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(71) Applicant (for all designated States except US): **BP ALTERNATIVE ENERGY INTERNATIONAL LIMITED** [GB/GB]; Chertsey Road, Sunbury on Thames, Middlesex, TW16 7BP (GB).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **FORSYTH, Jonathan, Alec** [GB/GB]; Holly Cottage, Speen Lane, Newbury, Berkshire RG14 1RN (GB). **HARPER, Roger, Neil** [GB/GB]; 52 Elm Road, Kingston, Surrey KT2 6HP (GB). **HINDERINK, Antonie Pieter** [NL/NL]; Huygenslaan 81, NL-4873 GP Ellen-Leur (NL). **HUDA, Badrul** [GB/GB]; 13 Westfield Road, Woking, Surrey GU22 9LZ (GB). **VAN DER POL, Evert** [NL/NL]; Jan van Cuykstraat 19, 5482 GL Schijndel (NL).

(74) Agent: **COLLINS, Frances, Mary**; BP International Limited, Global Patents & Technology Law (Central), Chertsey Road, Sunbury on Thames, Middlesex TW16 7LN (GB).

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- as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))
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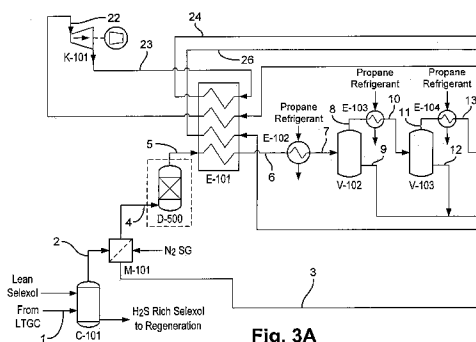


Fig. 3A

(57) Abstract: This invention relates to the recovery of carbon dioxide (26) and hydrogen (3,24) concentrated form from shifted a. synthesis gas stream comprising hydrogen and carbon dioxide thereby generating a carbon dioxide stream that is sequestered or used for enhanced oil recovery and a hydrogen stream that is used as fuel for a power plant thereby generation electricity. In the process of the present invention a shifted synthesis gas stream is fed to a hydrogen selective membrane separation unit (M101) at a pressure of at least 50 bar gauge and the hydrogen rich permeate stream (3) is fed directly to the combustor of a gas turbine without any requirement to re-compress the hydrogen. The residual gas stream (carbon dioxide enriched stream) from the membrane separation unit is cooled using at least one, preferably, at least two external refrigeration stages (E-101, E-102, E-103, E-104) such that the hydrogen containing offgas (24) is also obtained at above the operating pressure of the combustor of the gas turbine.

# INTERNATIONAL SEARCH REPORT

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## A. CLASSIFICATION OF SUBJECT MATTER

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C01B31/20

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)

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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

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                                                                                                                                                                                           | Relevant to claim No. |
|-----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| Y         | WO 2004/089499 A (FLUOR CORP [US]; REDDY SATISH [US]; VYAS SUNIL [US]; SCHERFFIUS JEFFRE) 21 October 2004 (2004-10-21)<br>cited in the application<br>page 6, line 27 - line 28<br>page 7, line 22 - line 26; figure 3<br>page 9, line 24 - page 10, line 11;<br>figures 2,3 | 1-19                  |
| P,Y       | US 2007/221541 A1 (MCCLANAHAN TIMMONS S [US] ET AL) 27 September 2007 (2007-09-27)<br>paragraphs [0067], [0087], [0089],<br>[0099], [0106]<br>figures 1,1a,1b; tables I,II<br><br>-----<br>-/--                                                                              | 1-19                  |



Further documents are listed in the continuation of Box C.



See patent family annex.

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- \*&\* document member of the same patent family

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European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040.  
Fax: (+31-70) 340-3016

Authorized officer

Göritz, Dirk

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| C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT |                                                                                                                                                                                                                                                                                                                                                                                                    |                       |
|------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| Category*                                            | Citation of document, with indication, where appropriate, of the relevant passages                                                                                                                                                                                                                                                                                                                 | Relevant to claim No. |
| A                                                    | <p>US 4 229 188 A (INTILLE GEORGE M)<br/> 21 October 1980 (1980-10-21)<br/> column 7, line 6 - line 8<br/> column 7, line 23 - line 36<br/> column 7, line 60 - column 8, line 15<br/> column 9, line 28 - line 65</p>                                                                                                                                                                             | 1,3,4,11              |
| A                                                    | <p>ROBESON L M ET AL: "High performance<br/> polymers for membrane separation"<br/> 1 November 1994 (1994-11-01), POLYMER,<br/> ELSEVIER SCIENCE PUBLISHERS B.V, GB,<br/> PAGE(S) 4970 - 4978 , XP024117916<br/> ISSN: 0032-3861<br/> [retrieved on 1994-11-01]<br/> figure 3</p>                                                                                                                  | 1,4,11                |
| A                                                    | <p>EP 0 945 163 A (GEESTHACHT GKSS FORSCHUNG<br/> [DE]; PETROLEO BRASILEIRO SA [BR])<br/> 29 September 1999 (1999-09-29)<br/> paragraphs [0007], [0009]<br/> sentences 1,2, paragraph 23<br/> paragraphs [0040], [0042], [0045] -<br/> [0047], [0049], [0051]</p>                                                                                                                                  | 1,3,9,11              |
| A                                                    | <p>WO 2006/097703 A (WEEDON GEOFFREY GERALD<br/> [TT]; TORGERSEN BJARNE [NO])<br/> 21 September 2006 (2006-09-21)<br/> page 13, line 12 - line 15<br/> page 14, line 17 - line 21<br/> page 15, line 1 - line 24<br/> page 16, line 10 - line 24<br/> page 17, line 4 - line 6<br/> page 18, line 18 - line 24<br/> page 35, line 19 - line 25<br/> page 37, line 8 - line 29<br/> figures 1,3</p> | 5-8,10,<br>14,18      |
| A                                                    | <p>US 2006/115691 A1 (HILMEN ANNE-METTE [NO]<br/> ET AL) 1 June 2006 (2006-06-01)<br/> paragraphs [0013] - [0017], [0031];<br/> figures 4,5</p>                                                                                                                                                                                                                                                    | 2,6,13                |
| A                                                    | <p>FR 2 884 305 A (AIR LIQUIDE [FR])<br/> 13 October 2006 (2006-10-13)<br/> page 6, line 11 - line 32<br/> page 9, line 27 - page 10, line 10<br/> figures 3-5</p>                                                                                                                                                                                                                                 | 14,17,19              |

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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| Patent document<br>cited in search report |    | Publication<br>date | Patent family<br>member(s)                                                                                                         | Publication<br>date                                                                                          |
|-------------------------------------------|----|---------------------|------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|
| WO 2004089499                             | A  | 21-10-2004          | AU 2004228010 A1<br>CA 2521010 A1<br>EP 1608445 A2<br>JP 2006522004 T<br>ZA 200507892 A                                            | 21-10-2004<br>21-10-2004<br>28-12-2005<br>28-09-2006<br>28-02-2007                                           |
| US 2007221541                             | A1 | 27-09-2007          | CA 2569759 A1                                                                                                                      | 21-09-2007                                                                                                   |
| US 4229188                                | A  | 21-10-1980          | NONE                                                                                                                               |                                                                                                              |
| EP 0945163                                | A  | 29-09-1999          | AT 187353 T<br>BR 9803522 A<br>CA 2247682 A1<br>CN 1229689 A<br>DE 69800049 D1<br>DE 69800049 T2<br>ES 2141628 T3<br>HK 1019413 A1 | 15-12-1999<br>14-12-1999<br>09-04-1999<br>29-09-1999<br>13-01-2000<br>03-08-2000<br>16-03-2000<br>12-04-2001 |
| WO 2006097703                             | A  | 21-09-2006          | EP 1858803 A1                                                                                                                      | 28-11-2007                                                                                                   |
| US 2006115691                             | A1 | 01-06-2006          | AU 2003288797 A1<br>EP 1590848 A1<br>JP 2006509345 T<br>WO 2004054029 A1<br>NO 320939 B1                                           | 30-06-2004<br>02-11-2005<br>16-03-2006<br>24-06-2004<br>13-02-2006                                           |
| FR 2884305                                | A  | 13-10-2006          | NONE                                                                                                                               |                                                                                                              |