



- (51) International Patent Classification:  
*B01D 63/02* (2006.01)    *B01D 53/22* (2006.01)
- (21) International Application Number:  
PCT/US2013/077205
- (22) International Filing Date:  
20 December 2013 (20.12.2013)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:  
13/755,656    31 January 2013 (31.01.2013)    US
- (71) Applicant: **THE BOEING COMPANY** [US/US]; 100 North Riverside Plaza, Chicago, Illinois 60606-2016 (US).
- (72) Inventor: **CAO, Tuan Q.**; 100 N. Riverside Plaza, Chicago, Illinois 60606 (US).
- (74) Agents: **WOO, Euclid, 45,838** et al.; The Boeing Company, P.O. Box 2515, MC 110-SD54, Seal Beach, California 90740-1515 (US).
- (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, BN, 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, IR, IS, JP, KE, KG, 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, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, 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.

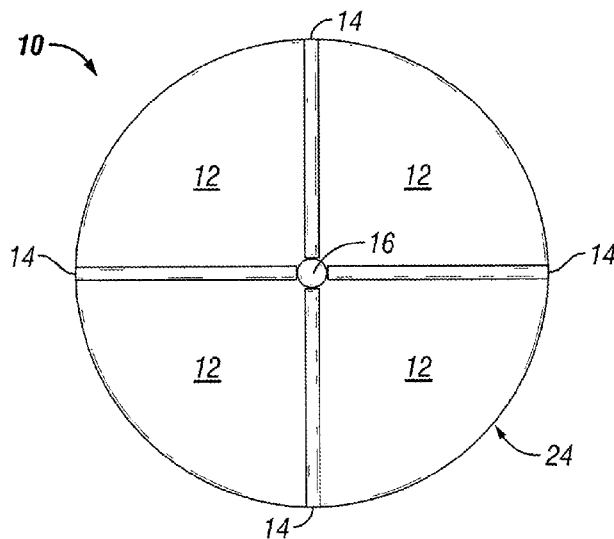
(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, 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, KM, ML, MR, NE, SN, TD, TG).

**Published:**

- with international search report (Art. 21(3))
- 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:  
31 December 2014

(54) Title: GAS SEPARATION MODULES AND METHODS FOR FORMING



**FIG. 1**

(57) Abstract: A gas separation module includes at least one inlet port, a plurality of outlet ports, and a plurality of hollow fiber membranes. Individual fibers have a feed end and a product end with a retentate interior side and a permeate exterior side. The module includes a feed tubesheet within the shell segregating the at least one inlet port and the permeate side of the fibers. The feed tubesheet includes a matrix and at least one segment joint. The segment joint separates segments of the feed tubesheet from one another. A formation method includes positioning a hollow fiber membrane material in association with at least one tubesheet segment joint and applying a matrix. The method includes forming a feed tubesheet from cured matrix and the segment joint and forming a plurality of hollow fiber membranes from the fiber material. The segment joint separates segments of the feed tubesheet from one another.



**INTERNATIONAL SEARCH REPORT**

International application No  
PCT/US2013/077205

**A. CLASSIFICATION OF SUBJECT MATTER**  
 INV. B01D63/02 B01D53/22  
 ADD.  
 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)  
 B01D  
 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

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 2 112 195 A2 (HONEYWELL INT INC [US]) 28 October 2009 (2009-10-28)	1-3,8-10
Y	paragraph [0027] - paragraph [0046]; claims 1-10	1-15
X	CA 2 823 157 A1 (ASAHI KASEI CHEMICALS CORP [JP]) 5 July 2012 (2012-07-05)	1,3-14
Y	paragraph [0019] - paragraph [0020]; figures 1-3	1-15
Y	US 2012/312162 A1 (THEODORE BRENT KENNETH [US] ET AL) 13 December 2012 (2012-12-13)	1-15
	paragraph [0055]; figure 2A	

Further documents are listed in the continuation of Box C.

See patent family annex.

\* Special categories of cited documents :

<p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier application or patent but published on or after the international filing date</p> <p>"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)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p>	<p>"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</p> <p>"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</p> <p>"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</p> <p>"&amp;" document member of the same patent family</p>
---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

Date of the actual completion of the international search  13 October 2014	Date of mailing of the international search report  27/10/2014
----------------------------------------------------------------------------------	----------------------------------------------------------------------

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  Kukolka, Florian
----------------------------------------------------------------------------------------------------------------------------------------------------------------------	--------------------------------------------

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2013/077205

Patent document cited in search report	Publication date	Patent family member(s)	Publication date	
EP 2112195	A2	28-10-2009	EP 2112195 A2	28-10-2009
			US 2009246429 A1	01-10-2009
-----				
CA 2823157	A1	05-07-2012	AU 2011350543 A1	01-08-2013
			CA 2823157 A1	05-07-2012
			CN 103298544 A	11-09-2013
			EP 2659951 A1	06-11-2013
			KR 20130093666 A	22-08-2013
			TW 201233433 A	16-08-2012
			US 2013306545 A1	21-11-2013
			WO 2012091070 A1	05-07-2012
-----				
US 2012312162	A1	13-12-2012	EP 2717997 A2	16-04-2014
			US 2012312162 A1	13-12-2012
			US 2014175227 A1	26-06-2014
			WO 2013048593 A1	04-04-2013
			WO 2013048594 A2	04-04-2013
-----				