



(51) International Patent Classification:
H01M 8/04 (2006.01) *G05D 7/00* (2006.01)

(21) International Application Number:
PCT/US2010/029312

(22) International Filing Date:
31 March 2010 (31.03.2010)

(25) Filing Language: English

(26) Publication Language: English

(71) Applicant (for all designated States except US): **UTC POWER CORPORATION** [US/US]; 195 Governor's Highway, South Windsor, Connecticut 06074 (US).

(72) Inventor; and

(75) Inventor/Applicant (for US only): **PERRY, Michael, L.** [US/US]; 1995 Main Street, Glastonbury, Connecticut 06033 (US).

(74) Agent: **DOIGAN, Lloyd, D.**; Carlson, Gaskey & Olds, 400 West Maple Road, Suite 350, Birmingham, Michigan 48009 (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, 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, IS, JP, KE, KG, KM, 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, PE, PG, PH, PL, PT, RO, RS, RU, 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, SD, SL, SZ, TZ, UG, ZM, 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, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— as to the identity of the inventor (Rule 4.17(i))

Published:

— with international search report (Art. 21(3))

(54) Title: NOVEL FUEL-CELL-FLOW-FIELD DESIGN WITH IMPROVED FLOW UNIFORMITY

(57) Abstract: A fuel cell includes a flow field in which an interdigitated flow field varies placement of blockages, which may be full or partial, to homogenize flow in all portions of the flow field. By homogenizing flow, each channel of the field is used most efficiently thereby increasing the efficiency of the overall fuel cell.

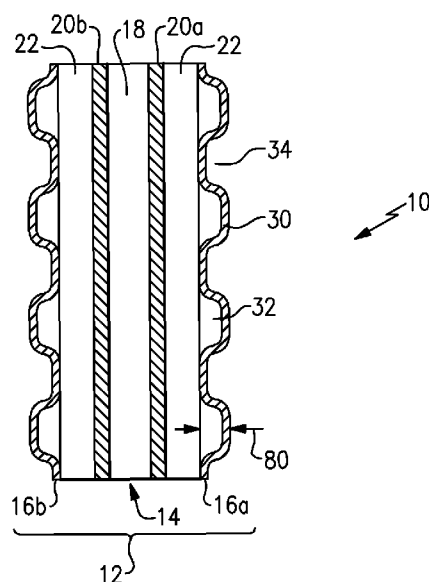


FIG.1

NOVEL FUEL-CELL-FLOW-FIELD DESIGN WITH IMPROVED FLOW UNIFORMITY

FIELD OF THE INVENTION

[0001] This invention generally relates to fuel cells and, more particularly, to flow fields for fuel cells.

DESCRIPTION OF THE RELATED ART

[0002] Fuel cells are widely known and used for generating electricity in a variety of applications. A typical fuel cell utilizes reactant gases, such as hydrogen and oxygen, to generate an electrical current. Typically, the fuel cell includes adjacent flow fields that each receives a reactant gas. Each flow field distributes the reactant gas to an adjacent gas distribution layer to a respective anode catalyst layer or a cathode catalyst layer adjacent an electrolyte layer to generate the electrical current. The electrolyte layer can be any layer that effectively transports ions, but does not conduct electrons. Some example fuel-cell electrolytes include: alkaline solutions (e.g., KOH), proton-exchange membranes (PEM) phosphoric acid, and solid oxides.

[0003] A typical flow field includes open, or parallel, channels that have fully open inlets and fully open outlets. A reactant gas entering through the channel diffuses through the gas distribution layer toward the catalyst. The open channels allow relatively unrestricted reactant gas flow and thereby produce a relatively low reactant gas pressure drop. However, the concentration of the reactant gases within the catalyst layers is low relative to the concentration in the channels, as required for a diffusive flux where the driving force for species flow is a concentration gradient. This low reactant concentration lowers the performance of the fuel cell relative to what would be obtained if the concentration was closer to that in the channels.

[0004] Another type of flow field includes entrance channels interdigitated with exit channels. Channels with fully open inlets and fully closed outlets are alternated with channels that have fully closed inlets and fully open outlets. These alternating channels force a reactant gas entering the open-entrance channels to flow through the gas distribution layer in order to exit the cell through an adjacent open-exit channel. In this case, the concentration of the reactant gases within the catalyst layers is closer to the reactant concentration in the channels due to the forced flow through the gas distribution layer and the cell performance is typically better than

with open, parallel channels. However, the pressure drop is higher with interdigitated channels due to forcing the flow through the gas distribution layer, which is much more restrictive to gas flow than open channels.

[0005] Another type of flow field is a combination of the two described above where the interdigitated channels are partially open or closed instead of fully open or closed, as taught in U.S. Patent Application 20080292938, which is assigned to the same entity and incorporated herein.

[0006] Uniform reactant flow across the active area of the cell is desirable, since this will result in a more uniform reaction rate across the active area of the cell (i.e., a more uniform current density distribution) and improve the overall performance of the cell. Some fuel cells have manifolds/inlets that direct reactant to the fuel cell flow field in a more uniform manner. Some flow fields have channels with variable depth and/or cross-sectional area to help normalize flow within a fuel cell field.

SUMMARY

[0007] This invention addresses a need for improved reactant flow distribution among channels in a fuel cell flow field.

[0008] One exemplary device for use in a fuel cell includes a flow field in which an interdigitated field varies placement of blockages, which may be full or partial, to homogenize flow in all portions of the field. By homogenizing flow, each channel of the field is used most efficiently thereby increasing the efficiency of the overall fuel cell.

[0009] One exemplary method for equalizing reactant flowing through a fuel cell field includes the steps of controlling the flow that enters each channel of a fuel cell flow field by placing at least one at least partial blockage in at least one channel such that flow tends to normalize in each said channel in said flow field and said channels are at least partially interdigitated. If the blockages are placed properly, flow through each channel approaches average for flow through all channels.

[0010] Another exemplary method of equalizing reactant flow through a fuel cell flow field includes the steps of analyzing flow that enters each channel of a fuel cell flow field, placing blockages in a channel in which flow is above average and removing blockages in channels in which flow is below average.

[0011] The above examples are not intended to be limiting. Additional examples are described below. The various features and advantages of this invention will become apparent to those skilled in the art from the following detailed description. The drawings that accompany the detailed description can be briefly described as follows.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] The various features and advantages of the disclosed examples will become apparent to those skilled in the art from the following detailed description. The drawings that accompany the detailed description can be briefly described as follows.

[0013] Figure 1 illustrates an example fuel cell.

[0014] Figure 2 illustrates an example flow field plate.

[0015] Figure 3 illustrates a flow distribution portion of the flow field plate.

[0016] Figure 4 illustrates another example flow distribution portion of a flow field plate.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0017] Figure 1 illustrates a partially exploded view of selected portions of an example fuel cell 10 for generating an electric current in a known electrochemical reaction between reactant gases, for example. It is to be understood that the disclosed arrangement of the fuel cell 10 is only an example and that the concepts disclosed herein may be applied to other fuel cell arrangements.

[0018] The example fuel cell 10 includes one or more fuel cell units 12 that may be stacked in a known manner to provide the assembly of the fuel cell 10. Each of the fuel cell units 12 includes an electrode assembly 14 and flow field plates 16a and 16b for delivering reactant gases (e.g., air and hydrogen) to the electrode assembly 14. The flow field plate 16a may be regarded as an air plate for delivering air and the flow field plate 16b may be regarded as a fuel plate for delivering hydrogen. The flow field plate 16a, flow field plate 16b, or both may also circulate coolant (in coolant channels) for maintaining a desired operating temperature of the fuel cell 10 and hydrating the reactant gases indirectly by maintaining the electrode assembly 14 in a desired temperature range.

[0019] The electrode assembly 14 includes an electrolyte 18 between a cathode catalyst 20a and an anode catalyst 20b. Gas diffusion layers 22 may be used between the respective flow field plates 16a and 16b and the electrode assembly 14 to facilitate distribution of the reactant gases.

[0020] The flow field plates 16a and 16b may be substantially similar. Thus, the disclosed examples made with reference to the flow field plate 16a may also apply to the flow field plate 16b. In other examples, the flow field plate 16b may be different or include some of the same features as the flow field plate 16a.

[0021] The flow field plate 16a includes a non-porous plate body 30. Non-porous refers to the body being solid and free of pores that are known in porous plates for holding or transporting liquid water or other fluids. Thus, the non-porous plate body 30 is a barrier to fluids.

[0022] The non-porous plate body 30 includes reactant gas channels 32 and coolant channels 34. The reactant gas channels 32 are located on a side of the flow field plate 16a that faces in the direction of the electrode assembly 14 in the fuel cell unit 12 and the coolant channels 34 are located on the opposite side of the flow field plate 16a.

[0023] The flow field plate 16a may be stamped or otherwise formed into the desired shape. In this regard, positive features on one side of the flow field plate 16a are negative features on the other side, and vice versa. Stamping allows the flow field plate 16a to be made at a relatively low cost with a reduced need for machining operations, for example. The flow field plate 16a may be formed from steel, such as stainless steel, or other suitable alloy or material.

[0024] Figure 2 illustrates one side of the flow field plate 16a. It is to be understood that the other side is the negative of the visible side. The channels 32 and 34 include inlets 42 for receiving a fluid (reactant gas or coolant) and outlets 44 for discharging the fluid. Optionally, the reactant gas channels 32 may include obstructions 45 in some of the channel inlets 42 and channel outlets 44. The obstructions 45 may completely block the given channel inlets 42 and channel outlets 44 such that the reactant gas channels 32 are interdigitated. Alternatively, the obstructions 45 may partially block (see 47 in Fig. 4) the given channel inlets 42 and channel outlets 44 such that the reactant gas channels 32 are partially interdigitated.

[0025] The flow field plate 16a extends between a first terminal end 36 and a second terminal end 38 of the non-porous plate body 30 and includes flow fields 40 (one shown). The term “flow field” as used in this disclosure may refer to any or all of the channels 32 and 34 for delivering the air, fuel, and coolant and any other area between the channels 32 and 34 and manifolds for transporting the air, fuel, or coolant. The reactant gas channels 32 may be regarded as a flow field for the reactant gas (e.g., air in the case of flow field plate 16a and fuel in the case of flow field plate 16b) and the coolant channels 34 may be regarded as a flow field for coolant.

[0026] The flow fields 40 may each include a first flow distribution portion 50 and a second flow distribution portion 52. The flow fields of the reactant gases are active areas that are side by side with the electrode assembly 14, for delivering the reactant gases to the electrode assembly 14 for the electrochemical reaction. Thus, the first flow distribution portion 50 and the second flow distribution portion 52 are also side by side with a portion of the electrode assembly 14. In the illustrated example, the first flow distribution portion 50 diverges from the first terminal end 36 to the channel inlets 42, and the second first flow distribution portion 52 converges from the channel outlets 44 to the second terminal end 38.

[0027] The flow field plate 16a includes another first flow distribution portion 50 and another second flow distribution portion 52 (as the negative) on the back side of the flow field plate 16a for distributing the coolant to and from the coolant channels 34.

[0028] In the illustrated example, the flow field plate 16a has an irregular octagonal shape to achieve the divergent and convergent shape. However, the shape is not limited to octagonal, and in other examples the flow field plate 16a may have a different polygonal shape or a non-polygonal shape, such as elliptical, to achieve the divergent and convergent shape.

[0029] The first flow distribution portion 50 and the second flow distribution portion 52 may each include a straight end wall 54 and two straight side walls 56 that non-perpendicularly extend from the straight end wall 54. The angle between the side walls 56 and the end wall 54 provides the respective diverging or converging shape. The angles shown may be varied, depending on a desired degree of divergence or convergence.

[0030] The diverging and converging shapes of the respective first flow distribution portion 50 and second flow distribution portion 52 facilitate distribution of a fluid to the given flow field 40. For instance, the flow of a fluid delivered into the first flow distribution portion 50 follows along the side walls 56 to the outer channels near the edges of the flow field plate 16a. If the side walls 56 were perpendicular to the straight end wall 54, the fluid would not flow smoothly near the corner and flow into the outer channels would be inhibited. By sloping the side walls 56 relative to the end wall 54 to create a divergent shape, the first flow distribution portion 50 more uniformly distributes the fluid to the channels. Likewise, the second flow distribution portion 52 converges and thereby funnels the fluid flowing from the channels to facilitate collection of the fluid.

[0031] The fuel cell 10 also includes manifolds 60, 62, 64, 66, 68, and 70 to deliver and collect reactant gas and coolant to and from the flow fields 40. The manifolds 60 and 64 are located near the side walls 56 of the first flow distribution portion 50, and the manifold 62 is located near the end wall 54. The manifolds 66 and 70 are located near the side walls 56 of the second flow distribution portion 52, and the manifold 68 is located near the end wall 54.

[0032] The individual manifolds 60, 62, 64, 66, 68, and 70 may be used as inlets for delivering the fuel, air, or coolant to a given flow field 40 or as outlets for collecting the fuel, air, or coolant from the given flow field 40 to facilitate fluid distribution or achieve other fuel cell objectives.

[0033] Referring also to Figure 2, the first flow distribution portion 50, the second flow distribution portion 52, or both may include a flow guide 78 that establishes a desired flow distribution between a given manifold 60, 62, 64, 66, 68, and 70 and the channels. For example, the flow guide 78 may include protrusions 80 within the first flow distribution portion 50 and/or second flow distribution portion 52. The shape of the protrusions 80, arrangement of the protrusions 80, or both, may contribute to establishing the desired flow distribution by limiting flow to or from selected reactant gas channels 32 and promoting flow to or from other of the reactant gas channels 32. Given this description, one of ordinary skill in the art will recognize and design particular shapes and arrangements to suit their particular needs.

[0034] The protrusions 80 may have a non-equiaxed cross-sectional shape, with long axes L and short axes S. In the given example, the long axes L of the protrusions 80 in the first flow distribution portion 50 diverge towards the sides of the field 40, 42 and the long axes L of the protrusions 80 in the second flow distribution portion 52 converge towards the manifold 68. The protrusions 80 are generally arranged in rows, but other arrangements are contemplated. In this example, the protrusions 80 have an oval cross-section. In other examples, the protrusions 80 may have other non-equiaxed or equiaxed cross-sectional shapes.

[0035] While the protrusions 80 in the first flow distribution portion 50 are intended to distribute the flow to the channels 32 and 34 equally, the flow rate in the first flow distribution portion 50 tends to form an unequal flow pattern as indicated by illustrative bar line 84 (see Figs. 3 and 4), in this case a bell curve (see Fig. 3). The bar line 84 is illustrative only because protrusions 80 may have other shapes, manifold 62 may have other shapes and the back pressure at field 40 may be shaped differently because the second flow distribution portion 52 may also have different shapes and differently shaped protrusions 80. In this pattern the higher flow rates tend to be in the center channels of the field 40.

[0036] Flow through the fuel cell 10 caused by the first flow distribution portion 50 (and any backpressure caused by the second flow distribution portion 52) by using pressure or flow sensors 86 placed in channels 32 to determine flow passing from the first flow distribution portion 50 to the channels. Once flow is determined, blockages are placed in the channels to encourage flow where it is lower and to discourage flow where flow is higher.

[0037] The blockages 45 placed in the channels 32, 34 and assisting the interdigitated process may be either partial or complete and are placed to homogenize or normalize flow in each channel. If the flow is not homogenized or normalized, flow through the channels is not equal and the fuel cell will not operate at peak efficiency. The fuel cell may also not get enough moisture entrained in a reactant flow and therefore dry-out and perform under specification. The fuel cell may also require more parasitic power to push the flow through the channels and decrease the efficiency of the fuel cell.

[0038] Therefore, the blockages in this embodiment are placed within the channels to essentially oppose the shape of the bar line 84 by making it harder to get through the channels that would get more flow and making it easier to flow through other channels that get less flow. Because the pressure drop in a channel increases as that channel elongates, the blockages are placed to shorten the channels that get too much flow and maintain a lower pressure drop that causes the flow to migrate to the longer channels that need more flow and have a higher pressure drop.

[0039] Referring to Figure 3, bar line 84 is roughly mirrored by imaginary line linking the blockages 45. Note also that some channels 88 may have more than one blockage to tune the flow through a channel. Note that the blockages 45 depicted in Fig. 3 are all complete blockages.

[0040] Referring now to Figure 4, the shape of the bar line 84 shows a “two-humped camel” that is off center. The blockages 45 are arranged similarly in concept to Figure 3 to oppose the flow – see imaginary line 92. Note that some of the blockages are partial blockages 47. Please also note that a channel need not have a blockage 94 to encourage flow therethrough.

[0041] It will be appreciated by one skilled in the art that the goal is to make the reactant flow, and thereby the reactant concentration, as uniform as possible in the catalyst layers, 20a and 20b. Due to the varying degree of interdigitation in the different channels the reactant concentration in these layers may vary even if the flow in each channel is uniform. Ideally, the current density of the cell should be uniform as possible, so the current density distribution across the active area of the cell can also be used as part of the method to optimize the cell design. The current density distribution can be measured by using segmented current collectors, as has been described in the open fuel cell literature.

[0042] Although a combination of features is shown in the illustrated examples, not all of them need to be combined to realize the benefits of various embodiments of this invention. In other words, a system designed according to an embodiment of this invention will not necessarily include all of the features shown in any one of the Figures or all of the portions schematically shown in the Figures. Moreover, selected features of one example embodiment may be combined with selected features of other example embodiments.

[0043] The preceding description is exemplary rather than limiting in nature. Variations and modifications to the disclosed examples may become apparent to those skilled in the art that do not necessarily depart from the essence of this invention. The scope of legal protection given to this invention can only be determined by studying the following claims.

CLAIMS

We claim:

1. A device for use in a fuel cell, comprising:
a plurality of interdigitated channels,
a reactant flow distribution for entering at least one of said channels and,
at least one obstruction member that blocks at least a portion of said distribution through at least one of said channels such that said distribution in each said channel tends to equalize with that of other said channels.
2. The device as recited in Claim 1 wherein said at least one obstruction member partially obstructs at least one said channel.
3. The device as recited in Claim 1 wherein said device further comprises an inlet through which said reactant gas flow distribution flows.
4. The device as recited in Claim 3 wherein a shape of a plurality of said obstruction members mirrors a shape of said inlet.
5. The device as recited in Claim 1 wherein a shape of a plurality of said obstruction members mirrors a shape of an inlet through which said reactant gas flow distribution flows.
6. The device as recited in Claim 1 wherein a shape of a plurality of said obstruction members mirrors a shape of said reactant gas flow distribution to at least partially offset said shaped distribution of flow through said channel.
7. The device as recited in Claim 1 wherein at least one channel has no blockages.

8. A method for distributing flow in a fuel cell, comprising:
determining flow of a reactant in a plurality of channels in a field,
placing at least one at least partial blockage in at least one channel such that flow tends to normalize in each said channel in said field and said channels are interdigitated.
9. The method of claim 8 in which said flow has a shaped-distribution as it enters said field.
10. The method of claim 9 further comprising:
placing a plurality of said at least one obstruction member in said at least one channel to mirror said shaped-distribution to at least partially offset said shaped distribution of flow through said channel.
11. The method of claim 9 further comprising:
not placing a blockage in at least one channel.
12. The method of claim 8 in which said field has an inlet and further comprising:
placing a plurality of said obstruction members in said channel to mirror a shape of said inlet.
13. The method of claim 8 in which the current density distribution across said cell is used to optimize the placement of said blockages in said channels.

14. A method for distributing flow in a fuel cell, comprising:
determining flow of a reactant in a plurality of channels in an interdigitated field, and
placing at least one at least partial blockage in a channel in which flow in said channel exceeds flow in other channels.
15. The method of claim 14, further comprising:
removing at least one at least partial blockage in a channel in which flow in said channel is lower than flow in other channels.

1/2

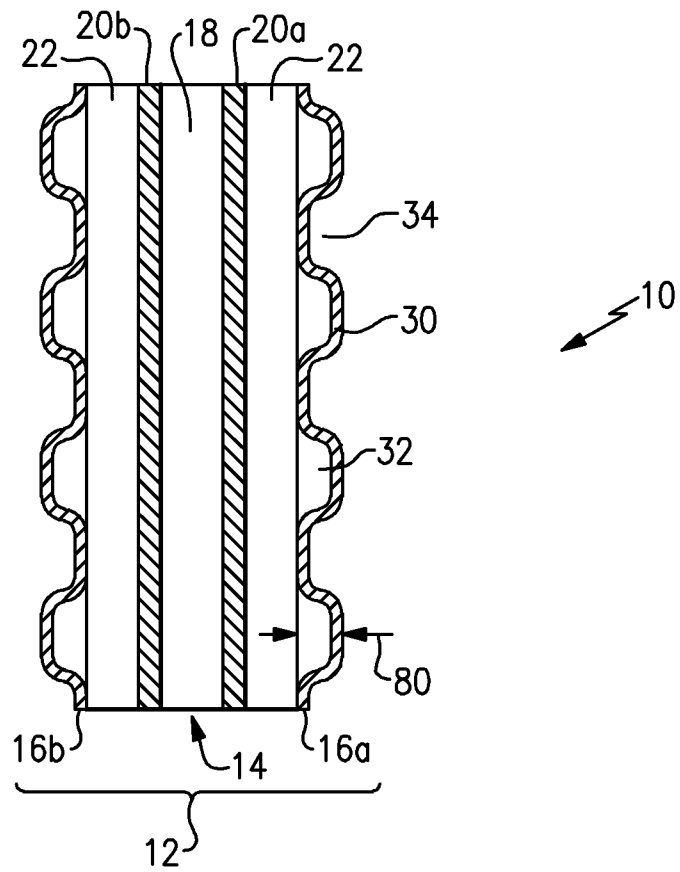


FIG. 1

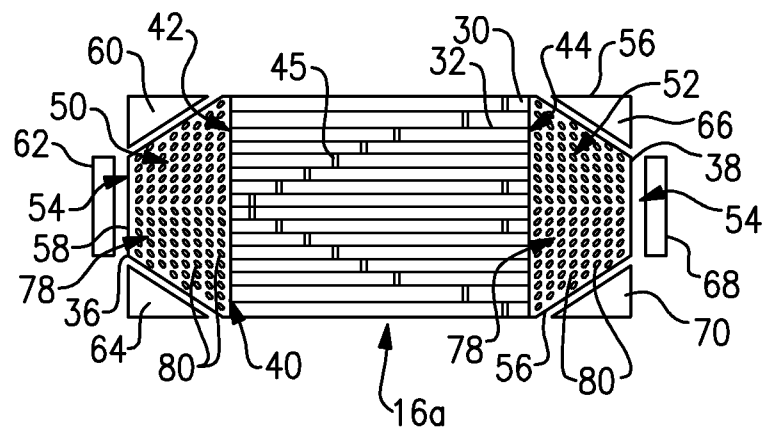


FIG. 2

2/2

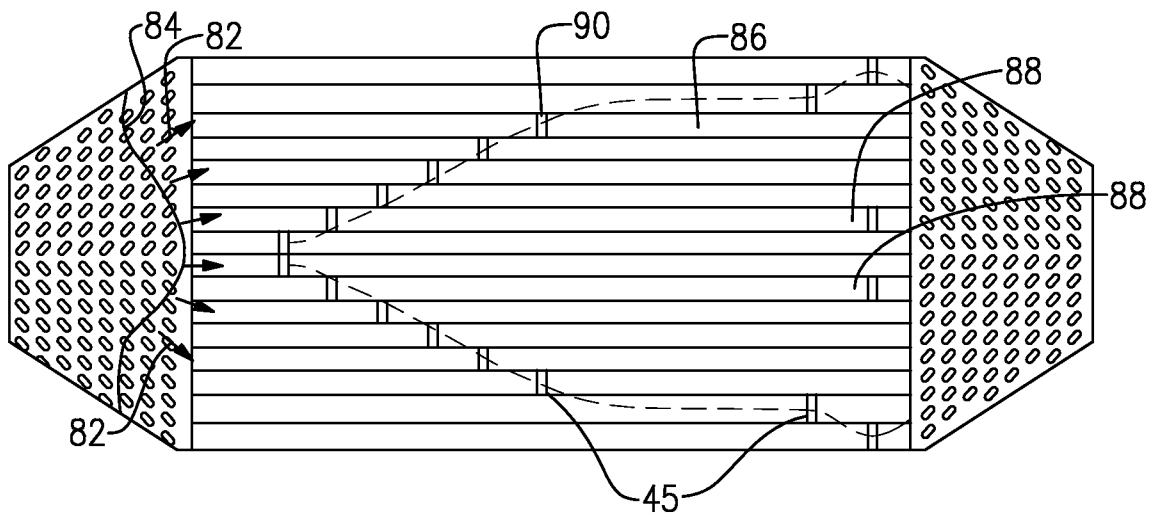


FIG. 3

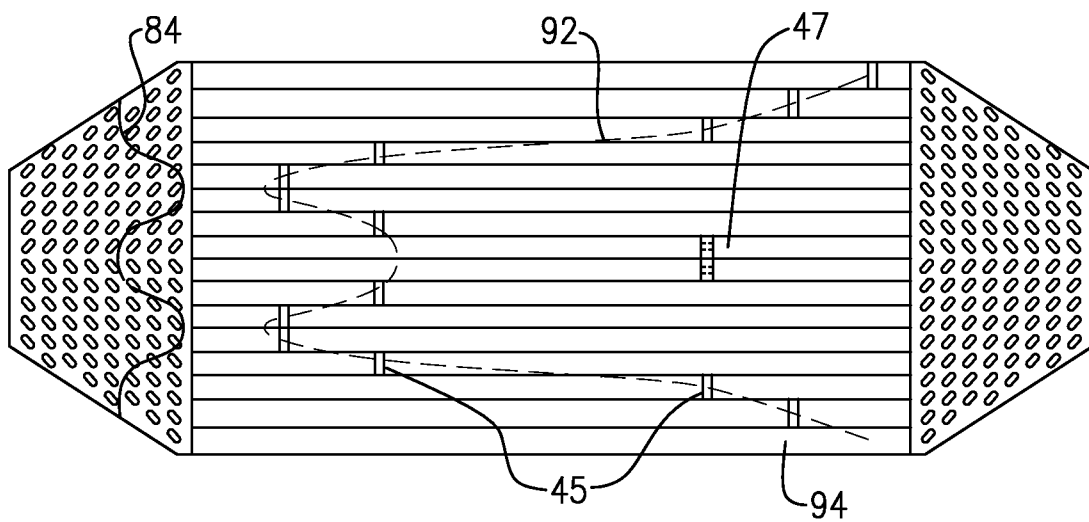


FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2010/029312**A. CLASSIFICATION OF SUBJECT MATTER****H01M 8/04(2006.01)i, G05D 7/00(2006.01)i**

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)

H01M 8/04; H01M 2/08; H01M 8/02; H01M 4/94; C25C 7/04

Documentation 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 models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & Keywords: "interdigitated channel, obstruction member, mirror, distribution, blockage, fuel cell, and similar terms"

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2008-0292938 A1 (PERRY et al.) 27 November 2008 See Figures 6-7, paragraphs [0025] and [0029] to [0031] and [0035] to [0036] and [0038] to [0040], claims 1-3 and 18	1-15
A	US 2005-0014059 A1 (KAYE IAN W.) 20 January 2005 See abstract, Figures 4A-4B and 7A-7B, paragraphs [0129]	1-15
A	US 2004-0067405 A1 (MARK CHRISTOPHER TURPIN et al.) 08 April 2004 See abstract, Figures 8-9, paragraphs [0046] to [0047] and [0072] to [0073]	1-15
A	US 2001-0041281 A1 (DAVID PENTREATH WILKINSON et al.) 15 November 2001 See abstract, Figures 2e and 4, paragraphs [0036] and [0041] to [0042]	1-15



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 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

24 JANUARY 2011 (24.01.2011)

Date of mailing of the international search report

25 JANUARY 2011 (25.01.2011)

Name and mailing address of the ISA/KR

Korean Intellectual Property Office
Government Complex-Daejeon, 139 Seonsa-ro, Seo-
gu, Daejeon 302-701, Republic of Korea

Facsimile No. 82-42-472-7140

Authorized officer

KIM, Kyong Min

Telephone No. 82-42-481-8173



INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2010/029312

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2008-0292938 A1	27.11.2008	CN 101366130 A	11.02.2009
		EP 1977463 A2	08.10.2008
		EP 1977463 A4	04.08.2010
		JP 2009-527870 T	30.07.2009
		KR 10-2008-0070063 A	29.07.2008
		US 2008-292938 A1	27.11.2008
		WO 2007-086828 A2	02.08.2007
		WO 2007-086828 A3	15.11.2007
		WO 2007-086828 A3	15.11.2007
US 2005-0014059 A1	20.01.2005	EP 1644997 A2	12.04.2006
		US 2005-008911 A1	13.01.2005
		US 2005-014059 A1	20.01.2005
		US 2007-0269703 A1	22.11.2007
		US 2009-202886 A1	13.08.2009
		US 7585581 B2	08.09.2009
		US 7655337 B2	02.02.2010
		WO 2005-020346 A2	03.03.2005
		WO 2005-020346 A3	29.09.2005
US 2004-0067405 A1	08.04.2004	CA 2437891-A1	22.08.2002
		CA 2437892-A1	22.08.2002
		CA 2445747-A1	14.11.2002
		EP 1264360 A1	11.12.2002
		EP 1264360 B1	07.06.2006
		EP 1386371 A1	04.02.2004
		EP 1405359 A2	07.04.2004
		GB 0103390 D0	28.03.2001
		GB 2372143 A	14.08.2002
		GB 2372143 B	09.04.2003
		GB 2372144 A	14.08.2002
		GB 2375063 A	06.11.2002
		GB 2375064 A	06.11.2002
		GB 2375222 A	06.11.2002
		GB 2377078 A	31.12.2002
		GB 2380853 A	16.04.2003
		JP 04-291575 B2	10.04.2009
		JP 2004-520692 A	08.07.2004
		JP 2004-523069 A	29.07.2004
		JP 2004-527883 A	09.09.2004
		KR 10-0840585 B1	23.06.2008
		KR 10-2003-0081438 A	17.10.2003
		KR 10-2004-0002930 A	07.01.2004
		TW 548871 A	21.08.2003
		TW 548871 B	21.08.2003
		TW 569486 A	01.01.2004
		TW 569486 B	01.01.2004
		US 2004-0137306 A1	15.07.2004
		US 2004-0142225 A1	22.07.2004

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2010/029312

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2001-0041281 A1	15. 11. 2001	US 2004-067405 A1	08. 04. 2004
		US 7067213 B2	27. 06. 2006
		WO 02-065565 A2	22. 08. 2002
		WO 02-065565 A3	22. 08. 2002
		WO 02-065566 A1	22. 08. 2002
		WO 02-090052 A1	14. 11. 2002
		WO 02-090053 A1	14. 11. 2002
		WO 02-091513 A1	14. 11. 2002
		WO 03-003497 A1	09. 01. 2003
		WO 03-034530 A2	24. 04. 2003
		WO 03-034530 A3	24. 04. 2003
		CA 2347199-A1	09. 11. 2001
		CA 2347203-A1	09. 11. 2001
		US 2001-041281 A1	15. 11. 2001
US 2001-0041281 A1	15. 11. 2001	US 6541145 B2	01. 04. 2003
		US 6586128 B1	01. 07. 2003