



(51) International Patent Classification:

B01D 3/00 (2006.01) **F26B 3/02** (2006.01)
F26B 21/00 (2006.01) **C12P 7/08** (2006.01)
B01D 5/00 (2006.01)

(21) International Application Number:

PCT/FI2010/050955

(22) International Filing Date:

23 November 2010 (23.11.2010)

(25) Filing Language:

Finnish

(26) Publication Language:

English

(30) Priority Data:

20096239 24 November 2009 (24.11.2009) FI

(71) Applicant (for all designated States except US): **ST1 BIOFUELS OY** [FI/FI]; Purotie 1, FI-00380 Helsinki (FI).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **PASANEN, Antti** [FI/FI]; Lugnetintie 3 A 2, FI-02770 Espoo (FI). **AHOKAS, Mikko** [FI/FI]; Strömbergintie 8 B 43, FI-00380 Helsinki (FI). **NIEMI-KORPI, Reetta** [FI/FI]; Ojahaantie 11 B 17, FI-01600 Vantaa (FI).(74) Agent: **BORENIUS & Co Oy Ab**; Tallberginkatu 2 A, FI-00180 Helsinki (FI).

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

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

(54) Title: APPARATUS FOR RECOVERY OF ORGANIC COMPOUNDS AND DRYING OF ORGANIC MASS

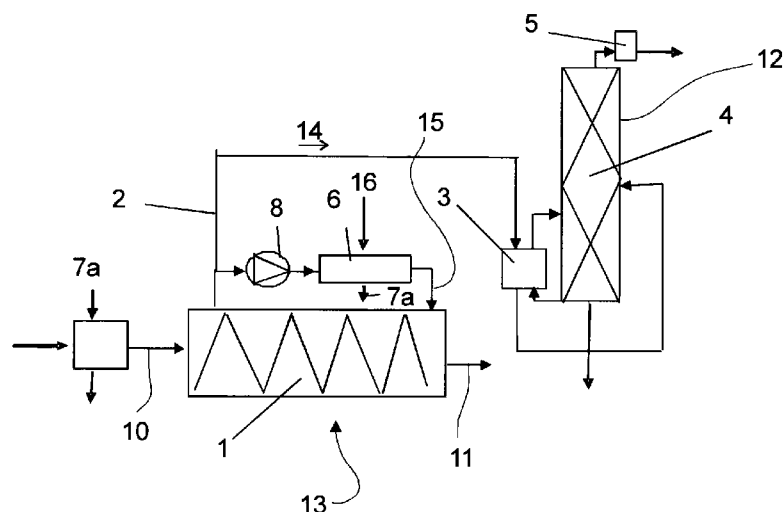


FIG1

(57) Abstract: The invention relates to an apparatus for recovery of organic compounds and drying organic mass. The apparatus comprises a dryer (13) incorporating a dryer vessel (1) equipped with a material inlet nozzle (10), a material outlet nozzle (11) and a gas discharge nozzle (2). The apparatus comprises a column (4) communicating with the gas discharge nozzle (2) of the dryer vessel (1) for feeding discharge gas (14) exiting via the gas discharge nozzle (2) of the dryer vessel (1) to the column (4) in order to concentrate in the column (4) the discharge gas (14) or the portion of the discharge gas (14) at least partially condensed. To the gas discharge nozzle (2) is connected a boiler (3) for transferring the thermal energy of the discharge gas (14) flowing through the gas discharge nozzle (2) at least partially to the column (4).

APPARATUS FOR RECOVERY OF ORGANIC COMPOUNDS AND DRYING OF ORGANIC MASS

Background of invention

5 The invention relates to an apparatus in accordance with the preamble of claim 1 for recovery of organic compounds and drying of organic mass.

 The apparatus disclosed in the invention is particularly suited for continuous or batchwise recovery of highly volatile organic compounds and drying organic mass.

10 The most crucial problem in the recovery of volatile organic compounds from a solid mass is related to the low thermal conductivity of a solid mass and the easily inflammable compounds contained therein.

 While possibly operating at an extremely high specific energy consumption, dryers using direct heating by steam may have a high efficiency. Also in the art are
15 known hot-air blowers operating with the risk that their hot air in combination with easily flammable organic compounds such as ethanol can form an explosive mixture. Further known is an SHS dryer that can be advantageously used for drying.

Brief summary of the invention

20 Now a method has been invented that is extremely efficient and safe in use at a low specific energy consumption.

 To the end of achieving its goal, the invention is characterized by the features disclosed in the appended independent claims.

 The other claims describe other preferred embodiments of the invention.

25 In the apparatus according to the invention, the gas outlet nozzle of the dryer apparatus, advantageously similar to that of a prior-art dryer apparatus disclosed in patent publication PCT/FI2005/050300, is connected to a boiler and routed therefrom to a concentrating and/or stripping column. The condenser of the distillation column may have a vacuum pump connected thereto.

30 The dryer according to the invention may use the bottom product of the stripping column for preheating the organic mass.

The method described herein offers extremely efficient energy utilization as the distillation column dispenses with the need for supplementary energy, e.g., for bioethanol concentration.

According to a preferred embodiment of the invention, the apparatus is
5 essentially gas-tight.

According to a preferred embodiment of the invention, the dryer incorporates one or more dryer vessels for final drying of the discharged organic mass.

The invention may advantageously use mechanical recompression.

According to a preferred embodiment of the invention, the dryers are con-
10 nected in such a fashion that the surplus energy of the first-stage dryer can be utilized in the subsequent stage with the help of mechanical steam recompression.

According to a preferred embodiment of the invention, the method is employed for recovery of highly volatile compounds from difficult-to-process organic or inorganic masses, such as mash resulting from ethanol production.
15 Generally, these masses are difficult to pump. Organic masses falling in this category may comprise fermented organic masses, as well as fermented waste containing highly volatile compounds such as ethanol, methanol, carbon dioxide, organic acids or sulfur.

20 **Brief description of the drawings**

Next some preferred exemplary embodiments of the invention are described in more detail by way of making reference to the appended drawings in which

Fig. 1 shows a single-stage dryer and a concentrating and/or stripping column
and

25 Fig. 2 shows a two-stage MVR dryer and a concentrating and/or stripping column.

Detailed description of the invention

The invention relates to an apparatus for recovery of organic compounds such
30 as water-containing organic compounds and drying organic mass.

The apparatus comprises a dryer 13 incorporating a dryer vessel 1 with a material inlet nozzle 10, a material outlet nozzle 11 and a gas discharge nozzle 2.

Dryer 13 comprises advantageously, but not necessarily, means for mixing the mass being dried during drying. It is further possible that dryer 13 incorporates a rotatable unit similar to a drum dryer (not shown in the diagrams) for mixing the mass being dried during the drying process.

5 The apparatus comprises a column 4 communicating with the gas discharge nozzle 2 of the dryer vessel 1 for feeding discharge gas 14 exiting via the gas discharge nozzle 2 of the dryer vessel 1 to column 4 for concentrating the discharge gas 14 contained in column 4. The function of column 4 may be, e.g., to strip by evaporation the discharge gas 14 free from, e.g., water and other components having
10 even higher volatility, such as ethanol.

To the gas discharge nozzle 2 is connected a boiler 3 for transferring the thermal energy of the discharge gas 14 flowing through the gas discharge nozzle 2 at least partially to column 4 prior to feeding the discharge gas 14 to column 4.

15 The boiler incorporates advantageously but not necessarily a heat exchanger for transferring the thermal energy of the discharge gas 14 flowing through the heat exchanger to the portion of discharge gas 14 contained in column 4 or to the discharge gas 14 that has at least partially been condensed in the column.

The column 4 is advantageously but not necessarily a distillation and/or stripping column.

20 The dryer vessel 1 includes a gas inlet nozzle 15. In Fig. 1 the gas discharge nozzle is of the dryer vessel 1 is shown communicating with the gas inlet nozzle 15 of the dryer vessel in such an arrangement that between the gas outlet nozzle and the gas inlet nozzle 15 is adapted a fan 8 for circulating discharge gas 14 back to the dryer vessel as a circulating gas. As further shown in Fig. 1, between the gas outlet
25 nozzle 2 and the gas inlet nozzle 15 is adapted a superheater 6 for elevating the temperature of the circulating gas. The apparatus may comprise an arrangement 7a, 7b for utilizing the condensate created in the superheater for predrying the material being fed into the dryer vessel.

30 The dryer 13 is advantageously but not necessarily essentially gas-tight in such a fashion that, e.g., the only outlet of the gas contained in the dryer is the gas outlet nozzle 2.

As shown in Fig. 2, the apparatus may incorporate a plurality of dryers 13 connected in series in such a fashion that the material outlet nozzle 11 of one upstream dryer 13 is connected to the material inlet nozzle 10 of another dryer 13 downstream in the process and/or acts as the material inlet nozzle 10 of the other
5 dryer.

In the case that the apparatus comprises a plurality of dryers, advantageously but not necessarily the apparatus comprises a fan 9 is incorporated for transferring the discharge gas 14 of the upstream dryer 13 to the downstream dryer 13. For instance, it is possible that the gas discharge nozzle 2 of the upstream dryer 13 is
10 adapted to communicate with the gas inlet nozzle 15 of the downstream dryer 13. A further possible arrangement is such that the downstream dryer 13 incorporates a gas discharge nozzle communicating with the gas discharge nozzle 15 of said downstream dryer 13 for recirculating the discharge gas 14 back to said downstream dryer vessel 1 and that between the gas discharge nozzle of the downstream dryer 13
15 and the gas discharge nozzle 15 is adapted a fan 8 and a superheater 6 and that the gas discharge nozzle 2 of the upstream dryer 13 communicates with the superheater 6. Fan 9 is advantageously but not necessarily adapted to elevate the pressure of discharge gas 14.

As shown in the diagrams, column 4 incorporates a condenser 12 having a
20 vacuum pump 5 connected thereto for generating a vacuum at the gas discharge nozzle 2 via the condenser 12. The vacuum level of the discharge gas 14 is advantageously but not necessarily in the range of 100 – 800 mbar.

In Fig. 1 is shown an apparatus comprising a dryer vessel 1 having a gas discharge nozzle 2. To the gas discharge nozzle is connected a boiler 3. The boiler
25 serves as boiler vessel for the concentration and/or stripping column 4. To the condenser of the concentration and/or stripping column is connected a vacuum pump 5. Energy infeed is advantageously accomplished by feeding steam, particularly superheated steam, or hot oil 16 to the superheater 6. In a conventional fashion the saturated steam circulated with the help of fan 8. The excess energy of the superheater can
30 be utilized in preheating stage 7a for preheating the material being fed to dryer vessel 1.

In Fig. 2 is illustrated an apparatus layout having two dryers of the type shown in Fig. 1 connected in series in such a way that the gas discharge nozzle 2 of the first dryer is connected to the superheater 6 of the second dryer. Fan 9 is connected to the gas discharge nozzle. In the fashion shown in Fig. 2 the excess energy of superheater 6 of the upstream dryer 13 is utilized in preheater stage 7a for preheating the material being fed into dryer vessel 1 and the excess energy of the superheater 6 of downstream dryer 13 is employed in column 4 by way of feeding condensate 7b into column 4.

10 Example

Next is described an exemplary embodiment of process parameters for a recovery process of a volatile compound such as ethanol from an organic mass received as fermented biowaste:

- fermented biowaste, dry solids content 20 %, EtOH content 2 %, temperature in dryer 200 °C, infeed material 2000 kg/h,
- evaporated mass 1400 kg/h,
- recovery of concentrated ethanol 400 kg/h,
- superheated steam (pressure 15 bar),
- dryer vessel pressure 800 mbar,
- distillation column pressure 400 mbar,
- dried biowaste (dry solids content 60 %) 600 kg/h,
- steam consumption 800 kg/h.

To a person skilled in the art it is obvious that the spirit of the invention may be implemented in a plurality of different ways along developments in the state of the art. Hence, the invention and its implementations are not limited by the above-described exemplary embodiments, but rather may be varied within the inventive spirit and scope of the appended claims.

What is claimed is:

1. An apparatus for recovery of organic compounds and drying organic mass, the apparatus comprising
 - 5 a dryer (13) incorporating a dryer vessel (1) equipped with a material inlet nozzle (10), a material outlet nozzle (11) and a gas discharge nozzle (2),
characterized in that
 - the apparatus comprises a column (4) communicating with the gas discharge nozzle (2) of the dryer vessel (1) for feeding discharge gas (14) exiting via the gas discharge nozzle (2) of the dryer vessel (1) to the column (4) in order to concentrate
 - 10 in the column (4) the discharge gas (14) or the portion of the discharge gas (14) at least partially condensed, and
 - to the gas discharge nozzle (2) is connected a boiler (3) for transferring the thermal energy of the discharge gas (14) flowing through the gas discharge nozzle (2)
15 at least partially to the column (4).
2. The apparatus of claim 1, **characterized** in that said boiler (3) incorporates a heat exchanger for transferring the thermal energy of the discharge gas (14) flowing through the heat exchanger to the portion of discharge gas 14 contained in column
 - 20 (4) or to the discharge gas in the column (14) that gas has at least partially been condensed.
3. The apparatus of claim 1 or 2, **characterized** in that said column (4) is a distillation and/or stripping column.
 - 25
4. The apparatus according to any of the claims 1 - 3, **characterized** in that
 - the dryer vessel (1) incorporates a gas inlet nozzle (15) and
 - the gas outlet nozzle (2) of the dryer vessel communicates with the gas inlet nozzle (15) of the dryer vessel in such a fashion that between the gas outlet nozzle (2) and the gas inlet nozzle (15) is adapted a fan (8) for recirculating the discharge gas (14) back to the downstream dryer vessel (1) as recirculating gas.
 - 30

5. The apparatus of claim 4, **characterized** in that between the gas outlet nozzle (2) and the gas inlet nozzle (15) is adapted a superheater (6) for elevating the temperature of the recirculating gas.

5 6. The apparatus of claim 5, **characterized** in that the apparatus comprises an arrangement for utilizing the condensate created in the superheater for predrying the material being fed into the dryer vessel.

7. The apparatus according to any of the claims 1 - 6, **characterized** in that the
10 dryer (13) is essentially gas-tight.

8. The apparatus according to any of the claims 1 - 7, **characterized** in that the apparatus incorporates a plurality of dryers (13) connected in series in such a fashion that the material outlet nozzle (11) of one dryer is connected to the material inlet
15 nozzle (10) of another dryer (13) and/or acts as the material inlet nozzle (10) of the other dryer.

9. The apparatus of claim 8, **characterized** in that the apparatus incorporates a fan (9) for transferring the discharge gas (14) of the upstream dryer (13) to the
20 downstream dryer (13).

10. The apparatus of claim 9, **characterized** in that the gas outlet nozzle (2) of the upstream dryer (13) communicates with the gas inlet nozzle (15) of the downstream dryer (13).
25

11. The apparatus of claim 10, **characterized** in that
- the downstream dryer (13) incorporates a gas discharge nozzle (2) communicating with the gas discharge nozzle (15) of said downstream dryer (13) for recirculating the discharge gas (14) back to said downstream dryer vessel (1),
30 - between the gas discharge nozzle (2) of the downstream dryer (13) and the gas discharge nozzle (15) is adapted a fan (8) and a superheater (6), and

- the gas discharge nozzle (2) of the upstream dryer (13) communicates with the superheater (6).

12. The apparatus according to any of the claims 9 - 11, **characterized** in that the fan (9) is adapted to elevate the pressure of discharge gas (14).

13. The apparatus according to any of the claims 1 - 12, **characterized** in that the column (4) incorporates a condenser (12) having a vacuum pump (5) connected thereto for generating a vacuum at the gas discharge nozzle (2) via the condenser (12).

14. The apparatus of claim 13, **characterized** in that the vacuum level of the discharge gas 14 is in the range of 100 – 800 mbar.

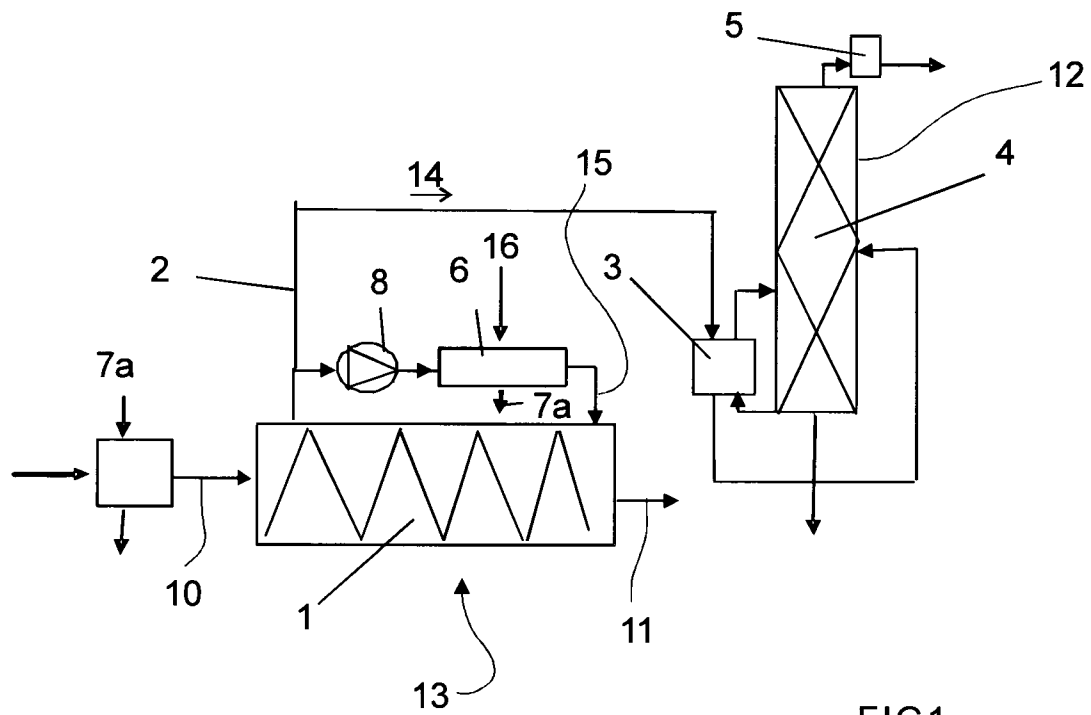


FIG1

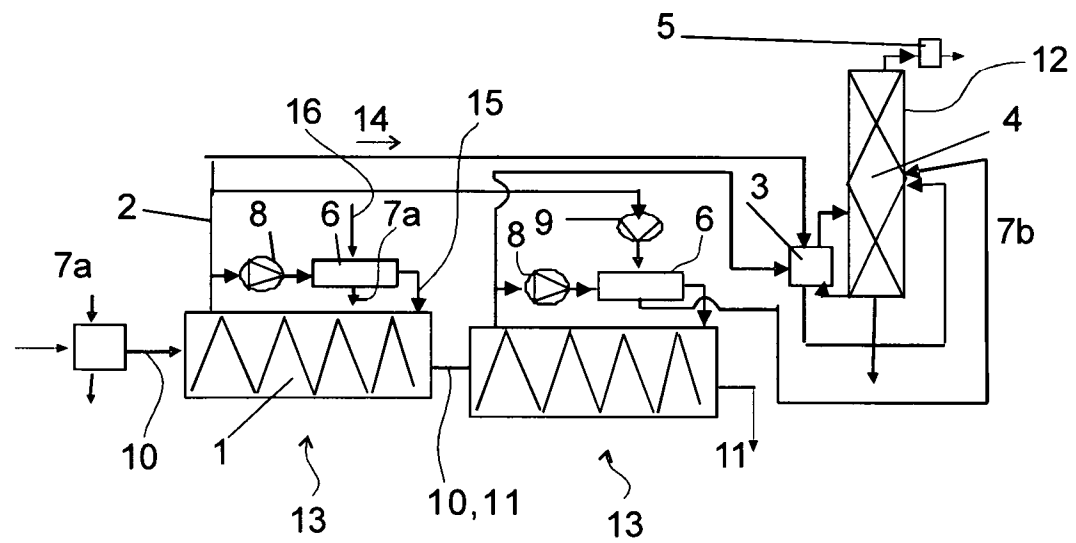


FIG2

INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI2010/050955

A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet

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)

IPC: B01D, F26B

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

FI, SE, NO, DK

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

EPO-Internal, WPI, COMPENDEX

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 4209432 A1 (HENKEL KGAA) 30 September 1993 (30.09.1993) paragraph 10, lines 8-45; paragraph 11, lines 28-31; Figure 1 and 2 & abstract [online] EPOQUENET EPODOC & WPI	1-3, 13, 14
Y		4, 5, 7, 8
Y	WO 2006024696 A1 (VÄLIMÄKI HEIMO) 09 March 2006 (09.03.2006) abstract; claims 1, 4, 5, 14, 18; Figure 1	4, 5, 7, 8
A	DE 3733748 A1 (WESTPHAL GEORG) 20 April 1989 (20.04.1989) & abstract [online] EPOQUENET EPODOC & WPI	1-14
A	WO 2008046635 A1 (GEA WIEGAND GMBH) 24 April 2008 (24.04.2008) abstract; Figure 1	1-14
A	US 4466202 A (MERTEN ULRICH) 21 August 1984 (21.08.1984) abstract; Figure 1	1-14

☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:

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

"E" earlier 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

09 March 2011 (09.03.2011)

Date of mailing of the international search report

15 March 2011 (15.03.2011)

Name and mailing address of the ISA/FI
National Board of Patents and Registration of Finland
P.O. Box 1160, FI-00101 HELSINKI, Finland

Facsimile No. +358 9 6939 5328

Authorized officer

Hetti Palonen

Telephone No. +358 9 6939 500

INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI2010/050955

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2004088230 A2 (THERMAL KINETICS SYSTEMS LLC) 14 October 2004 (14.10.2004) abstract, claims 1-28, page 14, lines 14-28; Figure 1	1-14
P, A	WO 2010005940 A1 (BROWN CHRISTOPHER J) 14 January 2010 (14.01.2010)	1-14
P, A	DE 102009000815 A1 (ACS AGROCHEMISCHE SYSTEME GMBH) 26 August 2010 (26.08.2010)	1-14

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/FI2010/050955

Patent document cited in search report	Publication date	Patent family members(s)	Publication date
DE 4209432 A1	30/09/1993	JP 7503890T T ES 2079981T T3 WO 9315816 A1 EP 0625924 A1 CA 2130005 A1 BR 9305862 A AU 3453193 A AT 130208T T	27/04/1995 16/01/1996 19/08/1993 30/11/1994 13/08/1993 18/02/1997 03/09/1993 15/12/1995
WO 2006024696 A1	09/03/2006	RU 67690U U1 EP 1800077 A1 CN 201155907Y Y FI 20045322 A	27/10/2007 27/06/2007 26/11/2008 04/03/2006
DE 3733748 A1	20/04/1989	None	
WO 2008046635 A1	24/04/2008	EP 2079539 A1 DE 102006049174 A1	22/07/2009 30/04/2008
US 4466202 A	21/08/1984	EP 0121357 A2 AT 38893T T CA 1193570 A1	10/10/1984 15/12/1988 17/09/1985
WO 2004088230 A2	14/10/2004	US 2007000769 A1 EP 1608448 A2 CA 2518809 A1	04/01/2007 28/12/2005 14/10/2004
WO 2010005940 A1	14/01/2010	CA 2730090 A1	14/01/2010
DE 102009000815 A1	26/08/2010	None	

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI2010/050955

CLASSIFICATION OF SUBJECT MATTER

Int.Cl.

B01D 3/00 (2006.01)

F26B 21/00 (2006.01)

B01D 5/00 (2006.01)

F26B 3/02 (2006.01)

C12P 7/08 (2006.01)