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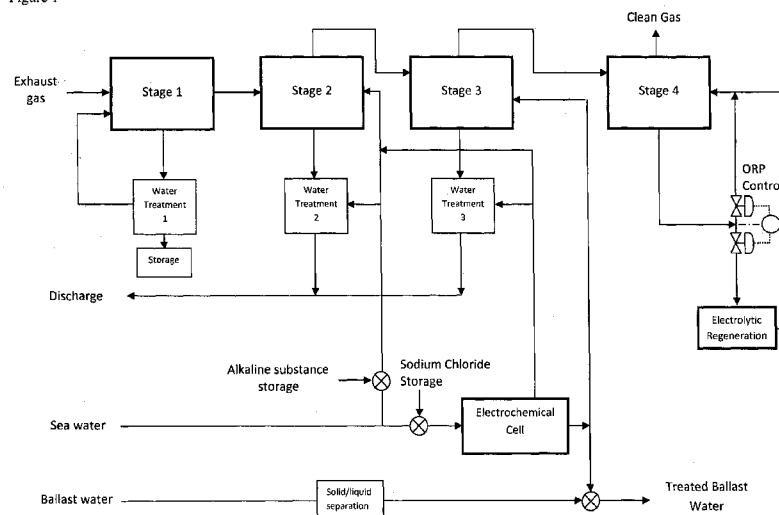
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[Continued on next page]

(54) Title: SYSTEMS AND METHODS FOR EXHAUST GAS CLEANING AND/OR BALLAST WATER TREATMENT

Figure 1



(57) Abstract: Embodiments of the present invention relate to a system and method for efficient removal of sulfur oxides (SOx), nitrogen oxides (NOx) and particulate matter (PM) contained in an exhaust gas generated from fuel combustion and efficient treatment of water containing microorganisms (e.g. ballast water).

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— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

**(88) Date of publication of the international search report:**  
27 December 2012

# INTERNATIONAL SEARCH REPORT

International application No PCT/SG2012/000095
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<b>A. CLASSIFICATION OF SUBJECT MATTER</b> INV. B01D53/50      B01D53/75      B01D53/92      B01D53/96      C02F1/467 ADD.		
According to International Patent Classification (IPC) or to both national classification and IPC		
<b>B. FIELDS SEARCHED</b>		
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) EPO-Internal, WPI Data		
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2010/104989 A1 (CALERA CORP [US]; FARSAD KASRA [US]; ELLIOTT ROBERT W [US]; O'CONNOR R) 16 September 2010 (2010-09-16) paragraphs [0006], [0718], [0080] - [0083], [0091], [0165], [0307]; figures 2,6c -----	1,2
X	US 3 781 407 A (KAMIJO T ET AL) 25 December 1973 (1973-12-25) figures 2,3 column col.1, line 54 - line 63 column 2, line 10 - line 24 column 5, line 29 - line 69 -----	1,2
X	EP 0 295 908 A2 (BECHTEL GROUP INC [US]) 21 December 1988 (1988-12-21) page 2, line 19 - line 28 page 3, line 30 - line 34 -----	1,2
-/--		
<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <span style="margin-left: 200px;"><input checked="" type="checkbox"/> See patent family annex.</span>		
* 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 application or patent 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	
15 June 2012	19/10/2012	
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  Burkhardt, Thorsten	

# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/SG2012/000095

## Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1.  Claims Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:
  
2.  Claims Nos.:  
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
  
3.  Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

## Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1.  As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2.  As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
3.  As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4.  No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

2(completely); 1(partially)

### Remark on Protest

- The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- No protest accompanied the payment of additional search fees.

# INTERNATIONAL SEARCH REPORT

International application No  
PCT/SG2012/000095

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 337 230 A (ELLESTAD ARNE ET AL) 29 June 1982 (1982-06-29) column 1, line 6 - line 11 column 4, line 58 - column 5, line 12 -----	2

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No PCT/SG2012/000095
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2010104989 A1	16-09-2010	AU 2010201373 A1	30-09-2010
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		US 4337230 A	29-06-1982
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**FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210**

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 2(completely); 1(partially)

Process for the removal of SO<sub>x</sub> from an exhaust gas comprising dosing at least one alkaline additive substance to form alkaline seawater with a pH of from 8-12 and contacting the exhaust gas with the alkaline seawater as scrubbing agent. The alkaline additive is introduced from an onboard storage or from the cathode side of an electrochemical cell.  
- The used scrubbing agent is adjusted to a pH of 6.5-9 by neutralization with alkaline additive substance.

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2. claims: 3(completely); 1(partially)

Process for the removal of SO<sub>x</sub> from an exhaust gas comprising dosing at least one alkaline additive substance to form alkaline seawater with a pH of from 8-12 and contacting the exhaust gas with the alkaline seawater as scrubbing agent. The alkaline additive is introduced from an onboard storage or from the cathode side of an electrochemical cell.  
- The alkaline additive substance is chosen from an alkaline (earth) metal hydroxide, carbonate, bicarbonate, oxide, sulphite or silicate.

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3. claims: 4(completely); 1(partially)

Process for the removal of SO<sub>x</sub> from exhaust gas comprising dosing at least one alkaline additive substance to form alkaline seawater with a pH of from 8-12 and contacting the exhaust gas with the alkaline seawater as scrubbing agent. The alkaline additive is introduced from an onboard storage or from the cathode side of an electrochemical cell.  
- The alkaline additive substance and the seawater form a solution, a colloid or a slurry

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4. claims: 5, 6, 8-10(completely); 1(partially)

Process for the removal of SO<sub>x</sub> from exhaust gas comprising dosing at least one alkaline additive substance to form alkaline seawater with a pH of from 8-12 and contacting the exhaust gas with the alkaline seawater as scrubbing agent. The alkaline additive is introduced from an onboard storage or from the cathode side of an electrochemical cell.  
- The alkaline additive substance is produced using an electrochemical cell from sea water or sodium chloride containing water. The sodium chloride may be introduced from an onboard storage.  
- Furthermore, ballast water may be disinfected using the oxidising agent generated at the anode side of the electrochemical cell.

**FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210**

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## 5. claims: 7(completely); 1(partially)

Process for the removal of SO<sub>x</sub> from exhaust gas comprising dosing at least one alkaline additive substance to form alkaline seawater with a pH of from 8-12 and contacting the exhaust gas with the alkaline seawater as scrubbing agent. The alkaline additive is introduced from an onboard storage or from the cathode side of an electrochemical cell.

- The scrubber has a one-through or multiple recirculation configuration.

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## 6. claims: 11, 12

A two step neutralization process for the removal of SO<sub>x</sub> from exhaust gas comprising :

- an open-loop first step neutralization to remove SO<sub>x</sub> from the gas
- a closed loop second step neutralization
- pH and oxidation-reduction potential adjustment of the used solvent using an electrochemical cell and aeration, respectively
- various monitoring and control steps

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## 7. claims: 13-17

A closed loop process for the removal of NO<sub>x</sub> using a scrubber with a reducing agent for creating a low oxidation-reduction-potential condition, regeneration and recirculation. Optional pre-treatment step to convert NO into NO<sub>2</sub>.

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