



(51) International Patent Classification:

H01M 8/06 (2006.01) *H01M 8/10* (2006.01)
F25D 17/02 (2006.01)

(21) International Application Number:

PCT/US2010/001079

(22) International Filing Date:

12 April 2010 (12.04.2010)

(25) Filing Language:

English

(26) Publication Language:

English

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(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.

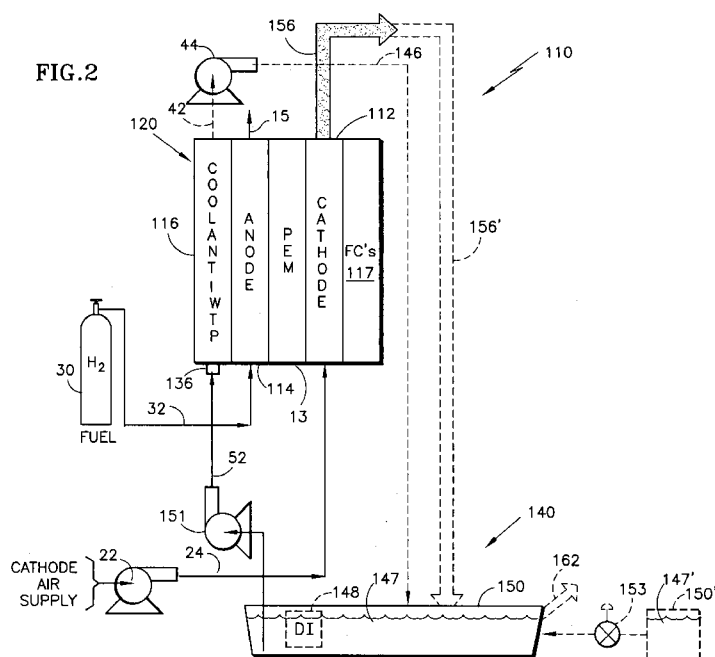
(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS,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

— of inventorship (Rule 4.17(iv))

[Continued on next page]

(54) Title: CONDENSER-FREE FUEL CELL BACKUP POWER SYSTEM



(57) Abstract: A fuel cell backup power system (110, 210, 310, 410) includes a fuel cell stack assembly (116, 216, 316, 416) having a coolant water flow path (116, 216, 316, 416) extending there through, and a thermal management system (140, 240, 340, 440) external thereof and connected to the coolant water flow path to supply coolant water (147, 247, 347, 447) to the stack assembly. The thermal management system is condenser-free, includes a reservoir (150, 150', 250, 350, 450) for storing coolant water, and is adapted to provide substantially the sole external source of water to the stack assembly for operation thereof. In various embodiments, a reservoir (150, 150') may be one or more discrete containers pre-filled with water (147, 147'); humidified oxidant exhaust (356) from the stack assembly may be directed into contact with the coolant water (347) in the reservoir (350); and/or a dehumidifier (480) may extract water from ambient air (490) and deliver it to a reservoir (450).



Published:

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

Condenser-Free Fuel Cell Backup Power System

BACKGROUND

[0001] The disclosure relates generally to fuel cells, and more particularly to the coolant and/or thermal management of and/or for a fuel cell power plant. More particularly still, the disclosure relates to the coolant/thermal management of/for a fuel cell backup power plant.

[0002] Fuel cell power plants are commonly used to produce electrical energy from reducing and oxidizing fluids to power electrical apparatus. In such power plants, one or typically a plurality, of fuel cells are arranged in a fuel cell stack, or cell stack assembly (CSA). Each cell generally includes an anode electrode and a cathode electrode separated by an electrolyte. The anode and the cathode each have a respective catalyst surface. A reducing fluid, or fuel reactant, such as hydrogen is supplied to the anode electrode, and an oxidant reactant such as oxygen or air is supplied to the cathode electrode. The reducing fluid and the oxidant reactant are typically delivered to and removed from the cell stack via respective manifolds. In a cell using a proton exchange membrane (PEM) as the electrolyte, the hydrogen electrochemically reacts at a catalyst surface of the anode electrode to produce protons and electrons. The electrons are conducted to an external load circuit and then returned to the cathode electrode, while the protons transfer through the electrolyte to the cathode electrode, where they react with the oxidant and electrons to produce water (product water) and release thermal energy.

[0003] The anode and cathode electrodes of such fuel cells are separated by different types of electrolytes, depending on operating requirements and limitations of the working environment of the fuel cell. One such electrolyte is a PEM electrolyte, which consists of a solid polymer well known in the art. Other common electrolytes used in fuel cells include phosphoric acid, sulfuric acid, or potassium hydroxide held within a porous, non-conductive matrix between the anode and cathode electrodes. It has been found that PEM cells have substantial advantages over cells with liquid acid or alkaline electrolytes in satisfying specific operating requirements because the membrane of the PEM provides a barrier between the reducing fluid and oxidant that is more tolerant to pressure differentials, is fixed and cannot be leached from the cell, and has a relatively stable capacity for water retention.

[0004] Fuel cell power plants typically include thermal management systems (TMS) for dealing with the management of water and the thermal energy produced. The electrochemical reaction in a fuel cell is more efficient at certain operating temperatures, and overheating can cause drying out of the PEM, which not only hinders or prevents the electrochemical reaction from occurring but also can lead to physical degradation of the membrane itself. Conversely, excessive moisture in the CSA can also lead to performance degradation when product water formed at the cathode, for example, accumulates and blocks reactants from reaching the cathode catalyst surface, thus inhibiting the electrochemical reaction.

[0005] In order to address the problems of excessive heat, drying, and moisture associated with fuel cells, various systems have been developed for carefully managing the fluid, typically water, balance in the CSA such that it stays sufficiently cooled and hydrated for maximum stack performance. Regardless of the system used, the coolant is distributed throughout the CSA via a fluid (coolant) flow path in order to prevent the formation of excessive thermal gradients and/or to properly humidify the reactants. Internal to the CSA, there may be various alternative modes of water management and cooling. Some fuel cells have used solid separator plates containing machined or formed channels to distribute coolant, whereas others have used porous separator plates, commonly known as water transfer plates (WTP), which allow water to move through the pores in the plates in response to a pressure difference. Heat may be removed from the CSA by transfer of sensible heat to the coolant (sensible cooling), as by incorporating the product water into the coolant flow. Another mechanism for heat removal, termed “evaporative cooling”, is by evaporation of water into the cathode air stream. This water may be supplied by the WTPs. Whereas the mechanism of sensible cooling typically relies upon significant flow and recirculation of coolant, evaporative cooling typically relies upon a relatively lesser flow and recirculation of coolant and achieves significant cooling via evaporation. At one extreme of evaporative cooling, very little, or no, coolant in the liquid phase is exhausted from the CSA. In other systems, both such mechanisms for cooling and hydration may be present to differing extents, with a low coolant flow configuration comprising both a limited circulation of coolant always in the liquid phase and a further recapture and recirculation of evaporated moisture entrained in the cathode exhaust air.

[0006] Although evaporative cooling systems typically require relatively less circulation of coolant water through the CSA than do water management systems that employ sensible cooling, their thermal management systems (TMS) have relied upon an external loop that includes a conventional condenser for condensing moisture from the cathode exhaust to provide a supply of coolant water for recirculation to maintain the CSA in thermal and hydration balance.

[0007] There is increased interest in the use of fuel cell power supply systems for providing back-up power for intervals of less than continuous operation, as for instance for emergency use, peak load supplementing, or the like. To enhance the economic competitiveness and appeal of such back-up systems, it is desirable that they be relatively compact and simple while continuing to provide the requisite back-up power. Heretofore, a typical fuel cell power system, whether used for back-up power or for continuous power, has included a fuel cell stack assembly (CSA) of the PEM type and a thermal management system loop connected thereto that includes a conventional condenser for condensing moisture from the cathode exhaust to provide a supply of coolant water to a reservoir, such as a water tank or accumulator, for recirculation. Such condensers are relatively large and expensive, typically including fans and considerable plumbing and heat transfer hardware, and accordingly adversely impact the competitiveness of the back-up system.

[0008] Referring to Fig. 1, there is depicted an example of such a fuel cell power system 10 as known in the prior art. A fuel cell stack assembly (CSA) 20 may be of the PEM type comprised of a plurality of fuel cells each including a polymer electrolyte membrane between respective anode and cathode electrodes, and having associated oxidant reactant flow paths 12, fuel reactant flow paths 14, and coolant flow paths 16 provided therein and there through in a known manner. The coolant flow paths have included the use of solid and/or porous separator plates. Air is supplied to the oxidant flow path 12 by a blower or compressor 22 via line 24. Fuel reactant, such as hydrogen 30, is supplied to the fuel reactant flow path 14 via line 32. Coolant, such as water, is supplied to the CSA 20 at a coolant inlet 36 which is connected to the internal coolant flow path 16. Spent fuel may be exhausted via line 15.

[0009] A thermal management system 40 for the CSA 20 is depicted as an external loop, or loops, connected between various exhaust ports of the CSA 20 and the coolant inlet 36. One such loop is connected to the discharge end of the coolant flow path 16, and conveys liquid-phase water from the CSA 20 to a reservoir or

accumulator tank 50, via line 42, pump 44, line 46, de-ionizer(DI) 48, and line 49. Water 47 in the accumulator tank 50 is returned to the coolant inlet 36 of CSA 20 by a pump 51 via line 52 from the accumulator tank. The thermal management system 40 also includes another loop connected to the exhaust, or discharge, end of the oxidant flow path 12 to receive the water-saturated cathode exhaust resulting from evaporative cooling in the CSA 20. That loop conveys the saturated exhaust via conduit 56 to a conventional condenser 58 that includes heat exchange surfaces and an associated cooling fan. The condenser 58 removes moisture in the humidified gas stream as liquid water, which is then delivered to accumulator tank 50 via line 60. A relatively drier cathode exhaust stream exits the condenser 58 via vent conduit 62. As used herein, the terms “condenser” and “conventional condenser” are intended to embrace the relatively large, costly, and/or complex condensing devices that have traditionally been used in the cathode exhaust streams to convert the moisture therein to water for subsequent delivery to a reservoir. Such a device is generally a heat exchanger with a flowing process gas stream on one side which contains a condensable component such as water vapor, and on the other side has a colder flowing stream which may be gas or liquid. For devices which use a gas on the cold side, the gas is generally ambient air which may be delivered actively by a fan to one side of a metal plate to recover heat from the exhaust stream as it passes over the other side of the plate, and concomitantly condenses water vapor contained in the exhaust stream.

SUMMARY

[0010] A typical fuel cell power system used for back-up power has heretofore included a fuel cell stack assembly (CSA) of the PEM type and a thermal management system that includes a conventional condenser for condensing moisture from the cathode exhaust to provide a supply of coolant water for recirculation. Such conventional condensers are relatively large and expensive, and thus may adversely impact the competitiveness of the back-up system.

[0011] Accordingly, the present disclosure relates to a fuel cell back-up power system having a fuel cell stack assembly (CSA), which in turn includes a fuel flow path extending there through for connection to a fuel source, an oxidant flow path extending there through for connection to a source of oxidant and for discharging humidified oxidant, and a coolant water flow path extending nominally there through

for connection to a supply of coolant water; and a thermal management system external of and connected to the CSA for supplying coolant water to the CSA, with the thermal management system being condenser-free and having a coolant reservoir as substantially the only source of coolant water for the CSA during its operation. The thermal management system is connected to the inlet of the coolant water flow path of the CSA to supply the coolant water for operation of the CSA.

[0012] The CSA may conveniently be of the PEM type, and may further conveniently include water transfer plates to manage and move the water in a desired and known manner internally of the CSA. Although some degree of sensible cooling may occur, the CSA may rely principally, or even entirely, upon internal evaporative cooling for the required cooling.

[0013] Generally speaking, the coolant supply arrangements of the thermal management systems of the several disclosed fuel cell back-up power system embodiments are devoid of a condenser, especially in the context of the conventional condensers as used in the prior art. In one disclosed embodiment, the coolant supply arrangement is reliant upon a supplemental supply of coolant water which may be a limited quantity of de-ionized (DI) water, as might be provided in discrete containers, with the duration of back-up operation being determined by the quantity supplied. In another disclosed embodiment, the coolant supply arrangement is reliant upon a supplemental supply of coolant water which may be continuous, as from a de-ionized supply of "local", or "house", water at the site.

[0014] In a further disclosed embodiment of the fuel cell back-up power system, the coolant supply arrangement includes a relatively simple and conventional dehumidifier which condenses water from the ambient air, particularly when the fuel cell is not operating, and delivers it to a water tank or accumulator for use as needed. The dehumidifier may be powered by the grid or other base power source during extended operation (when backup fuel cell is not operating) to create a reserve.

[0015] In a still further disclosed embodiment of the fuel cell back-up power system, a coolant supply arrangement delivers water-laden air from the cathode exhaust substantially directly (without inclusion of a conventional condenser) to a reservoir or water tank. The water-laden exhaust air is then passed in contact with relatively colder coolant water residing in the reservoir to extract, by condensation, at least some of the water from the air stream for addition to water already in the reservoir. The efficiency

of this arrangement is a function of the temperature difference between the coolant water in the reservoir and the water-laden exhaust air stream.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] Fig. 1 is a schematic view of a generalized fuel cell power system in accordance with the prior art;

[0017] Fig. 2 is a schematic view of a generalized fuel cell backup power system depicting a condenser-free, discrete supply of coolant water in accordance with one disclosed embodiment;

[0018] Fig. 3 is a schematic view of a generalized fuel cell backup power system depicting a condenser-free, local supply of coolant water in accordance with another disclosed embodiment;

[0019] Fig. 4 is a schematic view of a generalized fuel cell backup power system depicting a condenser-free supply of coolant water having a humid cathode exhaust stream directed into relatively cooler water in a reservoir in accordance with yet another disclosed embodiment; and

[0020] Fig. 5 is a schematic view of a generalized fuel cell backup power system depicting a condenser-free supply of coolant water utilizing a dehumidifier in accordance with still another disclosed embodiment.

DETAILED DESCRIPTION

[0021] Following are described several disclosed embodiments of fuel cell backup power systems, each having only condenser-free systems for supplying coolant water to the fuel cell stack assembly. As with the description and depiction of Fig. 1, the systems of Figs. 2-5 are generalized in their depiction and to some extent also in their description. The systems of Figs. 2-5 are all presented as fuel cell power backup systems in which the fuel cells are of the PEM type. In instances where an element is identical, the reference numeral is the same; and where an element is similar or analogous, but may differ somewhat, numerical prefix is used. For convenience of display, the depictions of the fuel cell stack assemblies of Figs. 2-5 illustrate “anode”, “cathode”, and “coolant-WTP” (and PEM), rather than the fuel flow path, oxidant flow path, and coolant flow paths of Fig. 1. However it will be appreciated that there is a significant correlation between the three flow paths and the mentioned elements,

and they are thusly correlated to Fig. 1 in their numbering. Still further, although the TMS of Fig. 1 was depicted as having both a liquid water flow loop (46, 49) and a condenser-included humid air-to-liquid water flow loop (56, 60), the depictions of Figs. 2-5 are of systems that typically include at least some amount of evaporative cooling that results in at least an exhaust of humid air, but which may or may not include any discharge and recirculation of coolant water in the liquid phase as from sensible cooling. For this reason, the liquid water loop, which may or may not exist and be connected to the discharge end of the coolant path, is depicted in broken line. [0022] Referring to Fig. 2, there is depicted a fuel cell backup power system 110 having a fuel cell stack assembly (CSA) 120 of the PEM type. The CSA 120 receives air through an air inlet (not shown) to a cathode 112, also representative of the oxidant flow path. The air is delivered to the cathode 112 via line 24 using a blower 22, for example. A proton exchange membrane 13 is arranged between the cathode 112 and an anode 114 to form a cell 117, arranged in a stack as known. One or more additional cells 117 are shown schematically in the stack. Hydrogen is received at a fuel inlet (not shown) communicating with the anode 114, also representative of the fuel flow path. The hydrogen is obtained from a source 30, as for example a discrete tank or container, via line 32. The CSA 120, and indeed each fuel cell 117, includes provision for cooling that cell, as here represented by a water transport plate (WTP) type of coolant delivery flow path 116. The use of a porous WTP 116 facilitates the delivery of water within the fuel cells for use at least in evaporative cooling.

[0023] Focus is now directed to the condenser-free thermal management system (TMS) 140 that provides coolant water for the CSA 120. A reservoir or accumulator tank 150 contains water 147 that is supplied via line 52 and pump 151 to the coolant inlet 136, which delivers water to the coolant flow path represented by coolant-WTP 116. It will be understood that the requirement for pump 151 might be avoided if the reservoir 150 is positioned such that it supplies coolant by gravity feed. The reservoir in this embodiment may be somewhat larger than a conventional accumulator, and is characteristically provided by one or more discrete water tanks 150, 150'. Those discrete water tanks 150, 150' may each contain a pre-filled quantity of de-ionized water 147, 147', or they may additionally include provision for local de-ionization of the pre-filled water, as represented by de-ionizer 148, which may be a de-ionization cartridge. The de-ionizer is shown for convenience of display as being within tank 150, but in practice it is likely to either precede or follow the tank 150, in series with

coolant water flow to the coolant inlet 136. In any event, the water 147, 147' supplied in the discrete water tanks 150, 150' will comprise the totality of the water available as a reservoir for cooling the CSA 120. In the example of a 5 kW fuel cell backup power system, 8 hours of operation should require a supply of about 108 liters of water. Accordingly, the duration of operation of such system may be scaled up through the provision of proportionally larger amounts of water. As depicted, there is an initial water tank 150, which might contain 108 liters of pre-filled water 147, and an optional reserve tank 150' which may contain a similar amount 147' for delivery to tank 150 via control valve 153. The tanks 150, 150' may thus be of relatively small size, providing economy and ease of handling.

[0024] Because the coolant water requirements in this embodiment of a TMS 140 may be provided entirely by the quantity of water in the pre-filled tanks, there is no requirement for water recovery from the operation of the CSA 120. Accordingly, there may be no need for an optional liquid water recirculation loop represented in broken line by lines 42 and 146, and pump 44. Similarly, although the CSA 120 is provided with some evaporative cooling, the water-saturated exhaust 156 from the cathode 112 may simply be vented to the environment or, optionally as depicted in broken line, it may be directed via conduit 156' to the reservoir or tank 150 where it may be partly de-humidified to recover some water, and the resulting less-humid exhaust is vented as indicated by 162.

[0025] Referring to Fig. 3, there is depicted a fuel cell backup power system 210 having a fuel cell stack assembly (CSA) 220 of the PEM type. The CSA 220 receives air through an air inlet (not shown) to a cathode 212, also representative of the oxidant flow path. The air is delivered to the cathode 212 via line 24 using a blower 22, for example. A proton exchange membrane 13 is arranged between the cathode 212 and an anode 214 to form a cell 217, arranged in a stack as known. One or more additional cells 217 are shown schematically in the stack. Hydrogen is received at a fuel inlet (not shown) communicating with the anode 214, also representative of the fuel flow path. The hydrogen is obtained from a source 30, as for example a discrete tank or container, via line 32. The CSA 220, and indeed each fuel cell 217, includes provision for cooling that cell, as here represented by a water transport plate (WTP) type of coolant delivery flow path 216. The use of a porous WTP 216 facilitates the delivery of water within the fuel cells for use at least in evaporative cooling.

[0026] Attention is now given to the condenser-free thermal management system (TMS) 240 that provides coolant water for the CSA 220. A reservoir or accumulator tank 250 contains water 247 that is supplied via line 52 and optional pump 251 to the coolant inlet 236, which delivers water to the coolant flow path represented by coolant-WTP 216. The sole, or at least principal, supply of water to the reservoir 250 is obtained from a local source independent of the CSA 220, as for example from a conventional “house” supply designated 270, via a control valve 272 and conduit 273. The control valve 272 may be operated and/or controlled in response to a water level control signal 274 derived using any of several known techniques, as by a signal voltage provided by a float 276 located in the reservoir 250. The house water supply 270 is of sufficient capacity to support the needs of the particular backup system 210. A de-ionizer 248, which may be a de-ionization cartridge, is located in series with coolant water flow to the CSA’s coolant inlet 236, and in this embodiment is conveniently positioned intermediate the source of the house water supply 270 and the reservoir 250.

[0027] As discussed with respect to the embodiment of Fig. 2, because the coolant water requirements of a TMS 240 in this embodiment may be provided entirely by the quantity of water 247 supplied to reservoir 250 by the local house water supply 270, there is no requirement for water recovery from the operation of the CSA 220. Accordingly, there may be no need for an optional liquid water recirculation loop represented in broken line by lines 42 and 246, and pump 44. Similarly, although the CSA 220 is provided with some evaporative cooling, the water-saturated exhaust 256 from the cathode 112 may simply be vented to the environment or, optionally as depicted in broken line, it may be directed via conduit 256’ to the reservoir 250 where it may be partly de-humidified to recover some water, and the resulting less-humid exhaust is vented as indicated by 262.

[0028] Referring to Fig. 4, there is depicted a fuel cell backup power system 310 having a fuel cell stack assembly (CSA) 320 of the PEM type. The CSA 320 receives air through an air inlet (not shown) to a cathode 312, also representative of the oxidant flow path. The air is delivered to the cathode 312 via line 24 using a blower 22, for example. A proton exchange membrane 13 is arranged between the cathode 312 and an anode 314 to form a cell 317, arranged in a stack as known. One or more additional cells 317 are shown schematically in the stack. Hydrogen is received at a fuel inlet (not shown) communicating with the anode 314, also representative of the fuel flow

path. The hydrogen is obtained from a source 30, as for example a discrete tank or container, via line 32. The CSA 320, and indeed each fuel cell 317, includes provision for cooling that cell, as here represented by a water transport plate (WTP) type of coolant delivery flow path 316. The use of a porous WTP 316 facilitates the delivery of water within the fuel cells for use at least in evaporative cooling.

[0029] Attention is now directed to the condenser-free thermal management system (TMS) 340 that provides coolant water for the CSA 320. A reservoir or accumulator tank 350 contains water 347 that is supplied via line 52 and optional pump 351 to the coolant inlet 336, which delivers water to the coolant flow path represented by coolant-WTP 316. The reservoir 350 in this embodiment may be an accumulator, or typically a water tank of somewhat greater size and capacity than would otherwise be the case. As with the Fig. 2 embodiment, provision is made for local de-ionization of the coolant water to be delivered to the CSA 320, as represented by de-ionizer 348, which may be a de-ionization cartridge. The de-ionizer 348 is shown for convenience of display as being within tank 350, but in practice it is more likely to either precede or follow the tank 350, in series with coolant water flow to the coolant inlet 336. The principal supply of water 347 to the tank 350 is derived from the saturated exhaust from cathode 312 without requiring a conventional condenser, as will be described.

[0030] The CSA 320 relies upon evaporative cooling to at least a significant extent, such that the exhaust from cathode 312 is highly saturated with water. Accordingly, that water-saturated exhaust 356 is conveyed via a conduit, similarly designated 356, substantially directly to the reservoir 350 and, more particularly, into heat exchange contact with relatively cooler residual coolant water 347 in the reservoir. At least some of the water in the relatively warmer water-saturated exhaust is released into the relatively cooler residual water of reservoir 350, thereby serving to augment and maintain the supply in the reservoir for re-use in the CSA 320. It will be understood that the rate of water retrieval in this manner from the water-saturated cathode exhaust stream is at least partly a function of the temperature difference between it and the relatively cooler water in the reservoir 350, and is greatest during the earlier stages of operation and diminishes as the temperature of the water in the reservoir 350 heats up toward the temperature of the CSA 320. The cathode exhaust stream accordingly becomes relatively less humid and is vented from reservoir 350 as indicated by 362.

[0031] As discussed with respect to the embodiments of Figs. 2 and 3, there may be no need for an optional liquid water recirculation loop represented in broken line by

lines 42 and 346, and pump 44, particularly to the extent the CSA 320 relies on evaporative cooling rather than sensible cooling and exhausts little or no water in the liquid phase. On the other hand, assuming some sensible cooling in the stack, the recirculation of that liquid water in optional lines 42 and 346 is available to help augment the supply 347 derived from the water-saturated cathode exhaust stream in conduit 356 as the temperature of the water in the reservoir 350 heats up toward the temperature of the CSA 320.

[0032] Referring to Fig. 5, there is depicted a fuel cell backup power system 410 having a fuel cell stack assembly (CSA) 420 of the PEM type. The CSA 420 receives air through an air inlet (not shown) to a cathode 412, also representative of the oxidant flow path. The air is delivered to the cathode 412 via line 24 using a blower 22, for example. A proton exchange membrane 13 is arranged between the cathode 412 and an anode 414 to form a cell 417, arranged in a stack as known. One or more additional cells 417 are shown schematically in the stack. Hydrogen is received at a fuel inlet (not shown) communicating with the anode 414, also representative of the fuel flow path. The hydrogen is obtained from a source 30, as for example a discrete tank or container, via line 32. The CSA 420, and indeed each fuel cell 417, includes provision for cooling that cell, as here represented by a water transport plate (WTP) type of coolant delivery flow path 416. The use of a porous WTP 416 facilitates the delivery of water within the fuel cells for use at least in evaporative cooling.

[0033] Reference is now made to the condenser-free thermal management system (TMS) 440 that provides coolant water for the CSA 420. A reservoir or accumulator tank 450 contains water 447 that is supplied via line 52 and optional pump 351 to the coolant inlet 436, which delivers water to the coolant flow path represented by coolant-WTP 416. The reservoir 450 in this embodiment may be a conventional accumulator, or may be a water tank of somewhat greater size and capacity than would otherwise be the case. As with the Figs. 2 and 4 embodiments, provision is made for local de-ionization of the coolant water 447 to be delivered to the CSA 420, as represented by de-ionizer 448, which may be a de-ionization cartridge. The de-ionizer 448 is shown for convenience of display as being within tank 450, but in practice it is more likely to either precede or follow the tank 450, in series with coolant water flow to the coolant inlet 436. The supply of water 447 to the tank 450 is derived principally, or entirely, from humidity in the ambient air without requiring a conventional condenser, as will be described.

[0034] A relatively simple and conventional dehumidifier 480 of the type used for room dehumidification is used to obtain water to supply reservoir 450. During the extended intervals of operation from a primary electrical supply, such as the electrical power grid, the CSA 420 may not be operating. During such time, the dehumidifier 480 is powered through leads 484 via power control module 481 receiving power from the grid, represented by leads 488. The dehumidifier 480 receives ambient air, as represented at 490, and removes water in a known manner, which then flows in its liquid phase, appearing as line 457, to the reservoir 450. This may serve as the sole source of water supply to the reservoir 450, and may be sufficient to support backup power operation of the CSA 420 if run in a water deficit mode for a limited number of hours. A dehumidified exhaust vent is represented by 482.

[0035] As a further option with respect to the embodiment of Fig. 5, and assuming some sensible cooling in the CSA 420, the optional recirculation of liquid water shown in broken lines 42, 44, and 446 is available to help augment the supply of water derived from the dehumidification of the ambient air. Still further, as with the embodiment of Fig. 3, although the CSA 420 is provided with some evaporative cooling, the water-saturated exhaust 456 from the cathode 412 may simply be vented to the environment or, optionally as depicted in broken line, it may be directed via conduit 456' to the reservoir 450 where it may be partly de-humidified to recover some water.

[0036] Although the disclosure has been described and illustrated with respect to the exemplary embodiments thereof, it should be understood by those skilled in the art that the foregoing and various other changes, omissions and additions may be made without departing from the spirit and scope of the disclosure. All such modifications and variations are intended to be included herein within the scope of this disclosure and protected by the accompanying claims.

CLAIMS

What is claimed is:

- 1 **1.** A fuel cell backup power system (110, 210, 310, 410) comprising:
2 a fuel cell stack assembly (116, 216, 316, 416), including a fuel flow path (114,
3 214, 314, 414) extending there through for connection to a source of fuel (30,
4 32), an oxidant flow path (112, 212, 312, 412) extending there through for
5 connection to a source of oxidant (22, 24) and discharging humidified oxidant
6 exhaust (156, 256, 356, 456); and a coolant water flow path (116, 216, 316, 416)
7 extending nominally there through for connection at an inlet (136, 236, 336, 436)
8 to a supply of coolant water (147, 247, 347, 447); and
9 a thermal management system (140, 240, 340, 440) external of the fuel cell
10 stack assembly and connected to the fuel cell stack assembly coolant flow path
11 inlet (136, 236, 336, 436) to supply coolant water (147, 247, 347, 447) to the fuel
12 cell stack assembly, said thermal management system being condenser-free and
13 adapted to provide substantially the sole external source of water to the fuel cell
14 stack assembly for operation thereof.
- 1 **2.** The fuel cell backup power system (110, 210, 310, 410) of claim **1**, wherein
2 the thermal management system: (140, 240, 340, 440) includes a reservoir (150,
3 150', 250, 350, 450) for storing coolant water (147, 247, 347, 447), said reservoir
4 being connected to supply coolant water to the fuel cell stack assembly coolant
5 flow path inlet (136, 236, 336, 436).
- 1 **3.** The fuel cell backup power system (110) of claim **2**, wherein at least one said
2 reservoir (150, 150') comprises a discrete container with pre-filled coolant water
3 (147, 147') obtained from other than the fuel cell stack assembly (116).
- 1 **4.** The fuel cell backup power system (110) of claim **3**, wherein the quantity of
2 said pre-filled coolant water (147, 147') obtained from other than the fuel cell
3 stack assembly (116) is sufficient to meet the backup power operating
4 requirements of said fuel cell stack assembly for at least several hours.

1 **5.** The fuel cell backup power system (210) of claim 2 including coolant water
2 supply means (248, 272) connected to the reservoir (250) and adapted for
3 connection to a local supply of water (270) other than the fuel cell stack assembly
4 (216) to provide at least part of the coolant.

1 **6.** The fuel cell backup power system (310) of claim 2 wherein the thermal
2 management system (340) includes a fluid conduit (356) connected between the
3 discharge end of the oxidant flow path (312) in fuel cell stack assembly (316) and
4 the reservoir (350) to deliver the humidified oxidant exhaust (356) into heat
5 exchange communication with supply coolant water (347) in the reservoir to
6 thereby extract additional supply coolant water from the oxidant exhaust.

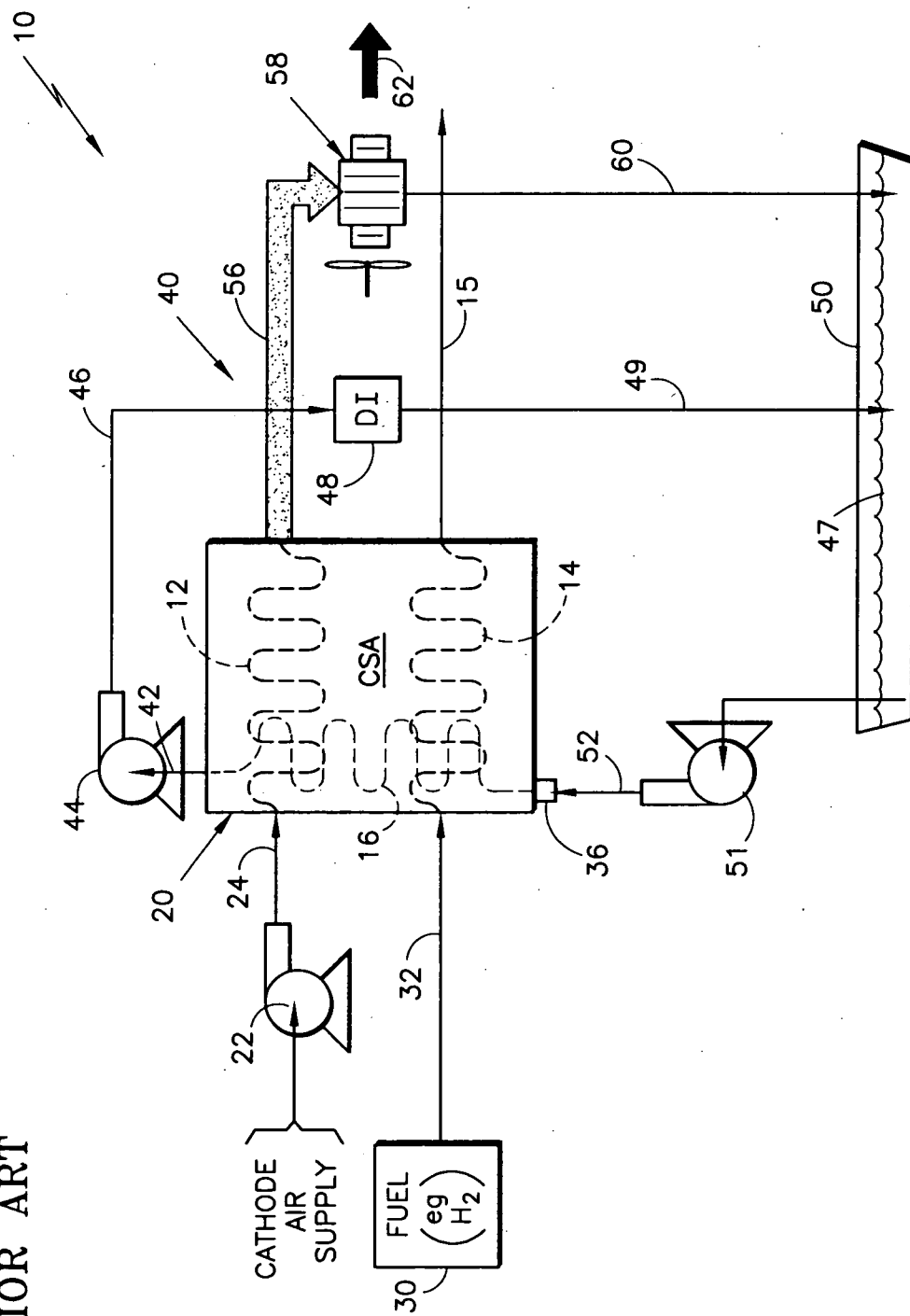
1 **7.** The fuel cell backup power system (310) of claim 6 wherein the fluid conduit
2 (356) delivers the humidified oxidant exhaust (356) into direct contact with the
3 supply coolant water (347) in the reservoir (350).
4

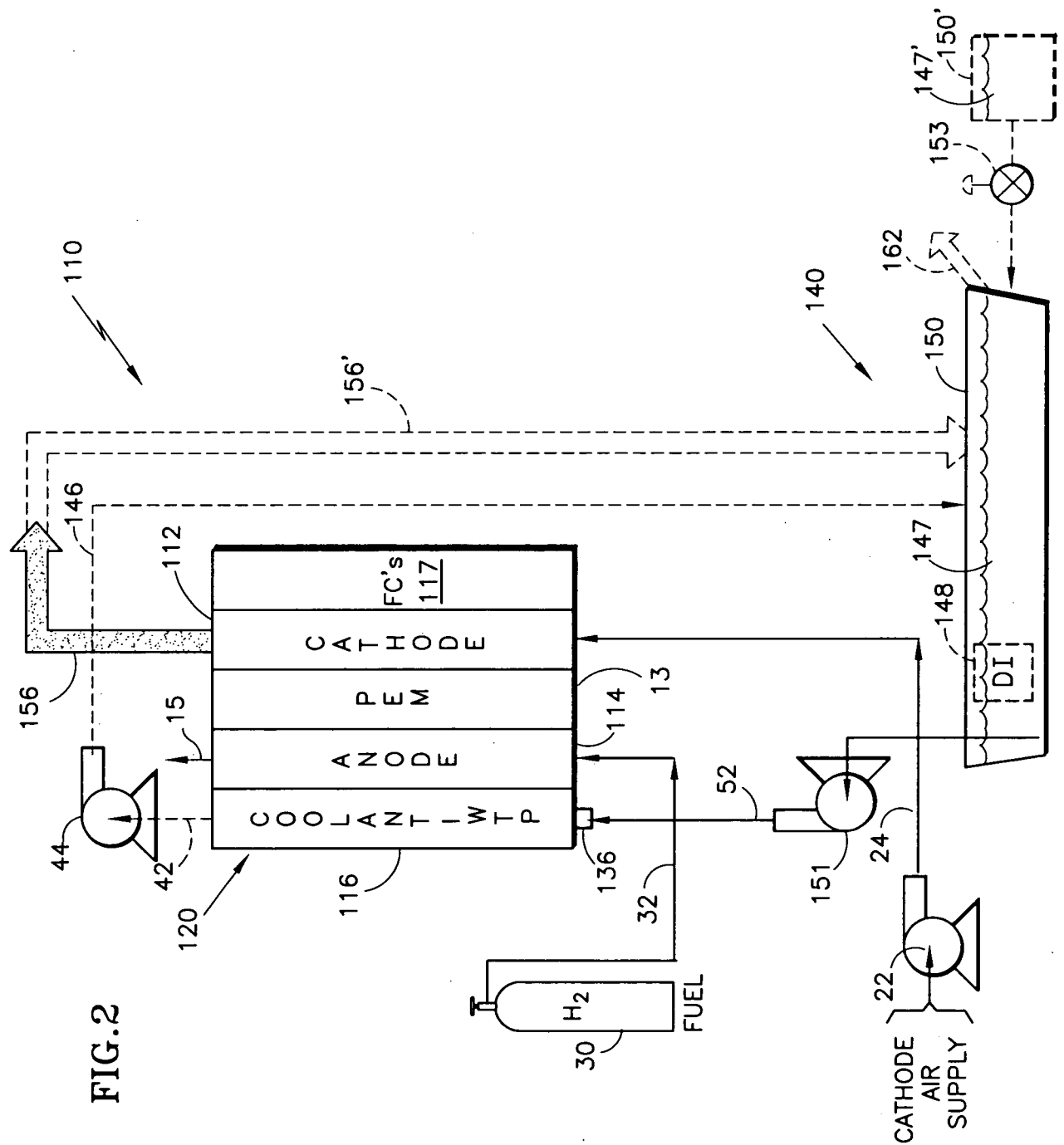
1 **8.** The fuel cell backup power system (410) of claim 2 wherein the thermal
2 management system (440) includes a dehumidifier (480) disposed to dehumidify
3 ambient air (490) to extract water from the ambient air, a conduit (457) connected
4 between the dehumidifier and the reservoir (450) for conveying the extracted
5 water to the reservoir.

1 **9.** The fuel cell backup power system (410) of claim 8 wherein the dehumidifier
2 (480) is electrically powered, and further including circuitry (484) connected to
3 the dehumidifier for connection (481) to the primary power grid (488) to power
4 the dehumidifier at least during extended intervals when the backup power system
5 (410) is not in use, thereby to supply coolant water 447 to the reservoir (450).

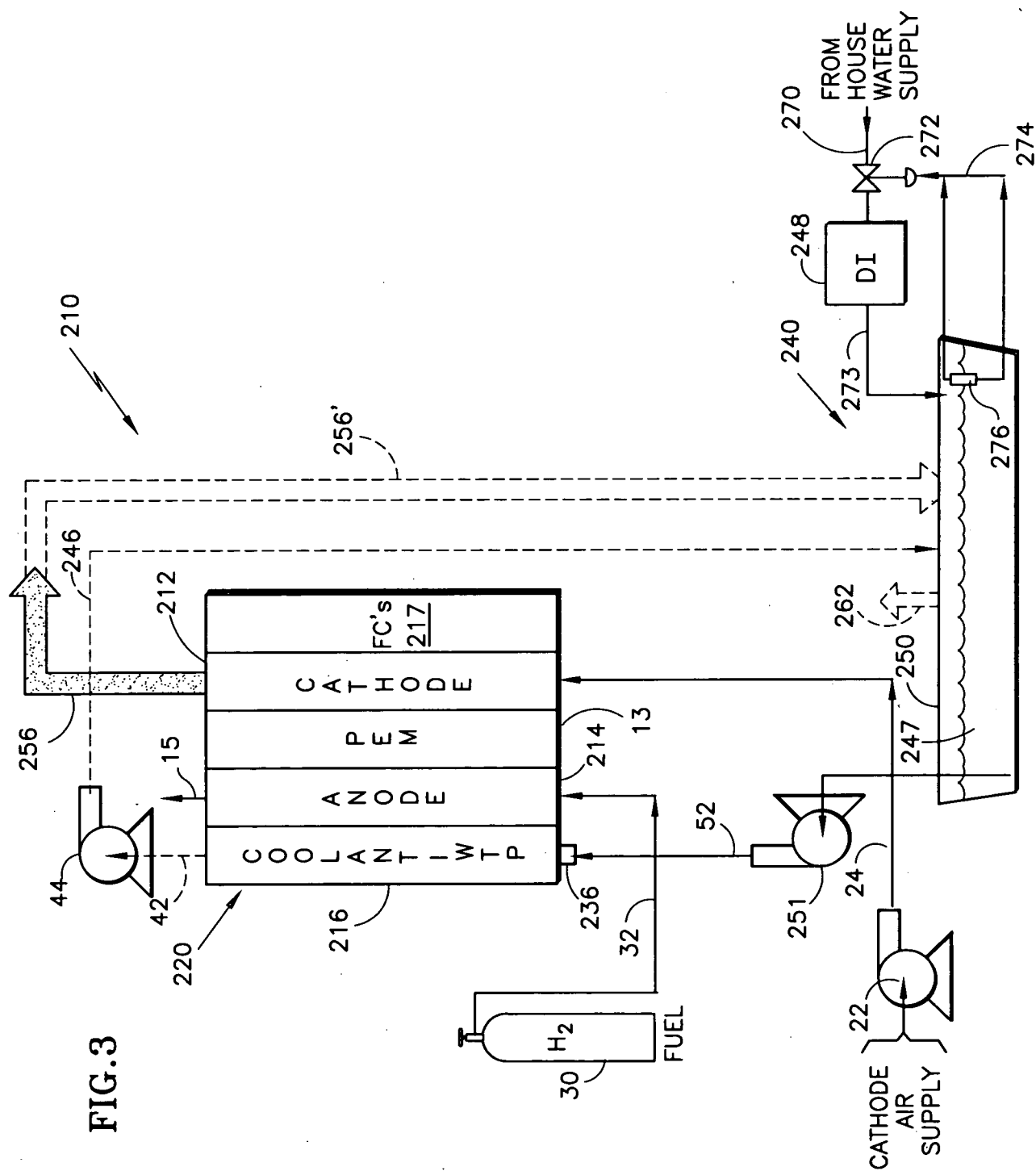
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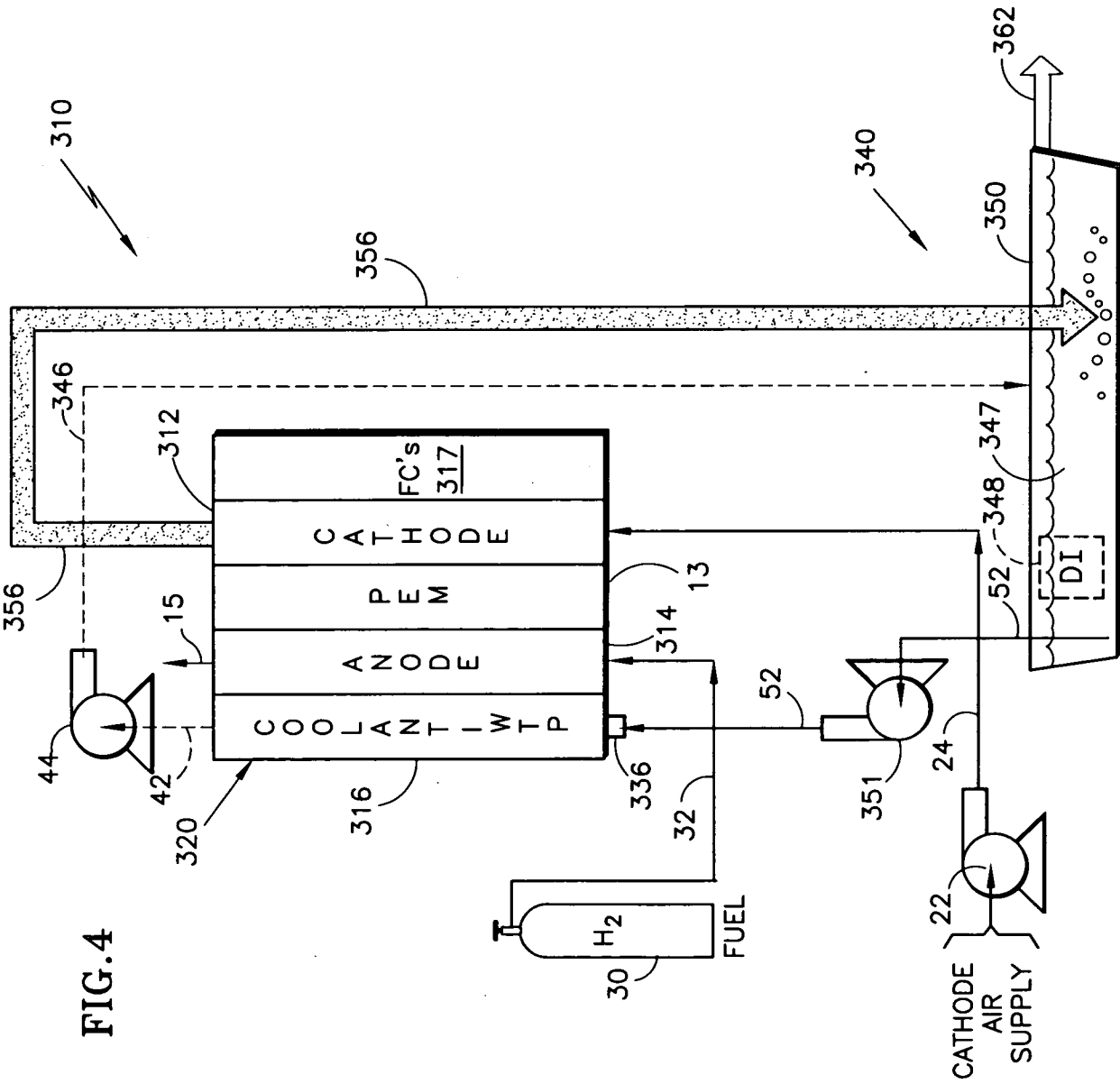
FIG. 1
PRIOR ART

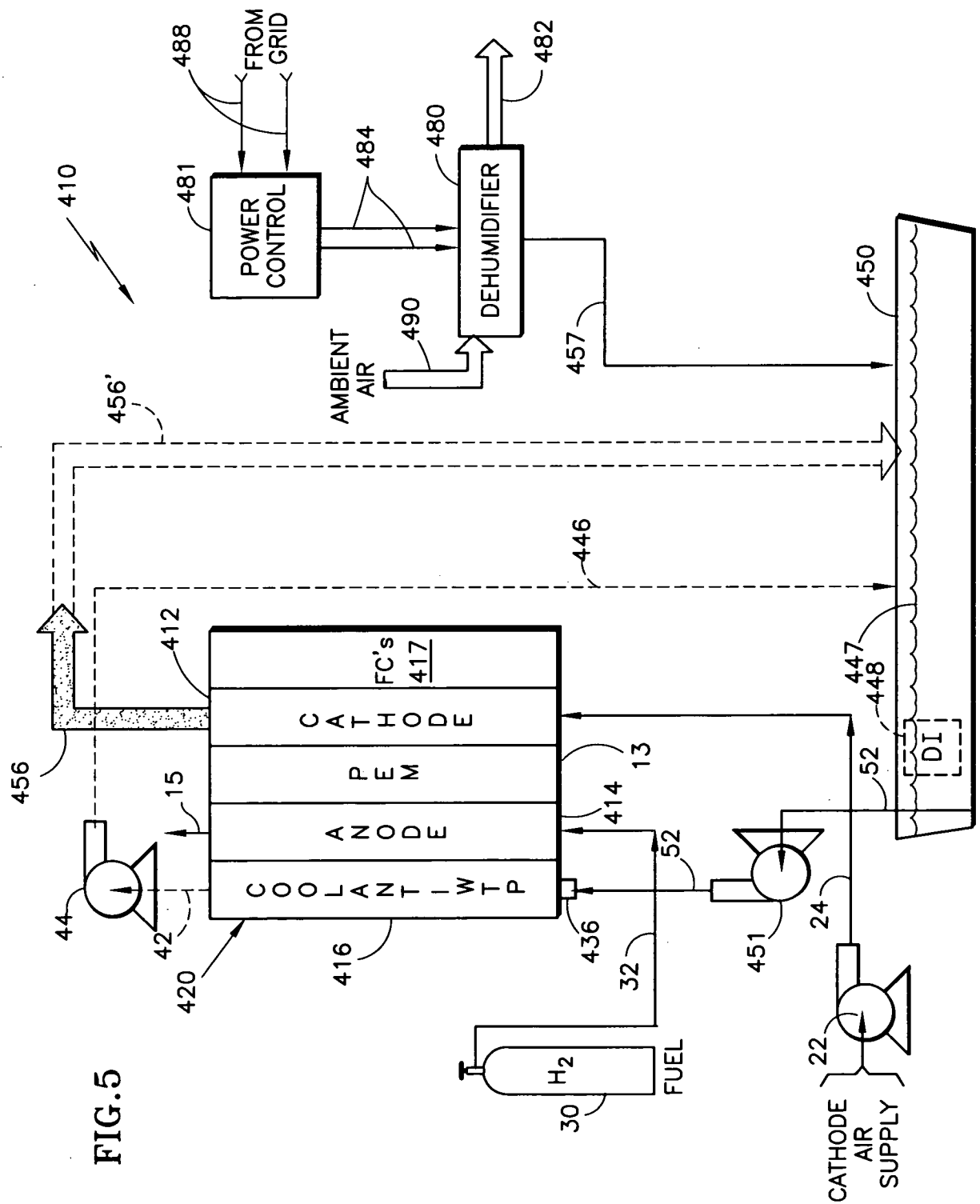




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A. CLASSIFICATION OF SUBJECT MATTER***H01M 8/06(2006.01)i, F25D 17/02(2006.01)i, H01M 8/10(2006.01)i***

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 8/06; G06F 15/16; H04J 3/22; H04B 7/02

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: fuel cell, oxidant flow, water, reservoir, coolant

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	TEGROTHENHUIS, WARD et al., Low-Cost Manufacturable Microchannel Systems for Passive PEM Water Management, 2008 DOE Annual Progress Report, pp 1075-1078, 30 November 2008 See figures 1-3, pp 1076-1077	1-9
A	US 2008-0226962 A1 (HSU, NIEN-HUI et al.) 18 September 2008 See abstract, figures 1-9, claims 1-22	1-9
A	US 2006-0204816 A1 (YAMAGUCHI, ATSUSHI) 14 September 2006 See abstract, figures 1-7, claims 1-20	1-9
A	US 6312842 B1 (REISER, CARL ANTHONY et al.) 06 November 2001 See abstract, figures 1, claims 1-12	1-9



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

20 DECEMBER 2010 (20.12.2010)

Date of mailing of the international search report

21 DECEMBER 2010 (21.12.2010)

Name and mailing address of the ISA/KR

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2010/001079Patent document
cited in search reportPublication
datePatent family
member(s)Publication
date

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None

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None