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ABSTRACT

A modular energy generation unit, comprising a housing having an interior volume that defines a first zone and a second zone. The first zone includes a fuel cell that generates electricity from a hydrogen source. A ventilation fan is disposed within the first zone and circulates air through the first zone via an inlet and outlet thereof. The second zone is fluidly sealed from the first zone and includes a controller operably connected to the fan. The housing is configured to abut in a stacked arrangement with a further energy generation unit.

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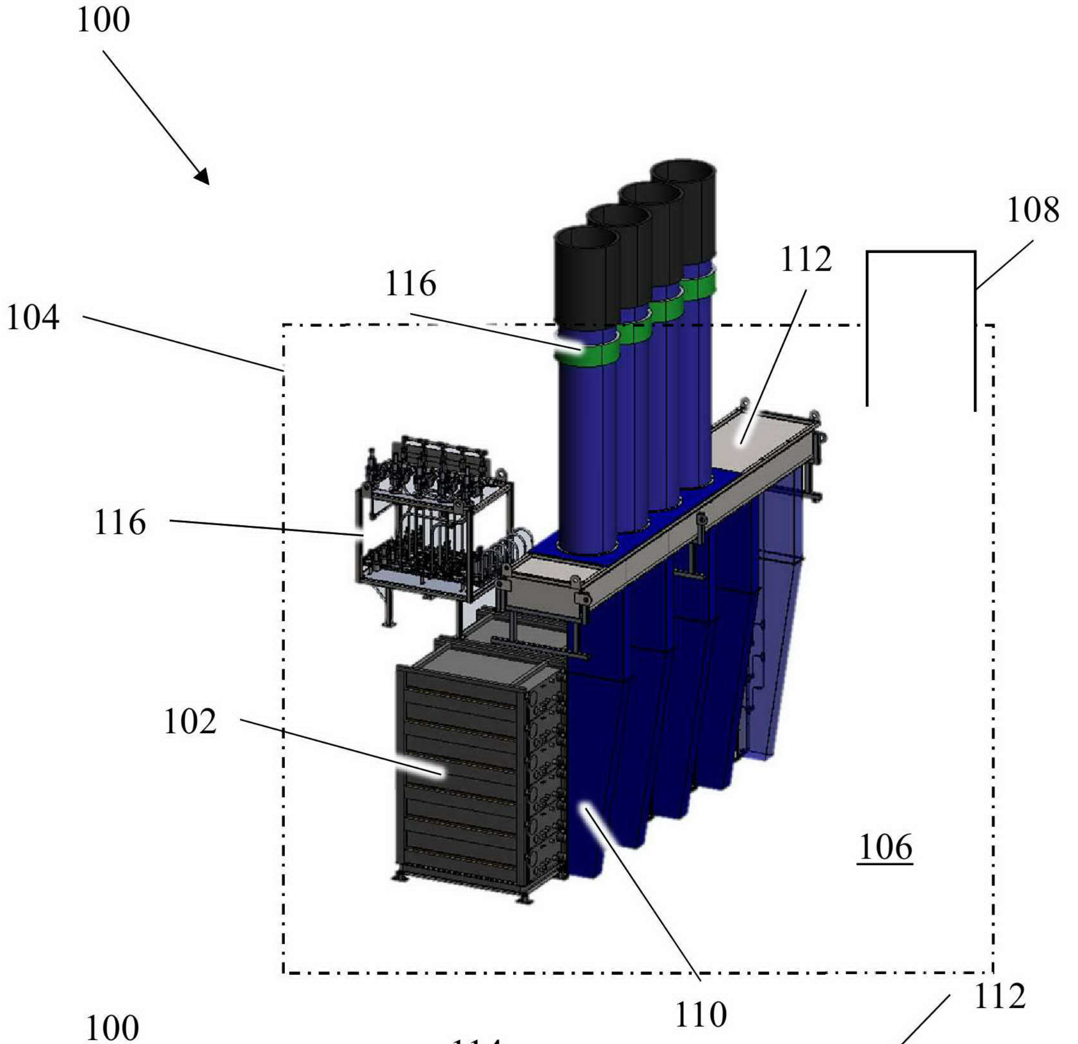

FIGURE 8

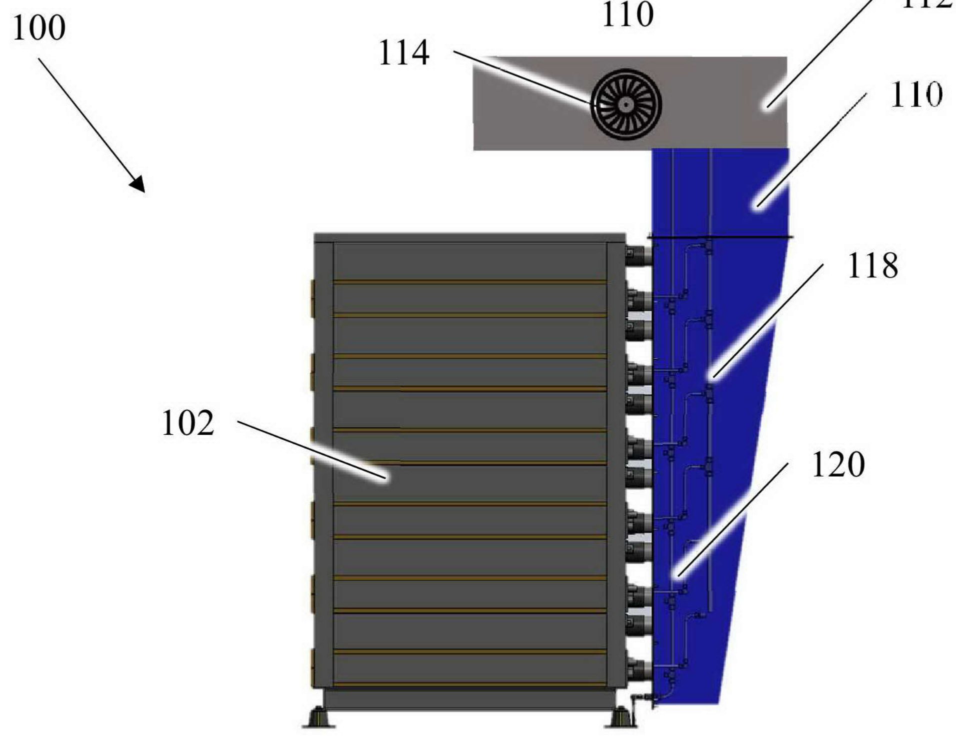

FIGURE 9

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MODULAR ENERGY GENERATION UNIT

TECHNICAL FIELD

[0001] The present invention relates to a modular energy generation unit. More particularly, the invention is directed towards a stackable energy generation unit that generates electricity from a hydrogen source and to an energy generation station comprising a plurality of stacked units.

BACKGROUND

[0002] With rising awareness of the impact of the burning of fossil fuels on global climate change, there is an increasing drive towards providing alternative means of energy generation.

[0003] Against this backdrop, the use of renewable energy generators is becoming more widespread – thanks in part to the "clean" electricity generation process. Examples of renewable energy generators include wind turbines, solar arrays and thermal energy systems. A drawback of such renewable generators is their low efficiency, which requires such generators to have a large footprint. This large footprint can make it difficult to install renewable generators in remote areas, where significant manpower and resources are needed to transport the components to location. In addition, the reliance on favorable local weather conditions necessitates the use of battery-based power storage to cover the fluctuations in electricity generation.

[0004] An alternative to renewable energy generator is a fuel cell. A fuel cell uses the chemical energy of a fuel source to cleanly and efficiently produce direct current (DC) electricity. Advantageously, fuel cells generate electricity continuously as long a fuel is supplied thereto – alleviating the need for battery storage. Furthermore, fuel cells can work with a wide range of fuels. Hydrogen is a commonly used fuel source for a fuel cell – advantageously, when used in a fuel cell to produce electricity, the only byproducts are water and heat.

[0005] Generally speaking, a hydrogen fuel cell comprises a pair of electrodes - a negatively charged anode and a positively charged cathode – and an electrolyte sandwiched therebetween. In use, the hydrogen fuel is fed to the anode, whilst air is fed to the cathode. A catalyst at the anode separates hydrogen molecules into protons and electrons, which take different paths to the cathode. The electrons go through an external circuit, creating an electrical flow and thereby generating electricity. Meanwhile, the protons migrate through the electrolyte to the cathode, where they combine with the oxygen and the electrons to produce the sole byproducts of water and heat.

[0006] The inherent flammability of hydrogen has some drawbacks. In particular, hydrogen is highly flammable in lower concentrations in air, which means it can ignite more easily. Because

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of this, global safety standards set-out minimum ventilation and leak detection requirements for hydrogen powered systems. To date, such standards have limited the scalability of hydrogen fuel-cell based generators. For example, existing regulatory standards have reduced the potential energy density of fuel-cell systems due to designated space requirements increasing the system footprint and thereby limiting use in space and weight constrained energy applications. In addition, the costs associated with meeting said standards have been increased due to the need to utilize hazardous IP rated components throughout the balance of plant that integrates the fuel-cell. Such limitations have delayed the uptake and mainstream acceptance of the technology that would otherwise provide an economical zero emission power generation solution for global adoption.

[0007] It would be desirable to provide an improved fuel cell based energy generating unit that alleviates at least some of the above identified problems and/or to offer the public a useful alternative.

[0008] The present invention was conceived with these shortcomings in mind.

SUMMARY

[0009] In a first aspect, there is provided a modular energy generation unit, comprising a housing having an interior volume that defines a first zone and a second zone; with the first zone including a fuel cell that generates electricity from a hydrogen source and a ventilation fan that circulates air through the first zone via an inlet and outlet thereof; and with the second zone being fluidly sealed from the first zone and including a controller operably connected to the fan, wherein the housing is configured to abut in a stacked arrangement with a further energy generation unit.

[0010] The housing may include a connection region, with all fluids entering into and exiting from the fuel cell of the unit passing through the connection region. The connection region may be disposed on a front face of the housing and the side, upper and lower faces thereof are substantially planar and devoid of openings. Each of the inlet and the outlet may be disposed within the connection region.

[0011] In some embodiments, the modular energy storage unit may further comprise an air feed line that provides process air to the fuel cell, with the air feed line passing through the connection region. A filter may be disposed within the air feed line, the filter being configured to remove particulate matter from process air before the process air enters the fuel cell.

[0012] A hydrogen feed line may provide hydrogen to the fuel cell, with the hydrogen feed line extending from the hydrogen source and passing through the connection region. The hydrogen feed line passes into the first zone via the outlet.

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[0013] In some embodiments, a pressure sensor may be located within the first zone, with the controller being operably connected thereto. At least one valve may be located along the hydrogen feed line and disposed within the first zone, with the controller being configured to operate the valve in response to a signal from the pressure sensor that indicates a hydrogen leak within the first zone. The controller may be configured to prohibit start-up of the ventilation fan in response to a signal from the pressure sensor that indicates a hydrogen leak within the first zone.

[0014] The modular energy storage unit may further comprise a coolant feed line that provides liquid coolant to the fuel cell, with the coolant feed line passing through the connection region.

[0015] In a second aspect, there is provided an energy generation station comprising an chamber and a plurality of modular energy generation units as described herein arranged in a stack therein.

[0016] The energy generation station may further comprise a chimney within the chamber that extends substantially vertically between each unit within the stack, the chimney providing a common passage for ventilation air to be exhausted from within the first zones of the respective units.

[0017] In some embodiments, a hydrogen supply assembly may be located within the chamber, the hydrogen supply assembly being fluidly connected to the respective fuel cell of each of the modular energy generation units via a common feed line that passes through the chimney.

[0018] The energy generation station may further comprise a second stack of modular energy generation units arranged proximate to the first stack of units. A second fluid chimney that extends substantially vertically between each unit within the second stack and a plenum that fluidly connects the first and second chimneys within the chamber.

[0019] In some embodiments, the chamber may include an exhaust that is in fluid communication with the or each chimney, the exhaust providing a passage for air from the energy generation units to be exhausted from the chamber. The chamber may also include an intake that extends into the chamber, the intake providing a passage for air to be drawn into the chamber and supplied to the respective units, wherein particulate matter is removed from the air prior to the air entering into a respective energy generation unit.

[0020] An auxiliary fan may be provided within the chamber, the auxiliary fan being arranged to operate in a push-pull arrangement with the ventilation fan of the respective units.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] The invention will now be described, by way of non-limiting example only, with reference to the accompanying drawings, in which:

Figure 1 is a front perspective view of a modular energy generation unit in accordance with an embodiment of the invention, the unit having a first zone within which a fuel cell is accommodated;

Figure 2 is a rear perspective view of the energy generation unit of Figure 1; showing a second zone thereof that is fluidly isolated from the first zone;

Figure 3 is a rear perspective view of the energy generation unit of Figure 1 with a rear panel removed, showing electrical components accommodated within the second zone;

Figure 4 is a front view of the energy generation unit of Figure 1, showing a connection region provided on a front panel;

Figures 5 and 6 are cut-away perspective views of the energy generation unit of Figure 1, showing fluid lines feeding into and out of the fuel cell within the first zone;

Figure 7 is a flow-chart that schematically shows the operation of a leakage detection system of the modular energy generation unit of Figure 1;

Figure 8 is a perspective view of an energy generation station comprising a plurality of energy generating units arranged in a stack; and

Figure 9 is a side view of the energy generation station of Figure 8, showing a ventilation chimney extending between each of the stacked energy generation units.

DETAILED DESCRIPTION

[0022] In general terms, the disclosure relates to a modular energy generation unit 10. The energy generation unit 10 comprises a housing 12 that is configured to enable the unit 10 to be stackable with further units 10. An interior volume of the housing 12 includes a first zone 14 and a second zone 16. A fuel cell 18 is accommodated within the first zone 14. The fuel cell 18 provides the electricity generation source of the unit 10. The first and second zones 14, 16 are fluidly isolated from one another. In this way, electrical components within the second zone – including a controller 20 – need not have a particular IP rating that would otherwise be required were said components operating in a common space with the fuel cell 18.

[0023] Air is circulated within the first zone 14 via a ventilation fan 22. The ventilation fan 22 is also accommodated within the first zone 14. Specifically, air is drawn into the first zone 14 via an inlet 24 and is exhausted therefrom via an outlet 26. Accordingly, any leakage of fuel from the fuel cell 18 or the supply thereto is channeled from the first zone 14 to an external location and safely dissipated.

[0024] In this specification, the term "fluid" is taken to encompass both gaseous fluids such as air and hydrogen and liquids such as water. In particular, it is understood that the fuel cell 18 described herein produces electricity through chemical reaction of several fluids, for example air and hydrogen.

[0025] The modular energy generation unit 10 will now be described in detail with particular reference to Figures 1 to 6.

[0026] The housing 12 is best shown in Figures 1 and 2. The housing 12 includes a connection region 30. All fluids that are associated with the fuel cell 18 pass into the housing 12 via the connection region 30. The inlet 24 and outlet 26 are also provided within the connection region 32. Each of the inlet 24 and outlet 26 may comprise more than one opening. Accordingly, it is understood that the connection region 30 provides a common location within which all fluid connections of the unit 10 are concentrated.

[0027] With particular reference to the embodiment shown in the Figures, the housing 12 is a substantially rectangular housing comprising substantially planar front and rear faces 32, 34, upper and lower faces 36, 38 and side faces 40. The generally rectangular shape of the housing 12 is a preferment in that in facilitates inherent stackability of the units 10, whilst also for the provision of adjacent stacks of units 10 to be arranged side by side. It is understood, however, that other shapes of housing are also possible, provided the upper and lower surfaces thereof are substantially planar. The faces 32-40 may be assembled together from separate panels, or, alternatively, at least some of the faces 32-40 may be integrally formed with one another. At least some of the panels are removable from the housing 12, so as to provide maintenance access to the components within at least the first zone 14.

[0028] In the illustrated embodiment, the first and second zones 14, 16 are linearly arranged end-to-end along a length of the housing 12. Specifically, the first zone 14 encompasses the majority of the internal volume of the housing 12 and extends from the front face 32 along a substantial length of the housing 12. The second zone 16 is disposed behind the first zone 14 and extends to the rear face 34. The upper and lower faces 36, 38 and side faces 40 are provided as substantially planar panels, substantially devoid of openings or projections. Accordingly, it is understood that access to the first zone 14 is provided via the front face 32 whilst access to the second zone 16 is provided via the rear face 34. In other embodiments, the first and second zones 14, 16 may be arranged differently, for example in a side by side relationship across a width of the housing 12, or, alternatively, arranged one atop the other across a height of the housing 12.

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Optionally, the first and second zones 14, 16 may be provided as separate compartments that are coupled together. In such embodiments, the second zone 16 can be disconnected from the first zone 14, to provide additional maintenance options or, for example, to substitute a new second zone 16 onto the first zone 14 should there be problems detected with the electrical components within the second zone 16. Such interchangeability may improve maintenance and reduce down time.

[0029] Best shown in Figures 2 and 3, the rear face 34 is a removable cover that selectably provides access to the electrical components within the second zone 16 including controller 20. The cover 34 is removeably attached to the remainder of the housing 12 by way of screws or fasteners. These screws can be removed via a screw-driver or the like to provide access to the second zone 16. It is also contemplated that access to the second zone 16 may be provided by way of an access flap or port within the back cover 34. In such an embodiment, the back cover 34 would not need to be removed in order to gain access to the second zone 16. Alternatively/additionally, the back cover 34 may be provided as a hinged door to facilitate tool-free access to the second zone 16. The rear face 34 is largely devoid of projections or openings, with the exception being a pair of low-profile grills 42 which serve to enable heat to be drawn out of the second zone 16 to cool the controller 20 and other electrical components therein.

[0030] Best shown in Figure 4, the connection region 30 is disposed on a front face 32 of the housing. In this way, several units 10 can be successively stacked atop each other without affecting the accessibility of the various fluid connections of the fuel cell 18. Further, with the upper and lower faces 36,38 being substantially devoid of any openings, projections and the like for said connections, the lower face or base 38 of a successive unit 10; is able to rest in abutment upon an upper face 36 of a unit 10 arranged therebelow. Likewise, the absence of fluid connections on the side faces 40 of the unit 10 allow stacks of units 10 to be abutted against one another in a side-by side arrangement to increase the system energy density. In other embodiments (not shown), the connection region 30 may be disposed elsewhere on the unit 10. For example, the connection region may be provided on the rear face 34 or side faces 40 of the unit 10, with the position of the connection region 30 being selected, at least in part, based on the internal configuration of the first and second zones 14,16. It is also contemplated that the connection region 30 may be provided as two split portions, for example with some connections on opposing side faces 40 of the unit 10. Such an arrangement would still allow stackability, however may limit the ability to arrange multiple units 10 in a side-by-side array.

[0031] As previously described, the connection region 30 provides a common location within which all fluid connections of the unit 10 are concentrated. Specifically, the inlet 24 provides a passage through which ventilation air is drawn into the first zone 14 by ventilation fan 22. The ventilation fan 22 is preferably located proximate to the inlet 24, within the first zone 14. The

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ventilation air is then exhausted through the outlet 26. In the illustrated embodiment, the inlet 24 is located towards an upper left hand corner of the front face 32 whilst the outlet 26 is located towards an opposing lower right hand corner of the front face 32. This spacing of the inlet 24 and outlet 26 encourages circulation of the ventilation air within the first zone 14.

[0032] Fuel is provided to the fuel cell 18 by a feed line 44. The feed line 44 passes into the first zone 14 via the connection region 30. A purge line 46 is also provided as a means for fuel to be purged from the first zone 14 and returned to the supply. In the illustrated embodiments, both fuel lines 44, 46 pass into the first zone 14 via the outlet 26. Notably, the fuel lines 44, 46 are closed lines ensuring that there is no mixing of the fuel with the ventilation air. In this manner, it is not necessary additional openings to be formed within the front face 32. Additionally, because the fuel lines 44, 46 are arranged within the outlet 26, the circulating ventilation air that is continuously exhausted therethrough can also serve to directly dissipate any fuel that may leak from lines 44, 46. Whilst the ventilation air would also dissipate leaked fuel from the lines 44, 46 if the lines 44, 46 passed through the connection region 30 by separate openings, it id understood that the effectiveness and speed of dissipation is maximized by placing the lines directly in the exit stream of the ventilation air flow.

[0033] The connection region 30 also includes a pair of openings 48, 50. The opening 48 provides a passage for process air to be drawn into the first zone 14 and communicated to the fuel cell 18. Exhaust from the fuel cell 18 is then exhausted from the unit 10 via opening 50. Additionally, a pair of ports 52, 54 are also provided within the connection region 30. The ports provided allow cooling fluid to be communicated to and from the fuel cell 18. Furthermore, all electrical connections 56 for the unit 10 are also provided within the connection region 30 – with pass through cables extending through the first zone 14 and into the second zone 16 to thereby provide power to the controller 20.

[0034] The communication of the various fluids into and out of the fuel cell 18 will now be described with particular reference to Figures 5 and 6.

[0035] The fuel cell 18 is a hydrogen fuel cell, and is completely encapsulated within the first zone 14. Several fluids are fed into and out of the fuel cell 18. In particular, hydrogen is fed into the fuel cell via fuel feed line 44. The feed line 44 comprises a rigid pipe that enters into the first zone 14 via the outlet 26. The feed line 44 is in fluid communication with a hydrogen source (which is discussed in more detail in relation to Figures 8 and 9). The purge line 46 is also provided as a rigid pipe that exits out of the housing 12 via the outlet 26. The purge line 46 transports unused hydrogen fuel from the fuel cell 18. Each of the fuel lines 44, 46 are segregated within the first zone 14. This segregation of the fuel lines 44, 46 means that any leakage of hydrogen is contained to the first zone 14 only. That is, the hazardous area of the unit 10 – i.e. the area in fluid

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communication with the hydrogen fuel – is contained within the first zone 14 only. This is advantageous, as only electrical components that are located within the first zone 14 (of which there are a limited number, discussed later) need have an appropriate hazardous area IP rating. Put differently, the arrangement of the fuel lines 44, 46 passing through the outlet 26 into the first zone 14 being a functional equivalent to conventional "pipe-in-pipe" arrangements where hydrogen fuel is typically transported within an inner pipe that is sheathed within an outer pipe, the outer pipe serving to contain any hydrogen that may leak from the inner pipe as a result of hydrogen embrittlement weakening said inner pipe. In this case, the housing 12 of the first zone 14 serves as the "outer pipe" of such conventional arrangements. By doing away with the complex pipe-in-pipe fuel feed lines, the connections of said fuel lines 44,46 to the fuel cell 18 are simplified.

[0036] Furthermore, with the ventilation fan 22 working to channel this leakage out from the unit 10, where it is dissipated externally to atmosphere. This prevents any leaked hydrogen from pooling within the contained area of the first zone 14, thereby reducing the risk of ignition. Advantageously, this allows the volume of the first zone 14, and the accompanying overall footprint of the unit 10 itself, to be reduced – enabling the unit 10 to operate in areas with space and footprint restrictions. This channeling/dispersion of leaked fuel from the first zone 14 by ventilation fan 22 allows the fuel cell 18 to be confined within the small volume compartment of the housing, a location that would otherwise be counterintuitive due to the hitherto large ventilation spaces that are associated with the storage of fuel cells and use of hydrogen as a fuel source.

[0037] Process air is communicated from the opening 48 to the fuel cell 18 via an air feed line 58. As shown in the Figures, the air feed line 58 is provided in the form of a pair of air hoses 58a, 58b. In particular, process air is drawn from outside the unit 10 and through the opening 48 and into a first air hose 58a by a pump 60. The pump 60 may be in the form of a blower or similar. As is explained later in more detail with reference to Figures 8 and 9, the ventilation air and the process air are both drawn from a common source outside of the unit 10. In this way, the source air for both the ventilation air and process air can be treated in a single process – ensuring both the ventilation and process air are pre-treated before entering the first zone 14. The pre-treatment may include chilling or cleaning of the air. A filter 62 is disposed along the air feed line 58a, between the opening 48 and the fuel cell 18. The filter 62 is a mechanical filter that removes particulate matter from the process air before the process air is communicated into the fuel cell 18. When used in combination with the pre-treatment as discussed above, the filter 62 serves as a secondary filter to ensure that the process air is treated in a "two-step" proves before entering the fuel cell 18. This two-step air treatment, combined with the sealed housing 12 allows the unit 10 to be installed in areas that are typically unsuitable for fuel cells – for example in areas prone to dusts and wind-borne debris. A second air hose 58b is provided that extends between the fuel cell 18 and the second opening 50. The second air hose 58b communicates exhaust from the fuel cell 18 outside of the unit 10. The exhaust includes water that is generated by the fuel cell 18 during the production of electricity. This water is in the form of a vapor or gas.

[0038] Heat is generated as a byproduct of the electricity generation of the fuel cell 18. In addition to the circulation of ventilation air by fan 22, the fuel cell 18 is also cooled directly by coolant. The coolant is preferably a liquid coolant. The coolant may be water. The coolant is communicated into and out of the fuel cell 18 via a cooling line in the form of tube 64. In particular, the tube 64 extends from the port 52 and through fuel cell 18, before exiting via port 54. The coolant serves to maintain an operating temperature of the fuel cell 18, which in turn maintains a safe temperature of the unit 10. Best shown in Figure 5, the tube 64 is directed upwardly towards the exit port 54. This upward slope assists in the management of air bubbles that may be formed within the coolant.

[0039] A leakage detection system 66 is provided within the first zone 14. The leakage detection system 66 is adapted to monitor and detect leakage of fuel from the fuel lines 44,46. The leakage detection system 66 comprises a sensor 68 that is operably connected to at least one of the fuel lines 44,46. The sensor 68 may, for example, be a pressure transducer that monitors for a pressure drop within the respective fuel line. The detection system 66 also comprises a valve 70 disposed along the feed line 44. The valve may be a solenoid valve that is operably connected to the controller 20. The valve is operable to close off the supply of hydrogen into the fuel cell 18 in the event that a leak is detected. With the valve 70 being closed, hydrogen is purged from the first zone 14 and returned to the supply via fuel line 46. As each of the sensor 68 and valve 70 are located within the first zone 14 in proximity to the fuel cell 18 and fuel lines 44,46, each are rated components to operate in hazardous areas. As previously described, should a fuel leak be detected during operation of the unit 10, any leaked hydrogen will be exhausted from the contained area of the first zone 14 via the circulating ventilation air.

[0040] The leakage detection system 66 may be used to provide a "safe start" procedure for the unit 10. The safe start procedure will now be described with particular reference to Figure 7.

[0041] In a measuring step, the controller 20 measures a characteristic of the fuel flow within fuel lines 44,46. The fuel flow characteristic is acquired by the sensor 68. The characteristic measured by the sensor 68 may be line pressure. Alternatively, the sensor 68 may measure, for example, temperature within the fuel lines. The sensor 68 sends a signal to the controller 20, the signal comprising data related to the flow characteristic.

[0042] In a comparing or detecting step, the controller 20 then compares the measured value of the flow characteristic acquired by the sensor 68 with a set or expected value. The set value may be a range. The set value may be a predetermined "safe" value based on a standard flow characteristic of the fuel, or, alternatively, the set value may be a previously acquired value by the sensor 68, with the controller 20 effectively monitoring for changes in the characteristic of the fuel flow – for example a pressure drop.

[0043] If the acquired value is outside of the expected value, a leakage condition is detected and a stop procedure initiated. The stop procedure comprises a disabling step operated by the controller 20. In the disabling step, the controller 20 closes the fuel supply valve 70. In this way, further supply of fuel to the fuel cell 18 is prohibited – limiting the loss of fuel and minimizing the risk of ignition/buildup of fuel.

[0044] If the acquired value is within the expected value or range, then no leak is detected and the unit 100 is said to be in a safe operating condition. In the safe operating condition, an enabling step follows in which the controller 20 initiates or enables the ventilation fan 22 to start. With the ventilation fan 22 operating, the energy generating unit 10 is in a normal operating condition and can be used to generate electricity.

[0045] Notably, it is understood that prior to the commencement of the "safe start" procedure, the ventilation fan 22 is in an off or disabled condition in which the fan is not rotating and does not have power supplied thereto. In this manner, the unpowered ventilation fan 22 is not considered to be an ignition source, as defined in many power standards. The ventilation fan 22 must receive power from the controller 20 in order to be enabled or turned on. In this manner, the ventilation fan 22 does not need have a particular rating to operate in the hazardous zone proximate the fuel cell 18. This is because the ventilation fan 22 is only enabled once the controller 20 has determined that start up may proceed – by, for example, conducting the automated fuel leak check or "safe start" procedure (as described in the previous passages). As a result, the ventilation fan 22 can be considered to be an "off the shelf" component that is both readily sourced and also replaced should maintenance be required.

[0046] An advantage of the energy generation unit 10 lies in its modularity. By modularity, what is meant is that the unit 10 is both stackable and scalable. An example of the modularity of the energy generation unit will now be discussed in reference to Figures 8 and 9.

[0047] Figures 8 and 9 show an energy generation station 100. The energy generation station 100 comprises a plurality of energy generation units 10. The electrical output of the energy generation station 100 can be tailored to suit need, by adjusting the number of energy generation units accommodated therein. The units 10 are arranged in a stack 102. Depending on the number of units 10 required, the station 100 may comprise one, two, three, four or more stacks 102. In particular reference to the embodiment shown, four stacks 102 are provided, with each stack 102

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comprising six abutting units 10. The stacks 102 may include a frame or rack within which the respective units 10 are supported.

[0048] The stacks 102 are enclosed within an enclosure 104. The enclosure 104 is shown in dotted outline in Figure 8. An interior volume of the enclosure 104 defines a chamber 106. The chamber 106 provides a controlled temperature environment within which the units 10 operate. The enclosure 104 can be a separate structure, for example a shipping container. Such an embodiment can be particularly useful for when the energy station 100 is to be installed at remote locations, facilitating transport of an assembled station 100 to location to minimize setup time. Alternatively, the enclosure 104 may be an existing structure such as a room within a building, with the stacks 102 being installed therein.

[0049] The chamber 106 provides a common source of process air and ventilation air for the units 10. What is meant by this is that both ventilation air and process air is drawn from the chamber 106 and into the respective units 10. This source air is brought into the chamber 106 via an intake 108. The intake 108 extends from the external environment and into the enclosure 104. The intake 108 may include an air treatment system as outlined previously. The air treatment system may comprise a chemical filter to remove particulate matter from the air as it is drawn into the chamber 106 – hence providing a "two-stage" air treatment process together with the filter 62 of each respective unit 10. The air treatment system may also include an air conditioning system or similar operable to maintain a constant, safe operating temperature within the chamber 106.

[0050] Each of the stacks 102 has a chimney 110 associated therewith. The chimney 110 extends between each of the units 10 within a respective stack 102. The chimney 110 provides a common passage for ventilation and process air of the units 10 to be exhausted from the chamber 106. With reference to the specific embodiment shown in Figure 8, there are four chimneys each being associated with a respective stack 102. It is understood, however, that, depending on the arrangement of the respective stacks 102, a single chimney 110 may be associated with two or more stacks 102. Each of the chimneys 110 extends substantially vertically, and extends out of the enclosure 104 to provide an exhaust through which the ventilation air is exhausted from the chamber 106 to the external environment. Notably, each chimney 110 provides a closed passage to the external environment that is sealed from the remainder of the chamber 106. Thus, the chimney 110 provides a pathway for any hydrogen that may have leaked within the units 10 to be safely vented. Whilst described and illustrated herein as having a traditional substantially upstanding "chimney" shape, it is understood that the term "chimney" is used for illustrative purposes only, and that the common ventilation passage may be provided by other functional equivalents such as ducting or piping.

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[0051] An air plenum 112 extends between each of the respective chimneys 110. The air plenum 112 enables each of the chimneys 110 to be fluidly connected to each other. An auxiliary fan 114 is provided within the air plenum 112. The auxiliary fan 114 is adapted to draw ventilation and process air from the units 10 and into associated chimney 110. In an alternate embodiment, dedicated auxiliary fans 112 can be provided within each chimney 110. Such an arrangement would be operationally equivalent to having a single common auxiliary fan 112 as described above. The auxiliary fan 114 forms part of a push-pull ventilation system. In particular, the auxiliary fan 112 is in direct fluid communication with the outlet 26 of each respective unit 10, whilst the ventilation fan 22 of each of said units 10 is located proximate the inlet 24 thereof. The push-pull arrangement ensures thermal management of each unit 10, by encouraging full air circulation therein – and also dissipation of any leaked fuel fluid. Furthermore, it is understood that the auxiliary fan 114 provides a redundancy into the ventilation system of each unit 10, satisfying marine requirements and thereby allowing the station 100 to be installed upon a vessel.

[0052] A gas supply assembly 116 is provided within the chamber 106. The gas supply assembly 116 provides the fuel to the fuel cell 18 of each respective unit 102 of the station 100. In particular, a feed conduit 118 extends from the gas assembly 116 into the plenum 112. The feed conduit 118 branches into each of the chimneys 110, passing there through and connecting via a valve arrangement to the fuel feed line 44 of each respective unit 10. In a similar manner, a return conduit 120 also extends through the chimney 110, with the return conduit being fluidly connected to the fuel purge lines 46 of the respective units. The return conduit 120 is also operably connected to the gas assembly 116, such that unused fuel can be recycled/stored for later use. Advantageously, it is understood that the complete fuel delivery system of the station 100 is fully contained/sealed within the ventilation system of the station 100. In particular, the conduits 118, 120 are enclosed within the chimney 110, whilst the feed and purge lines 44, 46 are contained within the first zone 14 of each unit 10. Because of this arrangement, any leakage of fuel along the conduits 118,120 and/or within the fuel lines 44, 46 of the units 10 can be safely and efficiently evacuated from the enclosure 104 via the push-pull fan arrangement, without the risk of hydrogen buildup within the enclosed space of units 10 or chamber 106.

[0053] Whilst not illustrated in the Figures, it is also contemplated that the station 100 may include a water recovery system. Specifically, the water recovery system may be operable to reclaim the water that is generated as a byproduct of the fuel cells 18. It is envisaged that such a system would include a condenser operable to cool the exhaust flow from each of the units 10, resulting in the water vapor from the exhaust flow condensing to liquid to allow for collection. Advantageously, water that is produced via a hydrogen fuel cell is particularly clean and free of contaminates, and is therefore suitable for drinking water. This may be particularly beneficial for instances when the station 100 is used in rural or remote areas that may have only limited access

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to clean water supply, or to provide a source of distilled water to operators of long haul transports to which the station 100 may be installed.

[0054] It is also contemplated that the water recovery system may form a closed loop arrangement with the gas supply assembly 116. Specifically, the water collected by the water recovery system can be converted back into hydrogen via an electrolysis process. The hydrogen can then be recycled back into the gas assembly 116 as a fuel for powering the fuel cells.

[0055] Summarily, it is to be understood that modular energy generation unit as described herein provides several performance advantages and usability improvements over existing duel-cell based systems. For example, provision of a housing having fluidly isolated zones reduces the need for electrical components requiring a hazardous IP rating, enabling increased usage of more readily available standard components. In addition, the concentration of all fluid and electrical connections within a connection region of the housing of each unit enables several units to be arranged in a stack to form a highly scalable and energy dense energy generation station, the output of which can be configured according to power requirements. Furthermore, the provision of a push-pull fan arrangement including a common auxiliary fan enables said station to meet global safety certification standards that may be required in applicable power applications in certain sectors, for example marine.

[0056] The reference in this specification to any prior publication (or information derived from it), or to any matter which is known, is not, and should not be taken as an acknowledgment or admission or any form of suggestion that that prior publication (or information derived from it) or known matter forms part of the common general knowledge in the field of endeavor to which this specification relates.

[0057] Throughout this specification and the claims which follow, unless the context requires otherwise, the word ‘comprise’, and variations such as ‘comprises’ and ‘comprising’, will be understood to imply the inclusion of a stated integer or step or group of integers or steps but not the exclusion of any other integer or step or group of integers or steps.

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LEGEND

10	Energy generation unit	50	Exhaust
12	Housing	52	Cooling Fluid in
14	First zone	54	Cooling fluid out
16	Second zone	56	Electrical connections
18	Fuel cell	58	Air feed line
20	Controller	60	Pump
22	Ventilation fan	62	Filter
24	Inlet	64	Coolant feed line
26	Outlet	66	Leakage detection system
30	Connection region	68	Sensor
32	Front face	70	Valve
34	Rear face		
36	Upper face	100	Energy generation station
38	Lower face	102	Stack
40	Side face	104	Enclosure
42	Grills	106	Chamber
44	Fuel Line	108	Intake
46	Purge Line	110	Chimney
48	Process Air In	112	Plenum
		114	Auxilliary Fan
		116	Gas supply assembly
		118	Feed conduit
		120	Return conduit

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CLAIMS

1. A modular energy generation unit, comprising a housing having an interior volume that defines a first zone and a second zone; with the first zone including a fuel cell that generates electricity from a hydrogen source and a ventilation fan that circulates air through the first zone via an inlet and outlet thereof; and with the second zone being fluidly sealed from the first zone and including a controller operably connected to the fan, wherein the housing is configured to abut in a stacked arrangement with a further energy generation unit.

2. The modular energy generation unit of claim 1, wherein the housing includes a connection region, with all fluids entering into and exiting from the fuel cell of the unit passing through the connection region.

3. The modular energy generation unit of claim 2, wherein the connection region is disposed on a front face of the housing and the side, upper and lower faces thereof are substantially planar and devoid of openings.

4. The modular generation unit of claim 2 or claim 3, wherein the inlet and outlet are disposed within the connection region.

5. The modular energy storage unit of any one of claims 2 to 4, further comprising an air feed line that provides process air to the fuel cell, with the air feed line passing through the connection region.

6. The modular energy storage unit of claim 5, further comprising a filter disposed within the air feed line of the fuel cell, the filter being configured to remove particulate matter from process air before the process air enters the fuel cell.

7. The modular energy storage unit of any one of claims 2 to 6, further comprising a hydrogen feed line that provides hydrogen to the fuel cell, with the hydrogen feed line extending from the hydrogen source and passing through the connection region.

8. The modular energy storage unit of claim 7, wherein the hydrogen feed line passes into the first zone via the outlet.

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9. The modular energy storage unit of claim 7 or claim 8, further comprising a pressure sensor located within the first zone, with the controller being operably connected thereto.

10. The modular energy storage unit of claim 9, further comprising at least one valve located along the hydrogen feed line and disposed within the first zone, with the controller being configured to operate the valve in response to a signal from the pressure sensor that indicates a hydrogen leak within the first zone.

11. The modular energy storage unit of claim 9 or claim 10, wherein the controller is configured to prohibit start-up of the ventilation fan in response to a signal from the pressure sensor that indicates a hydrogen leak within the first zone.

12. The modular energy storage unit of any one of claims 2 to 9, further comprising a coolant feed line that provides liquid coolant to the fuel cell, with the coolant feed line passing through the connection region.

13. An energy generation station comprising a chamber and a plurality of modular energy generation units as defined in anyone of claims 1 to 12 arranged in a stack therein.

14. The energy generation station of claim 13, further comprising a chimney that extends substantially vertically between each unit within the stack, the chimney extending outwardly from the chamber to provide a common passage for ventilation air to be exhausted from within the first zones of the respective units.

15. The energy generation station of claim 14, further comprising a hydrogen supply assembly located within the chamber, the hydrogen supply assembly being fluidly connected to the respective fuel cell of each of the modular energy generation units via a common conduit that passes through the chimney.

16. The energy generation station of any one of claims 13 to 15, further comprising a second stack of modular energy generation units arranged proximate to the first stack of units.

17. The energy generation station of claim 16, further comprising a second fluid chimney that extends substantially vertically between each unit within the second stack and a plenum that fluidly connects the first and second chimneys within the chamber.

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18. The energy generation station of any one of claims 12 to 17, wherein the chamber includes an exhaust that is in fluid communication with the or each chimney, the exhaust providing a passage for air from the energy generation units to be exhausted from the chamber.

19. The energy generation station of claim 18, wherein the chamber includes an intake that extends into the chamber, the intake providing a passage for air to be drawn into the chamber and supplied to the respective units, wherein particulate matter is removed from the air prior to the air entering into a respective energy generation unit.

20. The energy generation station of any one of claims 13 to 19, further comprising an auxiliary fan within the chamber, the auxiliary fan being arranged to operate in a push-pull arrangement with the ventilation fan of the respective units.

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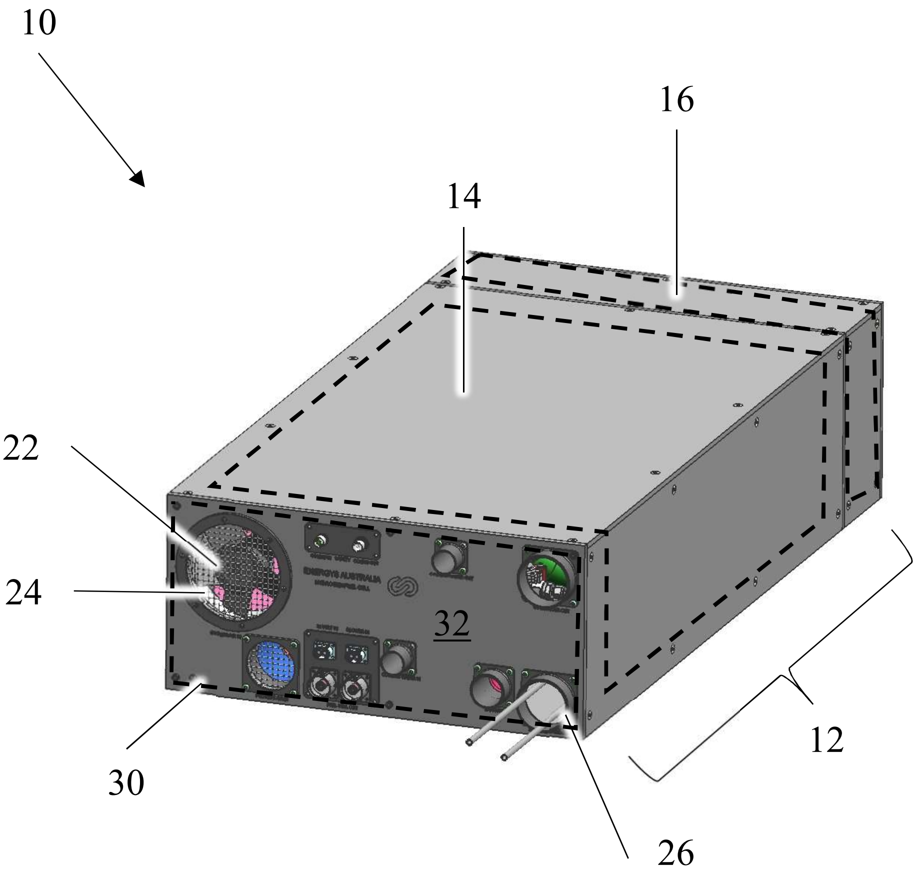

FIGURE 1

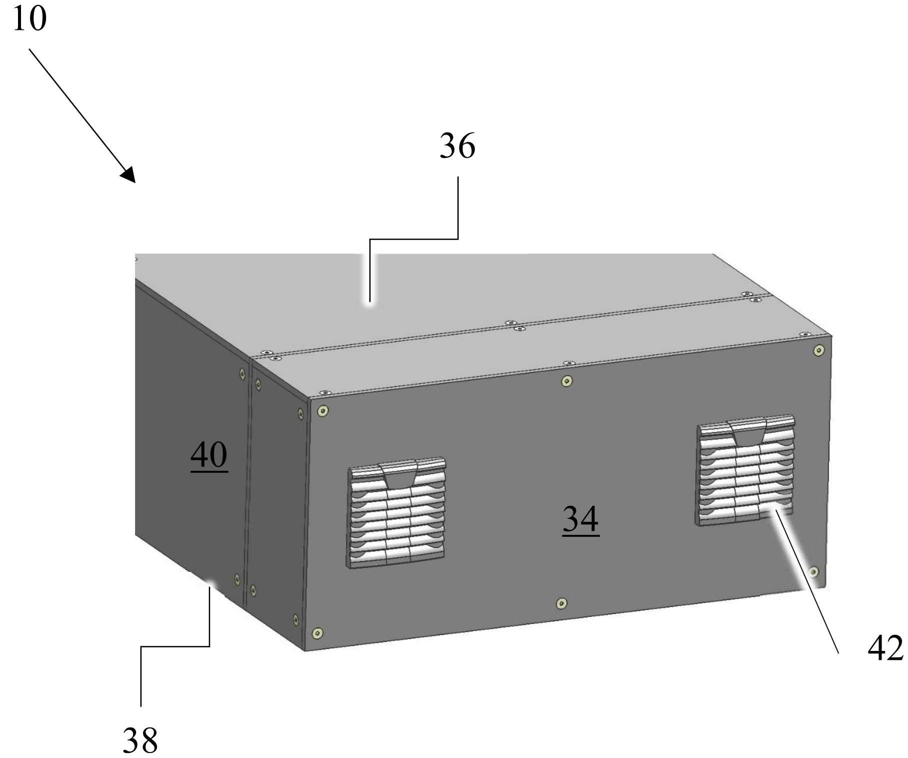

FIGURE 2

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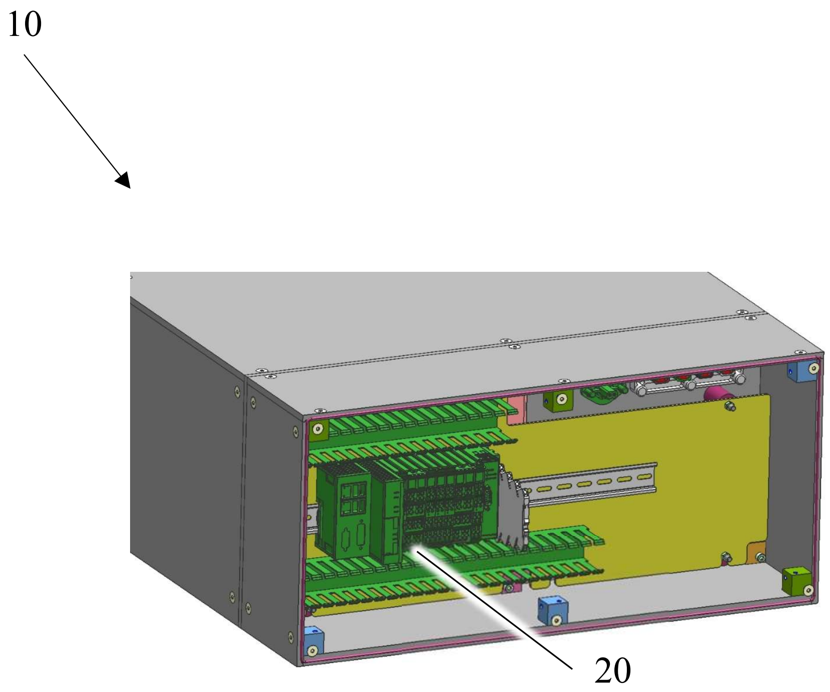

FIGURE 3

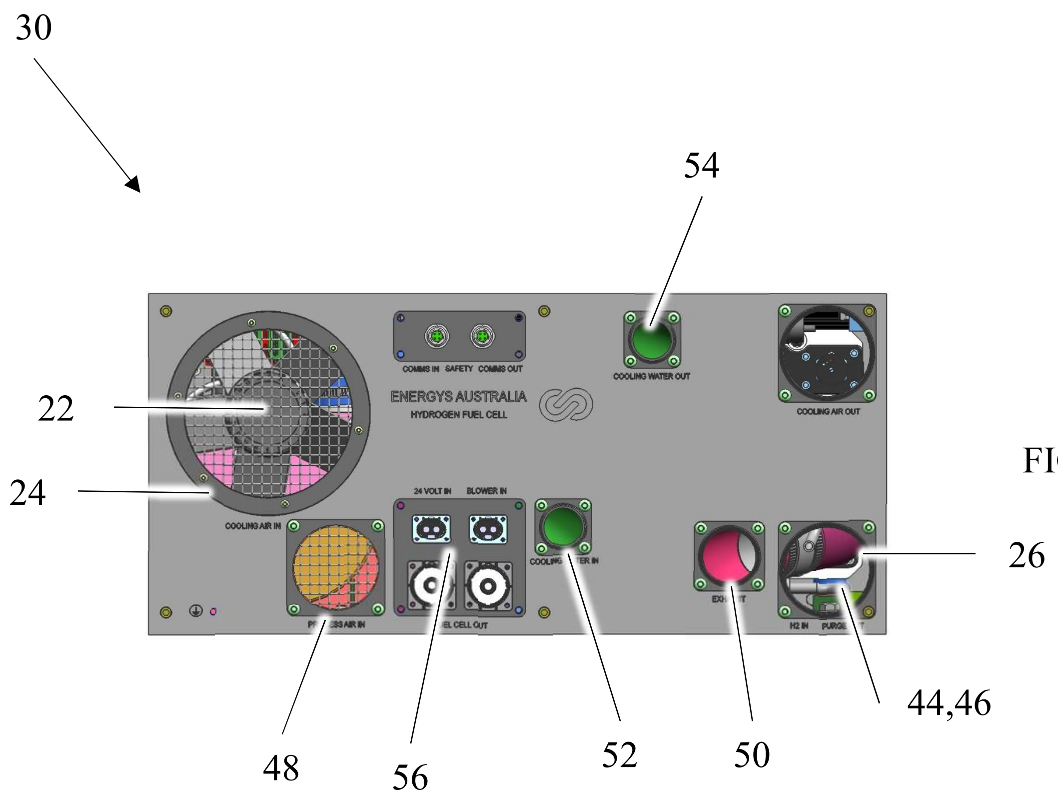

FIGURE 4

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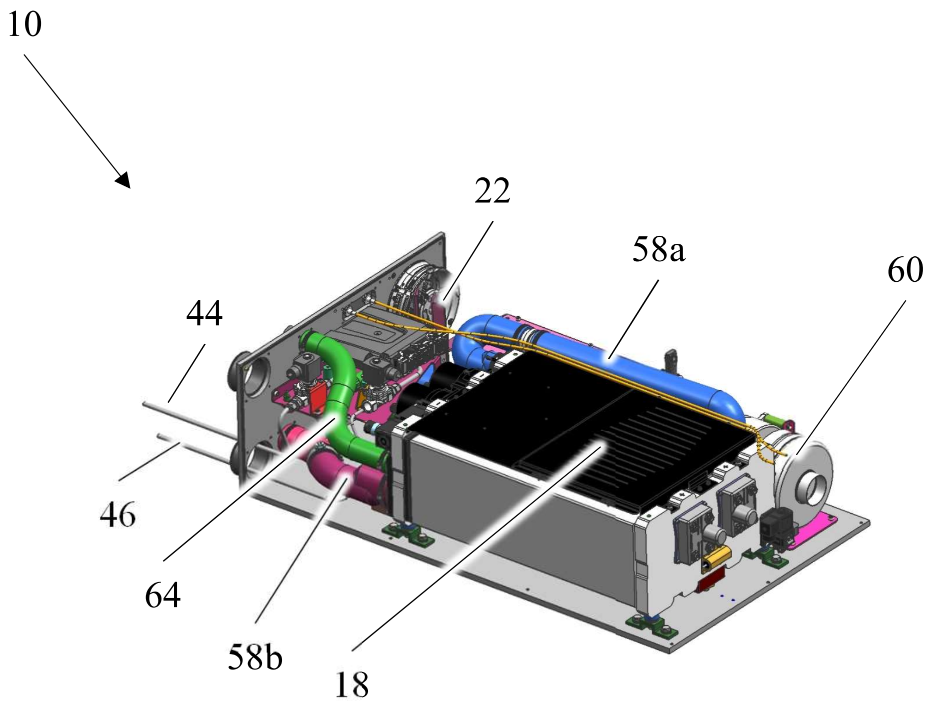

FIGURE 5

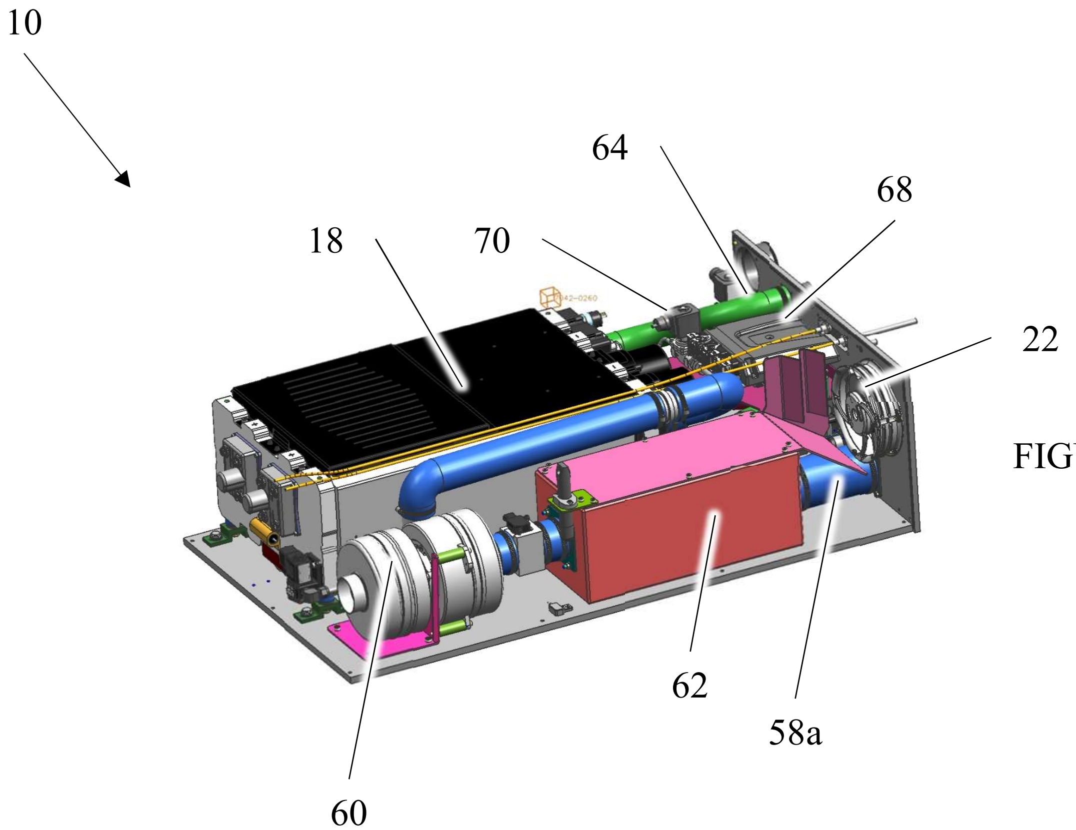

FIGURE 6

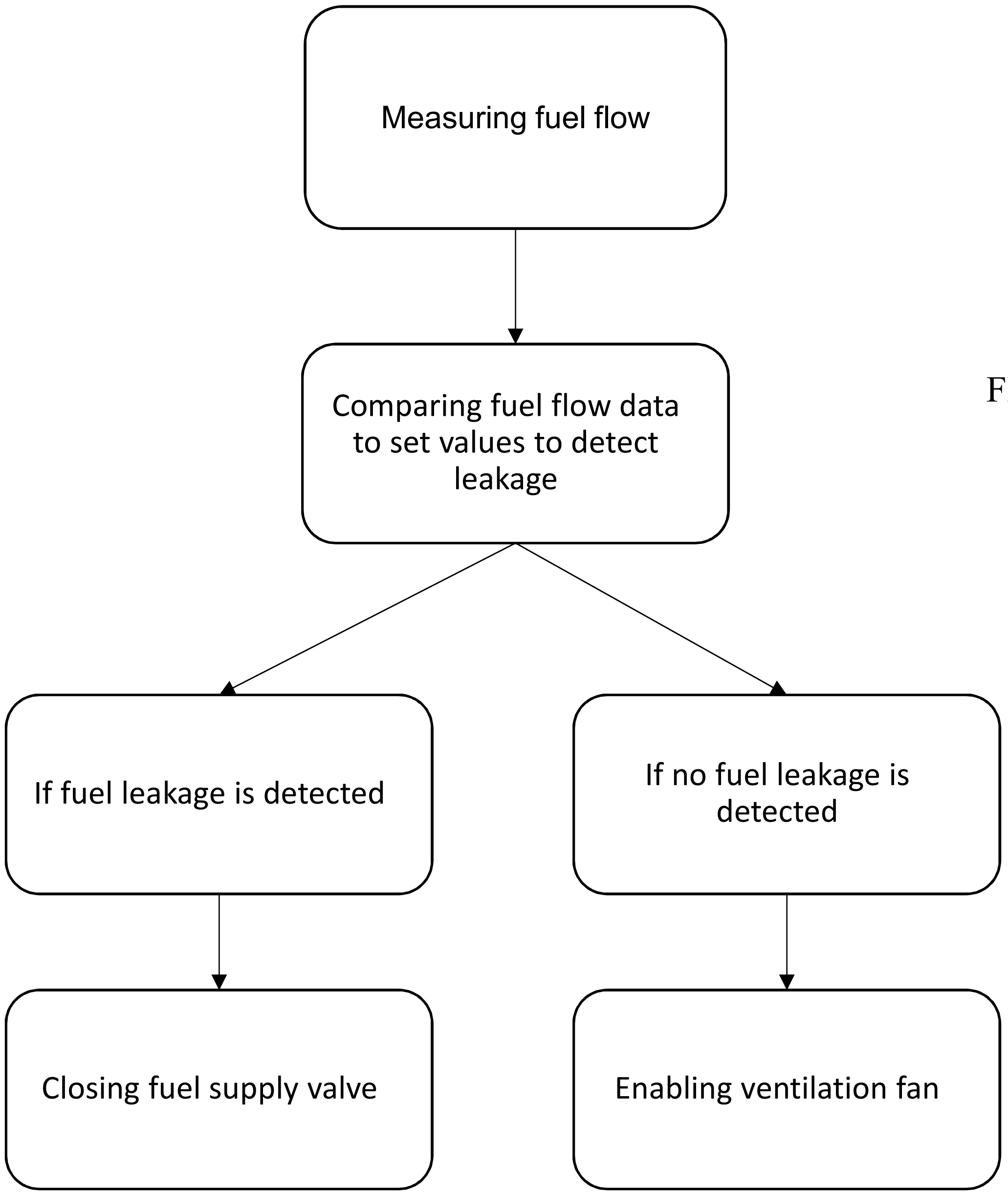
Measuring fuel flow
Comparing fuel flow data to set values to detect leakage
If fuel leakage is detected
If no fuel leakage is detected
Closing fuel supply valve
Enabling ventilation fan

FIGURE 7

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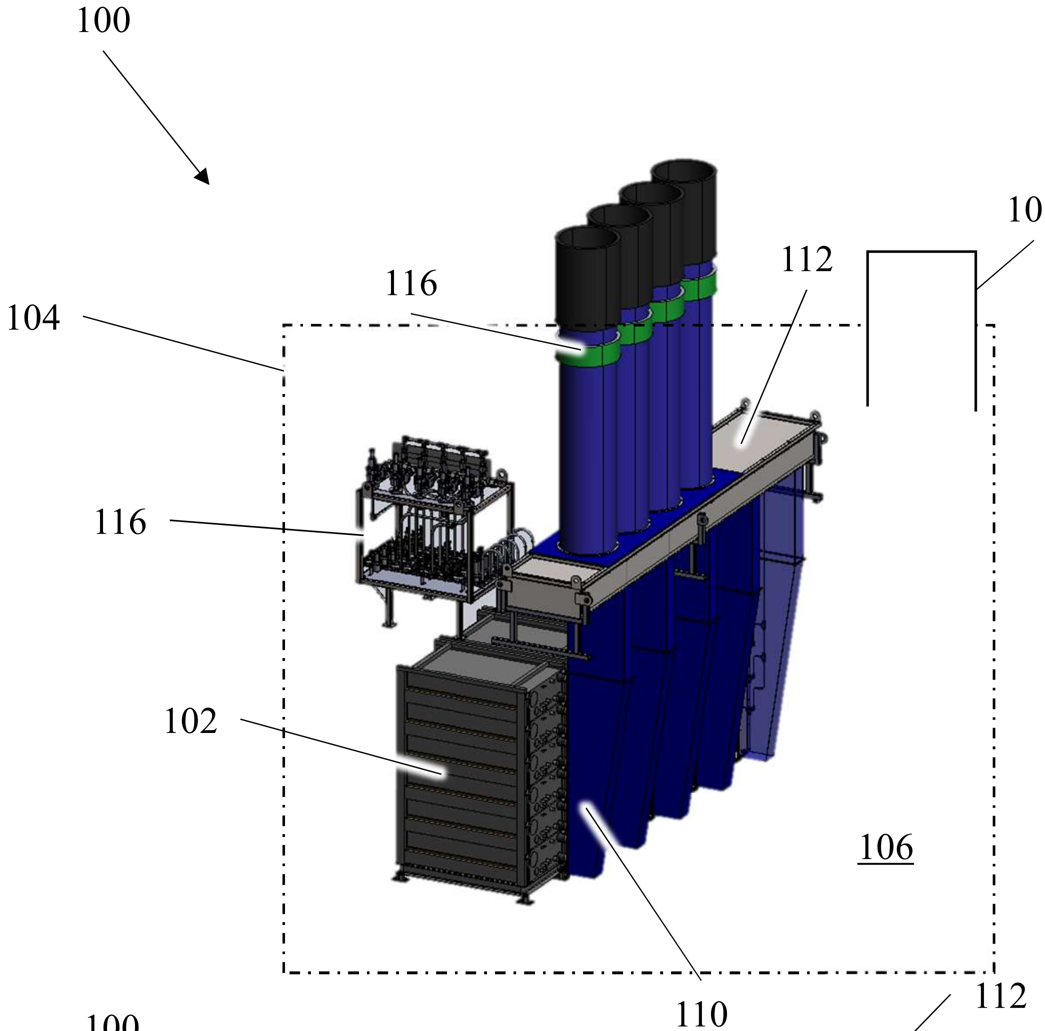

FIGURE 8

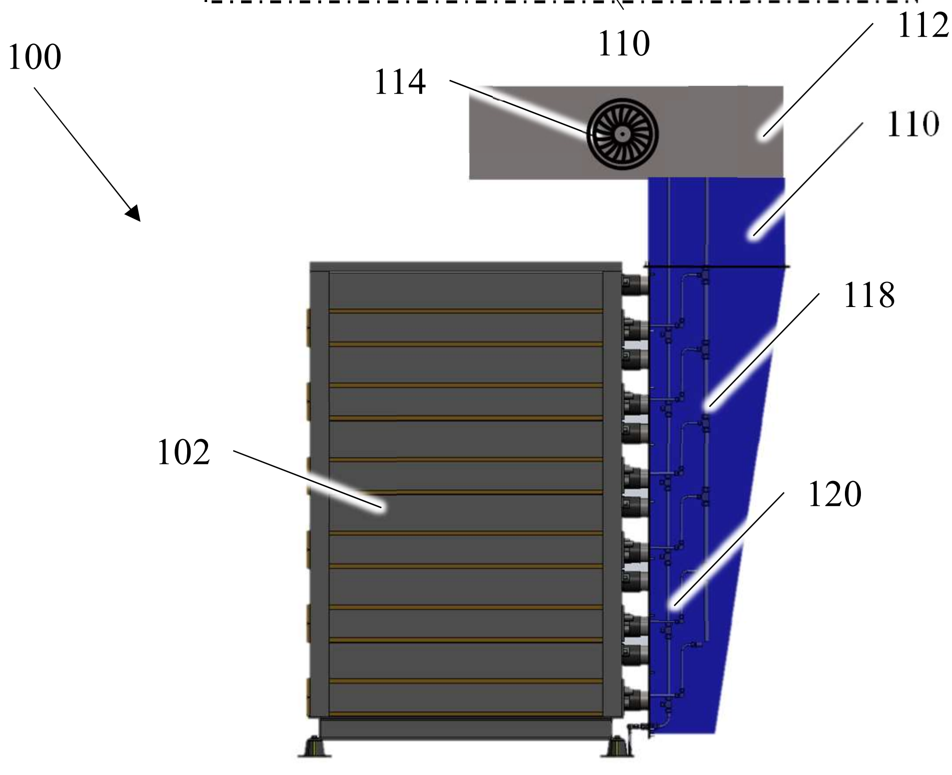

FIGURE 9