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(56) Documents Cited:
CN 108476823 A **US 20150223409 A1**
US 20120292176 A1

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(54) Title of the Invention: **Methods and apparatus for desalination**
Abstract Title: **Method and apparatus for desalination**

(57) Apparatus and method for desalination comprising: a greenhouse 10; a fan coil unit 20A including an air inlet and outlet, a coil, a fan for blowing air from the inlet over the coil to the outlet, and a condensation collector 22 for collecting condensation formed on the coil; piping 60 for carrying brackish water to a first end of the coil; a cooling tower 30 including one or more nozzles in communication with a second end of the coil, an air inlet in a lower region of the tower receiving air from the greenhouse, an air outlet in the upper region of the cooling tower, a filler between the air inlet and outlet to receive water from the nozzles, and a drain for drainage of water from the tower; outlet piping for receiving water from the drain; and a duct from the air outlet of the cooling tower to the air inlet of the first fan coil unit. A solar collector heater may by placed between the coil and nozzles. The fan coil unit and cooling tower may be inside the greenhouse. Also provided is a method of desalination. The system may provide effective desalination in arid regions.

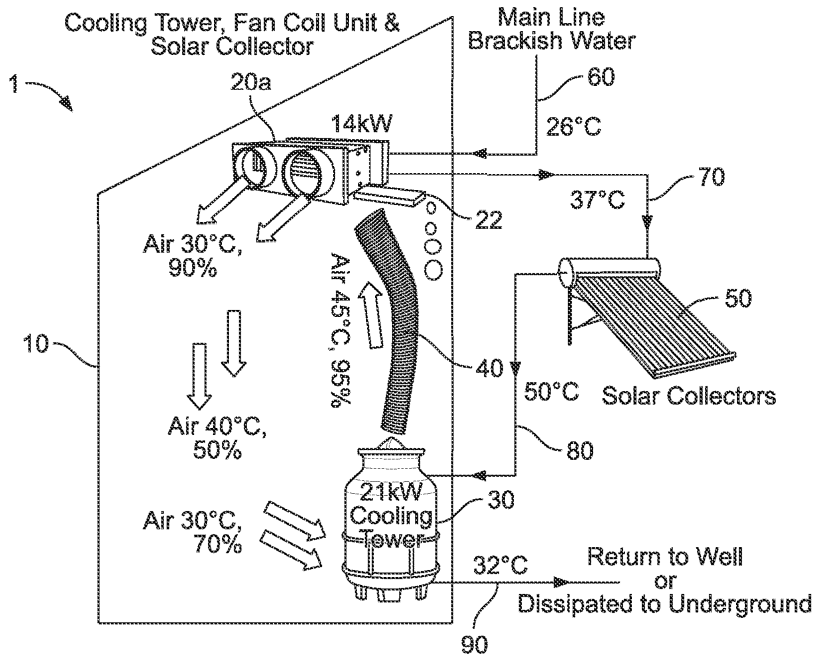


FIG. 1

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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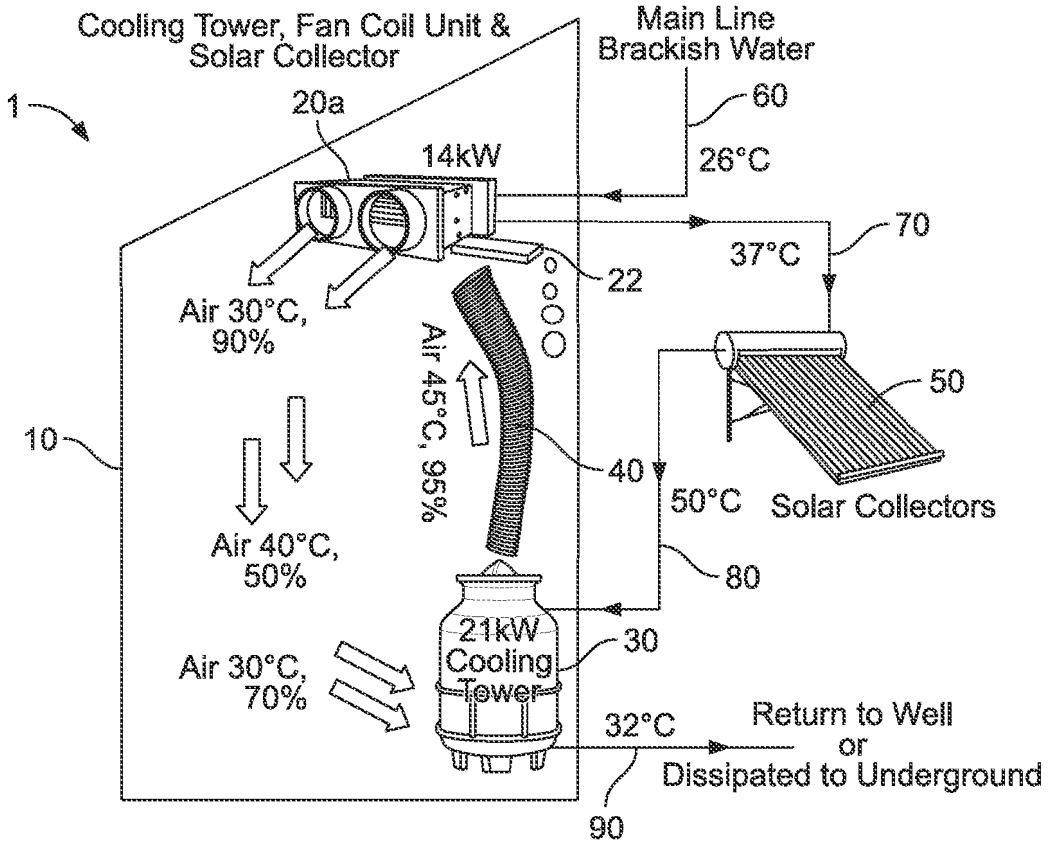


FIG. 1

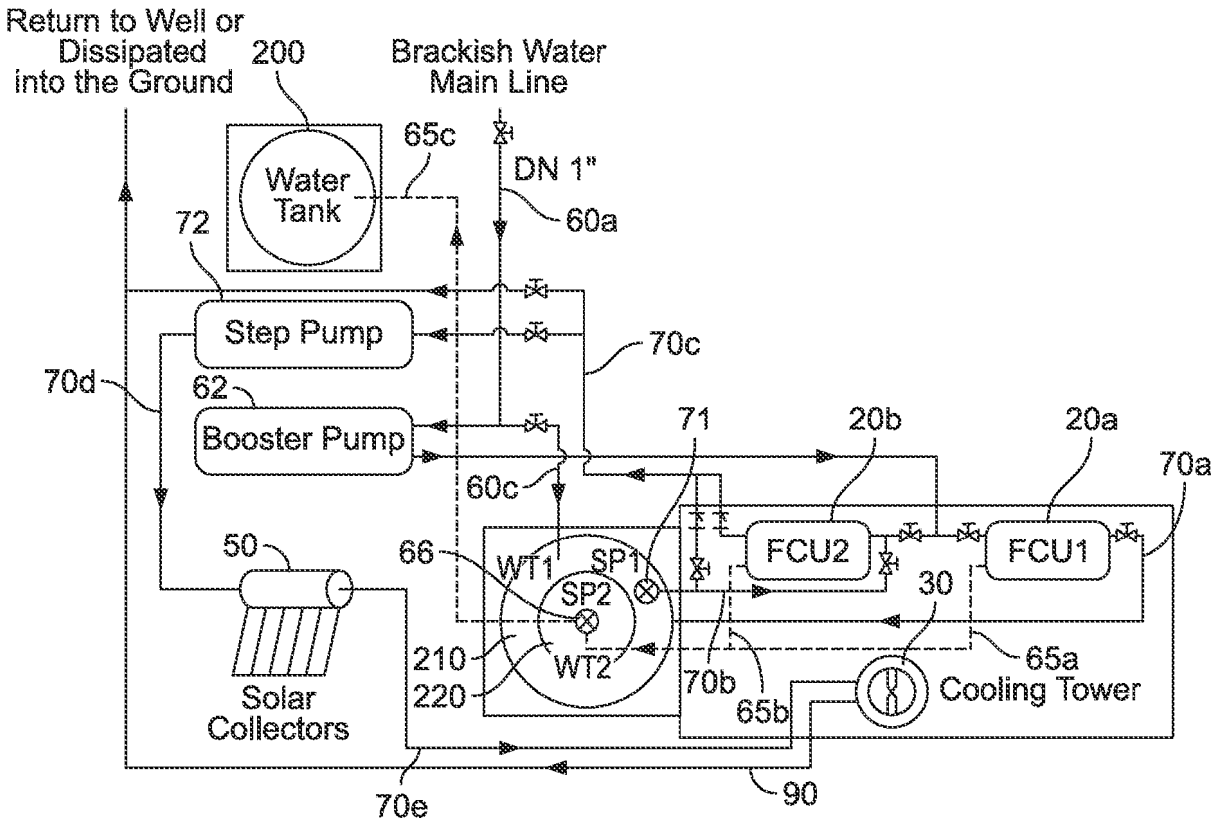


FIG. 2

11 11 19

11 11 19

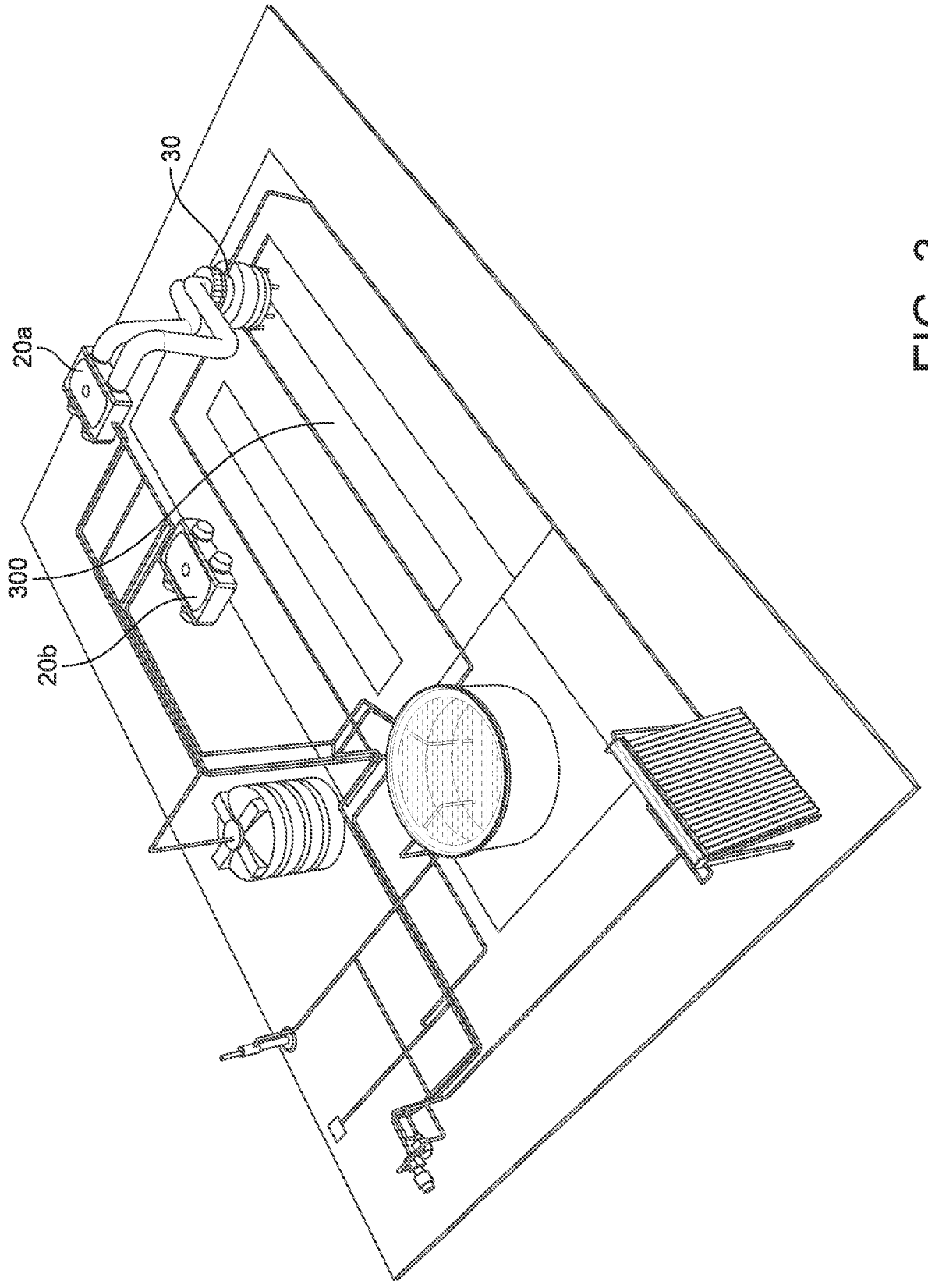


FIG. 3

11 11 19

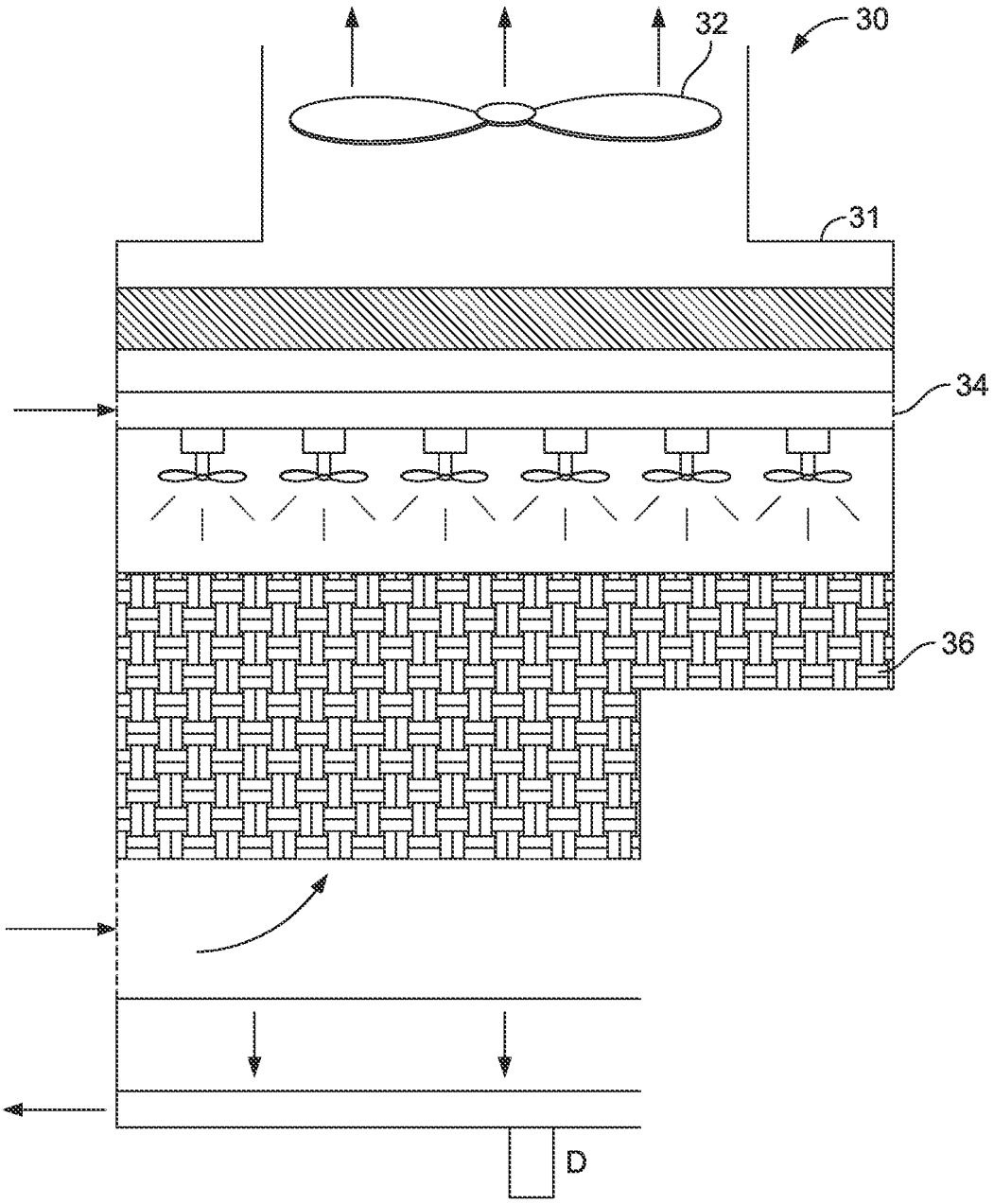


FIG. 4

11 11 19

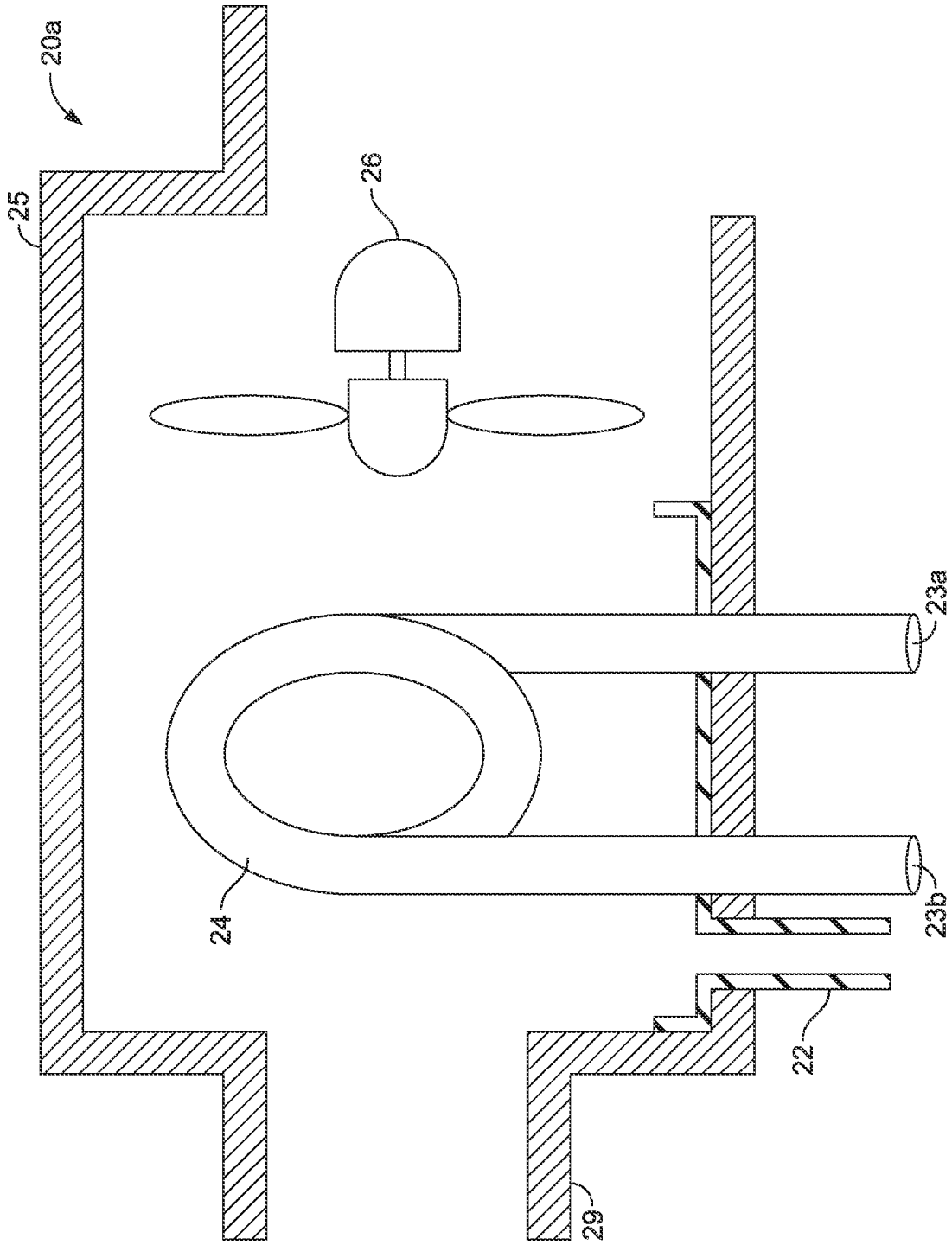


FIG. 5

METHODS AND APPARATUS FOR DESALINATION

The present invention relates to methods and apparatus for desalination. In particular, the following describes using a greenhouse environment to aid the process of desalination.

Methods of desalination carried out in greenhouses are known. However, a satisfactory system that is environmentally-friendly, inexpensive, and effective in arid regions has not previously been available. The invention aims to provide such a solution.

According to the invention there is provided an apparatus and a method defined by the claims.

For a better understanding of the invention and to show how the same may be put into effect, reference will now be made, by way of example only, to the accompanying drawings, in which:
Figure 1 shows a schematic representation of an apparatus for desalination;
Figure 2 shows a schematic representation of a system including the apparatus of Figure 1;
Figure 3 shows a perspective view of components of the apparatus of Figure 1;
Figure 4 shows a schematic representation of cooling tower for use in the apparatus of Figure 1; and
Figure 5 shows a schematic representation of fan coil unit for use in the apparatus of Figure 1.

Figure 1 shows a first embodiment of a desalination apparatus.

The desalination apparatus 1 comprises a greenhouse 10 housing a first fan coil unit 20A and a cooling tower 30 that is connected to the first fan coil unit 20 via a duct 40.

The greenhouse 10 may have a region containing plants and may provide a humid atmosphere suitable for the growth of those plants.

Optionally, the desalination apparatus also comprises a second fan coil unit 20B.

Preferably, the fan coil units 20 are mounted higher than the cooling tower 30. That is, preferably, the fan coil units 20 are mounted in the upper region of the greenhouse 10, and the cooling tower 30 sits in the lower region of the greenhouse 10.

Whilst it is not essential for the first fan coil unit 20A, second fan coil unit 20B, cooling tower 30, and duct 40 to be housed within the greenhouse 10 (since they merely need to be in communication with the internal volume of the greenhouse 10), this is preferred for convenience.

As shown in Figure 2, a first clean water reservoir 200 may be provided for storage of clean water. This may be a water tank.

A second clean water reservoir 220 may be provided for storage of clean water. This may be a pool. Preferably, the second clean water 220 reservoir is an open pool within the greenhouse. This may be closed to avoid contamination.

A brackish water reservoir 210 may be provided for storage of brackish water. This may be a pool. Preferably, the brackish water reservoir 210 is a pool outside the greenhouse.

The cooling tower 30 may be provided in any of a variety of forms, but a preferred form of cooling tower known in the art is shown in Figure 4. As can be seen from Figure 4, the cooling tower 30 may comprise: one or more nozzles 34; an air inlet 38 at the base of the cooling tower 30 for receiving air; an air outlet 32 at the top of the cooling tower 30 (optionally, assisted by a fan); a filler 36 through which fluid may pass between the air inlet 38 and the air outlet 32 and arranged to receive water from the one or more nozzles 34; and a drain 39 for receiving drainage water, through which brackish water that is not entrained in the air flow through the cooling tower 30 maybe drained. Preferably, these components are all housed within a tower body 31 that is arranged to stand in a vertical orientation with the air outlet 32 in an upper region and with the air inlet 38 and the drain 39 in a lower region. Preferably, the air inlet 38 is at the base of the cooling tower 30 and the air outlet 32 is at the top of the cooling tower 30.

As can be seen from Figure 5, the first fan coil unit 20A comprises: an air inlet 21; an air outlet 29; a first coil 24 having a first end 23A and a second end 23B; a fan 26 for blowing air from the air inlet 21 over the first coil 24 to the air outlet 29; and a condensation

collector 22 for collecting condensation formed on the surface of the first coil 24. Preferably, these components are all housed within a housing 25 which provides a flow path from the air inlet 21 via the fan 26 and then the first coil 24 to the air outlet 29. When provided, the optional second fan coil unit 20B comprises the same components (these will be referred to with the same reference numeral with the appended 'A' replaced by a 'B').

The fan coil units 20 may comprise multiple coils 24 and/or multiple fans 26, and will operate in substantially the same way as would be apparent to the skilled person.

The condensation collector 22 may be, for example, a funnel or a tray with a drain arranged to receive drips from the one or more first coil 24.

Brackish water passes through the coils 24 of the one or more fan coil units 20 and is delivered into the cooling tower 30 for entrainment into air passing therethrough. Preferably, between the one or more fan coil units 20 and the cooling tower 30, a heater 50 is provided for increasing the temperature of the brackish water. The heater 50 is preferably a solar collector 50. More preferably, the solar collector 50 is outside the greenhouse 10.

A duct 40 is provided. The duct 40 extends from the air outlet 32 of the cooling tower 30 to the air inlet 21 of the first fan coil unit 20A. That is, the duct 40 sealingly engages the air outlet 32 of the cooling tower 30 and the air inlet 21 of the first fan coil unit 20A. The duct 40 can therefore isolate the flow of air out of the cooling tower 30 from environment within the greenhouse 10 (i.e., the rest of the environment within the greenhouse 10 when the components are housed therein).

There is also provided inlet piping 60 for supplying brackish water. The inlet piping 60 is in communication with the first end 23A of the first coil 24.

Preferably, a first part of the inlet piping 60A leads to a pump 62 for pumping the water along a second part of the inlet piping 60B, which extends to the fan coil units 20.

In some embodiments, a further section of inlet piping 60C may be provided to deliver water to the brackish water reservoir 210.

The brackish water provided by inlet piping 60A, 60B passes through the first coil 24A of the first fan coil unit 20A. Piping 70 is provided to carry the brackish water from the first coil 24A to the cooling tower 30.

When more than one fan coil unit 20 is provided, these may have first coils 24 that communicate in series or parallel (optionally, there may be provided valving for switching to either of series or parallel operation). The fan coil units 20A, 20B are supplied with water by the inlet piping 60, and this is carried to the one or more nozzles 34 of the cooling tower 30 via supply piping 70. A pump 72 may be provided to drive water along the supply piping 70.

As can be seen in Figure 2, a second fan coil unit 20B may be provided. In the depicted option, the first coil 24A of the first fan coil unit 20A can supply brackish water to the second coil 24B of the second coil unit 20B (i.e., a series arrangement).

For example, the first end 23A of the first coil 24A of the first fan coil unit 20A can receive brackish water from the inlet piping 60, the second end 23B of the first coil 24A of the first fan coil unit 20A can supply brackish water to the first end 23A of the second coil 24B of the second coil unit 20B, and the second end 23B of the second coil 24B of the second coil unit 20B supplies the brackish water to the cooling tower 30.

Optionally, the second end 23B of the first coil 24A of the first fan coil unit 20A can supply brackish water to the first end 23A of the second coil 24B of the second coil unit 20B via a brackish water reservoir 210.

That is, the first coil 24A of the first fan coil unit 20A may supply water to the brackish water reservoir 210 via supply piping 70A, and the second coil 24B of the second fan coil unit 20B may be supplied with water from the brackish water reservoir 210 via supply piping 70B (optionally, via a pump 71).

The second coil 24B of the second fan coil unit 20B may then supply the cooling tower 30 via supply piping 70C, 70D, 70E.

An optional pump 72 may be provided with water via supply piping 70C and pump this to the cooling tower 30 via supply piping 70D, 70E.

In preferred embodiments, a heater 50 receives brackish water via supply piping 70D and pump this to the cooling tower 30 via supply piping 70E. Preferably, the heater 50 is a solar thermal collector. More preferably, the solar thermal collector 50 is outside the greenhouse 10.

The condensation collectors 22 of the fan coil units 20 may be connected to clean water piping 65A, 65B for delivering condensed water to a clean water reservoir (either directly to first clean water reservoir 200 or via second clean water reservoir 220). In one embodiment, the clean water piping 65A, 65B may deliver clean water to a second clean water reservoir 220, which is within the greenhouse 10. Preferably, clean water piping 65C may be provided to connect the second clean water reservoir 220 with the first clean water reservoir 200 separate from the greenhouse 10. A pump 66 may be provided to pump water to the first clean water reservoir 200 from the second clean water reservoir 220.

An outlet pipe 90 is provided for receiving brackish water from the drain 39 of the cooling tower 30. The outlet pipe 90 may return the brackish water to the well, or drain it into the ground.

Valving may be provided to control the flow of water through the various sections of piping.

A preferred embodiment of a method for desalination comprises the steps of: supplying brackish water to one or more coils 24 of one or more fan coil units 20; delivering water from the coil(s) 24 into one or more nozzles 34 of a cooling tower 30; drawing air from a greenhouse 10 into the cooling tower 30 to entrain at least some of the delivered water to form humidified air; directing the humidified air through a duct 40 to the coil(s) 24; and collecting condensation that forms on the coil(s) 24.

The air directed over the coil(s) 24 may be recirculated to the greenhouse 10. In this way a cycle is provided such that air is circulated through a region of the greenhouse 10, which may contain plants, and is drawn into the cooling tower 30.

Heated brackish water is delivered (for example, it may be sprayed) into the air passing through the cooling tower 30. The heated brackish water may have a temperature of at least 31 degrees centigrade, for example 37 degrees centigrade.

The water vapour is entrained into the air flow through the cooling tower 30 to provide a flow of humid air out of the air outlet 32 of the cooling tower 30 (in some embodiments, this may be driven by a fan).

The flow of humid air out of the air outlet 32 of the cooling tower 30 may be isolated from the remainder of the greenhouse 10 by a duct 40. The humid air from the air outlet 32 of the cooling tower 30 flows along duct 40 to the air inlet 21 of a fan coil unit 20, where it is driven over coil(s) 24 by a fan 26.

A flow of brackish water passes through the coil(s) 24 from its first end 23A to its second end 23B. The temperature of the brackish water within the coil(s) 24 is lower than the temperature of the humid air passing over the outside surface of the coil(s) 24 and so the water carried by the humid air condenses on the coil(s) 24.

By way of example, the temperature of the brackish water supplied to the coil(s) 24 may be in the range 24 to 30 degrees centigrade, for example 26 degrees centigrade. The brackish water may receive heat from the flow of air and so increase in temperature as it passes through the coil(s) 24. By way of example, the temperature of the brackish water leaving the coil(s) 24 (that is, the last of the coils 24 through which it passes) may be at least 31 degrees centigrade, for example 37 degrees centigrade.

This brackish water may be sent directly to the cooling tower 30 to be used as described above. However, it is preferred that the brackish water may be further heated to a temperature of at least 38 degrees centigrade, for example 50 degrees centigrade. This additionally heated brackish water may then be sent to the cooling tower 30 to be used as described above.

The heating means may be a solar collector 50.

The condensation can be collected by the condensation collector 22. The condensation is desalinated water. This may be used to water the plants in the greenhouse 10 or stored for other purposes, such as for use as drinking water. The condensation may be stored in a reservoir inside the greenhouse 10 (such as open pool 220) or outside the greenhouse 10 (such as water tank 200).

As mentioned above, in preferred embodiments a second fan coil unit 20B is provided. This fan coil unit 20B may be arranged in series or parallel with respect to the flow of brackish water through the coil(s) 24. However, whereas the air inlet 21 of the first coil unit 20A is sealingly connected via the duct 40 to the cooling tower 30, the air inlet 21 of the second coil unit 20B is open to the remainder of the greenhouse 10 (that is, it does not received the air directly from the cooling tower 30). Similarly, the air outlet 29 of the second coil unit 20B is open to the remainder of the greenhouse 10. This additional fan coil unit 20 therefore adds additional heat to the brackish water passing through its coil(s) 24 for increasing the temperature of the water provided to the cooling tower 30, and removes water from the air in the remainder of the greenhouse 10 (the air outside the cooling tower 30).

CLAIMS:

1. Apparatus for desalination comprising:
    a greenhouse;
    a first fan coil unit and including
        an air inlet,
        an air outlet,
        a first coil having a first end and a second end,
        a fan for blowing air from the air inlet over the coil to the air outlet, and
        a condensation collector for collecting condensation formed on the surface of the coil;
    inlet piping for carrying brackish water, in communication with the first end of the first coil;
    a cooling tower including
        one or more nozzles in communication with the second end of the first coil,
        an air inlet in a lower region of the cooling tower arranged to receive air from the greenhouse,
        an air outlet in an upper region of the cooling tower,
        a filler between the air inlet and the air outlet and arranged to receive water from the one or more nozzles, and
        a drain for the drainage of water from the cooling tower;
    outlet piping for receiving water from the drain; and
    a duct from the air outlet of the cooling tower to the air inlet of the first fan coil unit.

2. The apparatus of claim 1, further comprising a heater arranged to receive water from the second end of the first coil and to supply heated water to the one or more nozzles.

3. The apparatus of claim 2, wherein the heater is a solar collector.

4. The apparatus of claim 2 or claim 3, wherein the first fan coil unit and the cooling tower are inside the greenhouse.

5. The apparatus of any preceding claim, further comprising a second fan coil unit including
    an air inlet,
    an air outlet,

a second coil having a first end and a second end,
a fan for blowing air from the air inlet over the second coil to the air outlet, and
a condensation collector for collecting condensation formed on the surface of the second coil,

wherein:

the first end of the second coil is in communication with the second end of the first coil; and
the one or more nozzles are connected to the second end of the second coil.

6. A method for desalination comprising the steps of:
supplying brackish water to a first coil of a first fan coil unit;
delivering water from the first coil into one or more nozzles of a cooling tower;
drawing air from a greenhouse into the cooling tower to entrain at least some of the delivered water to form humidified air;
directing the humidified air through a duct to the first coil; and
collecting condensation that forms on the first coil.

7. The method of claim 6, further comprising:
recirculating the air directed over the first coil to the greenhouse.

8. The method of any one of claims 6 to 7, wherein the water from the first coil is heated before being delivered to the cooling tower.

9. The method of any one of claims 6 to 8, wherein the water from the first coil is heated to at least 50 degrees centigrade before being delivered to the cooling tower.

10. The method of any one of claims 6 to 9, wherein the water from the first coil is heated using a solar collector before being delivered to the cooling tower.

11. The method of any one of claims 6 to 10, wherein the condensation is provided to a reservoir inside the greenhouse.

12. The method of any one of claims 6 to 11, wherein the step of delivering water from the first coil into one or more nozzles of a cooling tower comprises:
delivering water from the first coil to a second coil of a second fan coil unit;

directing air from the greenhouse over the second coil;

recirculating the air directed over the second coil back to the greenhouse; and

delivering water from the second coil into the one or more nozzles of a cooling tower.

Intellectual Property Office

Application No:	GB1814684.5	**Examiner:**	Dr Andrew Williams
Claims searched:	1-12	**Date of search:**	26 February 2019

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1-4, 6-11	US 2012/0292176 A1 (MACHHAMMMER) Figure 1; paragraphs 0033-0043, 0058, 0067, 0095-0101, 0157.
A	-	US 2015/0223409 A1 (ABAHUSAYN) Abstract and figures.
A	-	CN 108476823 A (UNIV TIANJIN) WPI abstract (A/N: 2015-46232G) and figures.

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

Worldwide search of patent documents classified in the following areas of the IPC

A01G; C02F

The following online and other databases have been used in the preparation of this search report

EPODOC, WPI, Internet, Patent Fulltext, XPESP, XPSPRNG

International Classification:

Subclass	Subgroup	Valid From
C02F	0001/14	01/01/2006
A01G	0009/14	01/01/2006
A01G	0009/24	01/01/2006