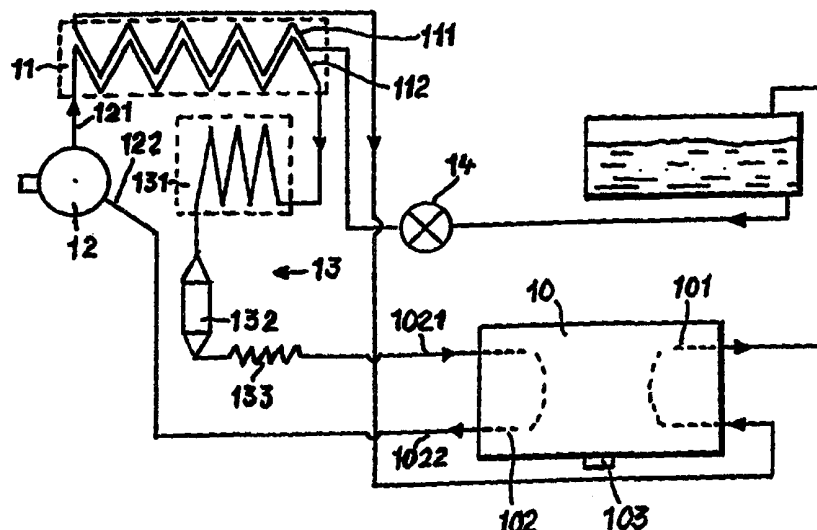




## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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<b>(21) International Application Number:</b> PCT/SE98/01668 <b>(22) International Filing Date:</b> 17 September 1998 (17.09.98)  <b>(30) Priority Data:</b> 9703424-3 23 September 1997 (23.09.97) SE  <b>(71) Applicant (for all designated States except US):</b> HVR WATER PURIFICATION AB [SE/SE]; Nybrogatan 12, S-114 39 Stockholm (SE).  <b>(72) Inventor; and</b> <b>(75) Inventor/Applicant (for US only):</b> LYSÉN, Rune [SE/SE]; Ehrensvärdsgatan 2, S-112 35 Stockholm (SE).  <b>(74) Agents:</b> NILSSON, Karl et al.; Stenhagen Patentbyrå AB, P.O. Box 4630, S-116 91 Stockholm (SE).		<b>(81) Designated States:</b> CN, JP, RU, US, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).  <b>Published</b> <i>With international search report.</i> <i>In English translation (filed in Swedish).</i>

**(54) Title:** APPARATUS FOR OBTAINING PURE WATER FROM CRUDE WATER



**(57) Abstract**

Apparatus for obtaining pure water from crude water includes an evaporator arrangement (10) that has a first circuit (101) for circulating crude water, a second circuit (102) for circulating liquid coolant, and membrane elements for separating the circulating crude water from the circulating liquid coolant and for obtaining pure water from the crude water by means of membrane distillation through the medium of the membrane elements. Connected to the first circuit (101) is one side (111) of a heat exchanger (11) for raising the temperature of the crude water prior to said water entering the evaporator arrangement (10). The apparatus also includes a heat pump (12) for lowering the temperature of the liquid coolant prior to said coolant entering the evaporator arrangement (10). The high-temperature side (121) of the heat pump is connected to the input side (1021) of the second circuit (102) via the remaining side (112) of the heat exchanger (11) and a cooling device (13). The low temperature side (122) of the heat pump is connected to the output side (1022) of the second circuit (102).

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## APPARATUS FOR OBTAINING PURE WATER FROM CRUDE WATER

## FIELD OF INVENTION

5 The present invention relates to apparatus for obtaining pure water from crude water, and more specifically to such apparatus that include an evaporator arrangement having a first circuit for circulating crude water, a second circuit for circulating liquid coolant, and membrane elements for  
10 separating the circulating crude water from the circulating liquid coolant and for obtaining pure water from the crude water through the medium of membrane distillation with the aid of the membrane elements that delimit the circulating crude water.

15

## DESCRIPTION OF THE BACKGROUND ART

It is known to purify water by means of different kinds of distillation processes, and it is also known to obtain fresh  
20 water from salt water for instance, by membrane distillation. See, for instance, Swedish Patent Specifications 408637 and 411446 in this regard.

Swedish Patent Specification 448085 expresses the aim of  
25 utilising the energy delivered to the process to a maximum. The process uses a membrane-equipped distillation unit, a first unit which functions to heat water to be distilled and to lead said water to one side of the membrane, and a second unit which functions to lead water that is colder than the  
30 first mentioned water to the other side of the membrane. The two units are interconnected by means of a connection line, such that water is transferred from the second unit to the first unit either intermittently or continuously. The water is heated to a requisite temperature in the first unit, by  
35 causing said water to flow via a heat exchanger that is connected to an energy source. Energy is transferred from the

second unit to the first unit, by means of a heat pump and two further heat exchangers.

5 Access to drinkable water is a vital necessity for the survival of all mankind. Unfortunately, however, the natural availability of drinkable water differs significantly in different parts of the world. In places where the supply of drinking water is insufficient to meet prevailing needs, it is necessary to produce drinking water artificially, and at a  
10 price which is reasonable for the people and the places concerned.

Many of the processes, apparatuses and devices earlier used to produce drinkable water from salt water for instance are  
15 encumbered with drawbacks. For instance, such processes and apparatus are highly energy consuming, generate disturbingly high sound levels and produce water that has an excessively high temperature, all of which results in a litre price that is too expensive for many people.

20 The object of the present invention is to endeavour to eliminate these and other drawbacks to the greatest possible extent, and, as a result, to provide an energy-lean apparatus which operates at a low sound level and which will produce  
25 clean water at a suitable drinking water temperature of about 8-10°C.

#### SUMMARY OF THE INVENTION

30 According to the present invention, an apparatus of the aforesaid kind that includes an evaporator arrangement, a first circuit for crude water and a second circuit for liquid coolant, for obtaining pure water by means of membrane distillation through membrane elements, also includes a heat  
35 exchanger which functions to raise the temperature of the crude water prior to said water entering the evaporator

arrangement, said first circuit being connected to one side of said heat exchanger, and further includes a heat pump which functions to lower the temperature of the liquid coolant prior to said coolant entering the evaporator arrangement, wherein the high temperature side of said heat pump is connected to the input side of said second circuit via the remaining side of said heat exchanger and a cooling device, and wherein the low temperature side of said heat pump is connected to the output side of said second circuit.

The invention will now be described in more detail with reference to the accompanying drawing, which illustrates an apparatus constructed in accordance with the invention.

#### DESCRIPTION OF PREFERRED EMBODIMENTS

The illustrated apparatus includes an evaporator arrangement 10 that has a first circuit 101 in which crude water is circulated from a crude water tank, a second circuit 102 for circulating liquid coolant (water), and membrane elements for separating the circulating crude water from the circulating liquid coolant and for obtaining pure water from the crude water by means of membrane distillation through the membrane elements. Membrane distillation in itself is well known from the aforesaid patent specifications and need not therefore be described here.

The illustrated apparatus includes a heat exchanger 11 which functions to raise the temperature of the crude water prior to said water entering the evaporator arrangement 10 and which is connected on one side 111 to the first circuit 101. In the illustrated case, the original temperature of the crude water is 67°C, while the temperature of the water entering the evaporator arrangement 10 is 70°C.

The temperature of the liquid coolant is lowered prior to the coolant entering the evaporator arrangement 10, by means of a heat pump 12. The high temperature side 121 of the heat pump is connected to the input side 1021 of the second circuit 102 via the remaining side 112 of the heat exchanger 11 and a cooling device 13. The low temperature side 122 of the heat pump 12 is connected to the output side 1022 of the second circuit 102.

The cooling device 13 includes a condenser 131, a dryer 132, and a capillary pipe 133, and functions to lower the temperature of the liquid coolant from 70°C to 5°C. The temperature of the coolant leaving the evaporator arrangement 10 is 8°C.

The *modus operandi* of the schematically illustrated apparatus is as follows:

At the beginning of the purification process, the heat pump 12 is started-up so as to deliver heat to the heat exchanger 11 and to cool the evaporator arrangement 10. There is activated at the same time a water pump 14 which sucks crude water from the crude water tank to the heat exchanger 11, in which the crude water is heated and then pumped into the first circuit 101 of the evaporator arrangement 10.

As the hot water circulates between the membranes in the evaporator 10 and comes into the proximity of the liquid coolant conducted in cooling plates, there is generated a vapour pressure which causes water molecules to pass through the membranes and condense on the cooling plates, wherewith the resultant condensate runs down and collects at the outlet 103.

An apparatus of this construction will utilise substantially all available heat and cold in the heat pump process, i.e.

the heat generated is utilised in heating the crude water at the same time as the cold thus generated is used to maintain the vapour pressure for carrying out the process, therewith resulting in low energy consumption.

5

The water purifying ability of the novel apparatus has been tested and several analysis measurements carried out. Table 1 below lists the concentrations of certain substances in the water, before and after its purification:

10

I	Bacteria	from 14,000	to 0
	Salt	from 31,000	to 1 ppm
	Radon	from 380	to 4 Bq/l
	Plutonium	from 2.4	to 0.1 Bq

15

Table II below lists the highest and lowest degree of purification in percent in respect of three different measurements for each substance:

20	II	Chloroform	99.8-98.6
		1,1,1-trichloroethane	99.9-99.6
		Trichloroethylene	99.7-99.4
		Dichlorobromomethane	99.8-98.7
		Carbon tetrachloride	99.7-98.7
25		Dibromochloromethane	99.7-98.7
		Bromoform	99.6-97.8

## CLAIMS

Apparatus for obtaining pure water from crude water, comprising an evaporator arrangement (10) having a first  
5 circuit (101) for circulating crude water, a second circuit (102) for circulating liquid coolant, and membrane elements for separating the circulating crude water from the circulating liquid coolant and for obtaining pure water from the crude water by means of membrane distillation through the  
10 medium of membrane elements delimiting the circulating crude water, **characterised** in that the apparatus includes a heat exchanger (11) which functions to raise the temperature of the crude water prior to said water entering the evaporator arrangement (10) and one side (111) of which is connected to  
15 said first circuit (101); and in that said apparatus further includes a heat pump (12) which functions to lower the temperature of the liquid coolant prior to said coolant entering the evaporator arrangement (10), wherewith the high-temperature side (121) of said vacuum pump is connected to  
20 the input side (1021) of the second circuit (102) via the remaining side (112) of said heat exchanger (11) and a cooling device (13), and the low-temperature side (122) of said heat pump is connected to the output side (1022) of the second circuit (102).



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 98/01668

## A. CLASSIFICATION OF SUBJECT MATTER

IPC6: C02F 1/04

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)

IPC6: C02F

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

SE,DK,FI,NO classes as above

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

EPODOC, WPI

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	SE 448085 B (SVENSKA UTVECKLING AB), 19 January 1987 (19.01.87), page 7, line 24 - page 8, line 2  -- -----	1



Further documents are listed in the continuation of Box C.



See patent family annex.

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Information on patent family members

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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