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(54) Title: LARGE AREA MEMBRANE EVALUATION APPARATUSES AND METHODS FOR USE THEREOF

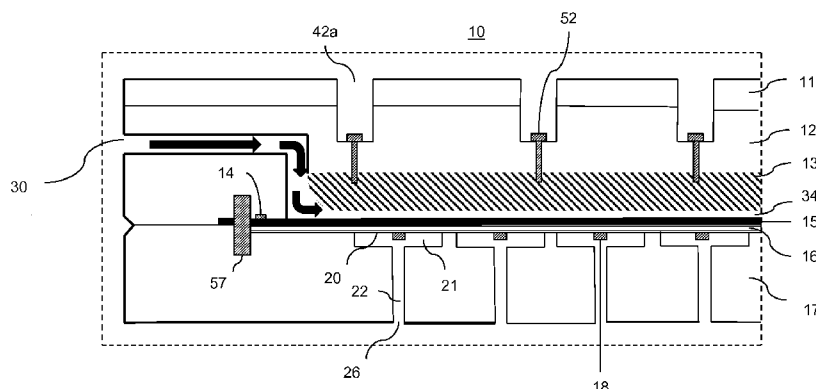


FIG. 1B

(57) **Abstract:** Permeable materials, such as perforated grapheme and other two-dimensional materials, can be used in filtration applications. However, there are presently no effective testing apparatuses or techniques to determine if a particular permeable material or other membrane is suitable for a given filtration process. Determining concentration polarization in a cross-flow filtration configuration can be especially difficult. Apparatuses disclosed herein for evaluating permeable materials, particularly perforated two-dimensional materials, in filtration membranes can include a flow channel, such as a lateral flow channel, in fluid communication with a membrane containing a permeable material, a porous substrate supporting the permeable material, and a plurality of fluid collection ports disposed laterally with respect to the flow channel. The fluid collection ports are disposed on the side of the permeable material that is opposite the flow channel. Other membranes can also be evaluated with the described apparatuses.



INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 15/22300

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - G01N 15/08 (2015.01)

CPC - G01N 15/0826; G01N 15/08; G01N 15/082

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)
CPC (G01N15/0826; G01N15/08; G01N15/082; B01D63/087; B01D65/102; B01D61/18; B01D2319/06; B01D2313/125; B01D63/082; B01D65/10; B01D2313/086; B01D2313/143; B01D63/081; B01D63/08; B01D61/12; B01D2321/10; B01D61/22; B01D65/08).

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC (73/38; 73/861.42; 210/232; 210/456; 210/475; 210/433.1; 210/321.84; 210/477; 422/562; 210/321.66; 210/321.83; 210/321.6; 210/321.69; 210/433.1; 210/424; 210/195.2; 210/636; 210/650; 210/321.78; 210/333.01; 210/321.69; 210/333.1; 210/321.8

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PatBase, Google Patents/Scholar - Terms: filtration cross-flow testing membrane module inlet feed outlet port apparatus flow channel conductive insulating permeate spacer shoe-insert filtrate direction plurality openings measure lateral length size ratio filter exit device multiple two several evaluate analyze electrical dielectric isolating upward

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6,168,714 B1 (ILIAS et al.) 02 January 2001 (02.01.2001) col 3, ln 11-25 and 41-44; col 4, ln 5-17 and 49-68; col 5, ln 1-60; figure 2A; claim 1	17
Y	US 4,846,970 A (BERTELSEN et al.) 11 July 1989 (11.07.1989) col 1, ln 29-34; col 2, ln 8-13; col 3, ln 20-44; col 4, ln 5-38 and 49-67; col 5, ln 1-45; figures 1-6	1-10
A		11-12
Y	US 2009/0277833 A1 (MIR et al.) 12 November 2009 (12.11.2009) para [0015], [0082]-[0085]; figure 5	1-10
A		11-12
Y	WO 2006/130815 A2 (WONG et al.) 07 December 2006 (07.12.2006) pg 7, ln 10-14; title	2 and 3
Y	US 5,064,515 A (HARAPANAHALLI) 12 November 1991 (12.11.1991) col 9, ln 15-31; abstract	10
A	US 2007/0056894 A1 (CONNORS) 15 March 2007 (15.03.2007) para [0020], [0033], [0036], [0053], [0067], [0075]; figures 1 and 10	11-12
A	EP 2,564,919 A1 (TUERK et al.) 06 March 2013 (06.03.2013) para [0025]; figure 1	11-12
A	US 2012/0090716 A1 (HOGSTEDT et al.) 19 April 2012 (19.04.2012) - the entire document	1
A	US 2007/0062856 A1 (PAHL et al.) 22 March 2007 (22.03.2007) abstract; para [0017], [0034]; figure 1	1

☐ 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

09 July 2015 (09.07.2015)

Date of mailing of the international search report

24 JUL 2015

Name and mailing address of the ISA/US

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 15/22300

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.: 18-22
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:
—please see supplemental box—

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.:
1-12 and 17

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.

Box III: Lack of unity

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.

Group I: Claims 1-12 and 17 directed a cross-flow filtration membrane test apparatus and method for testing membrane

Group II: Claims 13-16, directed to a cross-flow filtration membrane test apparatus including a lid, feed inserts, shoe inserts, sealing elements and connecting elements.

The inventions listed as Groups I-II 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:

Special Technical Features:

Group I does not require a lid body comprising an outer and an inner surface; a first feed insert comprising a first end and a second end, an outer surface and an inner surface, the outer surface of the first feed insert contacting the inner surface of the lid body during testing of the membrane and one of the feed inlet and the feed outlet being located at the first end of the first feed inlet; a first shoe insert comprising an outer surface and an inner surface, the outer surface of the first shoe insert connected to the inner surface of the first feed insert during testing of the membrane; a base body comprising an outer surface and an inner surface; a second feed insert comprising a first end and a second end, an outer surface and an inner surface, the outer surface of the second feed insert contacting the inner surface of the base body during testing of the membrane and the other of the feed inlet and the feed outlet being located at the first end of the second feed insert; a second shoe insert comprising an outer surface and an inner surface, the outer surface of the second shoe insert connected to the inner surface of the second feed insert during testing of the membrane; a permeate spacer having a first side and a second side, the permeate spacer being configured to receive a first membrane on the first side and a second membrane on the second side, the permeate spacer being disposed between the first shoe insert and the second shoe insert during testing of the membrane; a permeate outlet fluidically connected to the permeate spacer; a first sealing element disposed between the first feed insert and the permeate spacer and a second sealing element disposed between the second feed insert and the permeate spacer during testing of the membrane; and a plurality of connecting elements for holding the lid body, the first feed insert, the second feed insert and the base body in place during testing of the membrane, as required by Group II.

Group II does not require a membrane support, a plurality of permeate collection ports and a plurality of permeate outlets, each permeate outlet being fluidically connected to at least one permeate collection port, wherein the apparatus is configured to form a flow channel during testing of the membrane such that a first face of the membrane comprises a portion of the surface of the flow channel over a length of the membrane, the flow channel being fluidically connected to the feed inlet and the feed outlet, and wherein the apparatus is configured so that the permeate collection ports are disposed along the length of the membrane and on the same side as a second face of the membrane during testing of the membrane, as required by Group I.

Common Technical Features:

Group I and II share the technical feature of a cross-flow filtration test apparatus; feed inlet and outlet; testing membrane; and permeate outlet. However, these shared technical features do not represent a contribution over prior art, because the shared technical features are being anticipated by US 2007/0062856 A1 to Pahl et al. (hereinafter Pahl). Pahl teaches a cross-flow filtration membrane test apparatus for testing at least a membrane; feed inlet and outlet; testing membrane; and permeate outlet (abstract; para [0017], [0034]; figure 1 – A cross-flow filtration unit including: a series of liquid feed inlets 10, feed flow channels 12, permeate flow channels 20, permeate outlets 22 (outlet), retentate outlets 30 (permeate outlet) and two-ply microporous polymeric membranes 40. In an example, evaluating the data from different experiments are shown, where target protein data and permeate flow rate data were plotted against respective pore size ratios).

As the technical feature was known in the art at the time of the invention, this cannot be considered a special technical feature that would otherwise unify the groups. Groups I-II therefore lack unity under PCT Rule 13 because they do not share a same or corresponding special technical feature.

Note: Claims 18-22 are determined unsearchable because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).