A system and method for desalination of seawater W having an original water salinity and a original water concentration of scale forming components, the system comprising a pre-treatment sub-system for at least partial removal from said water W of said scale forming components, producing thereby a pre-treated feed water having a first concentration of scale forming components lower than said original concentration of scale forming components, a forward feed flow multi-effect evaporator adapted for distillation of said pre-treated feed water, producing thereby main desalted water product W₁, having a desalted water salinity lower than said water salinity, and main brine having a salt concentration of approximately 10%, a concentrator adapted for receiving therein said main brine and concentrating it, producing thereby more concentrated brine with an increased salt concentration of approximately 20%-22%, and releasing a first additional desalted water product W₂, and a crystallizer for receiving said more concentrated brine, adapted for crystallization thereof to obtain at least solid salt products and releasing a second additional desalted water product W₃.
FIELD OF THE INVENTION

This invention relates to desalination systems and methods, in particular a method using multi-effect evaporators.

BACKGROUND OF THE INVENTION

Distillation of water, being a commonly used method of desalination, is a process in which various soluble materials such as salt, contaminants etc. are eliminated from water containing these materials, leaving clean, usually drinkable water. One known method for achieving such distillation relies on water evaporation, much like salt and scale being accumulated on the bottom of an electric kettle after water has evaporated. In this process during evaporation of the water, soluble materials that are not volatile remain in a solid state residue, usually in the form of salt and scale, and are disposed of. The vapor can then be condensed back into the state of liquid, resulting in contaminant free water.

One of the problems in the above process is scale formation on the surfaces of the evaporation equipment, caused by compounds of the seawater such as, for example, calcium carbonate and sulfate. These and other scale formation compounds are usually removed from the seawater by means of different pre-treatment processes.

Also, disposal of the residual brine, i.e. concentrated solution of salts remaining after the distillation process, may cause an ecological problem. Moreover, the disposal of brines presents significant costs and challenges for the desalination industry, which increase the time required for permits and construction of new plants and result in higher cost of water treated thereby.

One way to deal with brines from seawater desalination is making use of zero liquid discharge (ZLD) systems. A ZLD system evaporates brine leaving a salt residue for disposal or reuse.
SUMMARY OF THE INVENTION

In accordance with one aspect of the present invention, there is provided a system for desalination of seawater $W$ having an original water salinity and a original water concentration of scale forming components, the system comprising:

- a pre-treatment sub-system for at least partial removal from said water $W$ of said scale forming components, producing thereby a pre-treated feed water having a first concentration of scale forming components lower than said original concentration of scale forming components;

- a forward feed flow multi-effect evaporator adapted for distillation of said pre-treated feed water, producing thereby main desalted water product $W_M$ having a desalted water salinity lower than said water salinity, and main brine having a salt concentration of approximately 10%.

- a concentrator adapted for receiving therein said main brine and concentrating it, producing thereby more concentrated brine with an increased salt concentration of approximately 20%-22%, and releasing a first additional desalted water product $W_1$; and

- a crystallizer for receiving said more concentrated brine, adapted for crystallization thereof to obtain at least solid salt products and releasing a second additional desalted water product $W_2$.

Any one or more of the following features may be included in the system according to the present invention:

- The amount of said main water product $W_M$ approximately equals to 0.65$W$.
- The amount of said first additional water $W_1$ approximately equals to 0.15$W$.
- The amount of said second additional water $W_2$ approximately equals to 0.15$W$.
- The scale forming components are at least sulfate ions.
- The pre-treatment system may further comprise at least de-carbonization columns adapted for removing said sulfate ions.
- The scale forming components are at least calcium ions.
- The pre-treatment system may further comprise a reactor adapted for creating calcium carbonate by reacting said calcium ions with soda ash.
The pre-treatment system may further comprise a clarifier adapted for removing said calcium carbonate.

The concentrator may further constitute a part of a single multi-effect evaporator/concentrator installation.

The concentrator may further constitute a part of a single multi-effect concentrator/crystallizer installation.

According to a further aspect of the present invention, there is provided a method of desalination of a seawater having a original water salinity and a concentration of scale forming components, the method comprising:

- at least partial removal from said seawater of said scale forming components and producing a pre-treated feed water having a first concentration of scale forming components lower than said feed water concentration of scale forming components;

- distillation of said pre-treated feed water by a forward feed flow multi-effect evaporator and producing main desalted water product W M having a desalted water salinity lower than said original water salinity, and main brine having a salt concentration of approximately 10%;

- producing from said main brine a more concentrated brine with increased salt concentration of approximately 20%-22%; and

- crystallizing said more concentrated brine and obtaining at least one salt product therefrom.

Any one or more of the following features may be included in the method according to the present invention:

- The method may further comprise removing said scale forming components by means of de-carbonization columns.

- The method may further comprise removing said scale forming components by means of a reactor and a clarifier.

- The method may further comprise producing said main brine by said evaporator.

- The method may further comprise providing a concentrator.

- The method may further comprise producing said more concentrated brine by said concentrator.
BRIEF DESCRIPTION OF THE DRAWINGS

In order to understand the invention and to see how it may be carried out in practice, embodiments will now be described, by way of non-limiting examples only, with reference to the accompanying drawings, in which:

Fig. 1 schematically illustrates one example of a system according to the present invention; and

Fig. 2 schematically illustrates another example of a system according to the present invention.

DETAILED DESCRIPTION OF EMBODIMENTS

Figs. 1 and 2 schematically show two examples of a system for seawater desalination according to the present invention, designated as 10 and 30, respectively.

The system 10 comprises a pre-treatment sub-system 11, a multi-effect evaporator 13 with its associated feed heater 21, a concentrator 17 (not shown) combined with a crystallizer 19 (not shown) in one common multi-effect concentrator/crystallizer installation 15, which has a succession of corresponding primarily concentrating (PC) effects and primarily crystallizing (PCR) effects. The concentrator 17 and the crystallizer 19 may further be two distinct separate installations.

Similarly, the system 30 comprises a pre-treatment sub-system 31, a multi-effect evaporator 33 with its associated feed heater 41, the evaporator 33 (not shown) incorporating a concentrator 37 (not shown) in one common multi-effect installation 35, having a succession of corresponding primarily desalinating (PD) effects and primarily concentrating (PC) effects, and a crystallizer 39.

Each of the systems 10 and 30 further comprises three condensers 12, 14 and 16. The condenser 12 is a falling film condenser and the condensers 14 and 16 are forced circulation condensers. The construction of the condensers 12, 14 and 16 is known per se.

The systems 10 and 30 further comprise a steam supply system 50 (not shown) for supplying vapor to the systems, as will be explained below.

With reference to Fig. 1, in operation of the system 10, seawater W first enters the pre-treatment sub-system 11 where predetermined scale forming components, such
as carbonate, are removed therefrom and it is fed as feed water \( W_F \), via the condenser 12 and the feed heater 21, to the multi-effect evaporator 13, where main desalination process takes place and three main products are produced: main desalted water \( W_M \) (not shown) which constitutes a majority of total water product \( W_{\text{TOTAL}} \) outcoming from the multi-effect evaporator 13, main brine \( B_M \) proceeding to further treatment in the desalination system, and a first condensate return \( R_1 \) flowing back to the steam supply system 50 and then is supplied as a vapor \( V_1 \) to the multi-effect evaporator 13.

The condensers 12 and 14 produce additional desalted water \( W_{\text{AL2}} \) and \( W_{\text{AL4}} \), which is produced from a vapor \( V_1' \) and withdrawn as a part of the total water product \( W_{\text{TOTAL}} \). The vapor \( V_1' \) satisfies \( V_1' = V_1 + D \), in which \( D \) refers to energy losses in the system.

Further treatment of the main brine \( B_M \) is performed in the multi-effect concentrator/crystallizer installation 15, in which concentration process, and subsequent crystallization process, take place in the corresponding PC and PCR effects of the concentrator/crystallizer installation 15, resulting in the production of:

(i) salts generally designated \( S \), and a bitterns solution \( B_S \) which are then withdrawn from the system as products having a potential of being used in the desalination plant or outside thereof;

(ii) additional desalted water \( W_{\text{AL1}} \) and \( W_{\text{AL2}} \), which is then fed to the multi-effect evaporator 13 together with an additional desalted water \( W_{\text{AL0}} \) coming from the condenser 16. \( W_{\text{AL1}}, W_{\text{AL2}} \) and \( W_{\text{AL0}} \) constitute together additional desalted water \( W_A \) which is brought in the evaporator 13 to the same temperature as the main water product \( W_M \), and from where it is then withdrawn as a part of the total water product \( W_{\text{TOTAL}} \) so that \( W_{\text{TOTAL}} = W_M + W_A + W_{\text{AL2}} + W_{\text{AL4}} \); and

(iii) second condensate return \( R_2 \) flowing to the steam supply system 50 and then is supplied as a vapor \( V_2 \) to the concentrator/crystallizer installation 15.

The additional desalted water \( W_{\text{AL1}} \) discharged from the condenser 16 is produced from a vapor \( V_2' \), which satisfies \( V_2' = V_2 + D \), in which \( D \) refers to energy losses in the system.

\( W_A \), which is a majority of the additional desalted water \( W_A \) is obtained as a result of the concentration process which takes place in the concentrator 17 [or PC effects 17 of the of the multi-effect concentrator/crystallizer installation 15], during which a brine \( B_c \) (not shown) more concentrated than the main brine \( B_M \) is produced.
The brine Bc is then used in the crystallization process, resulting in the production of the salts S, the bitterns solution BS and some more additional desalted water W_{A2}.

To operate as described above, the multi-effect evaporator 13 has evaporator inlets 13a to 13c. The inlet 13a is adapted for receiving therein the feed water Wp, the second inlet 13b is adapted for receiving therein the vapor Vi for use in the desalination process, and the third inlet 13c is adapted for receiving therein the additional desalted water W_A coming from the multi-effect concentrator/crystallizer installation 15. The evaporator 13 further comprises four evaporator outlets, namely, the outlet 13d for discharging therefrom the main product W_{TOTAL}, the outlet 13e for discharging therefrom the main brine B_M, the outlet 13f for discharging therefrom the first condensate return R_1 and the outlet 13g for discharging therefrom vapor Vi' to the condensers 12 and 14.

The concentrator/crystallizer installation 15 has two inlets, 15a and 15b, for receiving therein the main brine B_M and the vapor V_2, respectively. It further has five outlets 15c to 15g, for discharging therefrom vapor V_j' that goes to the condenser 16, the additional desalted water W_A, the bitterns solution BS, salts S and the second condensate return R_2, respectively. The outlet 15f refers to a group of outlets for discharging therefrom of different kinds of salts.

In one specific example of the system 10, salts S produced as a result of the crystallization process in the multi-effect concentrator/crystallizer installation 15 from the brine product Bc are industrial salt NaCl and calcium sulfate CaSO_4.

In such system 10, the pre-treatment sub-system 11 is adapted to remove from the seawater W mostly sulfate ions SO_4^{2-}. For this purpose, the pre-treatment system 11 may comprise de-carbonization columns 18, where acid is added to the seawater feed W and most of the sulfate ions SO_4^{2-} are removed. The sulfate ions may be substituted with anions such as chloride Cl'. Alternatively, the sulfate may be regenerated with a salt, such as Potash KCl or common salt NaCl. In this case, the solution of the respective sulfate will be created, from which a saleable commodity may be recovered by means known per se. During the pre-treatment process the alkalinity is further removed from the seawater feed together with the sulfate.

One particular example of the multi-effect evaporator 13 that may be used in the system 10 is of so-called 'forward feed flow' type, in which the feed water and the vapor both move downstream during the process. The evaporator may for example be of the
kind described in detail in PCT/IL2006/000302, which in its entirety is incorporated
herein by reference. This evaporator 13 in the described example is adapted to desalt the
water flowing therethrough so that the main brine $B_M$ released from the evaporator 13
has a salt concentration of approximately 10%. The evaporator according to the present
invention may comprise tubes as described in the above publication or fluted oval tubes.

The concentrator 17 [or PC effects 17 of the multi-effect concentrator/crystallizer installation 15] used in the system 10 may be of any appropriate type known in the art, capable to concentrate the main brine $B_M$ of the above salt concentration, to the extent that the brine product $B_c$ released therefrom has a salt concentration of approximately 20%-22%, allowing it to be further used in the production of salt products, in particular those indicated above, in the crystallizer 19.

With reference to Fig. 2, in the operation of the desalination system 30, seawater W first enters the pre-treatment sub-system 31 where predetermined scale forming components are removed therefrom, and is fed as feed water WF, via the condenser 12 and the feed heater 41, to the combined multi-effect evaporator/concentrator installation 35. In this installation 35, the following processes take place:

- the feed water WF undergoes a desalination process in the PD effects 33, which results in the production of main desalted water $W_M$ constituting a majority of total water product $W_{TOTAL}$, which is then withdrawn as a part of the total water product $W_{TOTAL}$;

- the main brine $B_M$ undergoes concentration in the PC effects 37 of the multi-effect installation 35, to produce brine $B_c$ and additional desalted water $W_A_1$, which is then withdrawn as a part of the total water product $W_{TOTAL}$.

The condensers 12 and 14 produce additional desalted water $W_{A_12}$ and $W_{A_14}$, which is withdrawn as a part of the total water product $W_{TOTAL}$.

The evaporator/concentrator installation 35 further produces a first condensate return $R_i$ which flows back to the steam supply system 50 and then is supplied as a vapor $V_i$ to thereto.

The brine $B_c$ from the multi-effect installation 35 flows to the crystallizer 39, in which a crystallization process takes place, resulting in the production of:
salt S and bitterns solution BS, which are then withdrawn from the system as products having a potential of being used in the desalination plant or outside thereof;

additional desalted water \( W_{A2} \), which is then fed to the multi-effect installation 35, constituting together with an additional water \( W_{A16} \) from the condenser 16 an additional water \( W_A \), so that \( W_A = W_{A2} + W_{A16} \), where it is brought to the same temperature as the main water product \( W_M \), and from where it is then withdrawn as a part of the total water product \( W_{TOTAL} \), so that

\[
WT_{TOTAL} = W_M + W_A + W_{A12} + W_{A14} + W_{A16} \quad \\
\]

second condensate return \( R_2 \) flowing to the steam supply system 50 similarly to be then supplied to the crystallizer 39 as a vapor \( V_2 \).

To operate as described above, the multi-effect installation 35 has multi-effect installation inlets 35a to 35c. The inlet 35a is adapted for receiving therein the feed water \( W_f \), the second inlet 35b is adapted for receiving therein the vapor \( V_1 \) for use in the desalination process, and the third inlet 35c is adapted for receiving therein the additional desalted water \( W_A \), coming from the crystallizer 39. The installation 35 further comprises four multi-effect installation outlets, namely, the outlet 35d for discharging therefrom the main product \( W_{TOTAL} \), the outlet 35e for discharging therefrom the brine product \( Bc \), the outlet 35f for discharging therefrom the first condensate return \( R_1 \) and the outlet 35g for discharging therefrom vapor \( Vc \) that goes to the condensers 12 and 14.

The crystallizer 39 has two crystallizer inlets, 39a and 39b, for receiving therein the brine product \( Bc \) and the vapor \( V_2 \), respectively. It further has five crystallizer outlets 39c to 39g, for discharging therefrom vapor \( Vc \) that goes to the condenser 16, the additional desalted water \( W_{A2} \), the bitterns solution BS, salts S and the second condensate return \( R_2 \), respectively. The outlet 39f refers a group of outlets for discharging therefrom of different kinds of salts, is desired.

In one particular example of the system 30, the salt S produced by the crystallizer 39 is industrial salt NaCl.

The pre-treatment sub-system 31 in such system 30 is adapted to remove substantially all calcium ions from the seawater \( W \). For this purpose, the pre-treatment system 31 may comprise a reactor 43 and a clarifier 44. During the pre-treatment process calcium ions from the seawater \( W \) react with soda ash \( Na_2CO_3 \) in the reactor 43
and hardly-soluble calcium carbonate CaCO₃ is created and then precipitates and removed from the seawater W in the clarifier 44. Optionally, a soluble base, such as caustic soda NaOH, in an amount substantially equivalent to the content of bicarbonate ion HCO₃⁻ in the seawater W, may be added thereto, thereby saving about one fourth of the required amount of soda ash. During the above process sulfates is removed together with calcium carbonate.

The multi-effect evaporator/concentrator installation 35 may have a configuration similar to that of the multi-effect evaporator 13, with a difference being mainly in that its PD effects 33 (not shown) are followed by the PC effects 37 (not shown). In the present example, the brine Bₘ produced by the PD effects 33 may have salt concentration of approximately 10%, and the brine Bₜ which produced therefrom by the PC effects 37 may have salt concentration of approximately 20%-22%.

An additional difference between the PD and PC effects in the installation 35 may be in that at least a part of the pipes and tubes in the PC effects 37 may be made of material different from the material of the pipes and tubes in the PD effects, to better withstand increased salt concentration of the brine passing therethrough.

The pre-treatment processes of sub-systems 11 and 31 of the systems 10 and 30 in the examples described above prevent scale and corrosion of the equipment used in the systems 10 and 30. Removing both calcium carbonate and sulfate in the sub-system 31, in addition, allows the multi-effect evaporator 33 to run smoothly even though brine having a high salt concentration flows therein.

Table 1 summarizes, in a non-limiting manner, parameters which the systems 10 and 30 may have, in accordance with the examples described above with reference to Fig. 1 and Fig. 2.

Table 1

<table>
<thead>
<tr>
<th>Parameter</th>
<th>System 10</th>
<th>System 30</th>
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<tbody>
<tr>
<td>Feed of seawater W [kg/hr]</td>
<td>625,237</td>
<td>625,100</td>
</tr>
<tr>
<td>Feed of cooling seawater to the condenser 14 [kg/hr] from a cooling tower T.</td>
<td>364,000</td>
<td>578,000</td>
</tr>
<tr>
<td>Feed of cooling seawater to the condenser 16 [kg/hr]</td>
<td>4,118,000</td>
<td>1,644,000</td>
</tr>
<tr>
<td>Feed of steam to the evaporator 13/multi-effect</td>
<td>25,700</td>
<td>40,800</td>
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As summarized in Table 1, there are differences between consumptions of the cooling water supplied to the condensers 14 and 16 and the steam supplied to different parts of the two systems 10 and 30. In particular, in the system 10 the steam consumption is 76,560 kg/hr and cooling water consumption is 4,482,000 kg/hr. In the system 30 the steam consumption is 61,100 kg/hr and cooling water consumption is 2,222,000 kg/hr. The main reason for this difference is the configurations of the multi-effect evaporators 13 and 33. The evaporator 33 consumes less steam. Consequently, less cooling water is required.

Based on the above Table 1, water and brine rates may be approximately calculated for the systems 10 and 30.

System 10

Main desalted water discharged from the evaporator 13 is calculated as follows:

\[ W_M = W_{TOTAL} - W_A = 590,950 - 174,300 = 416,650 \text{ kg/hr} \]

\[ \frac{W_M}{W} \times 100 = \frac{416,650}{625,237} \times m = 66.6\% \]
Additional desalted water discharged from the concentrator and the crystallizer:

\[
W^1_{\text{A/L}} = \frac{W^1_{\text{L}}}{W} \cdot 100 = \frac{1743}{625237} \cdot 100 = 27.8
\]

System 30

Main desalted water \(W_M^1\) and additional desalted water \(W_{A1}^1\) discharged from the multi-effect installation 35 is calculated as follows:

\[
\{W_M + W_{A1}\} = \frac{W_{\text{TOTAL}}}{W} = 591900 - 71100 = 520800 \text{ kg/hr}
\]

\[
\{W_M + W_{A1}\} = \frac{W_{\text{TOTAL}}}{W} \cdot 100 = 83.3
\]

Desalted water discharged from the crystallizer is calculated as follows:

\[
W_{\text{P}1} \cdot \frac{E_{\text{A}1}}{W} \cdot \frac{100}{100} = \frac{520800}{625100} - 100 = 83.3
\]

Total water recovery is calculated as follows:

\[
W_{\text{TOTAL}} \cdot 100\% = \frac{W_{\text{TOTAL}}}{W} \cdot 100
\]

System 10: \(W_{\text{TOTAL}} = \frac{590950}{625237} \cdot 100 = 94.5\)

System 30: \(W_{\text{TOTAL}} = \frac{591900}{625100} - 100 = 94.6\)

As shown above, both systems 10 and 30 are adapted for recovering of almost 95% of the water content of the feed seawater \(W\). It can be further roughly estimated from the above calculations, that water recovery is divided between different parts of the system as follows: evaporator/PC effects - about 65% (66.6%) of the total recovery, crystallizer/PCR effects - about 15% (11.3%) of the total recovery, and concentrator/PC effects - about 15% of the total recovery (95-65-11.3 = 18.7%).

The remaining 5% are salts and bitterns solution, whose contents are determined by the kind of the pre-treatment that is applied to the feed water \(W\).

Those skilled in the art to which this invention pertains will readily appreciate that numerous changes, variations, and modification can be made without departing from the scope of the invention, mutatis mutandis.
CLAIMS:

1. A system for desalination of seawater $W$ having an original water salinity and a
original water concentration of scale forming components, the system comprising:
   - a pre-treatment sub-system for at least partial removal from said water $W$ of said
   scale forming components, producing thereby a pre-treated feed water having a
   first concentration of scale forming components lower than said original
   concentration of scale forming components;
   - a forward feed flow multi-effect evaporator adapted for distillation of said pre-
   treated feed water, producing thereby main desalted water product $W_M$ having a
   desalted water salinity lower than said water salinity, and main brine having a
   salt concentration of approximately 10%;
   - a concentrator adapted for receiving therein said main brine and concentrating it,
   producing thereby more concentrated brine with an increased salt concentration
   of approximately 20%-22%, and releasing a first additional desalted water
   product $W_1$; and
   - a crystallizer for receiving said more concentrated brine, adapted for
   crystallization thereof to obtain at least solid salt products and releasing a second
   additional desalted water product $W_2$.

2. A system according to Claim 1, wherein amount of said main water product $W_M$
approximately equals to 0.65W.

3. A system according to Claims 1 or 2, wherein amount of said first additional
water $W_1$ approximately equals to 0.15W.

4. A system according to anyone of Claims 1 to 3, wherein amount of said second
additional water $W_2$ approximately equals to 0.15W.

5. A system according to anyone of Claims 1 to 4, wherein the scale forming
components are at least sulfate ions.

6. A system according to Claim 5, wherein the pre-treatment system comprises at
least de-carbonization columns adapted for removing said sulfate ions.

7. A system according to anyone of Claims 1 to 6, wherein the scale forming
components are at least calcium ions.
8. A system according to Claim 7, wherein the pre-treatment system comprises a reactor adapted for creating calcium carbonate by reacting said calcium ions with soda ash.

9. A system according to Claim 8, wherein the pre-treatment system comprises a clarifier adapted for removing said calcium carbonate.

10. A system according to anyone of Claims 1 to 9, wherein the concentrator constitutes a part of a single multi-effect evaporator/concentrator installation.

11. A system according to anyone of Claims 1 to 10, wherein the concentrator constitutes a part of a single multi-effect concentrator/crystallizer installation.

12. A method of desalination of a seawater having a original water salinity and a concentration of scale forming components, the method comprising:

   - at least partial removal from said seawater of said scale forming components and producing a pre-treated feed water having a first concentration of scale forming components lower than said feed water concentration of scale forming components;

   - distillation of said pre-treated feed water by a forward feed flow multi-effect evaporator and producing main desalted water product \( W_M \) having a desalted water salinity lower than said original water salinity, and main brine having a salt concentration of approximately 10%;

   - producing from said main brine a more concentrated brine with increased salt concentration of approximately 20%-22%; and

   - crystallizing said more concentrated brine and obtaining at least one salt product therefrom.

13. A method according to Claim 12, further comprising removing said scale forming components by means of de-carbonization columns.

14. A method according to Claims 12 or 13, further comprising removing said scale forming components by means of a reactor and a clarifier.

15. A method according to anyone of Claims 12 to 14, further comprising producing said main brine by said evaporator.

16. A method according to anyone of Claims 12 to 15, further comprising providing a concentrator.

17. A method according to Claim 16, further comprising producing said more concentrated brine by said concentrator.
FIG. 2
**INTERNATIONAL SEARCH REPORT**

**International application No**

PCT/IL2009/000864

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**A. CLASSIFICATION OF SUBJECT MATTER**

INV. B01D1/26 C02F1/04

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**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

BOID C02F

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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

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**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document with indication where appropriate of the relevant passages</th>
<th>Relevant to claim No</th>
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<tr>
<td>Y</td>
<td>WO 99/01380 A (BOROS BELA [HU]) 14 January 1999 (1999-01-14) abstract; claims 1,7; figure 1 page 4, line 1 - page 5, line 12</td>
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<td>Y</td>
<td>US 2008/164136 A1 (OPHIR AVRAHAM [IL] ET AL) 10 July 2008 (2008-07-10) cited in the application abstract; claim 1; figures 1,2 paragraphs [0005], [0015] - [0035]</td>
<td>1-4, 10-12, 15-17</td>
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<td>Y</td>
<td>FR 2 376 079 A (HITACHI LTD [OP]) 20 July 1978 (1978-07-20) abstract; claims 1,5; figures 1,4 page 1, line 30 - page 2, line 8 page 3, line 24 - line 35 page 5, line 10 - line 18 page 6, line 17 - line 24</td>
<td>5-9,13, 14</td>
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**Further documents are listed in the continuation of Box C**

**See patent family annex**

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Date of the actual completion of the international search: 29 December 2009

Date of mailing of the international search report: 02/02/2010

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**Name and mailing address of the ISA**

European Patent Office P B 5818 Patentlaan 2 NL 2280 HV Rijswijk Tel (+31-70) 340.2040 Fax (+31-70) 340.3016

**Authorized officer**

Weber, Christian

Form PCT/ISA/21 0 (second sheet) (April 2005)
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<tr>
<td>A</td>
<td>US 4 634 533 A (SOMERVILLE ROBERT L [US]) ET AL) 6 January 1987 (1987-01-06) abstract; figure 1 column 2, line 30 - line 48 column 4, line 40 - line 45 column 5, line 39 - line 44</td>
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<td>A</td>
<td>GB 1 083 637 A (FEDOR PETROVICH ZAOSTROVSKY; VADIM GENRIKHOVICH SHATSILLO; SEMEN ITSKO) 20 September 1967 (1967-09-20) page 1, line 19 - page 2, line 40; claim 1; figure 1</td>
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<td>A</td>
<td>US 3 376 204 A (TIDBALL ROBERT A) 2 April 1968 (1968-04-02) abstract; claims 1-7; figure 1 column 1, line 58 - column 2, line 47</td>
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## INTERNATIONAL SEARCH REPORT

**International application No**: PCT/IL2009/000864

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<td>wo 9901380 A</td>
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<td>AU 8352198 A</td>
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<td>HU 9701148 A2</td>
<td>29-06-1998</td>
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