

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
28 February 2008 (28.02.2008)

PCT

(10) International Publication Number
WO 2008/024089 A3

(51) International Patent Classification:

B01J 19/24 (2006.01)

(21) International Application Number:

PCT/US2006/014256

(22) International Filing Date: 12 April 2006 (12.04.2006)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:

11/109,220 18 April 2005 (18.04.2005) US

(63) Related by continuation (CON) or continuation-in-part (CIP) to earlier application:

US 11/109,220 (CIP)
Filed on 18 April 2005 (18.04.2005)

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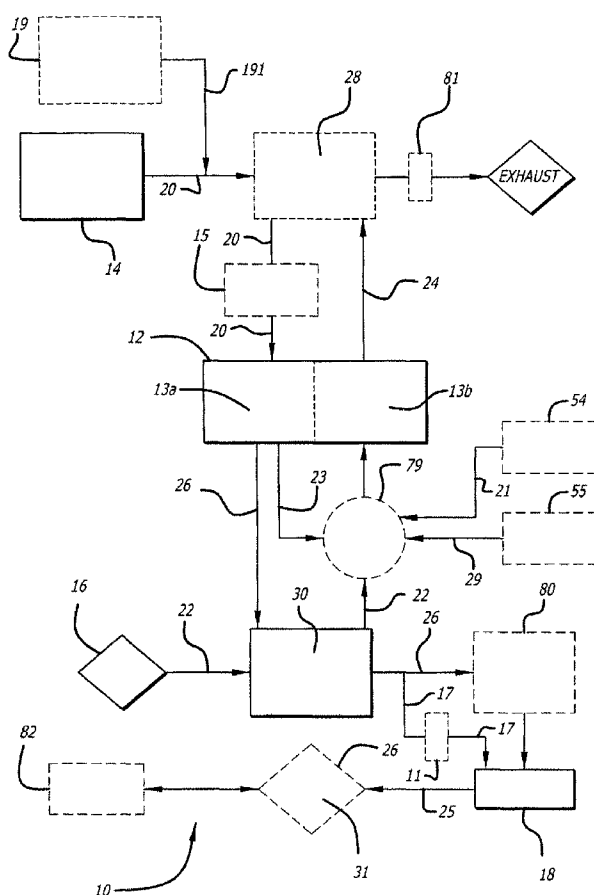
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(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU,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

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM,

[Continued on next page]

(54) Title: HYDROGEN GENERATION APPARATUS AND METHOD FOR USING SAME



(57) Abstract: A compact hydrogen generator for use with fuel cells and other applications includes a hydrogen membrane reactor having a combustion chamber and a reaction chamber. The two chambers have a fluid connection and a heat exchange relationship with one another. The hydrogen generation apparatus also includes a fuel supply, a fuel supply line for transporting fuel from the fuel supply to the reaction chamber, an oxygen supply, an oxygen supply line for transporting oxygen from the oxygen supply to the combustion chamber, as well as a tail gas supply line for transporting tail gases from the reaction chamber, a combustion by-product line for transporting combustion by-products from the combustion chamber, and a reaction product line for transporting hydrogen from the reaction chamber.



ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM),
European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI,
FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT,
RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA,
GN, GQ, GW, ML, MR, NE, SN, TD, TG).

— *before the expiration of the time limit for amending the
claims and to be republished in the event of receipt of
amendments*

Published:

— *with international search report*

(88) Date of publication of the international search report:

12 March 2009

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2006/014256

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - B01J 19/24 (2008.04)

USPC - 429/12

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(8) - B01J 19/24 (2008.04)

USPC - 429/12, 17

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)

Pat Base, Google, Google Patent

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X ----- Y	US 2002/0146604 A1 (MATOBA) 10 October 2002 (10.10.2002) entire document	38, 40 - 41 ----- 5, 39, 42, 45-54
Y	WO 02/086987 A2 (POWELL et al) 31 October 2002 (31.10.2002) entire document	1 - 9
Y	WO 03/055585 A1 (JOHNSTON et al) 10 July 2003 (10.07.2003) entire document	1 - 9
Y	US 5,997,594 A (EDLUND et al) 07 December 1999 (07.12.1999) entire document	39, 45-54
Y	US 5,360,461 A (MEINZER) 01 November 1994 (01.11.1994) entire document	42
Y	US 2004/0187386 A1 (WANGEROW et al) 30 September 2004 (30.09.2004) entire document	45-54
Y	US 2003/0191199 A1 (O'REAR) 09 October 2003 (09.10.2003) entire document	47, 49-51
A	US 6,653,005 B1 (MURADOV) 25 November 2003 (25.11.2003) column 6 lines 3-16	1-9, 38-42, 45-54

☐ Further documents are listed in the continuation of Box C.

* 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

04 December 2008

Date of mailing of the international search report

31 DEC 2008

Name and mailing address of the ISA/US

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P.O. Box 1450, Alexandria, Virginia 22313-1450

Facsimile No. 571-273-3201

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PCT Helpdesk: 571-272-4300

PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2006/014256

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 extra 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 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.:
1-9, 38-42, 45-54

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/US2006/014256

Continuation of Box III.

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I, claims 1-9, 38-42, 45-54, drawn to a hydrogen generator comprising a secondary fuel supply.

Group II, claims 10-13, drawn to a catalyst coated substrate.

Group III, claims 14-19, drawn to a separation plate.

Group IV, claims 20-27, drawn to a pretreatment chamber.

Group V, claims 28-29, drawn to a fuel heat exchanger connected to the fuel supply line and an oxygen heat exchanger connected to the oxygen supply line.

Group VI, claims 30-37, drawn to a water supply.

Group VII, claims 43-44, drawn to a methanator.

The inventions listed as Groups I-VII do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: the special technical feature of the Group I invention: a secondary fuel supply, as claimed therein is not present in the invention of Groups II-VII. The special technical feature of the Group II invention: a catalyst coated substrate as claimed therein is not present in the invention of Groups I, III-VII. The special technical feature of the Group III invention: a separation plate as claimed therein is not present in the invention of Groups I, II, IV-VII. The special technical feature of the Group IV invention: a pretreatment chamber as claimed therein is not present in the invention of Groups I, II, III or V-VII. The special technical feature of the Group V invention: a fuel heat exchanger connected to the fuel supply line and an oxygen heat exchanger connected to the oxygen supply line as claimed therein is not present in the invention of Groups I-IV, VI-VII. The special technical feature of the Group VI invention: a water supply as claimed therein is not present in the invention of Groups I-V, VII. The special technical feature of the Group VII invention: a methanator as claimed therein is not present in the invention of Groups I-VI.

Groups I, II, III, IV, V, VI, or VII lack unity of invention because even though the inventions of these groups require the technical feature of a hydrogen membrane generator, this technical feature is not a special technical feature as it does not make a contribution over the prior art in view of US 6,653,005 B1 (MURADOV) 25 November 2003 (25.11.2003) column 6 lines 3-16.

Since none of the special technical features of the Group I, II, III, IV, V, VI, or VII inventions are found in more than one of the inventions, unity of invention is lacking.