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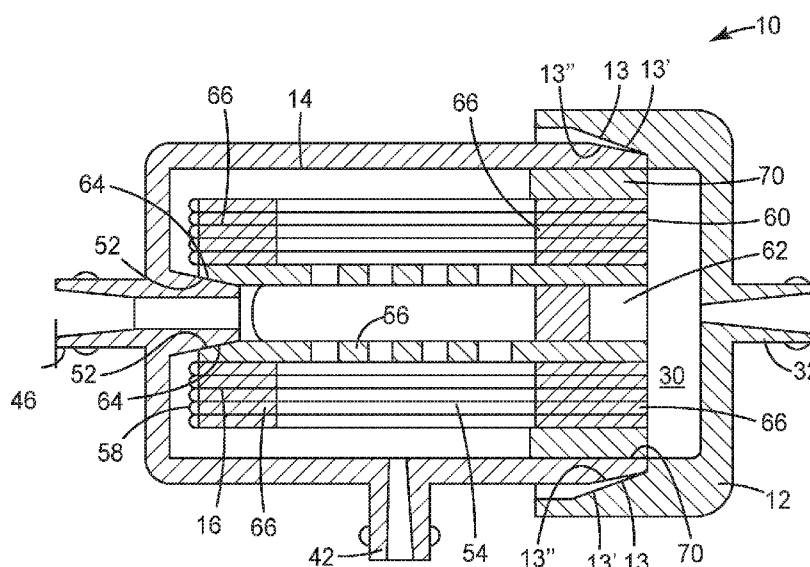
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(54) Title: SINGLE WELD CONTACTOR

**FIG. 3A**

(57) Abstract: A membrane contactor includes: a cap has an internally beveled surface and a cap port; a cup body has an externally beveled surface in sealing engagement with the internally beveled surface, a side port on a side of the cup body and an end port located on an end of the cup body; and a membrane cartridge is located within the cup body, is sealed to an open end of the cup body, and is in sealed fluid communication with the end port. A method of making a membrane contactor includes the steps of: sealingly mating a perforated center of a membrane contactor with the end port of a cup body; sealingly joining an end of the membrane cartridge adjacent an open end of the cup body; and sealingly joining a beveled surface of the cap to a beveled external surface of the cup body.

SINGLE WELD CONTACTOR

FIELD

5 In accordance with at least selected embodiments, the present disclosure is directed to novel or improved membrane contactors.

BACKGROUND

10 Membrane contactors are devices used to, among other things, degas liquids. For example, membrane contactors may be used to degas the ink used in, for example, industrial printers.

15 Hollow fiber membrane contactors typically operate on a diffusion principle. Such membrane contactors typically have a shell side and a lumen (or tube) side, and these sides are separated with a membrane, for example, a microporous membrane. In operation, the gas entrained liquid is introduced into one side of the contactor, while vacuum or a combination of vacuum and swept gas is passed through the other side. As the liquid passes through its side, the gas diffuses across the membrane into the other side.

20 Two small membrane contactors are illustrated in Figures 1 and 2 (both prior art). Such Liqui-Cel[®] brand contactors are commercially available from the Membrana-Charlotte Division of Celgard, LLC of Charlotte, NC. While these are excellent small membrane contactors, there is still a need for improved small membrane contactors or improved production methods for such contactors for at least certain applications.

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SUMMARY OF THE INVENTION

30 In accordance with at least selected embodiments, aspects or objects, the present disclosure or invention may address the above needs, and/or is directed to novel or improved membrane contactors, small or compact membrane contactors, single weld membrane contactors, small single weld membrane contactors, and/or related methods of manufacture and/or use. In accordance with at least certain embodiments, the present disclosure is directed new or improved small single weld contactors and/or methods for

production thereof. In accordance with at least particular embodiments, the present disclosure is directed new or improved small single weld hollow fiber membrane contactors including: a cap has an internally beveled surface and a cap port; a cup body has an externally beveled surface in sealing engagement with the internally beveled surface and a side port on a side of the cup body and an end port located on an end of the cup body; and a membrane cartridge is located within the cup body, is sealed to an open end of the cup body, and is in sealed fluid communication with the end port, and/or new or improved methods of making a membrane contactor including the steps of: sealingly mating a perforated center of a membrane contactor with the end port of a cup body; sealingly joining an end of the membrane cartridge adjacent an open end of the cup body; and sealingly joining a beveled surface of the cap to a beveled external surface of the cup body.

With reference again to the two small membrane contactors illustrated in Figures 1 and 2 (both prior art), while these are excellent small membrane contactors, improvements in their construction and/or manufacture could drive down cost, enhance performance for certain applications, or both. Figure 1 shows the 1x3 contactor; it requires two welds, W_1 and W_2 to seal the cap to the body and the membrane cartridge. Figure 2 shows the 2x6 contactor; it has two caps C_1 and C_2 .

In at least one embodiment, a new or improved membrane contactor includes: a cap has an internally beveled surface and a cap port; a cup body has an externally beveled surface in sealing engagement with the internally beveled surface and a side port on a side of the cup body and an end port located on an end of the cup body; and a membrane cartridge is located within the cup body, is sealed to an open end of the cup body, and is in sealed fluid communication with the end port. Such an inventive contactor may be made by a method of making a membrane contactor includes the steps of: sealingly mating a perforated center of a membrane contactor with the end port of a cup body; sealingly joining an end of the membrane cartridge adjacent an open end of the cup body; and sealingly joining a beveled surface of the cap to a beveled external surface of the cup body.

DESCRIPTION OF THE DRAWINGS

For the purpose of illustrating the invention, there is shown in the drawings prior contactors and a form that is presently preferred; it being understood, however, that this invention is not limited to the precise arrangements and instrumentalities shown in Figures

5 3A-C.

Figure 1 is a prior art membrane contactor.

Figure 2 is a prior art membrane contactor.

Figures 3A-C show an embodiment of the inventive membrane contactor.

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DESCRIPTION OF THE INVENTION

Referring to Figures 3A-C, there is shown an embodiment of the inventive membrane contactor 10. Contactor 10 generally includes a cap 12, a cup body 14, and membrane cartridge 16. The membrane cartridge 16 may be located within the cup body 14.

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The cap 12 and cup body 14 are sealingly joined by joint 13 along joining surfaces 13' and 13". Surface 13' may be an internally facing joining surface located on cap 12, and surface 13" may be an externally facing joining surface located on cup body 14. The joint 13 is illustrated as a scarf joint (i.e., surfaces 13' and 13" are beveled), but joint 13 may be a shear joint (i.e., surfaces 13' and 13" are parallel to the axis of the contactor 10), or a butt joint or any other combination of joint designs. Hereinafter, the contactor 10 will be illustrated with the scarf joint, but the shear joint may be used in place thereof.

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Cap 12 may be generally cup shaped (e.g., circular cross-section) with an open end 18 and a closed end 20, see Figure 3B. Cap 12 may also include an internally beveled surface 13', a shoulder 26, a skirt 28, a headspace 30, and a cap port 32 with an opening 34 therethrough. Cap port 32 may be a nipple extending away from cap 12. Beveled surface 13' may have a shallow angle, for example $<30^\circ$, or 4° - 15° . Skirt 28 extends beyond joint 13, thereby concealing joint 13. Nipple is a sealable fitting, for example - a Luer (or medical) fitting, NPT, straight tube, compression, quick-connect, or any other suitable fitting.

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Cup body 14 may be generally cup shaped (e.g., circular cross-section) with an open end 36 and a closed end 38, see Figure 3B. Cup body 14 may also include an externally beveled surface 13", a shoulder 40, a side port 42 with an opening 44 therethrough, and end port 46 with an opening 48 therethrough. Beveled surface 13" may complement the angle of beveled surface 13'. Side port 42 may be a nipple 47 extending away from the cup body 14. End port 46 may include a nipple extending away from the cup body 14. End port 46 also includes an inwardly extending nipple 50 with a mating external surface 52. Mating external surface 52 may be beveled. Mating external surface 52 may have a shallow angle, for example $<30^\circ$, or 4° - 15° . Nipple is a sealable fitting, for example - a Luer (or medical) fitting, NPT, straight tube, compression, quick-connect, or any other suitable fitting.

Membrane cartridge 16 generally includes a bundle of membranes (e.g., hollow fiber membranes) 54 surrounding and bonded to a perforated center tube 56, see Figure 3A. The cartridge 16 has a first end 58 and a second end 60. A plug 62 is disposed in the center tube 56 adjacent second end 60. A mating internal surface 64 is located at the first end of the perforated center tube 56 adjacent the first end 58. Mating internal surface 64 may be beveled. Mating internal surface 64 may complement the angle of mating external surface 52. The hollow fiber membranes of bundle 56 are closed at the first end 58 and open at the second end 60. The bundle 54 may be bonded to the center tube 56 by a potting material. Potting material (e.g., epoxy, polyurethane, thermoplastic polymer, and/or adhesive) may be formed into walls 66 at the first end 58 and the second end 60 of the cartridge 16.

Figure 3C illustrates that cartridge 16 may be made two-at-a-time, cartridge 16A and 16B. The membrane are wound around the center tube 56, so that the end of the membranes are closed 58A and 58B. If the membrane is a plurality of hollow fibers, the hollow fibers may be knit into a fabric (the lateral edges of the fabric will have closed or looped over ends) and then wound around the center tube 56. The membranes may be joined to the center tube 56 in a conventional fashion, i.e., potting at 66A, 66A/B, and 66B. Then, cartridge 16A and cartridge 16B are separated (e.g., cut apart) along line 68. Plugs 62 may be formed at the same time that the potting at 66A/B are formed.

In one embodiment, when assembled, see Figure 3A, (or assembling), cartridge 16 is inserted into cup body 14 by engaging mating surface 64 of the center tube 56 with the mating surface 52 of the end port 46. These mating surfaces 52 and 64 must be held in sealing engagement when cartridge 16 is fixed to cup body 14. This sealing engagement may be accomplished by luer lock, press fit, interference fit, snap fit, threading, welding, and/or gluing. These mating surfaces 52 and 64 may be held in sealing engagement when cartridge 16 is fixed to cup body 14 by, for example, material 70 or a mechanism (not shown). The material 70 or the mechanism also seals the cartridge 16 and cup body 14 in fluid tight engagement. Material 70 may be any material conventionally known in the art. Such materials 70 include potting and/or glue. Such mechanisms include threading, clips, o-rings, snap fittings. Once the cartridge 16 is fixed into cup body 14, cap 12 is joined to the assembly of the cartridge 14 and cup body 16 via joint 13. Joint 13 is a fluid tight joint. Joint 13 may be a welded joint or glued joint. The welded joint may be formed by spin welding. Headspace 30 is formed between cap 12 and the assembly of cup body 14 and cartridge 16, when shoulder 26 of cap 12 rest on shoulder 40 of cup body 14.

In one embodiment, in operation, gas entrained liquid enters contactor 10 via end port 46 and travels along center tube 56 until blocked by plug 62. The gas entrained liquid exits the perforated center tube 56 and travels radially across the external surfaces of the hollow fiber membranes, and exits contactor 10 via side port 42 (this path defines the shell side). Vacuum or vacuum/sweep gas are introduced via cap port 32 and are in fluid communication with the lumens of the hollow fibers via headspace 30 (this path defines the tube side). The entrained gas is drawn from the liquid across the membranes and exits via cap port 32.

In accordance with at least certain embodiments, aspects or objects, an inventive membrane contactor includes: a cap has an internally beveled surface and a cap port; a cup body has an externally beveled surface in sealing engagement with the internally beveled surface, a side port on a side of the cup body and an end port located on an end of the cup body; and a membrane cartridge is located within the cup body, is sealed to an open end of the cup body, and is in sealed fluid communication with the end port, and an inventive method of making a membrane contactor includes the steps of: sealingly mating a

perforated center of a membrane contactor with the end port of a cup body; sealingly joining an end of the membrane cartridge adjacent an open end of the cup body; and sealingly joining a beveled surface of the cap to a beveled external surface of the cup body.

- 5 The present invention may be embodied in other forms without departing from the spirit and the essential attributes thereof, and, accordingly, reference should be made to the appended claims, rather than to the foregoing specification, as indicated the scope of the invention.

We claim:

1. A membrane contactor comprises:

a cap has an internally facing joining surface and a cap port;

5 a cup body has an externally facing joining surface in sealing engagement with the internally facing joining surface, a side port on a side of the cup body, and an end port located on an end of the cup body; and

a membrane cartridge is located within the cup body, is sealed to an open end of the cup body, and is in sealed fluid communication with the end port.

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2. The membrane contactor of claim 1 wherein the sealing engagement of the internally facing joining surface and the externally facing joining surface is a scarf joint or a shear joint.

15 3. A membrane contactor comprises:

a cap has an internally beveled surface and a cap port;

a cup body has an externally beveled surface in sealing engagement with the internally beveled surface, a side port on a side of the cup body, and an end port located on an end of the cup body; and

20 a membrane cartridge is located within the cup body, is sealed to an open end of the cup body, and is in sealed fluid communication with the end port.

4. The membrane contactor of claim 3 wherein the cap further comprises an open end and a closed end, the internally beveled surface is located adjacent to the open end, and the cap port is located on the closed end.

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5. The membrane contactor of claim 3 wherein the cap further comprises a skirt extending beyond and concealing the sealing engagement of the externally and internally beveled surfaces.

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6. The membrane contactor of claim 3 further comprises a head space between the cap and the cup body and the membrane contactor, the cap port being in fluid communication with the head space.

5 7. The membrane contactor of claim 3 wherein the cap port comprises a nipple extending away from the cap.

 8. The membrane contactor of claim 3 wherein the end port includes an outwardly projection nipple and an inwardly projection nipple, the inwardly projection nipple is
10 sealingly joined with the membrane cartridge.

 9. The membrane contactor of claim 3 wherein the side port comprises a nipple extending away from the cup body.

15 10. The membrane contactor of claim 3 wherein the membrane cartridge includes a perforated center tube, a first end of the center tube adapted to sealing join with the end port and a second end of the center tube is plugged, and a bundle of hollow fibers surrounding and potted to the center tube, the hollow fibers are closed adjacent the first end of the center tube and open adjacent the second end of the center tube.

20

 11. A method of making a membrane contactor comprises the steps of:

 sealingly mating a perforated center of a membrane contactor with the end port of a cup body;

 sealingly joining an end of the membrane cartridge adjacent an open end of
25 the cup body; and

 sealingly joining a beveled surface of the cap to a beveled external surface of the cup body.

 12. The method of claim 11 wherein sealingly mating includes a luer fit, a press fit, an
30 interference fit, a snap fit, a thread fit, a weld fit, or a glue fit.

13. The method of claim 11 wherein sealing joining the end of the membrane cartridge to the cup body includes potting, gluing, threading, or O-ring sealing.

14. The method of claim 11 where sealing joining the beveled surfaces includes spin
5 welding and gluing.

15. Novel or improved membrane contactors, small or compact membrane contactors, single weld membrane contactors, small single weld membrane contactors, and/or related methods of manufacture and/or use, new or improved small single weld
10 contactors and/or methods for production thereof, new or improved small single weld hollow fiber membrane contactors including: a cap has an internally beveled surface and a cap port; a cup body has an externally beveled surface in sealing engagement with the internally beveled surface and a side port on a side of the cup body and an end port located on an end of the cup body; and a membrane cartridge is located within the cup body, is
15 sealed to an open end of the cup body, and is in sealed fluid communication with the end port, and/or new or improved methods of making a membrane contactor including the steps of: sealingly mating a perforated center of a membrane contactor with the end port of a cup body; sealingly joining an end of the membrane cartridge adjacent an open end of the cup body; and sealingly joining a beveled surface of the cap to a beveled external surface of
20 the cup body, as shown or described herein.

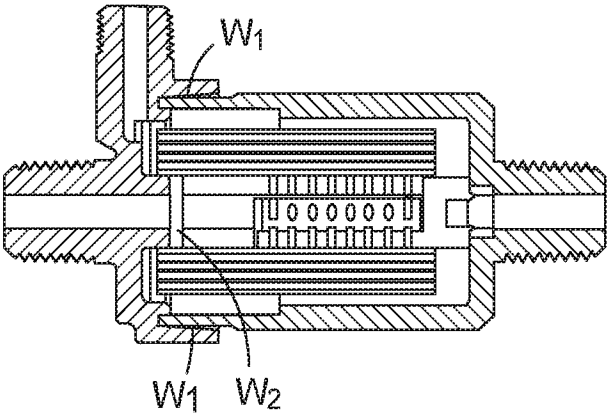


FIG. 1
Prior Art

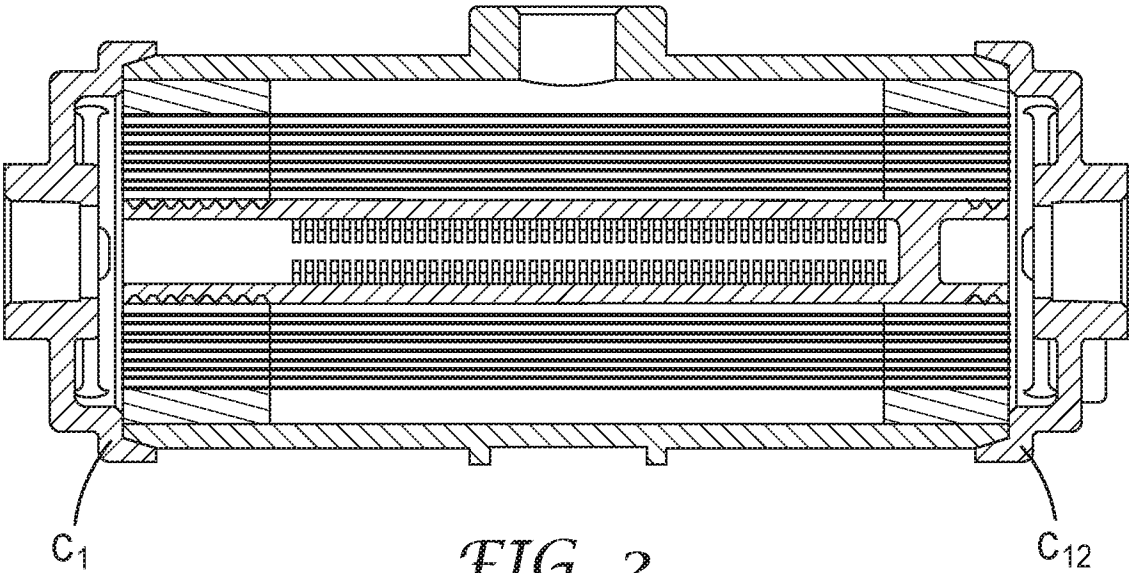


FIG. 2
Prior Art

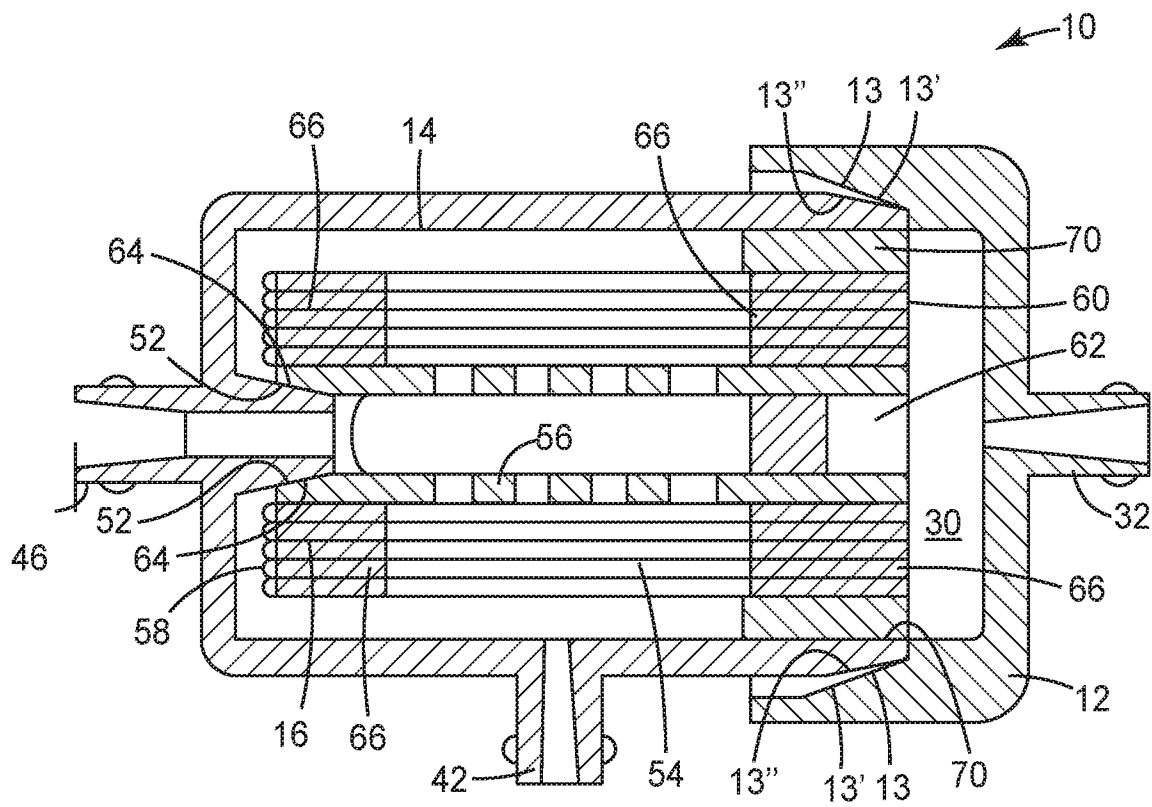


FIG. 3A

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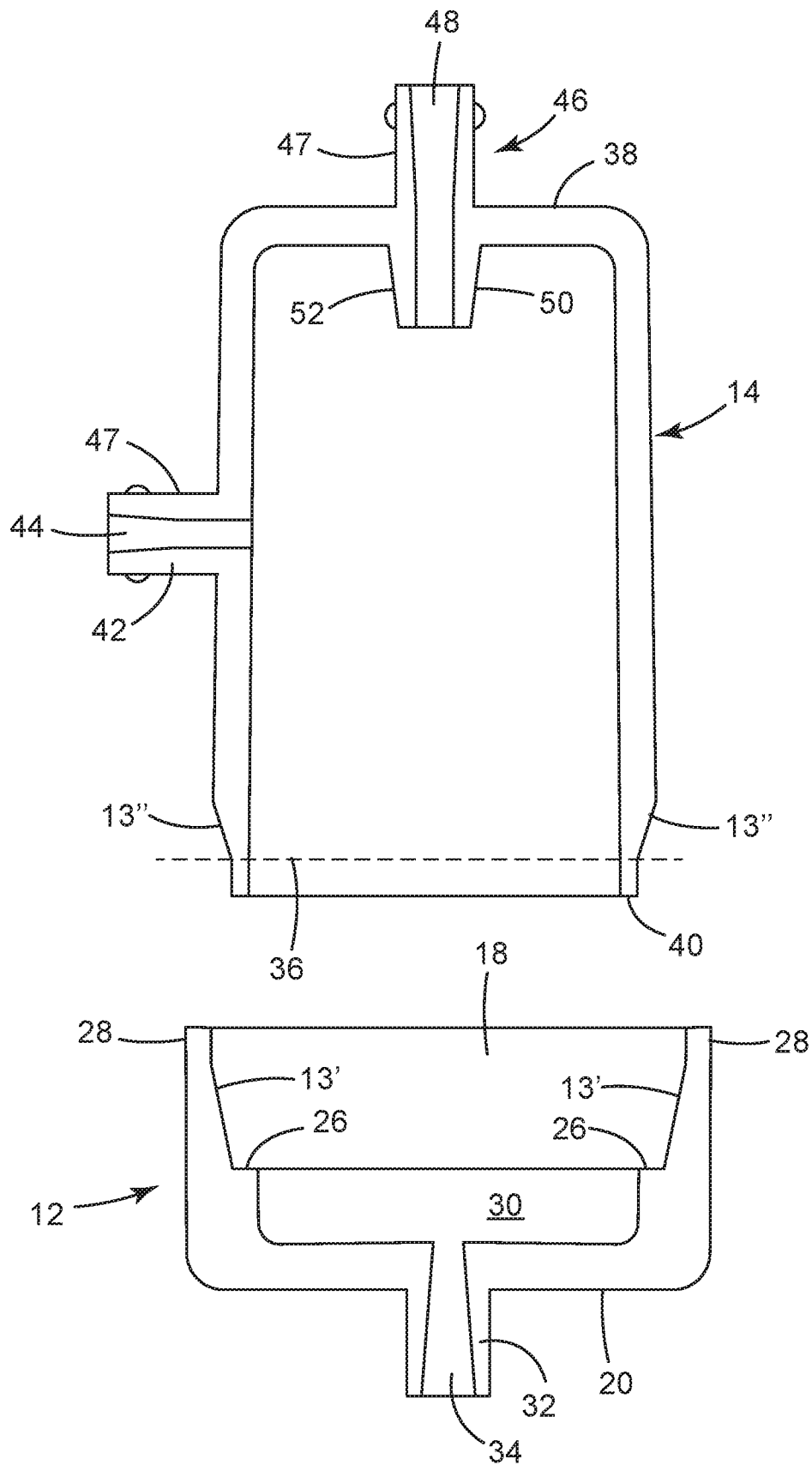


FIG. 3B

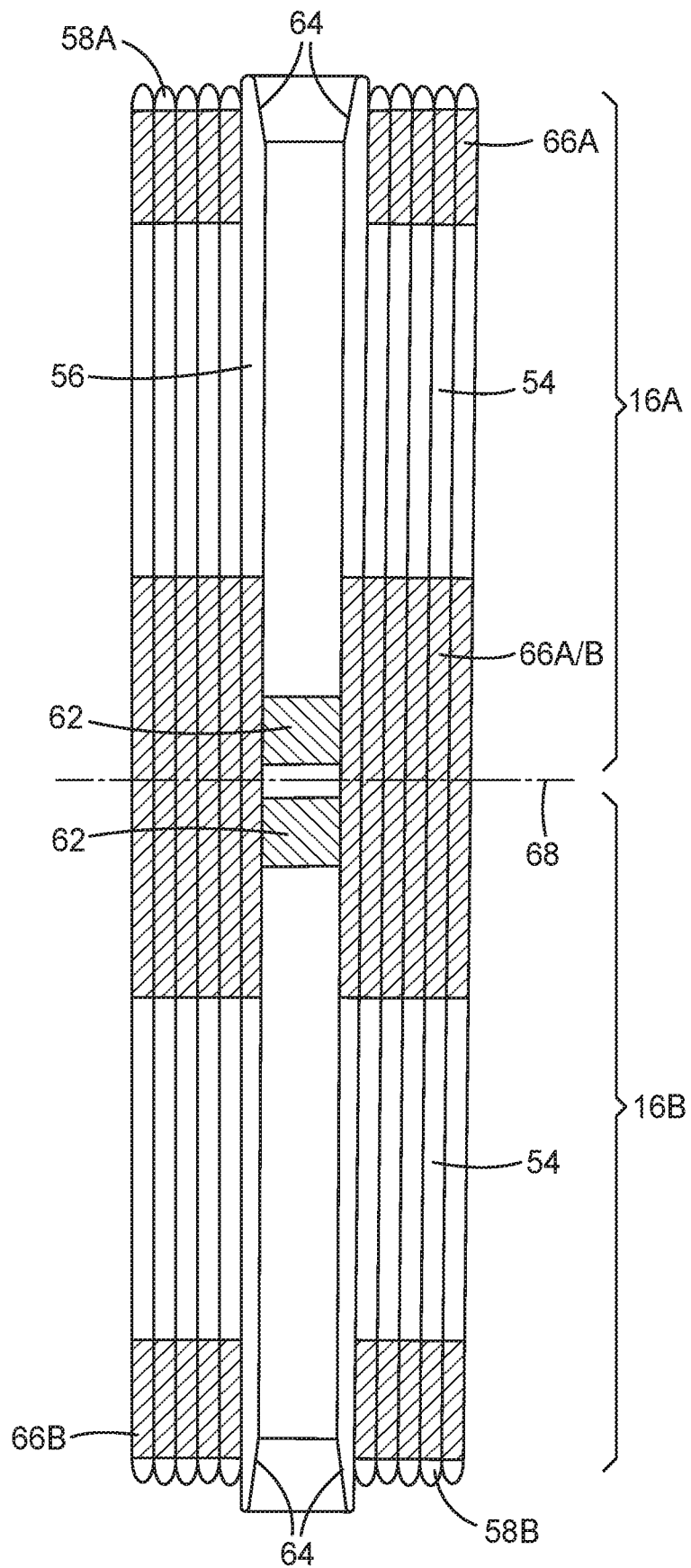


FIG. 3C

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2016/038328**A. CLASSIFICATION OF SUBJECT MATTER****B01D 63/02(2006.01)I, B01D 69/08(2006.01)I**

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHEDMinimum documentation searched (classification system followed by classification symbols)
B01D 63/02; B01D 35/30; B28B 1/48; B01D 63/00; B01D 61/00; B01D 69/08Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility modelsElectronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: membrane contactor, cap, closed, seal, cartridge, tube, fiber**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2007-0278145 A1 (TAYLOR, GARETH P. et al.) 06 December 2007 See paragraphs [0013]-[0015], [0033]; claims 1, 3, 5-6, 15; and figure 1A.	1-5, 7-9
Y		6, 10-14
Y	US 7638049 B2 (SENGUPTA, AMITAVA et al.) 29 December 2009 See column 2, lines 42, 46-48; column 4, line 22; claim 1; and figures 1, 4.	6, 10-14
A	US 5059374 A (KRUEGER, ROBERT T. et al.) 22 October 1991 See abstract; column 15, lines 13-36; and figure 2.	1-14
A	WO 2006-081059 A2 (CELGARD LLC) 03 August 2006 See page 3, lines 13-19; pages 4-5; claims 1-2, 12-13; and figure 1.	1-14
A	US 2005-0194305 A1 (VIDO, TONY R. et al.) 08 September 2005 See abstract; paragraphs [0013]-[0014]; claims 1, 17; and 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

29 September 2016 (29.09.2016)

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30 September 2016 (30.09.2016)

Name and mailing address of the ISA/KR

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2016/038328**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.: 15
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:
Claim 15 has more than one subject matter, and thus it is difficult to define the subject matter of claim 15 (PCT Rule 6.1(a)).
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:

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 an additional fees, this Authority did not invite payment of any 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.:

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

Information on patent family members

International application No.

PCT/US2016/038328

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