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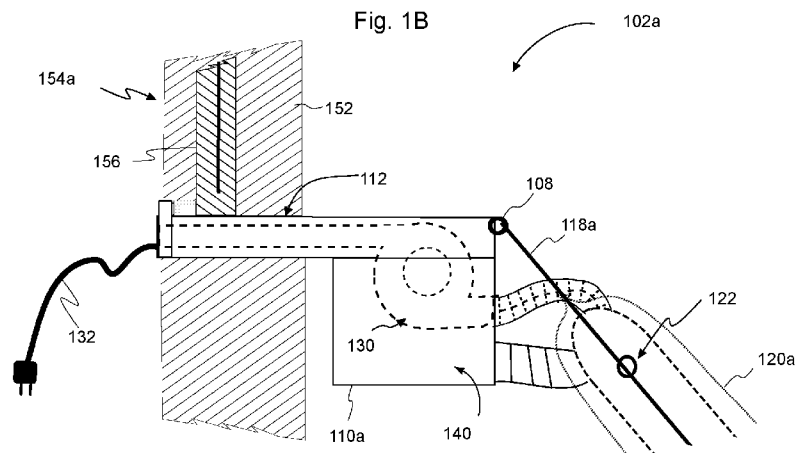
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(54) Title: PORTABLE SOLAR-HEATING SYSTEM HAVING AN INFLATABLE SOLAR COLLECTOR



(57) Abstract: A solar-heating system having an inflatable solar collector connected to a housing that can be installed, e.g., in a sash window of a house. The housing has an air blower that draws air from the interior of the house and directs it into the inflatable solar collector, which is positioned outside the window. The collector has a flexible permeable membrane that serves as a transpired absorber of solar radiation. The air flowing through the collector is heated when it percolates through the membrane exposed to solar light. The heated air is returned back to the interior of the house, thereby providing space heating. In certain embodiments, in addition to serving as a transpired absorber, the membrane can also serve as an air filter that removes particles, odor-causing pollutants, and/or allergens from the drawn air.



PORTABLE SOLAR-HEATING SYSTEM HAVING AN INFLATABLE SOLAR COLLECTOR

CROSS-REFERENCE TO RELATED APPLICATIONS

5 This application claims priority from U.S. Provisional Patent Application
Serial No. 61/107,738 filed on October 23, 2008, and entitled “Portable Solar Heating
Apparatus for Window Installations Having an Inflatable Solar Collector,” which is
incorporated herein by reference in its entirety.

10 BACKGROUND

Field of the Invention

The present invention relates to solar-energy utilization and, more specifically, to solar-heating systems.

15 Description of the Related Art

This section introduces aspects that may help facilitate a better understanding of the invention(s). Accordingly, the statements of this section are to be read in this light and are not to be understood as admissions about what is in the prior art or what is not in the prior art.

Heating, ventilation, and air conditioning (HVAC) systems account for about one half of the energy used in residential buildings in the United States. Solar HVAC technologies can be used to offset at least a portion of this energy. The U.S. Energy Information Administration (EIA) classifies solar-heating systems into three categories: low-, medium-, and high-temperature systems. Low-temperature systems are usually used to heat swimming pools and for space heating. Medium-temperature systems usually generate hot water for residential and commercial use. High-temperature systems concentrate sunlight using mirrors and/or lenses and are generally used for generating electricity.

30 A typical household solar-heating system is a low- or medium-temperature system that has a solar collector, with a heat-transfer fluid (e.g., air or water) flowing through the collector to absorb solar-generated heat and transport it to a storage or

distribution subsystem (e.g., a hot water tank or heat radiator). The solar collector is usually placed where solar-radiation levels are relatively high, e.g., on the roof of the house. A pump circulates the heat-transfer fluid through the solar collector and storage/distribution subsystem, thereby transporting the heat to the place of its

5 intended use.

An important consideration for the individual consumer is the cost and ease of deployment of the solar-heating system. For example, a relatively expensive solar-heating system has a relatively long pay-back period, which makes it unattractive to the consumer. A solar-heating system that is permanent or difficult to deploy might
10 similarly be unattractive because the consumer might prefer to have it deployed only when needed, e.g., during the winter months, and have it removed when not needed, e.g., during the periods of hot weather.

SUMMARY

15 Disclosed herein are various embodiments of a solar-heating system having an inflatable solar collector connected to a housing that can be installed, e.g., in a sash window of a house. The housing has an air blower that draws air from the interior of the house and directs it into the inflatable solar collector, which is positioned outside the window. The collector has a flexible permeable membrane that serves as a
20 transpired absorber of solar radiation. The air flowing through the collector is heated when it percolates through the membrane exposed to solar light. The heated air is returned back to the interior of the house, thereby providing space heating. In certain embodiments, in addition to serving as a transpired absorber, the membrane can also serve as an air filter that removes particles, odor-causing pollutants, and/or allergens
25 from the drawn air. Advantageously, inflatable solar collectors of the invention can be manufactured using inexpensive, durable, and readily available materials. The collectors are inherently resilient to impact and shock, relatively easy to deploy and remove as needed, easy to adjust to the surrounding terrain and secure at a desired tilt angle, and easy to clean.

30 According to one embodiment, provided is a system having (i) a housing with an air-intake register and an air-exhaust register and (ii) an inflatable solar collector

operatively connectable to the housing. The housing has an air blower configured to draw air through the air-intake register and direct the drawn air into a tube connectable to the inflatable solar collector. The inflatable solar collector has a first chamber and a second chamber separated by a flexible permeable membrane. In operation, air
5 pressure generated by the air blower causes the drawn air to flow through the tube into the first chamber, percolate through the permeable membrane into the second chamber, and exhaust from the second chamber through the air-exhaust register.

BRIEF DESCRIPTION OF THE DRAWINGS

10 Other aspects, features, and benefits of various embodiments of the invention will become more fully apparent, by way of example, from the following detailed description and the accompanying drawings, in which:

Figs. 1A-B show diagrammatic views of a solar-heating system according to one embodiment of the invention;

15 Figs. 2A-D show diagrammatic views of a housing that can be used in a solar-heating unit of the solar-heating system shown in Fig. 1 according to one embodiment of the invention;

Figs. 3A-B show perspective three-dimensional views of an inflatable solar collector that can be used in a solar-heating unit of the solar-heating system shown in
20 Fig. 1 according to one embodiment of the invention;

Figs. 4A-E schematically show representative flexible permeable layers that can be used to form a flexible permeable membrane for the inflatable solar collector of Fig. 3 according to various embodiments of the invention;

Figs. 5A-B show perspective three-dimensional blow-up views of various
25 airflow-distribution components that can be used in the inflatable solar collector of Fig. 3 according to one embodiment of the invention; and

Figs. 6A-B schematically show an airflow pattern in an inflatable solar collector of a solar-heating unit according to one embodiment of the invention.

DETAILED DESCRIPTION

Figs. 1A-B show diagrammatic views of a solar-heating system **100** having two substantially analogous solar-heating units **102a** and **102b** according to one embodiment of the invention. More specifically, Fig. 1A shows each of solar-heating units **102a** and **102b** deployed at the exterior of a structure (e.g., a house) **150**. Fig. 1B shows an enlarged cross-sectional view of a portion of solar-heating unit **102a**. Although each of solar-heating units **102a** and **102b** can be deployed at any suitable location adjacent to structure **150**, a location that can maximize the amount of solar energy collected by the solar-heating unit, such as a wall **152** with a southern exposure (in the Northern Hemisphere), is generally preferred.

Solar-heating unit **102** has a housing **110** and an inflatable solar collector **120** that is operatively connected to the housing. In general, housing **110** can be mounted in any suitable opening in a wall or roof of structure **150**. For example, housing **110a** of solar-heating unit **102a** rests on the lower windowsill of a first-floor window **154a** and is secured in place by a sliding sash **156**, which is pushed down against an upper side **112** of the housing (see Fig. 1B). Housing **110b** of solar-heating unit **102b** is similarly secured in a second-floor window **154b**.

Collector **120a** of solar-heating unit **102a** is deployed in a tilted position. More specifically, side rings or hooks **122** of collector **120a** are attached to tethers **118a**, with each of the tethers being tightly extended between a respective anchor **114** (see Fig. 1A) and a respective ring **108** of housing **110a** (see Fig. 1B). Anchors **114** are hammered into the ground to form a desired angle between tethers **118a** and the exterior surface of wall **152**, which causes collector **120a** to be oriented at that angle with respect to that surface.

Collector **120b** of solar-heating unit **102b** hangs vertically, under its own weight, from housing **110b** (Fig. 1A). Tethers **118b**, which are similar to tethers **118a**, are loosely connected to a wall hook **116**, e.g., to prevent excessive flapping of collector **120b** in wind gusts. One skilled in the art will understand that other suitable arrangements for mounting/securing housing **110** and/or collector **120** can similarly be used in other embodiments of the invention.

Inflatable solar collector **120** relies on internal air pressure to maintain its shape. When depressurized and deflated, collector **120** can be rolled up or folded to occupy a relatively small volume. In one embodiment, housing **110** has a compartment **140** that can be used to store collector **120** in a deflated state.

5 Housing **110** has an electrical air blower **130** (see Fig. 1B) whose power cord **132** can be plugged into an electrical outlet, e.g., inside structure **150**. In operation, air blower **130** draws air from the interior of structure **150** and directs the drawn air into collector **120**, thereby inflating it. The air flows through various chambers of collector **120** and is then exhausted back into the interior of structure **150**. When
10 collector **120** is exposed to solar radiation, the air flowing through the collector is heated up, which causes the heated air to transport the solar-generated heat from the collector to the interior of structure **150**, thereby providing space heating.

Figs. 2A-D show diagrammatic views of a housing **200** that can be used as housing **110** (Fig. 1) according to one embodiment of the invention. More
15 specifically, Fig. 2A shows a front view of housing **200**, which corresponds to a view, e.g., from the interior of structure **150** (also see Fig. 1B). Fig. 2B shows a top cross-sectional view of housing **200**. Figs. 2C-D show side cross-sectional views of housing **200** corresponding to planes CC and DD, respectively, shown in Fig. 2B.

Referring to Fig. 2A, a front panel **206** of housing **200** has an air-intake
20 register **202** for drawing air, e.g., from the interior of structure **150**, and an air-exhaust register **204** for returning the air heated in the solar collector (e.g., collector **120**, Fig. 1) back to the interior of the structure. In one embodiment, one or both of registers **202** and **204** have adjustable shutters **205** that can be used, e.g., to shut off the registers or to regulate the volume/direction of the air intake/exhaust.

25 Front panel **206** further has a control module **210** for controlling the operation of the solar-heating unit. Control module **210** has a temperature-control knob **212** that can be used to set a target room temperature. One or more temperature sensors (not explicitly shown in Fig. 2) located in housing **200** and/or in the solar collector coupled to the housing provide the corresponding temperature readings for control module
30 **210**. Based on the temperature setting and the temperature readings, control module **210** can turn ON and OFF an air blower or pump **230** located inside housing **200** (see

Figs. 2B-D). For example, control module **210** can turn ON air blower **230** when the temperature in the interior of structure **150** is lower than the temperature setting and the temperature inside collector **120**. Control module **210** can turn OFF air blower **230**, e.g., when (i) the temperature of the incoming air reaches the temperature setting
5 or (ii) the temperature of the outgoing air is lower than the temperature of the incoming air.

Referring to Figs. 2B-D, housing **200** has an intake chamber **222** that connects air-intake register **202** to an input port **228** of air blower **230**. In operation, air blower **230** draws air from intake chamber **222** and blows it into an air supply tube **232**
10 connected to an input port of the solar collector. The air pressure generated by air blower **230** pushes the air through air-supply tube **232** into the solar collector and forces the air to exhaust from an output port of the solar collector to housing **200** through an air-return tube **234**. An air exhaust chamber **224** of housing **200** then directs the air exhausted from air-return tube **234** to air-exhaust register **204**. In one
15 embodiment, each of tubes **232** and **234** has thermal insulation (not explicitly shown in Fig. 2) that inhibits heat exchange between the interior and exterior of the tube.

Referring to Figs. 2B and 2D, a top wall **242** of housing **200** has a movable lip **244** for engaging the sash of the window in which the housing is to be mounted. Housing **200** has a pair of springs **248**, each connected between a respective rod **246**
20 attached to lip **244** and an anchor beam **238** attached between the side walls of the housing. When housing **200** is placed on a windowsill, with front panel **206** facing the interior of the house, and the sash is pulled down against top wall **242**, springs **248** pull lip **244** against the interior side of the sash frame, thereby locking the housing in place.

25 Figs. 3A-B show perspective three-dimensional views of an inflatable solar collector **300** that can be used as collector **120** (Fig. 1) according to one embodiment of the invention. More specifically, Fig. 3A shows collector **300** in a deployed state, being operatively connected to a housing **310** that is installed in a sash window **354**. Housing **310** is generally analogous to housing **110** (Fig. 1) or housing **200** (Fig. 2).
30 Fig. 3B shows an enlarged view of an inner portion of collector **300**.

In a typical embodiment, collector **300** is constructed using flexible (e.g., fabric-like) sheets of material. As used herein, the term “flexible” refers to the inherent capability of an object or material to reversibly change its shape, e.g., to be folded and unfolded, to be rolled into a relatively tight roll and then unrolled back into a substantially flat sheet, and/or to be tightly packed into a relatively small volume and then unpacked without sustaining irreversible structural damage. The flexible sheets used in collector **300** are bonded together to form a plurality of chambers that can be inflated and deflated as appropriate or necessary, e.g., similar to an inflatable mattress or a pool raft. The description of the various chambers of collector **300** that is given below corresponds to a fully inflated state of the collector. In a deflated state, collector **300**, as whole, can be compacted, e.g., into a relatively tight roll whose volume does not exceed about 20%, 15%, or 10% of the volume of the collector in the fully inflated state.

Referring to Fig. 3A, collector **300** has a plurality of hooks **322** attached to a side seam of the collector. Hooks **322** can be used, e.g., as indicated in Fig. 3A, to attach collector **300** to tethers **318** in order to (i) adjust the orientation of the collector for optimum performance and/or (ii) secure the collector in windy conditions (also see Fig. 1). Collector **300** further has an optional protractor flap **324** that can be used in the process of orienting the collector at a desired tilt angle. The inner portion of collector **300** has an array **328** of parallel tubular chambers **330**. One function of tubular chambers **330** is to direct the air flow inside collector **300** so as to ensure optimal heat extraction from the collector. Another function of tubular chambers **330** is to create an internal support structure for collector **300**.

Now referring primarily to Fig. 3B, collector **300** has a flexible permeable membrane **336** that divides each tubular chamber **330** into an upper semi-cylindrical sub-chamber **334** and a lower semi-cylindrical sub-chamber **338**. If there is a pressure gradient across membrane **336**, then the membrane allows the air from one semi-cylindrical sub-chamber of tubular chamber **330** to leak or percolate into the other semi-cylindrical sub-chamber of that tubular chamber. The pertinent characteristics of membrane **336** are described in more detail below, primarily in reference to Fig. 4.

An upper wall **332** of semi-cylindrical sub-chamber **334** is made of a flexible airtight material that is transparent to visible light. Many commonly available polymeric materials, such as films made of vinyl, polyester, and/or polyethylene, have this characteristic. As a result, wall **332** serves as a glazing layer for membrane **336**,
5 which serves as an absorber of solar radiation. In one embodiment, a single sheet of flexible airtight material is used to form walls **332** of all sub-chambers **334**. More specifically, this single sheet of material is pleated and attached to membrane **336** as indicated in Fig. 3B.

A lower wall **340** of semi-cylindrical sub-chamber **338** is also airtight and
10 comprises a layer of material capable of reflecting back toward membrane **336** (i) the IR radiation that is emitted by the heated membrane and/or (ii) the visible light transmitted by the membrane. In the inflated state of collector **300**, walls **340** form an array of crude parabolic mirrors. These mirrors help to concentrate the reflected IR radiation and visible light onto membrane **336**, improve heat transfer from the
15 membrane to the air stream, reduce heat losses in the collector, and increase the efficiency of solar-energy conversion into usable heat. Alternatively or in addition, wall **340** comprises a thermally insulating layer that inhibits heat exchange across the wall. Similar to walls **332**, walls **340** of all sub-chambers **338** can be formed from a single sheet of flexible airtight material, pleated and attached to membrane **336**.

Referring back to Fig. 3A, collector **300** has an outer airtight shell **342** that
20 encloses array **328** of tubular chambers **330**. When collector **300** is inflated, shell **342** creates a cushion of substantially still air around array **328**, which helps to further reduce the unwanted heat losses from the array. In addition, shell **342** functions as an adjustable vessel for conveniently handling, positioning, and protecting tubular
25 chambers **330**. An upper wall **344** of shell **342** is made of a flexible material that is transparent to visible light, which can be the same as the material of wall **332**. In one embodiment, shell **342** has a wicking patch and a water-drain valve (neither explicitly shown) for removing condensates from the interior of collector **300**.

In a representative embodiment, membrane **336** serves as a glazed, transpired
30 absorber of solar radiation, with one or both of walls **332** and **344** providing the glazing for the membrane. As used herein the term “transpired absorber” means that

the corresponding entity absorbs a significant portion (e.g., more than 50%) of solar radiation impinging thereupon and allows an air stream to pass therethrough. In an alternative embodiment, in addition to serving as a transpired absorber, membrane **336** also serves as an air filter that captures allergens and/or particulate matter, e.g., particles having a size greater than about 10 μm and smaller than about 100 μm . In various embodiments, membrane **336** can have (i) a thickness between about 1 and 10 mm and (ii) a porosity, p , greater than about 50% or even greater than about 80%. Herein, porosity p is defined as a ratio of the pore volume within a square inch of membrane **336** to the total volume occupied by that square inch.

10 Figs. 4A-E show representative flexible permeable layers **410**, **420**, **430**, **440**, and **450** that can be used to form membrane **336** according to various embodiments of the invention. In general, membrane **336** can have one or more layers selected from layers **410-450**. In certain embodiments, membrane **336** might contain two or more layers of the same type separated by at least one layer of a different type. For
15 example, in one embodiment, membrane **336** might have one instance of layer **450** sandwiched between two instances of layer **430**. One skilled in the art will understand that, in various embodiments, other layers of various suitable materials can be used in addition to or instead of layers **410-450** to form membrane **336**.

Referring to Fig. 4A, layer **410** comprises a woven fabric or cloth. As used
20 herein, the term “woven fabric” refers to a sheet of material produced by interlacing two or more sets of yarns, fibers, threads, strings, and/or filaments, wherein the elements within the same set are substantially parallel to each other, and the elements from two different sets are oriented with respect to each other at a predetermined angle, e.g., 90 degrees. In various embodiments, layer **410** might have fibers with a
25 diameter between about 0.1 μm and about 100 μm , or a mixture of fibers of different diameters.

Referring to Fig. 4B, layer **420** comprises a sheet of porous permeable polymer. More specifically, layer **420** comprises a polymeric matrix having a regular or irregular network of interconnected channels, conduits, pores, voids, and cavities
30 that allow air to percolate through the layer. Representative examples of porous permeable polymers are sponges and porous solidified foams.

Referring to Fig. 4C, layer **430** comprises a sheet of pin-perforated material. In various embodiments, the perforation holes can be arranged in various patterns, regular or irregular, and have the same or different diameters. The material can be a solid polymer or polymeric foam, a woven or non-woven cloth, etc.

5 Referring to Fig. 4D, layer **440** comprises a non-woven fabric. As used herein, the term “non-woven fabric” refers to a sheet of fabric-like material made from long fibers or filaments that are bonded together by chemical, mechanical, thermal, or solvent treatment, but not by weaving or knitting. A representative example of a non-woven fabric is felt. In a representative embodiment, layer **440** can be made by
10 mechanically entangling various fibers or by pulverizing molten plastic or plastic film. In various embodiments, layer **440** might have fibers with a diameter between about 0.1 μm and about 100 μm , or a mixture of fibers of different diameters.

Referring to Fig. 4E, layer **450** comprises a sheet of permeable composite material. As used herein the term “composite material” refers to a material made from
15 two or more constituent materials having significantly different physical and/or chemical properties, which constituent materials remain separate and distinct on a macroscopic level within the finished structure. In a representative embodiment shown in Fig. 4E, layer **450** is a sheet of felt impregnated with particles **452** of activated carbon. When an air stream goes through layer **450**, particles **452** absorb
20 and/or adsorb allergens, pathogens, and/or odor-causing pollutants, thereby aiding the air-filtering function of membrane **336**.

Figs. 5A-B show perspective three-dimensional blow-up views of various airflow-distribution components that can be used in collector **300** (Fig. 3) according to one embodiment of the invention. More specifically, Fig. 5A shows a blow-up view,
25 in which an end panel **510** is detached from the front end of array **328** of parallel tubular chambers **330** (also see Fig. 3B). Fig. 5B shows a blow-up view, in which an end panel **540** is detached from the back end of array **328**.

Referring to Fig. 5A, end panel **510** has an air-distribution manifold **512** and an air-exhaust manifold **522**. Air-distribution manifold **512** has an input tube **532** that
30 can be connected, e.g., to tube **232** of housing **200** (see Fig. 2). Air-distribution manifold **512** also has an output port **514** that supplies air to and maintains air

pressure in outer shell **342** of collector **300** (see Fig. 3A). More specifically, when collector **300** is being deployed, port **514** supplies air for the inflation of shell **342**. After shell **342** is fully inflated and there is no pressure differential between air-distribution manifold **512** and the shell, port **514** seals off the shell to maintain the
5 corresponding air pressure therein. Air-exhaust manifold **522** has an output tube **534** that can be connected, e.g., to tube **234** of housing **200** (see Fig. 2).

End panel **510** has an airtight barrier **536** that physically separates manifolds **512** and **522** from one another, while serving as a shared wall for these manifolds. When end panel **510** is attached to the front end of array **328**, barrier **536** is mated
10 with membrane **336**, thereby blocking direct airflow between manifolds **512** and **522**. The air stream entering air-distribution manifold **512** from input tube **532** is divided and distributed substantially evenly between different semi-cylindrical sub-chambers **334** of array **328**. Similarly, the air streams received by air-exhaust manifold **522** from different semi-cylindrical sub-chambers **338** of array **328** are merged and
15 directed into output tube **534**. As used herein, the term “substantially evenly” means that the differences in air flux between different sub-chambers **334** does not exceed, e.g., 15%, 10%, or even 5%.

Referring to Fig. 5B, end panel **540** has an array of caps **542**. When end panel **540** is attached to the back end of array **328**, each cap **542** forms a terminal wall that
20 seals off the corresponding end of tubular chamber **330**. Note that, in each tubular chamber **330** near cap **542**, membrane **336** has an air-release port **538**. In operation, air-release port **538** injects a small jet of air into the corresponding semi-cylindrical sub-chamber **338** to increase airflow near the back end of array **328**. The increase in the airflow near the back end of array **328** is beneficial because it decreases variations
25 in heat exchange rates across the length of membrane **336**, e.g., a difference between the rates at the front and back ends of the array, thereby improving the overall heat-transfer efficiency.

Figs. 6A-B schematically show an airflow pattern in a solar-heating unit **600** according to one embodiment of the invention. More specifically, Figs. 6A and 6B
30 shows top and bottom views, respectively, of a collector **620** used in solar-heating unit **600**. Collector **620** comprises array **328** connected between end panels **510** and **540**

(see Fig. 5). Solar-heating unit **600** also has housing **200** (see Fig. 2), to which collector **620** is connected. Different arrows in Figs. 6A-B indicate the volumes and directions of local air fluxes throughout collector **620**. More specifically, the length and direction of the arrow indicate the volume and direction, respectively, of the air flux.

Referring to Fig. 6A, the air stream generated by air blower **230** in housing **200** enters, through tubes **232** and **532**, air-distribution manifold **512** of end panel **510**. Manifold **512** distributes the received air stream substantially evenly between different sub-chambers **334** of array **328**. The air flux in each sub-chamber **334** gradually decreases as the air moves toward end panel **540** because the air percolates through membrane **336** into the corresponding sub-chamber **338**. In one embodiment, the combined length of tubes **232** and **532** is smaller than about 1 m, or even smaller than about 0.5 m. The combined length of tubes **234** and **534** is substantially the same as the combined length of tubes **232** and **532**.

Referring to Fig. 6B, the air flux in each sub-chamber **338** gradually increases as the air moves from end panel **540** toward air-exhaust manifold **522** of end panel **510** due to the additional air percolating through membrane **336** from the corresponding sub-chamber **334**. Manifold **522** collects the air received from different sub-chambers **338**. The collected air exits collector **620** through tubes **534** and **234**.

The airflow pattern indicated in Fig. 6 has certain advantages over other possible airflow patterns when collector **620** is deployed so that end panel **510** is at a higher elevation above ground than end panel **540**. More specifically, the downdraft flow of the unheated air in sub-chambers **334** opposes the natural tendency of heated air to rise due to its relatively high buoyancy. As a result, the heated air is forced into sub-chambers **338**, which have lower heat losses than sub-chambers **334** due to the presence of IR-reflecting and/or thermally insulating layers in walls **340** (see Fig. 3B).

In addition, substantially all air flowing through collector **620** comes into contact with the underside of membrane **336**, which is heated by the solar light reflected by the crude parabolic mirrors formed by walls **340**, thereby extracting additional heat from the membrane. Advantageously, due to all these features of collector **620**, the

efficiency of solar-energy conversion into usable heat in solar-heating unit **600** is relatively high in comparison to other flat-panel air-heating solar collectors.

Inflatable solar collectors according to various embodiments of the invention offer one or more of the following advantages over comparable prior-art devices. An
5 inflatable solar collector according to a representative embodiment of the invention can be manufactured using inexpensive, durable, readily available materials. The collector is relatively easy to deploy and remove as needed. In the collapsed state, the collector occupies a very small volume and can be stored in a storage compartment of the housing, which houses the air blower and easy-to-operate temperature-control
10 circuitry. The collector is easy to adjust to the surrounding terrain and secure at a desired tilt angle. The collector is inherently resilient to impact and shock. Its smooth exterior shell sheds precipitation and is easy to clean. In addition to supplying heated air, certain embodiments of the collector can also serve as air filters.

As used in this specification, the term “inflatable” refers to an object that is
15 capable of (i) swelling or distending with air or gas, (ii) being puffed up, and/or (iii) expanding or increasing significantly in size when pumped with air or gas.

While this invention has been described with reference to illustrative embodiments, this description is not intended to be construed in a limiting sense. One of ordinary skill in the art will understand that airflow patterns that differ from the
20 pattern indicated in Fig. 6 can also be used in various embodiments of the invention. Various dyes and additives can be used to optimize the color and/or absorption spectrum of membrane **336** for optimal absorption of solar radiation. Although various embodiments of the invention have been described in reference to tubular chambers **330** having round or circular cross-sections, tubular chambers having other
25 cross-section geometries, e.g., rectangular or rectilinear, can similarly be used. Also, the tubular chambers can be designed and arranged so that they are not straight and/or parallel to one another. Various modifications of the described embodiments, as well as other embodiments of the invention, which are apparent to persons skilled in the art to which the invention pertains are deemed to lie within the principle and scope of the
30 invention as expressed in the following claims.

Unless explicitly stated otherwise, each numerical value and range should be interpreted as being approximate as if the word "about" or "approximately" preceded the value of the value or range.

Although the elements in the following method claims, if any, are recited in a particular sequence with corresponding labeling, unless the claim recitations
5 otherwise imply a particular sequence for implementing some or all of those elements, those elements are not necessarily intended to be limited to being implemented in that particular sequence.

Reference herein to "one embodiment" or "an embodiment" means that a particular feature, structure, or characteristic described in connection with the
10 embodiment can be included in at least one embodiment of the invention. The appearances of the phrase "in one embodiment" in various places in the specification are not necessarily all referring to the same embodiment, nor are separate or alternative embodiments necessarily mutually exclusive of other embodiments. The
15 same applies to the term "implementation."

Also for purposes of this description, the terms "couple," "coupling," "coupled," "connect," "connecting," or "connected" refer to any manner known in the art or later developed in which energy or matter is allowed to be transferred between two or more elements, and the interposition of one or more additional elements is
20 contemplated, although not required. Conversely, the terms "directly coupled," "directly connected," etc., imply the absence of such additional elements.

The use of terms such as height, length, width, top, bottom, is strictly to facilitate the description of the invention and is not intended to limit the invention to a specific orientation. For example, height does not imply only a vertical rise
25 limitation, but is used to identify one of the three dimensions of a three dimensional structure as shown in the figures. The same applies to other above-indicated terms.

The description and drawings merely illustrate the principles of the invention. It will thus be appreciated that those of ordinary skill in the art will be able to devise various arrangements that, although not explicitly described or shown herein, embody
30 the principles of the invention and are included within its spirit and scope.

Furthermore, all examples recited herein are principally intended expressly to be only

for pedagogical purposes to aid the reader in understanding the principles of the invention and the concepts contributed by the inventor(s) to furthering the art, and are to be construed as being without limitation to such specifically recited examples and conditions. Moreover, all statements herein reciting principles, aspects, and

5 embodiments of the invention, as well as specific examples thereof, are intended to encompass equivalents thereof.

CLAIMS

I claim:

1. A system, comprising:
 - a housing having an air-intake register and an air-exhaust register; and
 - 5 an inflatable solar collector operatively connectable to the housing, wherein:
 - the housing comprises an air blower configured to draw air through the air-intake register and direct the drawn air into a tube connectable to the inflatable solar collector;
 - the inflatable solar collector comprises a first chamber and a second chamber
 - 10 separated by a flexible permeable membrane; and
 - in operation, air pressure generated by the air blower causes the drawn air to flow through the tube into the first chamber, percolate through the permeable membrane into the second chamber, and exhaust from the second chamber through the air-exhaust register.
- 15 2. The system of claim 1, wherein the housing is adapted to be mounted in an opening of a structure having an interior and an exterior so that (i) the air-intake register and the air-exhaust register are located in the interior and (ii) the inflatable solar collector is located in the exterior.
- 20 3. The system of claim 2, wherein:
 - the opening is a sash window; and
 - the housing comprises a movable lip for engaging a sash of the sash window.
- 25 4. The system of claim 2, wherein, if the housing is mounted in the opening, then the air blower is located in the exterior.
5. The system of claim 1, wherein the housing comprises a compartment for storing the inflatable solar collector in a deflated state.

6. The system of claim 1, wherein the inflatable solar collector comprises means for engaging one or more tethers to secure the inflatable solar collector in a desired position.

5 7. The system of claim 1, wherein the tube is shorter than about 1 m.

8. The system of claim 1, wherein:
the permeable membrane is adapted to serve as a transpired absorber of solar radiation; and

10 a flexible wall of the first chamber is adapted to serve as a glazing layer for said absorber.

9. The system of claim 1, wherein:
the permeable membrane is adapted to transmit at least a portion of solar radiation
15 impinging thereupon; and
a wall of the second chamber comprises a reflective layer adapted to reflect said portion back toward the permeable membrane.

10. The system of claim 1, wherein:
20 the inflatable solar collector comprises a plurality of tubular chambers, each divided by the permeable membrane into a respective first sub-chamber and a respective second sub-chamber;
the first sub-chamber is part of the first chamber; and
the second sub-chamber is part of the second chamber.

25 11. The system of claim 10, wherein:
in an inflated state of the inflatable solar collector, the second sub-chambers are semi-cylindrical sub-chambers; and
walls of said semi-cylindrical sub-chambers form an array of crude parabolic
30 mirrors adapted to reflect radiation transmitted or emitted by the permeable membrane back toward the membrane.

12. The system of claim 10, wherein the inflatable solar collector comprises an air-distribution manifold adapted to distribute a stream of air received through the tube substantially evenly between the first sub-chambers.

5

13. The system of claim 10, wherein the inflatable solar collector comprises an end panel having (i) an air-distribution manifold adapted to distribute a stream of air received through the tube between the first sub-chambers and (ii) an air-exhaust manifold adapted to collect air from the second sub-chambers and direct the collected
10 air toward the exhaust register, wherein the end panel comprises an airtight barrier that serves as a shared wall for said manifolds.

14. The system of claim 13, wherein an edge of the barrier is mated with an edge of the permeable membrane.

15

15. The system of claim 10, wherein the tubular chambers are parallel to each other.

16. The system of claim 10, wherein the inflatable solar collector comprises an
20 inflatable shell that encloses the plurality of tubular chambers.

17. The system of claim 1, wherein, in operation, the permeable membrane serves as an air filter adapted to perform one or more of the following:

- 25 (i) remove particles having a size between about 10 μm and about 100 μm from the drawn air;
- (ii) remove an odor-causing pollutant from the drawn air; and
- (iii) remove an allergen or a pathogen from the drawn air.

18. The system of claim 1, wherein the permeable membrane comprises one or
30 more layers selected from a set consisting of:

- (i) a woven fabric;

- (ii) a sheet of porous permeable polymer;
- (iii) a sheet of pin-perforated material;
- (iv) a permeable non-woven fabric; and
- (v) a sheet of permeable composite material.

5

19. The system of claim 1, further comprising:
a control module; and

one or more temperature sensors operatively coupled to the control module to
provide to the control module one or more temperature readings from corresponding
10 locations in the system, wherein the control module is adapted to turn ON and OFF
the air blower based on said one or more temperature readings.

20. The system of claim 1, wherein the inflatable solar collector is reversibly
compactable to occupy a volume that is smaller than about 15% of the volume of said
15 collector in a fully inflated state.

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Fig. 1A

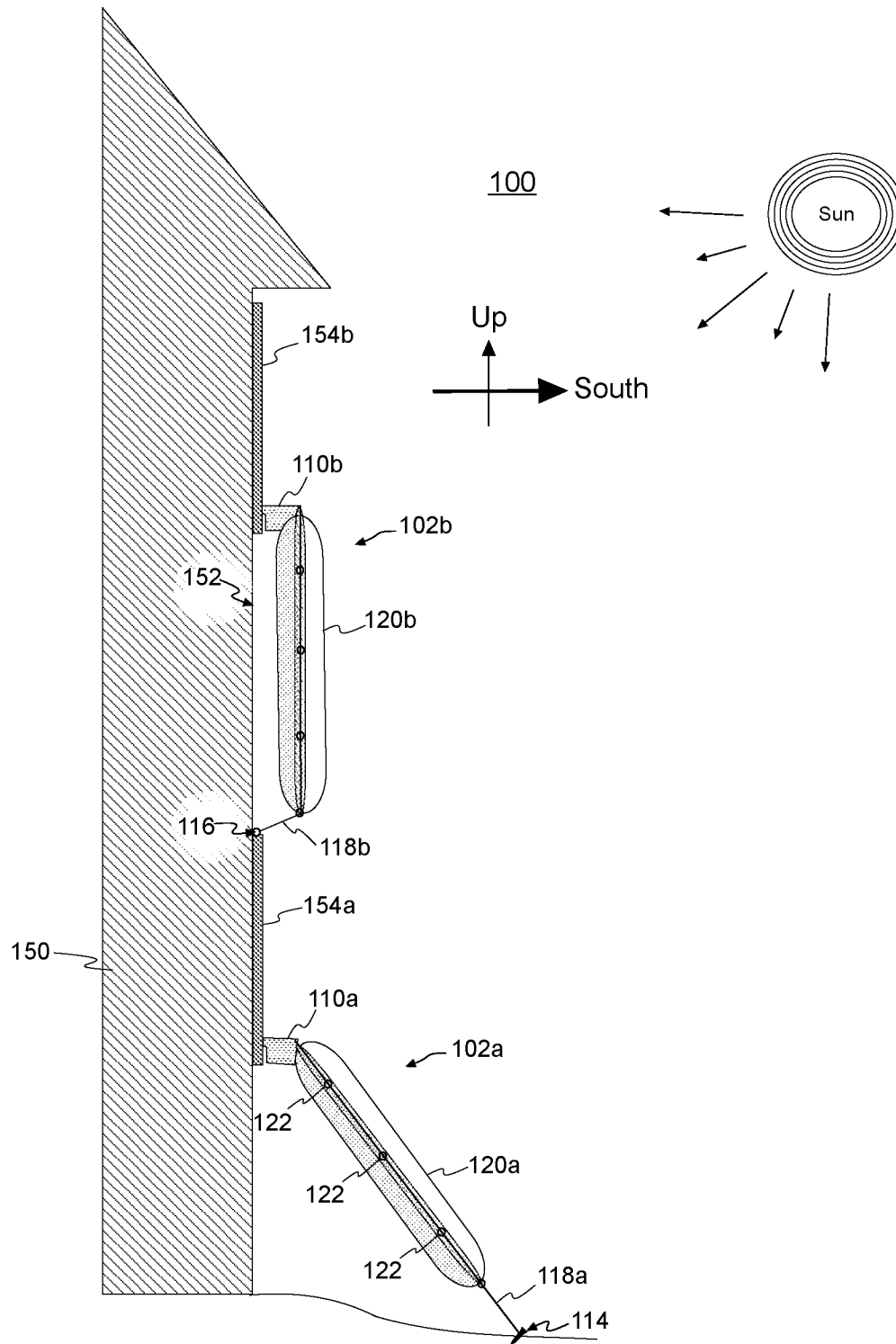


Fig. 1B

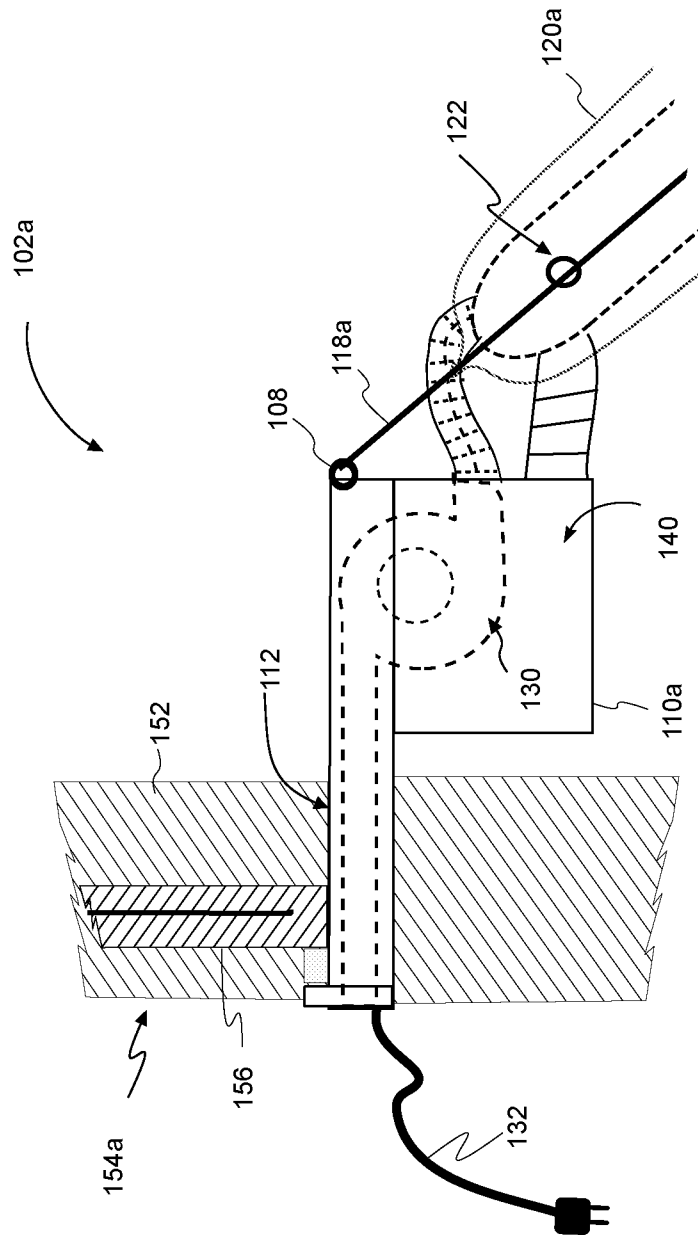


Fig. 2A

206

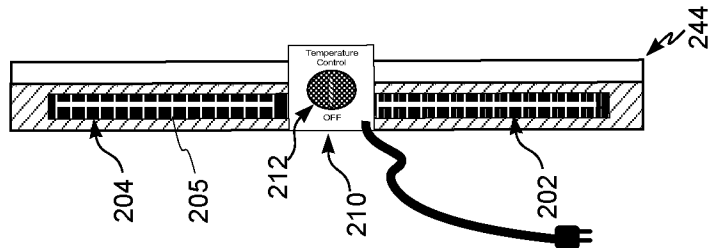


Fig. 2B

200

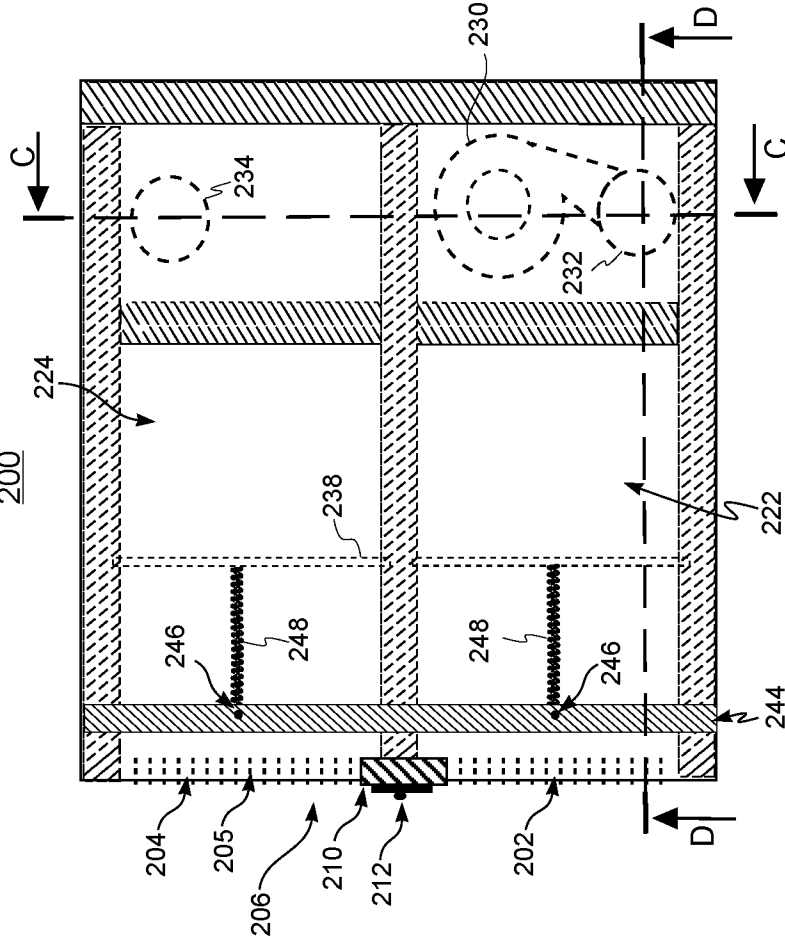


Fig. 2C

CC

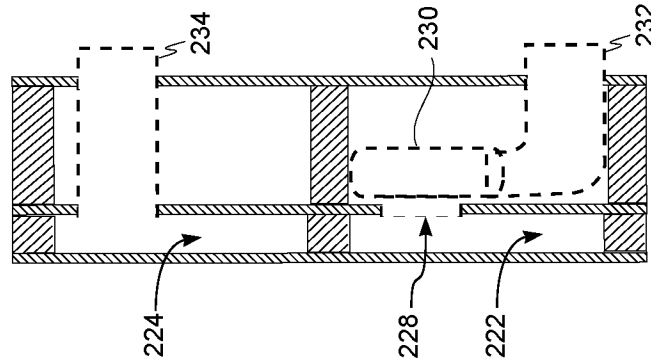


Fig. 2D

DD

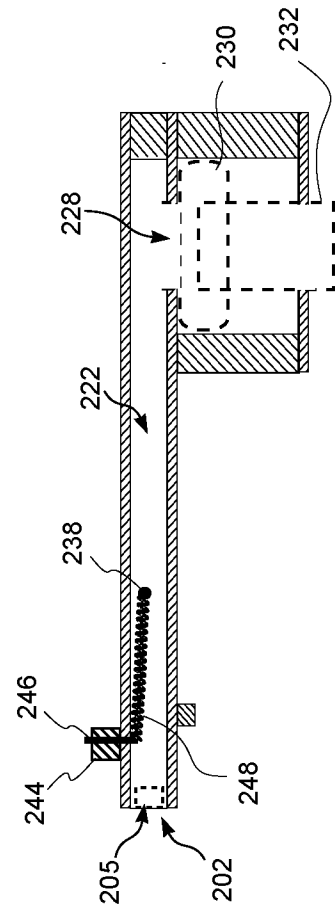


Fig. 3A

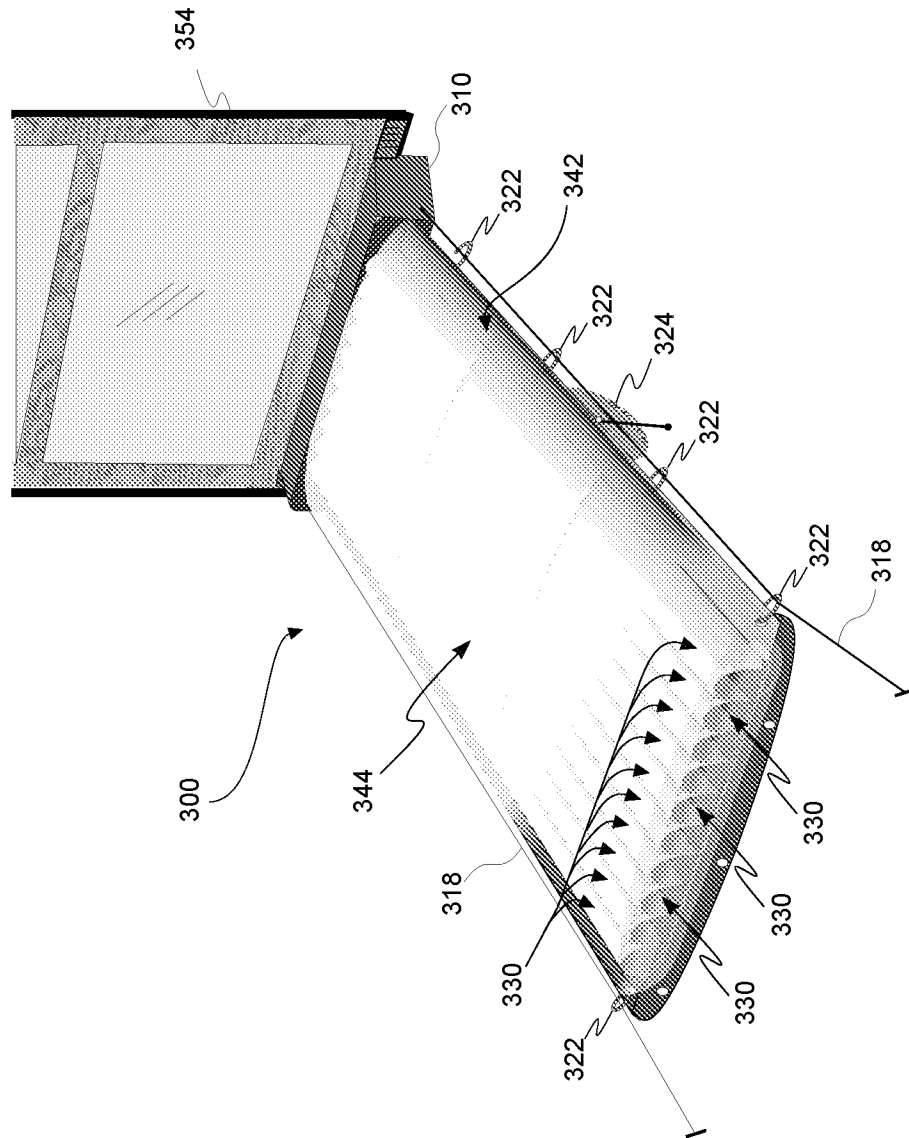


Fig. 3B

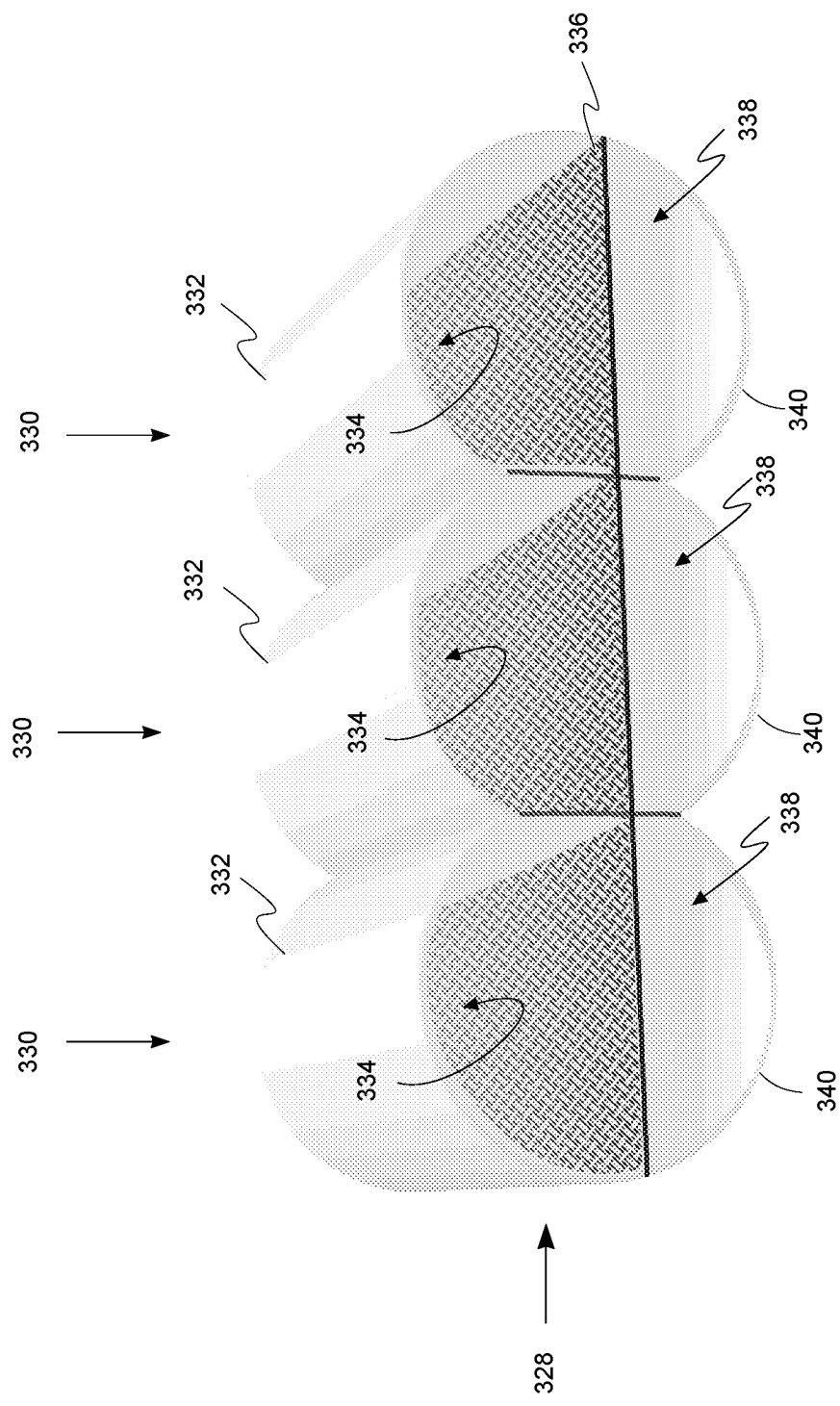


Fig. 4A

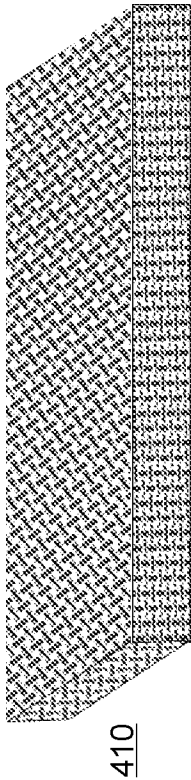


Fig. 4B

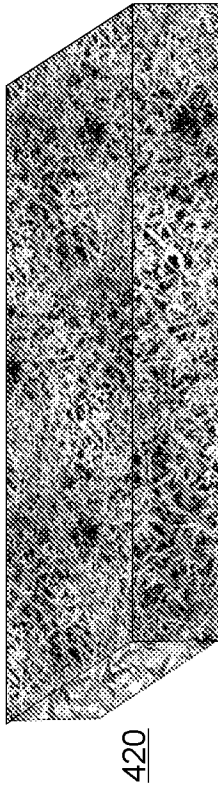


Fig. 4C

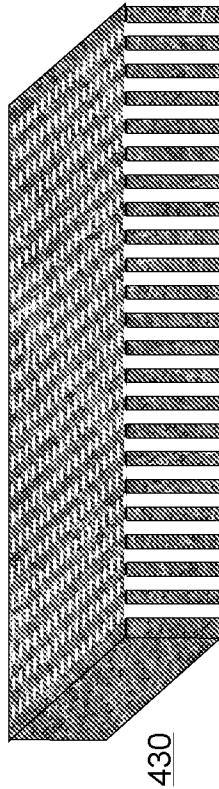


Fig. 4D

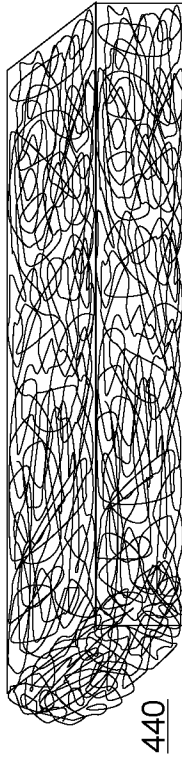
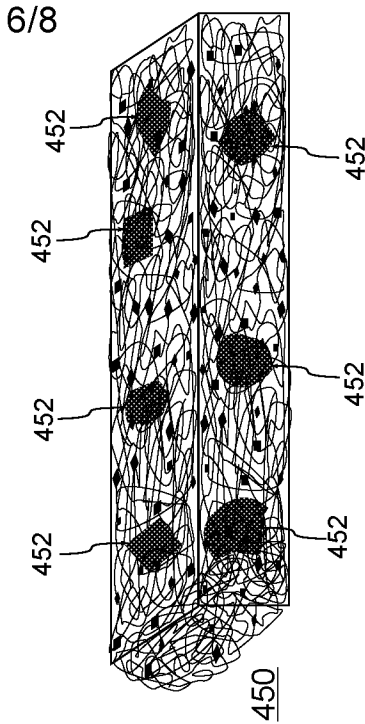


Fig. 4E



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Fig. 5B

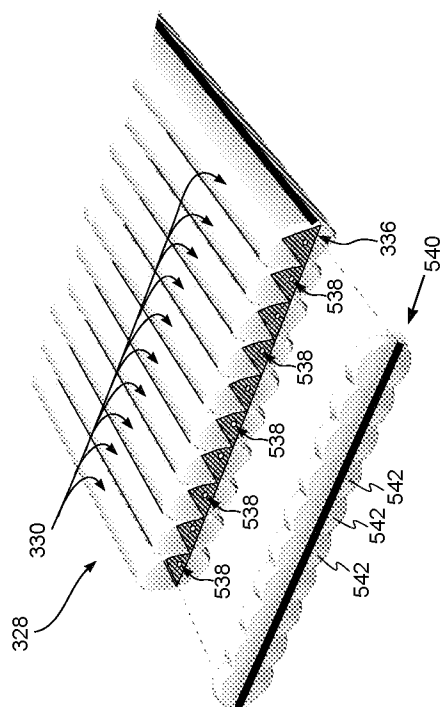


Fig. 5A

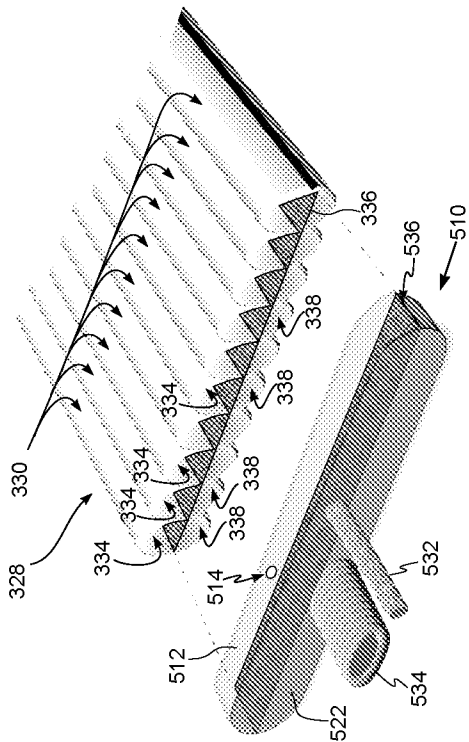


Fig. 6B

600

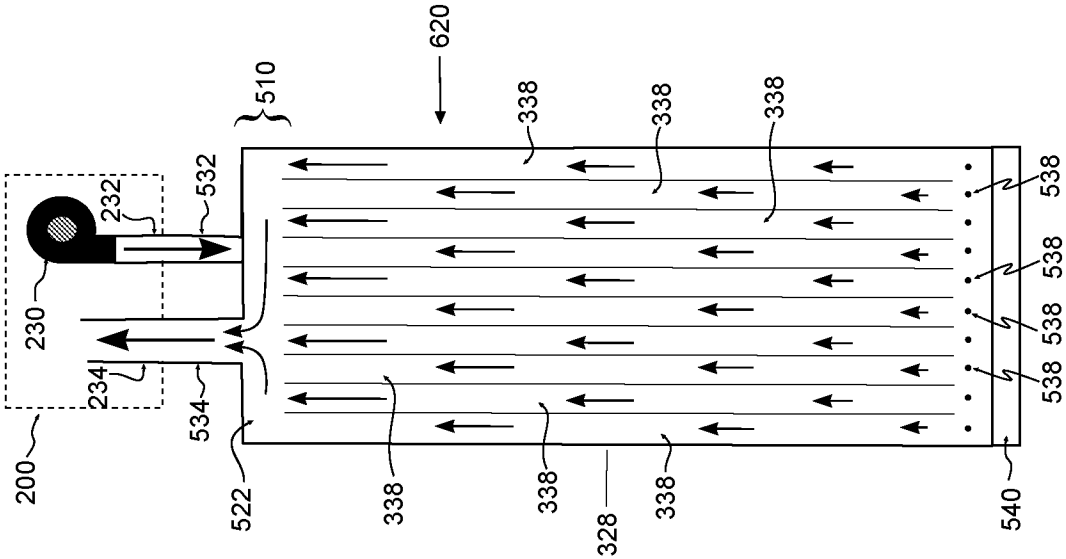


Fig. 6A

600

