation panel module according to the present invention, in its closed condition;

Figure 2 is a perspective view a collapsible insulation panel module of Figure 1, in its open condition;

Figure 3 is a perspective view of a panel module attached to either a fan or an air blower;

10 Figure 4 is a perspective schematic view of a series of modules, in open condition;

Figure 5 is a similar view to that of Figure 4, with the modules in closed condition;

Figure 6 is a cross-section, through line VI-VI in Figure 3; and

15 Figure 7 is a detail view of the bottom panel of a plenum, in place.

Figure 8 is a front view of a preferred form of central supporting structure according to the present invention.

Figure 9 is a front view of an alternate form of central support structure according to the present invention.

20 Figure 10 is a front view of another alternate form of central support structure according to the present invention, shown as being indefinite length.

Referring now to Figure 1 to 3, the basic collapsible insulation panel module 1 of the present invention is illustrated. It comprises a pair of hinged together lightweight rigid insulating panels 2. The preferred material for the panels is rigid foam, although
25 other appropriate materials, which will result in a rigid insulated wall, will be obvious to one skilled in the art. For instance, the panels may be fabricated as a thin box with a lightweight rigid frame, and upper and lower walls of stiff, lightweight plastic sandwiching a layer of fibreglass insulation.

Polyisocyanurate foam panels of between one and two inches in thickness are
30 used in a preferred embodiment of the present invention. Each panel will be framed

around its perimeter, and, at spaced intervals, with ribs extending between the top and bottom edges of the panels with a lightweight frame 3 of a rigid material such as aluminum, steel, extruded plastic, wood or the like. The function of the framework is to provide rigidity against bending forces which will be encountered during a normal operation as well as those which may accidentally be encountered, for instance during installation. Moreover, the perimeter frame will serve as a mounting surface for hinges 4 that are provided at the lower edges of the panels, to hinge them either to a centre support wall/structure or together.

It will be understood, moreover, that references herein to the lower edge of the panels are for convenience, and reference to the illustrated embodiments of Figures 1 to 6 only. It is entirely feasible to construct other embodiments of the invention in such a way that the panels are hinged to each other or to a centre support wall/structure along their upper longitudinal edges. If, for instance, one wished to have the default position of the panels to be folded into the centre, hanging them with the hinges along with the top edge may be appropriate. Furthermore, since it will be understood that the panels may be opened and closed by any means selected by one skilled in the art, it will be understood that in regard to some means of opening and closing, hanging the modules with the hinges along the top edge will be appropriate.

The outer surfaces of the panels 2 are preferably provided with a layer of light reflecting material 5. This may be, for instance, a layer of reflective aluminum foil, or it may be a coating of white paint. This reflective layer will maximise the light directed downwardly toward the plants being grown in the facility, and, if reflective aluminum is used, results in an increased insulation value for the insulated panels by acting as a radiant heat barrier.

The two panels 2 in each module are joined around their perimeter to each other by means firstly of the hinges 4 that extend along and join the lower edges of the panels to the lowermost edge of a supporting structure 12, a short section of which is shown in phantom in Figure 1, and by a series of flexible sheets that define a bellows arrangement around the remaining perimeter. The bellows consists of two congruent upper flexible membranes 6 that are rectangular. Each upper membrane is joined along its lower edge 7

to an upper edge of a panel 2, and along its upper edge 8 to the marginal edge of a longitudinally extending plenum 9, as shown in Figures 3, 6, and 7. Plenum 9 is mounted at the top edge of a central support member 12, and consists of a longitudinally extending box-like structure connected at one or more points along its width to ducting 14. The
5 plenum 9 may be arched, rectangular, square, or any other desired shape, but is preferably substantially prism shaped, as shown in Figure 6, and the outer side surfaces 91 are either coated with or constructed from light-reflective material such as light gauge metal to reflect light into the greenhouse. The lowermost panel 92 of the plenum is a horizontally oriented wall with an air distribution channel 93 or channels formed in it. In
10 the embodiment illustrated in Figure 7, air channel 93 is a longitudinal slot, and the lower panel 92 is aligned with the top longitudinal edge 121 of a central support structure 12. Central support structure 12 is preferably a corrugated web 20 (see Fig. 8) constructed from steel, aluminum, fibreglass, or any other rigid material (the selection of which will be a matter of choice to one skilled in the art). The corrugations function to strengthen
15 the structure 12, and also to distribute air entering the plenum evenly into both sides of the module. It will be understood, then, that all edges, connection to membrane 6, and connections between the plenum and central support will be airtight.

Moreover, it will be understood that central support 12, with plenum 9 and an associated lower chord 41 which may be a C-shaped metal cap to which hinges 4 are
20 connected will effectively function as a truss structure, strengthening the overall rigidity of the greenhouse, and serving as a rigid member from which to hang the modules in place.

It will be further understood that although a corrugated central support structure 12 has been described and illustrated as a preferred method of facilitating even air
25 distribution, and therefore balanced opening and closing of the modules, other means of distributing air evenly, such as independent air ducts into each side of a module, each duct being provided with a pressure regulation valve, are possible. Moreover, the modules may be unevenly weighted, whereby the lighter weight panel will consistently be lifted first, resulting in consistent opening and closing characteristics. Alternatively,
30 the panels may be opened and closed mechanically, by wires or a rack and pinion or a

pantograph or scissors arrangement.

Two alternate forms of central support structure 12 are shown in Figures 9 and 10. In Figure 9, the central support structure is illustrated as an open framework with top and bottom frame members 23, spaced apart by end frame members 24, and braced by corner braces 21. The frame members 23, 24 and corner braces 21 are fabricated from steel, aluminum, fibreglass, carbon fibre or any other appropriate lightweight material, as will be a matter of choice to one skilled in the art.

In Figure 10, a central support structure that is designed to also function as a truss is shown. In this embodiment, the top and bottom frame members 23, as well as the plenum 9 and end frame member 24 are constructed from heavier gauge metal, so as to allow the plenum 9 to function as a chord in the truss, and effectively become a structural component in the greenhouse frame. A continuous series of diagonal braces 25 are provided between the top and bottom frame members, to increase the rigidity of the truss.

The edges of the panels 2 are joined together by end membrane 10 that each are generally square or "diamond" shaped, and joined along their edges 101, 102, 103, 104 to each panel 2 and the end edges 11 of upper membrane 6. End membranes 10 are formed by folding the flexible membrane at the end of the membrane, 6, and continuing said membrane along the end "wall" to result in the end "triangles". This end triangle is then sealed to the end of the centre wall structure/support and the end edge of the insulated panels, as shown in Figure 1, with each triangular piece being joined to the vertical edge of support structure 12. To ensure that the end membranes 10 are well sealed to the ends of support structure 12, a vertical trim piece may be applied over the membrane 10, along the end edge of support structure 12, and fastened thereto with screws, rivets, or other suitable fasteners.

It will be understood, moreover, that at all seams between flexible membranes and panels, an air-tight seal is formed, by the use of suitable adhesives and/or sealants. Furthermore, it will also be noted that the longitudinal hinge 4 between the two panels will also be air-tight. In this regard, a membrane (not shown) may be adhesively applied, or mechanically sealed, to the longitudinal joint between the panels along the lower edge of support structure 12, either inside or outside the hinge 4. Alternatively, the hinge may

be constructed from an air impermeable material such as strips of rubber attached to the lower edges of the insulated panels and support wall.

Referring now to Figure 3, it will be seen that a fan or blower 13, or other air-flow apparatus, is connected by means of plenum 9 or manifold above the central support structure 12. When air is evacuated from the module, it collapses to an open position, as shown in Figure 2. When the airflow evacuating the module is discontinued, gravity results in the insulated panels "falling" to their horizontally inclined closed position, drawing air back into the module during this process. At their closed, inclined position, the panels will preferably be supported by wires 15 (or cables, straps or the like) inside the modules (as shown in Figure 1, in phantom), extending from the central support 12 to the upper edge of the panel 3. The function of this wire 15 is to ensure that the module will consistently fall to the correct position, without stress being placed on the plastic material of the membranes.

As seen in Figures 4 and 5, a series of modules can be mounted in a building, hung from the ceiling thereof. It will be understood that the modules must be arranged in parallel rows, and spaced apart such that, as shown in Figure 5, when the modules are in closed position, the edges of adjacent modules, as well as the contiguous ends of the modules which form the rows, will meet in a substantially air tight manner. The air tightness is substantially improved through the use of gasket seals. In this regard, it should be noted that it is not necessary for edge to edge contact of adjacent modules, or end to end contact of the panels forming a row, to be absolutely airtight. It is desirable, however, to prevent large airflows, and heat flows from the space below the modules to the space above the modules.

In their closed position, as shown in Figure 5, the lateral edges of the module define a continuous zig-zag shaped edge on each side of the modules. Accordingly, it is desirable that the building into which the modules are fitted be provided with a complementary perimeter margin, so that the lateral side edges of the panels can also be sealed, with respect to the walls of the building, against air and heat flow. It will also be understood that it is not necessary to provide a blower or fan 13 in connection with each module. If a remotely located blower/fan air flow apparatus is provided, it may be

connected by duct work to a plurality of modules, to open and close them in groups.

IN THE CLAIMS

1. An insulation system for use in a greenhouse, comprising at least one insulation panel adapted to be mounted in the ceiling of a greenhouse, and means to move said at least one panel from a closed position to an open position, whereby when said panel or panels are closed, air below said panels remains in the area of said greenhouse below said panels, and when said panel or panels are open, air below said panels can move to a space in said greenhouse above said panels.
2. An insulation system as described in claim 1, wherein said insulating panels are provided in pairs, each said pair comprising two rectangular panels hinged together along adjacent longitudinal edges.
3. An insulation system as described in claim 2, wherein said means to move said panels are connected to each said panel in a pair of panels, and act to fold said panels together.
4. An insulation system as described in claim 3, wherein said means to move said panels comprises a bellows formed by sealing securely a gas tight membrane to the edges of said panels in a said pair of panels other than the hinged together edges.
5. An insulation system as described in claim 4, wherein the hinged-together edges of a pair of panels is the lowermost edge in a v-shaped arrangement of panels defining a pair of panels.
6. An insulation system as described in claim 5, wherein pairs of panels are arranged parallel to each other to define a ceiling structure, with the upper edges of adjacent v-shaped pairs of panels abutting each other.

7. An insulation system as claimed in any one of claims 2 or 3, further comprising a central supporting element between each said pair of panels.
- 5 8. An insulation system as claimed in claim 7, wherein said central support element is a central vertical panel or framework between said insulation panels.
9. An insulation system as claimed in claim 8, wherein said insulation panels are hinged to said central vertical panels or framework along their lower edges.
- 10 10. An insulation system as claimed in claim 9, wherein said insulation panels are connected to said central support panel by flexible wires, cables or the like limiting the angle to which they can fall relative to the central support panel.
- 15 11. An insulation system as claimed in any one of claims 4, 5 or 6, further comprising a central supporting element between each said pair of panels.
12. An insulation system as claimed in claim 11, wherein said central support element is a central vertical panel or framework between said insulation panels.
- 20 13. An insulation system as claimed in claim 12, wherein said insulation panels are hinged to said central vertical panels or framework along their lower edges.
- 25 14. An insulation system as claimed in claim 13, wherein said insulation panels or framework are connected to said central support panel by flexible wires, cables or the like limiting the angle to which they can fall relative to the central support panel.
- 30 15. An insulation system as claimed in any one of claims 11 to 14, further

comprising a longitudinal plenum mounted over said central support panel or framework, adapted to permit air flow from said bellows.

- 5 16. An insulation system as claimed in claim 15, wherein said central support panel is provided with vertical corrugations, and wherein said plenum has a lower wall with a slot to accommodate said central support panel, whereby air flow to or from said plenum into or out of said bellows is via the corrugations of said central support panel, and said air flow is thereby substantially equally split between the sides of said bellows.
- 10 17. An insulation system as described in any one of claims 1 to 16, wherein said panels are made from a rigid framework incorporating an insulation material, surrounded by a perimeter frame of rigid material.
- 15 18. An insulation system as described in any one of claims 1 to 17, wherein said panels are provided with a reflective lower surface.
19. An insulation system as claimed in claim 17 or 18, wherein said insulation material is a foam insulation.
- 20 20. An insulation system as claimed in claim 19, wherein said insulation material comprises sheets of rigid foam insulation.
- 25 21. An insulation system as claimed in claim 17, 18, 19 or 20, wherein said framework is made from a material selected from the group consisting of plastics, aluminum, steel, fibreglass and wood.

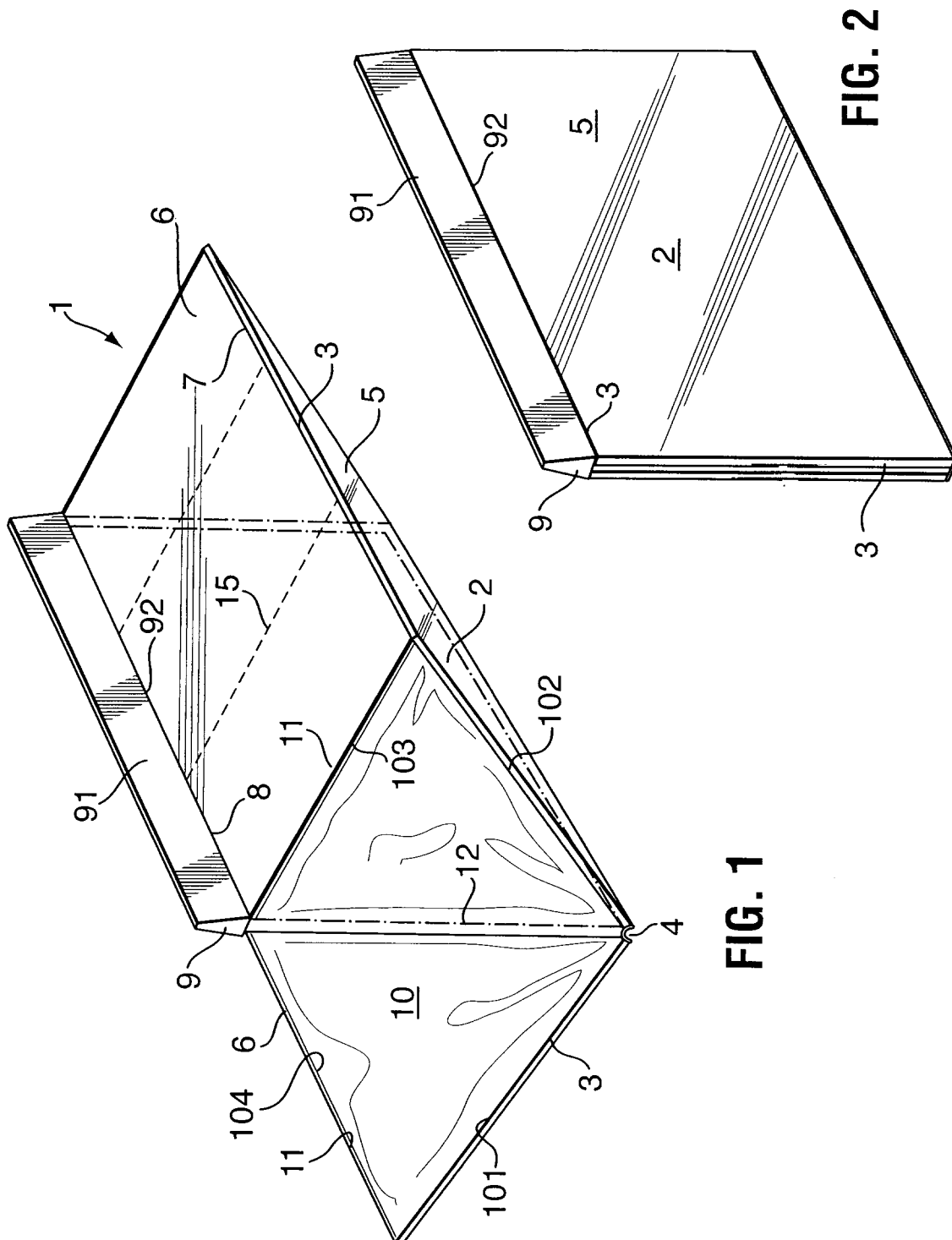
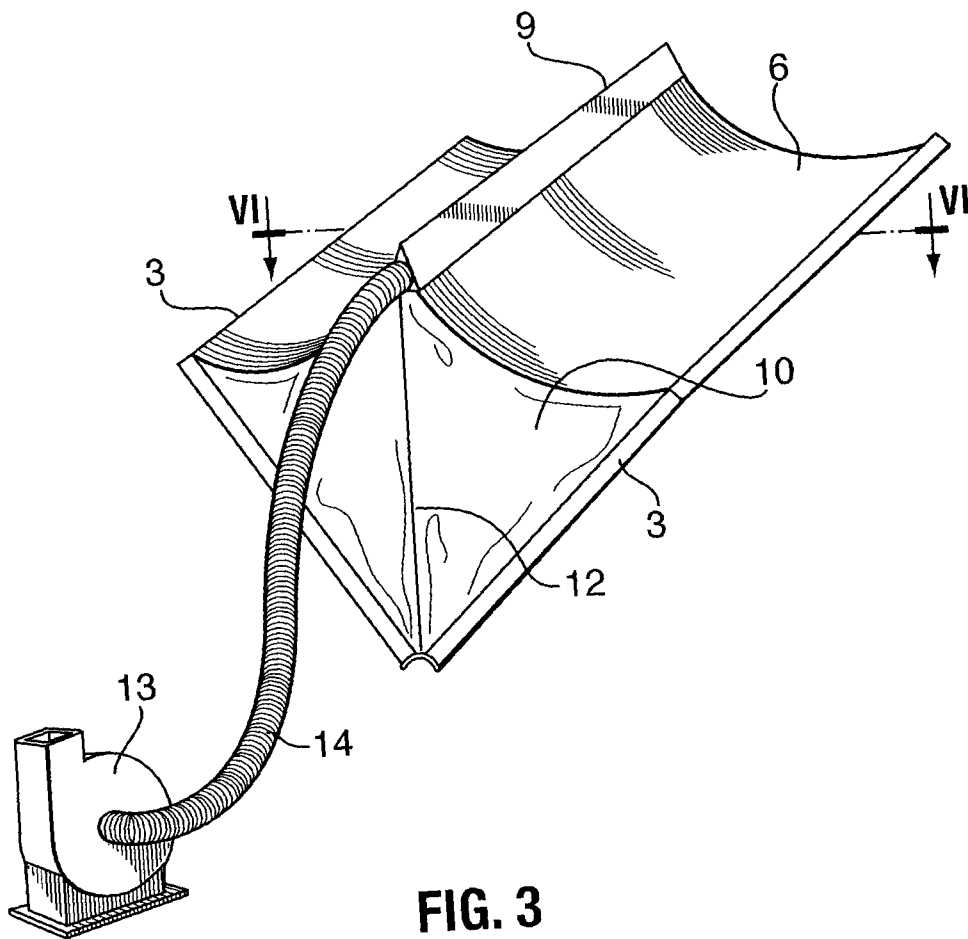


FIG. 2



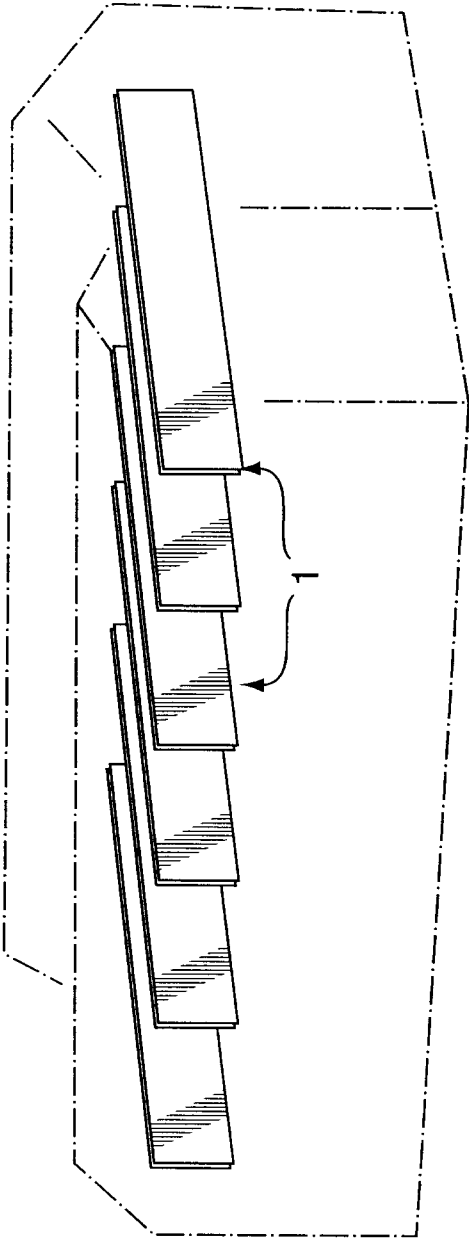


FIG. 4

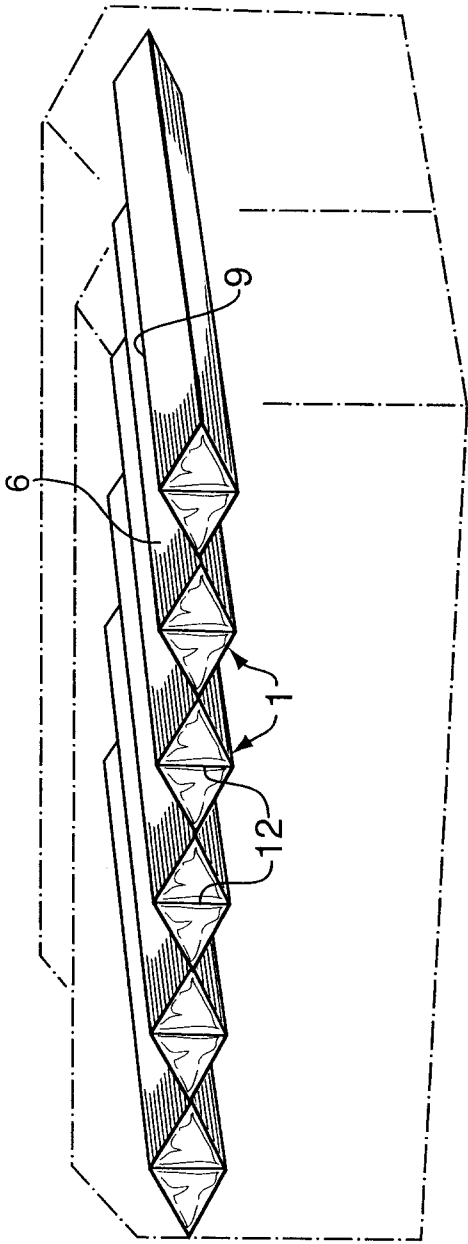


FIG. 5

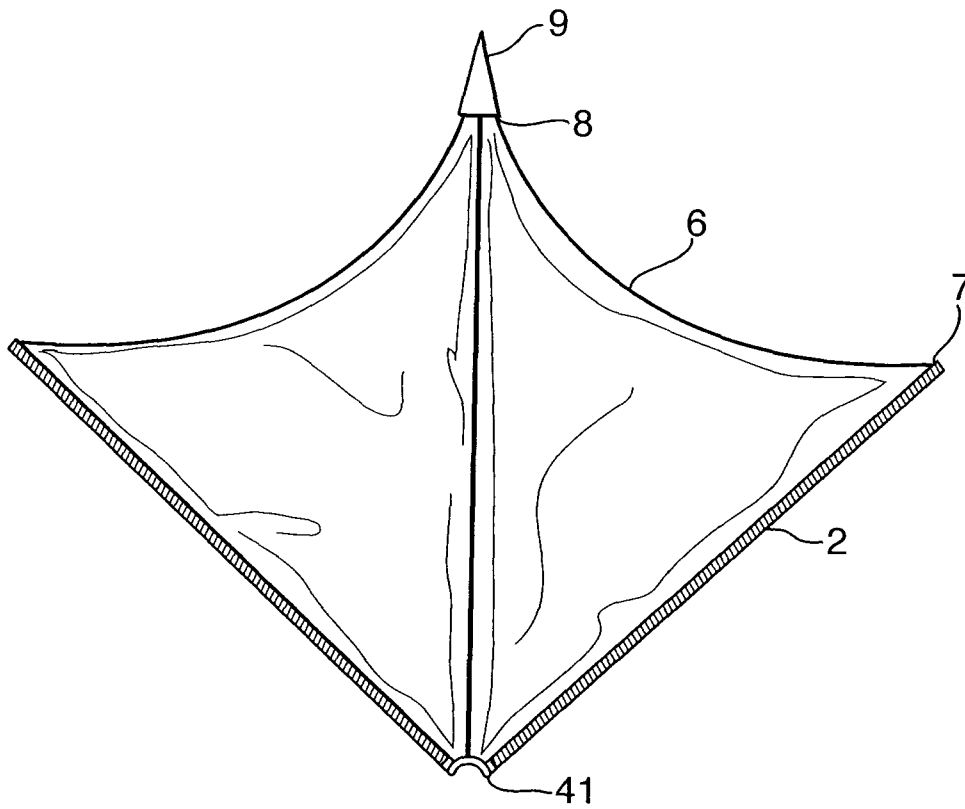


FIG. 6

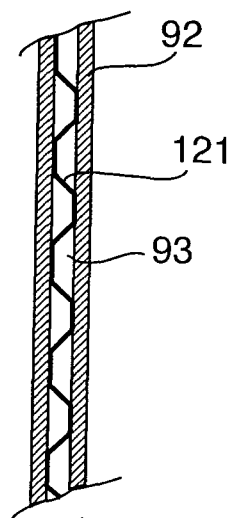


FIG. 7

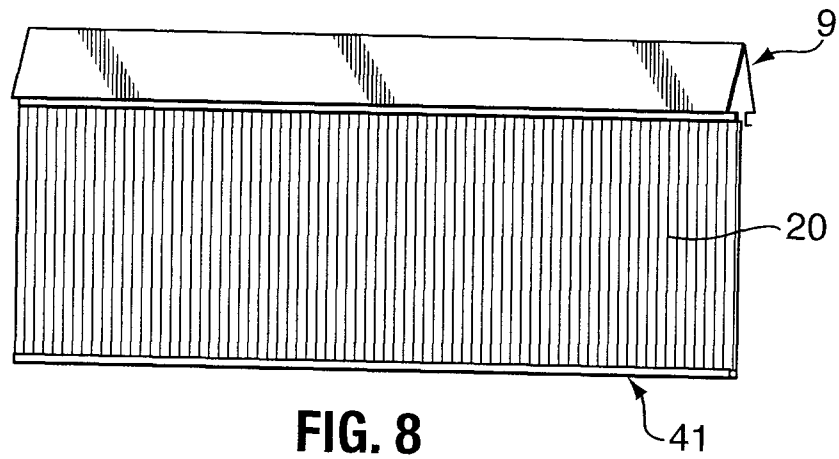


FIG. 8

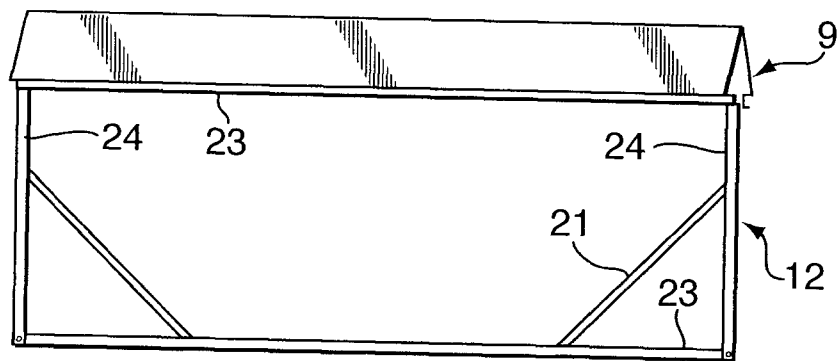


FIG. 9

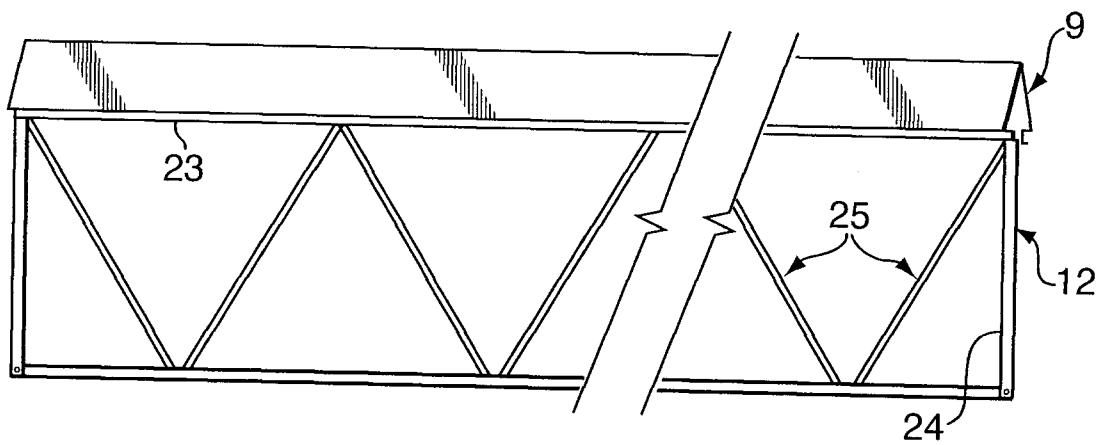


FIG. 10

INTERNATIONAL SEARCH REPORT

International application No.
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A. CLASSIFICATION OF SUBJECT MATTER IPC: A01G 9/14 (2006.01) , A01G 9/22 (2006.01) , A01G 9/24 (2006.01) , E04B 1/74 (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(2006.01): A01G, E04B CPC: 47/6; 20/20.1, 20.3, 20.5 USPC: 52/2, 52/66 Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used) Delphion and Canadian Patents Database (Keywords: insulated, insulation, insulated panels, insulation panels, panels, roof, greenhouse)														
C. DOCUMENTS CONSIDERED TO BE RELEVANT <table border="1"> <thead> <tr> <th>Category*</th> <th>Citation of document, with indication, where appropriate, of the relevant passages</th> <th>Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td>X</td> <td>US5655335 A (VERMEER, A. A.) 12 August 1997 (12-08-1997) *Cited by Applicant* *Whole document*</td> <td>1-3, 7-10, 17-21</td> </tr> <tr> <td>A</td> <td>US4312157 (Hertel, R. D. et al) 26 January 1982 (26-01-1982) *Whole document*</td> <td>1-21</td> </tr> <tr> <td>A</td> <td>EP 1529437 A1 (HALEY, C. P.) 11 May 2005 (11-05-2005) *Whole document*</td> <td>1-21</td> </tr> </tbody> </table>			Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	X	US5655335 A (VERMEER, A. A.) 12 August 1997 (12-08-1997) *Cited by Applicant* *Whole document*	1-3, 7-10, 17-21	A	US4312157 (Hertel, R. D. et al) 26 January 1982 (26-01-1982) *Whole document*	1-21	A	EP 1529437 A1 (HALEY, C. P.) 11 May 2005 (11-05-2005) *Whole document*	1-21
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☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.														
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INTERNATIONAL SEARCH REPORT

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International application No.
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