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(54) **Title**: TEMPERATURE REGULATION SYSTEM AND METHOD

(57) **Abstract**: An installation in which the temperature within a building is regulated by circulating water from, or through a heat exchanger which is in thermal communication with, a heat sink such as a water tank, underground water source, body of water or tank of phase changing material, through window units or through a heat source which is in thermal communication with a heater, between the window panes, to cool or heat the interior of the building.

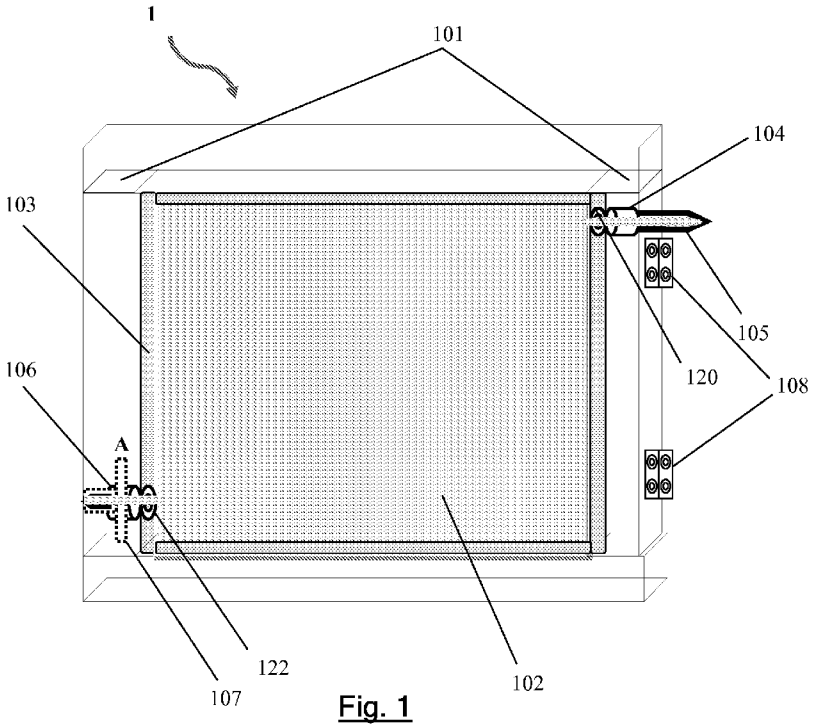


Fig. 1

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Temperature Regulation System and Method

Field of the invention

The invention relates to systems and methods for regulating the temperature within the interior of buildings.

Background to the invention

In many countries in the world with hot climates, maintaining a comfortable temperature within a room or building in an affordable and efficient way presents a substantial challenge. Existing methods of regulating the temperature of a room or building include providing air-conditioning units and fans. Air-conditioning units are expensive to run, fans are inefficient and both consume electricity. In many areas of the world where indoor temperature control is needed the most, for example, in remote tropical areas where infrastructure may be poor, there may not be an adequate electricity supply readily available.

The invention aims to provide a system for regulating the temperature of a room, or a plurality of rooms, utilising resources more readily available in many countries with hot climates, such as wind and solar energy or underground water sources.

One means by which a room or building is heated is by the sun shining through the windows and being absorbed within the room, thereby imparting the suns thermal

energy to the room. For example, a single window can increase the temperature within a room by up to 15°. Conventional means for cooling a room or building, such as those mentioned above, do not attempt to prevent or reduce this source of room/building heating. Therefore, a means for cooling a room or building that actively reduces the extent that external sources of heat, primarily the sun, heat the room or building would provide a benefit.

Thus, in some embodiments, the invention aims to reduce solar heating of the living space within a building.

Another method of temperature regulation is to actively heat the room or building when the interior temperature becomes uncomfortably low, commonly due to heat loss to the exterior environment. A primary source of heat loss for a building is through the buildings windows and roof. Conventional means for building heating include central heating systems whereby water is heated and circulated around a building through one or more heat radiating bodies (for example radiators). Such heat radiating bodies may be located below windows to heat air that is cooled by thermal contact with said windows.

However, in many areas of the world both extremes are experienced. For example, during the summer months a room or building may become uncomfortably hot and the winter months a room or building may become uncomfortably cold. Accordingly, it would be advantageous to provide a system operable to regulate the temperature of a room or building in circumstances of both extremes of hot and cold.

Therefore, in some embodiments the invention further aims to provide a system that can regulate the temperature within a room or building.

Summary of the invention

According to a first aspect of the present invention there is provided a unit for location within a window frame, the unit comprising at least two transparent sheets and a support which extends around and retains the transparent sheets and defines a water retaining volume therebetween, and first and second apertures through the support to enable the ingress and egress of water to and from the water retaining volume.

The invention extends in a second aspect to a kit comprising a unit according to the first aspect of the invention and a first water guide for mounting to a window frame to cooperate with the first aperture to guide water into the water retaining volume through the first aperture.

In a third aspect, the invention extends to a window assembly comprising a window frame for mounting in an aperture through a wall, and a unit according to the first aspect of the present invention adapted to be retained by the window frame, wherein the window frame comprises a first water guide operable to guide water through the first aperture of the unit in at least one configuration of the window assembly to allow water to flow into the water retaining volume through the first aperture.

According to a fourth aspect of the invention there is provided an installation comprising a building, the building comprising a plurality of walls, at least one wall having an aperture therethrough with a window assembly according to the third aspect of the invention fitted thereto, the window frame being fitted to the aperture, a unit according to the first aspect of the present invention retained by the said window frame, and a first water guide fitted in or to the window frame and operable to guide water through the first aperture of the unit in at least one configuration of the window assembly to allow water to flow into the water retaining volume through the first aperture. Preferably, the walls have a plurality of said apertures therethrough with said window frames therein. Preferably, at least one unit according to the first aspect of the present invention is retained in an aperture through an exterior wall of the building so that sunlight passes through the unit into a room within the building. The building may comprise a plurality of said window assemblies according to the third aspect of the invention. Features discussed herein in relation to individual window assemblies and units may apply to some or each of the plurality of window assemblies.

Optional features of the unit, the kit, the window assembly and the installation will now be discussed.

Typically, a second water guide is provided, for example, within the window frame, for receiving water from the second aperture of the unit. Thus, a path may be provided for water to flow into the water retaining volume through the first water guide, into the first aperture, and out of the second aperture, through the second water guide, in at least one configuration of the window assembly. Typically, the unit is mounted within

the window frame such that the second aperture is below the first aperture, and the second water guide is below the first water guide.

The installation may further comprise a water tank, or water source, and one or more conduits to conduct water from the water tank, or water source, to a said first water guide. Typically also one or more conduits conduct water from a said second water guide to the water tank or water source to enable water to be circulated from the water tank or water source through one or more said units. The water tank or water source is preferably covered or underground. The water source may be a well. The water tank or water source typically comprises water which is cooler than mean ambient air temperature within the building during daylight hours. However, a water tank may be located at ground level or above ground, in which case it should be thermally insulated.

Thus, the installation may circulate water from a water tank or water source through one or more said units to cool the interior of a building and to carry away heat arising from the absorption of solar radiation. Accordingly, the invention provides energy efficient cooling of buildings. Some infra-red light may be absorbed by the flowing water. Some infra-red light may be absorbed by the transparent sheets and conducted to the flowing water. Some infra-red light may be absorbed by air within the building and transported to the flowing water by conduction, radiation and/or convection.

The installation may comprise a closed loop circuit extending through one or more said units and a heat exchanger in thermal communication with a heat sink. Water may be directed around the said closed loop circuit in use. The heat sink may be a body of water, for example, a water tank or an underground water source, such as a well, a river or an ocean. The heat sink may be a phase changing material. The phase changing material may be located underground, for example in an underground tank. Thus, water may be circulated through one or more serial units and a heat exchanger in thermal communication with a tank of phase change material. Thus, water within the closed loop circuit may be reused while avoiding or minimising the efflux of water which has been heated within the window units into the water source.

The installation may comprise a further heat exchanger in thermal communication with a heat storage means, such as a phase changing material, for example paraffin

or fatty acids, wherein water heated within the water retaining volumes of the units transfers thermal energy to the phase changing material for storage for future use, such as domestic hot water. By a phase changing material we refer to a material with a high heat of fusion operable to store or release energy upon melting or solidifying respectively. The phase changing material should have a phase transition temperature within the range of temperatures expected at the location where it is or is to be installed. Thus, the phase changing material should change phase in ordinary use, thereby storing and subsequently releasing heat.

The phase changing material may be in thermal communication with a room within the building to exchange heat with both water in the conduits which conduct water through the units, and a room having at least one said unit. The phase change material may have a phase transition temperature within the normal temperature variation range of the room during at least one season.

An infra-red absorbing additive may be added to water within the closed loop circuit. The infra-red absorbing additive may, for example, comprise nano-particles which disperse within the water, forming a colloid. The nano-particles may comprise aluminium oxide or copper oxide particles. The nano-particles may further comprise a mixture of materials.

Preferably, water flowing through the water retaining volumes of units comprises an anti-bacterial additive or algicide to prevent bacterial build up or algae formation within the units. Alternatively, the circuit may comprise an ultra-violet radiation emitter operable to expose water flowing through the closed loop circuit to ultra-violet radiation such that bacteria within the water may be killed.

The installation may comprise a closed loop circuit extending through one or more said units and a heat exchanger in thermal communication with a heat source. Water may be directed around the said closed loop circuit in use. The heat exchanger may comprise or consist of a pipe or tank through which the water flows. The heat source may be a heating means, for example, a heater, such as a boiler, or a thermal spring. The heat source may be a body of phase changing material operable to receive and store electromagnetic radiation from the sun (for example, through a window or solar concentrator) and to change phase in sufficiently bright sunlight to store energy. The heat source is preferably operable between an operating mode where it heats water within the circuit and a non-operating mode.

Alternatively, the installation may comprise one or more said units, a heat exchanger in thermal communication with a heat source; a water tank, water source or heat exchanger in thermal communication with a heat sink; conduits operable to allow the flow of water through the installation and directing means (for example, a flow regulator) operable to direct the flow of water to either the heat exchanger or to the water tank, water source or heat exchanger in thermal communication with a heat sink.

The closed loop circuit may pass through both a heat exchanger in thermal communication with a heat source comprising a body of phase changing material (eg. operable to receive and store electromagnetic radiation from the sun) located above ground and a heat exchange in thermal communication with a heat sink comprising body of phase changing material located underground. In a cooling mode, water is circulated through the underground heat exchanger and not the said above ground heat exchanger, and one or more units. In a heating mode, water circulating through the units and at least the above ground heat exchanger (and typically not the underground heat exchanger). The directing means may comprise one or more valves.

Therefore, the installation may provide cooling of the building when the ambient air temperature within the building is high, or provide heating of the building when the ambient air temperature within the building is low.

Typically, the unit is a window unit and the transparent sheets are rigid, for example, transparent window panes. Rigid transparent window panes may, for example, be made of glass, or rigid plastics material. The rigid transparent window panes are typically spaced apart and preferably parallel. In this case, the window unit typically occludes a window frame, either on its own or together with one or more further window units, which further window units may be single, double or triple glazed window units (i.e. conventional window units) or window units according to the invention.

However, in some embodiments, the unit is flexible and the transparent sheets are flexible, for example, the transparent sheets may be made of flexible plastics material. In this case, the unit may be a window blind. The window blind may be attached to a window frame on the outside or inside of one or more window units.

The window blind may be rollable to form a deployable blind which may, for example, be attached to a window frame in use. The transparent sheets are preferably spaced apart when the window blind is in use. Further, a window blind may not prevent air flow through the window frame but be provided in addition to one or more rigid window units which substantially prevent air flow through the window frame when the window is closed.

Water conduits are typically provided to conduct water to the first water guide and to receive water from the second water guide. Within a building, a number of window assemblies may be connected in series, with a water conduit extending from the second water guide of a first window assembly to the first water guide of a second window assembly, or in parallel, with a first common water distribution conduit in communication with the first water guides of a plurality of window assemblies and a second common water distribution conduit in communication with the second water guides of a plurality of window assemblies.

As discussed further below, the water conduits typically communicate with an underground water tank or water source or are circulated through a heat exchanger in thermal communication with a heat sink, such as a water tank or water source or tank of phase changing material. Water from the underground water tank, water source or heat exchanger in thermal communication with a heat sink is typically circulated through one or more units to cool the interior of the building and to carry away heat received by adsorption or conduction.

A water tank may be located at or above ground level and, in this case, the water tank should be thermally insulated. The water tank may be supplied by a water mains system. Optionally, the water source may be a water mains system.

The unit may be operable between an open configuration in which the first and/or second apertures are not in fluid communication with the first and/or second water guides respectively, and in which the window assembly is open to allow air to pass through the area bounded by the window frame, and a closed operating configuration in which the first or second apertures are in fluid communication with the first and second water guides respectively so that water can flow from a water conduit through the first water guide into the first aperture, and out through the second aperture and the second water guide. Where the unit is a window unit and the transparent sheets are rigid then, in the closed operating configuration, the unit preferably occludes the

window frame, on its own or in combination with other window units, to substantially prevent air from passing through the area bounded by the window frame.

The unit may have a closed non-operating configuration, in which the area bounded by the window frame is occluded by the unit (and optionally one or more other units or window panes), but where water is prevented from either or both flowing from a water conduit through the first water guide into the first aperture, and flowing out of the second aperture through the second water guide.

Thus, it may be that the window formed by the window frame and unit can be opened and closed wherein, in an open position, the first and/or second aperture may be disengaged from the respective water guide so that water is unable to flow through the unit, and in a closed position, the window may adopt a closed operating configuration in which water can flow through the unit, and a closed non-operating configuration in which water is prevented from flowing through the unit.

One or more valves may be provided to regulate the flow of water into or out of the water retaining volume.

The first water guide may comprise a valve which engages with a formation on the unit when the unit is in a closed position to enable the valve to be opened, or to open the valve. When the valve is open water can flow out through the first water guide and when the valve is closed water cannot flow out through the first water guide.

The unit may comprise a valve for regulating the flow of water through the first aperture which engages with a formation on the window frame when the unit is in a closed position to enable the valve to be opened, or to open the valve. When the valve is open water can flow into the water retaining volume through the first aperture and when the valve is closed water cannot flow into the water retaining volume through the first aperture.

The second water guide may comprise a valve which engages with a formation on the unit when the unit is in a closed position to enable the valve to be opened, or to open the valve. When the valve is open water can flow out of the second aperture through the second water guide and when the valve is closed water cannot flow through the second aperture and second water guide.

The unit may comprise a valve for regulating the flow of water through the second aperture which engages with a formation on the window frame when the unit is in a closed position to enable the valve to be opened, or to open the valve. When the valve is open water can flow out of the water retaining volume through the second aperture and when the valve is closed water cannot flow into the water retaining volume through the second aperture.

The unit or window frame may comprise a lock which is associated with a said valve so that locking of the window using the lock is coupled to opening of a said valve to allow the flow of water into or out of the unit. This may prevent the window from being opened accidentally or deliberately while water is flowing through the water retaining volume.

Preferably, the unit is pivotably connected to the window frame (for example, by a pivot such as a hinge or plurality of hinges) to enable the unit to be operated between and open and a closed position.

The unit may comprise three or more transparent (and typically rigid) sheets which the support extends around, defining a plurality of water retaining volumes therebetween. The plurality of water retaining volumes are typically in fluid communication with each other although it may be that they are sealed from each other by the support and the support includes a separate first aperture and second aperture in respect of each water retaining volume.

The unit may comprise three or more transparent (and typically rigid) sheets which the support extends around, defining one or more water retaining volumes and one or more insulating volumes therebetween. The one or more water retaining volumes and the one or more insulating volumes are typically sealed from each other by the support and the support includes a separate first aperture and second aperture for each of the one or more water retaining volumes.

The insulating volume may retain an inert gas such as argon, but may retain another gas, for example air. Alternatively, the insulating volume may enclose a vacuum.

A transparent sheet may comprise an infra-red absorbing material, such as an infra-red absorbing coating, having a higher absorptivity of infra-red light than the bulk of the material from which the transparent sheet is made. Where the infra-red

absorbing material is provided as a coating it is typically provided on a surface of the transparent sheet facing the water retaining volume so that absorbed heat is conducted directly to water within the water retaining volume in use. Where a unit comprises at least a first and a second transparent sheet, with the second transparent sheet located closer to the interior of the building than the first transparent sheet, the second transparent sheet may comprise an infra-red absorbing material such that the second transparent sheet absorbs a higher proportion of the infra-red light from sunlight which is incident on the respective sheet than the first transparent sheet.

Preferably, where the transparent sheets comprise a rigid plastics material, the transparent sheets further comprise an ultra-violet reflective coating to prevent absorption of ultra-violet radiation, which may cause degradation of the transparent sheets.

Two or more adjacent transparent sheets (e.g. rigid transparent window panes) within the same unit may have different spacings therebetween. First, second and third transparent sheets may be provided with a first water retaining volume extending from the first transparent sheet to the second transparent sheet and a second water retaining volume extending from the second transparent sheet to the third transparent sheet, wherein the first transparent sheet is either on the outward side of a wall of a building or (if the unit comprises further spaced apart transparent sheets) is outward of the second and third transparent sheets, wherein the spacing between the second and third transparent sheets is greater than the spacing between the first and second sheets so that the second water retaining volume is greater than the first water retaining volume. Thus, if water is fed into the first and second water retaining volumes at the same volume flow rate the speed of water flow through the second water retaining volume will be slower than the speed of water flow through the first water retaining volume. This can be more efficient for the absorption of solar infra-red light as water within the outer water retaining volume, which will typically heat up faster as the result of solar heating, will run more quickly.

A slidable wiper may be provided within the or each water retaining volume operable by a manual control to slide across and wipe the surfaces of the transparent sheets defining the respective water retaining volume. The manual control may comprise a pull card.

A building may comprise a plurality of units at least two of which have different numbers of said spaced apart transparent sheets defining water retaining volumes therebetween.

A pump may be provided to pump water from a said water tank or water source to the one or more said units. The pump may, for example, be powered by solar or wind energy, or by a thermodynamic engine, for example a Stirling engine. Where a thermodynamic engine is employed, the engine may use heated water which has been passed through one or more window units as a heat source. The engine may use the water tank or water source as a heat sink. A thermostat may be provided to regulate the flow of water, for example, by controlling the throughput of a said pump, or by switching on and off water flow through one or more said units by regulating one or more valves. The pump may be operable to not function when a window unit, or any one of a plurality of window units, is in an open configuration.

One or more window frames having a said unit may be provided on the roof of the building.

Preferably, the flow of water through the plurality of units is controlled by a temperature sensor, such as a thermostat, to maintain a desired temperature within the building.

The building may further comprise one or more heat exchangers through which water is circulated before or after it is passed through a said unit. The heat exchangers function to further cool or heat the building and to receive and carry away heat from or transfer heat to the interior of the building. The said heat exchangers may, for example, be provided on or in the interior or external walls, on or in the interior or exterior roof, on or within floors. The said heat exchanger may comprise two sheets, which may or may not be transparent, and a support which extends around and retains the transparent sheets. A heat exchanger may comprise fins, ridges or protrusions to extend its surface area.

Water collection means may be provided to collect water that may form on the unit during operation of the unit, due to condensation, for example. The water collection means may comprise a water drainage pipe operable to remove collected water.

A unit may further comprise an air space in thermal communication with a said transparent sheet and one or more aperture to enable air from within the building to enter and leave the unit, to enable the air to be cooled or heated in use. An air space may be defined between air facing sides of two parallel sheets, at least one of which has a water facing side, on the opposite side to air facing side, which in part defines a water receiving volume. Thus an air space may be sandwiched between two water receiving volumes. Alternatively, an air space may be sandwiched between a water retaining volume and an insulating volume.

The water retaining volume and the insulating volume may be defined by an inner sheet and an outer sheet. The outer sheet may comprise glass, and the inner sheet may comprise an insulating material, for example, Perspex or acrylic. The water retaining volume and the insulating volume are preferably arranged such that the air space is defined by the inner sheets of the water retaining volume and the insulating volume.

The support of the unit may comprise a window surround and a seal. The seal may be operable to ensure the water retaining volume and the insulating volume are sealed and to shield the materials of the unit and window frame from thermal gradients that may arise during use.

Preferably, the insulating volume comprises an inert gas, for example argon, but may comprise an alternative gas or gas mixture. Alternatively the insulating volume may comprise a vacuum.

A ventilator, such as a fan, may be provided to actively transport air through the air space.

A building comprising one or more units and one or more heat exchangers operable to heat or cool the building when required is a more cost effective and energy efficient temperature regulation solution than a combination of distinct heating and cooling systems that may otherwise be installed.

According to a fifth aspect of the present invention there is provided a method of cooling a building comprising the steps of providing a window assembly located in an aperture within the wall of a building, the window assembly comprising a window frame and a unit located within the window frame, the unit having spaced apart first

and second transparent sheets, and directing water between the first and second transparent sheets.

Typically, the window assembly is a window assembly according to the third aspect of the invention.

The unit is typically a unit according to the first aspect of the invention. The spaced apart transparent sheets are typically rigid and may be transparent window panes. The method typically comprises providing a unit according to the first aspect of the invention located within a window frame in an aperture through a wall (which is typically an external wall) of the building, so that sunlight can pass through the transparent sheets. The window frame typically lines the periphery of an aperture through a wall and is typically formed of wood, metal or a plastics material. However, a window frame may be the periphery of an aperture through a wall, with a first water guide attached to or inset into the periphery of the aperture and, typically, a second water guide attached or inserted into the periphery of the aperture.

The method may comprise the step of receiving water from a water source or water tank, which is typically underground, and directing the received water between the spaced apart transparent sheets. Water may be returned to the water source or water tank, to conserve water. Water may be circulated around a closed loop circuit through the spaced apart transparent sheets of one or more window units and a heat exchanger in thermal communication with a heat sink (for example, a water source or water tank). The water source may be a well or borehole, or a water tank located underground or an insulated water tank located above ground. Optionally, the water source may be a mains water supply.

Water may be directed through a plurality of units according to the first aspect of the invention in turn, typically before being returned to the water source or tank, or directed through the heat exchanger.

The method may comprise the step of circulating water around a closed loop circuit through the spaced apart transparent sheets of one or more window units wherein the closed loop circuit comprises a heat exchanger in thermal communication with a heat source operable to heat the water within the closed loop circuit. The heat source may be a heater, such as a boiler, or a thermal spring, or other source of heat from the ground, or a phase changing material for example.

Alternatively, the method may comprise the step of providing one or more said units, a heat exchanger in thermal communication with a heat source, a water tank or water source, conduits operable to allow the flow of water through the installation and directing means (for example a flow regulator comprising one or more valves) operable to direct the flow of water to either the heat exchanger or the water tank or water source.

The method may comprise the step of providing a first operating mode, wherein water is directed by the directing means such that water flows through the heat exchanger and the one or more units via the conduits. The method may further comprise the step of providing a second operating mode, wherein water is directed by the directing means such that water flows from the water tank or water source, or through the heat exchanger in thermal communication with a heat sink through the one or more units via the conduits.

The method may comprise the step of operating the directing means to switch between the first and second operating modes.

In the first operating mode, water heated by the heat source flows through the one or more units such that heat from the water in the one or more units is transmitted by radiation, for example, into the room or building and thus heating the room or building. Operating the directing means switches from the first operating mode to the second operating mode. In the second operating mode, cold water from the water tank or water source is directed via the conduits through the one or more units, such that thermal energy from the room or building is absorbed by the cold water and carried away from the room or building back to the water tank or source, or heat exchanger in thermal communication with a heat sink. Water so returned is cooled within the water tank or source, or heat exchanger in thermal communication with a heat sink, before passing through the installation again. Therefore, the second operating mode provides a method of cooling a room or building.

In general, water should be circulated through conduits which are not exposed to external sunlight which would otherwise not pass into the building through one or more windows, for example, by ensuring that the conduits are opaque or located within the walls of the building.

Preferably, the water source is capped by a cover that comprises at least one integrated solar panel, a water pumping means (such as a pump), a rechargeable battery and typically also a flow sensor. The water source cover is preferably made of a thermally isolating material such as a plastics material. The water source cover may further comprise access ports for water conduits extending from the water source to the window assembly.

The water source, one or more water conduits and the water retaining volume or volumes of one or more units may form a circuit around which water may be circulated. The volumes of the one or more units may be connected to the circuit in parallel. The speed of water flow may be variable, for example, it may be responsive to temperature measured using a thermostat.

Where the installation comprises a closed loop circuit extending through one or more said units and a heat exchanger in thermal communication with a heat sink or heat source, the method comprises directing water around the said closed loop circuit. The heat sink may be a body of water, for example, a water tank, a tank of phase changing material, a body of water such as a river, lake or sea, or an underground water source, such as a well. The heat source may be a heater, such as a boiler, a tank of phase changing material or a thermal spring or other source of ground heat. Thus, water within the closed loop circuit may be reused while avoiding or minimising the efflux of water which has been heated within the units or heat exchanger into the water source.

An infra-red absorbing additive may be added to water within the closed loop circuit. The infra-red absorbing additive may, for example, comprise nano-particles which disperse within the water, forming a colloid. The nano-particles may comprise aluminium oxide or copper oxide particles. The nano-particles may further comprise a mixture of materials.

It is desirable that the water from the water source flows continuously from the water source, or around the circuit, through the unit to ensure that the thermal gradient between the water and the heated glass allows for efficient transfer of heat from the glass to the water, or that the thermal gradient between the heated water and the glass allows for efficient transfer of heat from the water to the glass. Nevertheless, water could flow periodically in a batch process.

The circuit may be defined in part by one or more heat exchangers, located within the building, through which water flows to cool the interior of the building and to carry away heat. Alternatively, the circuit may be defined in part by one or more heat exchangers, located within the building, through which water flows to heat the interior of the building. Thus, the method may comprise directing water through the water receiving volumes of one or more said units and one or more heat exchangers in parallel or in series.

Typically, water flowing through the water retaining volumes of units comprises an anti-bacterial or algicidal additive to prevent bacterial build up or algae growth within the circuit. Alternatively, the circuit may comprise an ultra-violet radiation emitter operable to expose water flowing through the closed loop circuit to ultra-violet radiation such that bacteria within the water may be killed. As discussed above, the or each unit may comprise a slidable wiper within the or each water retaining volume. The wiper may be slid periodically across the surfaces of the transparent sheets defining the respective water retaining volume, to clean surfaces of the transparent sheets.

Further optional features of the fifth aspect of the invention correspond to those discussed above in relation to the first four aspects of the invention.

Description of the Drawings

An example embodiment of the present invention will now be illustrated with reference to the following Figures in which:

Figure 1 is a perspective view of a window unit;

Figure 2 is a perspective view of a window frame;

Figure 3 is a perspective view of a cover used to cap the underground water source;

Figure 4 is a perspective view of the underground water source with water conduits;

Figure 5 is a perspective view of an example embodiment of the cooling system with no water flowing;

Figure 6 is a perspective view of (a) an example embodiment of the cooling system with water flowing and (b) an example embodiment of the cooling system with water flowing wherein an underground body of water is acting as a heat sink for a closed water circuit;

Figure 7 is a perspective view of an example embodiment with the inclusion of a retractable blind;

Figure 8 is a view of an example embodiment of the cooling system as applied to a building;

Figure 9 is perspective view of an example embodiment with an air circulator included;

Figure 10 is a perspective view of a window unit comprising a water retaining volume and an insulating volume with an air space there between;

Figure 11 is a perspective view of a window unit installed within a window frame in an open configuration;

Figure 12 is a perspective view of a cooling unit installed into the ceiling of a building;

Figure 12A is a perspective view of an alternate ceiling mounted heat exchanger;

Figure 13 is a plan view of a cooling system including window units and ceiling-based heat exchangers;

Figure 14 is a plan view of a heating system comprising window units, radiator units and ceiling-based radiator units;

Figure 15 is a plan view of a temperature regulation system comprising window units, a pump, and heat exchangers operable to switch between (a) a cooling mode and (b) a heating mode; and

Figure 16 is a plan view of an example switching means comprising two rotatable valves, operable to switch between (a) a heating and (b) a cooling mode; and

Figure 17 is a perspective view of a ceiling unit.

Detailed Description of an Example Embodiment

With reference to Figures 1 to 16, an installation comprises a building having walls with apertures therethrough in which window units 1 (being examples of units according to the invention) are retained, bordered by window frames 2. The installation also includes an underground water source 4 and water conduits 205 and 206 connecting the underground water source and the window frame.

Each window unit comprises two parallel transparent glass window panes of approximately rectangular shape (which function as the transparent sheets); a water retaining volume between the two transparent window panes, which is typically prefilled with water 102; a seal 103 between the peripheries of the glass panes; window surround 101 (which together with the seal functions as the support which extends around and retains the transparent sheets); a first and second engagement means 105, a first water guide 104; a second water guide 106; a window lock 107; and attachment hinges 108. In the closed position illustrated in Figure 1, the first and second water guides align with first and second apertures 120, 122, through the seal, which provide a route for water to enter and leave the water retaining volume within the window unit.

The window frame comprises a first support means 201 within which a first water conduit 203 runs to supply water to the window unit, and a second support means 202 within which a second water conduit 206 runs for the egress of water from the window unit. A first water guide 204 connects the water conduit within the first support means to the first aperture of the unit. A second water guide 207 connects the second water conduit within the second support means to the second aperture of the unit.

The underground water source comprises a body of water 205 and an aperture through which water can be transported from, and to, the body of water. In this embodiment the underground water source is a well and the aperture is the opening of the water source to the well body extending from the body of water to the surface. The well aperture is capped by a plastic cover 307 where the well body terminates at the surface. The plastic cover comprises a solar panel 304, a variable throughput water pump 303 powered by electrical energy provided by the solar panel through a

connector cable 305, a flow sensor 308 and a rechargeable battery 309 for storing excess energy received from the solar panel, where possible, and providing energy when insufficient power is available from the solar panel. Alternatively, the variable throughput water pump may be entirely or partly powered by a heat engine, such as a Stirling engine, which may, for example, extract energy from the temperature gradient between the body of water and the returning water heated within the water retaining volumes in the window units. The flow sensor is located within the second water conduit (wherein water is returned to the well) and is electrically connected to the variable speed water pump via a wire. The water conduits of the window frame extend into the well through the plastic cover.

The window unit is connected to the window frame via hinges 108. The window unit is operable to pivot about the hinges between an open position and a closed position. The first water guide includes a valve and, when the window unit is in the closed position, an engaging formation in the window unit contacts and opens the valve to allow water to flow from the first water conduit through the first water guide and the first aperture, into the water retaining volume within the window unit. When the window unit is in the open position, the engaging formation on the window unit does not contact the valve, which is closed, preventing water from flowing from the first water conduit through the first water guide into the water retaining volume through the first aperture.

The window unit includes a window lock operable to move between two positions, A and A'. When the window unit is in the closed position and the lock is in position A, the second aperture is closed off, the flow of water out of the water retaining volume through the second aperture into the second water guide and second water conduit is blocked and so the window is in a closed non-operating configuration. When the window lock is in position A', the second aperture is open and water can flow out of the window unit through the second water guide into the second water conduit and so the window is in a closed operating configuration. When the window is unlocked and the window unit is open, the second aperture remains closed off and so water does not flow out of the window unit.

A flow sensor powered by the solar panel is operable to detect the flow rate within the outlet pipe. The flow sensor is connected to a variable throughput pump. A temperature sensor is located within a room within the building which is to be cooled and is linked to the pump via a wired connection. Data from the flow sensor and the

temperature sensor determines the rate at which the variable throughput pump will pump water through the water circuit formed by the well, the water conduits and the water retaining volumes within the window units.

As illustrated in Figure 8, the water retaining volumes of a plurality of window units can be connected in parallel with a first water conduit in fluid communication with the first water guides of a plurality of windows and a second water conduit in fluid communication with the second water guides of the plurality of windows so that water flows from the water source or tank through the water retaining volumes of one or more of a plurality of window units connected in parallel and is then returned to the water source or tank. By connecting the window units in parallel, water can continue to flow through some window units and not others, for example, because some windows are open (causing a valve to prevent water flow through that window unit) or a manually operable valve is set to prevent water flow through a particular window unit.

By returning water to the water tank, the system can avoid unnecessary consumption of water by reusing water. Provided that the total volume of water present in the water tank or water source is sufficient, it will be cooled sufficiently by conduction through the ground to continue to cool the interior of the building. Alternatively, water may flow around a closed loop water circuit and through a heat exchanger 410 illustrated in Figure 6b, which heat exchanger is in thermal communication with the water source, to cool the circulating water without the returning water flowing directly into the water source.

Water flowing through the water retaining volumes of units within a closed loop circuit comprises anti-bacterial and algicidal additives to prevent bacterial and algal build up within the circuit. Alternative embodiments may comprise an ultra-violet radiation emitter operable to expose water flowing through the closed loop circuit to ultra-violet radiation such that bacteria within the water may be killed.

In an example embodiment illustrated in Figure 13, water heated within the units 1301 passes through a further heat exchanger 1302 immersed in a phase changing material 1304 which is solid at room temperature such that the heat from the water changes the phase of the phase changing material. This stores the heat for future use, for example for providing a heat source for domestic hot water. The further heat exchanger is in thermal communication with heat storage medium 1304 comprising a

phase changing material, for example paraffin or fatty acids. Hot water could be obtained through a conduit 1303 connected to a tap. The heat transferred to the solid (at room temperature) phase changing material causes all or a part of the phase changing material to melt. If the phase changing material is allowed to solidify, the stored heat is released for use.

Some or all of the window units can have more than two spaced apart transparent window panes, and thereby define two or more water retaining volumes. In this case, the plurality of water retaining volumes may be in fluid communication so that water can be introduced through a single aperture of the window unit and received out of a single aperture of the window unit. Alternatively, separate first and second water guides, or first and second water guides with multiple outlets can be provided to direct water into and receive water from separate first and second apertures of the window unit in respect of individual water retaining volumes.

By providing multiple water retaining volumes, different volumes of water may be retained within a window unit having transparent window panes of a given surface area. It can be preferable to have multiple water retaining volumes separated by window panes rather than a single thicker water retaining volume to improve the mechanical strength of the window unit, reduce convection within the water retaining volume and increase the overall cooling effect.

The number of water retaining volumes within a window unit is used to determine the type of window that could be fitted to a living environment. For example, a window having seven parallel window panes defining six water retaining volumes may be used for a room measuring 15 feet by 15 feet, whilst a room measuring 10 feet by 10 feet may be fitted with a window with transparent window panes of the same surface area but with five parallel window panes defining four water retaining volumes.

The spacing between transparent window panes may be around 10mm. However, in some units there may be different spacings between transparent window panes (defining water retaining volumes of different thickness) within one or more window units. For example, a first water retaining volume could have a thickness of 10mm whilst second and third water retaining volumes, which are closer to the interior of the building, could have thicknesses of 15 and 20mm respectively.

In an alternative embodiment illustrated in Figure 7a and 7b, the cooling system comprises a window blind unit 7, a receptacle for the window blind unit 110, a first and second water conduit and an underground water source. The window blind unit comprises two spaced apart flexible transparent sheets 112 and a flexible support 115 which extends around and retains the flexible transparent panes and defines a water retaining volume therebetween. A first and second water guides through the flexible support enable the ingress and egress of water from an underground water source to and from the water retaining volume. The water retaining volume, the water conduits and the underground water source form a circuit around which water may flow.

In this example embodiment, the first water conduit comprises two parts; a rubber tube 118 extending from the first water guide within the window blind unit; and a rigid water conduit extending from the rubber tube to the underground water source. The second water conduit is a rigid water conduit and extends from the second water guide in the window blind unit to the underground water source.

The first water guide comprises a valve means 114 operable to allow or disallow water into the water retaining volume upon displacement away from the valve means by the first part of the first water conduit.

The window blind unit is installed above a window, attached to the upper portion of a window frame, and the window blind unit preferably matches the interior dimensions of the window frame, such that when fully extended the collapsible unit covers the entirety of the window from the sun. However, the window blind unit may not occlude the entire window.

The window blind unit has two configuration; a fully collapsed/compact configuration; and a fully extended configuration. Pulling upon the rubber tube water guide opens the valve means and initiates water flow into the empty water retaining volume of the collapsible unit. As water fills the water retaining volume, the window blind unit extends out of the receptacle until the water retaining volume is filled, and the window blind unit is fully extended.

In operation, the user pulls the flexible water conduit (rubber tube). Water begins to flow into the water retaining volume and as a consequence the window blind unit extends out of the receptacle. When fully extended water circulates around the water

circuit such that, heat incident on the window is attenuated as it goes through the window blind unit.

In an alternative embodiment illustrated in Figures 9, 10 and 11, a window unit comprises two water retaining volumes 901 and 902, each of which is defined between two transparent window planes, and an air space 903 intermediate the two water retaining volumes. For example, there may be four parallel transparent glass panes with water retaining volumes between each outer glass pane and the pane directly inwards of the respective outer pane, and an air space between the two innermost panes. The water retaining volumes are as described in the unit based cooling system embodiment above and may be in fluid communication or supplied with water by separate water guides. The window surround of the unit further comprises an inlet vent 904 and an outlet vent 905 operable to allow air to enter the air retaining volume via the inlet vent and to exit the air retaining volume via the outlet vent. Air may flow through the air retaining volume passively by convection, however ventilation means, such as a fan, may be provided to draw air through the air retaining volume.

In the latter case, when the unit is operated such that water flows through the water retaining volumes as in the previous embodiments, the ventilation means drives air from the room to be cooled through the air retaining volume. Air within the air retaining volume is in thermal contact with both water retaining volumes and is therefore cooled as heat is transferred to the water.

In a further alternative embodiment, a window unit comprises a water retaining volume 902 and an insulating volume 906, each of which is defined between two transparent window planes, and an air space 903 intermediate the water and insulating volumes. For example, there may be four parallel transparent sheets, two outer sheets and two inner sheets; the water retaining volume defined by one inner sheet 907 and one outer sheet 908 and the insulating volume defined by one inner sheet 909 and one outer sheet 910. The inner sheets comprise a thermally insulating material such as a plastic, for example Perspex. The inner sheets further comprise an ultra-violet reflective coating to prevent absorption of ultra-violet radiation, which may cause degradation of the transparent sheets. The outer sheets comprise glass. Therefore, the air space between the water retaining volume and the insulating volume is defined by the inner sheets of the water retaining volume and the insulating volume.

Upon installation into a window frame as described in previous embodiments, the window unit is arranged such that the outer sheet 910 of the insulating volume is on the exterior of the room or building, and the outer sheet 908 of the water retaining volume is on the interior of the room or building. In this way the insulating volume provides insulation to the window unit and ensures that air flowing through the air space is thermally insulated from the air exterior to the room or building.

The window unit further comprises a sealing means between the window surround and the transparent window panes that define the water retaining volume and insulating volume such that the retaining volumes do not leak. In addition the sealing means acts as a thermal shield to protect the surround materials from thermal gradients potentially caused by the water within the water retaining volume.

The window surround of the unit further comprises an inlet vent 905 and an outlet vent 904 operable to allow air to enter the air space via the inlet vent and to exit the air space via the outlet vent. Air may flow through the air space passively by convection, however ventilation means, such as a fan, may be provided to draw air through the air retaining volume. When cooling, air will pass through the air space in generally downwards direction. When heating, air will rise through the air space.

The air flowing through the air space is cooled via thermal conduction of the air with the water retaining volume of the window unit.

The insulating volume may comprise an inert gas, such as argon, but may comprise an alternative gas or gas mixture such as air.

In an alternative embodiment illustrated in Figure 12, in addition to the above embodiments, the installation includes one or more heat exchangers, in the form of additional cooling means. For example, an additional water circuit is formed by a cooling unit 706 located on the ceiling of the room to be cooled connected to the underground water source 205 via two water conduits 710, 711. The cooling unit comprises a water retaining volume formed by two heat-conducting elements, a first aperture 707, a second aperture 708 and a condensation collection means 712. The cooling unit further comprises cooling fins 709 extending along and away from the body of the cooling unit, increasing the surface area of the cooling unit and enhancing the heat transfer from the air to the water within the cooling unit. Heat exchangers of

this type can be provided on the surface of or within internal or external walls, the roof of individual rooms or the external roof of the building, further removing heat from the interior of the building.

Figure 12A illustrates an alternate embodiment of a heat exchanger 706 in which a pipe 714 extending through a tank of phase changing material 713. When the living space is relatively cold the phase change material will solidify and release any stored heat. When the temperature is relatively high, the phase change material will melt absorbing heat. As cold water is passed through the phase changing material, this will decrease the temperature of the phase changing material causing it to solidify and drain more heat from the living space. Heat stored by the phase changing material is released back into the living space when the temperature drops.

In an alternative embodiment illustrated in Figure 14, a heating system is provided comprising; one or more units as described in any previous embodiment; a heat exchanger in thermal communication with a heat source 1401, for example ground source heat or an electric or fuel operated heater; a heat pump 1402; and conduits 1403 to allow water to flow through the heat exchanger to the one or more units.

The heating system may further comprise one or more ceiling-based heat exchangers 1404 and one or more wall- or floor-based heat exchangers 1405.

In an alternative embodiment illustrated in Figures 15a, 15b and 16, a temperature regulation system is provided comprising a plurality of units as described in the any previous embodiment, a water tank, a heat exchanger in thermal communication with a heater 1503, a pump, directing means operable to direct water through either the heat exchanger or the water tank, and conduits to allow water to flow there through.

The directing means may comprise two valves 1601 and 1602, functioning as directing means 1504, and operable to switch between a first operating mode 1501 and a second operating mode 1502. In the first operating mode, water is directed through the water tank such that cold water is directed through the plurality of units. Thermal energy is absorbed from the room or building by the cold water and carried away. In the second operating mode water is heated by the heat source and directed through the plurality of units. Heat is transmitted from the units and absorbed by the room or building, thereby causing the room or building to be heated. In the second

operating mode heated water is circulated through the plurality of units in a closed loop.

For example, during the summer the first operating mode may be activated such that the installation provides cooling to the building. During the winter, the directing means may be operated to switch from the first operating mode to the second operating mode such that the installation provides heating to the building.

In a further embodiment, the temperature regulation system may comprise a plurality of units as described in the any previous embodiment, a first heat exchanger in thermal communication with a heat sink, a second heat exchanger in thermal communication with a heater, a pump, directing means operable to direct water through either the first heat exchanger or the second heat exchanger, and conduits to allow water to flow there through.

Further variations and modifications may be made within the scope of the invention herein disclosed.

Claims

1. A unit for location within a window frame, the unit comprising at least two transparent sheets and a support which extends around and retains the transparent sheets and defines a water retaining volume therebetween, and first and second apertures through the support to enable the ingress and egress of water to and from the water retaining volume.

2. A unit according to claim 1, wherein the unit is a window unit and the transparent sheets are rigid transparent window panes.

3. A unit according to claim 1, wherein the unit is flexible and the transparent sheets are flexible.

4. A unit according to any one preceding claim, comprising three or more transparent sheets which the support extends around, defining a plurality of water retaining volumes therebetween.

5. A unit according to claim 4 wherein the plurality of water retaining volumes are in fluid communication with each other.

6. A unit according to any one preceding claim, wherein a transparent sheet comprises an infra-red absorbing material having a higher absorptivity of infra-red light than the bulk of the material from which the transparent sheet is made.

7. A unit according to any one preceding claim, wherein two or more adjacent transparent sheets within the same unit have different spacings therebetween.

8. A unit according to any one preceding claim further comprising an air space in thermal communication with a said transparent sheet and one or more aperture to enable air to enter and leave the unit, to enable the air to be cooled in use.

9. A unit according to claim 8, wherein the air is either heated or cooled during use.

10. A kit comprising a unit according to any one preceding claim, and a first water guide for mounting to a window frame to cooperate with the first aperture to guide water into the water retaining volume through the first aperture.

11. A window assembly comprising a window frame for mounting in an aperture through a wall, and a unit according to any one of claims 1 to 9 adapted to be retained by the window frame, wherein the window frame comprises a first water guide operable to guide water through the first aperture of the unit in at least one configuration of the window assembly to allow water to flow into the water retaining volume through the first aperture.

12. An installation comprising a building, the building comprising a plurality of walls, at least one wall having an aperture therethrough with a window assembly according to claim 11 fitted thereto, the window frame being fitted to the aperture, a said unit retained by the said window frame, and a first water guide fitted in or to the window frame and operable to guide water through the first aperture of the unit in at least one configuration of the window assembly to allow water to flow into the water retaining volume through the first aperture.

13. An installation according to claim 12, wherein a second water guide is provided for receiving water from the second aperture of the unit.

14. An installation according to claim 12 or claim 13, further comprising a water tank, or water source, and one or more conduits to conduct water from the water tank, or water source, to a said first water guide.

15. An installation according to claim 14, wherein the water tank or water source is a well or mains water supply.

16. An installation according to claim 14 or claim 15, wherein one or more conduits conduct water from a said second water guide to the water tank or water source to enable water to be circulated from the water tank or water source through one or more said units.

17. An installation according to any one of claims 12 to 16, having a closed loop water circuit comprising one or more conduits, a plurality of said units and a heat exchanger in thermal communication with a heat sink.

18. An installation according to claim 17, wherein the heat sink is a well, a river, a lake, a sea, or a tank of phase changing material.

19. An installation according to claim 17, wherein the heat exchanger is in thermal communication with a heat source.

20. An installation according to claim 19, wherein the heat source is a heater.

21. An installation according to any one of claims 12 to 20, wherein a plurality of said units are connected in parallel.

22. An installation according to any one of claims 12 to 21, wherein a plurality of said units are connected in series, with a water conduit extending from the second water guide of a first window assembly to the first water guide of a second window assembly.

23. An installation according to any one of claims 12 to 22, wherein a or the unit is operable between an open configuration in which the first and/or second apertures are not in fluid communication with the first and/or second water guides respectively, and in which the window assembly is open to allow air to pass through the area bounded by the window frame, and a closed operating configuration in which the first are second apertures are in fluid communication with the first and second water guides respectively so that water can flow from a water conduit through the first water guide into the first aperture, and out through the second aperture and the second water guide.

24. An installation according to claim 23, wherein a or the said unit has a closed non-operating configuration, in which the area bounded by the window frame is occluded by the unit, but where water is prevented from either or both flowing from a water conduit through the first water guide into the first aperture, and flowing out of the second aperture through the second water guide.

25. An installation according to any one of claims 12 to 24, comprising one or more valves to regulate the flow of water into or out of the water retaining volume.

26. An installation according to claim 25, wherein the unit or window frame comprises a lock which is associated with a said valve so that locking of the window using the lock is coupled to opening of a said valve to allow the flow of water into or out of the unit.

27. An installation according to any one of claims 12 to 26, wherein the building comprises a plurality of units at least two of which have different numbers of said spaced apart transparent sheets defining water retaining volumes therebetween.

28. An installation according to any one of claims 12 to 27, wherein the building further comprises one or more heat exchangers through which water is circulated before or after it is passed through a said unit.

29. An installation according to any one of claim 12 or claim 13, comprising one or more said units, a heat exchanger in thermal communication with a heat source, a water tank or water source, conduits operable to allow the flow of water through the installation and directing means operable to direct the flow of water to either the heat exchanger or the water tank or water source.

30. A method of cooling a building comprising the steps of providing a window assembly located in an aperture within the wall of a building, the window assembly comprising a window frame and a unit located within the window frame, the unit having spaced apart first and second transparent sheets, and directing water between the first and second transparent sheets.

31. A method according to claim 30 wherein the window assembly is a window assembly according to claim 11.

32. A method according to claim 30 or claim 31 wherein the spaced apart transparent sheets are rigid and transparent window panes.

33. A method according to any one of claims 30 to 32, comprising the step of receiving water from a water source or water tank and directing the received water between the spaced apart transparent sheets.

34. A method according to claim 33, wherein water is directed through a plurality of said units in turn, typically before being returned to the water source or tank.

35. A method according to claim 33 or claim 34 further comprising directing water through one or more heat exchangers located within the interior of a building.

36. A method according to claim 35, comprising the step of directing water through a heat exchanger attached to the ceiling of a room within the interior of a building.

37. A method of heating a building comprising the steps of providing a window assembly located in an aperture within the wall of a building, the window assembly comprising a window frame and a unit located within the window frame, the unit having spaced apart first and second transparent sheets, and directing water between the first and second transparent sheets.

38. A method according to claim 37 wherein the window assembly is a window assembly according to claim 11.

39. A method according to claim 37 or claim 38 wherein the spaced apart transparent sheets are rigid and transparent window panes.

40. A method according to any of claims 37 to 39 further comprising directing water through one or more heat exchangers located within the interior of a building.

41. A method according to claim 40, comprising the step of directing water through a heat exchanger attached to the ceiling of a room within the interior of a building.

42. A method of regulating the temperature of a building comprising the steps of;

providing one or more units, a heat exchanger in thermal communication with a heat source; a water tank, water source or heat exchanger in thermal communication with a heat sink; and conduits operable to allow the flow of water through the one or more units and directing means operable to direct the flow of water through either the heat exchanger in thermal communication with a heat source or the water tank, water source or heat exchanger in thermal communication with a heat sink;

providing a first operating mode, wherein water is directed by the directing means such that water flows through the heat exchanger in thermal communication with a heat source and the one or more units via the conduits;

providing a second operating mode, wherein water is directed by the directing means such that water flows from the water tank, water source or heat exchanger in thermal communication with a heat sink through the one or more units via the conduits; and

operating the directing means to switch between the first and second operating modes.

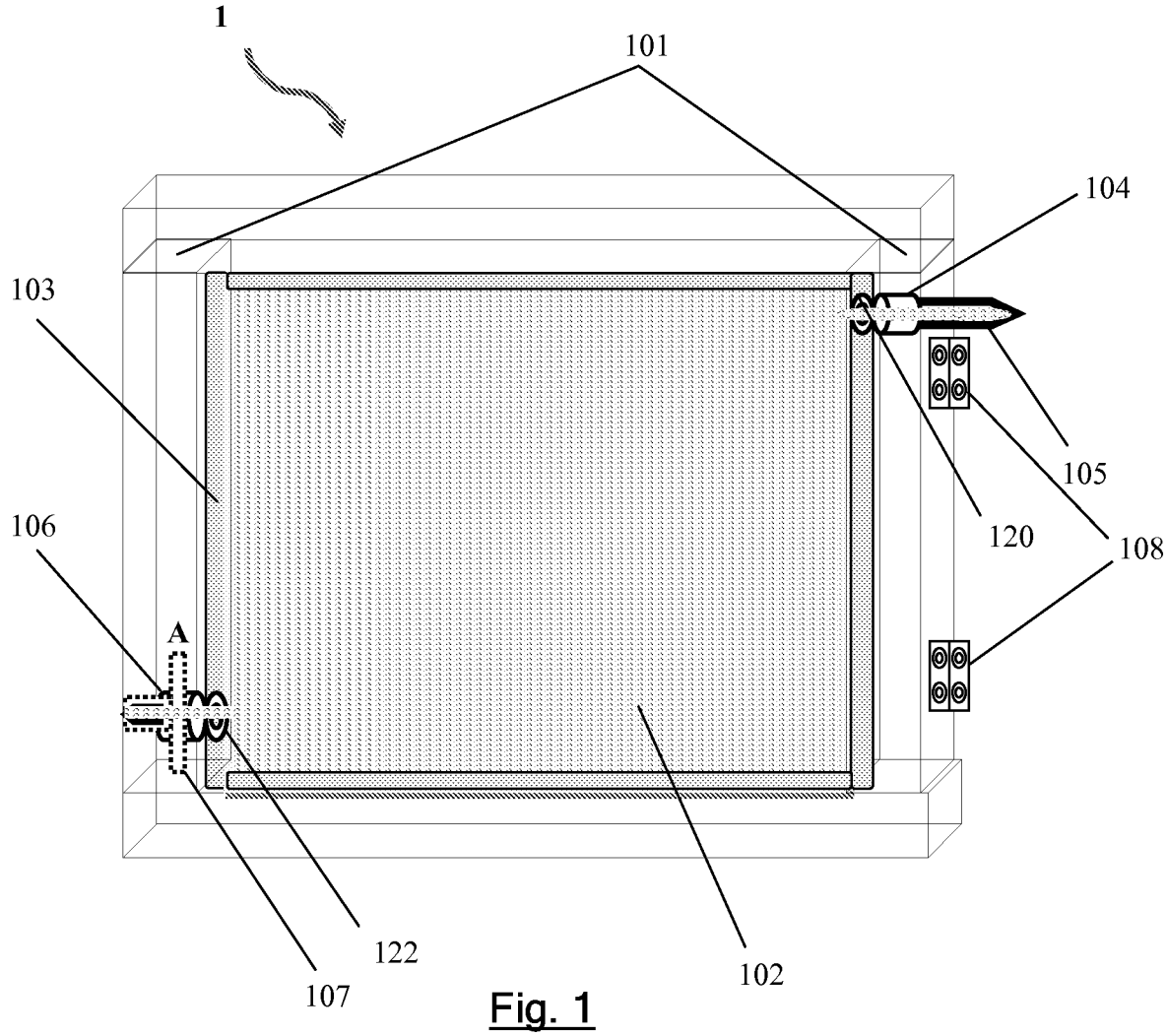

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Fig. 1

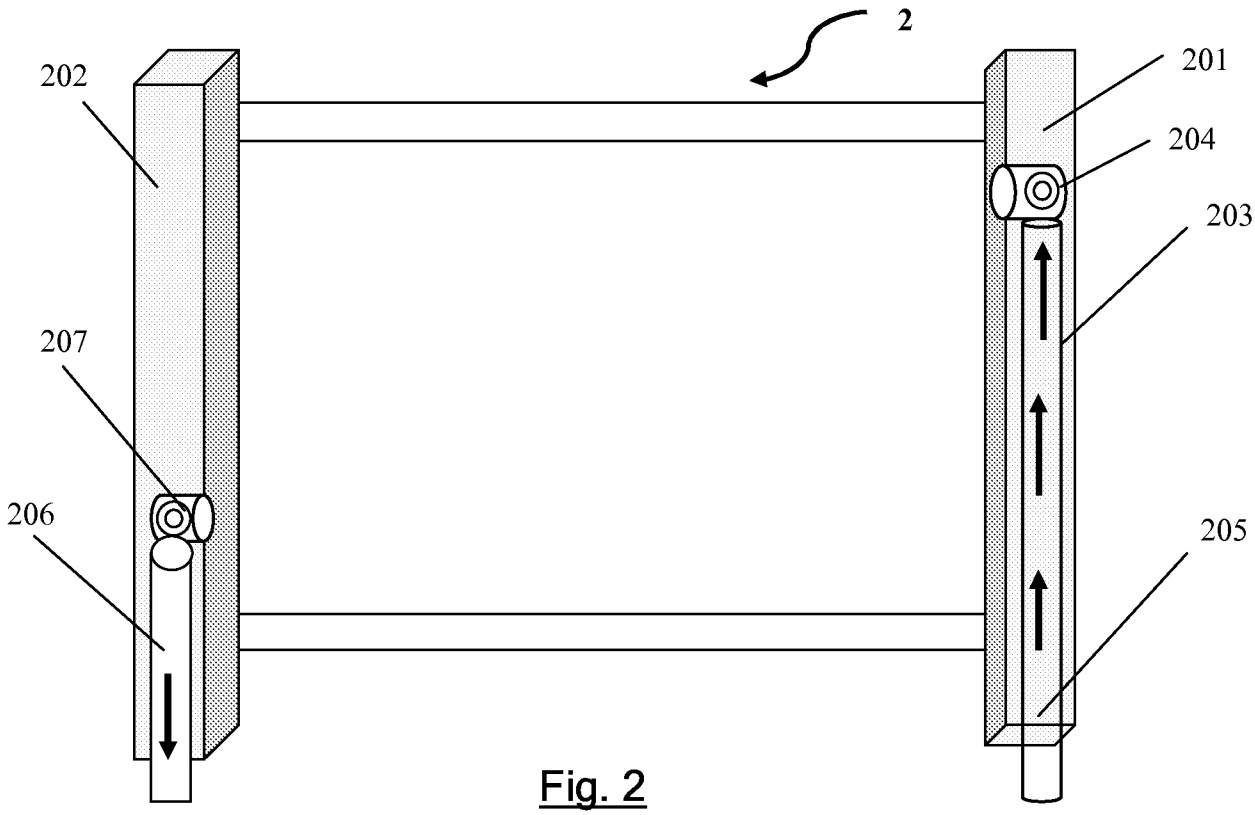

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Fig. 2

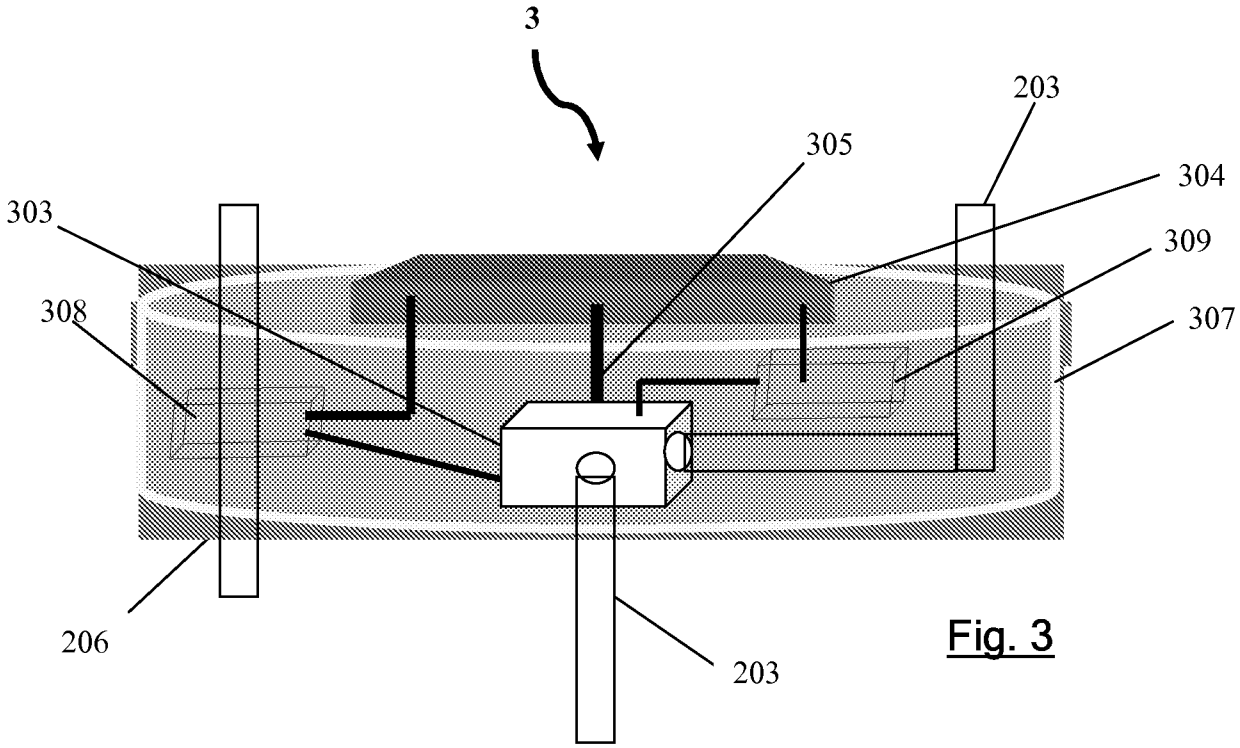


Fig. 3

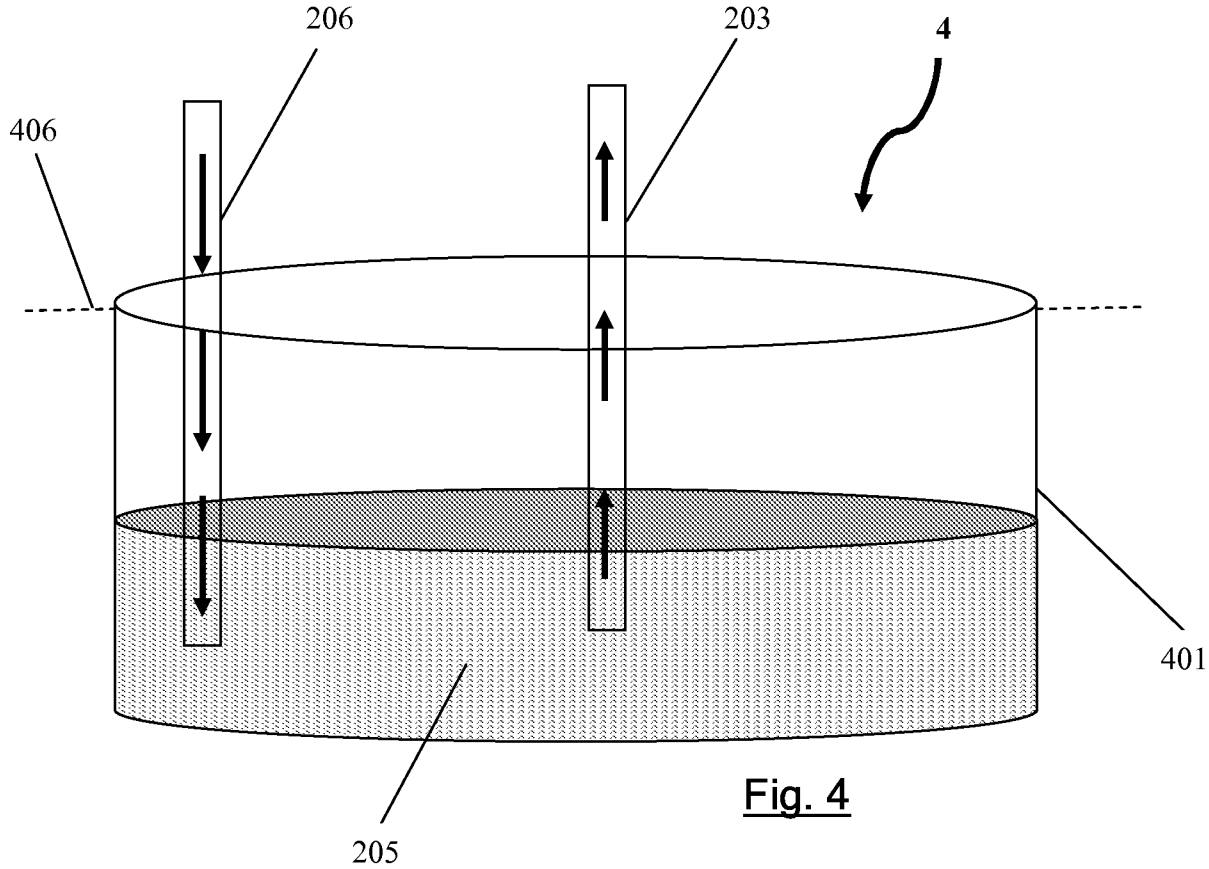


Fig. 4

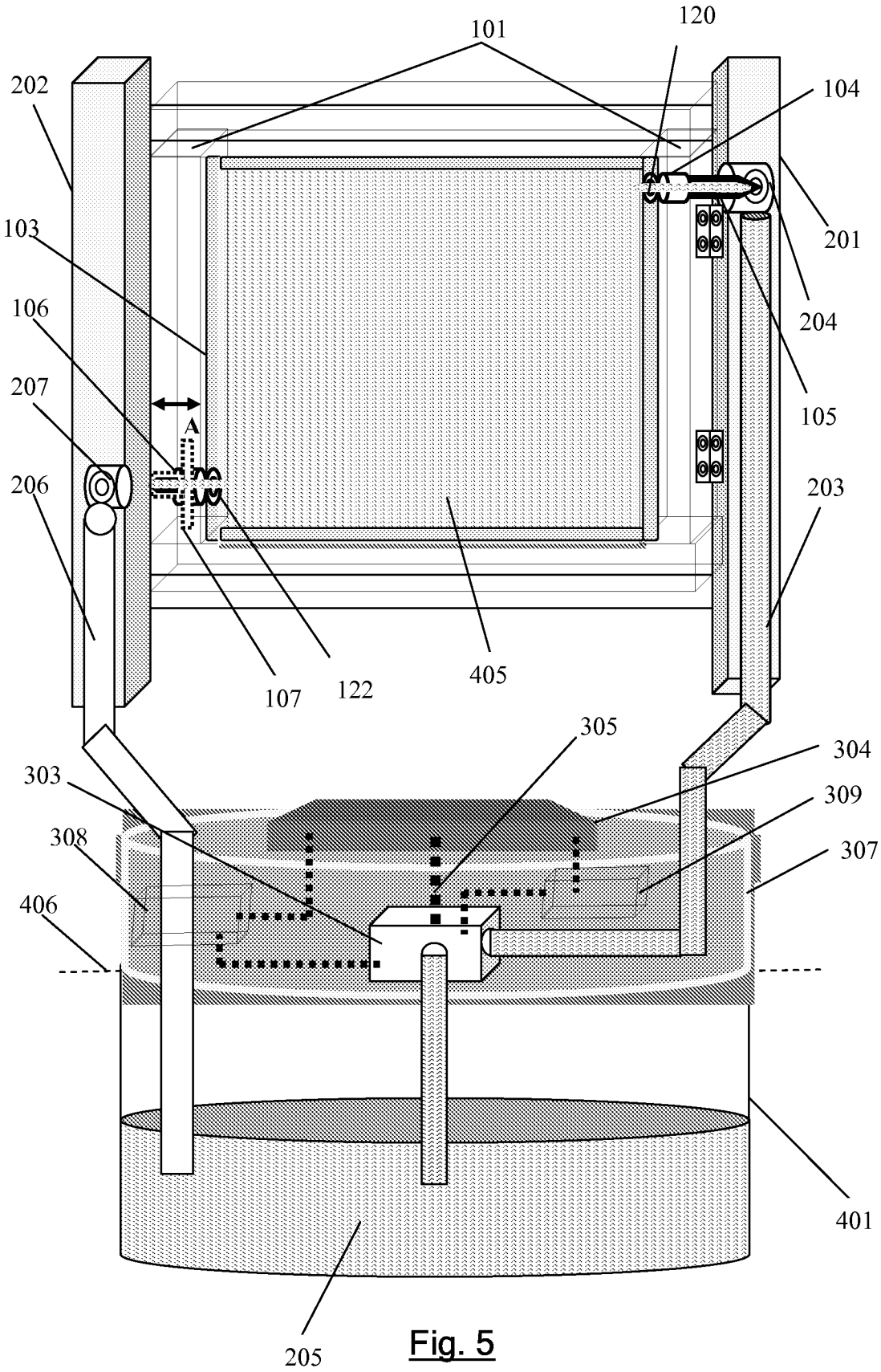

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Fig. 5

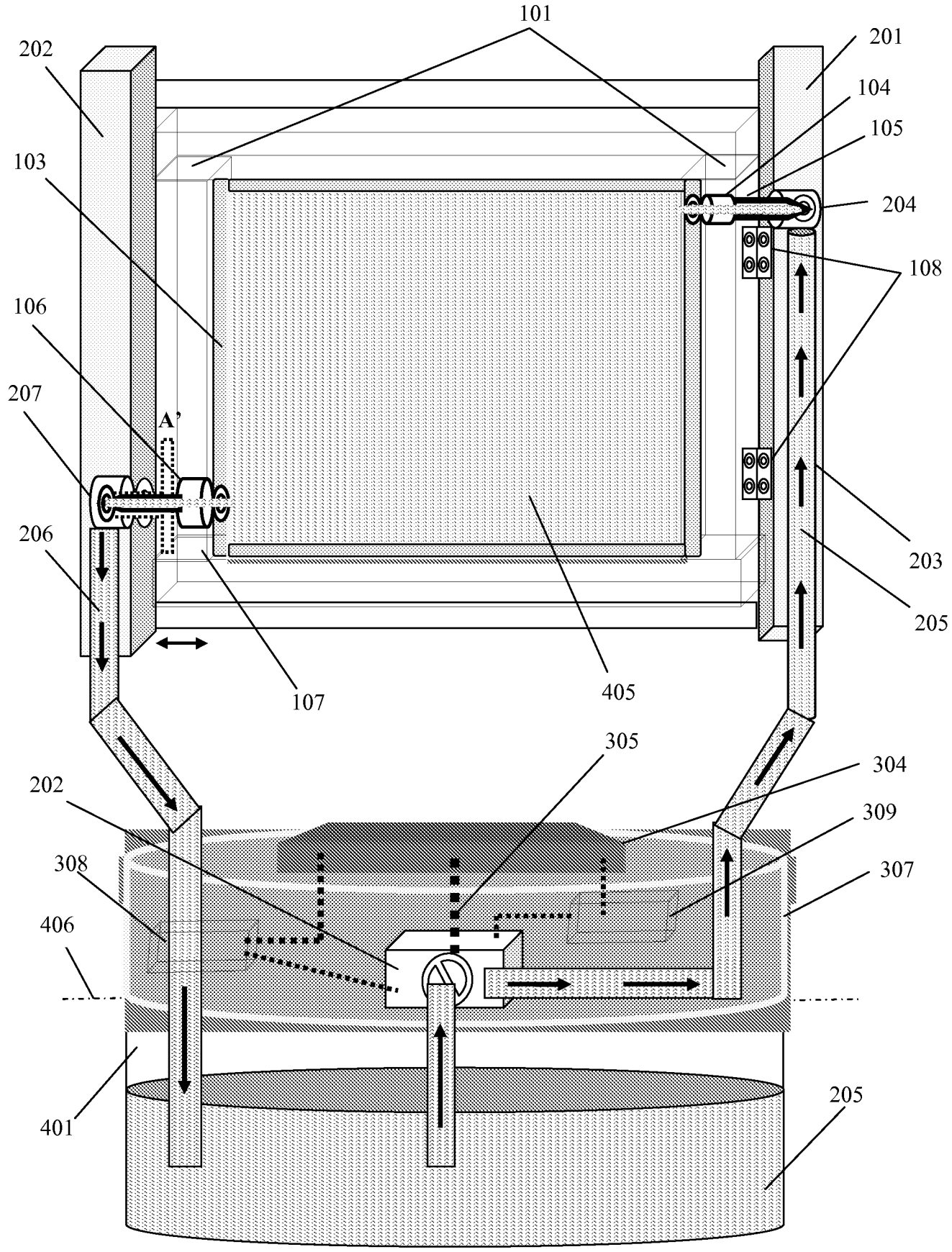

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Fig. 6a

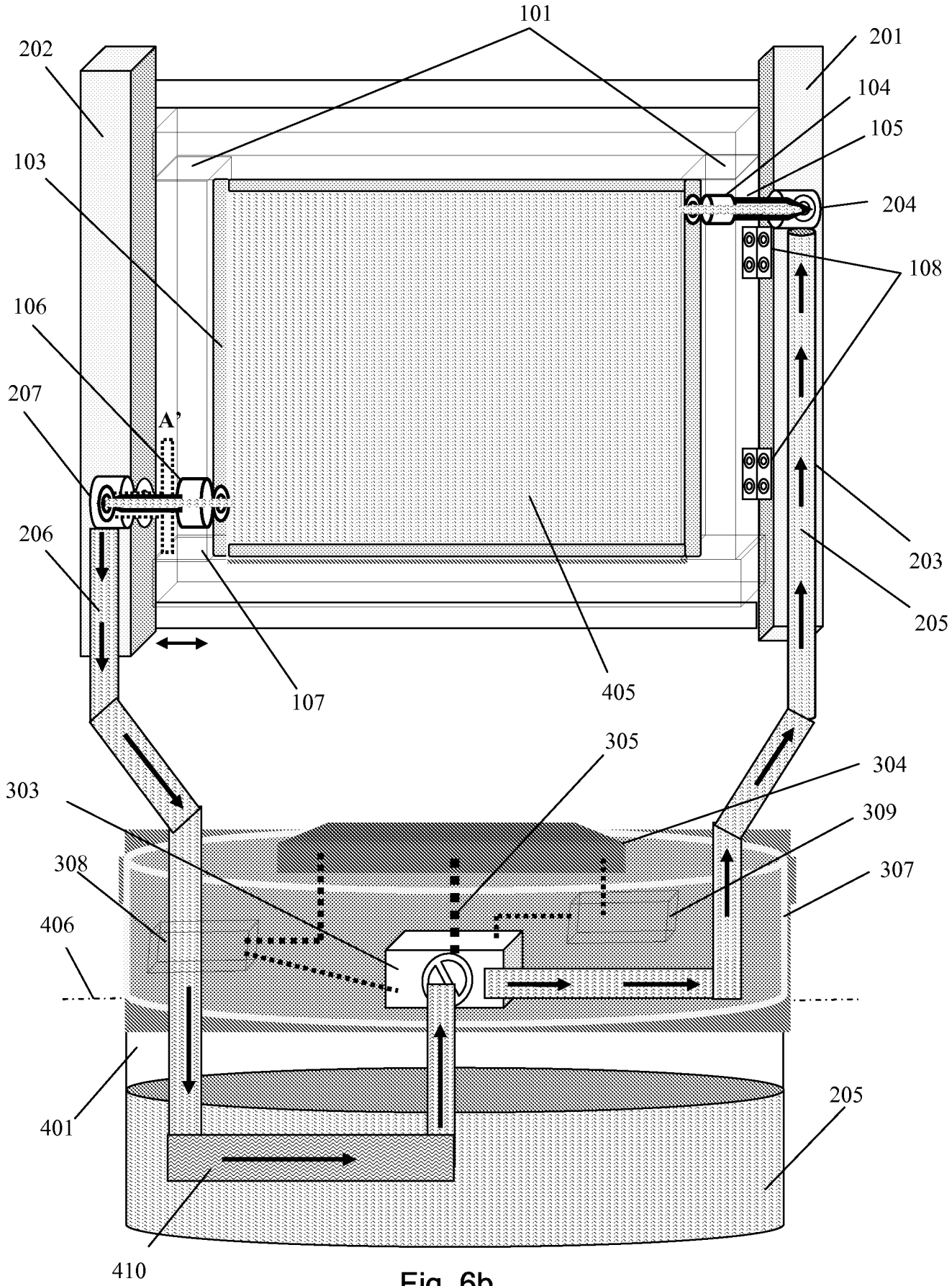

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Fig. 6b

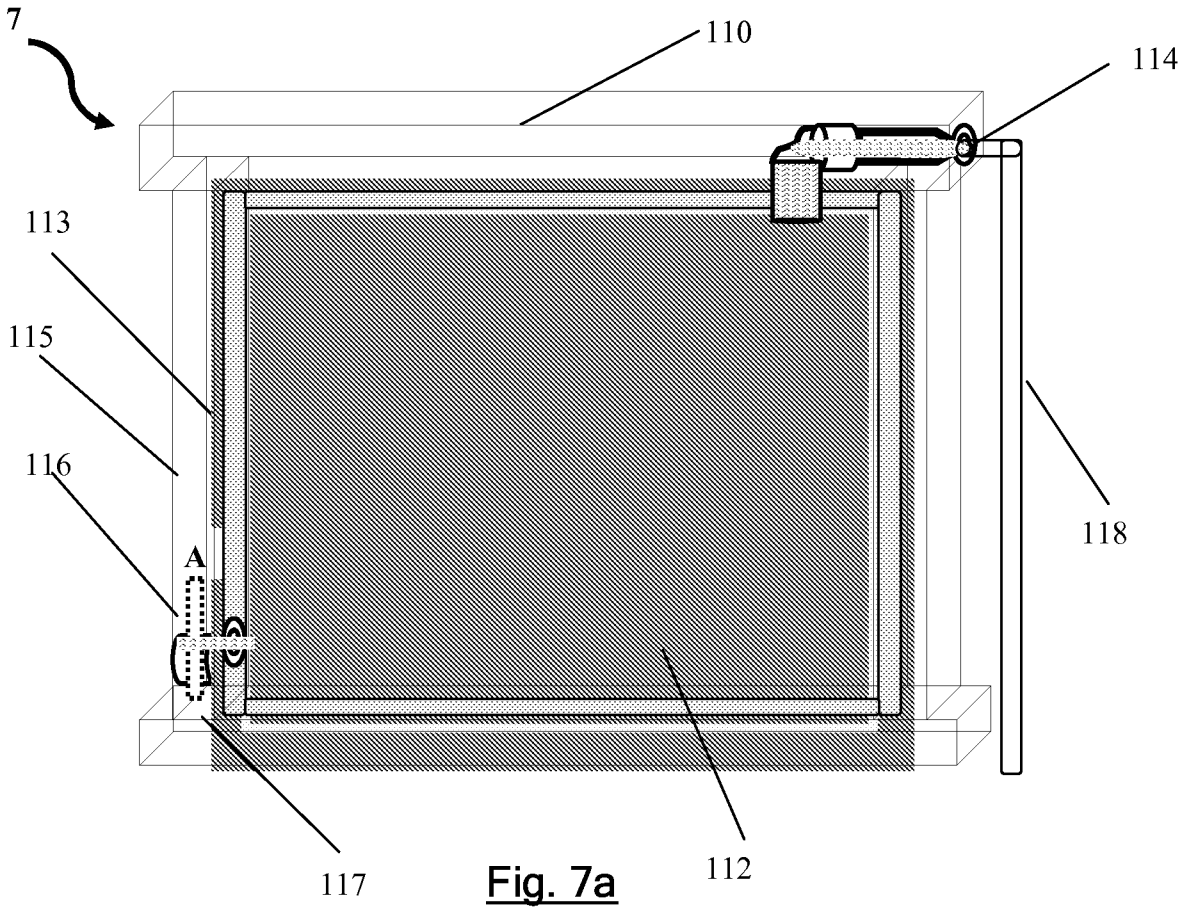


Fig. 7a

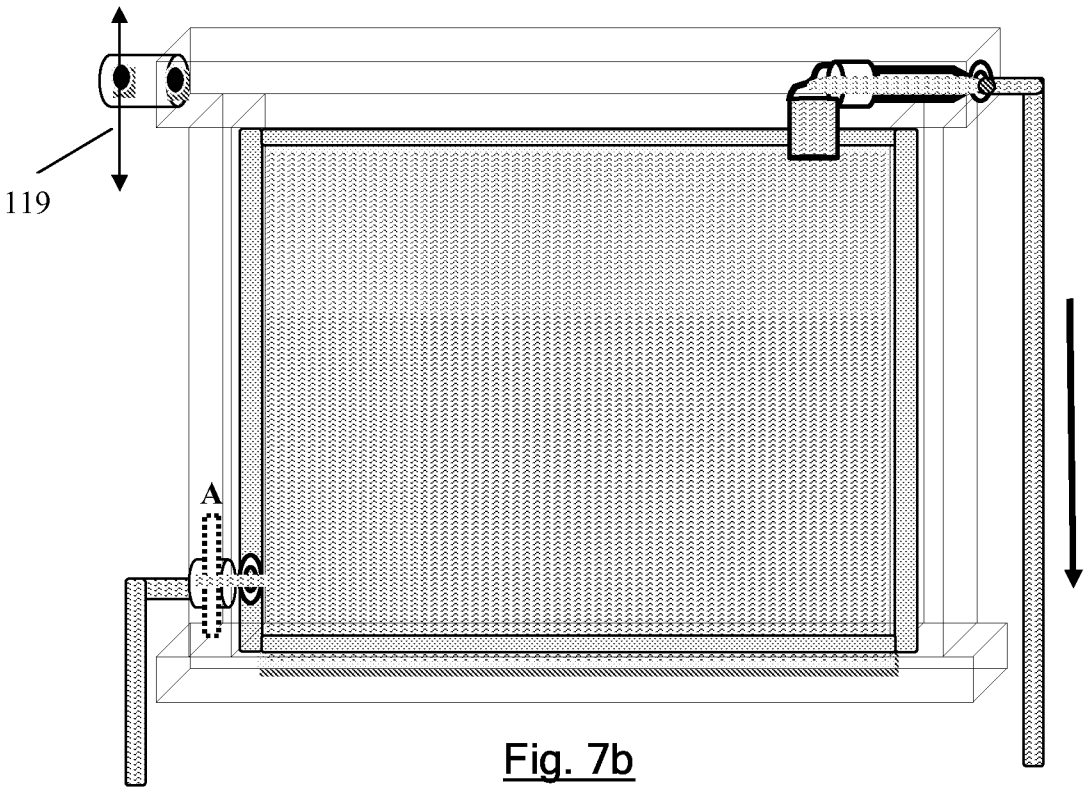


Fig. 7b

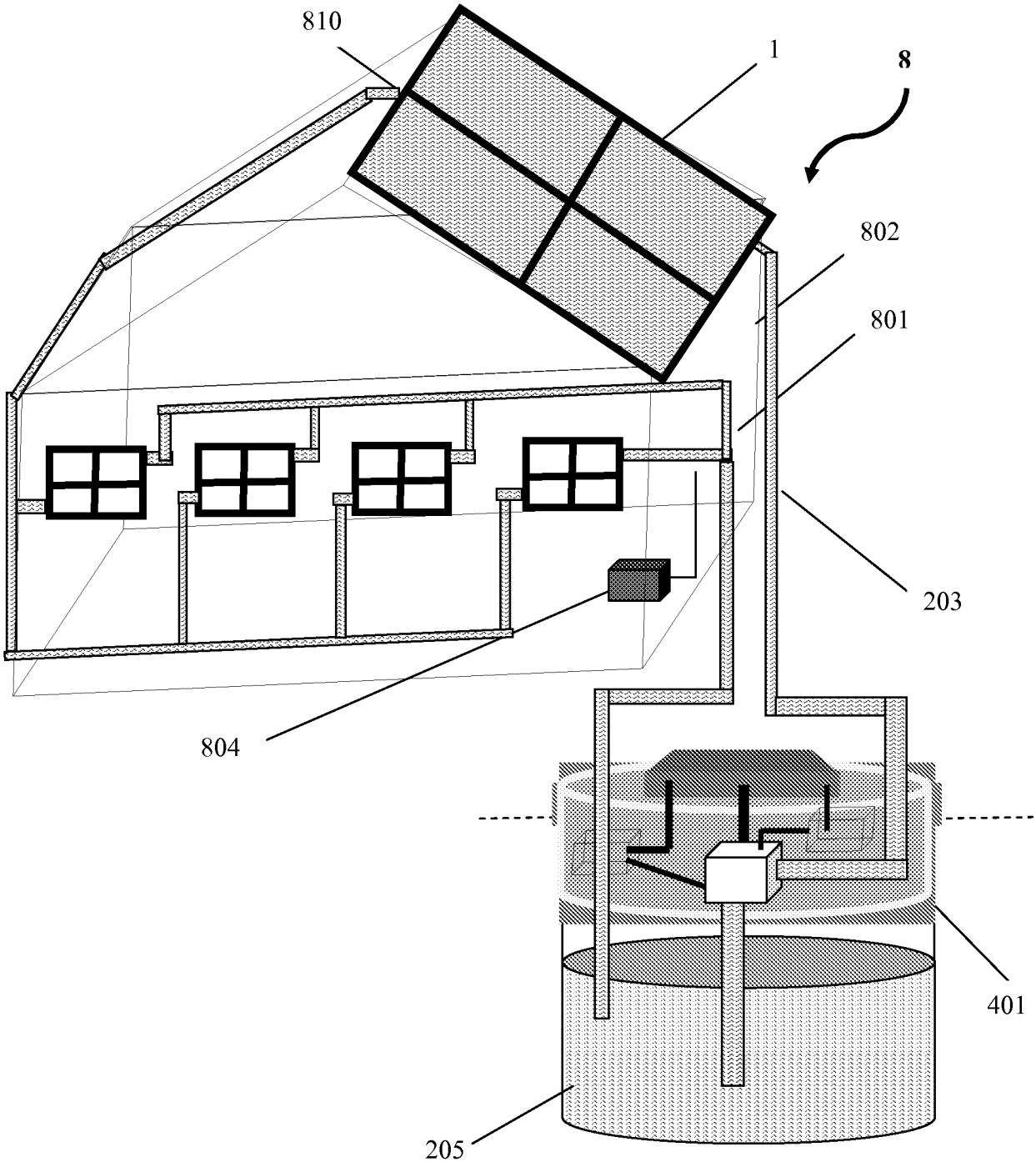


Fig. 8

Fig. 9

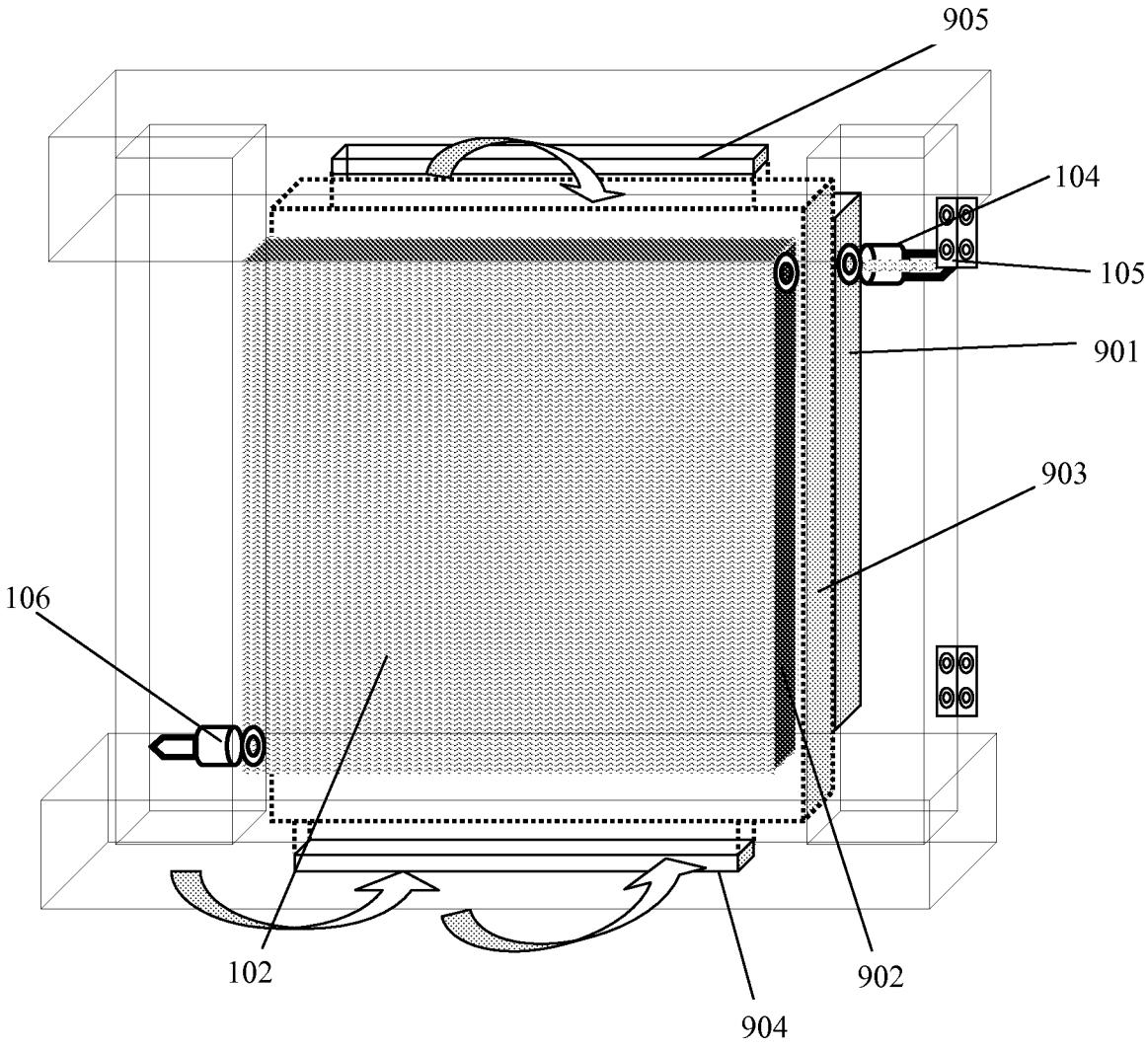
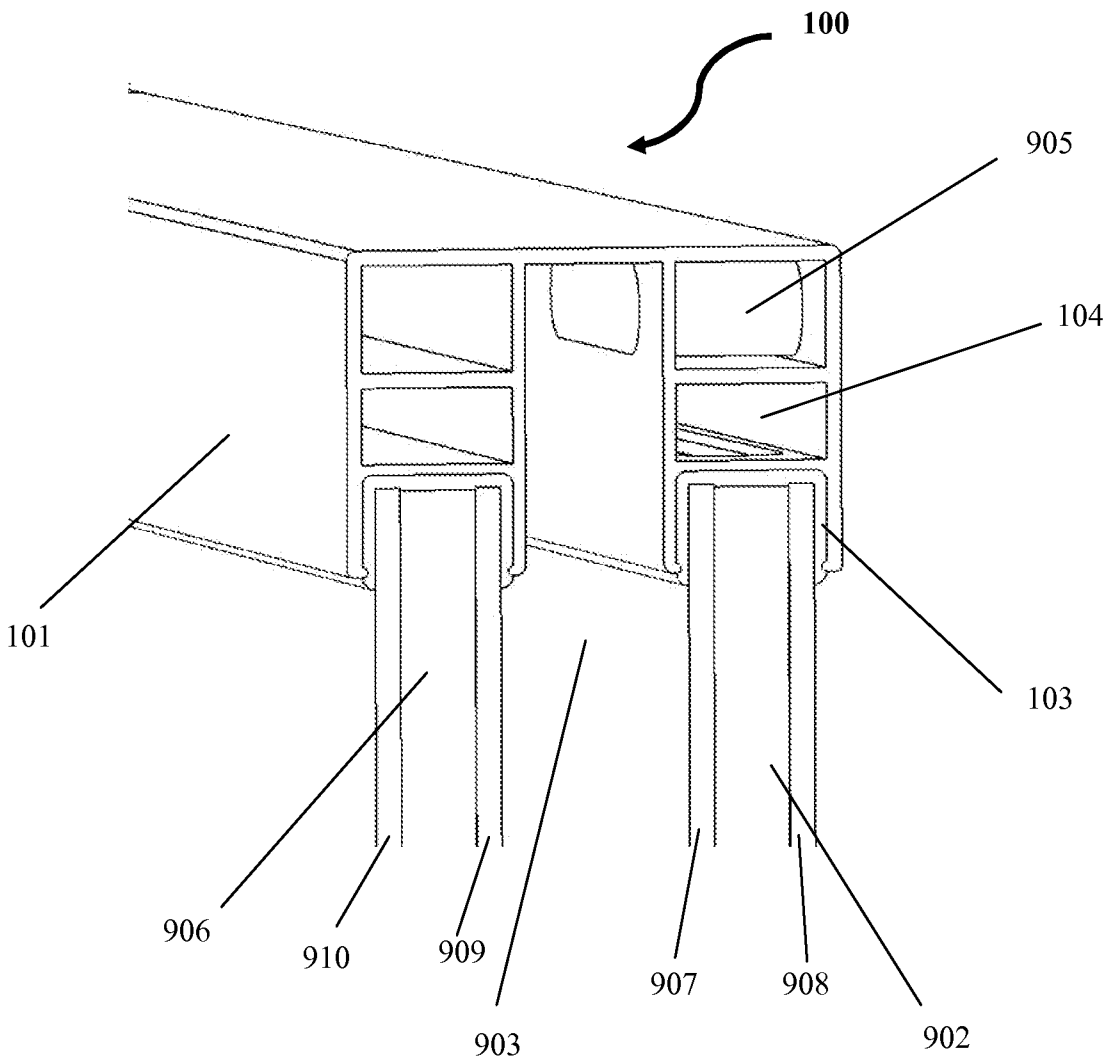


Fig. 10



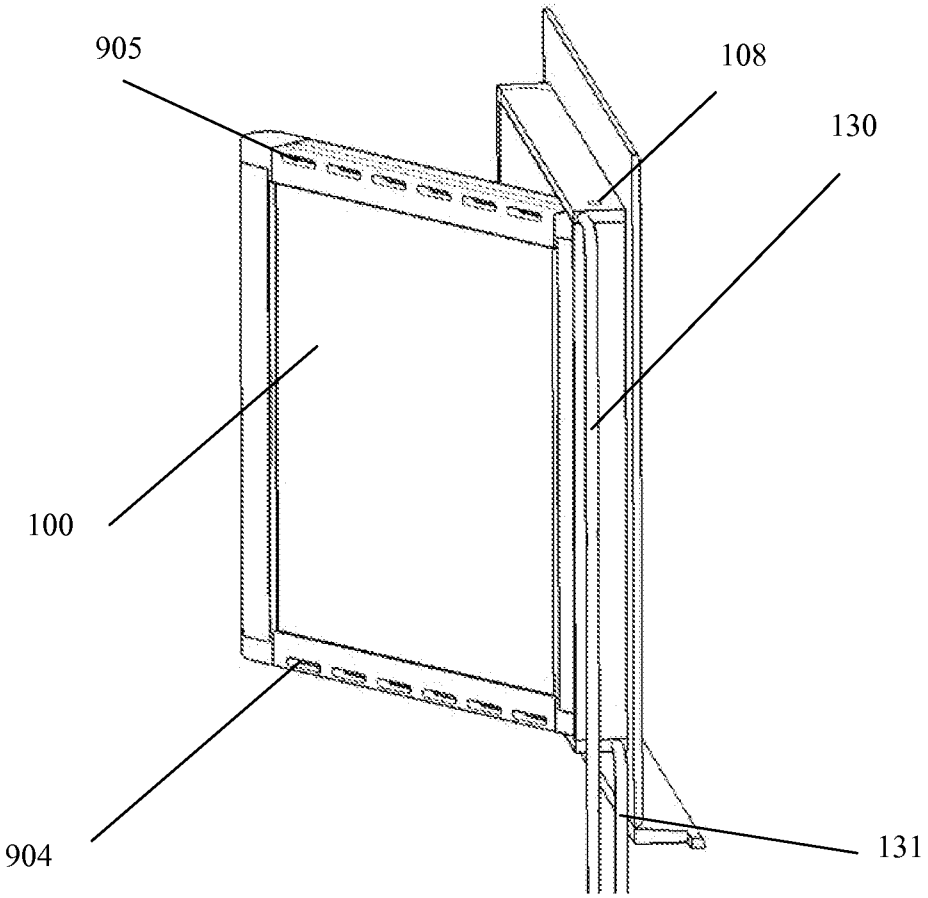
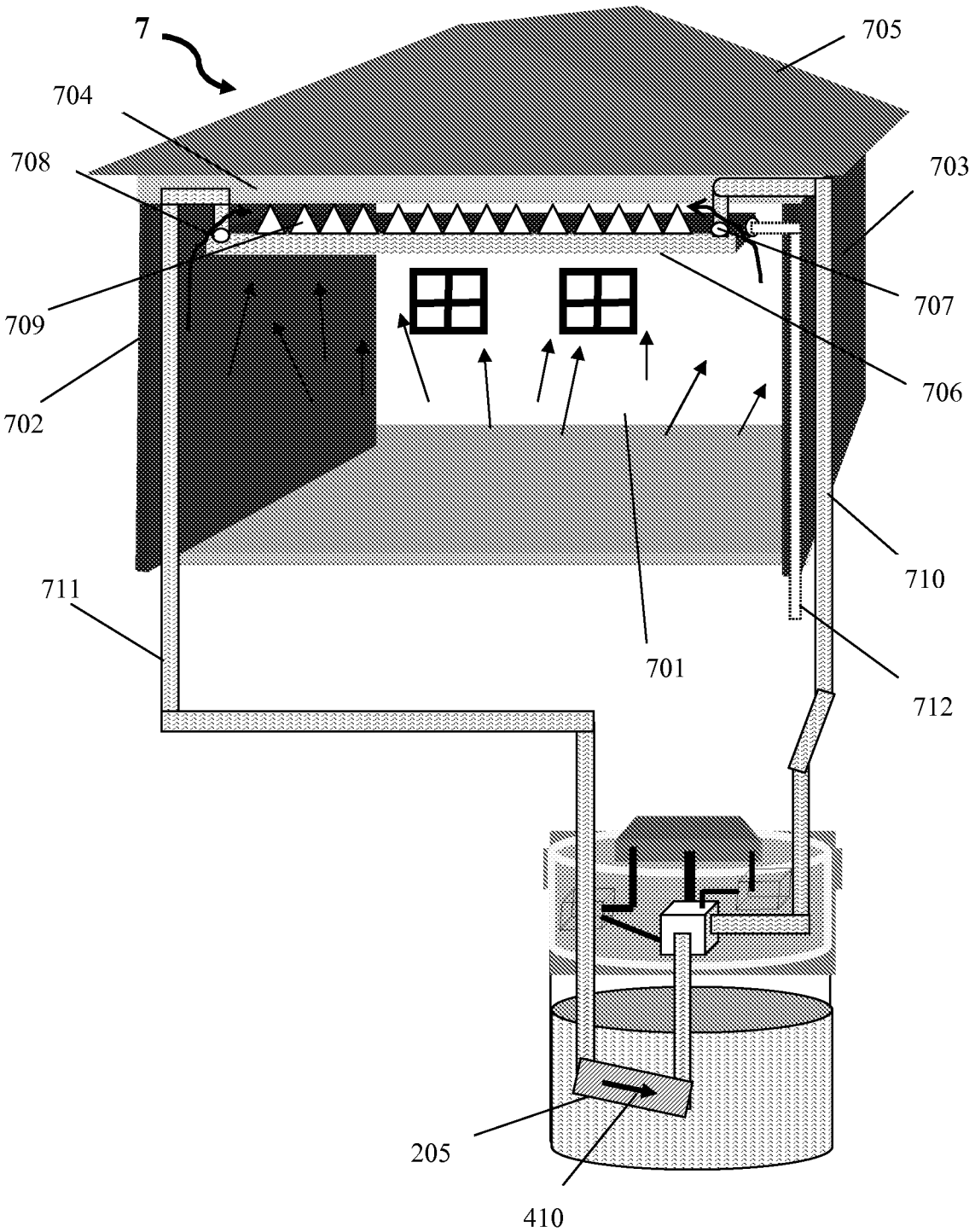


Fig. 11

Fig. 12



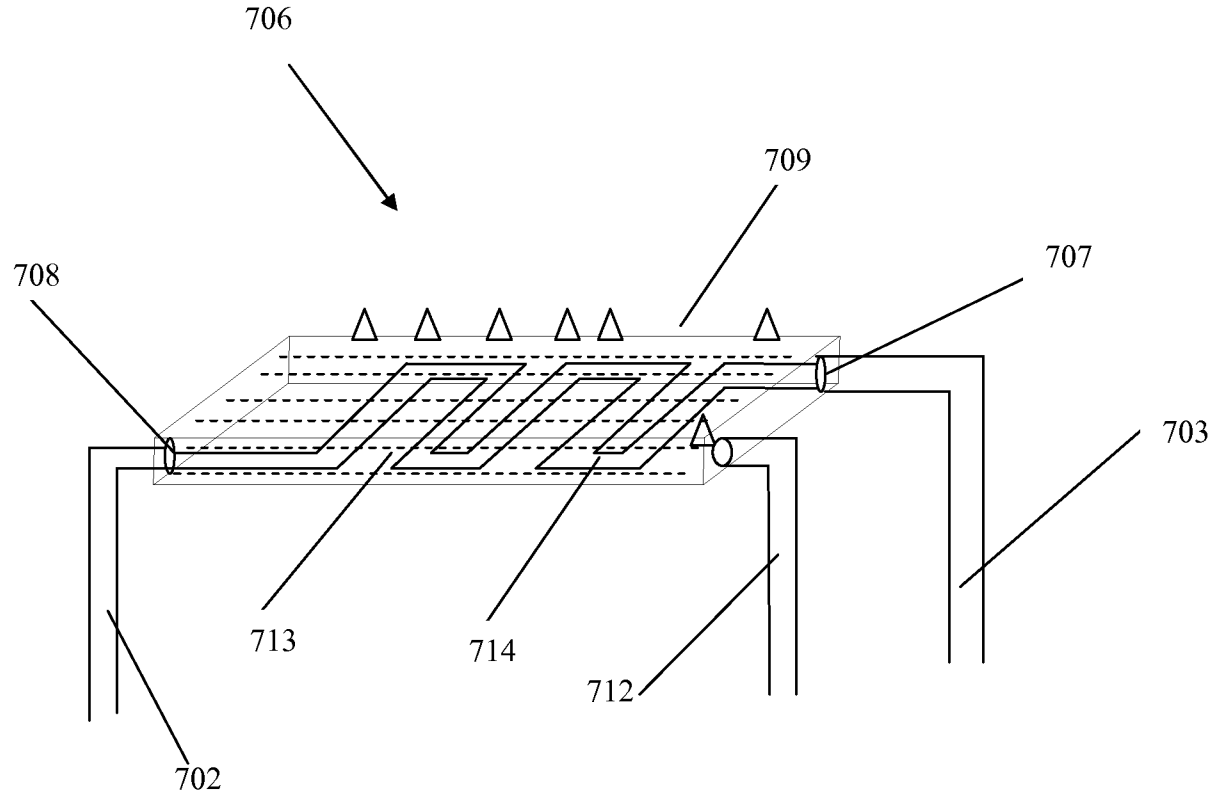


Fig. 12a

Fig. 13

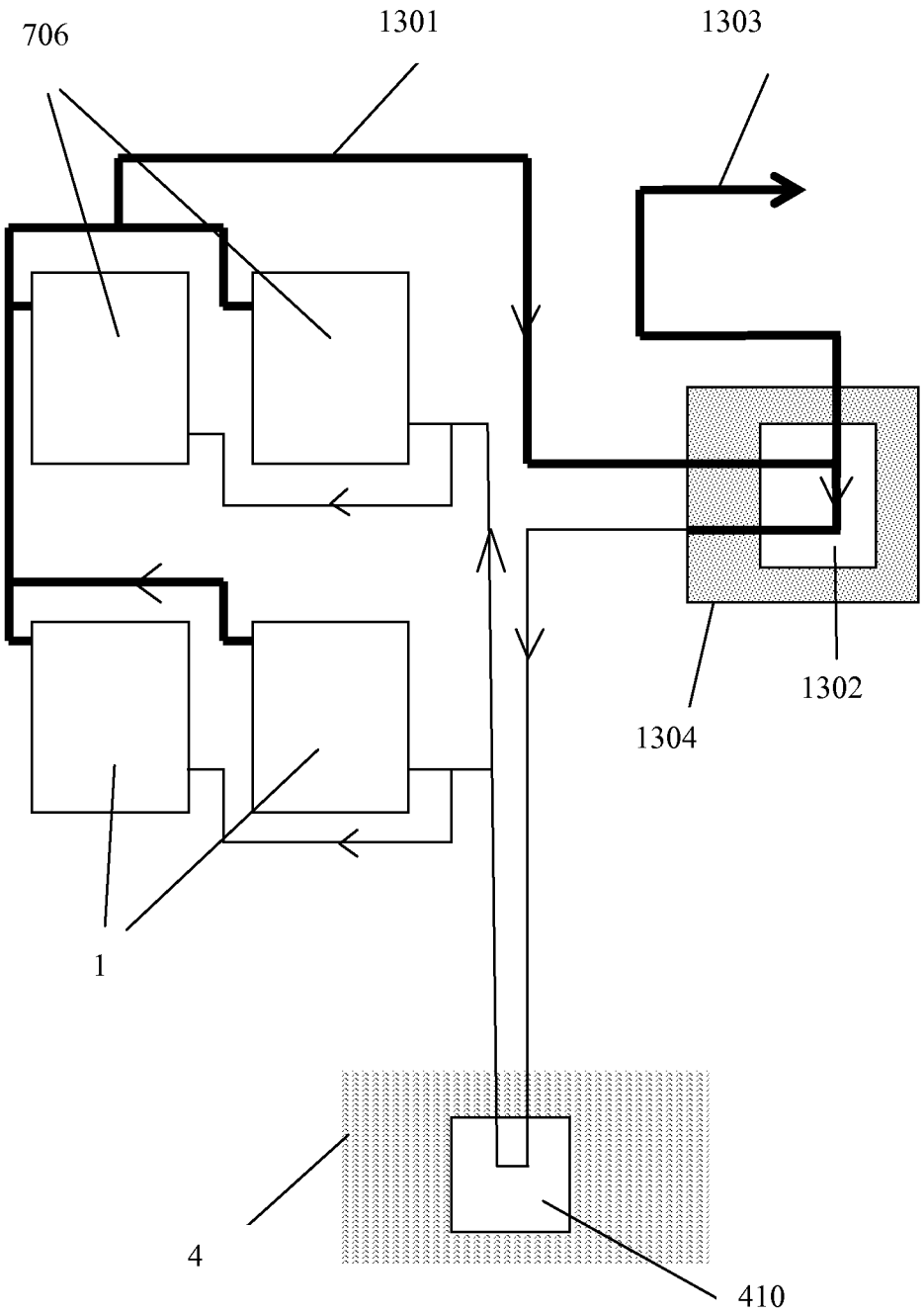
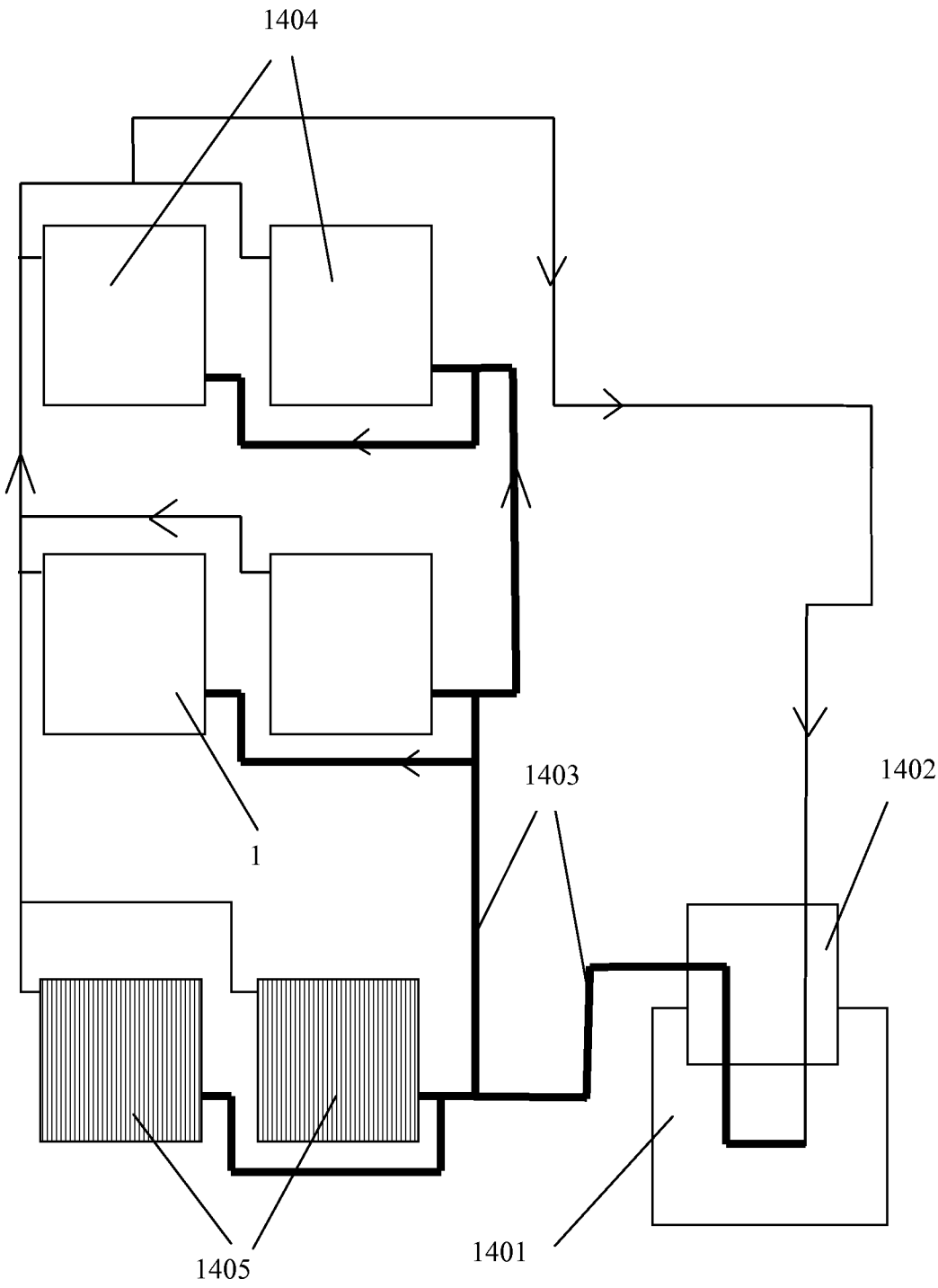


Fig. 14



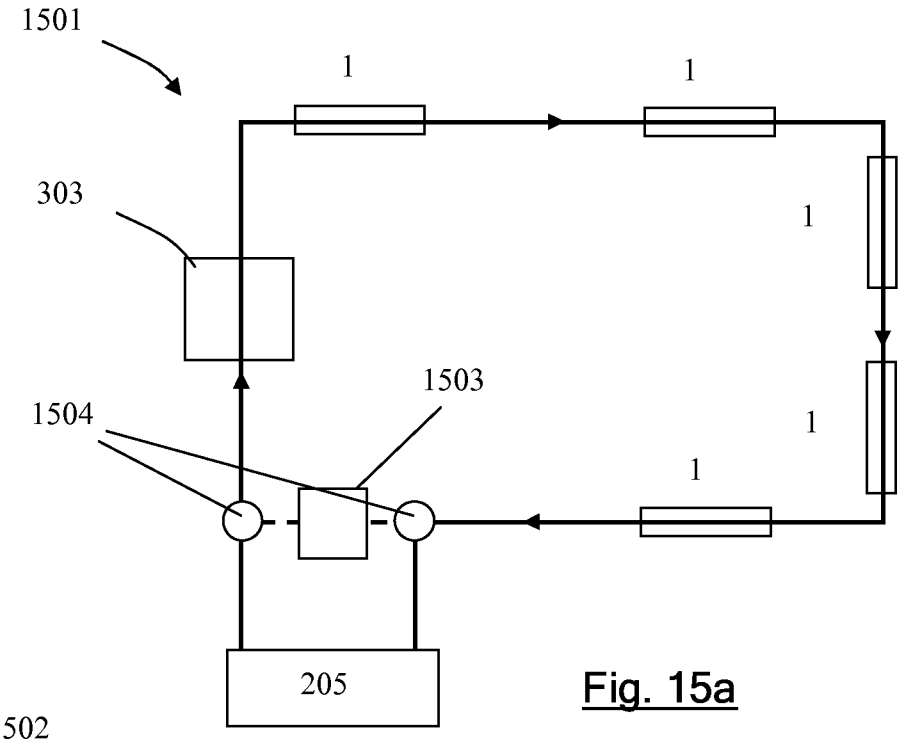


Fig. 15a

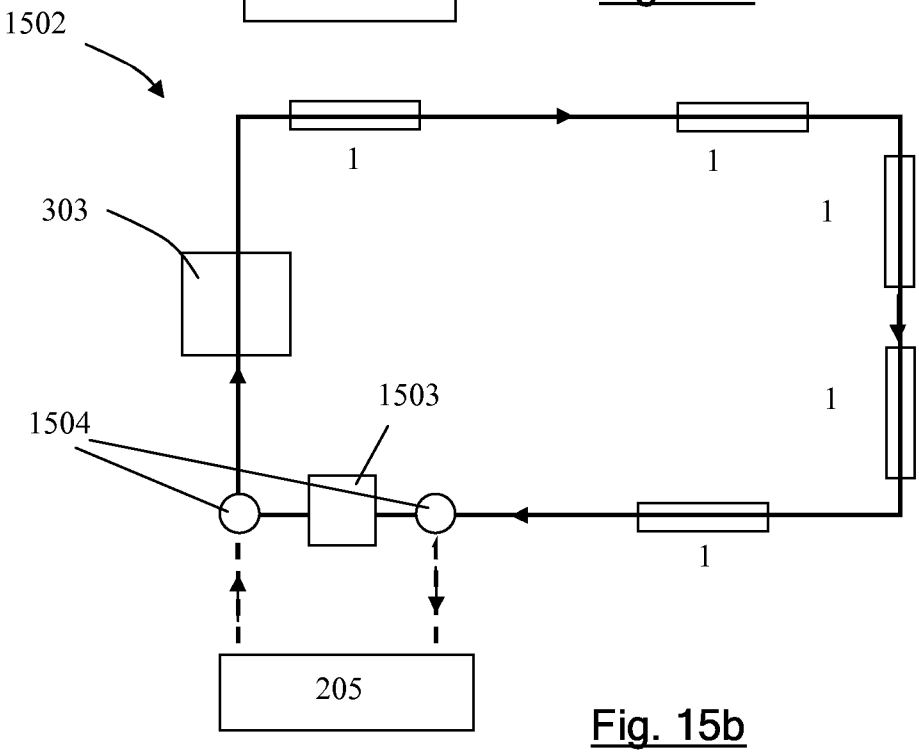


Fig. 15b

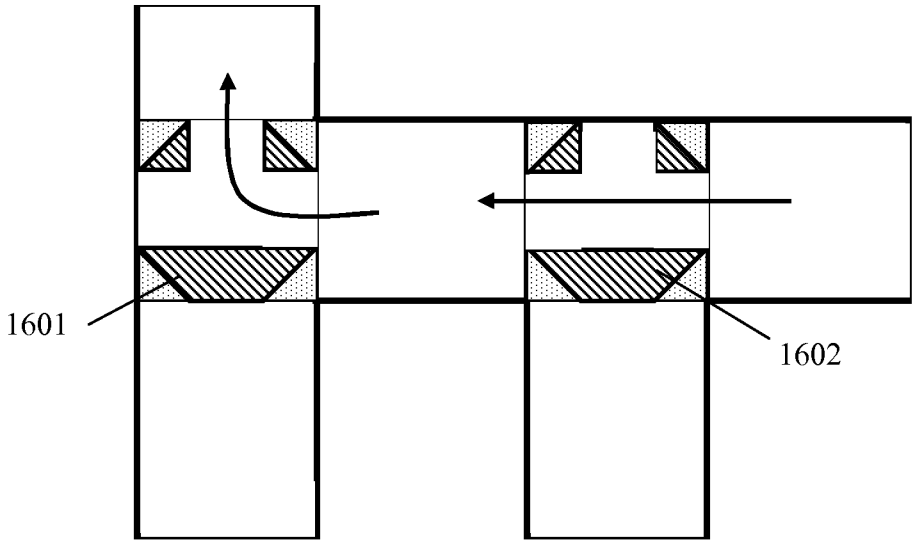


Fig. 16a

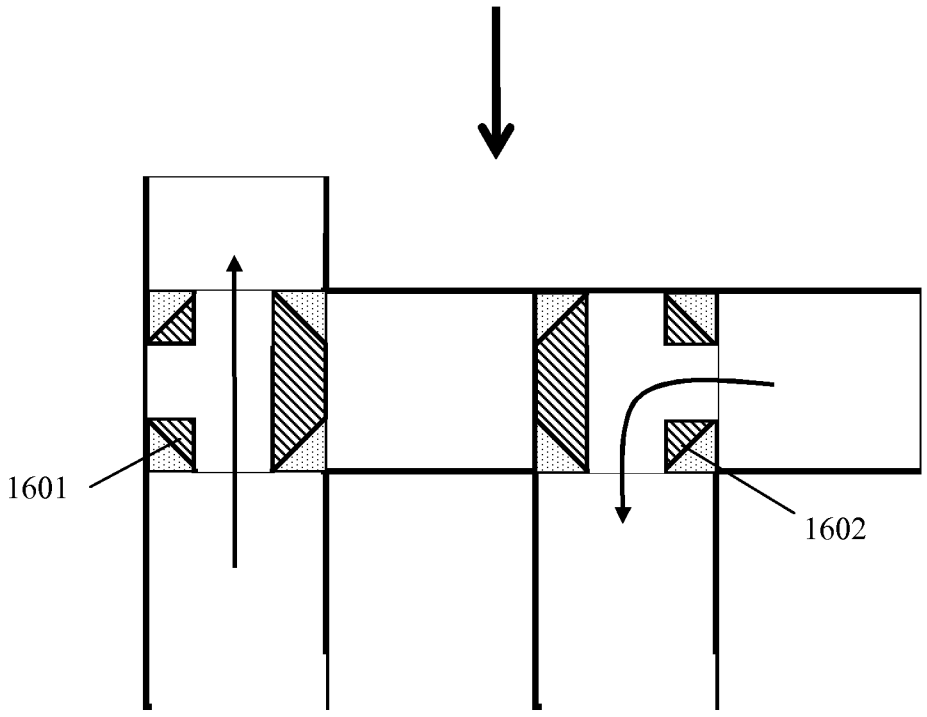


Fig. 16b