DESALINATION APPARATUS AND METHOD

FIELD OF THE INVENTION

The present invention relates to the apparatus and methods for desalination of salt water. More particularly, the present invention relates to apparatus and methods of desalination of salt water by process of reverse osmosis (RO).

BACKGROUND OF THE INVENTION

Presently, there are two general categories in seawater desalination. The first method is the evaporation of water through application of heat. Water is then collected from the condensation of the steam. The second method makes use of a natural phenomenon known as reverse osmosis, where seawater is forced within a pressure vessel against a semi-permeable membrane, which allows water to permeate. With the advancement of membrane technology, this seawater reverse osmosis (SWRO) is gaining wider acceptance as a cost effective method of desalination. Commercial SWRO plant design based on existing technologies is relatively complex which require heavy investments in mechanism, plant and equipment. Nevertheless, with the increasing global water shortages, such heavy investments are still justifiable as an option.

Most conventional SWRO desalination plants typically require pumps to create pressure within pressure vessels to effect reverse osmosis process. This is one of the main operational cost factors due to the high electrical energy requirement. There are also systems with energy recovery mechanism to reduce the total energy consumption.

One alternative method of reducing the energy requirement in pressurising the seawater for the reverse osmosis process to occur is to make

use of gravitationally induced pressure through high water column head. Since 1960's, there have been numerous patent applications making use of such hydrostatic pressures as a cost effective alternative to enable seawater reverse osmosis. Basically, there are two categories of such application, namely, onshore method and offshore method. In offshore system, reverse osmosis production unit is lowered onto sufficiently deep seabed. Water produced is then pumped up to surface for consumption.

With the onshore method, a deep vertical shaft is constructed and filled up with seawater. This creates a hydrostatic pressure for reverse osmosis units to operate at the base of the vertical shaft. Freshwater is then pumped up to the surface. Another variation to this method as disclosed in EP 0764610 is to first pump the seawater to a higher ground to create the hydrostatic pressure for the reverse osmosis production unit at ground surface level. Comparatively, this latter method may not be as energy effective since all of the seawater would have to be pumped up to the water tank above. The permeate makes up only a portion of the full seawater feed, typically between 40% to 70% depending on the various factors such as pressure head, total dissolved solid (TDS) and temperature. Whereas for the underground shaft method, only the desalted water needs to be pumped up the full height. Because the seawater intake and the brine discharge water columns are linked at the base, which liken to a U-shaped tube, the head at both water columns would equilibrate near the surface level, save for the marginal effect due to difference in density between seawater inflow and brine discharge.

US 5,916,441 discloses an on-shore method. The reverse osmosis takes place in a pressure vessel, and the shafts are suggested to be driven to 3,000 ft. The invention requires a two stage reverse osmosis process to produce drinking and agricultural use water. GB 2068774 discloses a method where reverse osmosis takes place in pressure vessels and the reverse osmosis mechanism is located in underground gallery/ cross shaft. US 4,125,463 utilises a series of independent but connected vertical reverse

osmosis pressure vessels. There is a need to remove the whole piping system to maintain the reverse osmosis membranes. EP 0968755 A2 and WO 9906323 disclose offshore methods. Here again reverse osmosis takes place in pressure vessels.

At present, commercially operated desalination plants that utilise natural hydrostatic pressure is rare and possibly, non-existent. The prior art technology as cited in documents referred to above all suffer distinct disadvantages as discussed below.

Although the energy savings are relatively substantial compared to conventional desalination methods, the lack of commercialisation of hydrostatic reverse osmosis method could be due to the following reasons:

a) High construction and operating costs

The required height or depth of water head disclosed to date is between 500m to 1000m. These are extremely deep underground shafts. Furthermore, there are also requirements for horizontal or cross shafts to house the reverse osmosis units at the base of the shafts. Although, mining technologies are available to enable the construction of such deep shafts, the infrastructure investment cost may be prohibitive to make the overall investment feasible.

b) Difficult and complicated to maintain

One of the most common problems of reverse osmosis system is the fouling and blockage of membranes. While the piping and mechanism required for hydrostatic reverse osmosis are relatively less complicated than conventional reverse osmosis systems, there is still a need to maintain the membranes within pressure vessels on a regular basis. As such, the maintenance costs can be high since work need to be undertaken within confined underground galleries at more than 500m below surface level.

c) Need for favourable geographical features
Especially for above ground hydrostatic reverse osmosis systems, the desalination plant location needs to be as close to ideal as possible to enable such system to perform economically. Otherwise the heavy infrastructure cost required would be prohibitive and cause the total production cost to be uneconomical.

Any discussion of documents, devices, acts or knowledge in this specification is included to explain the context of the invention. It should not be taken as an admission that any of the material forms a part of the prior art base or the common general knowledge in the relevant art in Singapore or elsewhere on or before the priority date of the disclosure and claims herein. All statements as to the date or representation as to the contents of these documents is based on the information available to the applicant and does not constitute any admission as to the correctness of the dates or contents of these documents.

It is an object of the present invention to provide an apparatus and method of desalination of seawater by reverse osmosis utilising natural hydrostatic pressure.

A further object of the present invention is to alleviate at least one disadvantage associated with the prior art.

SUMMARY OF THE INVENTION

This invention discloses a method and apparatus for desalination of sea water with reverse osmosis. The general embodiment of our method includes enabling sea water intake to flow gravity-wise from the sea to a sub-terranean intake vertical column of sufficient depth to attain requisite hydrostatic pressure for reverse osmosis to take place. The sea water may

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be drawn into the intake vertical column via an intake shaft in an inclined gravity-wise manner. Reverse osmosis takes place in a reverse osmosis diffusion unit which includes a reverse osmotic membrane enabling desalinated water to diffuse therethrough, leaving undiffused sea water as brine. The reverse osmosis diffusion unit may be hoisted to any depth along the intake vertical column, including depths having sufficient hydrostatic pressure to enable reverse osmosis to take place.

The reverse osmosis diffusion unit may be provided with an outlet enabling desalinated water diffused through the reverse osmotic membrane to be discharged gravity-wise, preferably via an outlet pipe, to a desalinated water reservoir in a gravity-wise manner relative to said sub-terranean vertical column. Preferably, detachable coupling means is provided with means to close-off outlet pipe and to detach the reverse osmosis unit therefrom prior to hoisting said unit up the vertical intake column.

The desalinated water collected in the reservoir may then be extracted out with an extraction pump for consumption or distribution. The brine from the reverse osmosis may be irreversibly conducted via a one-way valve into at least a sub-terranean discharge vertical column of about the same depth as, and parallel to, the sub-terranean intake vertical column. The brine collected in the sub-terranean discharge vertical column may be removed with a discharge pump at a rate to attain sufficient hydrostatic pressure differential or gradient between said brine's level in said sub-terranean discharge vertical column and sea water intake in said sub-terranean intake vertical column so as to optimize the reverse osmosis rate.

Preferably, the hydrostatic pressure differential or gradient between the intake and sub-terranean discharge vertical column is attained by regulating the (i) rate of sea water intake into said sub-terranean intake vertical column and/or (ii) rate of brine removal from said sub-terranean discharge vertical column. The hydrostatic pressure differential or gradient may be maintained at a desirable level to produce a desirable water flow throughput.

A preferred method of taking in sea water into the sub-terranean intake vertical column is to do so via a gravity-wise inclined pathway at a controllable flow rate. The sea water is preferably filtered and pre-treated prior to intake into the sub-terranean intake vertical column. This may include providing particulate filter means at the intake shaft prior to the intake of sea water into the intake vertical column. Precipitation and oxidation means may also be preferably provided at the intake shaft to pre-treat the sea water prior to flowing into the intake vertical column.

In one preferred embodiment, the desalinated water collected is conducted to a designated storage which may include any one of a man-made underground reservoir or tank, a natural underground reservoir including aquifer, water table or sub-terranean cavern, and/or a land surface storage and distribution network.

In another preferred embodiment, multiple units of the sub-terranean intake vertical columns are provided the sea water from the multiple vertical columns is irreversibly conducted to a common sub-terranean discharge vertical column. Each of the intake vertical columns may undergo reverse osmosis and collection of desalinated water independently of each other so that the shutting down of one column for maintenance work or servicing of the reverse osmosis unit will not affect the other columns. The multiple units of sub-terranean intake vertical columns may preferably be configured around a common sub-terranean discharge vertical column into which brine from each of said intake vertical columns may be conducted.

In another preferred embodiment, the rate of the removal of brine from the discharge vertical column by pump means and the intake of sea water into the intake vertical column through intake shaft are controllable so as to maintain a sufficient hydrostatic pressure differential between said brine's level in said sub-terranean discharge vertical column and sea water intake in said sub-terranean intake vertical column.

Other aspects and preferred aspects are disclosed in the specification and / or defined in the appended claims, forming a part of the description of the invention.

The present invention has been found to result in a number of advantages, such as:

- ease of maintenance as each of the unit cell is self-contained and independent;
- no requirement for pressure vessel, hence eliminating the need for complex and complicated mechanism, piping and instrumentations;
- ease of replacement, servicing and maintenance of the modular reverse osmosis membrane;
- faster circulation of seawater and brine discharge; and
- minimal environmental impact at brine discharge point.

Further scope of applicability of the present invention will become apparent from the detailed description given hereinafter. However, it should be understood that the detailed description and specific examples, while indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from this detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

Further disclosure, objects, advantages and aspects of the present application may be better understood by those skilled in the relevant art by reference to the following description of preferred embodiments taken in conjunction with the accompanying drawings, which are given by way of illustration only, and thus are not limitative of the present invention, and in which:

Figure 1 is vertical cross-sectional view of the assembly of a desalination apparatus;

Figure 2 is horizontal cross-sectional view across line A-A of the apparatus shown in Figure 1;

Figure 3 is the horizontal cross-sectional view across line B-B of the apparatus shown in Figure 1; and

Figure 4 shows the sequence of removing and replacing a typical reverse osmosis membrane module in the apparatus.

DETAILED DESCRIPTION OF THE INVENTION

The invention will be described in detail with reference to a preferred embodiment. The desalination plant is located close to the sea for easy drawing of seawater for desalination preferably by gravitational flow means.

A preferred embodiment of the invention will be described by way of illustration only and not limiting in any manner. Referring to Figure 1, the seawater inlet (1) is located at sufficient depth below average mean sea level to ensure the lowest seawater level during lowest tide will be above the seawater inlet. The seawater flows by gravity to a seawater filtering system (2). Established systems known in prior art for filtering seawater is adopted to ensure seawater is filtered to remove solid particles to produce the "cleanest" possible quality using existing commercially available technology. Such technology will not be described here.

Next the raw seawater is subjected to a pre-treatment process (3) to remove organics and suspended solids in accordance with those currently practised by commercial reverse osmosis plants prior to feeding seawater into the reverse osmosis process. Once pre-treated, the seawater will be channelled through an inclined shaft (4) by gravity into a number of independent reverse osmosis production modules or unit cells (5) within a vertical shaft (6). With the low permeability ratio, the total dissolved solids

(TDS) of the brine discharge is not significantly higher than the seawater at inlet. In addition, by increasing the circulation of seawater through increasing the flow out rate of brine from the brine discharge cell, the build up of brine concentration can also be controlled and minimised. As such, the impact on marine environment at point of discharge is minimised.

Where economic feasibility or geographical constraints of the site do not allow the use of gravity induced seawater inflow, mechanical piping and pump systems can be adopted to introduce filtered and treatment sea water onto the unit cells (5).

The apparatus consists of a large diameter vertical shaft (6), preferably approximately 8 meters in diameter and 150 meters deep or more as appropriate. The apparatus is installed in a well which may be drilled in land surface or may be drilled in offshore areas using techniques known to the art. The well is drilled to a predetermined depth to accommodate the apparatus. These dimensions are subject to the required production rate as well as the hydrostatic pressure required to enable the reverse osmosis process to occur. These are further dictated by, but not limited to, the salinity of seawater, permeability of the reverse osmosis membrane and the desired yield of freshwater from the whole system. In the present invention the depth of the vertical shaft (6) would be about 150 meters below ground or more. At this length of the vertical shaft (6), the water head in the unit cell (5) that is the seawater column would be relatively lower than most conventional pressure heads used in reverse osmosis systems. As explained later, shorter water heads would reduce permeability of the seawater. This setback can be offset or compensated by the provision of greater number of reverse osmosis modules (9) within the vertical shaft (6). Alternatively, additional plants working in series can be provided to achieve the required volume. Further shallower vertical shaft also reduces the initial capital investment costs. Within the shaft are at least three main types of vertical wells, namely, reverse osmosis production well or termed as unit cell (5) where the reverse osmosis

process takes place; brine discharge well (7), and an access well (8). These vertical wells may be arranged in any other configurations. In a preferred embodiment, the unit cell (5), the brine discharge well (7), and the access well (8) are arranged in honeycomb like formation.

There are a number of the unit cells (5) constructed forming a series of vertical wells. In the present embodiment there are seven unit cells (5). Another access well (8) not necessarily of the same shape and dimension as unit cell (5) is provided. All the seven unit cells (5) and the access well (8) are preferably of equal dimensions. They are placed along the inner circumferential edge of the unit cell (5) as illustrated in Figures 2 and 3. The unit cells (5) are configured to utilise the maximum space beyond the central core region comprising the brine discharge well (7). Each of the unit cell 5 is an independent well where reverse osmosis process takes place at the reverse osmosis membrane module (9) located at the basal portion of each well. The reverse osmosis membranes are exposed directly to the hydrostatically pressured seawater. The permeate is allowed to flow freely towards the outlet pipe (10) at the bottom of the reverse osmosis membrane module (9), which then flows by gravitational force into the storage reservoir (11) at the base of the vertical shaft (6). The bottom region of the vertical shaft (6) below the unit cell is storage reservoir (11) to receive permeate from reverse osmosis membrane module (9). All the reverse osmosis membrane modules (9) are standardised so that they are all interchangeable. This feature would avoid high inventory of spare reverse osmosis membrane modules (9), which can be costly.

The water in the storage reservoir (11) is then pumped to the surface for distribution via the extraction pump (15) and the extraction pipe (16). The storage reservoir (11) is exposed to the atmosphere via the access wall (8), Thus, the storage reservoir (11) is at atmosphere pressure.

Alternatively, the desalted water from the reservoir could be pumped to an underground cavern for storage and future use; or discharged into aquifers to recharge depleted groundwater or for groundwater extraction at a faraway distance. In situations where groundwater has been over extracted, the recharging of aquifer by this way would also minimize the possible ground settlement of the urban or residents areas.

The near brine quality water at the base of all the unit cells (5) is then channelled via a pipe (12) to the central brine discharge well (7). There is a one-way pressure valve (13) installed to avoid any backflow of brine into the unit cell 5. This pressure valve (13) also enables any one of the unit cells (5) to be totally drained during maintenance independent of other unit cells. A pump (14) is situated at the top of the brine discharge well (7) to discharge the central brine discharge as well as to induce the circulation of raw seawater from the unit cell (5) to the central core brine discharge well (7) through the connecting pipe (12). By controlling the rate of the brine discharge pump (14), the circulation of the seawater can be regulated. For instance, to accelerate the circulation, the flow rate of the brine discharge pump (14) is increased. When the water level within the core brine discharge well (7) reduces, an imbalance level of hydrostatic pressure is being created between the discharge well (7) and the unit cell (5). The seawater level at the unit cell (5) referred to also as the seawater column is always kept at the highest point through the continuous flow of pretreated seawater from the inclined shaft (4). This differential hydrostatic pressure would cause the seawater from the unit cell (5) to flow into the central core brine discharge well (7). Similarly, by reducing the pumping rate of the brine discharge pump (14), the circulation of the seawater is accordingly slower. An optimised flow rate would minimise clogging up of the reverse osmosis membrane.

The design and construction of the reverse osmosis membrane module (9) enables easy set up and removal and hence eases the on-going maintenance of the system. The whole reverse osmosis membrane module

(9) can be removed and lifted up to the ground level for regular cleaning and maintenance; and then lowered back into the unit cell (5) by hoisting means or by other mechanical handling means.

Figure 4 shows the sequence in replacing the reverse osmosis membrane module (9). The reverse osmosis membrane module (9) within each unit cell (5) is replaced one at a time and hence, would not affect the continuous production of the desalinated water. During Stage 1, the inflow of pretreated water is stopped and a pump (16) is used to discharge the seawater within the unit cell (5). The one-way pressure valve (13) placed in the conduit (12) connecting the unit cell (5) and the central core (7) will stop any backflow of seawater from the central core (7) into the unit cell (5) due to the imbalance hydrostatic pressure created. A vertical hoist (17) is then fixed to the reverse osmosis membrane module (9). As shown in Stage 2, once the seawater level is discharged until a level in the unit cell (5) below the reverse osmosis membrane module (9), the pump (16) is stopped. The reverse osmosis membrane module (9) is then lifted up and removed for servicing and cleaning as illustrated in Stage 3 and Stage 4 respectively. Referring to Stage 5, a new or clean reverse osmosis membrane module (9) is then lowered and connected to the outlet pipe (10) by using a self locking coupler (not shown). In Stage 6, which is the final stage, the pre-treated seawater is released to flow back into the unit cell (5) via the inclined shaft 4. Once the seawater level reaches the top of the unit cell (5), the desalination process recommences. An alternate method of replacing the reverse osmosis membrane module (9) does not require the discharging of the pretreated seawater within the unit cell (5). This can be achieved with a specially designed self-locking coupler between the reverse osmosis membrane module (9) and the outlet pipe (10). Such coupler enables the reverse osmosis membrane module (9) to be replaced while submerged under the water column, and prevents any seawater flowing into the storage reservoir (11) through outlet pipe (10). The reverse osmosis membranes in the reverse osmosis module in each of the unit cells are built of commercially available

membranes. As the size of the reverse osmosis membranes are preferably uniform, the reverse osmosis membranes can be standardised. With the standardisation of the reverse osmosis membrane module, replacement of defective membrane modules can be carries out much more efficiently. Further the removed reverse osmosis membrane modules can then be serviced, maintained and shared as back up module.

It will be appreciated that the plurality of unit cells (5) can be arranged in any other manner, subject to the unit cells being in liquid communication with the central core (7) via a connecting pipe (12). There could also be a plurality of brine discharge wells (7) wherein each brine discharge well serves at least one unit cell (5). Where the vertical shaft is large, there could be provided a cluster comprising of unit cells (5) and brine discharge wells (7) in each cluster.

There could be more than one reverse osmosis membrane module (9) in each unit cell (5) subject to a spatial configuration wherein each reverse osmosis membrane module (9) is removable from the unit cell for routine maintenance work. The outlet pipe (10) from each module (9) is in liquid connection to the storage reservoir (11). Where the output of desalinated water from the unit cells (5) is large, there can be provided more than one extraction pipe (16) and pumps (15) to pump out the desalinated water.

It will be appreciated that each of reverse osmosis production unit or unit cell (5) is self contained and independent of other unit cells. This configuration simplifies on-going maintenance of each unit all and in particular the membrane modules (9). Each unit cell (5) can be drained, the reverse osmosis membrane filler(s) within it can be lifted up for cleaning and maintenance without significantly interrupting the operation of the other unit cells. The reverse osmosis membranes can be lifted and reintroduced into the unit cells by a fully mechanised means. The honeycombs like assembly of unit cells within a vertical shaft also results in saving of space. As such the

invention provides an economical and feasible method of desalination of seawater.

It will be further appreciated that an assembly of desalination plants as described above can be arranged subject to the arrangement that a common sea water inlet, a common means to filter the seawater and a common seawater treatment means can be provided.

Similarly the reservoirs at the base of each vertical shaft can be connected by conduit means and a common or single extraction pipe can be provided to remove the desalinated water from the reservoirs so connected.

One of the major advantages of the present invention is the elimination of the need of pressure vessels as in prior art. The reverse osmosis membrane immersed in the well is directly exposed to hydrostatic pressure of the salt water. In conventional practice, the membrane removes the need for complex and complicated mechanism piping and instrumentations, resulting in a overall simplified, less expensive desalination plants.

As the height of the waterhead in the unit cell (5) can be individually controlled, the invention offers the possibility of using different types of membranes, ranging from low pressure to high pressure reverse osmosis membrane, enabling the maximising of desalination rates in the vertical shaft.

As the seawater inlet is constructed below the seawater levels, it enables the seawater to flow into pre-treatment chamber by gravity. Similarly, the pre-treated seawater then flows into reverse osmosis unit cells by gravity. Thus by using gravity induced flow, a saving of energy cost is realised.

While this invention has been described in connection with specific embodiments thereof, it will be understood that it is capable of further modification(s). This application is intended to cover any variations uses or

adaptations of the invention following in general, the principles of the invention and including such departures from the present disclosure as come within known or customary practice within the art to which the invention pertains and as may be applied to the essential features hereinbefore set forth.

As the present invention may be embodied in several forms without departing from the spirit of the essential characteristics of the invention, it should be understood that the above described embodiments are not to limit the present invention unless otherwise specified, but rather should be construed broadly within the spirit and scope of the invention as defined in the appended claims. Various modifications and equivalent arrangements are intended to be included within the spirit and scope of the invention and appended claims. Therefore, the specific embodiments are to be understood to be illustrative of the many ways in which the principles of the present invention may be practiced. In the following claims, means-plus-function clauses are intended to cover structures as performing the defined function and not only structural equivalents, but also equivalent structures. For example, although a nail and a screw may not be structural equivalents in that a nail employs a cylindrical surface to secure wooden parts together, whereas a screw employs a helical surface to secure wooden parts together, in the environment of fastening wooden parts, a nail and a screw are equivalent structures.

"Comprises/comprising" when used in this specification is taken to specify the presence of stated features, integers, steps or components but does not preclude the presence or addition of one or more other features, integers, steps, components or groups thereof."

CLAIMS

1. A method of desalination sea water comprising the steps of:

(i) enabling sea water intake to flow gravity-wise from the sea to at least an sub-terranean intake vertical column of sufficient depth to attain requisite hydrostatic pressure for reverse osmosis;

(ii) allowing reverse osmosis to occur across a reverse osmotic membrane wherein desalinated water is diffused through said membrane and leaving undiffused sea water as brine;

(ii) collecting desalinated water obtained from said reverse osmosis in a gravity-wise manner relative to said sub-terranean vertical column;

(iii) enabling brine from said reverse osmosis to irreversibly flow into at least a sub-terranean discharge vertical column of about the same depth as, and parallel to, said sub-terranean intake vertical column;

(iv) removing said brine collected in said sub-terranean discharge vertical column at a rate to attain sufficient hydrostatic pressure differential or gradient between said brine's level in said sub-terranean discharge vertical column and sea water intake in said sub-terranean intake vertical column.

2. A method according to Claim 1 wherein the hydrostatic pressure differential or gradient between the intake and sub-terranean discharge vertical column is attained by regulating at least one of the

(i) rate of sea water intake into said sub-terranean intake vertical column

(ii) rate of brine removal from said sub-terranean discharge vertical column.

3. A method according to Claim 2 wherein the hydrostatic pressure differential is maintained at a desirable level to produce a desirable water flow throughput.

4. A method according to Claim 1 wherein the sea water intake into the sub-terranean intake vertical column is provided in a gravity-wise inclined pathway at a controllable flow rate.

5. A method according to Claim 4 wherein the sea water is filtered and pre-treated prior to intake into the sub-terranean intake vertical column.

6. A method according to Claim 1 wherein the desalinated water collected is conducted to a designated storage including any one of

- a man-made underground reservoir or tank,
- a natural underground reservoir including aquifer, water table or sub-terranean cavern, and
- a land surface storage and distribution network.

7. A method according to Claim 1 wherein the sea water from multiple units of sub-terranean intake vertical columns is irreversibly conducted to a common sub-terranean discharge vertical column.

8. A method according to Claim 7 wherein each of the sub-terranean intake vertical columns undergo reverse osmosis and collection of desalinated water independently of each other.

9. A method according to Claim 8 wherein the multiple units of sub-terranean intake vertical columns are configured around a common sub-terranean discharge vertical column.

10. An apparatus for desalination of sea water comprising

(i) at least one sub-terranean intake vertical column (6)

- wherein sea water may be drawn thereinto via an intake shaft (4) inclined gravity-wise; and
- having a depth sufficient to provide hydrostatic pressure to enable reverse osmosis to take place;

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(ii) a reverse osmosis diffusion unit (9), including a reverse osmotic membrane enabling desalinated water to diffuse therethrough, wherein said unit (9) is

- hoistable to any depth along said intake vertical column (6), including depths having sufficient hydrostatic pressure to enable reverse osmosis to take place; and
- is provided with an outlet pipe (10) enabling desalinated water diffused through said reverse osmotic membrane to be discharged gravity-wise to a desalinated water reservoir (11);

(iii) a sub-terranean discharge vertical column (7), in parallel with, and which lower end is connected to corresponding end of said intake vertical column (6) wherein remaining undiffused sea water (hereinafter "brine") may be conducted into from said intake vertical column (6) via a one-way valve (13);

(iv) a brine discharge pump (14) for removing brine from said discharge vertical column (7); and

(v) a desalinated water extraction pump (15) for extracting water from the reservoir (11).

11. An apparatus according to Claim 10 wherein multiple intake vertical columns (6) are arranged around a discharge vertical column (7) into which brine from each of said intake vertical columns (6) is conducted.

12. An apparatus according to Claim 10 wherein particulate filter means is provided at the intake shaft (4) prior to intake of sea water into the intake vertical column (6).

13. An apparatus according to Claim 10 wherein water treatment means, including precipitation and oxidation means, is provided at the intake shaft (4) prior to intake of sea water into the intake vertical column (6).

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14. An apparatus according to Claim 10 wherein the reverse osmosis unit (9) is provided with a reverse osmotic membrane suitable for reverse osmosis to take place at designated depths of the intake vertical column (6) having sufficient hydrostatic pressure.

15. An apparatus according to Claim 10 wherein the reverse osmosis unit (9) is provided with detachable coupling means to enable desalinated water diffused through the reverse osmotic membrane to be drained gravity-wise via an outlet pipe (10) to the desalinated water reservoir (11).

16. An apparatus according to Claim 10 wherein the detachable coupling means is provided with means to close-off outlet pipe (10) and to detach the reverse osmosis unit (9) therefrom prior to hoisting said unit (9) up the vertical intake column (6).

17. An apparatus according to Claims 11 and 16 wherein shutting down operation of a vertical intake column (6) for the detachment and hoisting up of one reverse osmosis unit (9) therefrom does not stop reverse osmosis process in other vertical intake columns.

18. An apparatus according to Claim 11 wherein the multiple intake vertical columns (6) are arranged around the discharge vertical column (7) in such configuration so that segmental columnar space is provided for at least an extraction pipe (16) for drawing desalinated water from the reservoir (11).

19. An apparatus according to Claim 10 wherein the rate of

- the removal of brine from the discharge vertical column by pump means (14); and
- the intake of sea water into the intake vertical column (6) through intake shaft (4)

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are controllable so as to maintain a sufficient hydrostatic pressure differential between said brine's level in said sub-terranean discharge vertical column and sea water intake in said sub-terranean intake vertical column.

20. A plant for desalination of sea water including at least an apparatus according to any one of Claims 10 – 19.

21. Desalinated water obtained from any one of:

- a method according to any one of Claims 1 – 9;
- an apparatus according to any one of Claims 10 – 19; or
- a plant according to Claim 20.

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