(54) Title: ATMOSPHERIC MOISTURE HARVESTING

(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 flows 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.
ATMOSPHERIC MOISTURE HARVESTING

GOVERNMENTAL SUPPORT AND INTEREST

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

FIELD OF THE INVENTION

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

BACKGROUND OF THE INVENTION

[03] 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.

[04] 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

[05] 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.

[06] 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

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

[08] Figure 1 is schematic illustration of a first embodiment of an atmospheric moisture harvesting arrangement according to the invention;

[09] Figure 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 Figure 1;

[10] Figure 3 is schematic illustration of a third embodiment of an atmospheric moisture harvesting arrangement according to the invention; and

[11] Figure 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

[12] Figure 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.

[13] The atmospheric moisture harvester 102 suitably is configured according to any of the embodiments of atmospheric moisture harvesters disclosed in co-pending application number 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.

[14] As further illustrated in Figure 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.
[15] In the embodiment 100 illustrated in Figure 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.)

[16] 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.

[17] 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 Figure 1, is illustrated in Figure 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.

[18] A third embodiment 300 of an atmospheric moisture harvesting arrangement according to the invention is illustrated in Figure 3. In this embodiment 300, components that are essentially the same as those illustrated in Figures 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.

[19] 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.

[20] 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.

[21] Finally, a fourth embodiment 400 of an atmospheric moisture harvesting arrangement according to the invention is illustrated in Figure 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 Figure 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.

[22] 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.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - F25D 21/14 (2010.01)
USPC - 62/291
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
US: 62/291
IPC: F25D 21/14 (2010.01)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC: 62/92,283,291,498

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PubWest(PGPB,USPT,USOC,EPAB,JPAB); google;dehumidifier, dehumidification, condensate, condensation, removal, collection,
misture, retain, retention, cleanse, filter, purify, germicide, germicidal, uv filter, ultraviolet filter, building, building envelope, building
wall, HVAC system, HVAC, drinking water, potable, potable water, reservoir, boil

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
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<tr>
<td>X</td>
<td>US 5,203,989 A (REIDY) 20 April 1993 (20.04.1993) Entire document, especially fig. 2; col. 5.</td>
<td>1 and 7-8</td>
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</table>

Further documents are listed in the continuation of Box C.

Date of the actual completion of the international search
22 July 2010 (22.07.1010)

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