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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

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(54) Title: METHOD FOR THE CONTINUOUS DESALINIZATION AND DEVICE FOR THE IMPLEMENTATION OF SAID METHOD

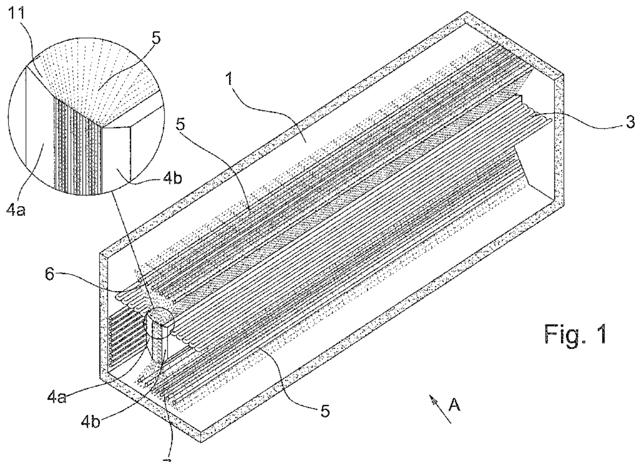

Fig. 1

(57) Abstract: This invention refers to a method and a device for desalinating sea water, brackish water or from industrial processes. The device is suitable to use renewable energy sources such as solar or geothermal energy. The device is of the type that includes a tank (1) for the containment of the water to desalinate, in which there are heating means fitted to cause the evaporation of said water to desalinate, cooling means fitted to favour the subsequent condensation of the steam and means fitted to the collection of the condensed water and it is characterized in that: said tank (1), fitted to contain said water to desalinate, is filled up to a certain level (2); said heating means, for evaporating said water include a first heat exchanger (3), immersed in the water to desalinate and positioned nearby said level (2); said cooling means (5a), fitted to cause the condensation of the steam, are in heat exchange connection with the heating means (5b), immersed in said water to desalinate, said heat exchange simultaneously causing: a) the reduction of the temperature of said means (5a), therefore the suitable conditions for the condensation of the steam; b) the increase in temperature, into the depths, of said water to desalinate.

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METHOD FOR THE CONTINUOUS DESALINIZATION AND DEVICE FOR THE IMPLEMENTATION OF SAID METHOD

DESCRIPTION

This invention refers to a method, and to a device for implementing the said method, to desalinize sea water, brackish water or from industrial processes, in a continuous and self supported mode. In particular, the device according to the invention is suitable to use renewable energy sources, by means of solar energy and geothermal energy.

The need of replacing fossil fuels in many areas of human activities is strongly felt, in particular for the primary resource "freshwater", that must be regenerated, where the natural availability is not present or it has been depleted; the technologies for the production of desalinated water, normally resort to electrical energy (reverse osmosis) or thermal (distillation from gas / oils combustion), since a long time even resorting to natural sources, but paying a little attention to energy management.

The object of the this invention is to propose a method and a device for the implementation of the said method for the desalting in accordance with, respectively, claims 1 and 2, using renewable sources (thermal and electric solar, geothermal, photovoltaic or wind) and in regimes of moderate temperatures, taking into high consideration the management and handling of the concerned energy quantities, inside an essentially adiabatic system, with the possibility to compensate the phase shifts between the energy needs and the natural availability, in giving or in having, at particular time, by resorting to the sun or subsoil or wind, depending on the necessity.

The method is of the type which expects to cause the evaporation of said water to desalinate, the subsequent condensation of the steam and the collection of the condensed water, **characterized by:**

- working in a closed tank in which the water to desalinate and the water vapour resulting from evaporation of said water are simultaneously present;
- heating said water to desalinate in the nearness of the surface of said

water, so that said surface and said produced steam are at a higher temperature than the temperature present in the depth of the water to desalinate;

- causing the condensation of said steam and to collect the condensed water, said condensation taking place on cooling means, which are in heat exchange connection with the heating means, immersed in said water to desalinate, said heat exchange simultaneously causing:
  a) the reduction of temperature of said cooling means, then the suitable conditions for the condensation of the steam;
  b) the increase of temperature, in depth, of said water to desalinize.

The device is of the type that includes a tank for the containment of the water to desalinize, in which there are heating means fitted to cause the evaporation of said water to desalinize, cooling means fitted to favour the subsequent condensation of the steam and means fitted to the collection of the condensed water, **characterized in that**:

- said tank, fitted to contain said water to desalinize, is filled up to a certain level, so as to present a free surface of the water;
- said heating means, fitted to cause the evaporation of said water to desalinate, include a first heat exchanger, immersed in the water to desalinate and positioned in the nearness of said free surface;
- said cooling means, fitted to cause the condensation of the steam, are in heat exchange connection with the heating means, immersed in said water to desalinate, said heat exchange simultaneously causing:
  a) the reduction of the temperature of said cooling means, therefore the suitable conditions for the condensation of the steam;
  b) the increase in temperature, into the depths, of said water to desalinate;
- conveying means fitted to collect the condensed water on said cooling means.

According to a preferred embodiment, they are provided two heat exchangers arranged vertically, at both outer sides of the upper half of the liquid phase; they will be able to support the standstill processes, if any, or next to regimes of uniform entropy in the space bounded by the main tank, locally lowering the temperature of the surrounding water which, due to the higher density, reintroduces the convective motions.

The use of a device in compliance with the invention allows the production, at very low operating costs, of fresh water for multiple uses: plant engineering and food industry, agronomy, animal husbandry, and finally also for the human use.

The use of a device in compliance with the invention also allows significant contributions in the remediation and purification actions of water bodies from industrial processes that weigh on the rural and urban territories, where the human action has reached critical levels that natural processes cannot face.

The invention will now be described, for illustrative and not limitative purposes, according to a preferred embodiment and with reference to the accompanying figures, in which:

- figure 1 is a perspective view of the device according to the invention;
- figure 2 is a view in section, obtained by a transverse plane, of the device according to the invention.

With reference to the attached figures, with (A) it is shown a device, according to the invention, to desalinate sea water, brackish water or from industrial processes. Said device (A) includes a tank (1), preferably waterproof and thermally insulated, having the shape of a parallelepiped, filled in with water to desalinate for about two thirds of the volume. In alternative, the tank (1) can have a cylindrical or similar shape, with horizontal generators.

Immediately below the free surface of the water (2) it is positioned a first heat exchanger (3), for example consisting of a bundle of pipes run through by a heating heat transfer fluid fed, for example, by a thermal or geothermal or solar system (not represented), said first heat exchanger (3) having the function to heat the water to produce steam.

According to a preferred embodiment, the heat transfer fluid enters in the first exchanger (3) from the central side, as shown in fig. 2, and exits from the peripheral side, in order to carry more heat into the central parts with respect to the peripheral ones. This fact allows to trigger the convective motions, as indicated by circular arrows (F1) and (F2), respectively, in the gaseous and liquid phases, the purpose of which will be clarified below.

At about the halfway point of the height of the tank (1), they are positioned two bars (4a, 4b) which extend over the entire length of the tank (1) itself, whose function will be explained below. Said bars (4a, 4b) are positioned on a multiplicity of metal sheets (5) opened like a fan, both above (5a), and below (5b) of said bars (4a, 4b). In the part between the bars (4a, 4b) the sheets (5) are compact, while in the part opened like a fan, both above (5a) and under (5b), they are stretched with the dual purpose of exposing more specific surfaces and to allow the passage of fluids through them.

Said metal sheets opened like a fan (5a) upwards have the function of cooling means because they cause the steam cooling, causing the condensation. Besides said metal sheets opened like a fan (5b) towards the bottom have the function of heating means because they cause the heating of the underlying mass of water, in which they are immersed.

As an alternative to the stretched metal (5), it can be used the metal thatch (not shown) which, in respect of a shorter duration, offers the advantage of having a greater specific surface area favoring, therefore, the condensation of the steam.

In the upper fan (5a) of the stretched sheets (5) a second heat exchanger (6) is placed, while in the lower fan (5b) a third heat exchanger (7) is placed. Both said second and third heat exchanger (6, 7) are, for example, constituted by tube bundles placed in contact with said stretched sheets (5). Said second and third heat exchanger (6, 7) are connected by a first pipe (8), run through a heat transfer fluid, pushed by a pump (9).

The two bars (4a, 4b) are thermally insulating and the sheets (5), in the section between said two bars (4a, 4b) are treated so as to not allow water infiltrations, for example by the interposition of a sealant (10), as shown in the enlarged details of figures, said sealant (10) being preferably conductive, to enhance the passage of heat from the upper fan (5a) to the bottom (5b). In fact the group comprising the sheets (5) and the bars (4a, 4b) constitutes a sort of "thermal tunnel" (5c), as it is able to transmit heat between the upper fan (5a) and the lower (5b), without dispersing laterally, in that the bars themselves are thermally insulating.

The upper edges of the bars (4a, 4b) are inclined towards the central side so as to constitute a storage put in communication with the outside through a second pipe (12). Said second outlet pipe (12) is in heat exchange connection, through a fourth exchanger (13), preferably in counterflow, fed by a third loading pipe (14) that feeds the tank (1) with water to desalinate and maintains a constant level (2) in the tank (1) itself, by means of a valve (15) controlled by a level relief device (16).

According to a preferred embodiment, it is provided a fifth heat exchanger (17), disposed along the side walls, whose function is to subtract heat to the water. This fact allows to trigger convective motions, as indicated by the circular arrows (F2), the purpose of which will be clarified below.

The operation of the device according to the invention is as follows.

The water to desalinate is heated by the first heat exchanger (3). The fact of being placed in nearness of the free surface (2) fosters the water evaporation, therefore the upper part of the tank (1) is brought to the condition of the water vapour saturation. When fully operational, in the tank we find the following situation(1):

- the water temperature in the nearness of the free surface (2) may be approximately between 40 and 70 ° C, preferably highest in the central zone, conditioning the upper fan (5a) towards similar temperatures;
- the water temperature into the depths may be approximately between 15 and 25 ° C, conditioning the lower fan (5b) towards similar temperatures;

- the upper fan (5a) and the lower fan (5b), are so subjected to a thermal gradient through the thermal tunnel (5c), highly conductive, which allows a flow of heat which gets to reset the gradient;
- the saturated steam, above the free surface, coming into contact with the upper fan (5a), at a lower temperature, condenses in the water and releases the latent heat, which goes to support high temperatures on the upper fan (5a), continuing to feed a flow of heat towards the lower fan (5b) through the thermal tunnel (5c);
- the condensed and desalinated water is collected in the reservoir (11) and is extracted through said second outlet pipe (12);
- with said third load pipe (14), the level of the free surface (2) is continuously maintained.

In order to increase the heat flow from the upper fan (5a) to the lower fan (5b), said third and fourth heat exchanger (6) and (7) are provided, connected by said first pipe (8), which is run through by a heat transfer fluid, pushed by said pump (9).

The convective motions that occur in the steam, indicated by the circular arrows (F1), foster the flow of the steam itself towards the upper fan (5a), improving the heat exchange between the steam and the stretched metal sheet (5) and, therefore, the condensation.

The convective motions that take place into the water, indicated by the circular arrows (F2), supports the water flow itself on the lower fan (5b), improving the heat exchange between water and the stretch metal sheets (5) and, therefore, the heat contribution towards the free surface (2). In this way it is establishes an aqueous counter-current flow stream with the upper gaseous flow, with the consequent increase of the evaporation rate. The convective motions in the water can be increased by cooling the same water in proximity of the walls of the tank (1), by means of said fifth heat exchanger (17).

For the purpose of the heat recovery from the condensed water effluent, which runs through said second pipe (12), it is provided said fourth heat exchanger (13) which transfers the heat from said condensed water to the water to desalinate by entering, through said third pipe (14) .

The described process is strongly fostered if the tank (1) is well thermally insulated, tending to adiabatic conditions, since it tends to a careful reuse of exploitable energies, organizing and supporting convective motions that make efficient desalting process, thanks to inertial dynamics , the action will also continue in the temporary absence of external support (for example in night-time hours).

As it appears clear from the foregoing description, the device according to the invention enables the recourse to contributions from both renewable and fossil energies (or especially produced by thermal waste of various origin), acting support the effectiveness and competitiveness with previous technologies, for example by using heat pumps, supporting forced and continuous regimes, the process becomes extremely economical and competitive.

The invention has been described, for illustrative and not limitative purposes, according to some preferred embodiments. The skilled in the art will be able to find several other embodiments, all falling within the scope of the appended claims.

CLAIMS

1. Method to desalinize sea water, brackish water or from industrial processes, in continuous or in alternative mode, of the type which provides to cause the evaporation of said water to desalinize and the subsequent condensation of the steam and condensed water collection, **characterized in that**:
   - to operate in a closed tank (1) in which they are present the water to desalinize and the steam resulting from the evaporation of said water;
   - to heat said water to desalinize in the nearness of the free surface (2) of said water, so that said free surface (2) and said produced steam are at a higher temperature than the temperature into the depths of the water to desalinize;
   - to cause the condensation of said steam and to collect the condensed water, said condensation taking place on cooling means (5a), which are in heat exchange connection with the heating means (5b), immersed in said water to desalinize, said heat exchange simultaneously causing:

     a) the reduction of temperature of said cooling means (5a), then the suitable conditions for the condensation of the steam;

     b) the increase of temperature, into the depths, of said water to desalinize.
2. Device to desalinize sea water, brackish water or from industrial processes, in continuous or in alternative mode, of the type which provides for a containment tank (1) of the water to desalinize, in which there are heating means fitted to cause the evaporation of said water to desalinize, cooling means fitted to facilitate the subsequent condensation of the steam and means fitted to the condensed water collection, **characterized in that:**
   - said tank (1), fitted to contain said water to desalinize, is filled up to a level (2);

- said heating means, fitted to cause the evaporation of said water to desalinate, include a first heat exchanger (3), immersed in the water to desalinate and positioned in the nearness of said level (2);
- said cooling means (5a), fitted to establish the condensation of the steam, are in heat exchange connection with the heating means (5b), immersed in said water to desalinize, said heat exchange simultaneously causing:
  a) the reduction of the temperature of said means (5a), then the suitable conditions for the condensation of the steam;
  b) the increase of the temperature, into the depths, of said water to desalinize;
- conveying means (11, 12) fitted to collect the condensed water on said cooling means (5a).

3. Device to desalinize water according to claim 2, characterized in that said tank (1) has the shape of a parallelepiped, or cylindrical or elliptical or of any other form and with generators in horizontal or inclined in every other slope .
4. Device to desalinize water according to claim 3, characterized in that said tank (1) is thermally insulated.
5. Device to desalinize water according to claim 2, characterized in that said heating means fitted to cause the evaporation of said water to desalinate, include a first heat exchanger (3) fed by a heat transfer fluid.
6. Device to desalinize water according to claim 5, characterized in that said heat transfer fluid enters said first exchanger (3) through the central side and exits from the peripheral sides, in order to carry more heat into the central parts rather than those peripheral, said differentiated heating facilitating the formation of convective motions (F1) into the steam.
7. Device to desalinize water according to claim 5, characterized in that said heat transfer fluid is heated by renewable power sources like

thermal solar or geothermal or photovoltaic or wind.

8. Device to desalinize water according to claim 2, characterized in that said cooling means (5a) are in heat exchange connection with said heating means (5b), immersed in said water to desalinize, through a thermal tunnel (5c) bordered by a pair of bars (4a, 4b) located in the tank (1) just below said free surface (2), said bars (4a, 4b) having the function to thermally insulate said thermal tunnel (5c) from the surrounding water.

9. Device to desalinize water according to claim 8, characterized in that said cooling means (5a) are in heat exchange connection with said heating means (5b), immersed in said water to desalinize through a second heat exchanger (6) connected through a pipe (8), in which a heat transfer fluid flows, with a third heat exchanger (7), so as to transfer the heat from said cooling means (5a) to said heating means (5b).

10. Device to desalinize water according to at least one of the claims from 2 to 9, characterized in that said cooling means (5a) and said heating means (5b) include a plurality of stretched metal sheets (5) opened like a fan, said metal sheets being compact in the zone between the bars (4a, 4b) and constituting said thermal tunnel (5c).

11. Device to desalinize water according to at least one of the claims from 2 to 9, characterized in that said cooling means (5a) and said heating means (5b) are made by a metal thatch.

12. Device to desalinize water according to claim 2, characterized in that said conveying means, fitted to collect the condensed water on said cooling means (5a), include a storage (11) connected with an outlet pipe (12) .

13. Device to desalinize water according to at least one of the claims from 2 to 12, characterized in that said outlet pipe (12) is in heat exchange connection, through a fourth heat exchanger (13), with a loading pipe (14) for the feeding of the tank (1).

14. Device to desalinize water according to at least one of the claims from 2 to 13, characterized in that said loading tube (14) is provided with a valve (15), controlled by a level detection device (16), so as to maintain a constant level (2) of the water in the tank (1).

15. Device to desalinize water according to at least one of the claims from 2 to 14, characterized in that it includes a fifth heat exchanger (17), arranged along the side walls, fitted to take away the heat from the water, in order to trigger convective motions (F2) into the mass of water.

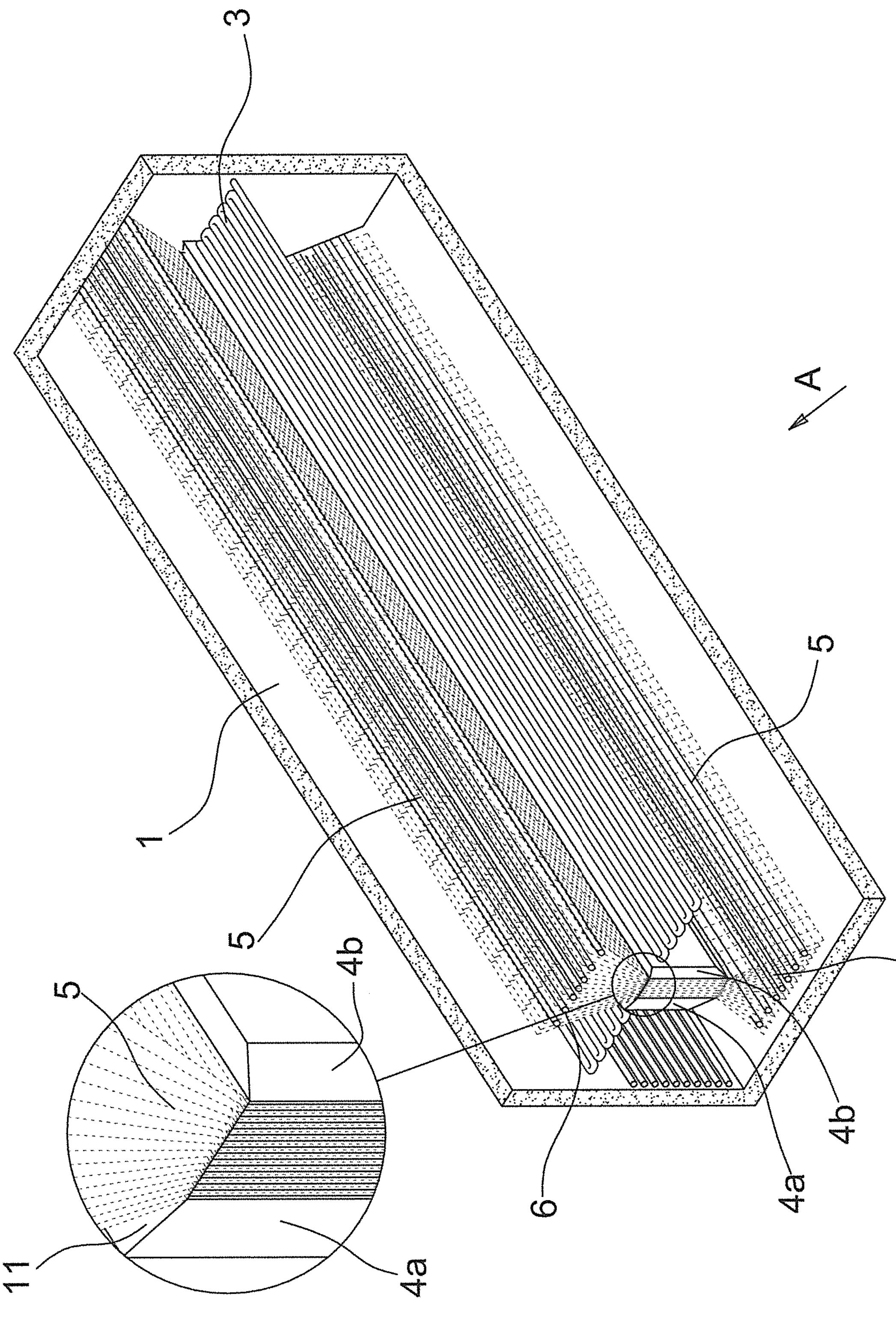

Fig. 1

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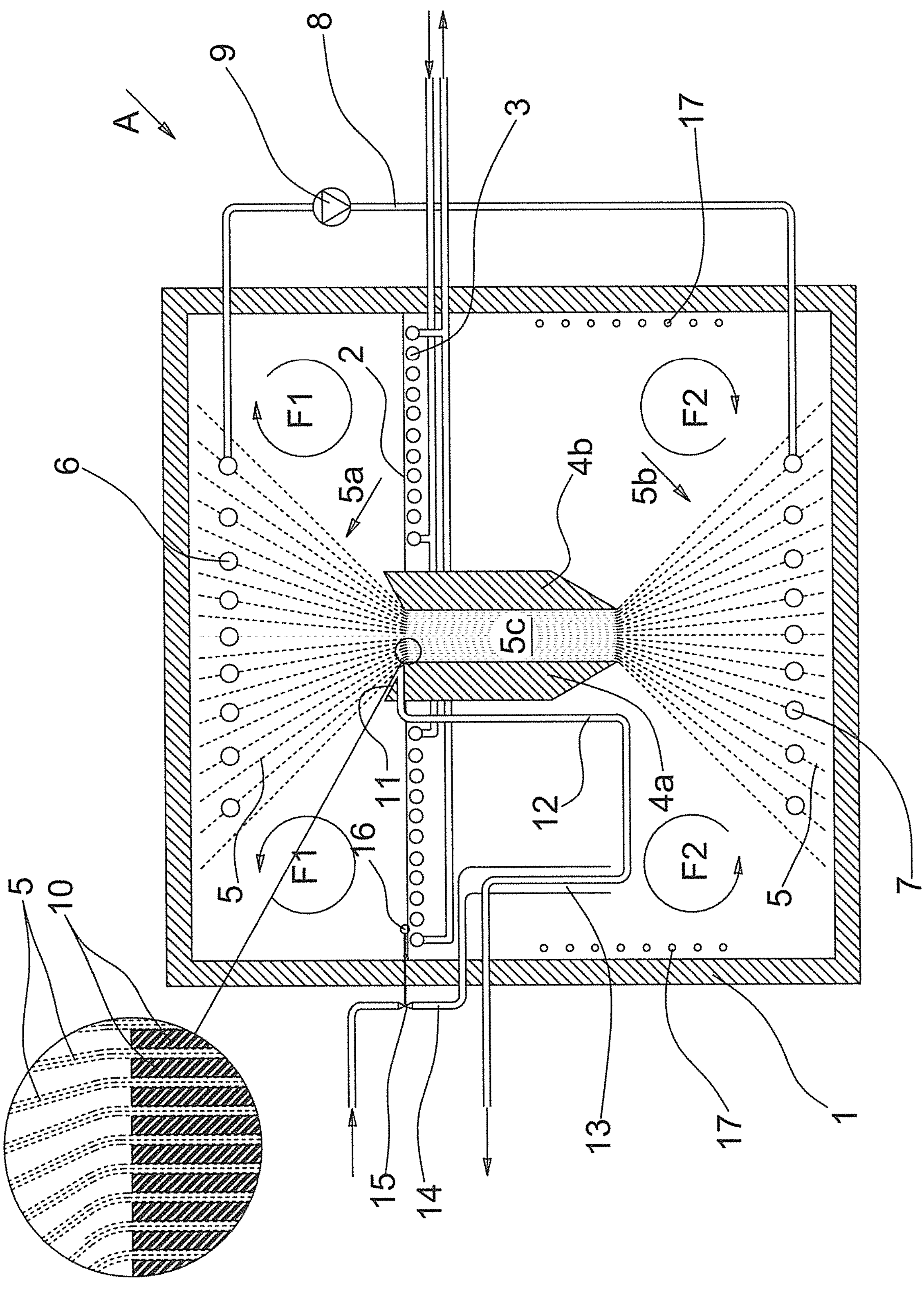

Fig. 2

INTERNATIONAL SEARCH REPORT

International application No
PCT/IT2016/000090

A. CLASSIFICATION OF SUBJECT MATTER
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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)
B01D C02F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

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X	WO 2007/011201 A1 (ZONNEWATER B V [NL]; DE KONING JAN CORNELIS [NL]) 25 January 2007 (2007-01-25) abstract; figures page 4, line 21 - page 5, line 10 -----	1-7,9-15
A	WO 2011/004416 A1 (ESAE S R L [IT]; LAVANGA VITO [IT]; SPARACINO ANTONIO CESARE [IT]) 13 January 2011 (2011-01-13) abstract; figures page 9, paragraph 35 page 10, paragraphs 36,37 page 11, paragraphs 44,45 page 12, paragraph 47 page 17, paragraph 66 page 27, paragraph 100 -----	1-5

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[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
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Name and mailing address of the ISA/	Authorized officer
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4

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2010/034043 A1 (GIG KARASEK GMBH [AT]; KARASEK ANDREAS [AT]; BETHGE DANIEL [AT]) 1 April 2010 (2010-04-01) abstract; figures columns 5,6 -----	1-5
A	FR 2 853 895 A1 (COSTES DIDIER [FR]) 22 October 2004 (2004-10-22) abstract; figures pages 2,3 -----	1-5

4

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
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		WO 2010034043 A1	01-04-2010
FR 2853895 A1	22-10-2004	NONE	

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[Continued on next page]

(54) Title: THERMAL DESALINATION PLANT

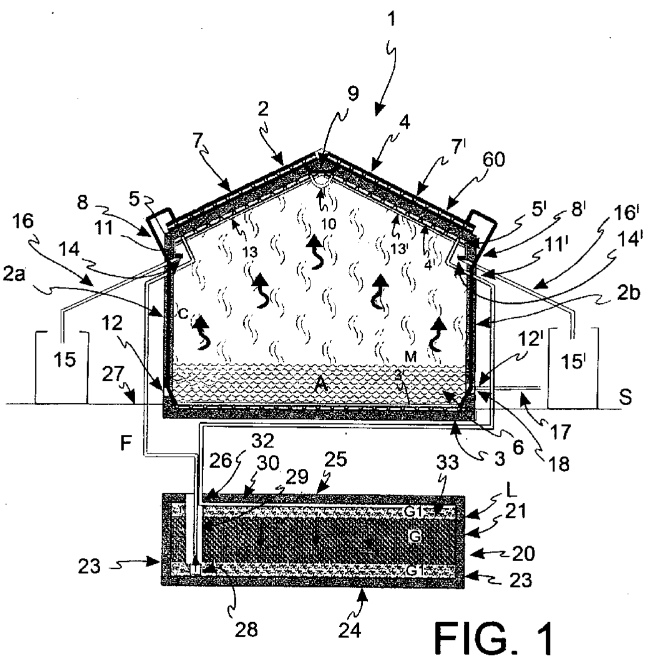

FIG. 1

(57) Abstract: The present invention concerns a device suitable for producing desalinated water mainly actuated by renewable energy sources. In particular, the present invention concerns a thermal desalination plant comprising at least one chamber (2, 100') into which the water to be desalinated (A) is introduced, at least one condensation circuit (F) and at least one evaporation circuit (C), said circuits being independent from one another and crossed by a heat transfer fluid, wherein said condensation circuit (F) comprises a portion positioned beneath the level of the ground or of a body of water and it is in heat exchange relationship with said ground or with said body of water.

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DESCRIPTION

Thermal desalination plant

[0001]. The device claimed by the present invention is suitable for producing desalinated water, to be sent to suitable successive integrations that depend upon the destinations and uses. The device is mainly actuated by renewable energy sources.

STATE OF THE ART

[0002]. There are many regions of the world where the availability of fresh water is already or is becoming scarce.

[0003]. Currently, different solutions have been proposed for the desalination of salt water, often dependent upon evaporation/condensation or osmosis processes. 85% of world production of desalinated water is produced through *multi-stage flash distillation,* based on a vacuum distillation process. There are also many plants based on reverse osmosis technology, where the salts are separated from the water using semi-permeable membranes and pressure. These large desalination plants in order to operate require large amounts of energy as well as specialised infrastructures, making the plant and operating cost-benefit ratio very hard to manage as well as having an environmental impact that is not always acceptable.

[0004]. More manageable plants, based on the principle of evaporation/condensation, are described in US 4,235,679 and WO 03/022746. Both documents describe a floating device that uses the sun's energy as main energy source. US 4,235,679 foresees a single circuit suitable for promoting, in the different steps of its operation, at one stage the evaporation process, at another stage the condensation process. WO 03/022746 foresees a distinct device in two chambers, one light and hot, the other dark and cold, in which the evaporation and the condensation, respectively, take place. The steam goes from the evaporation chamber to the condensation chamber thanks to the presence of a fan.

[0005]. The present invention aims to drastically reduce the cost/benefit ratio in the production of desalinated water to be sent to successive and suitable integration processes, through a more efficient use of the sun's energy and/or of other renewable energy sources.

SUMMARY OF THE INVENTION

[0006]. The present invention concerns a system that comprises a thermal desalination plant actuated and supplied with power by renewable sources. The thermal desalination plant of the present invention is characterised in that it comprises two highly efficient mutually independent circuits: one, the hot circuit, which exploits the substantial energy provided by the thermo-surfaces (driver of the evaporation), the other, the cold circuit, which uses the efficacy of the thermo-well to disperse the heat or, in the case in which it is not possible to have said thermo-well, the water to be desalinated itself is used to disperse the heat (driver of the condensation).

[0007]. The system can be attached to solid earth or floating.

[0008]. In the embodiment attached to solid earth, as a non-limiting example, the system comprises a thermal desalination plant and a thermo-well. The following are provided i) a thermo-well used for condensation, with a main role of exchanging with the subsurface, roughly one metre deep, and on top it is completed with a layer of natural insulation; ii) a regular pentagon-shaped greenhouse, fluid-tight and insulated (made from expanded polystyrene EPS or similar).

[0009]. Inside said greenhouse there are suitable exchangers (derived from said thermo-surfaces, corrugated plates and tubes containing a heat transfer fluid) on the lower plane and on the upper oblique walls.

[0010]. Outside of said greenhouse, on the upper layers, there are exchangers, i.e. thermo-surfaces (heliothermal diode, i.e. corrugated plates and tubes containing a heat transfer fluid covered by a cell-structured translucent material) suitable for collecting the heat from solar radiation, direct and diffused.

[0011]. The device is completed by a system for filling, replacing and maintaining suitable levels of water to be desalinated (coming from the sea or brackish water or water for refining) arranged in the lower space of the greenhouse.

[0012]. In the floating embodiment, the device is made up of a fluid-tight and insulated cylindrical structure (with heavy thermal insulation) which performs the functions of a greenhouse, arranged horizontally (so that it floats) on the water to be distilled.

[0013]. On the inner and outer walls, four diametrically opposite exchangers are applied (derived from said thermo-surfaces, corrugated plates and tubes containing a heat transfer fluid).

[0014]. The cylinder is equipped on the two side circles (one acts as a removable lid) with two inlet-outlet holes for the water to be desalinated, so as not to have a salinity that is too high inside the cylinder, avoiding incrustations and difficulty of evaporation of the water.

[0015]. The movement of the water and of the salt can occur passively, through the differences in saline concentrations that are present between the inside and the outside of the floating thermal desalination plant.

[0016]. The cylinder is completed by suitable weights and floats so as to fill until the lower inner exchanger is covered.

[0017]. In the embodiments attached to solid earth and floating, said outer and inner exchangers are joined by crossed and circulating water connections.

[0018]. The two circulating water connections are activated by electrical energy coming from a photovoltaic panel of suitable power, slaved to a twilight device, or directly from direct voltage, the circulators will be associated with inverters to deal with variable voltage loads.

[0019]. Said upper inner exchangers are completed by water trays to collect and convey to the outside the condensation water percolated downwards.

[0020]. Said upper outer exchangers are covered with a sheet of POLIBOLL of the type used for packaging with aluminium foil (alternatively cell-structured polycarbonate or in general a cell-structured translucent material with high radiation transmittance and substantial overall heat resistance).

[0021]. The energy (hot water) deriving from the upper outer exchangers is brought by mere circulation (in closed circuit) into the lower inner exchangers and this will substantially raise the temperature of the salted water contained in the tank, allowing evaporation and environment saturation pressures to be reached.

[0022]. The inner upper exchangers are kept at lower temperatures thanks to the exchange with the cold well below, in the case of the thermal desalination plant attached to solid earth, or the body of water on which the thermal desalination plant itself floats, where said body of water is a body of brackish water or the sea, in the floating embodiment (through mere circulation).

[0023]. The steam will condense on the inner upper exchangers and will percolate to the collection point, where it will be conveyed outside.

BRIEF DESCRIPTION OF THE FIGURES

[0024]. Further characteristics and advantages of the present invention will become clearer from the following description of embodiments given purely as a non-limiting example, in which:

Figure 1 shows a schematic side section view of a thermal desalination plant attached to solid earth with a thermo-well according to the invention;

Figure 2 shows a perspective section view of a different embodiment of the thermal desalination plant of the invention;

Figure 3 shows a perspective section view of a detail of the exchanger according to the invention.

[0025]. With reference to figure 1, the thermal desalination plant of the invention, wholly indicated with reference numeral 1, comprises a chamber 2, typically in the form of a greenhouse, with which two mutually independent closed circuits are associated, a condensation circuit F, which comprises a thermo-well 20, and an evaporation circuit C.

[0026]. Such a chamber 2 will have a shape such as to allow it to have a flat lower part 3 and an upper part 4 having a configuration capable of allowing the water to be run off and collected; as a non-limiting example, the upper part 4 can consist of one or more valances, i.e. a convex surface. In a preferred embodiment the chamber 2 is regular pentagon shaped.

[0027]. In said regular pentagon shaped embodiment, the chamber 2 comprises a flat lower part 3, an upper part 4 with two valances, two side walls 2a and 2b, a front face and a rear face (not shown).

[0028]. The chamber 2 is fluid-tight and insulated, and in an embodiment it consists of panels typical of refrigerator cells or else masonry made impermeable on the inside and coated on the outside with suitable insulating material, typically EPS.

[0029]. The greenhouse 2 has one or more sealed openings on the side walls 2a and/or 2b and/or on the front or rear face. In particular, in the embodiment described in figure 1 there are two sealed openings 11 and 11′ on the top part of the side walls 2a and 2b and two sealed openings 12 and 12′ on the bottom part of the same side walls 2a and 2b. Said sealed openings are used to pass pipes.

[0030]. Inside the chamber 2 there is the water to be desalinated A, up to a level M.

[0031]. The water to be desalinated A enters into the chamber 2 through one or more pipes that pass through the sealed openings arranged on the bottom part of the side walls. In the example shown in figure 1, the water to be desalinated A enters through the pipe 17 that passes through the sealed opening 12′ arranged on the bottom part of the side wall 2b.

[0032]. The water to be desalinated A enters into the chamber 2 through the pipe 17 without using up energy where the lower part 3 of the chamber 2 is advantageously positioned at a lower level than the level of the water present in the body of water from which the water to be desalinated A (not shown) is taken. By the principle of communicating vessels, inside the chamber 2 the water A will reach a level M that will be equal to the level of the water in said body of water.

[0033]. In a further embodiment, where the lower part 3 of the greenhouse 2 is positioned at a level equal to or higher than the level of the water in the body of water, the water A will be let into the chamber 2 until it reaches the level M using suitable pumping means, for example submerged pumps.

[0034]. It is foreseen for there to be a valve device 18 positioned on the pipe 17 to modulate the entry of the water to be desalinated A.

[0035]. Said condensation circuit F and evaporation circuit C comprise exchangers equipped with a coil crossed by a fluid that has the characteristics of a heat transfer fluid.

[0036]. Said condensation circuit F comprises one or more heat exchangers arranged on the inner upper part 4′ of said chamber 2. In the example shown in figure 1 two heat exchangers 5 and 5′ are depicted arranged on the inner upper part 4′ of the chamber 2, connected together by the tube 10.

[0037]. Said evaporation circuit C comprises one or more heat exchangers arranged on the inner lower part 3′ of said chamber 2 and one or more heat exchangers on the outer upper part of the same chamber 2. The example shown in figure 1 shows a heat exchanger 6 arranged on the inner lower part 3′ of the chamber 2 and two heat exchangers 7 and 7′ arranged on the outer upper part connected together by the tube 9.

[0038]. In said evaporation circuit C the heat exchanger 6 arranged on the inner lower part of the chamber 2 is connected to the heat exchangers 7, 7′ positioned on the outer upper part through the tubes 8, 8′. The tubes 8 and 8′ cross the walls of the chamber 2 through the sealed openings 12 and 12′.

[0039]. Said condensation circuit F, in the embodiment depicted in figure 1, also comprises a thermo-well 20.

[0040]. In said condensation circuit F the heat exchangers 5 and 5′ arranged on the inner upper part

4′ of the chamber 2 are connected to the thermo-well 20 through draw pipes 29 and feeding pipes 30. Said pipes 29 and 30 come out from the side walls of the chamber 2 through the sealed openings 11 and 11′.

[0041]. Said evaporation circuit C and condensation circuit F are connected to pumping means.

[0042]. Said heat transfer fluid is typically water.

[0043]. The tubes 8, 8′, 9, 10 and the pipes 29 and 30 are built from any material suitable for containing water. In a preferred embodiment said tubes are made from PVC.

[0044]. The heat exchangers 5, 5′ and 6 arranged inside the chamber 2 are built from plate with corrugated section. The plate can be made from aluminium, galvanized steel or highly thermally conductive alloys. The plate has throats arranged horizontally in which said coil is inserted.

[0045]. The coil can be made with tubes, corrugated and not, possibly multi-layer, of PVC (woven, meshed or with metal cores), polyethylene, copper, steel.

[0046]. Suitable anchoring means take care of fixing the whole thing to the upper and lower inner parts of the chamber 2.

[0047]. In an embodiment, the heat exchangers 7, 7′ arranged on the outer upper part of the chamber 2 comprise a plate with corrugated section that has throats in which the coil is inserted. Plate and coil are built from the same materials used for the exchangers arranged in the inner part of the greenhouse. The throats allow the heat captured by the plate to be concentrated on the edges of the throats themselves, thus promoting the heat exchange with the heat transfer fluid circulating inside the coil. Moreover, the exchangers arranged on the outer upper part of the chamber 2 are coated, totally or only on some portions, with a layer of non-reflective aluminium painted or treated in a suitable manner to transform light into heat and, further outside, with a layer of honeycombed translucent material, for example a film of POLIBOLL of the type used for packaging. Such a film has the function of easily allowing solar radiation to pass by irradiation, but blocking heat dispersion by conduction towards the outside, thanks to the presence of the cells full of air.

[0048]. Suitable anchoring means 60 take care of fixing the outer heat exchangers 7, 7′ to the outer upper part 4 of the chamber 2.

[0049]. Said thermal desalination plant in the embodiment attached to solid earth comprises at least one thermo-well in the condensation circuit F. The thermo-well 20 comprises a casing 21 that comprises side walls 23 and a bottom 24. The casing 21 is sealed fluid-tight. Such a casing 21 can have any shape: cubic, parallelepiped, cylindrical, etc. and in particular a shape will be selected that maximises the surface area to promote the heat exchange towards the outside.

[0050]. Said casing 21 is externally coated by a suitable plate, for example a corrugated plate, which maximises the heat exchange area per unit surface.

[0051]. Said thermo-well 20 is completely buried up to a few metres deep, so as to be able to exploit the substantial temperature stability of the ground in the various seasons.

[0052]. The casing 21 is preferably made from cement, both for reasons of strength and of low cost, but it can also be manufactured from a different material that is suitable for remaining a long time underground.

[0053]. The casing 21 is closed on top by a lid 25 that has a hole so as to pass through a vertical duct 26 that extends from the bottom 24 of the thermo-well 20 and protrudes above it up to the surface S of the ground. The vertical duct 26 can be made from the same material from which the casing 21 is manufactured or from a different material and it can have any shape in section. At ground level, the duct 26 comprises an inspection hatch 27, whereas near to the base it comprises one or more openings 28 that place the inside of the duct 26 in communication with the thermo-well 20.

[0054]. The drawing 29 and feeding 30 pipes, part of the closed condensation circuit F that passes through the upper inner heat exchangers 5 and 5′ of the chamber 2, are housed inside the duct 26.

[0055]. The feeding pipe 30 comprises an elbow portion 32 that is arranged in the upper portion of the thermo-well 20, beneath the lid 25. Such an elbow portion 30 has holes that allow the fluid circulating inside the pipes 29, 30 to come out.

[0056]. The inside of the casing 21 of the thermo-well 20 is filled with inert material G in granular form, which constitutes the heat exchange medium inside the thermo-well. Such a material preferably has a granulometry of between 5 mm and 50 mm; preferably, the inert material G will consist of a mixture of grains of different size, i.e. 5-10 mm/10-25 mm/25-40 mm, in suitable ratios. More preferably, the mixture comprises about 1/3 of each of the sizes indicated above.

[0057]. In order to be able to perform the heat exchange function, the inert material G must have high heat conductivity.

[0058]. The inert material G has a heat conductivity, measured at room temperature, preferably over 0.6 Kcal/m.°C, more preferably over 1.2 Kcal/m.°C.

[0059]. The inert material G is preferably selected from stones, gravel, marble or synthetic resins suitable for remaining in contact with water.

[0060]. The filling with the inert material G can, in the lower and/or upper portion of the casing 21, comprise a portion with material having a larger piece size G1, for example a size of about 100 mm. In this way, homogenisation areas of the fluid are formed at the inlet and/or at the outlet of the thermo-well 20.

[0061]. Figure 1 shows the elbow portion 32 of the feeding pipe 30 and the relative homogenisation area 33 in the upper portion of the thermo-well 20, but in other embodiments the feeding of the fluid can be arranged at the base of the thermo-well 20 and its drawing with the pumping means can be arranged in the upper portion.

[0062]. In use conditions, the thermo-well 20 is typically filled with the heat transfer fluid. In figure 1 L indicates the level of the heat transfer fluid in the thermo-well 20. In this way, by arranging the pumping means near to the bottom 24, a high head is obtained that decreases the need for power of the pumping means.

[0063]. As shown in the embodiment of figure 1, the heat transfer fluid, entered into the thermo-well 20 through the feeding pipe 30, which has holes in the homogenisation area 33, fills the homogenisation area 33 and then percolates through the material G and G1 as shown by the arrows. In this way the heat transfer fluid gives up heat to the inert material G, is collected at the bottom and, through the openings 28, enters into the duct 26 that, through the principle of communicating vessels, will be filled to the same level as the thermo-well 20. The pumping means will then take care of drawing the heat transfer fluid and of circulating it through the drawing pipe 29.

[0064]. In order to promote the heat exchange between thermo-well 20 and surrounding earth, the casing 21 will advantageously not be insulated and will also have a shape such as to maximise the heat exchange surface with the surrounding earth.

[0065]. From what has been stated above, it is clear that the heat transfer fluid must have a good heat exchange with the inert material G. For this purpose it is useful for the path of the fluid, from when it comes into contact with the inert material G to when it comes out from the thermo-well 20, to be maximised. It is also important for all of the mass of the inert material G to be involved in the heat exchange, avoiding the formation of preferential paths. It is for this reason that the homogenisation areas 33 have been provided and it has been foreseen to completely fill the casing 21 with the heat transfer fluid. In general, it will be advantageous for the heat transfer fluid to enter into the thermo-well 20 from one side and come out from the diametrically opposite side.

[0066]. The system outlined here operates in the following way: the heat transfer fluid contained in the evaporation circuit C gains heat in passing in the coil arranged inside the heat exchangers 7, 7′ to then give it up, through the heat exchanger 6, to the water A contained in the chamber 2. The very structure of the chamber, fluid-tight and insulated, avoids the dispersion of this heat and thus promotes the heating of the water A contained in it. The portion of water A that reaches a temperature equal to its vapour pressure will become steam that will tend to rise towards the upper part of the chamber. Rising, the steam will come into contact with the condensation circuit F having a lower temperature, in particular with the lower surface 13, 13′ of the heat exchangers 5, 5′ arranged on the inner upper part 4′ of the chamber 2, where it will tend to condense.

[0067]. The lower surface 13, 13′ of the heat exchangers 5, 5′ arranged on the inner upper part 4′ of the chamber 2, preferably coated with an aluminium foil, will act as condensation surface for the water that will then be conveyed in the water trays 14, 14′, positioned below said heat exchangers 5, 5′. From the water trays 14, 14′ the condensation water will be made to flow through pipes 16, 16′ into collection tanks 15, 15′ suitably positioned outside of the chamber 2. Said pipes 16, 16′ will come out from the chamber through the sealed openings 11, 11′.

[0068]. Said condensation water, through the pipes 16, 16′, will flow to the collection tanks 15, 15′ by natural falling should the tanks 15 and 15′ be advantageously positioned at a lower level than the water trays 14, 14′.

[0069]. The collection tanks 15 and 15′ will be produced in any material suitable for containing water, they may or may not be closed by a lid and they can be placed in connection, through a suitable circuit and by using pumping means, in particular submersible pumps, with the user or with a subsequent processing plant of the water collected in the tanks themselves (not shown).

[0070]. The thermal desalination plant of the present invention, maximising the efficiency of the condensation and evaporation circuits, allows an extremely favourable operating cost/benefit ratio. The condensation circuit F, thanks to the presence of the thermo-well, can dispose of the heat very quickly, thus avoiding the loss of efficiency of the system that would inevitably be caused by the thermal saturation thereof where it were not possible to effectively dispose of the heat from the cold condensation circuit F.

[0071]. In a second embodiment, represented in figure 3, the thermal desalination plant is a floating device and is represented as a whole with the reference numeral 100.

[0072]. The device 100 comprises a rectangular or square flat surface 101. In an embodiment, said flat surface 101 is rectangular and is arranged in such a way that the two long sides of the rectangle join up along the joining line 101u. The flat surface 101 thus arranged, together with two circular faces 102 and

103, constitutes a cylindrical chamber 100′ that performs the functions of a greenhouse. Of course, other shapes that allow the purpose of the invention to be achieved will also be possible.

[0073]. The chamber 100′ is arranged horizontally (so that it floats) on the water to be distilled. The chamber 100′, after application for use, comprises two portions: one that stays above and one below the floating line. The flat surface portion 101a and the portions 102a and 103a of the circular faces 102 and 103 will thus remain above the floating line, whereas the portions 101b, 102b and 103b thereof will remain below the floating line.

[0074]. The flat surface 101 foresees one or more sealed openings for the passage of tubes. In particular, in the embodiment represented in figure 2 there are four sealed openings, two openings 111 and 111′, arranged on the flat surface 101a above the floating line, and two openings 112 and 112′, arranged on the flat surface 101b below the floating line. The openings 111, 112′ and 111′, 112 are preferably positioned diametrically opposite one another.

[0075]. Inside the chamber 100′ there is the water to be desalinated A, up to a level M that corresponds to the floating line.

[0076]. The water to be desalinated A enters into the chamber 100′ through the holes 117 and 117′ arranged on the circular faces 102 and 103, until it reaches the desired level M.

[0077]. In an alternative embodiment, said holes for the entry of the water to be desalinated are arranged on the flat surface 101.

[0078]. On said holes 117 and 117′ there is a gate valve or another suitable closing device (not shown) that allows the entry of water to be adjusted.

[0079]. The chamber 100′ is fluid-tight and insulated and it is coated with suitable insulating material, typically PES, and it is structured so as to be able to float.

[0080]. Also in this embodiment, the thermal desalination plant comprises two mutually independent closed circuits: a condensation circuit F and an evaporation circuit C, comprising heat exchangers equipped with a coil crossed by a fluid that has the characteristics of a heat transfer fluid.

[0081]. Said condensation circuit F comprises one or more heat exchangers 105 that cover the inner upper part 104a of said chamber 100′ and one or more heat exchangers 108 that cover the outer lower part 101b of the same chamber 100′. Said heat exchangers 105 and

108 are connected through the tubes 129 and 129′ that cross the walls of the chamber 100′ thanks to the sealed openings 111 and 111′.

[0082]. Said evaporation circuit C comprises one or more heat exchangers 106 that cover the inner lower part 104b of said chamber 100′ and one or more heat exchangers 107 that cover the outer upper part 101a of the same chamber 100′. Said heat exchangers 106 and 107 are connected through the tubes 118, 118′ that cross the walls of the chamber 100′ thanks to the sealed openings 112 and 112′.

[0083]. Said heat exchangers leave two symmetrical flat surface portions 101 free. The floating line is located in the flat surface portion 101 not covered by said heat exchangers. Said flat surface portions 101 not covered by heat exchangers have variable dimensions, of between 1/4 and 1/1000 of the cylindrical surface 101, preferably about 1/100, and they are arranged so as to comprise the floating line.

[0084]. Said evaporation circuit C and condensation circuit F are connected to pumping means.

[0085]. The pumping means are typically electric pumping means and will thus comprise suitable wiring that reaches the electrical power supply.

[0086]. The heat exchangers are built as described for the exchangers present in the embodiment attached to solid earth first described, i.e. they will comprise a corrugated sheet with throats through which the coil passes.

[0087]. Figure 3 shows a section of the flat surface 101, in particular of the upper portion 101a covered by heat exchangers in the inner part and in the outer part. The inner heat exchanger 105 comprises a corrugated plate 130, a coil 131 and, in the free face facing towards the inside of the chamber 100′, it is covered by an aluminium plate 132 suitable for promoting the condensation of the water. There is also a layer of insulating material 133, of the type normally used in the insulation of walls of buildings. Proceeding outwards, there is the outer heat exchanger 107 that comprises a corrugated plate 130, a coil 131 and, in a preferred embodiment, a layer of non-reflective aluminium 134, painted or treated to transform light into heat and a layer of cell-structured translucent material 135, for example a film of POLIBOLL of the type used for packaging.

[0088]. The lower face of the heat exchanger 105 arranged on the inner upper part 104a of the cylindrical surface 101, covered by an aluminium foil 132, will act as condensation surface for the water that will then be conveyed into the water trays 124, 124′. From the water trays, the condensation water will be made to flow through pipes 125 into suitably positioned collection tanks (not shown). Said pipes 125 will come out from the chamber through the openings 111, 111′.

[0089]. Said collection tanks can be positioned adjacent to the chamber 100′ and will also be floating.

[0090]. Alternatively, where the thermal desalination plant is slaved to the needs of desalinated water of a boat, said collection tanks can be arranged on the boat itself.

[0091]. Suitable pumping means will be used if the arrangement of the collection tanks does not allow just the force of gravity to be used to fill them.

[0092]. The system outlined here operates in the following way: the heat transfer fluid gains heat in passing in the coil that crosses the heat exchanger 107 that covers the outer upper surface 101a to then give it up, through the heat exchanger 106 that covers the inner lower surface 104b, to the water A contained in the chamber 100′. The chamber 100′, fluid-tight and insulated, avoids the dispersion of this heat and thus promotes the heating of the water A contained in it.

The portion of water A that reaches a temperature equal to its vapour pressure will become steam that will tend to rise towards the upper part of the chamber 100'. Rising, the steam will come into contact with the condensation circuit F, in particular with the aluminium foil 132 arranged on the lower surface of the heat exchanger 105 that covers the inner upper part 104a of the chamber 100' where said steam will tend to condense.

[0093]. The condensation water, collected by the water trays 124, 124', positioned beneath said heat exchanger 105, is made to flow into the collection tanks through the pipes 125 that cross the chamber 100' through said sealed openings 111, 111'.

[0094]. Also in this embodiment, the thermal desalination plant of the present invention, maximising the efficiency of the condensation and evaporation circuits, allows an extremely favourable operating cost/benefit ratio.

[0095]. There are many advantages of the present invention.

[0096]. In the floating embodiment just like the one attached to solid earth, the desalination capability depends upon the temperature that the water A is able to reach inside the chamber 2 or 100'. Regarding this, it is possible to adjust the flow going in by acting upon the closure device present at the level of the holes 117, 117′ or of the pipes 17. In this way, the water A can reach or maintain the temperature necessary for evaporation even in conditions of low irradiation.

[0097]. The possibility of adjusting the flow going in is also useful in order to limit the deposit of salt on the bottom of the chamber 2 or 100′.

[0098]. In most applications it is beyond the purposes of a desalination plant to obtain salt and the inevitable salt deposits inside the plant are periodically removed. This work of removing the salt deposits involves a cost that is added to by the cost linked to the halting of the plant. The thermal desalination plant of the present invention foresees that, particularly in periods where the plant works very little, for example at night, when the residual heat necessary for the evaporation of the water has run out, it be possible to open the closure device present at the level of the holes 117, 117′ or of the pipes 17 so as to increase the inlet of water and eliminate the salt deposits without any cost.

[0099]. The water to be desalinated A is then exchanged with the water outside continually, where the plant operates continuously, with the closure devices always open, or else cyclically over a short period, day-night, where the closure devices are kept closed from dusk until the residual heat sufficient for the evaporation of the water has run out. Therefore, the thermal desalination plant of the present invention does not accumulate leftover water to be disposed of. The regulatory need to obtain post-process water having the same composition (within very stringent limits) as that of the water introduced is thus observed without any burden.

[00100]. Optionally, the efficiency of the thermal desalination plant of the present invention can be implemented with contributions from renewable sources such as a wind power station - typically a micro-wind power station - and/or photovoltaic panels. Said renewable source will be able to supply a agenerator suitable to produce the electric power needed for the pumping means to operate so that the thermal desalination plant can operate with complete energy autonomy.

[00101]. The heat energy produced by the same generator can be recovered through a suitable heat exchanger, to heat the evaporation circuit C of the thermal desalination plant.

[00102]. Said generator can be coupled with a heat pump, so that the heat pump absorbs the excess energy and converts it into heat energy to be sent to the hot evaporation circuit, in this way extending the hours of use of the thermal desalination plant, for example by exploiting a windy night.

[00103]. The presence of the two highly efficient circuits, hot and cold, allows the thermal desalination plant of the present invention to maintain a temperature gradient sufficient to make the evaporation/condensation process take place in the presence of minimal energy supply.

[00104]. The thermal desalination plant can have many applications both in residential and industrial areas, in areas neighbouring bodies of natural brackish or sea water, rather than waste water intended for purification. It takes care of the preliminary step of producing desalinated water, to be sent with subsequent refinement to the residential or agro-industrial processes. The cost of the plant is very low, it has low operating costs (zero if associated with a photovoltaic and/or wind power kit) essentially due to the hydraulic circulation in closed circuits, without head.

[00105]. The thermal desalination plant, having extremely low installation costs and being totally functional independently from the electrical power mains, can easily be used even in remote areas where there is a great need to have desalinated water.

[00106]. The thermal desalination plant can be sized with suitable sections and volumes, both for the evaporation circuit and the condensation circuit, according to the uses foreseen and its location.

CLAIMS

1. Thermal desalination plant comprising at least one chamber (2, 100′) in which the water to be desalinated (A) is introduced, at least one condensation circuit (F) and at least one evaporation circuit (C), said circuits being independent from one another and crossed by a heat transfer fluid, wherein said condensation circuit (F) comprises a portion positioned beneath the ground or a body of water and it is in heat exchange relationship with said ground or with said body of water.
2. Thermal desalination plant according to claim 1, wherein said chamber (2) has a flat lower part (3) and an upper part (4) having a configuration capable of allowing the water to be run off and collected, preferably said chamber (2) is regular pentagon shaped and constitutes a thermal desalination plant attached to solid earth.
3. Thermal desalination plant according to any one of claims 1 to 2, wherein said chamber (100′) is structured so as to be able to float and it is preferably a cylindrical structure arranged horizontally on the water to be distilled to constitute a floating thermal desalination plant.

4. Thermal desalination plant according to any one of claims 1 to 3, wherein said chamber (2, 100′) is fluid-tight and insulated and has sealed openings (11, 11′, 12, 12′, 111, 111′, 112, 112′) used for the passage of pipes.
5. Thermal desalination plant according to any one of claims 1 to 4, wherein said water to be desalinated (A) enters into said chamber (2, 100′) until it reaches a level (M) through holes (117, 117′) or, alternatively, through one or more pipes (17) that pass through said sealed openings (11, 11′, 12, 12′) due to the principle of communicating vessels or, where this is not possible, through pumping means.
6. Thermal desalination plant according to any one of claims 1 to 6, wherein on said holes (117, 117′) and on said pipes (17) there is a gate valve or another suitable valve device (18).
7. Thermal desalination plant according to any one of claims 1 to 7, wherein said evaporation circuit(C) comprises:
   - one or more heat exchangers (6, 106) equipped with a coil arranged on the inner lower part of the chamber (2, 100′);
   - one or more heat exchangers (7, 7′, 107)

equipped with a coil positioned on the outer upper part of the chamber (2, 100');

- the tubes that connect said coils together.

8. Thermal desalination plant according to any one of claims 1 to 8, wherein said condensation circuit (F) comprises:
   - one or more exchangers (105) equipped with a coil arranged on the inner upper part (104a) of said chamber (100');
   - one or more exchangers (108) equipped with a coil that cover the outer lower part of said chamber (100');
   - the tubes that connect said coils together.
9. Thermal desalination plant according to any one of claims 1 to 9, wherein said condensation circuit (F) comprises:
   - one or more heat exchangers (5, 5') equipped with a coil arranged on the inner upper part (4') of said chamber (2);
   - at least one thermo-well (20);
   - the tubes that connect said coils and said thermo-well together.
10. Thermal desalination plant according to any one of claims 1 to 19, wherein said heat transfer fluid is water.

11. Thermal desalination plant according to any one of claims 1 to 10, wherein said heat exchangers (5, 5', 6, 7, 7', 105, 106, 107) are built from plate with corrugated section and said plate has throats arranged horizontally, in which said coil is inserted.

12. Thermal desalination plant according to any one of claims 1 to 11, wherein said heat exchangers (7, 7', 107) arranged on the outer upper surface of the chamber (2, 100') are coated, totally or just one some portions, with a layer of non-reflective aluminium painted or treated in a suitable manner to transform light into heat and, further outside, with a layer of cell-structured translucent material, for example a film of POLIBOLL.

13. Thermal desalination plant according to any one of claims 1 to 12, wherein said thermo-well (20) comprises at least one buried casing (21), at least one supply duct of a heat transfer fluid and at least one drawing duct of said heat transfer fluid, wherein said casing (21) is fluid-tight and is not insulated and preferably has a shape in which the outer surface/volume ratio is maximised and comprises, inside of it,

an inert material (G) in granular form with which said heat transfer fluid is placed in contact so as to obtain a heat exchange between said heat transfer fluid, said inert material (G) and the ground outside of said casing (21).

14. Thermal desalination plant according to any one of claims 1 to 13, wherein said evaporation circuit (C) and condensation circuit (F) are connected to pumping means.

15. Thermal desalination plant according to any one of claims 1 to 14, wherein the lower face of the heat exchangers (5, 5', 105) forming part of the condensation circuit (F), arranged on the inner upper part (4', 104a) of the chamber (2, 100'), is preferably coated with an aluminium foil (132) and acts as a condensation surface for the water that is then conveyed into the water trays (14, 14', 124, 124'); from said water trays said condensed water is made to flow into collection tanks (15, 15') positioned outside of the chamber (2, 100') through pipes (16, 16', 125) that pass through said sealed openings (11, 11', 111, 111').

16. Thermal desalination plant according to any one of claims 1 to 15, wherein the electrical

energy needed for the operation of said pumping means is provided by a generator fed with power by renewable sources such as a wind power station, typically a micro-wind power station, and/or photovoltaic panels.

17. Thermal desalination plant according to any one of claims 1 to 16, wherein the heat energy produced by said generator is recovered through a suitable heat exchanger to heat said hot evaporation circuit (C).

18. Thermal desalination plant according to any one of claims 1 to 17, wherein said generator is coupled with a heat pump that absorbs the excess energy and converts it into heat energy to be sent to said hot evaporation circuit (C).

19. Thermal desalination plant according to any one of claims 1 to 18, wherein said body of water is a body of brackish water or the sea.

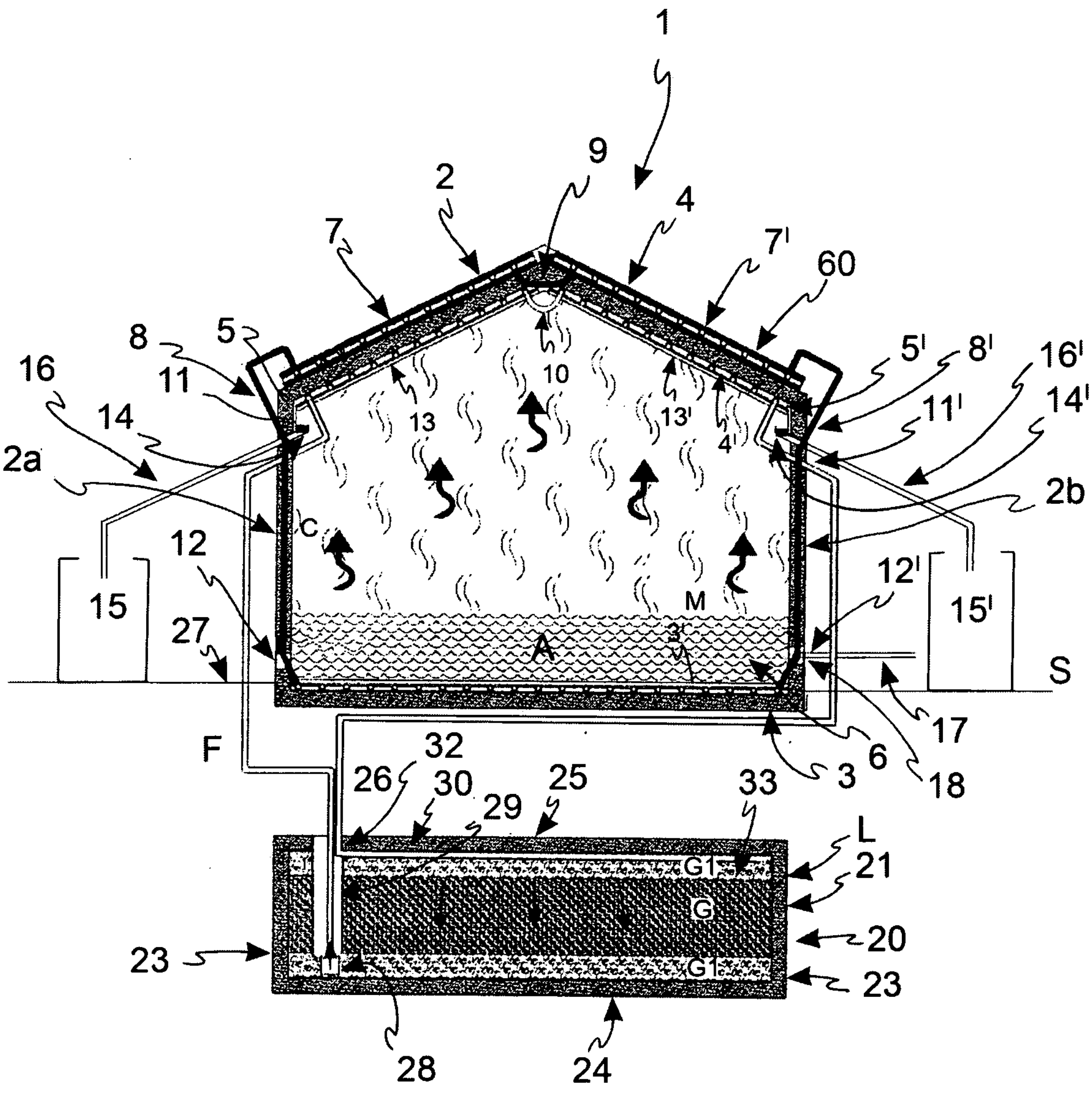
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FIG. 1

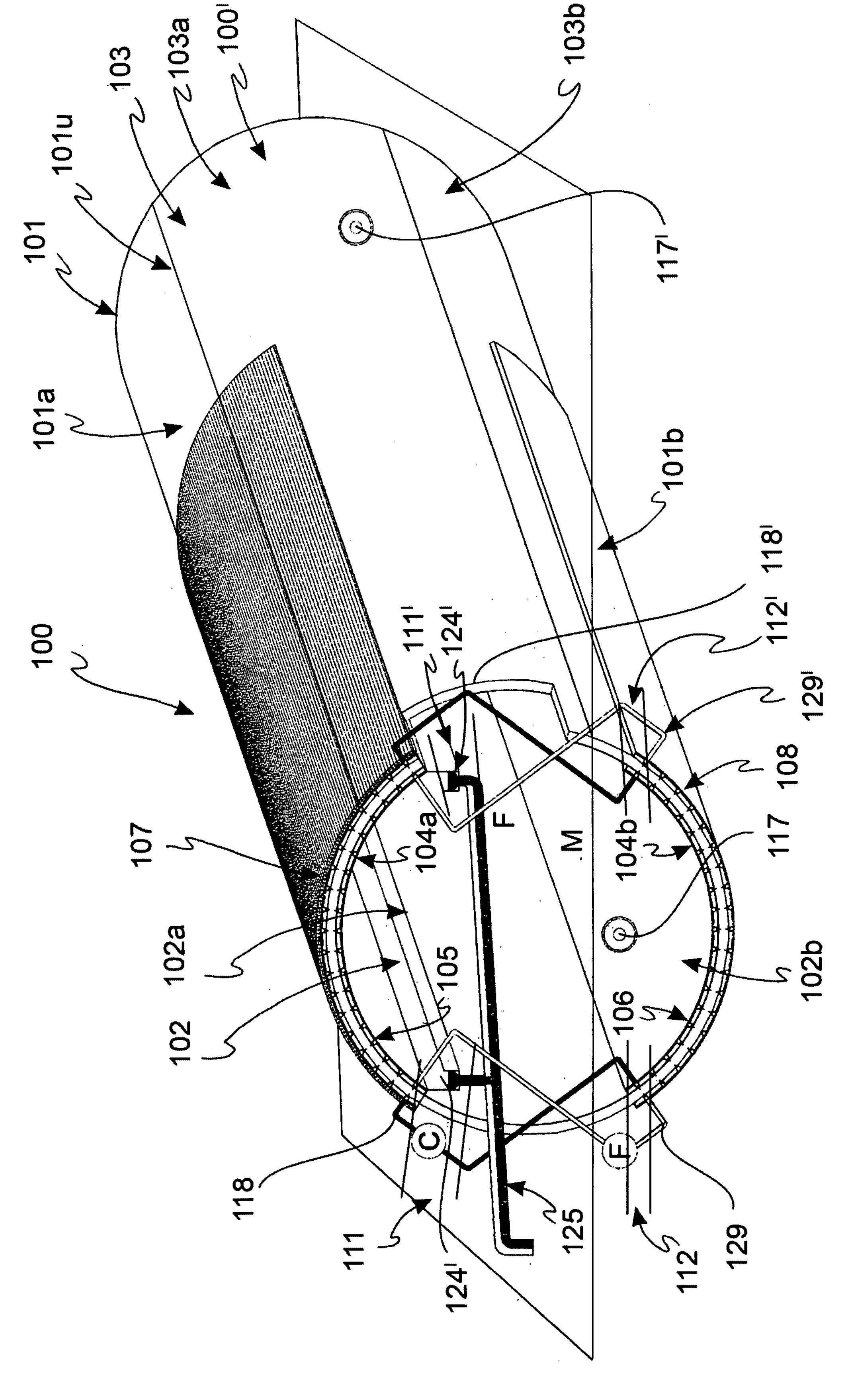
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FIG. 2

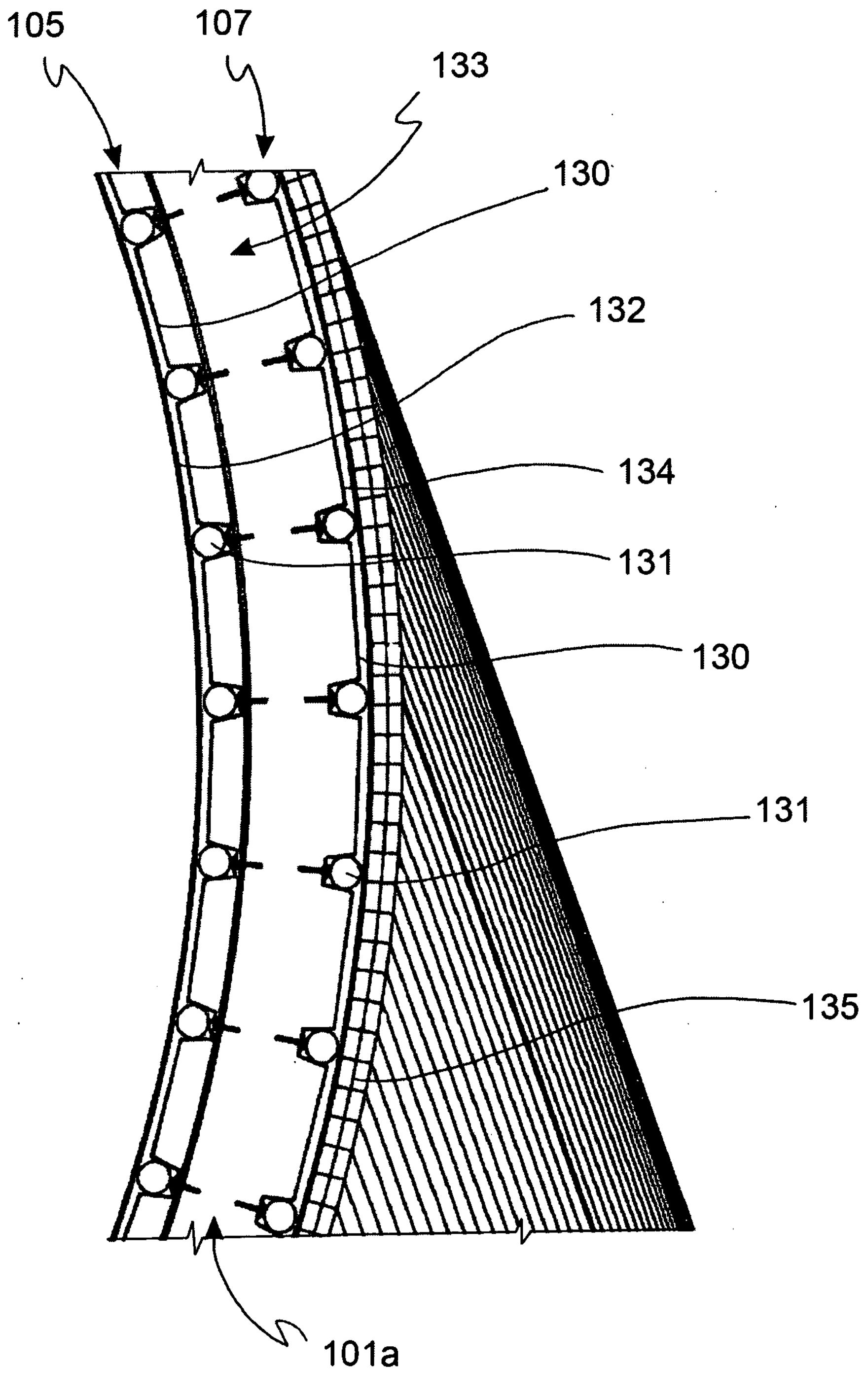

FIG. 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/IT2010/000302

A. CLASSIFICATION OF SUBJECT MATTER
INV. C02F1/14 B01D1/00 B01D5/00 C02F1/10 C02F1/04
ADD. C02F103/08

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)
C02F B01D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	WO 98/40313 A1 (MARKOPULOS JOHANNES [AT]) 17 September 1998 (1998-09-17) page 3, lines 12-32 page 4, line 19 - page 5, line 14 page 6, line 1 - page 9, line 2 figures 1,5	1,2,4-19 3
X	EP 0 111 646 A1 (TAVARES JOAQUIM DIPL MATH) 27 June 1984 (1984-06-27) page 3, line 22 - page 6, line 21; figures 1-4	1,2, 4-11, 14-19
A	FR 2 851 766 A1 (RENAUT YVES [FR]; BARON MURIEL [FR]) 3 September 2004 (2004-09-03) figures 1-2	1,2

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
24 November 2010	07/12/2010

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Borello, Ettore

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 6 342 127 B1 (POSSIDENTO WILLIAM [US]) 29 January 2002 (2002-01-29) the whole document -----	3

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IT2010/000302

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
WO 9840313	A1	17-09-1998	AT	404467	B	25-11-1998
			AT	202766	T	15-07-2001
			AU	728428	B2	11-01-2001
			AU	6601998	A	29-09-1998
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FR 2851766	A1	03-09-2004	NONE			
US 6342127	B1	29-01-2002	NONE			

(12) NACH DEM VERTRAG ÜBER DIE INTERNATIONALE ZUSAMMENARBEIT AUF DEM GEBIET DES PATENTWESENS (PCT) VERÖFFENTLICHTE INTERNATIONALE ANMELDUNG

(19) Weltorganisation für geistiges Eigentum
Internationales Büro

(43) Internationales Veröffentlichungsdatum
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B01D 1/06 (2006.01) ***C02F 1/08*** (2006.01)
B01D 1/26 (2006.01) ***B01D 3/06*** (2006.01)
B01D 1/30 (2006.01) ***B01D 3/12*** (2006.01)

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(22) Internationales Anmeldedatum: 17. September 2009 (17.09.2009)

(25) Einreichungssprache: Deutsch

(26) Veröffentlichungssprache: Deutsch

(30) Angaben zur Priorität:
A 1485/2008 23. September 2008 (23.09.2008) AT

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(75) Erfinder/Anmelder *(nur für US)*: **KARASEK, Andreas** [AT/AT]; Eichengasse 16, A-2651 Reichenau (AT). **BETHGE, Daniel** [AT/AT]; Holzplatz 2, A-2620 Neunkirchen (AT).

(74) Anwalt: **PATENTANWALTSKANZLEI MATSCHNIG & FORSTHUBER OG**; Siebensterngasse 54, A-1071 Wien (AT).

(81) Bestimmungsstaaten *(soweit nicht anders angegeben, für jede verfügbare nationale Schutzrechtsart)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Bestimmungsstaaten *(soweit nicht anders angegeben, für jede verfügbare regionale Schutzrechtsart)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), eurasisches (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), europäisches (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

[Fortsetzung auf der nächsten Seite]

(54) Title: FALLING FILM PLATE SHORT-PATH EVAPORATOR

(54) Bezeichnung : PLATTENFALLFILM-KURZWEG VERDAMPFER

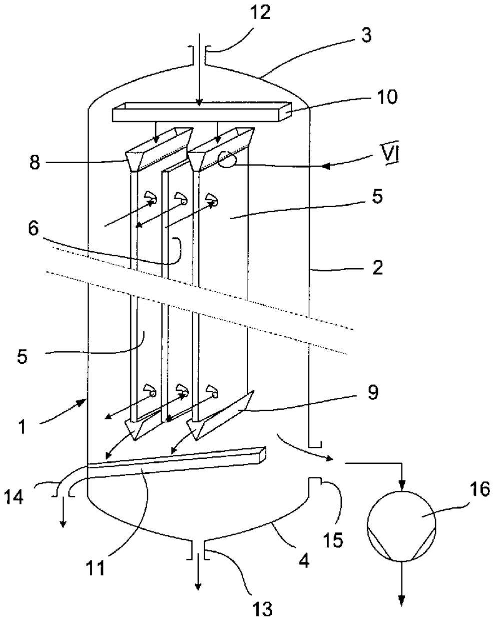

Fig. 1

(57) Abstract: A falling film plate evaporator for the falling film evaporation of a liquid substance, comprising at least one heatable evaporator plate (5) which is disposed substantially vertically in a housing (1), a distributor pan (8) which is disposed above the at least one evaporator plate and from which the substance located therein can be fed to the evaporator plate to form a film trickling down the outside surface of the evaporator plate, a collection means (9) for the concentrate which is associated with the lower plate edge, at least one connection (15, 15o, u) for a pumping means (16) for evacuating the interior of the housing, and further comprising a condensing device for subsequently condensing the developing vapor, wherein the condensing device is designed as at least one condensation plate (6), which is disposed inside the housing substantially vertically and parallel to the at least one evaporator plate (5) and which can be cooled by a cooling fluid flowing through the inner hollow space thereof and with which a collection means (4) for distillate trickling down the condensation plate is associated.

(57) Zusammenfassung: Ein Platten-Fallfilmverdampfer zur Fallstromverdampfung einer flüssigen Substanz, mit zumindest einer, in einem Gehäuse (1) im Wesentlichen vertikal angeordneten, beheizbaren Verdampferplatte (5), mit einer oberhalb der zumindest einen Verdampferplatte angeordneten Verteilerwanne (8), aus der die darin befindliche Substanz der Verdampferplatte unter Bildung eines an der Außenfläche der Verdampferplatte

[Fortsetzung auf der nächsten Seite]

WO 2010/034043 A1

Veröffentlicht:

— *mit internationalem Recherchenbericht (Artikel 21 Absatz 3)*

— *vor Ablauf der für Änderungen der Ansprüche geltenden Frist; Veröffentlichung wird wiederholt, falls Änderungen eingehen (Regel 48 Absatz 2 Buchstabe h)*

herabrinnenden Films zuführbar ist, mit einem der unteren Plattenkante zugeordneten Auffangmittel (9) für das Konzentrat, mit zumindest einem Anschluss (15, 15o, u) für ein Pumpmittel (16) zum Evakuieren des Gehäuseinnenraumes, sowie mit einer Kondensationseinrichtung zur anschließenden Kondensation des entstehenden Brüdens, wobei die Kondensationseinrichtung als zumindest eine, innerhalb des Gehäuses im Wesentlichen vertikal und parallel zu der zumindest einen Verdampferplatte (5) angeordnete Kondensationsplatte (6) ausgebildet ist, die mittels eines, ihren inneren Hohlraum durchströmenden Kühlfluidums kühlbar ist und der ein Auffangmittel (4) für von der Kondensationsplatte herabrinnendes Destillat zugeordnet ist.

PLATTENFALLFILM-KURZWEG VERDAMPFER

Die Erfindung bezieht sich auf einen Platten-Fallfilmverdampfer zur Fallstromverdampfung einer flüssigen Substanz , mit zumindest einer, in einem Gehäuse im Wesentlichen vertikal angeordneten, beheizbaren Verdampferplatte, mit einer oberhalb der zumindest einen Verdampferplatte angeordneten Verteilerwanne, aus der die darin befindliche Substanz der Verdampferplatte unter Bildung eines an der Außenfläche der Verdampferplatte herabrinnenden Films zuführbar ist, mit einem der unteren Plattenkante zugeordneten Auffangmittel für das Konzentrat, mit zumindest einem Anschluss für ein Pumpmittel zum Evakuieren des Gehäuseinnenraumes, sowie mit einer Kondensationseinrichtung zur anschließenden Kondensation des entstehenden Brüdens.

Verdampfer dieser Art sind bekannt und werden seit Jahren von der Anmelderin erzeugt und geliefert.

Die Stofftrennung durch Verdampfen mit anschließender Kondensation der Dämpfe zählt zu den thermischen Trennverfahren. Sie wird angewendet, um flüssige Stoffgemische in leichter und schwerer siedende Fraktionen zu trennen. Beispielsweise kann Wasser von organischen Substanzen separiert werden. Im industriellen Maßstab werden häufig sogenannte Fallfilmverdampfer eingesetzt. Das sind senkrecht stehende Rohrbündelwärmetauscher, in denen das Stoffgemisch oben aufgegeben, mit Hilfe einer geeigneten Einrichtung gleichmäßig verteilt und auf der Innenseite der Rohre als Film nach unten strömt. Beheizt wird mantelseitig mit Heizdampf oder Wärmeträgermedium. Durch die Zuführung der Wärme verdampfen die leicht siedenden Bestandteile (im Beispiel Wasser), zurück bleibt ein Konzentrat. Die erzeugten Dämpfe strömen mit der Flüssigkeit im Gleichstrom in den Rohren abwärts. In einem Abscheider werden evtl. mitgerissene Flüssigkeitströpfen abgeschieden. Anschließend können die Dämpfe z. B. in einem Kondensator gegen Kühlwasser niedergeschlagen werden.

Turbulenz im Film und damit ein guter Wärmeübergang wird sichergestellt durch ausreichende Benetzung der Rohre. Deshalb wird teilweise rezirkuliert, d. h. ein Teil des Konzentrats wird zur Aufgabe gemischt; oder der Apparat wird mehrmals Durchfahren, d. h. der Verdampfer wird in Sektionen unterteilt, die das Stoffgemisch nacheinander durchfließt.

Eine kostengünstige Variante des Fallfilmverdampfers stellt der Platten-Fallfilmverdampfer dar. Bei einem solchen Verdampfer wird der Flüssigkeitsfilm nicht auf der Innenfläche von Rohren erzeugt, sondern auf der Oberfläche von Platten mit einem inneren Hohlraum. Es sind immer zwei Platten miteinander verbunden und verschweißt, so dass in dem abgeschlossenen Bereich Heizdampf oder ein anderes Wärmeträgerfluidum zirkulieren kann. Auf den Außenflächen, die aufgrund der Verschweißtechnik die Form eines Kissens haben kann, strömt der Produktfilm. Ein Verdampfer enthält eine Vielzahl von parallel angeordneten Plattenpaaren. Die Aufgabe erfolgt über Rinnen, die an der Oberkante der Plattenpaare angeordnet sind. Das Konzentrat, das an der Unterkante von den Platten tropft, wird gesammelt und ausgeschleust. Die erzeugten Brüden verlassen den Wärmetauscher und werden z. B. in einem Kondensator niedergeschlagen.

Unter der Einwirkung von Hitze neigen viele Stoffgemische bzw. enthaltene Komponenten dazu, sich zu zersetzen oder zu polymerisieren. Auch kann es zu Belagsbildungen auf den Heizflächen kommen. Das wird vermieden indem der Druck im Verdampfer erniedrigt wird, da dadurch die Siedetemperatur ebenfalls sinkt. Wässrige, hitzeempfindliche Lösungen werden daher im Grobvakuum eingedampft. Hierzu zählt z. B. die Eindampfung von Milch zur Herstellung von Milchpulver. Der Vakuumdruck lässt sich aber nicht beliebig erniedrigen. Grund ist der Druckverlust, der durch die Strömung der Dämpfe von der Verdampferfläche zum Kondensator entsteht. In den üblichen Apparaten beträgt dieser mindestens einige mbar. Damit ist das erreichbare Vakuum in den herkömmlichen Verdampfern limitiert.

Es gibt eine Vielzahl an Produkten, die sich ausschließlich im Druckbereich unter 1 mbar destillieren lassen. Hierzu gehört die Gewinnung von Omega-3 Fettsäuren aus Fischöl, Carotin aus Palmöl, verschiedener Fraktionen aus Wachs, das Aufkonzentrieren von Emulgatoren (Monoglyceride), die Monomerabtrennung aus Polymergemischen, um nur einige Beispiele zu nennen.

Diese Stoffe werden in sog. Kurzwegverdampfern oder Molekulardestillationsapparaten destilliert. Hier befindet sich die Kondensationsfläche in unmittelbarer Nähe zur Verdampferfläche. Die Dämpfe strömen quasi ohne Druckverlust vom Verdampfer zum Kondensator. Damit ist ein Betrieb bei Drucken weit unter 1 mbar möglich.

Im industriellen Maßstab haben sich sogenannte „gewischte" Apparate durchgesetzt. Das sind Dünnschichtverdampfer in denen der Film mit Hilfe eines mechanischen Systems („Wischer") auf der Innenseite einer von außen beheizten zylindrischen Fläche verteilt und umgewälzt wird. Die erzeugten Dämpfe werden am konzentrisch angeordneten Innenkondensator kondensiert. Der Kondensator besteht aus ringförmig angeordneten Rohren. Inerte und nicht kondensierbare Gase werden über die Mitte abgesaugt. Das Konzentrat wird in einer ringförmigen ggf. beheizbaren Tasse am unteren Ende der zylindrischen Verdampferfläche gesammelt und ausgeschleust. Der Destillataustrag befindet sich unterhalb des Kondensators. Die Gase werden über einen Vakuumstutzen abgesaugt.

Ein Nachteil dieser Apparate ist das Vorhandensein von mechanisch bewegten Teilen, der Verschleiß, die erforderliche Wartung, der Preis und die Begrenzung der Baugröße. Die größten Verdampfer weisen heute eine Verdampferfläche von ca. 50 m^2 auf für Mengen von ca. 5 t/h. Es wurden daher immer wieder Anstrengungen unternommen, diese Nachteile zu überwinden.

In der EP 1 429 856 B1 ist ein Fallstromverdampfer mit integrierter Kondensation geoffenbart, der mehrere aufrecht stehende, gemeinsam in einem Gehäuse untergebrachte Verdampferrohre mit einem beheizbaren Hohlraum sowie gleichfalls in dem Gehäuse untergebrachte, aufrecht stehende Kondensationsrohre, die je koaxial zu den Verdampferrohren innerhalb derselben angeordnet sind. Die Kondensationsrohre werden von innen her mittels eines Kühlmittels gekühlt. Die flüssige Substanz wird mittels einer Verteilerwanne den Verdampferrohren oben zugeführt und läuft dann als Film an deren Innenfläche herab; an den Außenmänteln der Kondensationsrohre herabfließendes Destillat wird unten aufgefangen.

Dieser bekannte Fallstromverdampfer kann zwar flüssige Substanzen bei einem höherem Vakuum verarbeiten, da keine, einen Druckabfall bewirkende Rohrleitungen zu einer externen Kondensationseinrichtung vorliegen, doch ist der gesamte Aufbau durch die Vielzahl koaxialer Rohrpaare mit zugehörigen Beschickungs- und Auffangmitteln ziemlich komplex, was auch für die Führung der Heiz- und Kühlfluida zutrifft. Der komplizierte Aufbau erschwert und verteuert die Herstellung ebenso, wie später erforderliche Wartungsarbeiten, insbesondere auch Reinigungsarbeiten.

Aus der DE 690 10 214 T2 ist ein Lamellenverdampfer bekannt geworden, der sich durch eine besondere Führung des eintretenden Heizdampfes in Kondensationsräume sowie der erzeugten Brüden auszeichnet. Die Platten des Lamellenverdampfers, die als „Wärmeübertragungsplatten" bezeichnet werden, besitzen einerseits Löcher und andererseits ein System von zwischen den Platten liegende Dichtungen, wodurch eine Vielzahl von Kammern geschaffen wird, nämlich Verteilungskammern, Verdampfungsräume und Kondensationsräume. Des Weiteren ist das Innere des Behälters in einen oberen Raum und einen unteren Raum geteilt.

Die Brüden entstehen durch zumindest teilweise Verdampfung der aus den Verteilungskammern in die Verdampfungsräume strömenden Flüssigkeit und werden über den unteren Raum zu einem Auslass geführt. Vermutlich aufgrund der geringen Druckverluste eignet sich dieser Apparatetyp besonders für den Einsatz der mechanischen Brüdenverdichtung, wobei die Brüden mit Hilfe eines Kompressors 37 auf einen höheren Druck komprimiert werden. Damit steigt auch die Kondensationstemperatur. Die Brüden können auf diese Weise als Heizdampf genutzt werden. Sind die Druckverluste gering, fällt die Verdichterarbeit entsprechend kleiner aus.

Es für den Fachmann klar, dass sich ein Lamellenverdampfer nach der DE 690 10 214 T2 für eine Destillation im Feinvakuum nicht eignet. Lammellen- und Plattenfallfilm-Kurzweg Verdampfer sind für verschiedene Einsatzfälle konzipiert. Die DE 690 10 214 T2 nennt als Beispiel die Meerwasserentsalzung und gibt als charakteristischen Druck 0,15 bar an. Bei der Erfindung ist ein Beispiele die Gewinnung von Carotin aus Palmöl und die angewendeten Drücke liegen üblicherweise bei weniger als 5 mbar bis unter 0,001 mbar.

Es ist eine Aufgabe der Erfindung, einen Fallstromerdampfer mit integrierter Kondensation zu schaffen, der bei sehr niedrigem Druck in industriellem Maßstab einsetzbar ist, wobei die Herstellung einfach und kostengünstig erfolgen soll.

Diese Aufgabe wird mit einem Platten-Fallfilmverdampfer der eingangs erwähnten Art gelöst, bei welchem die Kondensationseinrichtung als zumindest eine, innerhalb des Gehäuses im Wesentlichen vertikal und parallel zu der zumindest einen Verdampferplatte angeordnete Kondensationsplatte ausgebildet ist, die mittels eines, ihren inneren Hohlraum durchströmenden Kühlfluidums kühlbar ist und der ein Auffangmittel für von der Kondensationsplatte herabrinnendes Destillat zugeordnet ist.

Dank der Erfindung ergibt sich ein einfacher Aufbau, welcher einerseits zu geringeren Strömungsverlusten, verglichen mit den bisherigen Verdampfer/Kondensator-Apparaten, führt und der andererseits eine weitaus einfachere und kostengünstiger Herstellung der Einzelteile und deren Montage ermöglicht, sodass auch flüssige Stoffgemische verarbeitet werden können, die einen Betrieb bei niedrigen Drücken, z. B. unter 1 mbar erfordern, wobei eine industrielle Verarbeitung bei hohen Durchsatzleistungen und großen Verdampferflächen möglich ist. Letztlich können dadurch viele Produkte kostengünstiger hergestellt werden, als es bis jetzt möglich war.

Bei einer zweckmäßige Weiterbildung der Erfindung ist vorgesehen, dass innerhalb des Gehäuses abwechselnd Verdampferplatten und Kondensationsplatten angeordnet sind, wodurch sich eine hohe Effizienz im Betrieb bei vernünftigen Gesamtabmessungen ergibt.

Die Herstellung des Verdampfers wird weiter verbilligt, wenn gemäß einer Variante die zumindest eine Verdampferplatte und die zumindest eine Kondensationsplatte gleichartig ausgebildet sind.

In manchen Fällen kann es auch zweckmäßig sein, wenn die zumindest eine Verdampferplatte und/oder die zumindest eine Kondensationsplatte um eine im Wesentlichen vertikale Achse zylindrisch gekrümmt sind, da hierdurch auf die meist zylindrische Krümmung des Gehäuses Rücksicht genommen werden kann.

Eine bei vielen Stoffgemischen zweckmäßige zwei- oder mehrstufige Destillation kann kosten- und raumsparend bei hohen Durchsatzleistungen erfolgen, wenn innerhalb eines gemeinsamen Gehäuses zumindest zwei Kombinationsstufen von Verdampferplatten und Kondensationsplatten angeordnet sind, sowie Mittel vorgesehen sind, um das von der zumindest einen Kondensationsplatte einer ersten Stufe herabgeronnene und aufgefangene Destillat einer Verteilerwanne für eine Verdampferplatte einer weiteren Stufe zuzuführen.

In Hinblick auf die Verarbeitung entsprechend kritischer Stoffgemische ist es vorteilhaft, wenn das Pumpmittel zum Evakuieren des Gehäuseinnenraumes auf einen Innendruck von weniger als 1 mbar ausgebildet ist.

Bei praxiserprobten Varianten kann der Abstand zwischen den Oberflächen einander zugeordneter Platten zwischen 5 und 150 mm betragen.

Im Sinne eines sauberen Auffangens des Destillats ist es vorteilhaft, wenn das Auffangmittel für von der zumindest einen Kondensationsplatte herabrinnendes Destillat der Bodenteil des Gehäuses ist.

Zur Berücksichtigung bestimmter Eigenschaften der zu verarbeitenden Stoffe, insbesondere deren temperaturabhängigen Viskosität kann es empfehlenswert sein, wenn Heizmittel für die Auffangrinne und/oder der Bodenteil des Gehäuses vorgesehen sind.

Will man zur weiteren Erhöhung der Effizienz auch die Gehäusewandung als Kondensationsfläche heranziehen, so ist es zweckmäßig, wenn Kühlmittel für zumindest benachbart zu Verdampferplatten gelegene Bereiche der Gehäusewandung vorgesehen sind.

Um solche flüssige Stoffgemische, die beim Verdampfen stark zum Spritzen neigen, d. h. Gemische mit hohem Leichtsiederanteil, gut verarbeiten zu können, ist bei einer Variante vorgesehen, dass zwischen Verdampferplatten und Kondensationsplatte Tröpfchenabscheider vorgesehen sind.

Für solche Fälle kann aber auch zusätzlich oder als Alternative mit besonderem Vorteil vorgesehen sein, dass die Verdampferplatten im Sinne einer von oben nach unten geringer werdenden Temperatur beheizbar sind.

Im Sinne einer überaus gleichmäßigen Wärmeverteilung vor allem in horizontaler Richtung ist es vorzuziehen, wenn die Verdampferplatte mittels eines ihren inneren Hohlraum durchströmenden Heizfluidums beheizbar ist.

Die Erfindung samt weiteren Vorteilen ist im Folgenden an Hand beispielsweiser Ausführungsformen näher erläutert, die in der Zeichnung veranschaulicht sind. In dieser zeigen

Fig. 1 einen Fallstromverdampfer nach der Erfindung in einer schaubildlichen Prinzipdarstellung,

Fig. 2 eine Anordnung von vier Verdampfer- und drei Kondensationsplatten,

Fig. 3 einen Fallstromverdampfer nach der Erfindung in schematischer Seitenansicht in Richtung des Pfeils III der Fig. 5,

Fig. 4 den Fallstromverdampfer nach Fig. 3 in einer weiteren Seitenansicht in Richtung des Pfeils IV der Fig. 5,

Fig. 5 einen Schnitt durch den Fallstromverdampfer längs der Linie V-V der Fig. 3,

Fig. 6a und 6b zwei mögliche Varianten der Verteileröffnungen im Bereich des Details VI der Fig. 1,

Fig. 7 die beispielsweise Anordnung eines Tröpfchenabscheiders zwischen einer Verdampferplatte und einer Kondensationsplatte, und

Fig. 8 diagrammartig die Anordnung von drei Verdampfer/Kondensationsstufen innerhalb ein es einzigen Gehäuses.

Zunächst sei der prinzipielle Aufbau eines erfindungsgemäßen Platten-Fallfilmverdampfers unter Bezugnahme auf die Fig. 1 und 2 erläutert. Innerhalb eines ~~im~~ zumindest vakuumdruckfesten Gehäuses 1 mit einer zylindrischen Seitenwand 2, einem pombierten Dachteil 3 und einem ebensolchen Bodenteil 4 sind zwei Verdampferplatten 5 und zwischen diesen eine Kondensationsplatte 6 angeordnet. Alle drei Platten stehen senkrecht und liegen parallel zueinander. Tatsächlich werden meist mehr als drei Platten innerhalb des Gehäuses angeordnet sein, beispielsweise, wie in Fig. 2 gezeigt, vier Verdampferplatten 5 und drei Kondensationsplatten 6. Dachteil 3 und oder Bodenteil 4 können an den zylinderischen Teil auch angeflanscht sein, wobei der zylindrische Teil, die Seitenwand 2, nicht notwendigerweise kreiszylindrisch sein muss.

Sowohl die Verdampferplatten 5 als auch die Kondensationsplatten 6 besitzen einen inneren Hohlraum und können zum Heizen bzw. Kühlen von einem Fluidum durchströmt werden, wobei im normalen Betrieb die Verdampferplatten 5 beheizt und die Kondensationsplatten 6 gekühlt werden. Daher hat jeder der Platten 5, 6 zumindest zwei Anschlüsse 7, die als Zulauf-Anschluss bzw. als Abfluss-Anschluss dienen können. Die Platten 5, 6 sind vorzugsweise gleichartig ausgebildet und können beispielsweise aus zwei miteinander am Rand sowie unter Bildung einer leicht polsterartigen Struktur über ihre Fläche an vielen Stellen miteinander punktverschweißt sein. Als Heizfluidum stehen dem Fachmann in Abhängigkeit der erforderlichen Temperaturen unterschiedliche Fluida zur Verfügung, um nur zwei Beispiele zu nennen etwa Heißdampf oder Thermalöle. Gleiches gilt für das Kühlfluidum, das beispielsweise Wasser sein kann.

An jeder Verdampferplatte 5 ist an ihrem oberen Ende eine Verteilerwanne 8 und an ihrem unteren Ende als Auffangmittel eine Auffangrinne 9 vorgesehen. Weiters ist bei diesem Beispiel den Verteilerwannen 8 ein Vorverteiler 10 und den Auffangrinnen 9 eine Austragrinne 11 zugeordnet. Ein Einlassstutzen 12 am oberen Ende des Dachteils 3 dient zur Zuführung einer flüssigen Substanz, ein Abflussstutzen 13 zum Abführen des Destillats, das hier von dem Bodenteil 4 aufgefangen wird.. Über einen der Austragrinne 11 zugeordneten Auslassstutzen 14 kann ein Konzentrat abgeführt werden und ein seitlicher Vakuumstutzen 15 kann mit einem geeigneten Pumpmittel, wie z. B. einer zweistufigen Vakuumpumpe 16 in Verbindung mit einer nicht gezeigten Kältefalle verbunden werden.

Die Verteilerwannen 8 besitzen eine Vielzahl von Austragsöffnungen, durch welche die Substanz auf die Platten 5 strömt, um zu verhindern, dass Tröpfchen der Substanz auf eine benachbarte Kondensationsplatte 6 gelangt. Ein Detailbereich mit solchen Öffnungen 17 ist in zwei Varianten in Fig. 6 gezeigt, wobei Fig. 6 zeigt, dass die untere Kante der Verteilerwannen 8 eine gewellte, hier trapezförmig gewellte Struktur besitzt, bzw. gezackt ist, wie Fig. 6b zeigt, sodass in beiden Fällen die erwähnten Öffnungen 17 entstehen.

Um das natürlich nicht gewünschte Spritzen von Substanz auf die Kondensationsplatten 6 zu vermeiden, kann zwischen benachbarten Platte 5, 6 ein Tröpfchenabscheider 18 angeordnet sein, der dem Fachmann bekannt ist und beispielsweise, wie in Fig. 7 gezeigt, aus schräg gestellten Blechlammellen bestehen kann.

Der Platten-Fallfilmverdampfer nach der Erfindung arbeitet wie folgt: Die flüssige Substanz, im allgemeinen ein Stoffgemisch, wie bereits weiter oben erwähnt, wird über den Einlassstutzen 12 zunächst an den Vorverteiler 10 geführt und gelangt von diesem zu den Verteilerwannen 8 am oberen Ende der Verdampferplatten 5, die entsprechend der gewünschten Betriebsbedingungen bereit sind und eine Temperatur üblicherweise bis zu 350 ° C und mehr aufweisen können. In bestimmten Fällen mit leicht verdampfenden Fraktionen sind aber auch Temperaturen unter 100 ° C möglich. Die flüssige Substanz rinnt nun als Film über die äußeren Flächen der Verdampferplatten 5 herab, verdampft zumindest teilweise und schlägt sich als Kondensat auf den gekühlten Kondensationsplatten 6 nieder. Der Begriff "gekühlt", ist in Abhängigkeit der zu kondensierenden Substanz zu verstehen, d. h. es kann beispielsweise mit Temperaturen zwischen 20 und 200 ° C gekühlt werden. Das Verdampfen wird durch das mittels der Pumpe 16 aufrecht erhaltene Vakuum begünstigt, welches in den meisten Fällen kleiner als 5 mbar ist und sogar weniger 0,001 mbar betragen kann. Da der Abstand zwischen den Oberflächen der Verdampferplatten 5 und den Kondensationsplatten 6 im Allgemeinen im Zentimeter-Bereich liegt und ein relativ hohes Vakuum aufrecht erhalten wird, gelangen Moleküle des gewünschten Konzentrats ohne wesentliche Zusammenstöße an die Kondensationsplatten.

Um auf den Tröpfchenabscheider 18 zurückzukommen, soll erwähnt werden, dass dieser nicht notwendigerweise über die gesamte Höhe der oft einige Meter langen Platten 5, 6 sich erstrecken muss, sondern auch nur Teilbereiche, z. B. den einen oberen Teilbereich, abdecken kann. Weiters ist es möglich, ein unerwünschtes Spritzen von Substanz durch eine geeignete Temperaturführung zu vermeiden, insbesondere dadurch, dass die Verdampferplatten 5 im Sinne einer von oben nach unten geringer werdenden Temperatur beheizt werden. Im einfachsten Fall gelingt dies dadurch, dass das Heizfluidum im Sinne der in Fig. 7 gezeigten Pfeile über die Anschlüsse 7 bei den Verdampferplatten 5 von oben nach unten geführt wird. Das Kühlfluidum kann dem gegenüber, gleichfalls im Sinne der in Fig. 7 gezeigten Pfeile von unten nach oben geführt werden.

In den Auffangrinnen 9 wird eine Fraktion der Substanz, insbesondere das Konzentrat aufgefangen und über die Austragrinne 11 und den Auslassstutzen 14 ausgetragen. Die Austragrinnen 11 können, falls es beispielsweise die Produktviskosität erfordert, beheizbar ausgeführt sein. Zu diesem Zweck sind diese entweder doppelwandig ausgebildet, oder es sind an die Rinnen entsprechende Heizrohre (nicht gezeigt) aufgeschweißt, die von einem Heizfluidum durchströmbar sind. Selbstverständlich ist auch eine elektrische Beheizung sämtlicher zu beheizenden Elemente denkbar, was auch für die Verdampferplatten gilt. Allerdings ist in der Praxis, jedenfalls für die Verdampferplatten, eine Beheizung mit einem Heizfluidum in Hinblick auf die breitflächige Erwärmung vorzuziehen.

Eine zweite Fraktion, vorzugsweise das Destillat, rinnt von den Kondensationsplatten 6 auf den Boden 4 des Gehäuses 1 und wird über den Abflussstutzen 13 ausgetragen. Ebenso wie die Auffangrinnen 9 und die Austragrinne 11 könnte auch der Bodenteil 4 beheizbar ausgeführt werden, wiederum entweder durch eine doppelwandige Ausführung oder durch Heizrohre oder andere Heizelemente.

Andererseits ist es möglich, zur Verbesserung der Effizienz zumindest Abschnitte der Seitenwand 2 des Gehäuses 1 zu kühlen, um eine zusätzlich Kondensationsfläche zu schaffen. In einem solchen Fall können insbesondere die benachbart zu der zylindrischen Seitenwand 2 liegenden Verdampferplatten 5 eine entsprechende koaxiale zylindrische Krümmung aufweisen.

Zur weiteren Veranschaulichung der Erfindung ist in den Fig. 3 bis 5 eine andere, einfache Variante der Erfindung mit lediglich drei Platten dargestellt. Es soll betont werden, dass auch diese Ausführung zur Vereinfachung mit lediglich drei Platten dargestellt ist, die in dieser Form als Pilotapparatur verwendet werden könnte, dass in der Praxis jedoch erheblich mehr Platten vorgesehen sind. Soweit nicht anders angegeben, bezeichnen gleiche Bezugszeichen gleiche Teile wie bei der vorangehend beschriebenen prinzipiellen Ausführung. Es ist eine einzige, mittige Verdampferplatte 5 vorgesehen, der beidseitig zwei Kondensationsplatten 6 zugeordnet sind. Die Zuführung des Heizmediums erfolgt über zwei Heizstutzen 19o und 19u, wogegen für Zufluss und/oder Abfluss des Kühlfluidums Kühlstutzen vorgesehen sind, von welchen in Fig. 5 lediglich zwei untere Kühlstutzen 20u ersichtlich sind.

Wie bei der Ausführung nach den Fig. 1 und 2 kann das Destillat über einen Abflussstutzen 13 und der von der Austragrinne 11 aufgenomme, an der Verdampferplatte 5 herabgeronnene Rückstand an einem Auslassstutzen 14 entnommen werden. Am Dachteil 3 ist noch ein Schauglasstutzen 21 vorgesehen, um die Vorgänge bei der Verteilung der Substanz im oberen Bereich gegebenenfalls verfolgen bzw. um allfällige Verunreinigungen rechtzeitig feststellen zu können. Bei dieser Ausführungsform sind zwei Absaug- bzw. Vakuumstutzen 15o, 15u vorgesehen, nämlich einer im oberen und einer im unteren Bereich. Alternativ könnte ein Vakuumanschluss auch mittig am Zylinder angeordnet sein.

Für eine möglichst schonende thermische Stofftrennung sollte die Temperatur niedrig gehalten und die Verweilzeit beachtet werden. Tatsächlich führt für viele Substanzen eine um 10 ° C höhere Verdampfungstemperatur auf dieselbe Zersetzungsrate wie eine Verdoppelung der Verweilzeit. Zur Sicherstellung einer ausreichenden Bedeckung der Platten, was bei Stoffgemischen mit schlechten Benetzungsverhalten besonders zu beachten ist, kann daher nicht immer die Maßnahme der Rezirkulation angewendet werden, da deren Nachteile eine langgestreckte Produktverweilzeitverteilung ist. Vielmehr wird in diesem Fall das Stoffgemisch mehrmals über die Verdampferapparatur gepumpt und durchläuft dabei unterschiedliche Abschnitte. Das zulaufende Stoffgemisch (Substanz) wird nur auf einige Verdampferplatten, minimal eine, aufgegeben und das Konzentrat wird unter diesen Platten gesammelt und mit Hilfe einer Pumpe auf andere Verdampferplatten geleitet, wobei dieser Vorgang mehrmals wiederholt werden kann. Bei entsprechender Unterteilung der Destillatauffangwanne können auch verschiedene Destillatfraktionen gewonnen werden.

Eine entsprechende Variante der Erfindung ist lediglich schematisch in dem Diagramm der Fig. 8 gezeigt, wonach innerhalb eines einzigen Gehäuses 1 eine Vielzahl von Verdampfer- und Kondensationsplatten angeordnet ist. Über eine Leitung, die mit dem Pfeil A bezeichnet ist, wird die Substanz, das Stoffgemisch zugeführt und gelangt zunächst entsprechend verteilt von oben zu fünf Verdampferplatten, wird an deren unteren Ende wieder aufgefangen und erneut, weiteren, jedoch anderen Verdampferplatten zugeführt, dort wieder am unteren Ende aufgenommen und letztlich einer einzigen Verdampferplatte von oben zugeführt und als Konzentrat an einer mit dem Pfeil K bezeichneten Leitung entnommen. Die Rückführleitungen sind mit 22 bezeichnet, wobei es dem Fachmann klar ist, dass in der Praxis hier nicht gezeigte Ventile und Pumpen verwendet werden. Eine nicht dargestellte Destillatauffangwanne ist so unterteilt, dass drei Fraktionen von Destillat bezeichnet mit D1, D2 und D3 an entsprechenden Leitungen herausgeführt werden können.

ANSPRÜCHE

1. Platten-Fallfilmverdampfer zur Fallstromverdampfung einer flüssigen Substanz ,

mit zumindest einer, in einem Gehäuse (1) im Wesentlichen vertikal angeordneten, beheizbaren Verdampferplatte (5),

mit einer oberhalb der zumindest einen Verdampferplatte angeordneten Verteilerwanne (8), aus der die darin befindliche Substanz der Verdampferplatte unter Bildung eines an der Außenfläche der Verdampferplatte herabrinnenden Films zuführbar ist,

mit einem der unteren Plattenkante zugeordneten Auffangmittel (9) für das Konzentrat,

mit zumindest einem Anschluss (15, 15o, u) für ein Pumpmittel (16) zum Evakuieren des Gehäuseinnenraumes, sowie

mit einer Kondensationseinrichtung zur anschließenden Kondensation des entstehenden Brüdens,

dadurch gekennzeichnet, dass

die Kondensationseinrichtung als zumindest eine, innerhalb des Gehäuses im Wesentlichen vertikal und parallel zu der zumindest einen Verdampferplatte (5) angeordnete Kondensationsplatte (6) ausgebildet ist, die mittels eines, ihren inneren Hohlraum durchströmenden Kühlfluidums kühlbar ist und der ein Auffangmittel (4) für von der Kondensationsplatte herabrinnendes Destillat zugeordnet ist.

2. Platten-Fallfilmverdampfer nach Anspruch 1, dadurch gekennzeichnet, dass innerhalb des Gehäuses (1) abwechselnd Verdampferplatten (5) und Kondensationsplatten (6) angeordnet sind.

3. Platten-Fallfilmverdampfer nach Anspruch oder 2, dadurch gekennzeichnet, dass die zumindest eine Verdampferplatte (5) und die zumindest eine Kondensationsplatte (6) gleichartig ausgebildet sind.

4. Platten-Fallfilmverdampfer nach einem der Ansprüche 1 bis 3, dadurch gekennzeichnet, dass die zumindest eine Verdampferplatte (5) und/oder die zumindest eine Kondensationsplatte (6) um eine im Wesentlichen vertikale Achse zylindrisch gekrümmt sind.

5. Platten-Fallfilmverdampfer nach einem der Ansprüche 1 bis 4, dadurch gekennzeichnet, dass innerhalb eines gemeinsamen Gehäuses (1) zumindest zwei Kombinationsstufen von Verdampferplatten (5) und Kondensationsplatten (6) angeordnet sind, sowie Mittel (22) vorgesehen sind, um das von der zumindest einen Kondensationsplatte einer ersten Stufe herabgeronnene und aufgefangene Destillat einer Verdampferplatte (5) einer weiteren Stufe zuzuführen.

6. Platten-Fallfilmverdampfer nach einem der Ansprüche 1 bis 5, dadurch gekennzeichnet, dass das Pumpmittel (16) zum Evakuieren des Gehäuseinnenraumes auf einen Innendruck von weniger als 1 mbar ausgebildet ist.

7. Platten-Fallfilmverdampfer nach einem der Ansprüche 1 bis 6, dadurch gekennzeichnet, dass der Abstand zwischen den Oberflächen einander zugeordneter Platten (5, 6) zwischen 5 und 150 mm beträgt.

8. Platten-Fallfilmverdampfer nach einem der Ansprüche 1 bis 7, dadurch gekennzeichnet, dass das Auffangmittel für von der zumindest einen Kondensationsplatte (6) herabrinnendes Destillat der Bodenteil (4) des Gehäuses (1) ist.

9. Platten-Fallfilmverdampfer nach einem der Ansprüche 1 bis 8, dadurch gekennzeichnet, dass Heizmittel für die Auffangrinne (9) und/oder der Bodenteil (4) des Gehäuses (1) vorgesehen sind.

10. Platten-Fallfilmverdampfer nach einem der Ansprüche 1 bis 9, dadurch gekennzeichnet, dass Kühlmittel für zumindest benachbart zu Verdampferplatten (5) gelegene Bereiche der Gehäusewandung (2) vorgesehen sind.

11. Platten-Fallfilmverdampfer nach einem der Ansprüche 1 bis 10, dadurch gekennzeichnet, dass zwischen Verdampferplatten (5) und Kondensationsplatte (6) Tröpfchenabscheider (18) vorgesehen sind.

12. Platten-Fallfilmverdampfer nach einem der Ansprüche 1 bis 11, dadurch gekennzeichnet, dass die Verdampferplatten (5) im Sinne einer von oben nach unten geringer werdenden Temperatur beheizbar sind.

13. Platten-Fallfilmverdampfer nach einem der Ansprüche 1 bis 12, dadurch gekennzeichnet, dass die Verdampferplatte (5) mittels eines ihren inneren Hohlraum durchströmenden Heizfluidums beheizbar ist.

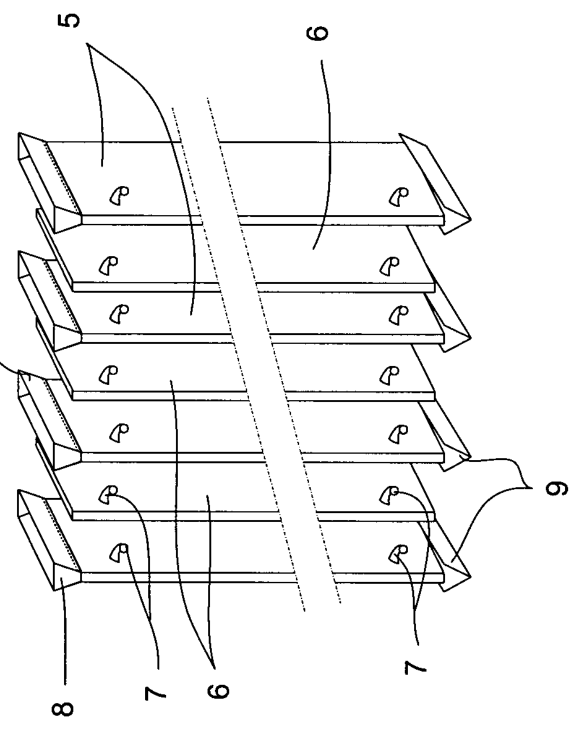

Fig. 2

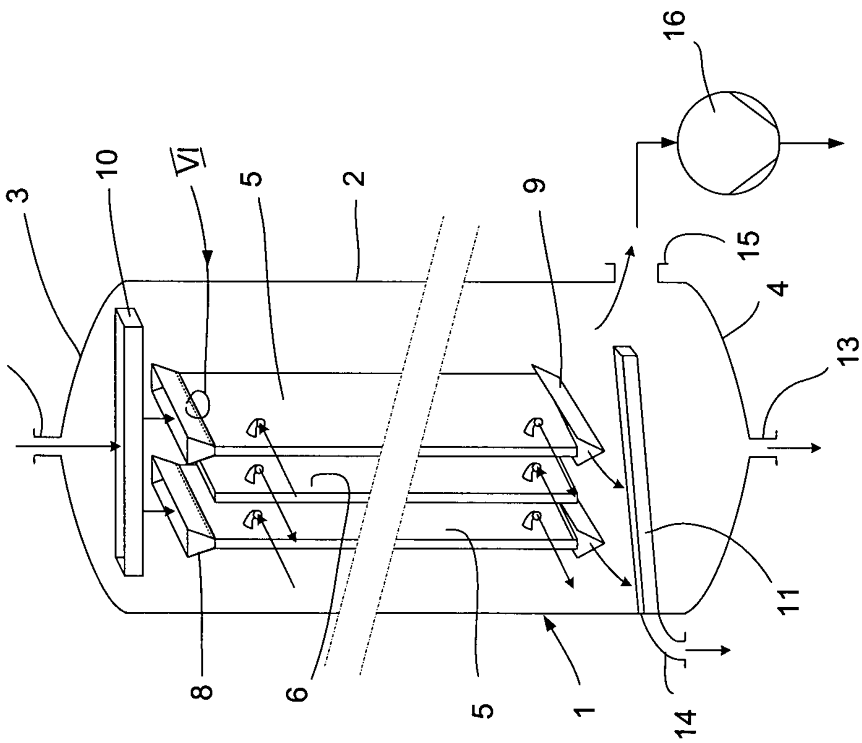

Fig. 1

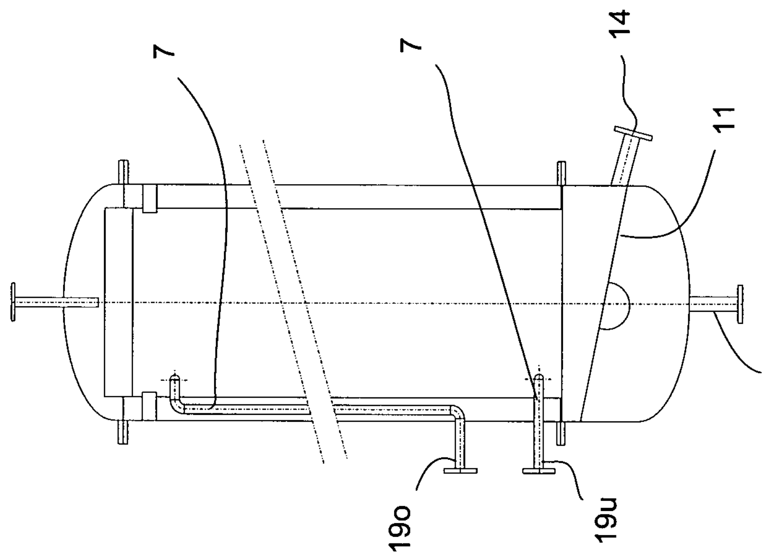

Fig. 4

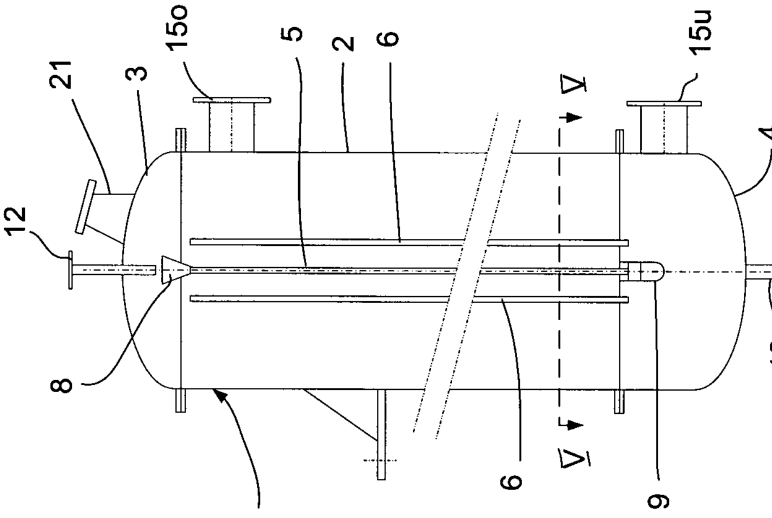

Fig. 3

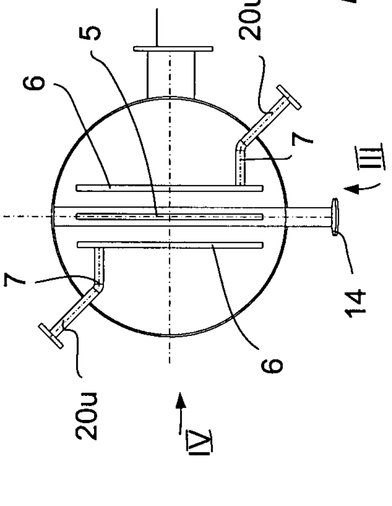

Fig. 5

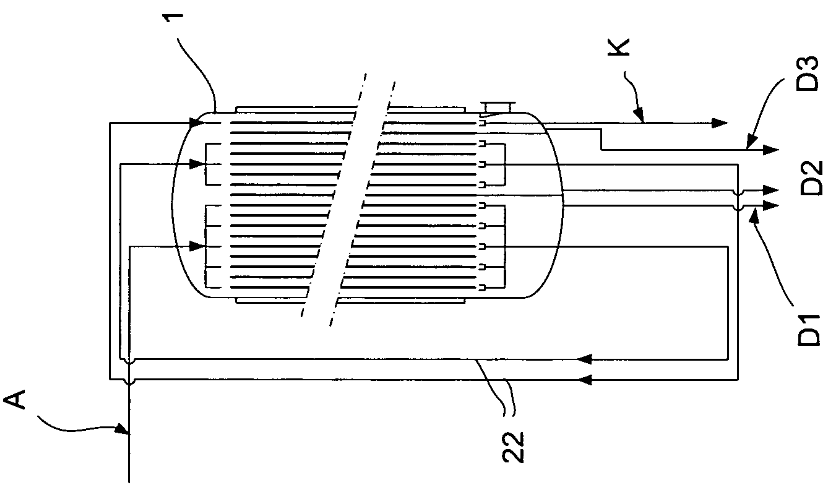

Fig. 8

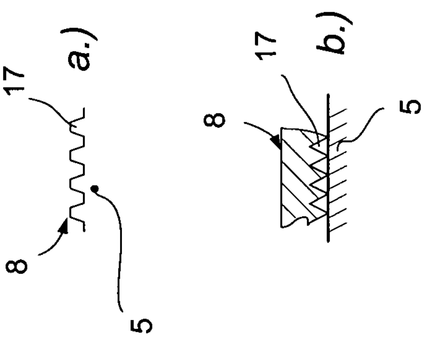

Fig. 6

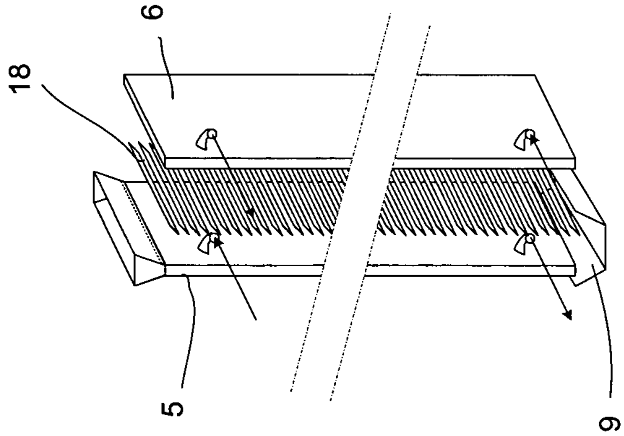

Fig. 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/AT2009/000359

A. CLASSIFICATION OF SUBJECT MATTER
INV. B01D1/06 B01D1/22 B01D1/26 B01D1/30 C02F1/08
B01D3/06 B01D3/12

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)
B01D C02F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 189 610 A (SHELL INT RESEARCH [NL]) 6 August 1986 (1986-08-06) page 5, line 24 - page 6, line 11 page 7, line 16 - line 24 claim 7 figures 1,3 -----	1-13
A	GB 1 015 725 A (VITAMINS LTD) 5 January 1966 (1966-01-05) page 2, line 31 - line 53 figures 1,2 -----	4,13
A	WO 02/05920 A (BITTERLY JACK G [US]; BITTERLY STEVEN E [US]) 24 January 2002 (2002-01-24) page 22, line 12 - line 13 -----	7
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[X] Further documents are listed in the continuation of Box C.

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Date of the actual completion of the international search	Date of mailing of the international search report
16 Februar 2010	24/02/2010

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	García Alonso, Nuria

INTERNATIONAL SEARCH REPORT

International application No
PCT/AT2009/000359

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 90/01977 A (AQUAMAX OY [FI]) 8 March 1990 (1990-03-08) page 5, line 2 - line 11 figure 1	8
A	US 3 843 463 A (BROWN M) 22 October 1974 (1974-10-22) column 9, lines 18-32 - lines 51-64 figures 3,4 column 8, line 47 - column 9, line 17	9
A	US 6 635 150 B1 (LE GOFF PIERRE [FR] ET AL) 21 October 2003 (2003-10-21) column 4, lines 13-21 - lines 30-43 figures 2,3	11

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/AT2009/000359

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INTERNATIONALER RECHERCHENBERICHT

Internationales Aktenzeichen
PCT/AT2009/000359

A. KLASSIFIZIERUNG DES ANMELDUNGSGEGENSTANDES
INV. B01D1/06 B01D1/22 B01D1/26 B01D1/30 C02F1/08
B01D3/06 B01D3/12

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B. RECHERCHIERTE GEBIETE

Recherchierter Mindestprüfstoff (Klassifikationssystem und Klassifikationssymbole)
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Recherchierte, aber nicht zum Mindestprüfstoff gehörende Veröffentlichungen, soweit diese unter die recherchierten Gebiete fallen

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C. ALS WESENTLICH ANGESEHENE UNTERLAGEN

Kategorie*	Bezeichnung der Veröffentlichung, soweit erforderlich unter Angabe der in Betracht kommenden Teile	Betr. Anspruch Nr.
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A	GB 1 015 725 A (VITAMINS LTD) 5. Januar 1966 (1966-01-05) Seite 2, Zeile 31 - Zeile 53 Abbildungen 1,2	4,13
A	WO 02/05920 A (BITTERLY JACK G [US]; BITTERLY STEVEN E [US]) 24. Januar 2002 (2002-01-24) Seite 22, Zeile 12 - Zeile 13	7

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16. Februar 2010	24/02/2010
Name und Postanschrift der Internationalen Recherchenbehörde Europäisches Patentamt, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Bevollmächtigter Bediensteter Garcia Alonso, Nuria

INTERNATIONALER RECHERCHENBERICHT

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C. (Fortsetzung) ALS WESENTLICH ANGESEHENE UNTERLAGEN

Kategorie*	Bezeichnung der Veröffentlichung, soweit erforderlich unter Angabe der in Betracht kommenden Teile	Betr. Anspruch Nr.
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Angaben zu Veröffentlichungen, die zur selben Patentfamilie gehören

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WO 2007/011201 A1

(54) **Title:** SEPARATION APPARATUS AND METHOD

(57) **Abstract:** The invention relates to a separation apparatus for separating a liquid from a solution, in particular fresh water from seawater. The separation apparatus comprises an evaporation space in which operatively an amount of the solution is present from which a liquid vapor evaporates under the influence of heat. The separation apparatus further comprises a condensation space which is in connection with the evaporation space via a condensation tube and which is arranged for condensing liquid vapor. The separation apparatus also comprises a flow -through device for transporting the liquid vapor from the evaporation space to the condensation space, wherein the flow-through device is arranged for intermittently transporting the liquid vapor.

Title: Separation apparatus and method

The invention relates to a separation apparatus for separating a liquid from a solution, in particular fresh water from seawater, comprising an evaporation space in which operatively an amount of the solution is present from which a liquid vapor evaporates under the influence of heat, and a condensation space which is in connection with the evaporation space via a condensation tube and which is arranged for condensing the liquid vapor, further comprising a flow-through device for transporting the liquid vapor from the evaporation space to the condensation space.

Such a separation apparatus is known from Canadian patent publication CA 2 308 805 in which a desalination system is described. In the evaporation space, an amount of seawater is provided from which water vapor is created under the influence of solar energy. Via the condensation tube, the water vapor flows to a separate condensation space where precipitation to fresh water takes place. A flow-through device designed as a vacuum pump ensures that a flow of water vapor is forced from the evaporation space to the condensation space.

With the aid of such desalination systems, fresh water can be obtained from seawater, so that, in areas where seawater and sunlight are, unlike fresh water, widely available, drinking water can still be obtained relatively easily. However, the production of the fresh water is low.

The invention contemplates a separation apparatus of the type mentioned in the introduction, where, while preserving the advantages, the disadvantages mentioned are obviated. In particular, the invention contemplates a separation apparatus where the production of the liquid can be increased. To this end, the flow-through apparatus is designed for intermittently transporting the liquid vapor.

By intermittently transporting the liquid vapor from the evaporation space to the condensation space, in a surprising manner, a higher production of precipitated liquid is obtained. A physical explanation for this phenomenon may be that the condensation process is accelerated if the liquid vapor is at rest for some time and/or that, with a continuously flowing liquid vapor, apart from condensation, a part can evaporate again directly thereupon. With intermittent, so batchwise transport of the liquid vapor, the vapor can settle down after each transport period, so that gas flows, and any associated turbulences, decrease or even completely disappear in the condensation space during the period of rest, resulting in an increase of the desired condensed liquid.

It is noted that American patent publication US 4 518 503 describes a water purification device for batchwise purification of drinking water. Water vapor in an evaporation space is brought to a condensation space via a connection which is not arranged for intermittently transporting liquid vapor.

It is further noted that French patent publication FR 1 097 030 describes a distillation process for removing gases from a liquid. In the system as described in FR '030, there is no connection for transporting liquid vapor from a condensation space to an evaporation space.

Preferably, the flow-through device is arranged for substantially periodically transporting the liquid vapor, so that the control can be implemented relatively simply.

By choosing the period in which transport of the liquid vapor takes place so as to be relatively short, a separation apparatus is obtained where a relatively large amount of liquid vapor can be transported from the evaporation space to the condensation space, while the transported liquid vapor can still stagnate in the condensation space. This further increases the production of liquid.

In an advantageous manner, in the evaporation space, a cloth can be provided of which operatively a part reaches into the amount of solution. It is thus achieved that the amount of solution is soaked into the cloth due to capillary action, so that the surface of the solution which is adjacent to the gas present in the evaporation space increases.

By building up the cloth from a multiple number of strips, of which operatively each has a part which reaches into the amount of solution, the surface of the solution which is operatively adjacent to the gas present in the evaporation space is increased still further, so that the evaporation process, and consequently the production of liquid also accelerates.

It is noted that use of a cloth built up from a multiple number strips, of which operatively each has a part which reaches into the amount of solution, is not limited to the separation apparatus according to claim 1. Thus, the cloth built up from a multiple number of strips can also be used in a salt basin, in which operatively seawater is stored which evaporates under the influence of sun and wind, so that sea salt initially dissolved in the seawater remains behind in the salt basin as a residue. Since the surface seawater which is in contact with sunlight and air artificially increases due to the cloth built up from a multiple number of strips, the evaporation process, and consequently the production of sea salt, will accelerate. Preferably, multiple salt basins connectable to one another are placed in one another's proximity, so that a salt production can be obtained all year round. By using the cloth built up from a multiple number of strips in the salt basins, the salt production can increase and/or the area of salt basins can be reduced. The strips of cloth may, for instance, be suspended from optionally locally supported cables. Preferably, the strips of cloth are designed in black, so that the thermal action of the sunlight is utilized as much as possible. In order to prevent growth of salt crystals on the cloth, the cloth preferably comprises a carton-like material, such as tissue paper, which has a relatively low cost price and can easily be removed from the evaporated salt. In use in a salt basin in which no or relatively little salt growth takes place, other material can also be used for the cloth, such as textile.

The invention further relates to a method for separating a liquid from a solution.

Further advantageous embodiments of the invention are given in the subclaims.

The invention will be explained in more detail on the basis of exemplary embodiments shown in the drawings, in which:

Fig. 1 shows a schematic perspective view of a separation apparatus according to the invention;

Fig. 2 shows a schematic top plan view of the separation apparatus of Fig. 1;

Fig. 3 shows a schematic perspective view of a condensation pipe and closing device; and

Fig. 4 shows a schematic perspective view of a different separation apparatus according to the invention.

The Figures are only schematic representations of preferred embodiments of the invention. In the Figures, same or corresponding parts are designated by the same reference numerals.

Figs. 1 and 2 show a preferred embodiment of a separation apparatus 1 according to the invention. The separation apparatus 1 has an evaporation space 2 and a condensation space 3 which are in connection with each other via a condensation tube 4. The evaporation space 2 is enclosed by a radiation-transmitting construction, designed as a frame 5, in which glass plates 6 are included. Due to the radiation-transmitting construction, which acts as a greenhouse, the temperature in the evaporation space 2 can rise considerably under the influence of sunlight. In the evaporation space 2, a rack 7 is set up from which a multiple number of strips 8 of cloth are suspended.

In use of the separation apparatus 1, an amount of seawater 9 is present in the evaporation space 2, which is a solution of water with *inter alia* minerals and salts. With the aid of the separation apparatus 1, also called desalination system, the water can be separated from the sea salts dissolved therein in a relatively quick manner. The multiple strips 8 of cloth each reach into the seawater, so that the cloth is moistened through capillary action. Due to the relatively high temperature in the evaporation space 2, for instance 90°C, and the relatively large surface of seawater 9 which is in contact with the air in the evaporation space 2, an evaporation process comes into operation in which a water vapor is created. Via the condensation tube 4, the liquid vapor, which hardly contains any salt, flows to the condensation space 3, where the liquid vapor condenses, so that fresh water is obtained. In the evaporation space 2, seawater with a larger concentration of salt remains behind. After evaporation of all water, practically all sea salt which was present in the seawater remains behind as a residue.

The condensation space 3 is designed as a condensation pipe 10 which is preferably white on the outside, so that heating up of the condensation space 3 as a result of directly incident sunlight is minimized. The fresh water which precipitates in the condensation pipe 10 is collected, for instance in a reservoir, or is available with the aid of access means, such as a tap. As Fig. 3 shows, in an advantageous manner, the condensation pipe 10, at an end 20, may be provided with a closing device 21 having an opening 22, for instance designed as a disc with a hole, also called restriction. It is thereby achieved that the water vapor transported to the condensation space 3 cannot leave the condensation pipe 10 easily, but somewhat stagnates, so that the process of condensing is speeded up. Through the opening 22 in the closing device 21, the condensed water can be discharged. By providing the opening 22 eccentrically, adjacent to the lowest point 24 of the edge 23 of the closing device 21, condensed water is prevented from remaining in the condensation pipe 10, which would be undesired for reasons of hygiene. The condensation pipe 10 preferably comprises heat-absorbing material, such as pebbles or stones, so that the temperature in the condensation pipe also stays relatively low during the day. This increases the amount of condensed fresh water in an advantageous manner. The cooled air is fed back to the evaporation space 2. However, it is also possible to supply fresh outside air to the evaporation space 2.

The separation apparatus 1 further comprises a flow-through device, designed as an electric fan 11 acting as a pump which is set up in the condensation tube 4. Preferably, the electric fan is driven by solar and/or wind energy, for instance with the aid of solar cells and/or a wind turbine, so that no external electrical energy is needed for the operation of the separation apparatus 1. The fan 11 transports water vapor from the evaporation space 2 to the condensation space 3. The drive of the fan 11 is such that the liquid vapor is transported intermittently, batchwise, so that an efficient condensation can take place. Here, the fan is switched on and off periodically. In this manner, the fan can transport the liquid vapor relatively briefly, for instance for a period of about 5 seconds, after which an inactive period, for instance a period of about 4 seconds, follows. So, the total cycle takes up about 10 seconds, which may also be shorter, however, for instance about 5 seconds, or longer, for instance about half a minute. Also, the part of the cycle in which the fan is actually driven may vary.

It is noted that the flow-through device may also be implemented as a different module with a pumping action, for instance with the aid of blades. Further, the pump may also derive its action from compression and/or suction utility. Further, the pump may be set up in or near the condensation tube 4, for instance in the evaporation space 2 or in the condensation space 3. In addition, it is also possible to design the flow-through device with different mechanical elements, for instance with the aid of a valve system which enables periodic flow of water vapor from the evaporation space 2 to the condensation space 3 depending on vapor pressures built up.

In an advantageous embodiment, the separation apparatus 1 comprises a partition 13 which is placed between the evaporation space 2 and the condensation space 3. It is thereby achieved that, with wind from particular wind directions, the condensation space 3 is cooled by the air flowing past, while the evaporation space 2 does not lose any extra heat, since the evaporation space 2 is then placed out of the wind. This increases the heat difference between the condensation space 3 and the evaporation space 2, which accelerates the production of fresh water. The construction with the partition 13 is particularly favorable with strong wind and/or when the wind usually blows from a substantially fixed direction, like in the Caribbean. Preferably, the partition comprises glass, so that sunlight can also radiate the evaporation space 2 through the glass of the partition 13. This promotes the direct incidence of light in the evaporation space 2, also when the evaporation space 2 is on the shady side of the partition 13. By designing the glass of the partition 13 so as to be reflective on the side 14 facing the evaporation space 2, it is achieved that the shady side of the evaporation space 2 is also radiated by the sun, albeit indirectly. Here, the direct sunlight is incident on the reflecting glass on the side 14 of the partition 13 facing the evaporation space 2 and can thus still be incident on the evaporation space 2, so that the temperature in the evaporation space 2 can rise still further, while, with a different position of the sun, still incidence of light through the partition 13 to the evaporation space 2 remains possible. Preferably, the side 14 of the partition 13 facing the evaporation space 2 has a curve bending away in the direction of the evaporation space 2, so that the light incident on the partition 13 can be focused towards the evaporation space 2, which increases the heat production still further.

Fig. 4 shows a further preferred embodiment of the separation apparatus 1 according to the invention. The evaporation space 2 has a similar design, with a frame 5, glass plates 6, a rack 7, a multiple number of strips 8 of cloth. In use, in the evaporation space 2, an amount of seawater is present which evaporates as a result of sunlight and is collected in the condensation space 3. The flow-through device is not shown explicitly in the Figure. The embodiment shown in Fig. 4 comprises no partition and is particularly suitable for desertlike areas where ambient temperatures run high and where usually no appreciable wind can be found. The condensation space 3 comprises a cooling device included in a separate chamber 15. The chamber comprises, for instance, an above-described condensation pipe and/or heat-absorbing material, in order to obtain a lowest possible temperature. The condensation space 3 further extends via a connecting tube 4 into a tube system 16 in the evaporation space 2. The tube system 16 comprises a number of horizontal tubes 16a, 16c connected with each other via tubes 16b oriented transversely thereto. Further, the tube system 16 comprises a number of upstanding tubes 16d which take in the water vapor via an open end 16e. Each upper part of the upstanding tubes 16d thus forms, with the respective open ends 16e, a condensation tube 17 through which the water vapor can be transported from the evaporation space 2 to the condensation space 3. Thus, the condensation space 3 comprises the cooling device in the chamber 15, the connecting tube 4 and the interior space of the lower part of the tube system 16. In an advantageous manner, the lower part of the tube system 16 may be wrapped with cloth of which a part reaches into the amount of seawater, so that the water vapor in the tube system 16 is already cooled with the seawater before the water vapor is fed to the separate chamber 15. Thereby a better cooling can be obtained and/or the heat capacity of the material in the chamber 15 is used less. The cooled air leaves the separate chamber 15 via a second connecting tube 19 which, via an inlet tube 18, opens into the interior of the evaporation space 2, where the air can be saturated again with evaporated seawater. Of course, the tube system 16 can also be designed in different manners. As appears from the exemplary embodiments described in the application, the condensation space 3 may be located both outside the evaporation space, for instance with the aid of a separate apparatus, and inside the evaporation space, for instance with the aid of a tube system.

The invention is not limited to the exemplary embodiments described herein. Many variants are possible.

Thus, the evaporation space may comprise a layer of radiation-absorbing material, for instance designed in black, which surrounds at least a part of the strips of cloth. It is thereby achieved that, after sunset, temperature differences arise in the evaporation space which generate a natural air flow. The air flow makes it possible that, for some time, water vapor can successfully be discharged through the condensation tube, so that the production process of fresh water does not end abruptly after sunset, but decreases gradually, resulting in a higher total production of water per twenty-four hours.

Also, instead of a setup in which the multiple number of strips of cloth are arranged substantially next to one another, other setups can be chosen as well, for instance a setup where the cloth has at least a part of a pyramid shape of which the base reaches into the amount of seawater during use of the separation system. It is thereby achieved that, in the case of a pyramid shape with a substantially square base, at least three inclined faces of the pyramid can be radiated directly by sunlight, which will promote the evaporation process and consequently the production of fresh water.

It is further noted that such a separation apparatus cannot only be used for separating fresh water from seawater, but more generally for separating a liquid from a solution, for instance water from a solution with pollutants, or heavy metals.

Such variants will be clear to a skilled person and are understood to be within the scope of the invention as set forth in the following claims.

CLAIMS

1. Separation apparatus for separating a liquid from a solution, in particular fresh water from seawater, comprising an evaporation space in which operatively an amount of the solution is present from which a liquid vapor evaporates under the influence of heat, and a condensation space which is in connection with the evaporation space via a condensation tube and which is arranged for condensing liquid vapor, further comprising a flow-through device for transporting the liquid vapor from the evaporation space to the condensation space, wherein the flow-through device is arranged for intermittently transporting the liquid vapor.

2. A separation apparatus according to claim 1, wherein the flow-through device is arranged for substantially periodically transporting the liquid vapor.

3. A separation apparatus according to claim 1 or 2, wherein the period within which transport of the liquid vapor takes place is relatively short.

4. A separation apparatus according to any one of the preceding claims, wherein, in the evaporation space, a cloth is provided of which operatively a part reaches into the amount of solution.

5. A separation apparatus according to any one of the preceding claims, wherein the cloth is built up from a multiple number of strips of which operatively each has a part reaching into the amount of solution.

6. A separation apparatus according to any one of the preceding claims, wherein the cloth at least partly has a pyramid shape of which the base operatively reaches into the amount of solution.

7. A separation apparatus according to any one of the preceding claims, wherein the evaporation space further comprises a layer of radiation-absorbing material which surrounds at least a part of the cloth.

8. A separation apparatus according to any one of the preceding claims, wherein the evaporation space is enclosed by a radiation-transmitting construction.

9. A separation apparatus according to any one of the preceding claims, further comprising a partition placed between the evaporation space and the condensation space.

10. A separation apparatus according to any one of the preceding claims, wherein the partition comprises glass.

11. A separation apparatus according to any one of the preceding claims, wherein the glass of the partition is reflective on the side facing the evaporation space.

12. A separation apparatus according to any one of the preceding claims, wherein the side of the partition facing the evaporation space has a curve bending away in the direction of the evaporation space.

13. A separation apparatus according to any one of the preceding claims, wherein the flow-through device comprises a pump.

14. A separation apparatus according to any one of the preceding claims, wherein the condensation space comprises heat-absorbing material.

15. A method for separating a liquid from a solution, in particular fresh water from seawater, comprising evaporating a liquid vapor from an amount of solution in an evaporation space under the influence of heat, wherein the liquid vapor is transported from the evaporation space via a flow-through device to the condensation space, further comprising condensing the liquid vapor in a condensation space, wherein the transporting of the liquid vapor takes place intermittently.

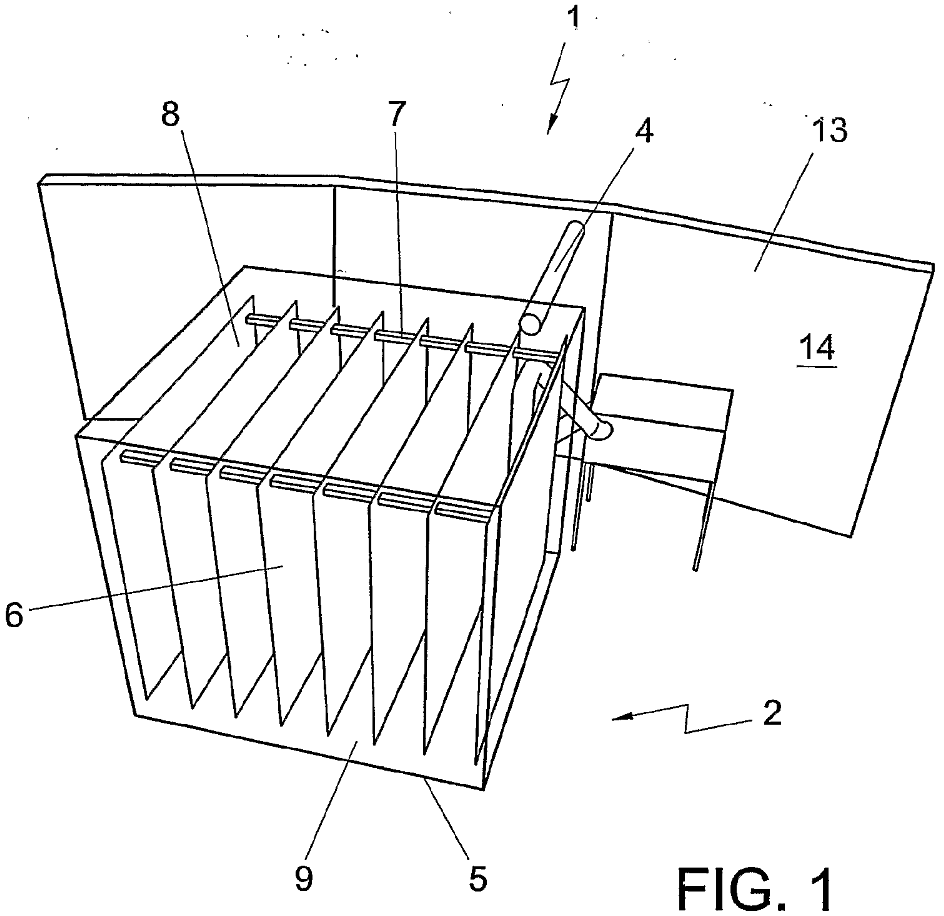

FIG. 1

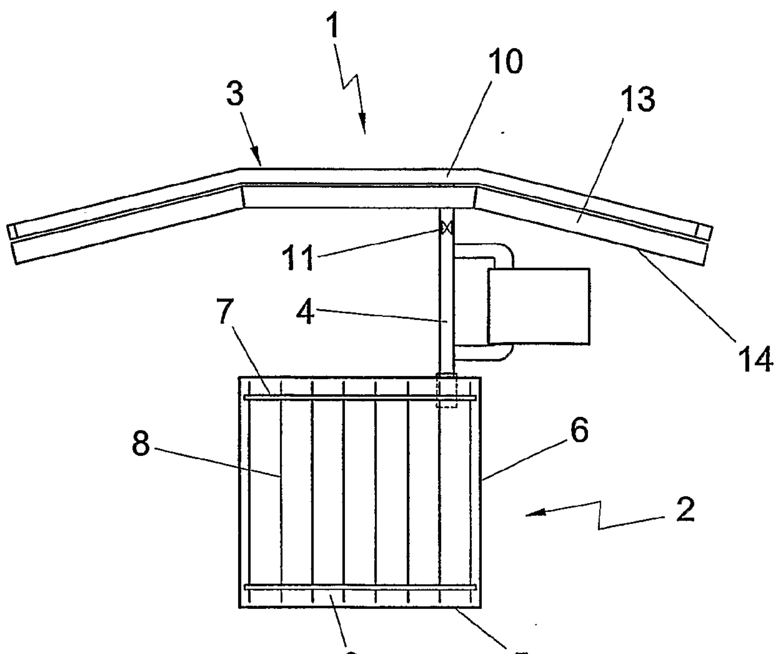

FIG. 2

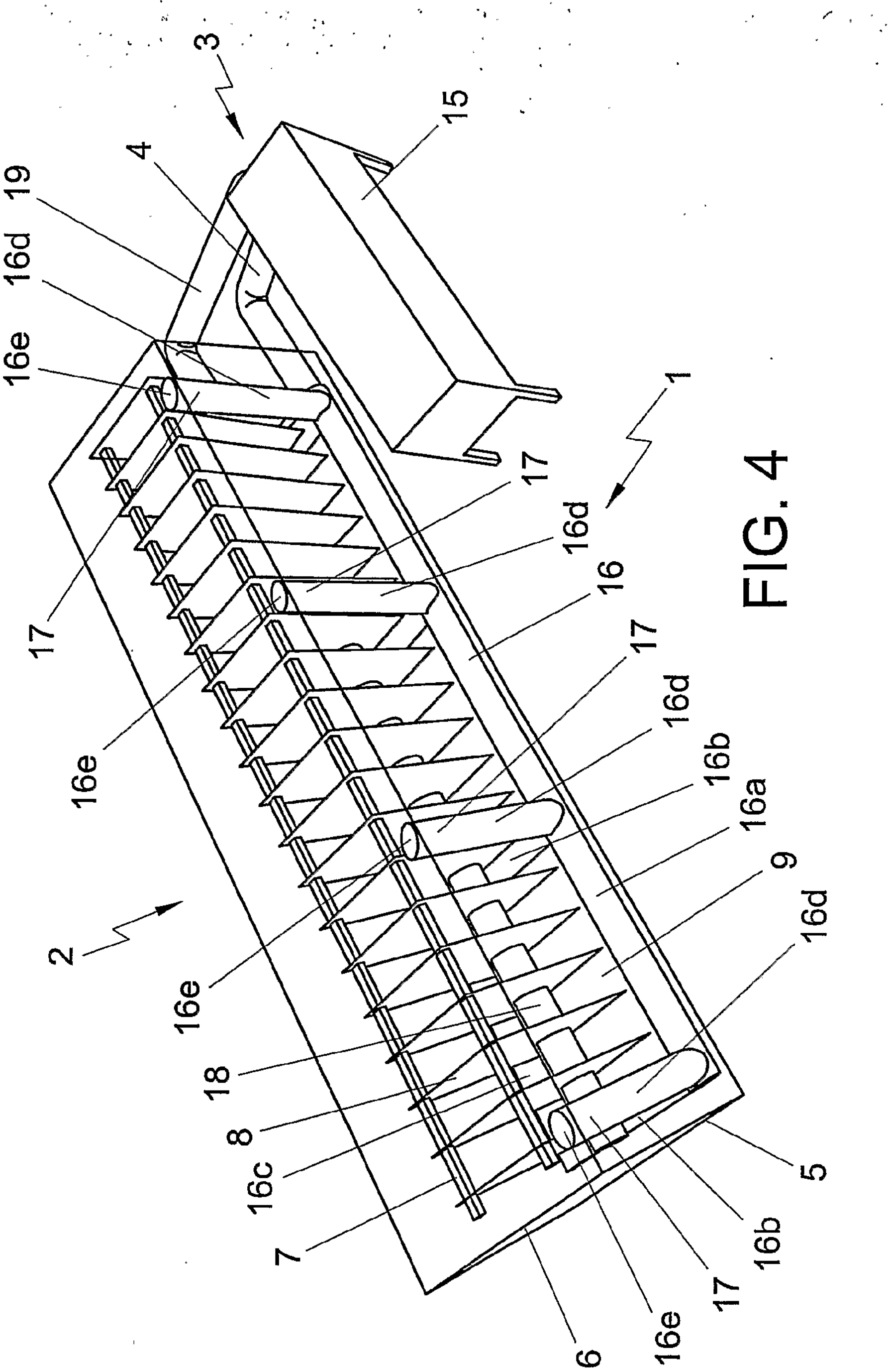
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FIG. 4

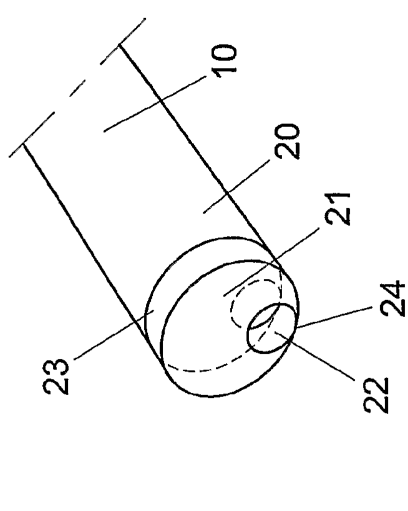
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FIG. 3

INTERNATIONAL SEARCH REPORT

'NL2005/000515

A. CLASSIFICATION OF SUBJECT MATTER

C02F1/14 B01D1/00

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)

C02F B01D B01B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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X	US 4 518 503 A (FERMAGLICH ET AL) 21 May 1985 (1985-05-21) cited in the application column 8, lines 58-65; figures 1,2 -----	1,15
X	US 4 172 767 A (SEAR, WALTER E) 30 October 1979 (1979-10-30) column 4, lines 38-49; claims 1-4; figures 1,3 -----	1
X	US 3 257 291 A (GERBER HEINZ JOSEPH) 21 June 1966 (1966-06-21) column 6, lines 32-46; figures 1,8,9 ----- -/--	1

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 January 2006	27/01/2006

Name and mailing address of the ISA	Authorized officer
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INTERNATIONAL SEARCH REPORT

/NL2005/000515

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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INTERNATIONAL SEARCH REPORT

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NL2005/000515

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(60) **Références à d'autres documents nationaux apparentés :**

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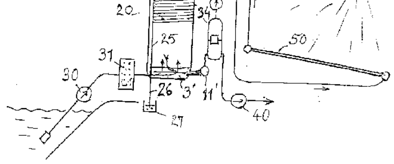
(72) **Inventeur(s) :** COSTES DIDIER.

(73) **Titulaire(s) :**

(74) **Mandataire(s) :**

(54) DISTILLATEUR D'EAU SALEE A PLAQUES CONTINUES ET ETAGES DE PRESSION.

(57) Ce distillateur fonctionne notamment par l'énergie solaire, à un niveau de chauffage de l'ordre de 65. Il comporte des plaques alvéolaires (1) en matière plastique placées verticalement et dans les canaux desquels monte de l'eau salée initialement froide, qui se trouve chauffée du fait de la condensation de vapeur sur les parois, et entre ces plaques, avec un faible écart, des tissus (2) sur lesquels s'écoule de l'eau salée, provenant des plaques et d'un chauffage supplémentaire, et qui donne lieu à évaporation. Sur la hauteur sont intercalées par exemple une cinquantaine de réglettes 20 à faible pente qui maintiennent les écarts et qui, dotées d'une lamelle supérieure 21, collectent l'eau condensée sur les plaques et l'acheminent vers un conduit latéral 25 aboutissant au réservoir de réception de l'eau douce Les réglettes comportent une couche perméable appliquée contre les tissus et qui permet l'écoulement de l'eau salée malgré la pression d'appui. En bas, l'excès d'eau salée est extrait par une pompe 40, en même temps que l'air initialement dissous dans l'eau salée ou provenant de fuites. La température décroissant vers le bas, ainsi que la pression de vapeur, on obtient dans les étages une distillation fractionnée à haut rendement avec une fabrication très simple et économique, détaillée par le brevet. Le distillateur est associé à des panneaux solaires économiques utilisant des plaques alvéolaires, décrits par une autre invention de l'auteur, ou à d'autres sources de chaleur, normalement perdues



FR 2 853 895 - A1

1. Préambule.

Pour fournir l'eau potable dans des régions arides chaudes, on propose un distillateur d'eau salée associé à des panneaux solaires, de construction économique. Le distillateur pourrait être utilisé, au dessous de 100°, en récupération de puissances thermiques autrement perdues.

Les distillateurs sont caractérisés par le rendement brut de distillation, rapport de la chaleur de vaporisation de l'eau douce produite, soit environ 0,7 kWh/kg, à la chaleur fournie. Des panneaux solaires plans, inclinés dans la direction favorable, donnent en région aride environ 5 kWh par jour et mètre carré, jusqu'à une température de 70° environ. Les distillateurs les plus simples, à vitre inclinée au dessus d'un bac d'eau salée, produisent environ 1 litre d'eau douce par jour et mètre carré, avec un rendement de l'ordre de 0,14. Dans des distillateurs plus élaborés, de l'eau chaude se refroidit avec évaporation et la vapeur diffuse vers une surface de condensation, refroidie par un circuit d'eau salée, ainsi préchauffée avant chauffage supplémentaire et passage à l'évaporateur. Le flux de vapeur étant d'autant plus intense que la pression partielle d'air est plus basse, on fait se succéder de nombreux étages dégazés, à pressions décroissantes avec la température. En utilisant des combustibles fossiles, la température atteint 130° environ et le rendement 20. Dans chaque étage, il ne semble pas qu'on ait visé un échange à contre-courants permettant l'homogénéisation des différences de température, pour un rendement maximal. Les étages sont constitués de récipients métalliques avec des collecteurs internes et sont reliés par des canalisations.

L'auteur a déjà proposé des distillateurs à pression atmosphérique comportant en alternance des surfaces verticales d'évaporation et de condensation, dont le faible écart doit permettre d'une part une diffusion de vapeur aussi intense que possible, d'autre part l'établissement d'un régime de température proche du contre-courant parfait. Ceci permettrait l'utilisation de matériaux à bas prix (tissus pour l'évaporation et plaques alvéolaires en polypropylène pour la condensation) compensant économiquement la faible diffusion de la vapeur en présence d'air. Ces distillateurs simples pourraient surtout être intéressants pour des petites installations. Les cales entre les surfaces ont été prévues verticales. Elles ne doivent pas donner lieu à des mélanges entre les écoulements très proches de l'eau salée et de l'eau douce coulant en gouttes d'une épaisseur de l'ordre de 2 mm sur les plaques de polypropylène.

On vise ici à conserver une réalisation simple et des matériaux à bas prix mais en organisant, sur la hauteur des plaques et tissus, des étages multiples de pression pour intensifier les échanges et la production d'eau douce, sans nécessiter de collecteurs entre les étages. Le distillateur pourra fonctionner sans appliquer de différences de pression, mais avec un rendement moindre.

2. Invention.

Selon la présente invention, considérant un distillateur à surfaces verticales rapprochées, alternativement des tissus d'évaporation (2) et des plaques de condensation (1), on crée des étages de pression multiples en intercalant, dans la hauteur, des réglettes (20) à faible pente qui :

- par leur résistance en compression, permettent l'appui mutuel des surfaces et le maintien de leurs écarts, malgré l'application de la pression atmosphérique extérieure (multipliée sur l'appui par le rapport de la surface totale à la surface des réglettes),

- collées contre les plaques de condensation avec une légère pente et munies d'une lèvre supérieure de séparation (21), collectent vers un bord l'eau douce condensée sur l'étage supérieur,

- appuyées contre le tissu d'évaporation en intercalant un grillage fin (22), permettent malgré la pression d'appui l'écoulement de l'eau salée, qui s'effectue avec une pression motrice relativement forte entre deux étages et entraîne de l'air résiduel.

A titre d'ordre de grandeur, les écarts entre plaques seraient de l'ordre de 3 à 4 mm et les réglettes, d'une hauteur d'appui de 6mm, seraient disposées tous les 40 mm, sur des hauteurs totales de l'ordre de 2m, donc avec un nombre d'étages de 50 procurant un excellent rendement. Les plaques de condensation (1) en polypropylène doivent, contre les réglettes, supporter la pression d'écrasement.

3. Description.

La description s'appuie sur les Figures suivantes :

Fig 1. Coupe à échelle amplifiée, avec collecteurs en parties supérieure et inférieure,

Fig 2. Coupe à échelle amplifiée sur une bande de rive,

Fig 3. Elévation pour la partie supérieure,

Fig 4. Schéma d'installation avec distillateur et panneau solaire,

Fig 5. Coupe d'un panneau solaire,

Fig 6. Graphique du flux thermique calculé dans un étage selon les températures et le dégazage.

Les plaques alvéolaires de polypropylène extrudé 1 et 1' sont disposées verticalement, leurs canaux parcourus par de l'eau salée introduite "froide" en bas et chauffée par la condensation de la vapeur sur les parois externes, avant de recevoir un supplément extérieur de chauffage. Ces plaques alternent avec des rectangles 2 en tissu perméable sur lesquels s'écoule l'eau salée "chaude" introduite en haut et s'évaporant en partie dans la descente. L'ensemble parallélépipédique sera dénommé "paquet".

Selon les Figures 1à 3, la collecte en haut et en bas des plaques 1 s'effectue dans des boites à eau 3 et 3' coiffant l'ensemble du paquet de plaques par leurs jupes 4 et 4'. Ces boites sont réalisée en une matière relativement souple telle qu'un caoutchouc armé, avec un fond relativement épais ou renforcé d'une tôle pour supporter la pression extérieure mais des jupes plus minces, qui enveloppent le pourtour supérieur du paquet de plaques. Ceci permet de s'accommoder de faibles variations de l'épaisseur globale du paquet, soumis à des différences variables de pression.

Les rectangles 2 en tissu sont tendus verticalement entre leurs collecteurs 6 en haut et 6' en bas, constitués chacun d'une feuille 8, 8' en toile étanche soudable, repliée en U sur le bord de tissu et cousue. Les serrages des coutures 7, 7' permettent en haut un certain rapport pression-débit, et en bas une aspiration efficace de l'eau salée résiduelle dite saumure, accompagnée d'air résiduel. Le collecteur 6' en bas, en dépression par rapport à l'étage qui le surmonte, est maintenu en forme par une inclusion rigide, par exemple une barre 9 en plaque alvéolaire dont les âmes ont été percées de trous.

Les collecteurs 6, 6' se terminent à une extrémité latérale par des connexions étanches à des tubes souples tels que 10, 10' qui aboutissent, après un court trajet destiné à permettre les débattements dus aux variations de pression, à des collecteurs généraux 11 en haut et 11' en bas qui sont des tubes à trous, à faibles pertes de charge.

Ces rectangles 2 sont tendus horizontalement vers les bords verticaux du paquet par serrage collé entre des règles de rive 11 et 11'. Le tissu est retourné en extrémité sur un mince jonc 12 en butée contre ces règles qui portent des reliefs externes d'appui contre les bords des plaques.

Pour empêcher le glissement vers le bas des collecteurs 6, ceux-ci contiennent des joncs 15 de section rectangulaire qui, mis en travers, s'appuient sur des plaques 16, 16' collées de part et d'autre du sommet des plaques 1 et sur lesquelles s'appuient les collecteurs 6. En leurs extrémités, ces plaques constituent des butées aux règles de rive 11, 11' et contribuent à recevoir l'appui des boites à eau 3,3'. Un échange thermique entre les collecteurs et les plaques étant défavorable, celles-ci doivent être relativement isolantes. On utilise une matière plastique suffisamment résistante, par exemple en polypropylène plein, la perte thermique étant alors admissible. Sur les bords du paquet, du côté des tubes 10, 10' traversants en bout des collecteurs 6, 6', les plaques 16, 16' portent des creux destinés à ne pas écraser ces tubes, et des plaquettes supplémentaires collées pour boucher l'orifice subsistant. De l'autre côté, l'orifice entre ces plaques est bouché par des plaquettes collées 18.

Chaque réglette quasi-horizontale entre étages, notée 20, est constituée :

- d'une lanière 20, en matériau relativement isolant, par exemple une mousse dense plastique,
- d'une lamelle mince 21 en matière plastique débordant vers le haut pour constituer au dessus de la lanière un canal d'écoulement de l'eau condensée,
- d'une lamelle mince en grillage de plastique 22 pour permettre l'écoulement de l'eau et d'une certaine quantité d'air, malgré la compression des réglettes sur le tissu. La maille de grillage est choisie pour assurer une perte de charge répartissant convenablement les pressions sur l'ensemble des étages

Les réglettes sont collées sur les plaques 1, 1' avec une légère pente, pour que s'écoule vers un côté l'eau douce collectée. De ce côté, contre les règles de rive 11, 11', se trouvent des tubes 25 de descente avec des orifices de petit diamètre en face des réglettes. Ces tubes sont notamment constitués par découpe dans une plaque alvéolaire. Ils aboutissent en bas de manière étanche à des tubes 26 descendant sous le distillateur sur une hauteur suffisante pour que les récipients 27 de réception de l'eau douce puissent être ouverts à la pression atmosphérique.

L'eau salée est prélevée par exemple en mer par une pompe 30 et, par l'intermédiaire d'un filtre 31, est injectée dans la boite à eau 3' pour circuler de bas en haut dans les plaques. Elle aboutit dans la boite 3 puis passe dans les plaques 50 du panneau solaire avant de revenir au collecteur haut 11 et de s'écouler sur les tissus. Elle est alors reprise par les collecteurs 6' et le collecteur général 11' sous l'effet de l'aspiration par la pompe 40.

La pompe 40 extrait à la fois l'eau salée ("saumure") arrivant en bas des tissus 2 et de l'air qui était dissous dans l'eau d'entrée ou provient de fuites. La pression totale dans les étages entre les réglettes 20 diminue ainsi vers le bas comme la pression de vapeur, à mesure que l'eau salée se refroidit. La saumure et l'air extraits passent dans un vase de décantation 34 où s'établit un niveau libre d'eau sous une atmosphère d'air à faible pression, puis à la pompe à eau 40. Un flotteur dans le vase met en action une pompe d'extraction d'air 36 ou un éjecteur à pression d'eau pour maintenir le niveau entre deux limites.

Sur les deux parois du paquet correspondant aux règles de rive 11, 11' sont étendues des feuilles étanches souples telles que 38 pour parfaire l'étanchéité. La pression atmosphérique cause sur le paquet de plaques une compression mécanique générale, supportée en hauteur et en largeur par les plaques alvéolaires et en épaisseur par les réglettes entre étages et les zones correspondantes en écrasement dans les plaques. Les plaques alvéolaire doivent présenter une résistance suffisante.

Selon un brevet précédent de l'auteur, les panneaux solaires sont en plaques alvéolaires noires 50 avec des collecteurs en toile souple dont le diamètre peut être suffisant pour des panneaux de grande largeur. Les plaques sont posées sur des banquettes en sol sableux convenablement inclinées, et isolées vers le haut par une couche d'air 51 sous une feuille transparente 52 posée sur cales et grillages, et lestée.

Un échelon de distillation, avec son distillateur et ses panneaux solaires, fournissant de l'eau douce et une eau salée plus concentrée, peut fonctionner isolément mais la production d'eau douce est alors limitée à une faible fraction du débit d'eau salée, par exemple 1/15 pour une évolution sur 40°. Pour limiter le débit prélevé en mer, on peut conduire la saumure sortant de la pompe 40 vers d'autres échelons de distillation ou encore mélanger à l'eau d'appoint une partie de la saumure, alors avec une certaine perte thermodynamique. L'eau salée très concentrée peut être envoyée à un marais salant. Pour faciliter le dégazage, on peut distiller sur un intervalle de température plus faible, admettant ainsi une température de sortie plus élevée, mais alors, pour limiter la chaleur demandée aux panneaux solaires, on préchauffe la première eau entrante dans un échangeur à contre-courants, à partir de la dernière eau sortante. Cet échangeur peut être construit en utilisant des plaques alvéolaires.

4. Calculs.

Dans l'échange horizontal de chaleur, la chute de température entre eau descendante dans le tissu et eau montante dans les canaux est la somme de trois termes:

- environ 1° pour la différence entre eau de mer et eau douce de la pression de vapeur saturante (pression osmotique) selon la température, terme qui s'accroît si la salinité augmente, dans le cas de plusieurs échelons.

- la chute par conduction dans les couches d'eau et dans la paroi de condensation, proportionnelle au flux thermique et calculée en fonction des épaisseurs et des conductions,

- la chute en diffusion air plus vapeur, en situation laminaire du fait de la faible épaisseur, avec proportionnalité au flux thermique, et calculée en fonction de l'écart entre les surfaces d'échange et des pressions partielles de vapeur et d'air, par des formules connues (Fick, Schirmer).

La somme des débits descendants d'eau salée et d'eau douce est égale au débit montant d'eau. Le rendement brut de distillation est égal à la variation de température sur la hauteur, divisée par la chute de température horizontale. Le rendement global tiendra compte des énergies consommées pour les pompages d'eau et pour les auxiliaires.

Un programme de calcul fournit le flux thermique dans un étage à contre-courants d'épaisseur "a" pour les températures aux parois ("ta" et "tb" sur tissu en haut et en bas de l'étage, différence "dt" entre les eaux descendante et montante) et la pression totale en air plus vapeur, exprimée comme une pression de vapeur pour une température "ts" de saturation plus élevée. La valeur ts-ta est ainsi un repère de dégazage.

On constate que les flux thermiques varient peu selon le niveau de température, dans une plage 30°-70° par exemple, mais surtout comme les différences de température, ce qui permet de calculer le distillateur pour un seul étage type, avec la condition d'assurer sur la hauteur le dégazage ainsi fixé. La chute de température par diffusion est réduite par de faibles valeurs de l'écart "a" entre tissu et plaque (léger avantage pour a=3mm, par rapport à a=4mm), de faibles valeurs de ta-tb donc des étages nombreux, et de faibles valeurs pour ts-ta . Pour l'écart a= 3,5 mm, une température de référence ta=50°, et dt=4° (3° pour conduction et diffusion, les flux variant comme dt-1), la Figure 7 donne les flux calculés en fonction de ts-ta et de ta-tb.

Sur la Figure 7 est marqué un point correspondant à ts-ta= 10° et ta-tb=2°, donnant un flux de 1086 W/m² condensant 0,45 g/sm² .

Les calculs ont également concerné les pertes de charge apparaissant dans les circuits d'eau, notamment pour la prise d'eau en mer et pour relever les hauteurs de ruissellement dans le distillateur. Le débit de prise d'eau est réduit par le recyclage partiel évoqué. On estime que l'énergie de pompage et de dégazage sera de 0,5 à 1 kWh par m3 d'eau douce produite.

5. Performances.

On se donne par exemple une variation de température de 40°, pour l'eau salée chauffée de 20° à 60° dans le condenseur, puis portée à 64° dans les panneaux solaires. Le rendement de distillation est alors de 40/4=10. Le distillateur prévu comporte en alternance des tissus d'épaisseur 1 mm et des plaques d'épaisseur 2 mm, séparés par des espaces de 3,5 mm, ce qui donne 2 surfaces d'échange pour 10 mm, ou 200 m² par m3. Pour le flux supposé de 1086 W/m² on obtient donc 90 g/s par m3. Supposant une insolation efficace de 8 heures par jour ou 28800 secondes, ceci correspond à environ 2500 kg d'eau par jour et par m3. La chaleur solaire utilisée est 0,7 x 2500 /10 = 175 kWh par jour ce qui correspond à 35 m² de panneaux solaires pour le distillateur de 1 m3. Pour cette production de 2500 kg par jour, on utilise donc 135 m² de plaque alvéolaire d'une masse de l'ordre de 0,45 kg/m² soit 61 kg. Approximativement, avec les autres éléments, les matériaux représentent environ 150 kg de matière plastique usuelle.

Dans un tel appareil, la production d'eau est proportionnelle au produit de la surface de captage et de la surface des plaques d'échange dans le distillateur. Pour des prix donnés au mètre carré de captage et de distillation, l'optimum économique est obtenu en égalant les prix des deux fonctions. Il paraît clair que vis-à-vis de l'exemple choisi, avec 100 m² de plaques d'échange plus les tissus, et 35 m² de panneaux solaires dont la construction est très simple, on aura avantage à augmenter relativement la surface des panneaux en diminuant le rendement. L'intérêt d'un stockage d'eau chaude pour le fonctionnement nocturne du distillateur sera évalué.

Des évaluations sur les prix des matériaux utilisés et sur la mise en œuvre, artisanale ou industrielle, montrent que l'investissement peut être inférieur à ceux usuellement consentis pour la production d'eau douce. L'énergie mécanique requise est inférieure à celle des autres procédés, qui requièrent en général plus de 3 kWh/m3, et l'énergie solaire est gratuite.

Revendications

1. Distillateur d'eau salée comportant un ensemble de surfaces rectangulaires verticales parallèles, constituées en alternance de tissus (2) sur lesquels descend de l'eau salée fournie chaude en haut, et de plaques dites alvéolaires (1) intégrant des conduits verticaux dans lesquels monte de l'eau salée introduite froide en bas et, reprise en haut, recevant un supplément de chaleur avant d'être acheminée au sommet des tissus, les espaces intermédiaires donnant ainsi lieu à un transfert de vapeur et à une condensation d'eau douce sur les plaques alvéolaires, caractérisé en ce que ces espaces, latéralement fermés par des bordures verticales, contiennent des réglettes (20) à faible pente collées contre les plaques alvéolaires et dont le relief supérieur constitue un canal d'écoulement de l'eau condensée vers au moins une des bordures.

2. Distillateur selon la revendication 1, caractérisé en ce que les réglettes (20) sont appuyées contre les tissus (2) par l'intermédiaire d'une couche (22) comportant des passages verticaux.

3. Distillateur selon l'une des revendications précédentes, caractérisé en ce que les tissus (2) pénètrent dans les collecteurs horizontaux d'eau salée en haut (6) et en bas (6') formés d'une toile étanche soudable repliée et cousue de manière lâche sur les tissus, le collecteur bas soumis à aspiration étant garni intérieurement d'une structure (9) de maintien contre l'écrasement et chaque collecteur étant raccordé à un collecteur général, d'alimentation (34) en haut ou d'évacuation (33) en bas.

4. Distillateur selon l'une des revendications précédentes, caractérisé en ce que les plaques (1) aboutissent en haut et en bas à des boites à eau.

5. Distillateur selon l'une des revendications précédentes, caractérisé en ce que les mouvements d'eau sont induits par au moins une pompe (50) placée en aspiration sur les collecteurs bas des tissus et collectent ainsi à la fois de l'air et de l'eau, créant dans les étages entre les réglettes (20) une pression décroissant vers le bas en fonction des températures.

Fig 1

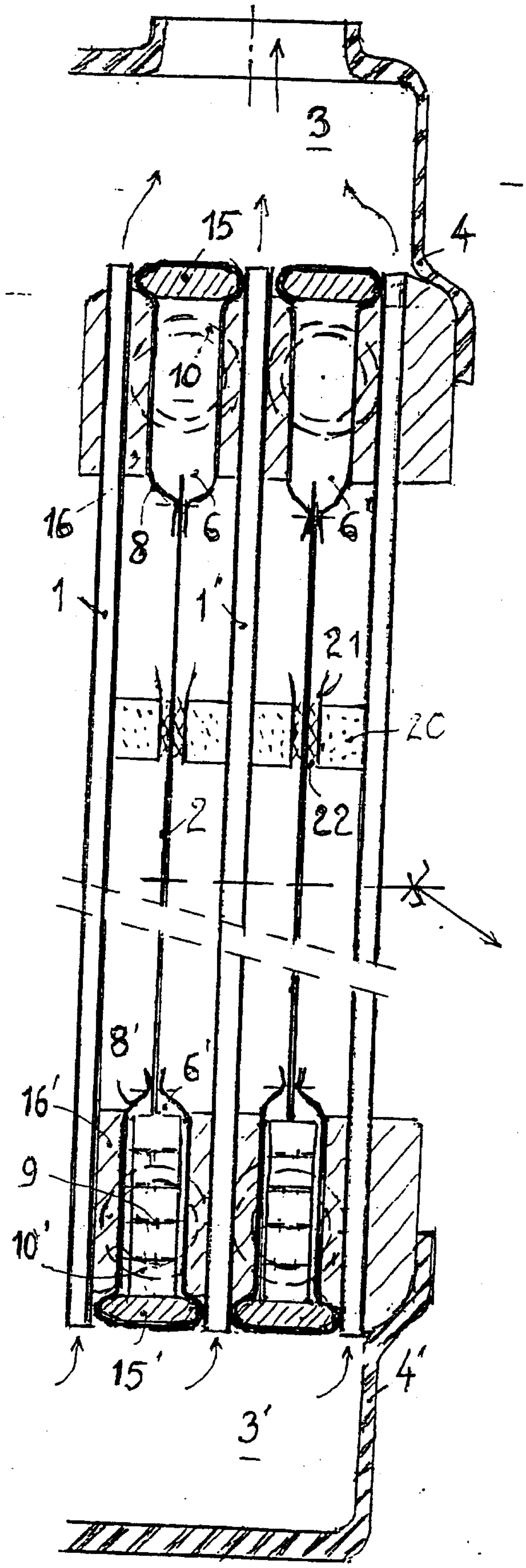


Fig 3

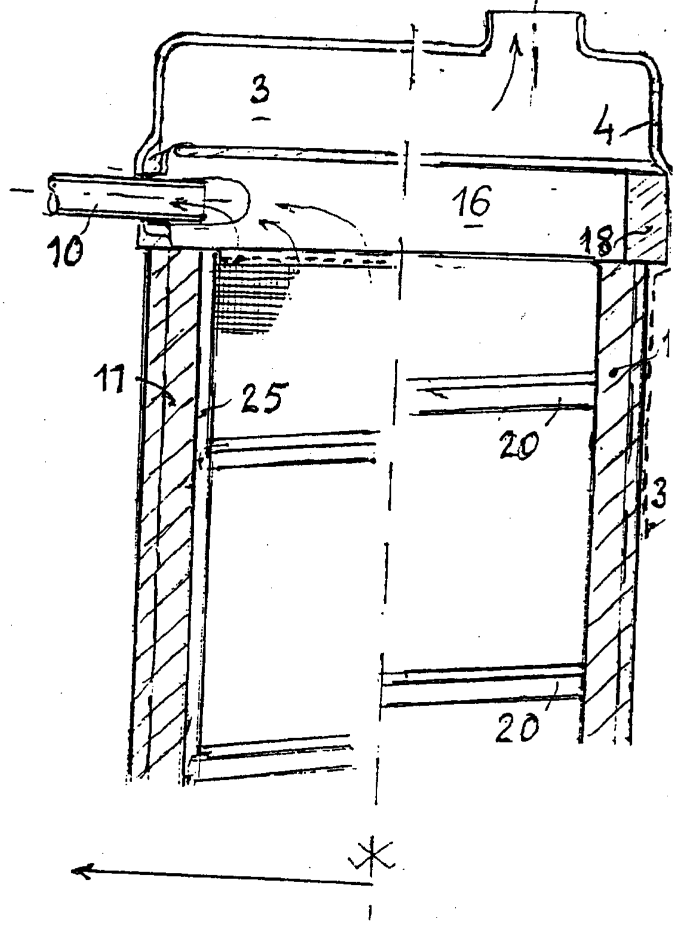


Fig 2

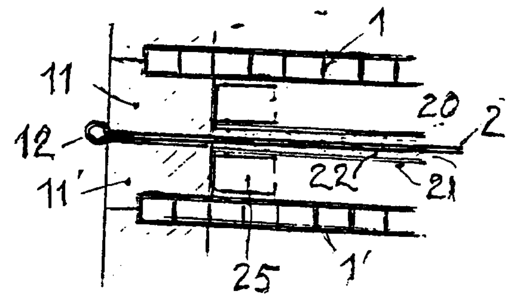


Fig 4

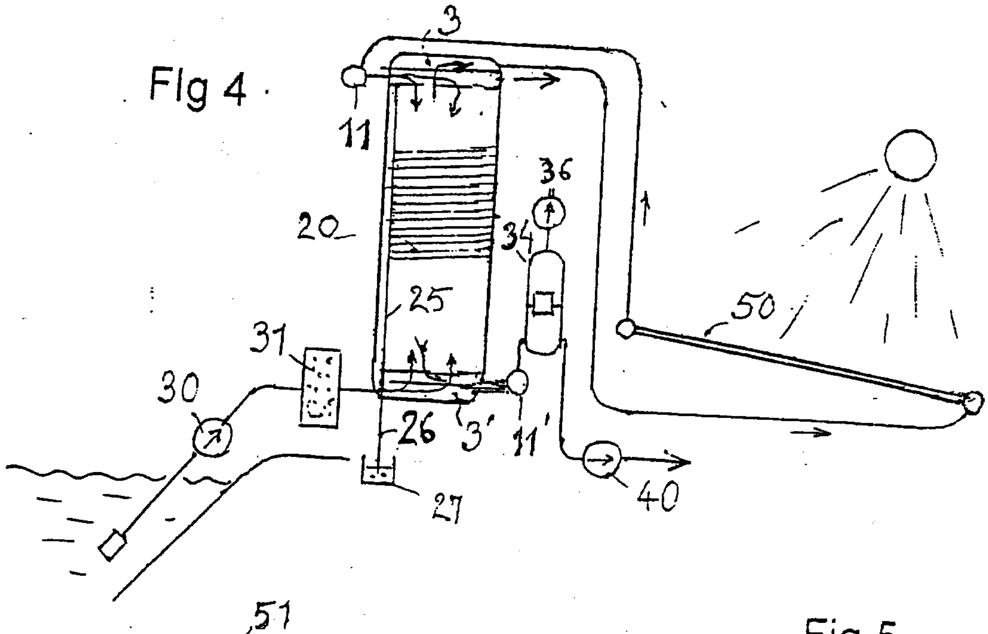


Fig 5

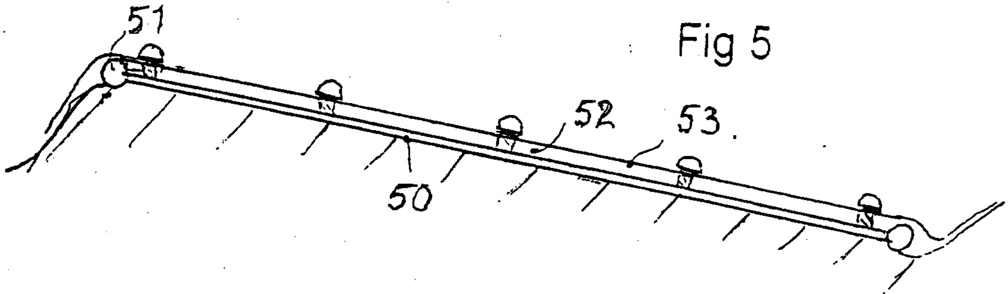
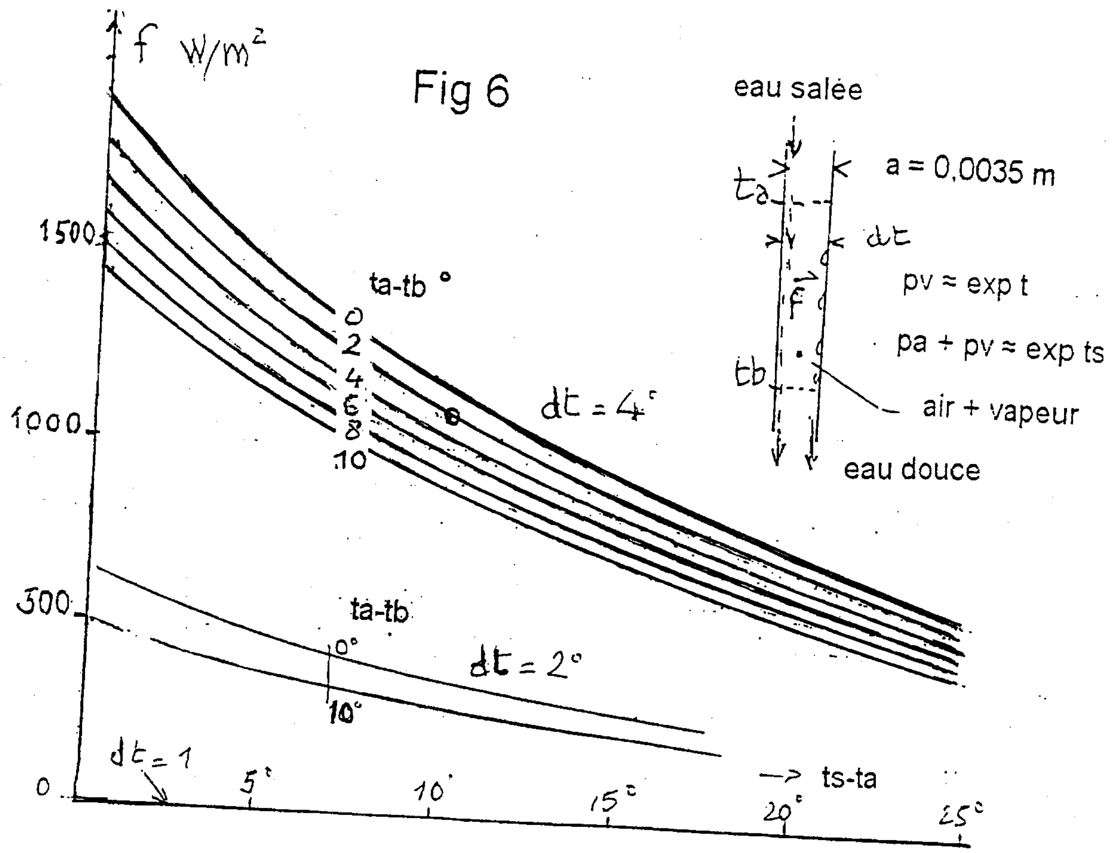


Fig 6



RÉPUBLIQUE FRANÇAISE

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INPI INSTITUT NATIONAL DE LA PROPRIETE INDUSTRIELLE

RAPPORT DE RECHERCHE PRÉLIMINAIRE

établi sur la base des dernières revendications déposées avant le commencement de la recherche

N° d'enregistrement national

FA 642465
FR 0304802

DOCUMENTS CONSIDÉRÉS COMME PERTINENTS		Revendication(s) concernée(s)	Classement attribué à l'invention par l'INPI
Catégorie	Citation du document avec indication, en cas de besoin, des parties pertinentes		
A	FR 2 815 336 A (COSTES DIDIER) 19 avril 2002 (2002-04-19) * le document en entier * -----	1	C02F1/08
			DOMAINES TECHNIQUES RECHERCHÉS (Int.CL.7)
			C02F B01D

1

Date d'achèvement de la recherche	Examinateur
1 avril 2004	Van Belleghem, W

CATÉGORIE DES DOCUMENTS CITÉS

X : particulièrement pertinent à lui seul
Y : particulièrement pertinent en combinaison avec un autre document de la même catégorie
A : arrière-plan technologique
O : divulgation non-écrite
P : document intercalaire

T : théorie ou principe à la base de l'invention
E : document de brevet bénéficiant d'une date antérieure à la date de dépôt et qui n'a été publié qu'à cette date de dépôt ou qu'à une date postérieure.
D : cité dans la demande
L : cité pour d'autres raisons

& : membre de la même famille, document correspondant

ANNEXE AU RAPPORT DE RECHERCHE PRÉLIMINAIRE
RELATIF A LA DEMANDE DE BREVET FRANÇAIS NO. FR 0304802 FA 642465

La présente annexe indique les membres de la famille de brevets relatifs aux documents brevets cités dans le rapport de recherche préliminaire visé ci-dessus.
Les dits membres sont contenus au fichier informatique de l'Office européen des brevets à la date du 01-04-2004
Les renseignements fournis sont donnés à titre indicatif et n'engagent pas la responsabilité de l'Office européen des brevets, ni de l'Administration française

Document brevet cité au rapport de recherche	Date de publication	Membre(s) de la famille de brevet(s)	Date de publication
FR 2815336 A	19-04-2002	FR 2815336 A1	19-04-2002

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