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(54) **ATMOSPHERIC MOISTURE HARVESTING**

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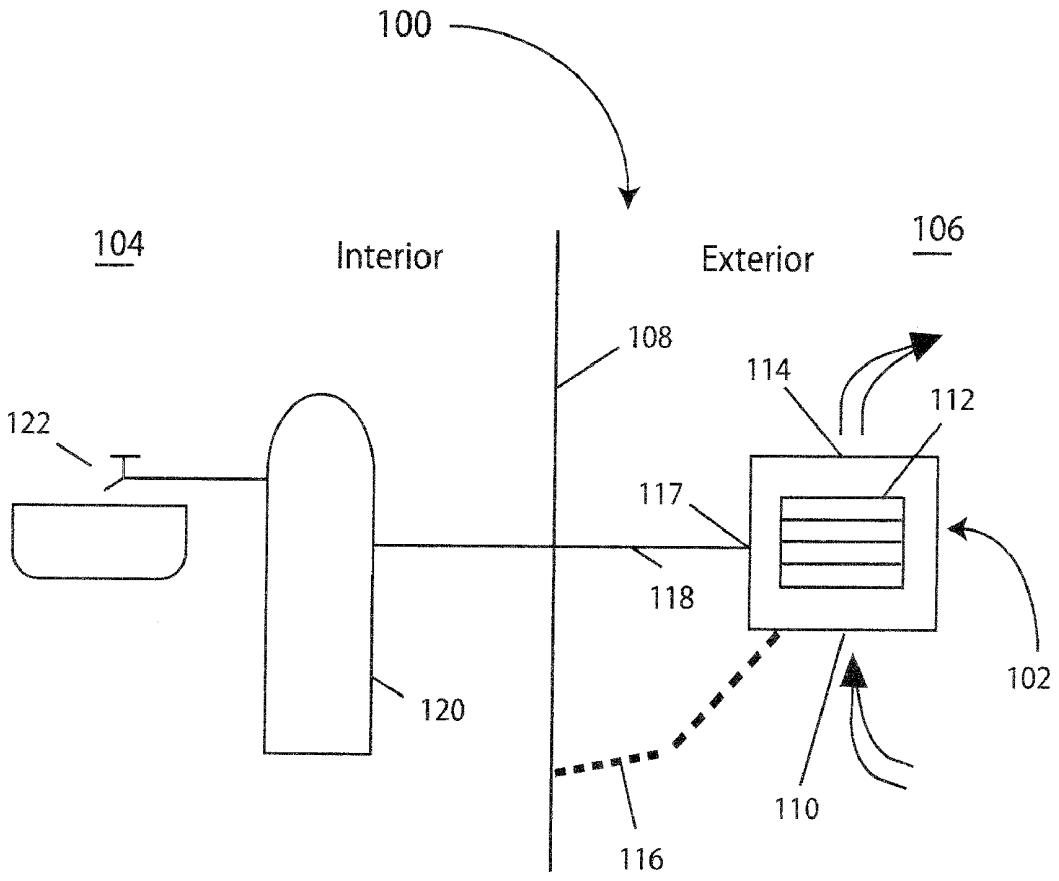
(57) **ABSTRACT**

The invention relates to atmospheric moisture harvesting. In particular, the invention capitalizes on the recognition that the air outside of a building usually has higher relative humidity than the air inside of the building. Therefore, the present invention relocates and/or modifies the configuration of an atmospheric moisture harvester such that more-moisture-laden, higher-relative-humidity outdoor air lows over the cooled water condensation surface of the atmospheric moisture harvester as the source for water to be delivered and consumed safely inside a dwelling or building. This increases the efficiency of atmospheric moisture harvesting and, at the same time, maintains the ability to access water obtained by the atmospheric moisture harvester from inside the building, thereby fostering ease of use.



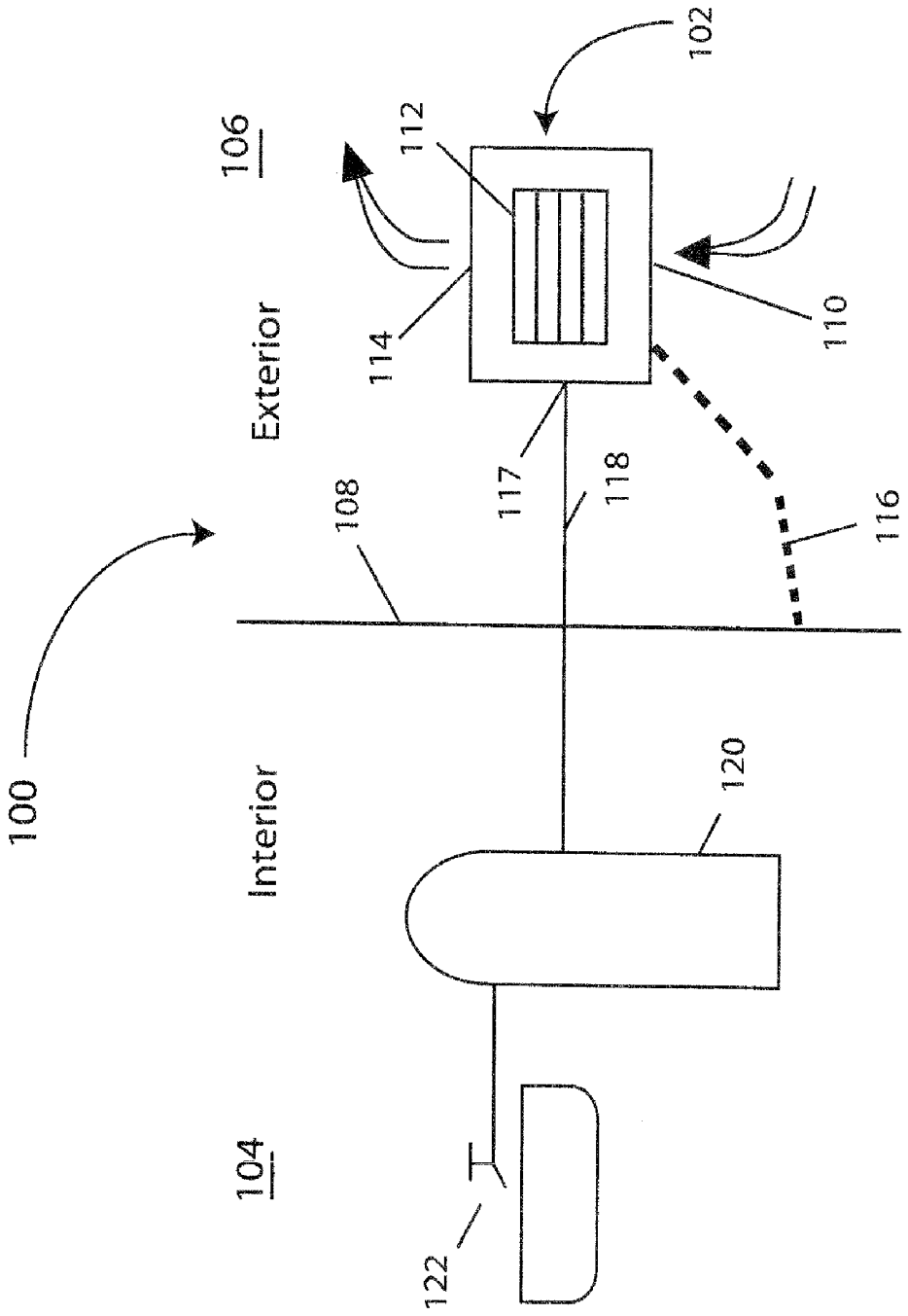

100
102
104
106
108
110
112
114
116
117
118
120
122
Exterior
Interior

Figure 1

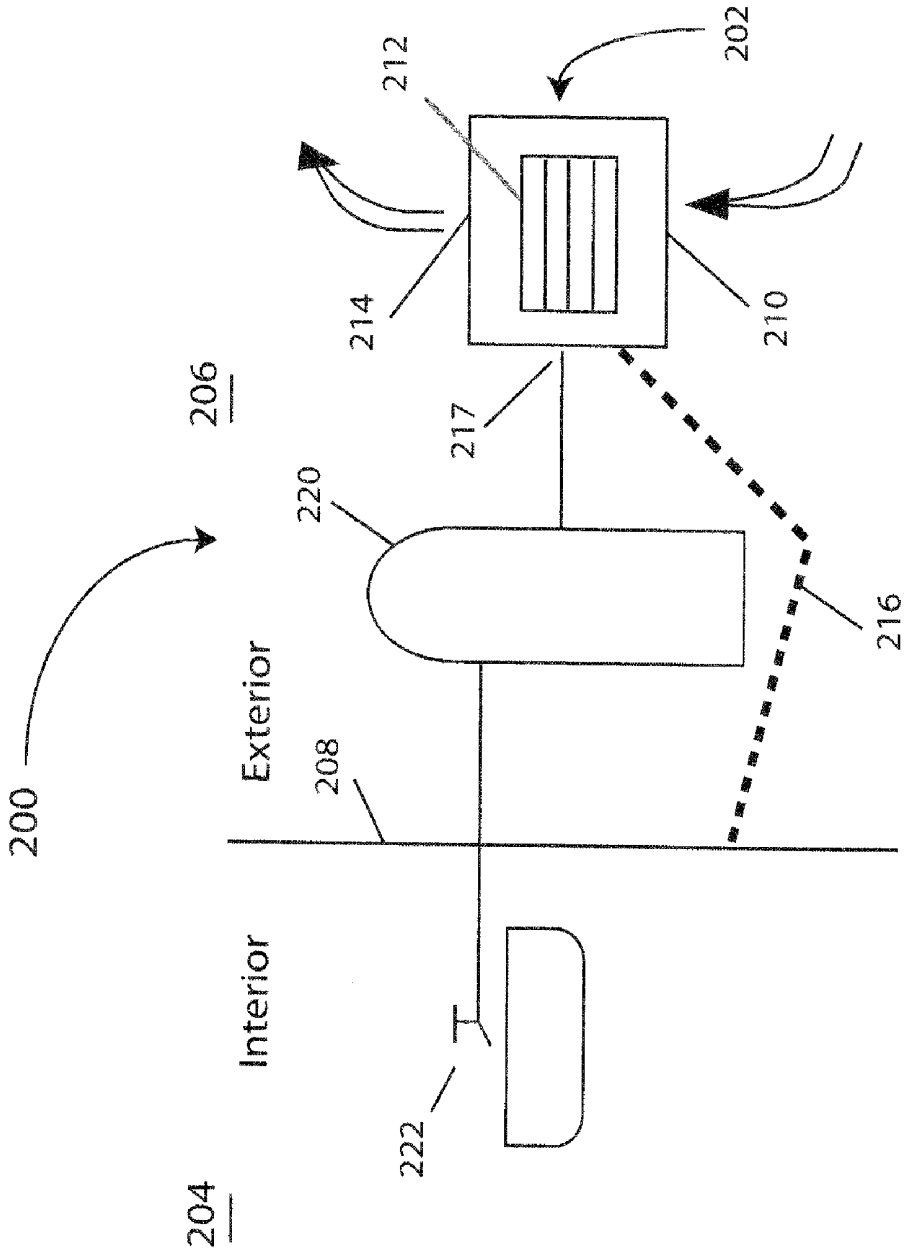

202
212
214
210
206
217
220
216
200
Exterior
208
Interior
222
204

Figure 2

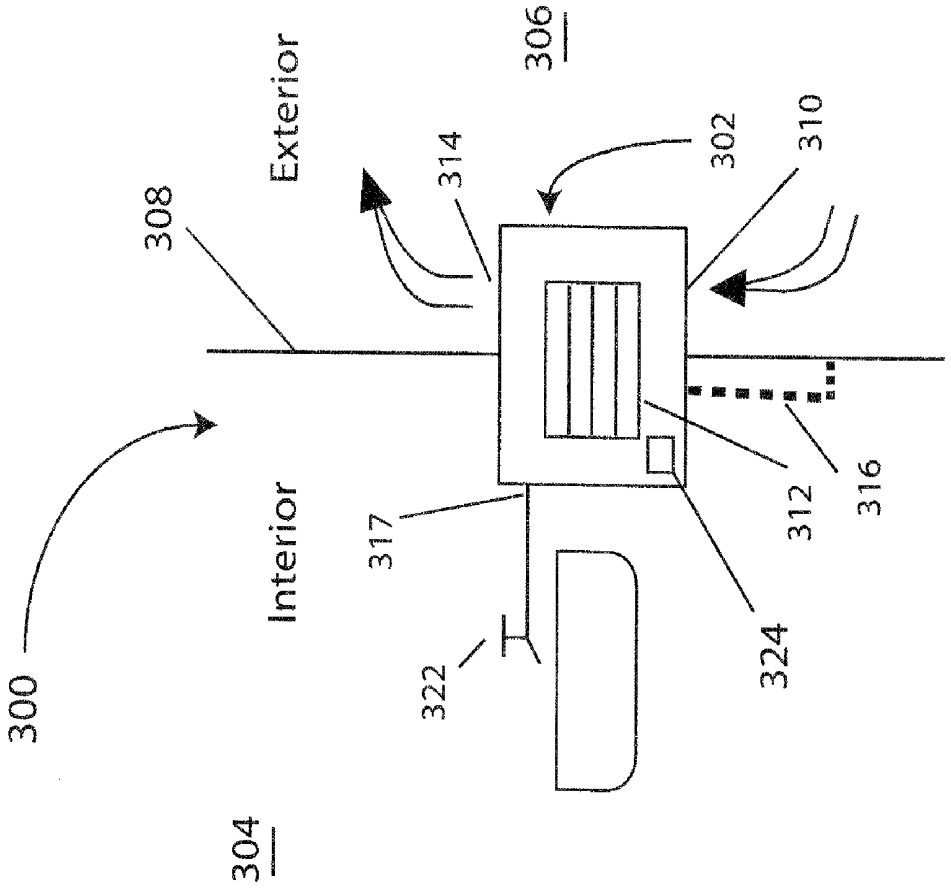

306
Exterior
314
302
310
308
300
Interior
317
312
316
322
324
304

Figure 3

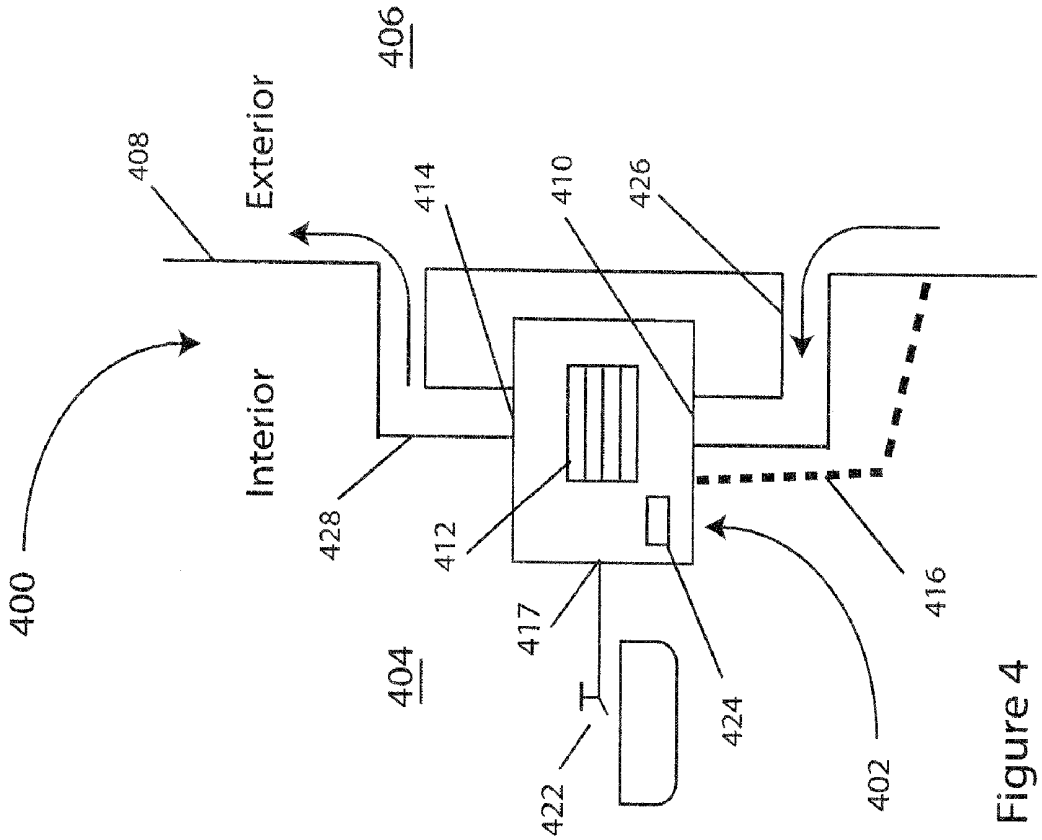

406
Exterior
408
414
410
426
Interior
400
428
412
417
404
424
422
402
416

Figure 4

ATMOSPHERIC MOISTURE HARVESTING

GOVERNMENTAL SUPPORT AND INTEREST

[0001] This invention was made with Governmental Support under Contract Number N00014-08C-0007 dated Mar. 4, 2008 (extended/expanded on Feb. 25, 2009) and issued by the Office of Naval Research (ONR). The Government has certain rights in the invention.

FIELD OF THE INVENTION

[0002] The invention relates to atmospheric moisture harvesting, i.e., extracting water from the air for human consumption.

BACKGROUND OF THE INVENTION

[0003] Atmospheric moisture harvesting to obtain drinking water is known. In this process, air containing water vapor is passed over a cooled or chilled surface, and moisture contained within the air condenses on that surface. The condensed water is then collected and, typically after some form of treatment to kill germs (e.g., ultraviolet irradiation, exposure to ozone, etc.), it is suitable for human consumption.

[0004] To the best of my knowledge, where atmospheric moisture harvesters have been used to obtain drinking water, the conventional practice has been to install them and use them indoors or to produce water outdoors and deliver it there also.

SUMMARY OF THE INVENTION

[0005] The present invention capitalizes on the recognition that the air outside of a building usually has higher relative humidity than the air inside the building. This is due to the fact that buildings are usually climate-controlled, e.g., air-conditioned, which reduces the relative humidity of the air inside of them. Therefore, the present invention relocates and/or modifies the geometric layout or configuration of an atmospheric moisture harvester such that more-moisture-laden, higher-relative-humidity outdoor air flows over the cooled water condensation surface of the atmospheric moisture harvester as the source for water to be consumed. This increases the efficiency of atmospheric moisture harvesting. At the same time, the present invention maintains the ability to access the water obtained by the atmospheric moisture harvester from inside the building, thereby fostering ease of use.

[0006] Thus, according to the invention, an arrangement for atmospheric moisture harvesting has a building with an interior and an exterior and an atmospheric moisture harvester with a condensing surface over which air can flow; an air inlet; an air outlet; and a water outlet. The atmospheric moisture harvester's air inlet is in communication with the building's exterior such that outside air can flow over the condensing surface, and the atmospheric moisture harvester's water outlet is in communication with the building's interior such that water obtained from the outside air by means of the atmospheric moisture harvester can be accessed from inside the building.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] The invention will now be described in greater detail in connection with the Figures, in which:

[0008] FIG. **1** is schematic illustration of a first embodiment of an atmospheric moisture harvesting arrangement according to the invention;

[0009] FIG. **2** is schematic illustration of a second embodiment of an atmospheric moisture harvesting arrangement according to the invention, which is a variant of the first embodiment illustrated in FIG. **1**;

[0010] FIG. **3** is schematic illustration of a third embodiment of an atmospheric moisture harvesting arrangement according to the invention; and

[0011] FIG. **4** is schematic illustration of a fourth embodiment of an atmospheric moisture harvesting arrangement according to the invention.

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

[0012] FIG. **1** shows a first embodiment **100** of an atmospheric moisture harvesting arrangement according to the invention. In this embodiment **100**, an atmospheric moisture harvester **102** is located entirely outside of a building, the interior of which is labeled as **104**, the exterior of which is labeled as **106**, and an exterior wall of which is labeled as **108**.

[0013] The atmospheric moisture harvester **102** suitably is configured according to any of the embodiments of atmospheric moisture harvesters disclosed in co-pending application Ser. No. 12/418,077 filed May 11, 2009 and entitled "Atmospheric Water Harvesters with Variable Pre-Cooling" (either with or without pre-cooling of the air before the air passes over the condensing surface), the entire contents of which are incorporated by reference. Alternatively, the atmospheric moisture harvester **102** may be configured with pre-cooling that is not variable. As illustrated by the double-stemmed arrows, outdoor air enters the atmospheric moisture harvester **102** through an inlet **110**; the air is cooled as it passes over a condensing surface **112**, which causes moisture in the air to condense into liquid form; and the air exits the atmospheric moisture harvester through an outlet **114**. Assuming the atmospheric moisture harvester **102** is constructed in accordance with the embodiments disclosed in the above-referenced co-pending application, or as a generally similar device that has non-variable pre-cooling, the condensing surface **112** will be the surface of an evaporator in a vapor compression cycle-based refrigeration circuit. As illustrated by the dashed line **116**, the atmospheric moisture harvester **102** is suitably powered by electricity from the building's electrical system. Additionally, controls for the atmospheric moisture harvester **102** are suitably located inside the building, and control signals are also represented by the dashed line **116**.

[0014] As further illustrated in FIG. **1**, liquid water that is obtained from the outside air by means of the atmospheric moisture harvester **102** exits the atmospheric moisture harvester **102** via water outlet **117** and passes into the interior **104** of the building via a conduit **118**, e.g., a pipe. The water may be pumped from the atmospheric moisture harvester **102** into the building; alternatively, depending on the relative vertical positioning of the components in the arrangement **100**, the water may simply flow into the building due to gravity.

[0015] In the embodiment **100** illustrated in FIG. **1**, it is anticipated that the atmospheric moisture harvester **102** may

be sized to produce on the order of about 20 gallons of water per day for an average family home. Therefore, a water treatment/reservoir unit **120** is located inside the building to store that water, and the water treatment/reservoir unit **120** receives the water flowing from the atmospheric moisture harvester **102**. The water treatment/reservoir unit **120** may include one or more means such as a UV-based bacteriostat, an ozone generator, a chlorinator, etc., by means of which germs that may have entered the water can be neutralized. Additionally or alternatively, the water treatment/reservoir unit **120** may include various water filtration devices to remove particulate matter from the water, or that/those filtration device(s) may be provided directly in the atmospheric moisture harvester **102**. (To obtain economies of scale, two or more atmospheric moisture harvesters **102** can be run in parallel, with a single, common air intake/air filtering mechanism serving all atmospheric moisture harvesters **102** in the group and all atmospheric moisture harvesters **102** in the group delivering water to a single, common water treatment/reservoir unit **120**.)

[0016] When it is needed, water is withdrawn from the water treatment/reservoir unit **120**, e.g., via a tap or spigot **122**. Depending on the relative vertical positioning of the water inlet to and water outlet from the water treatment/reservoir unit **120** and/or whether there is pressurization in the system, the water may need to be pumped out of the water treatment/reservoir unit **120** or, alternatively, it may flow out of the water treatment/reservoir unit **120** due to gravity.

[0017] A second embodiment **200** of an atmospheric moisture harvesting arrangement according to the invention, which arrangement **200** is similar to the arrangement **100** illustrated in FIG. **1**, is illustrated in FIG. **2**. The embodiment **200** is generally identical to the embodiment **100**, with the only difference being that the water treatment/reservoir unit **220** is located outside of the building instead of inside the building. Thus, the water outlet **217** from the atmospheric moisture harvester **202** is in indirect communication with the interior **204** of the building (e.g., via the water treatment/reservoir unit **220**), in contrast to being in direct communication with the interior of the building as in the first embodiment **100**. The two embodiments are otherwise identical, and the same reference numerals are used to identify the same components but are increased by **100** to a 200 "series" of reference numerals.

[0018] A third embodiment **300** of an atmospheric moisture harvesting arrangement according to the invention is illustrated in FIG. **3**. In this embodiment **300**, components that are essentially the same as those illustrated in FIGS. **1** and **2** and described above have correspondingly similar reference numerals, but in the 300 "series" of reference numerals. In the third embodiment **300**, the atmospheric moisture harvester **302** extends through the wall **308** of the building. One portion, which houses the condensing surface **312**, is located outside of the building so that outside air can flow easily across the condensing surface **312** as illustrated by the double-stemmed arrows, and the other portion, which has the water outlet **317**, is located inside the building. The atmospheric moisture harvester **302** may be mounted in a window in a manner similar to that in which a window-unit air conditioner is mounted, or it may be mounted in some other opening in the wall **308** that is specifically configured to accommodate the atmospheric moisture harvester **302**.

[0019] In this third embodiment **300**, the atmospheric moisture harvester **302** is significantly smaller than the atmospheric moisture harvesters **102** and **202** employed in the first and second embodiments **100** and **200**, respectively. Thus, the atmospheric moisture harvester **302** is foreseen as producing on the order of about five to ten gallons of water per day, and that amount of water can be stored in a reservoir (not shown) that is in the atmospheric moisture harvester **302**, per se. Germicidal means and filtration means (not shown) are also housed within the atmospheric moisture harvester. Furthermore, depending on the vertical positioning of the water outlet **317** and the tap or spigot **322**, water may be pumped out of the reservoir or it may flow out of the reservoir due to gravity.

[0020] Finally with respect to this third embodiment **300**, although the atmospheric moisture harvester **302** is powered by electricity from the building's electrical system as in the above-described embodiments and as indicated by the dashed line **316**, because the portion of the atmospheric moisture harvester **302** with the water outlet **317** is located inside the building and is therefore easily accessible, a control panel **324** may be provided directly on the atmospheric moisture harvester **302**. Therefore, the dashed line **316** represents the flow of electricity to the atmospheric moisture harvester **302** but not the flow of control signals to or from the atmospheric moisture harvester.

[0021] Finally, a fourth embodiment **400** of an atmospheric moisture harvesting arrangement according to the invention is illustrated in FIG. **4**. The fourth embodiment **400** is substantially similar to the third embodiment **300**. Unlike the third embodiment **300**, however, in the fourth embodiment **400**, the atmospheric moisture harvester **402** is located entirely inside the building, which might be desired in order to limit access and/or possible damage to the atmospheric moisture harvester **402** or to reduce weatherproofing requirements. Therefore, to facilitate such an arrangement, an inlet duct **426** is provided to convey air from outside of the building to the inlet **410** in the atmospheric moisture harvester **402**, and an outlet duct **428** is provided to convey the air from the outlet **414** in the atmospheric moisture harvester **402** back to the exterior of the building once that air has passed over the condensing surface **412**. (In FIG. **4**, the inlet and outlet ducts **426** and **428** are external to the atmospheric moisture harvester **402**; it is possible, of course, for the ducting to be provided inside the atmospheric moisture harvester **402** as a component thereof.) Otherwise, the fourth embodiment **400** of an atmospheric moisture harvesting arrangement is essentially the same as the third embodiment **300**.

[0022] The foregoing disclosure is only intended to be exemplary of the methods and apparatus of the present invention. Departures from and modifications to the disclosed embodiments may occur to those having skill in the art. The scope of the invention is set forth in the following claims.

I claim:

1. An arrangement for atmospheric moisture harvesting, comprising:

a building having an interior and an exterior that are separated by a wall; and

an atmospheric moisture harvester having a condensing surface over which air can pass; an air inlet; an air outlet; and a water outlet;

wherein the atmospheric moisture harvester's air inlet is in communication with the building's exterior such that outside air can flow over the condensing surface and wherein the atmospheric moisture harvester's water outlet is in communication with the building's interior such

that water obtained from the outside air by means of the atmospheric moisture harvester can be accessed from inside the building.

2. The arrangement of claim **1**, wherein the atmospheric moisture harvester is located completely outside of the building.

3. The arrangement of claim **2**, wherein the atmospheric moisture harvester's water outlet is in direct communication with the building's interior.

4. The arrangement of claim **3**, further comprising a water treatment/reservoir unit located inside the building and into which water flows from the atmospheric moisture harvester's water outlet after it enters the building, which water treatment/reservoir unit is constructed and arranged to germicidally treat and/or filter the water received and stored therein.

5. The arrangement of claim **2**, wherein the atmospheric moisture harvester's water outlet is in indirect communication with the building's interior.

6. The arrangement of claim **5**, further comprising a water treatment/reservoir unit located outside the building and into which water flows from the atmospheric moisture harvester's water outlet before it enters the building, which water treatment/reservoir unit is constructed and arranged to germicidally treat and/or filter the water received and stored therein.

6. The arrangement of claim **1**, wherein the atmospheric moisture harvester extends through an aperture in the wall, with the air inlet located outside the building and the water outlet located inside the building.

7. The arrangement of claim **1**, wherein the atmospheric moisture harvester is located completely inside the building, the arrangement further comprising an air inlet duct which is configured to convey air from outside of the building to the atmospheric moisture harvester.

8. The arrangement of claim **7**, further comprising an air outlet duct which is configured to convey air from the atmospheric moisture harvester back outside of the building.

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