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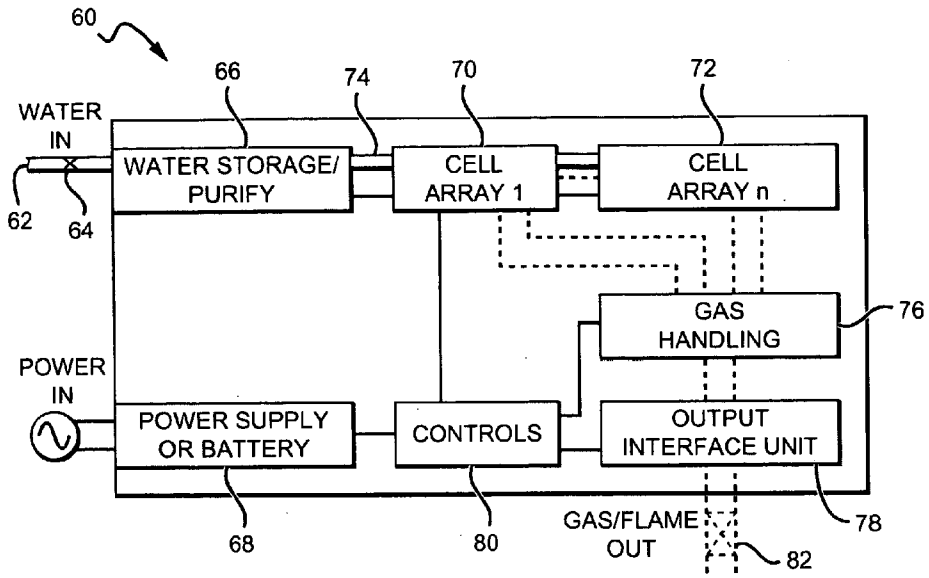


FIG. 5

(57) Abstract: Devices, systems and methods for improved electrical appliances which allow for efficient and safe production.of hydrogen and oxygen gas for a flame are disclosed. An appliance for providing gas for combustion may comprise a water inlet, a power source, and an electrolyzer with at least one electrolysis transistor generating hydrogen and oxygen. The appliance may also comprise a gas handling unit for collecting the output of the electrolyzer and transporting it to a burner, and an output interface.

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COMPACT ELECTRIC APPLIANCE FOR PROVIDING GAS FOR COMBUSTION

[0001] This application claims the benefit of provisional application Serial Number 60/966,578 to Umesh Mishra et al., which was filed on August 28, 2007.

BACKGROUND OF THE INVENTION

Field of the Invention

[0002] Two well-known sources for home/industrial heating and cooking are gas and electricity. Gas-based cooking uses two common types of methods: piped gas, which is provided and metered by utility/gas companies; or gas cylinders such as propane, liquefied natural gas (LNG), and compressed natural gas (CNG). These gasses can also be used for home or industrial heating, with one example being piped natural gas. Electric cooking uses an electric stove integrated into a kitchen or other point-of-use.

[0003] Gas sources that provide clean flames (without soot) are also needed for sterilization, biological purposes, and pharmaceutical industry use. Additionally, clean flame can be used in: jewelry-making applications, such as fabricating or repair; soldering and brazing for

electronics; drilling of ceramic or quartz; and, on a large scale, for welding and cutting metal and underwater welding and cutting.

[0004] However, an efficient, portable electrical appliance that provides a clean flame does not exist. This may be due to the large footprint that would be needed for such an appliance, use of caustic electrolytes in some systems, and the lack of efficiency of previous methods in converting electricity to gas, which can then be burnt to provide heating or other use of the flame. Hydrogen-based burners/cookers could also be used, and are based on modifications of conventional burner designs in which hydrogen is piped or stored in a pressure cylinder or as a hydride. For generating hydrogen using electrolysis, efficiency at high electrode current density is a major challenge.

[0005] Current efforts to enhance efficiency and current density rely on improving the electrolyte and electrodes. These efforts lead to incremental advances that typically fail to address high-density, high-efficiency electrolysis. While this leads to gradual improvements, a radical departure from this approach is needed to address high-density, high-efficiency applications.

[0006] Various known processes can be utilized for the electrolysis of water. Hydrogen can typically be obtained through the electrolysis of water using either: liquid alkaline electrolyzers; proton exchange membrane ("PEM") electrolyzers; or, high temperature steam electrolyzers. Alkaline electrolyzers use extremely caustic KOH solutions

to reduce operating voltages and increase cell efficiency. They also operate at lower (although still elevated) temperatures relative to steam electrolysis. However, current densities are still low, and large platinized or nickel coated stainless steel electrodes are required. Additionally, the highly caustic electrolytes severely limit material choices and pose considerable safety and disposal concerns.

[0007] PEM-based electrolyzers use advanced polymer membranes in place of alkaline electrolytes. This enhances the usability of the system, and provides modest current densities at acceptable efficiencies. These current densities lead to systems requiring large quantities of expensive membrane and platinized electrode materials, as well as expensive assembly techniques.

[0008] High temperature steam electrolysis requires less electrical power than other systems, but requires large amounts of thermal energy to maintain operating temperatures of 1000 °C. For high-efficiency operation, these electrolyzers need large, constant heat sources such as nuclear power plants or solar concentrator heating systems. Steam electrolysis also suffers from low current density and requires steady-state operation. Finding electrode materials that can withstand the aggressive high-temperature oxidizing and reducing environments that are present in steam electrolyzers is a significant challenge.

[0009] The table in **FIG. 1** compares key performance characteristics for alkaline and PEM-based electrolyzers

with those of the electrolysis transistor described in more detail below. The parameters indicate that low-current density products, caustic electrolytes (in the case of alkaline electrolyzers), low efficiency, and large system footprints are characteristic of alkaline and PEM-based electrolyzers, which present a significant barrier to technological progress and innovation. As shown and as will be discussed in further detail below, the electrolysis transistor offers significant improvements in these areas.

[0010] While incremental advances continue to be made in conventional two-terminal technologies, such as new nano-structured electrodes, composite metal-oxide catalysts, increased ionic conductivity membranes, and high-density plastics for caustic containment, none of these approaches bring about dramatic improvements in performance. These barriers have limited the penetration of electrolysis systems in the marketplace.

SUMMARY OF THE INVENTION

[0011] The present invention provides systems and methods for improved electrical appliances which allow for, amongst other improvements, efficient and safe production of hydrogen and oxygen gas for a flame. One embodiment comprises an appliance for providing gas for combustion, with the appliance comprising a water inlet and a power source. The appliance further provides an electrolyzer with at least one electrolysis transistor generating hydrogen and oxygen. A gas handling unit is also provided,

with the gas handling unit collecting the output of the electrolyzer and transporting it to a burner. An output interface is also provided.

[0012] Pursuant to another specific, exemplary embodiment, a system for providing gas for combustion is disclosed. The system comprises a water supply, a power source, an electrolyzer with an array of electrolysis transistors for generating hydrogen and oxygen, a gas handling unit for collecting the output of the electrolysis transistors, and a flame and/or gas outlet.

[0013] In accordance with yet another specific, exemplary embodiment, a method for providing gas for combustion is disclosed. The method comprises providing a water source and a power source, with the power source activating an appliance. An electrolyzer is also provided, with the electrolyzer comprising at least one electrolysis transistor for generating hydrogen and oxygen. Furthermore, a unit for collecting the gas output of the electrolyzer is provided, and an output interface through which gas and/or a flame may exit an appliance is also provided.

[0014] These and other further features and advantages of the invention would be apparent to those skilled in the art from the following detailed description, taken together with the accompanying drawings, in which:

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] **FIG. 1** is a table comparing a few existing electrolyzer technologies with one embodiment of an electrolysis transistor used in accordance with the present invention;

[0016] **FIG. 2** is a cross-sectional view of one embodiment of an electrolysis transistor used with an embodiment of a gas generator/burner device according to the present invention;

[0017] **FIG. 3** is a schematic of a conventional 2-electrode cell compared with one embodiment of an electrolysis transistor used with an embodiment of a gas generator/burner device according to the present invention;

[0018] **FIG. 4** is a cross-sectional view of one embodiment of an electrolysis transistor used with an embodiment of a gas generator/burner device according to the present invention;

[0019] **FIG. 5** is an architectural schematic of one class of embodiment of an electrolysis gas generation/burner unit according to the present invention; and

[0020] **FIG. 6** is a diagram view of one embodiment of an electrolysis gas generation/burner system according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0021] The following description presents preferred embodiments of the invention representing exemplary modes contemplated for practicing the invention. This description is not to be taken in a limiting sense but is made merely for the purpose of describing the general principles of the invention, the scope of which is better understood by the appended claims.

[0022] The present invention provides a major departure from past electrolysis methods to provide an improved electrical appliance that efficiently and safely produces a gas for a flame. An electric apparatus is provided for supplying a flame for various applications, such as gas-based cooking, water/home heating, or industrial applications such as brazing and welding. In a preferred embodiment, the flame is also compact and clean burning. The present invention is particularly applicable to a new system and method for generating a combustion gas comprising hydrogen-oxygen (H_2-O_2) mixtures from a compact appliance. The process used to generate the gas and flame is based upon a novel method for the electrolysis of water, namely the electrolysis transistor. The present invention utilizes the electrolysis transistor disclosed in U.S. Patent Application 12/156,178 to Umesh Mishra, et al. ("the '178 Application"), which is assigned to the same assignee of the present invention and is incorporated in its entirety herein by reference.

[0023] The electrolysis transistor allows for the electrolysis of water to produce hydrogen and oxygen, and provides many improvements and overall superior performance compared with other existing electrolyzer technologies. For example, some of the improvements resulting from the electrolysis transistor include: high-density electrochemistry and products utilizing the same; very high current densities (or equivalently compact footprint); high-efficiency electrolysis and electrochemical processes; and, cost effectiveness. The appliance incorporating the electrolysis transistor generates a hydrogen-oxygen mix and enables controlled burning of the generated hydrogen-oxygen mixture, using only electricity from the mains (or any other suitable form of power such as a battery, solar cell array, or other renewable power source) and water as the only inputs.

[0024] Other advantageous features of the present invention include, but are not limited to: zero to minimal storage of flammable gas (when compared to storage requirements for other gas-based burners), with storage limited to providing an instant-on service feature; integrated gas detection and leak protection auto-shutoff; gas flow monitoring and indicating for appliances requiring low-flow service; closed and open water flow systems; portable features for both indoor and outdoor use, including on-board vehicular use; and, methods for integration of the apparatus for common home use such as kitchen use and water/gas heating use.

[0025] The present invention is applicable to any electrical device (including those powered by battery or renewable energy sources such as solar, wind, and the like) for generating a combustible gas and a flame for various uses. Such uses may include, but are not limited to: gas burners for cooking, water heating, home heating, sterilization, jewelry making, welding, and cutting via torches. Devices according to preferred embodiments are also applicable to electric/battery power appliances that produce a combustible gas mixture in an efficient, compact, cost-effective manner. The resulting combustion mixture may be used in a variety of different applications, for example by burning the gas itself, or by adding it to a fuel mixture in Internal Combustion Engines (ICE) to enhance fuel efficiency, reduce emissions, and provide other benefits related to the more complete and efficient burning of fuel.

[0026] **FIG. 2** shows one embodiment of an electrolysis transistor 10 utilizing established micro-fabrication techniques in which the core technical innovations of a proximal gate 12 on a micro-fabricated, nano-structured electrode 14 are provided. The gating electrode lowers the barrier at the electrode-electrolyte interface, reducing the voltage necessary for electrolysis. The result of this effect is at least a 10x increase in generation density compared to other electrolyzers. The advantages of this type of gated electrode arrangement and innovations designed to improve performance of this arrangement are discussed in detail in the '178 Application.

[0027] In an electrolyzer, there is a barrier to electrolysis at each electrode. **FIG. 3(a)** provides an illustration for a conventional 2-electrode cell 20, a simplified equivalent circuit 22 with the potential barriers represented by diodes, and a schematic 24 of this potential barrier. These barriers depend on the interface properties of the electrode-electrolyte system, and it is desirable for these barriers to be as low as possible. Conventionally, this has been achieved by optimizing the electrode-electrolyte system.

[0028] An analogy for the operation of the electrolysis transistor can be found in the field of semiconductor MOS transistors as illustrated in **FIG. 3(b)**. In a semiconductor MOS transistor device 26, a barrier exists between the source and drain electrodes, 28 and 30 respectively. This barrier is modulated by applying a voltage to the gate electrode 32. As the barrier is lowered and as shown in schematic 34, the channel current increases exponentially for a given source-drain voltage.

[0029] An exemplary embodiment of an electrolysis transistor 36 is described in the '178 Application, and extends this concept to the barrier at the electrode-electrolyte interface, as shown in **FIG. 3(c)**. This allows independent control of the electrolysis barrier, with the gate electrode 38 acting in much the same way as the gate terminal 32 in the MOS transistor 26 described above. This solution can provide an approximate 10x potential increase of generation current density to 10 A/cm^2 or more, while

maintaining high-efficiency and eliminating caustic electrolytes.

[0030] As illustrated in schematic 40, at the cathode, electrons must tunnel through the potential barrier to the hydrogen ion or a hydrogen containing radical for electrolysis to take place, and a similar process is required at the anode where electrons tunnel from a radical/molecule to empty states in the anode. In a two terminal electrolysis cell, the only way the barrier can be reduced and the current increased for these processes is by increasing the cell voltage, which reduces the efficiency of the device.

[0031] **FIG. 4** shows one possible embodiment for an electrolysis transistor 42 according to the '178 Application that can be incorporated into one embodiment of a device according to the present invention. A proximal gate 44 near the cathode 46 can lower the barrier to electron transport without requiring a large cell voltage. By applying a positive voltage to the gate, image charges in the cathode create an enhanced field in the electrolyte, thus reducing the barrier and leading to electrolysis and the formation of hydrogen and oxygen.

[0032] To prevent screening of the electrodes, the gate and the dielectric can be brought sufficiently close to the cathode. Semiconductor nano-fabrication technology, capable of manufacturing integrated transistors with feature sizes in the 10s of nm range, can be utilized to fabricate such structures where the gate and dielectric can be brought sufficiently close to the cathode.

Alternatively, other processes known in the art for producing nano-structured materials can be used to fabricate the electrodes.

[0033] The electrolysis transistor can overcome many key roadblocks plaguing the current state of the art electrolysis, including but not limited to: low current density-efficiency product; exotic electrode materials, caustic electrolytes and/or expensive polymer electrolytes; and, complex, high-cost systems. The electrolysis transistor can also provide the following advantages, which include but are not limited to: a reduction in the module footprint and weight; an increase in generation efficiency; and, a reduction in overall system complexity.

[0034] A reduction in the footprint and weight of the device can be achieved through an increase in the generation density of the electrolytic cell, or in other words, an increase in the volume of hydrogen and oxygen (liters per minute) generated by the cell. Since there is a 1:1 relationship between the rate of hydrogen generation and the current applied to the electrodes, the current density at an electrode in a cell is an appropriate measure for generation density as long as the coulombic efficiency is close to one.

[0035] In one embodiment of an electrolysis transistor that may be incorporated into a device according to the present invention, commingled hydrogen and oxygen are generated using nano-structured GaN semiconductor surfaces as a cathode, and proximal Ti/Pt electrodes as anodes.

However, it is understood that other suitable materials may also be used.

[0036] **FIG. 5** shows an architectural schematic of the electrolysis gas generation/burner unit 60 according to the present invention, which incorporates a desired embodiment of an electrolysis transistor as discussed above. Water can be provided to the unit in many different ways, and depending on the application, can include a mechanism for storing a supply of water for use in gas generation. In the embodiment shown, a water inlet 62 is provided that serves as the path for water to enter the unit 60, and a control valve 64 can be provided on the inlet 62 to block the inlet or to allow water to pass.

[0037] The architectural embodiment shown includes a water reservoir 66 for additional water storage or capacity, and the water inlet 62 is coupled to the water reservoir 66 such that water entering the unit through the inlet 62 is passed into the reservoir 66. The water reservoir 66 may include an additional water purification unit/filter mechanism (not shown) if desired, to clean and purify the water in the reservoir 66. In other embodiments of the unit according to the present invention, a connection to a continuous water supply is integrated, meaning the reservoir may not be needed. However, in these embodiments, the water purification unit/filter can still be included.

[0038] Units according to the present invention may be powered in many different ways, from many different supplies/sources 68. The power can be from: AC (mains)

converted to DC via an integrated AC-DC power supply; AC (mains) converted to lower voltage AC through a step-down transformer or switch-mode convertor; or, in other embodiments an AC-DC power supply can be replaced with a battery from which the appropriate voltages for driving the electrolysis cells and the control electronics can be derived using convertors. Both AC and DC control voltages may also be supplied to the unit, if needed, for controlling the cells, fluid handling sub-systems, safety devices and user interface. Still, in other embodiments, both the AC-DC power supply and the battery can be combined for a dual-use option. In some embodiments, a DC battery, fuel cell, or other type of power source (e.g. solar or other renewable) may be converted to an AC signal voltage via a DC-AC inverter. In different embodiments, the cell can comprise an AC-DC conversion circuit/apparatus (if powered from main supplies) or DC to AC conversion circuit/apparatus (if powered by a battery e.g. car, and AC is needed), or both.

[0039] The unit may also comprise one or more electrolysis cells (as discussed above) in different arrangements, with the cells utilizing water from the water inlet 62 or water reservoir 66 for use in the electrolysis process. In the embodiment shown, a series of electrolysis cells represented by 70 and 72 are arranged in an array, with each cell of the array having arrays of electrodes that are designed according to the intended use and scalability requirements. While there are two cells shown in FIG. 6, it is understood that any number of cells may be incorporated depending on the intended use and

applications. In the unit shown, each of the arrays accepts water from a water reservoir 66 through water conduits 74, with the water being supplied to each of the electrolysis cells 70, 72 in the arrays. The detailed description of the electrolysis cell structure and architecture is provided in U.S. Provisional Application No. 60/866,560 and the '178 Application, both of which are incorporated herein by reference.

[0040] The electrolyzer produces hydrogen and oxygen in a commingled fashion, with the gas being fed to a gas handling unit 76 that collects the output (hydrogen and oxygen) from multiple cells 70, 72 and feeds it to the output interface unit 78 where flame may then exit the system via the flame/gas outlet 82. The output interface unit 78 design is flexible, and is based upon the desired end use or application. In different embodiments, it can include one or more sub-units, consisting of the following optional features: gas detection and an indicator with an auto-shutoff feature to turn off the electrolyzer if the flame is not lit or is quenched, an output gas flow monitor, an additive to give visibility to the flame (for flame/burner-based applications), gas storage, a knob-controlled burner for direct flame-based applications, an easy/auto shutoff safety control, a display, and a user interface. The control unit 80 may interface with the various portions of the unit to monitor and maintain the electrolysis process as well as the gas output process.

[0041] Aspects of the present invention may be practiced in many ways, with one embodiment providing a safe

application relying on the fast response of the electrolysis transistor to have an extremely small dead volume of the mixed gases. Dead volume refers to the volume of gasses not immediately being consumed by the flame, with dead volume of gas typically forming during the electrolysis process or remaining in the unit when it is not in operation, such as when the unit is turned off or when it is not in use. The reduction or elimination of the dead volume results in a negligible possibility of an explosion by ignition of the dead volume gasses.

[0042] The block diagram of **FIG. 6** shows one embodiment of a system 90 according to the present invention. The system uses on-demand generation of hydrogen or stoichiometric hydrogen-oxygen mixtures to reduce the dangers associated with storing high volumes of hydrogen and to make the device safe. When using stoichiometric hydrogen-oxygen mixtures, there are three main issues that need to be addressed: 1) the flame temperature is too high for some applications such as cooking; 2) the flame has high UV content; and, 3) the flame velocity is very high. If these issues are not appropriately addressed, the functionality of the device may become compromised. These complications are attended to by appropriately diluting the stoichiometric mixture with air using aspirator-based approaches and incorporating several layers of safety mechanisms using both active and passive devices that might be electro-mechanical or purely mechanical.

[0043] A brief description of the operation of a system 90 according to a preferred embodiment is as follows:

a. An air compressor or an elastomer/flexible membrane-based passive compressor pressurizes the water so the electrolyzer operates at adequate pressure, which allows the stoichiometric mixture to be driven to the nozzle at velocities greater than the flame velocity. A pressure valve ensures the gasses exit only when the pressure is high enough.

b. A very small dead volume above the electrolyzer may exist so that even in the case of flash back, only the safety valve on the electrolyzer will be actuated and the event will not result in a catastrophic explosion.

c. A flashback arrestor lies immediately above the electrolyzer to prevent the flame from entering the electrolyzer. This might be a classic design or a special design integrated into the delivery tubing.

d. A mix control module dilutes the gases so the flame temperature is lowered if required to reduce UV emission and NO_x (oxides of nitrogen) formation. The module might use just the Venturi effect or the Venturi effect with the addition of compressed air to ensure effective mixing. UV and infrared sensors may be used to estimate flame temperature and control feedback. Alternatively, more conventional temperature sensors such as thermocouples may be used.

e. The nozzle array design ensures the gas velocities remain higher than the flame velocity while allowing the flame to be dispersed to produce uniform heating.

f. An automatic spark igniter lights the flammable mixture when they are first ejected

g. Appropriate impurity addition to the gas mixture imparts color to the flame for easy detection of the flame itself.

h. A hydrogen or reducing gas sensor monitors any gas leakage with an auto-shutoff feature to turn off the electrolyzer if the flame is not lit or is quenched.

i. The power convertor uses the most appropriate architecture to convert the input power to the voltage and current needed for the anode and gate drives.

j. The control module, made using microcontrollers or FPGAs or ASICs, executes a failsafe algorithm to turn off the system in case the hydrogen is not ignited or there is a flash back into the system to ensure safe shutdown.

k. The appliance comprising the electrolysis cell uses the electrolysis transistor architecture to operate at very high current density (>2A/cm^2, >4A/cm^2, >6A/cm^2) simultaneously with high

efficiency (>6A/cm^2 and >50%, >4A/cm^2 and >60%, >2A/cm^2 and >70%).

[0044] At the end of an operation session, an appropriate cell flush using air can ensure that no explosive gas mixture remains in the system. An additional UV sensor at the flash arrestor could be used to provide rapid turn-off of the electrolyzer power and flush the system in case of flashback. The safety and control of the system could be effected with or without the use of microprocessor control.

[0045] Many different modifications and variations can be implemented in the embodiments described above. Several safety and control mechanisms have been described above, but not all of them may be necessary and employed in practice. For example, in some applications (such as micro-welding and metal cutting), high flame temperature is required and thus diluting/ballasting with air may be not necessary. However, the user should still take certain precautions, such as wearing appropriate safety implements like goggles. Also, for applications such as micro-welding, the high current density electrolyzer cell can be located in the handset, resulting in an extremely small dead space for the stoichiometric hydrogen-oxygen mixture, thus making such systems safe by design.

[0046] The present invention provides many advantages over conventional approaches for supplying combustible gas or conventional approaches for heating and cooking. For example, the piped gas approach often used in heating and

cooking requires gas piping infrastructure, which does not exist in many parts of the world. Thus, transportation and storage of gas presents logistics, cost, and hazard issues, which are mitigated by point-of-use generation as is provided in the present invention. Even if piped gas is available, susceptibility of gas piping to accidents (such as during earthquakes and other natural disasters), makes the infrastructure vulnerable, especially in high-risk, densely populated areas.

[0047] Additionally, another advantage pertains to cooking, as electric ranges are not acceptable or are less preferable in many cultures and styles of cooking. The controlled heat and instant on/off feature of a true gas flame is desirable in many cooking approaches. If electricity can be efficiently and cost-effectively converted into a flame-compact appliance as proposed in the present invention, these issues can be overcome.

[0048] Moreover, other advantages are appropriate for applications such as sterilization and jewelry-making, where a clean (i.e. soot and impurity free) and compact flame is required. The present invention provides for a pure hydrogen/oxygen-based flame with no carbon containing impurities.

[0049] Yet another advantage lies in the electrolysis aspect of the invention. Although electrolysis for the production of hydrogen, oxygen and other materials is well-known, conventional methods require equipment with a large footprint, complex system design, caustic chemicals (such as KOH) in one class of systems, and high power/high cost

of operation due to the less efficient nature of these systems when compared to the present system utilizing electrolysis transistors. Because of this, up until the electrolysis transistor, the use of an electrolysis-based appliance to generate gas to achieve a flame has not been convenient.

[0050] While several illustrative embodiments of the invention have been shown and described, numerous variations and alternate embodiments will occur to those skilled in the art. Such variations and alternate embodiments are contemplated, and can be made without departing from the spirit and scope of the invention as defined in the appended claims.

WE CLAIM:

1. An appliance for providing gas for combustion, comprising:

a water inlet;

a power source;

an electrolyzer comprising at least one electrolysis transistor generating hydrogen and oxygen;

a gas handling unit for collecting the output of said electrolyzer and transporting said output to a burner; and

an output interface.

2. The appliance of claim 1, wherein said at least one electrolysis transistor further comprises:

a neutral electrolyte;

one or more working electrodes for transferring charge to or from said electrolyte; and

one or more gate structures for reducing the voltage necessary for electrolysis.

3. The appliance of claim 2, wherein said one or more working electrodes comprises a cathode and/or an anode.

4. The appliance of claim 1, wherein said electrolyzer comprises an array of cells of electrolysis transistors.

5. The appliance of claim 1, wherein the architecture of said at least one electrolysis transistor is used to operate at very high current density (>2A/cm^2, >4A/cm^2, >6A/cm^2) simultaneously with high efficiency (>6A/cm^2 and >50%, >4A/cm^2 and >60%, >2A/cm^2 and >70%).

6. The appliance of claim 1, wherein commingled hydrogen and oxygen are generated.

7. The appliance of claim 1, further comprising a water purification mechanism for filtering and de-ionizing the water entering the appliance.

8. The appliance of claim 1, wherein said water inlet comprises a control valve for controlling the rate of water flow through said inlet.

9. The appliance of claim 1, further comprising a water reservoir for storage and increasing the water capacity of the appliance.

10. The appliance of claim 9, wherein said reservoir comprises a water purification mechanism for filtering and de-ionizing the water in said reservoir.

11. The appliance of claim 1, wherein said power source may comprise AC (mains), an integrated AC-DC supply, a battery, a fuel cell, solar power, or various combinations thereof.

12. The appliance of claim 1, wherein at least one water conduit supplies water to each of the at least one electrolysis transistors.

13. The appliance of claim 1, wherein said output interface has at least one sub-unit comprising a gas

detector and indicator, an output gas flow monitor, an additive to give visibility to flame, gas storage, a knob-controlled burner, an easy auto-shutoff control, a display, and/or a user interface.

14. The appliance of claim 1, further comprising a flame and/or gas outlet.

15. A system for providing gas for combustion, comprising:

a water supply;

a power source;

an electrolyzer comprising an array of electrolysis transistors for generating hydrogen and oxygen;

a gas handling unit for collecting the output of said electrolysis transistors; and

a flame and/or gas outlet.

16. The system of claim 15, wherein on-demand generation of hydrogen and/or stoichiometric hydrogen-oxygen mixtures are incorporated to increase device safety.

17. A method for providing gas for combustion, comprising:

providing a water source;

providing a power source to activate an appliance;

providing an electrolyzer comprising at least one electrolysis transistor generating hydrogen and oxygen;

providing a unit for collecting the gas output of said electrolyzer; and

providing an output interface through which gas and/or a flame may exit an appliance.

18. The method of claim 17, wherein said electrolyzer comprises an array of cells of electrolysis transistors.

19. The method of claim 17, further comprising providing a powered, passive, or manual air compressor for pressurizing said water to allow said appliance to operate at adequate pressure.

20. The method of claim 17, further comprising providing a pressure valve to ensure gasses exit said appliance when pressure is high enough.

21. The method of claim 17, further comprising a small dead volume above said electrolyzer so only a safety valve will be actuated in the event of a flashback.

22. The method of claim 18, further comprising providing a flashback arrestor to prevent flame from entering said electrolysis cells.

23. The method of claim 17, further comprising providing a mix control module to dilute said gas output to reduce UV emission and NO_x formation.

24. The method of claim 17, further comprising a nozzle array or a single nozzle for ensuring gas velocities remain higher than flame velocity.

25. The method of claim 17, further comprising providing an automatic spark igniter to light the flammable mixture of said gas when it is first ejected.

26. The method of claim 17, further comprising providing an impurity additive to said gas output to impart color to said flame.

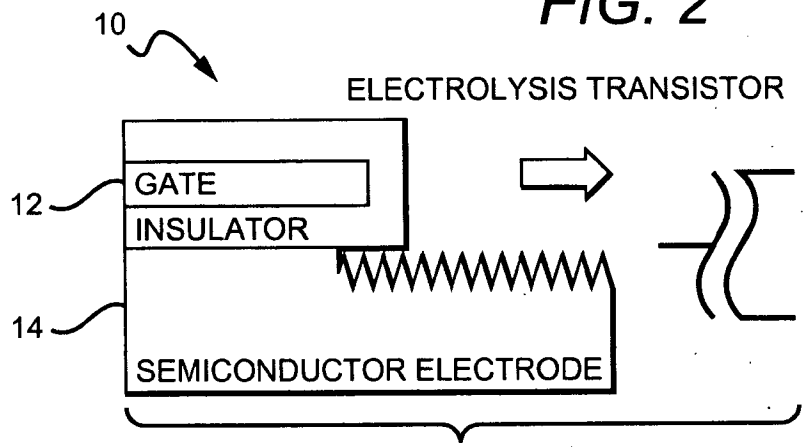
27. The method of claim 17, further comprising providing a control module for executing a failsafe algorithm to turn off the system in case said gas is not ignited or there is a flashback.

28. The method of claim 17, further comprising providing a cell flush using air to remove any excess explosive gas mixture from said appliance before appliance is turned off.

FIG. 1

CELL TYPE / PARAMETER	ALKALINE	PEM	ELECTROLYSIS TRANSISTOR
ELECTROLYTE	CAUSTIC: ALKALINE LYE	PERFLUORATED SULFONATED POLYMER	SODIUM SULFATE
TEMPERATURE	70-150°C	80°C	25-150°C
CURRENT DENSITY	0.5 A/cm^2	0.5 A/cm^2	>2.5 A/cm^2
EFFICIENCY	65%	65%	> 80%

FIG. 2



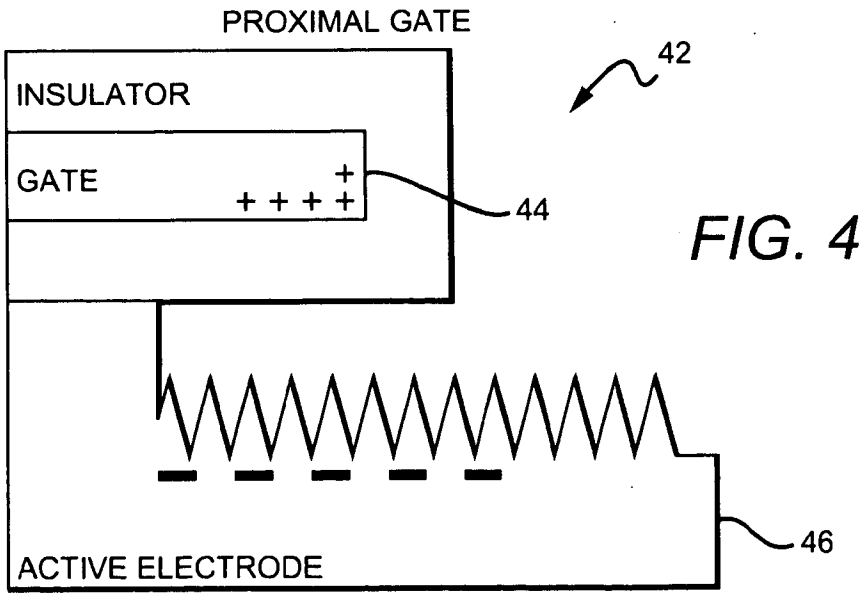


FIG. 4

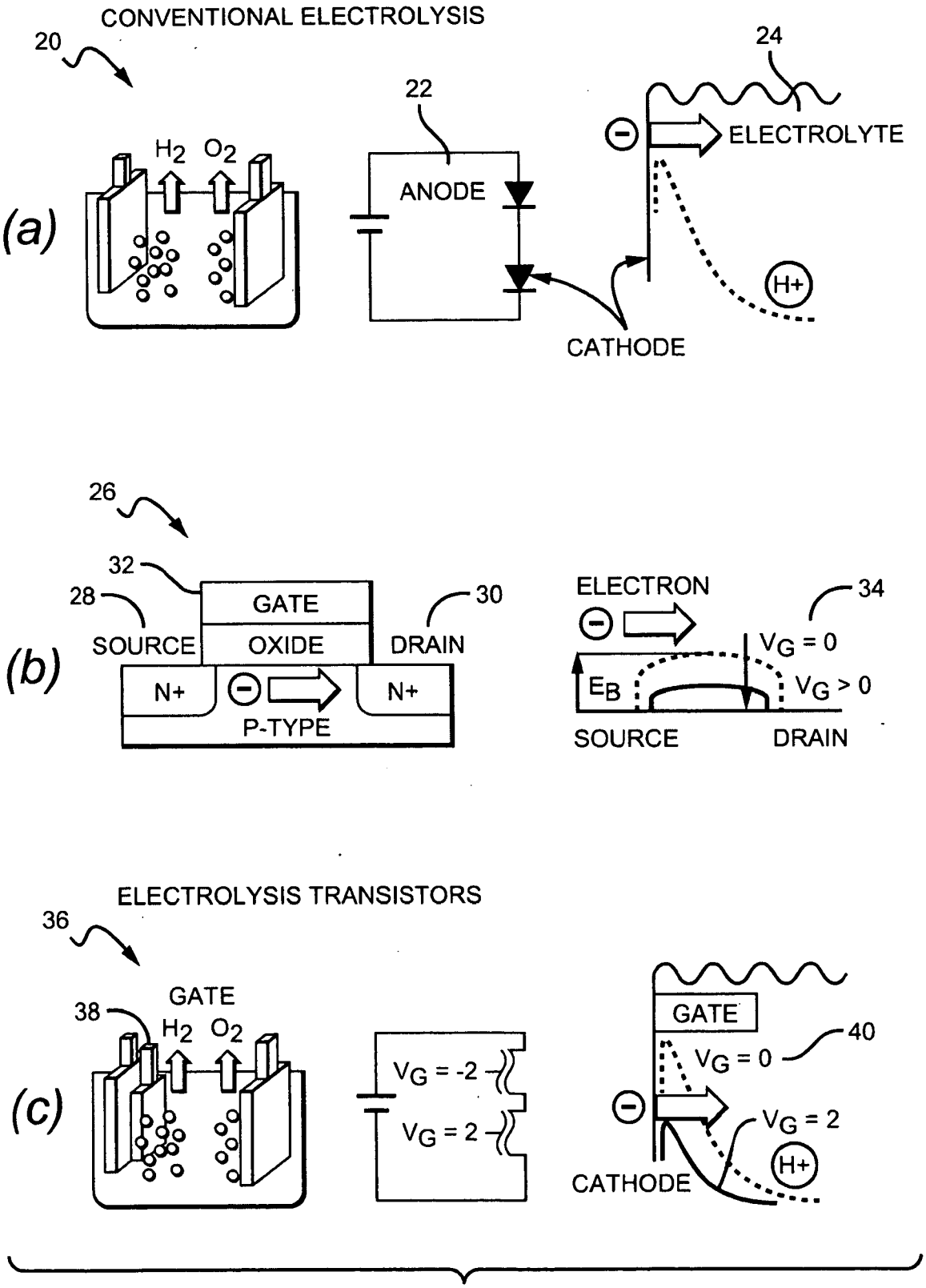

CONVENTIONAL ELECTROLYSIS
20
22
24
ELECTROLYTE
ANODE
H_2 O_2
(a)
H+
CATHODE
26
32
28
GATE
30
SOURCE
OXIDE
DRAIN
(b)
N+
N+
P-TYPE
ELECTRON
34
$V_G = 0$
E_B
$V_G > 0$
SOURCE
DRAIN
ELECTROLYSIS TRANSISTORS
36
GATE
38
H_2 O_2
(c)
$V_G = -2$
$V_G = 2$
GATE
40
$V_G = 0$
$V_G = 2$
H+
CATHODE

FIG. 3

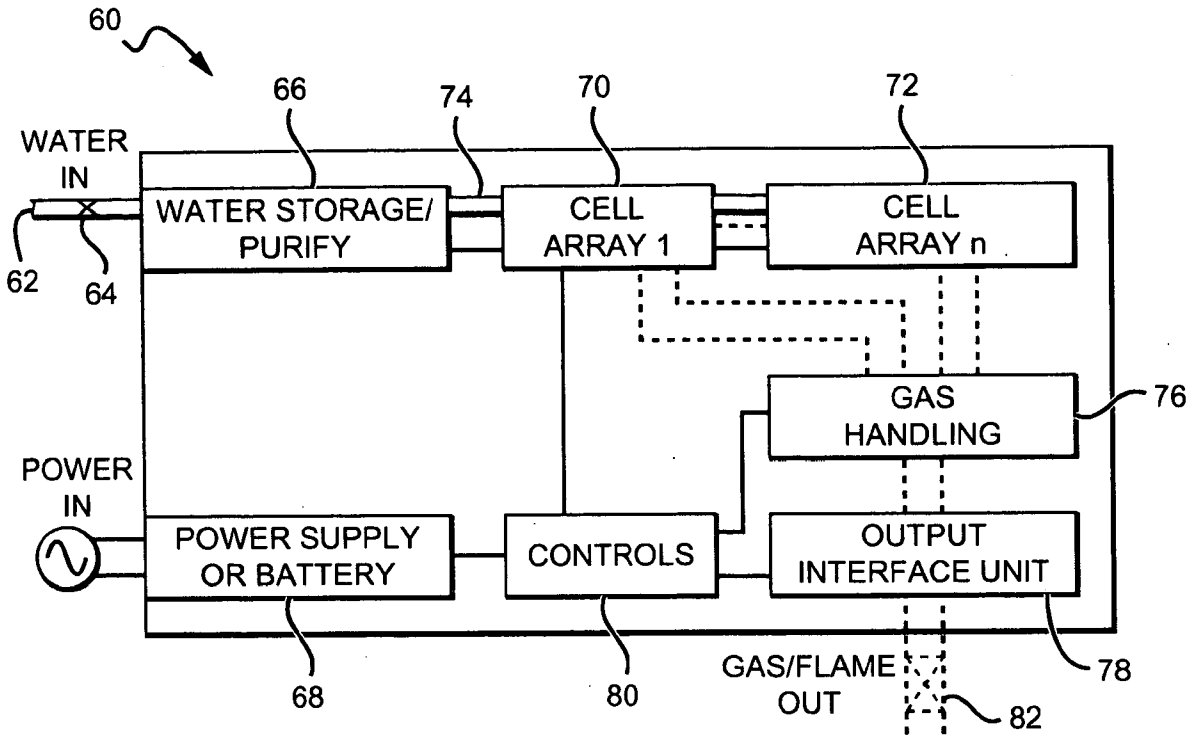

60
66
74
70
72
WATER IN
WATER STORAGE/ PURIFY
CELL ARRAY 1
CELL ARRAY n
62
64
GAS HANDLING
76
POWER IN
POWER SUPPLY OR BATTERY
CONTROLS
OUTPUT INTERFACE UNIT
68
80
GAS/FLAME OUT
78
82

FIG. 5

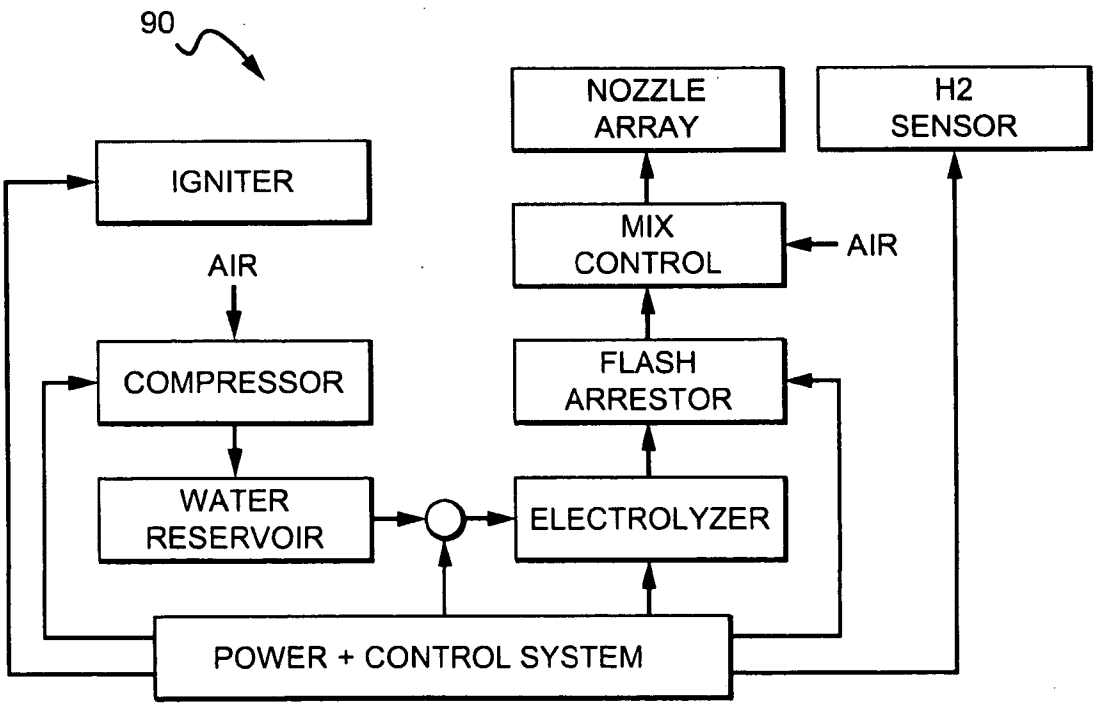

90
NOZZLE ARRAY
H2 SENSOR
IGNITER
MIX CONTROL
AIR
AIR
COMPRESSOR
FLASH ARRESTOR
WATER RESERVOIR
ELECTROLYZER
POWER + CONTROL SYSTEM

FIG. 6