



(43) International Publication Date
24 July 2014 (24.07.2014)

- (51) International Patent Classification:
H01M 8/04 (2006.01) *H01M 8/24* (2006.01)
H01M 8/08 (2006.01)
- (21) International Application Number:
PCT/GB2014/050013
- (22) International Filing Date:
3 January 2014 (03.01.2014)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
1300906.3 18 January 2013 (18.01.2013) GB
- (71) Applicant: AFC ENERGY PLC [GB/GB]; 5-7 Cranwood Street, Finsgate, London EC1V 9EE (GB).
- (72) Inventor: AKHTAR, Naveed; 62 Chapelfields, Charterhouse Road, Godalming Surrey GU7 2BX (GB).
- (74) Agent: MANSFIELD, Peter Turquand; Fugro House, Hithercroft Road, Wallingford Oxfordshire OX10 9RB (GB).
- (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).

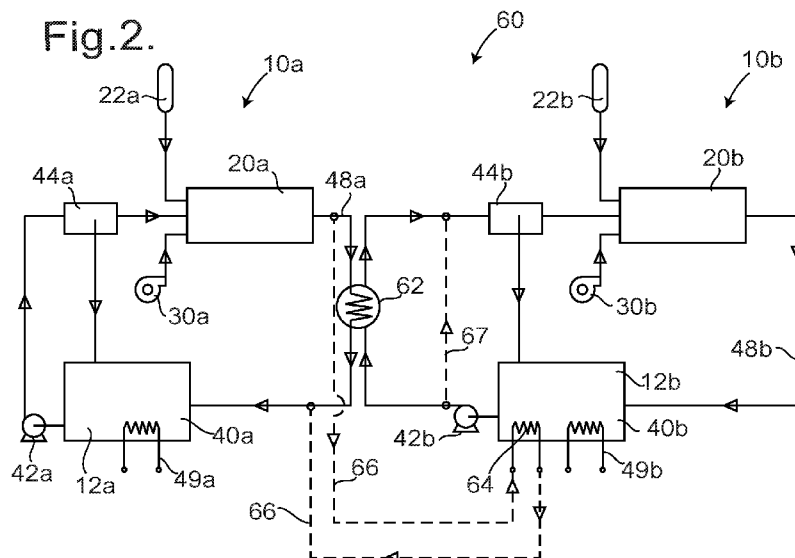
Declarations under Rule 4.17:

— as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))

Published:

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

(54) Title: FUEL CELL SYSTEM



(57) Abstract: A liquid electrolyte fuel cell system (60) comprises at least two fuel cell stacks (20a, 20b), each comprising a plurality of fuel cells, each fuel cell comprising a liquid electrolyte chamber between opposed electrodes, the electrodes being an anode and a cathode. At least one fuel cell stack (20a) is arranged to operate at an elevated temperature such as 65°C, and at least one fuel cell stack (20b) is arranged to operate at a temperature below the elevated temperature, such as 35°C. The system (60) comprises a heat exchanger (62; 64) to transfer heat from at least one fuel cell stack (20a) at the elevated temperature to at least one fuel cell stack (20b) at the lower temperature. This may be achieved by heat exchange between the respective electrolytes.

WO 2014/111686 A1

Fuel Cell System

The present invention relates to liquid electrolyte fuel cell systems, preferably but not exclusively incorporating alkaline liquid-electrolyte fuel cells, and to methods of
5 operating such fuel systems.

Background to the invention

Fuel cells have been identified as a relatively clean and efficient source of electrical
10 power. Alkaline fuel cells with a liquid electrolyte are of particular interest because they operate at relatively low temperatures, are efficient and mechanically and electrochemically durable. Acid fuel cells and fuel cells employing other liquid electrolytes are also of interest. Such fuel cells typically comprise an electrolyte chamber separated from a fuel gas chamber (containing a fuel gas, typically hydrogen) and a further gas chamber (containing
15 an oxidant gas, usually air). The electrolyte chamber is separated from the gas chambers using electrodes. Typical electrodes for alkaline fuel cells comprise a conductive metal, typically nickel, that provides mechanical strength to the electrode, and the electrode also incorporates a catalyst coating which may comprise activated carbon and a catalyst metal, typically platinum.

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In operation, it is conventional to operate the fuel cells at a temperature above 50 °C, for example at between 60 ° and 70 °C, because the efficiency of the cells is greater at such a temperature than at near ambient temperature. However operation at such a temperature leads to greater evaporation from the aqueous electrolyte, such as potassium hydroxide,
25 and so increases the risk of forming crystals for example of potassium carbonate or potassium hydroxide. Such crystals are most likely to form at the cathode, where the electrochemical reactions associated with cell operation consume water (in addition to the loss through evaporation); and the crystals are detrimental to the operation of the cell because they inhibit gas diffusion. Furthermore, degradation of the electrode materials
30 occurs to a greater extent at an elevated temperature such as 60 ° or 70 °C than at lower temperatures.

Discussion of the invention

35 The fuel cell system of the present invention addresses or mitigates one or more

problems of the prior art.

According to the present invention there is provided a liquid electrolyte fuel cell system comprising at least two fuel cell stacks, each fuel cell stack comprising a plurality of
5 fuel cells, each fuel cell comprising a liquid electrolyte chamber between opposed electrodes, the electrodes being an anode and a cathode; the fuel cell stacks comprising at least one first fuel cell stack arranged to operate at an elevated temperature, and at least one second fuel cell stack arranged to operate at a temperature below the elevated
10 temperature; and the system comprising a heat exchanger to transfer heat from at least one first fuel cell stack to at least one second fuel cell stack.

By way of example, a first electrolyte may be recirculated through at least one first fuel cell stack, and a second electrolyte may be circulated through at least one second fuel cell stack, and the heat exchanger may be arranged to exchange heat between the first
15 electrolyte and the second electrolyte. The heat exchanger may be arranged to exchange heat between the first electrolyte after it has passed through the first fuel cell stack, and the second electrolyte as it is passed towards the second fuel cell stack.

In a second aspect the invention provides a method of operating a liquid electrolyte
20 fuel cell system comprising at least two fuel cell stacks, the method comprising operating at least one first fuel cell stack at an elevated temperature, and operating at least one second fuel cell stack at a temperature below the elevated temperature, and transferring heat from at least one first fuel cell stack to at least one second fuel cell stack.

25 The elevated temperature at which each first fuel cell stack operates may be between 50 °C and 90 °C, more preferably between 60 °C and 70 °C; the lower temperature, at which each second fuel cell stack operates, may be between 25 °C and 50 °C, for example between 30 °C and 50 °C, or about 40 °C.

30 In a conventional liquid electrolyte fuel cell system, the electrolyte or the stack is generally cooled by circulating a coolant fluid such as air or water, and the heat is dissipated into the environment, or may be utilised for domestic heating or other purposes. The present invention enables at least some of the excess heat to be utilised to improve the total efficiency of the system, in generating additional electrical power.

35

The invention will now be further and more particularly described, by way of example only, and with reference to the accompanying drawings in which:

Figure 1 shows a schematic diagram of the fluid flows supplied to a fuel cell stack to which the invention would be applicable;

Figure 2 shows a schematic diagram of the fluid flows of a fuel cell system incorporating fuel cell stacks as described in relation to figure 1; and

Figure 3 shows a modification to the fuel cell system of figure 2.

10 Referring to figure 1, a fuel cell system 10 includes a fuel cell stack 20 (represented schematically), which uses an aqueous solution of potassium hydroxide as electrolyte 12, for example at a concentration of 6 moles/litre. The fuel cell stack 20 is supplied with hydrogen gas as fuel, air as oxidant, and electrolyte 12. Hydrogen gas is supplied to the fuel cell stack 20 from a hydrogen storage cylinder 22 through a regulator 24 and a control valve 26, and an exhaust gas stream emerges through a first gas outlet duct 28. Air is 15 supplied by a blower 30, and any CO₂ is removed by passing the air through a scrubber 32 and a filter 34 before the air flows through a duct 36 to the fuel cell stack 20, and spent air emerges through a second gas outlet duct 38.

20 The fuel cell stack 20 is represented schematically, as its detailed structure is not the subject of the present invention, but in this example it consists of a stack of fuel cells, each fuel cell comprising a liquid electrolyte chamber between opposed electrodes, the electrodes being an anode and a cathode. In each cell, air flows through a gas chamber adjacent to the cathode, to emerge as the spent air. Similarly, in each cell, hydrogen flows 25 through a gas chamber adjacent to the anode, and emerges as the exhaust gas stream. Thus in each cell the cathode separates the air-containing gas chamber from the electrolyte chamber, and the anode separates the hydrogen-containing gas chamber from the electrolyte chamber. More generally, a fuel cell may use a different source of oxygen, instead of air; and may use a different source of fuel, other than hydrogen.

30 Operation of the fuel cell stack 20 generates electricity, and heat, and also generates water by virtue of the chemical reactions described above. In addition water evaporates in both the anode and cathode gas chambers so both the exhaust gas stream and the spent air contain water vapour. The rate of evaporation depends on the electrode 35 surface area exposed to reactant gases, the flow rate of the reactant gases, and the

operating temperature. It also depends on the partial pressure of water vapour in the anode and cathode gas chambers. The overall result would be a steady loss of water from the electrolyte 12; the loss of water can be prevented by condensing water vapour from the spent air in the outlet duct 38 (or from the exhaust gas), for example by providing a
5 condenser 39. In addition, the chemical reaction occurring at the cathode generates hydroxyl ions and consumes water, so concentrating the electrolyte in the vicinity of the cathode.

The electrolyte 12 is stored in an electrolyte storage tank 40 provided with a vent 41.
10 A pump 42 circulates electrolyte from the storage tank 40 into a header tank 44 provided with a vent 45, the header tank 44 having an overflow pipe 46 so that electrolyte returns to the storage tank 40. This ensures that the level of electrolyte in the header tank 44 is constant. The electrolyte is supplied at constant pressure through a duct 47 to the fuel cell stack 20; and spent electrolyte returns to the storage tank 40 through a return duct 48. The
15 storage tank 40 includes a heat exchanger 49 to remove excess heat.

In the duct 36 the air stream passes through a heat exchanger 50, and then a humidification chamber 52. An aqueous liquid such as distilled water is supplied through a duct 53 to the humidification chamber 52; the excess water emerging from the
20 humidification chamber 52 is discharged through a duct 55 to waste.

The water supplied through the duct 53 is preferably at an elevated temperature, for example it may be heated by heat exchange with the electrolyte in the return duct 48. This will ensure that it is at a temperature only a few degrees lower than the operating
25 temperature of the fuel cell stack 20. For example the water may be passed through a heat exchanger (not shown) to exchange heat with the spent electrolyte in the return duct, before being supplied through the duct 53. In this case the humidification chamber 52 may be sufficiently warm that no separate heat exchanger 50 is required: the humidification chamber 52 both heats and humidifies the air stream at the same time, by direct contact
30 with water.

Although only one fuel cell stack 20 is shown, it will be appreciated that a fuel cell system 10 might include a plurality of fuel cell stacks 20 supplied with the electrolyte in parallel, and with a common recirculation system for the electrolyte.

Conventionally the electrolyte 12 would be maintained at an elevated temperature between 60°C and 70°C during operation. The internal electrical resistance of the fuel cells decreases with temperature, so operation at such an elevated temperature reduces the internal resistance, and so increases the power output of the fuel cell stack 20. Initially, on
5 start-up, it may therefore be necessary to provide an external source of heat, for example by supplying a hot liquid to the heat exchanger 49, so as to raise the temperature of the electrolyte 12 to the desired operating value. This may for example be 65°C. During steady-state operation it is not necessary to provide additional external heat, as heat is generated by operation of the fuel cell stack 20, so that it is necessary to remove excess heat from the
10 electrolyte 12, for example using the heat exchanger 49, as mentioned above.

Referring now to figure 2, a fuel cell system 60 of the present invention incorporates at least two fuel cell systems 10: a first fuel cell system 10a operates as described above, at an operating temperature of between 60° and 70°C; and a second fuel cell system 10b
15 operates at a lower operating temperature, which may be between 30° and 50°C. Components within the first and second fuel cell systems 10a and 10b which are the same as components described in relation to figure 1, are referred to by the same reference numerals, but distinguished by the suffixes a and b respectively; figure 2 is a schematic representation, and does not shown all the features that were shown in figure 1.

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Thus each fuel cell system 10a or 10b includes a fuel cell stack 20a or 20b, to which hydrogen is supplied from a storage cylinder 22a or 22b, air is supplied by a blower 30a or 30b, and electrolyte 12a or 12b is supplied from a header tank 44a or 44b which is fed from a storage tank 40a or 40b by a pump 42a or 42b; and spent electrolyte returns to the
25 storage tank 40a or 40b through a return duct 48a or 48b.

The fuel cell system 60 includes a heat exchanger 62 to enable heat transfer between spent electrolyte 12a in the return duct 48a, and electrolyte 12b as it is flowing to the header tank 44b.

30

The first fuel cell system 10a is operated as described above. Initially, starting at ambient temperature the electrolyte is heated up using the heat exchanger 49a, such that the electrolyte 12a is at an operating temperature between 60°C and 70°C. During operation it is not necessary to remove heat from the electrolyte 12a using the heat
35 exchanger 49a, as the excess heat is removed by the heat exchanger 62.

The second fuel cell system 10b uses the heat from the heat exchanger 62 to raise the temperature of the electrolyte 12b from ambient temperature to an operating temperature which may be 35 °C or 40 °C. Hence the fuel cell system 60 enables a larger number of fuel cell systems 10 to be operated, without requiring an external source of heat to heat the electrolyte for each fuel cell system 10. The external source of heat is used only to heat up the electrolyte 12a in each fuel cell system 10a that is arranged to operate at the elevated temperature. The waste heat from the fuel cell systems 10a that operate at an elevated temperature is then used to heat the electrolyte for additional fuel cell systems 10b operating at a lower temperature that is nevertheless above ambient temperature.

Although the power output from each fuel cell system 10b that is operating at such a lower temperature will be less than it would have output at the elevated temperature, nevertheless the system 60 produces a greater electrical output, because it combines the output from the elevated temperature fuel cell systems 10a with that from the lower temperature fuel cell systems 10b. The waste heat from the fuel cell system 10b that operates at a lower temperature may be removed using the heat exchanger 49b, and may be used as a source of low-temperature heat, for example for domestic heating.

Additionally it has been found that fuel cell failures are more likely to occur in a fuel cell stack 20a operating at an elevated temperature than in a fuel cell stack 20b operating at a lower temperature. By way of example, in a laboratory situation, fuel cells operating at 70 °C were found to operate on average for only 6 weeks before a pronounced degradation was observed, whereas identical fuel cells operating at 32 °C have been found to operate for over 24 weeks without any major degradation. A significant reason for this difference is that evaporation of water from the electrolyte occurs much more rapidly at the elevated temperature of 70 °C than at the lower temperature of 32 °C. A further reason is that the electrochemical reaction that takes place at the electrolyte/gas/catalyst interface within the cathode requires oxygen molecules to be transported through electrolyte. During operation the electrolyte in this vicinity tends to become more concentrated due to the electrochemical reaction, and becomes warmer, and both these changes decrease oxygen solubility. The effect is to increase the internal resistance, and to generate additional heat. This can lead to further evaporation of water, accelerating the problem.

Although the system 60 is described as exchanging heat between spent electrolyte 12a in the return duct 48a, and the electrolyte being supplied between the pump 42b and

the header tank 44b, by means of the heat exchanger 62, it will be appreciated that the exchange of heat may be brought about differently. For example, the storage tank 40b may be provided with an additional heat exchanger 64, and the heat exchanger 62 omitted, with the electrolyte return duct 48a communicating via the heat exchanger 64 with the storage tank 40a, and the pump 42b communicating directly with the header tank 44b. These alternative connections 66 and 67 are indicated by broken lines in figure 2. In this case the electrolyte 12b is therefore heated in the storage tank 40b.

Referring now to figure 3, a fuel cell system 70 represents an alternative modification of the fuel cell system 60. As with the fuel cell system 60, it incorporates at least two fuel cell systems 10: a first fuel cell system 10a operates as described above, at an operating temperature of between 60° and 70°C; and a second fuel cell system 10b operates at a lower operating temperature, which may be between 30° and 50°C. Components within the first and second fuel cell systems 10a and 10b which are the same as components described in relation to figure 1, are referred to by the same reference numerals, but distinguished by the suffixes a and b respectively; figure 3 is a schematic representation, and does not shown all the features that were shown in figure 1.

In the first fuel cell system 10a of the fuel cell system 70, the return electrolyte duct 48a returns the used electrolyte directly to the electrolyte storage tank 40a. As regards the second fuel cell system 10b, the electrolyte pump 42b is arranged to pass the electrolyte 12b through the heat exchanger 49a of the electrolyte storage tank 40a, via three-way valves 71, before it flows into the header tank 44b.

Hence, during start-up, the three-way valves 71 are arranged to supply hot fluid to the heat exchanger 49a, and so to heat up the electrolyte 12a. Once the first fuel cell system 10a is operating, and therefore generating heat, then the electrolyte pump 42b is started up and the three-way valves 71 are switched so the electrolyte 12b flows through the heat exchanger 49a and so takes heat out of the storage tank 40a. When steady state operation is achieved, the heat generated in the first fuel cell system 10a is used to maintain the temperature of the second fuel cell system 10b. The excess heat generated in the second fuel cell system 10b may be removed using the heat exchanger 49b, and may be used as a source of low-temperature heat, for example for domestic heating.

Claims

1. A liquid electrolyte fuel cell system comprising at least two fuel cell stacks, each fuel cell stack comprising a plurality of fuel cells, each fuel cell comprising a liquid electrolyte chamber between opposed electrodes, the electrodes being an anode and a cathode; the fuel cell stacks comprising at least one first fuel cell stack arranged to operate at an elevated temperature, and at least one second fuel cell stack arranged to operate at a temperature below the elevated temperature; and the system comprising a heat exchanger to transfer heat from at least one first fuel cell stack to at least one second fuel cell stack.
2. A fuel cell system as claimed in claim 1 wherein the heat exchanger is arranged to transfer heat between a first electrolyte in the at least one first fuel cell stack and a second electrolyte in the at least one second fuel cell stack.
3. A fuel cell system as claimed in claim 2 wherein the first electrolyte is recirculated through at least one first fuel cell stack, and the second electrolyte is circulated through at least one second fuel cell stack, and the heat exchanger is arranged to exchange heat between the first electrolyte and the second electrolyte.
4. A fuel cell system as claimed in claim 3 wherein the heat exchanger is arranged to exchange heat between the first electrolyte after it has passed through the first fuel cell stack, and the second electrolyte as it is passed towards the second fuel cell stack.
5. A method of operating a liquid electrolyte fuel cell system comprising at least two fuel cell stacks, the method comprising operating at least one first fuel cell stack at an elevated temperature, and operating at least one second fuel cell stack at a temperature below the elevated temperature, and transferring heat from at least one first fuel cell stack to at least one second fuel cell stack.
6. A method as claimed in claim 5 wherein the elevated temperature at which each first fuel cell stack operates is between 50 °C and 90 °C, and the lower temperature, at which each second fuel cell stack operates, is between 25 °C and 50 °C.
7. A method as claimed in claim 6 wherein the elevated temperature is between 60 °C and 70 °C; and the lower temperature is between 30 °C and 50 °C.

Fig. 1.

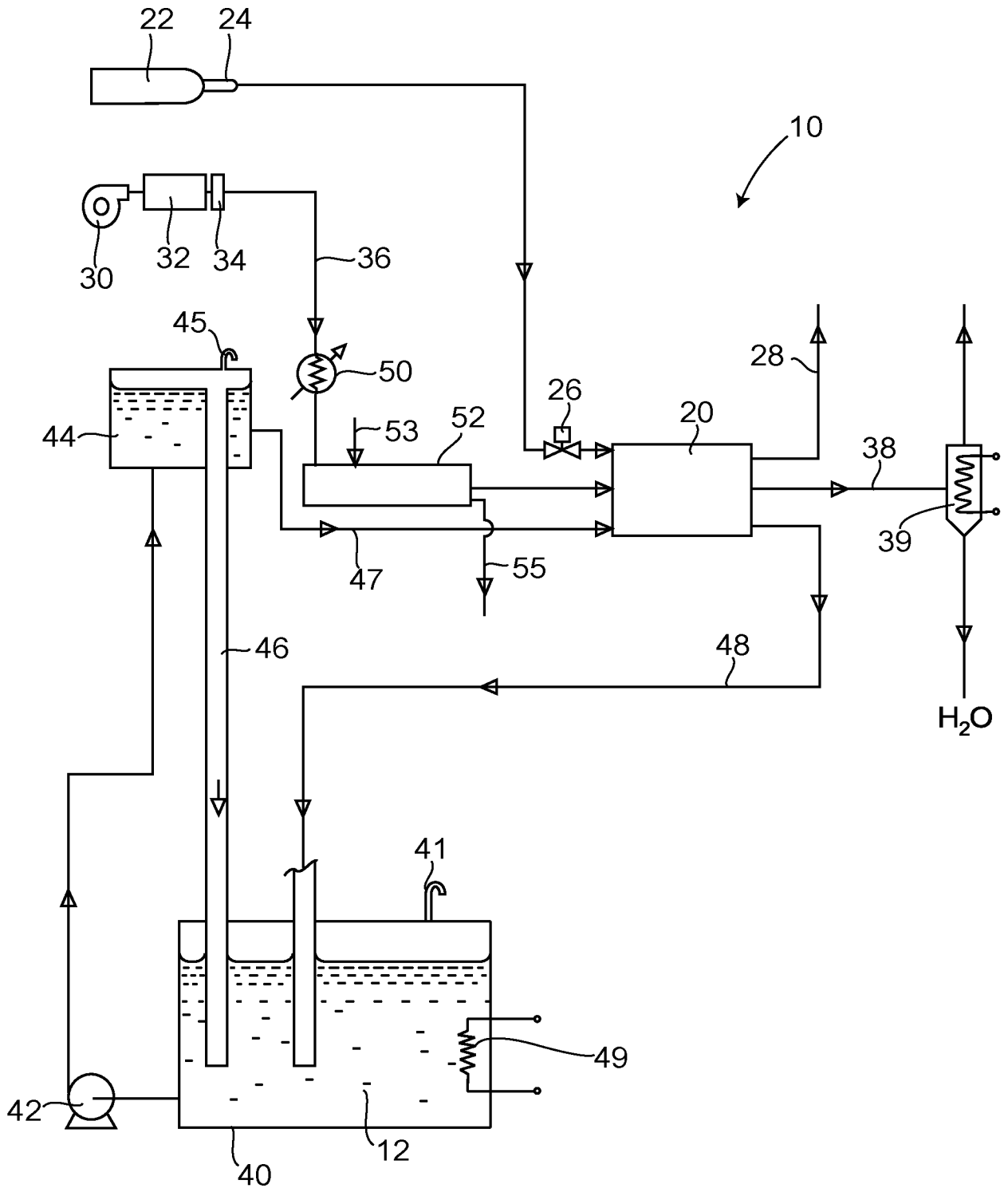


Fig.2.

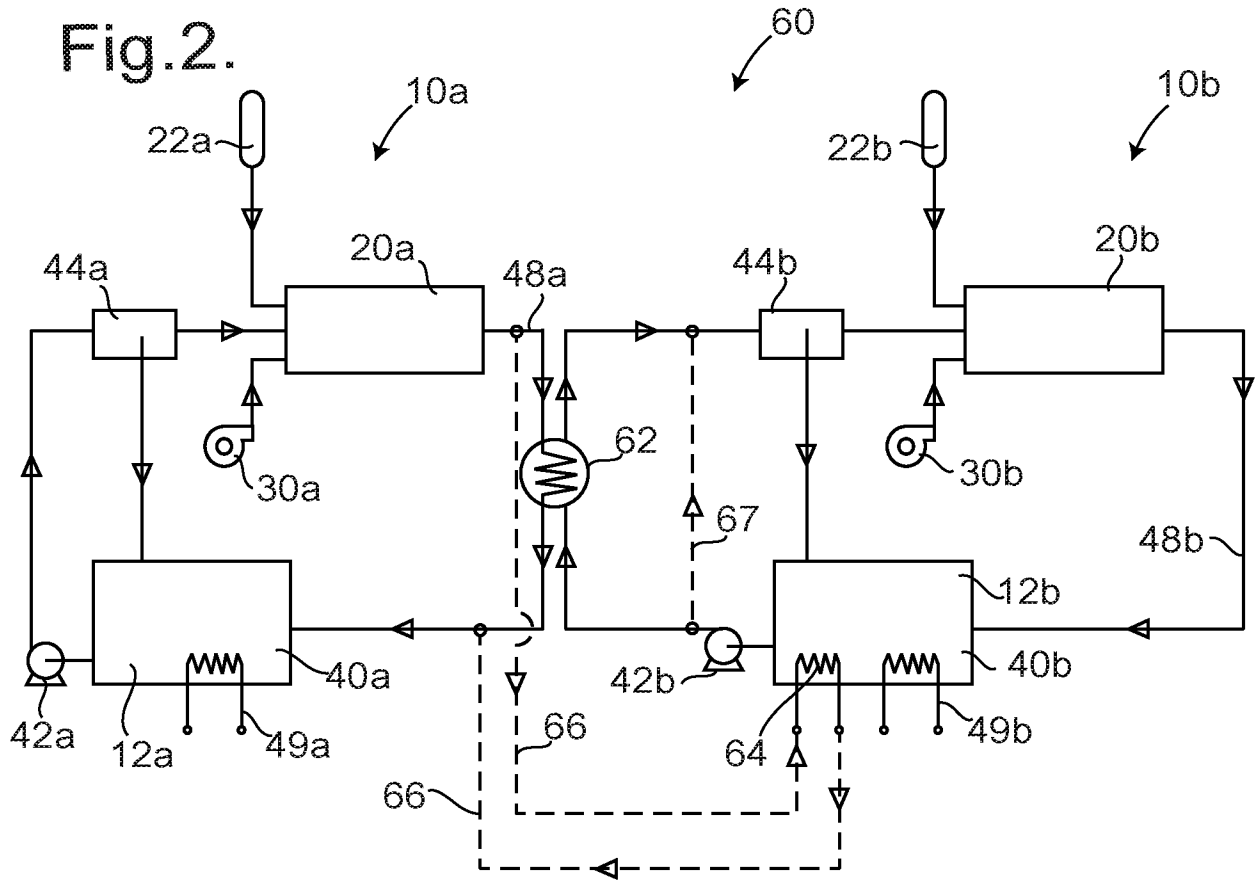
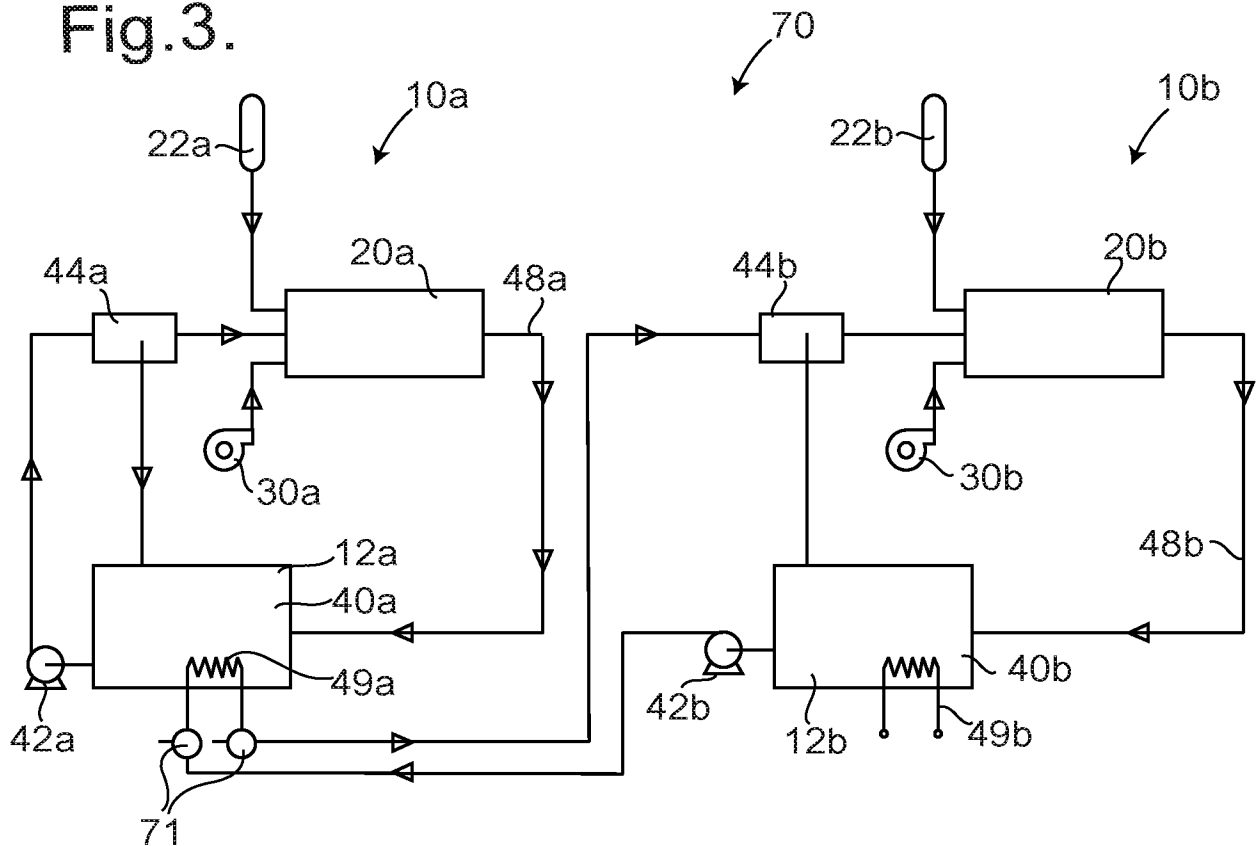


Fig.3.



INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2014/050013

A. CLASSIFICATION OF SUBJECT MATTER
 INV. H01M8/04 H01M8/08 H01M8/24
 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)
 H01M

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2006 294402 A (TOYOTA MOTOR CORP) 26 October 2006 (2006-10-26) figure 1 paragraphs [0029] - [0041], [0075], [0076], [0113] - [0115] -----	1,5-7
A	US 3 843 410 A (SPAHRBIER D) 22 October 1974 (1974-10-22) figures abstract column 1, line 62 - column 2, line 69 column 4, line 56 - column 5, line 36 ----- -/--	1-7

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>"&" document member of the same patent family</p>
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Date of the actual completion of the international search 31 March 2014	Date of mailing of the international search report 07/04/2014
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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 Riba Vilanova, Marta
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INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2014/050013

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 2010/003545 A1 (HORNE CRAIG RICHARD [US] ET AL HORNE CRAIG R [US] ET AL) 7 January 2010 (2010-01-07) figures 13A-13D paragraphs [0084] - [0099] claims 17-31</p> <p style="text-align: center;">-----</p>	1-7
A	<p>US 6 294 278 B1 (WOHR MARTIN [DE] ET AL) 25 September 2001 (2001-09-25) figure column 1, line 47 - column 3, line 6 column 3, line 20 - column 4, line 9 column 4, lines 25-33</p> <p style="text-align: center;">-----</p>	1-7
A	<p>BIDAULT F ET AL: "Review of gas diffusion cathodes for alkaline fuel cells", JOURNAL OF POWER SOURCES, ELSEVIER SA, CH, vol. 187, no. 1, 1 February 2009 (2009-02-01), pages 39-48, XP025866068, ISSN: 0378-7753, DOI: 10.1016/J.JPOWSOUR.2008.10.106 [retrieved on 2008-11-05] section "2. AFC technical review" figures 2,4 tables 1,2</p> <p style="text-align: center;">-----</p>	1-7
A	<p>K. TOMANTSCHGER ET AL: "Development of low cost alkaline fuel cells", JOURNAL OF POWER SOURCES, vol. 18, no. 4, 1 November 1986 (1986-11-01), pages 317-335, XP055110978, ISSN: 0378-7753, DOI: 10.1016/0378-7753(86)80089-1 figures 3,10,11 page 319, line 2 - page 320, line 3</p> <p style="text-align: center;">-----</p>	1-7

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No PCT/GB2014/050013

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 2006294402	A	26-10-2006	NONE
US 3843410	A	22-10-1974	NONE
US 2010003545	A1	07-01-2010	AU 2009268735 A1 14-01-2010
			CN 102089918 A 08-06-2011
			EP 2311130 A2 20-04-2011
			JP 2011527509 A 27-10-2011
			KR 20110033929 A 01-04-2011
			US 2010003545 A1 07-01-2010
			US 2011045332 A1 24-02-2011
			US 2011117411 A1 19-05-2011
			WO 2010005954 A2 14-01-2010
US 6294278	B1	25-09-2001	DE 19857398 A1 15-06-2000
			EP 1009050 A2 14-06-2000
			US 6294278 B1 25-09-2001