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(54) **METHOD AND APPARATUS FOR ELECTOLYSIS-ASSISTED GENERATION OF HYDROGEN**

(76) Inventor: **Chester Sohn**, Gig Harbor, WA (US)

Correspondence Address:
FREDERIC M. DOUGLAS
15333 CULVER DRIVE, SUITE 340 PMB 114
IRVINE, CA 92604-3051 (US)

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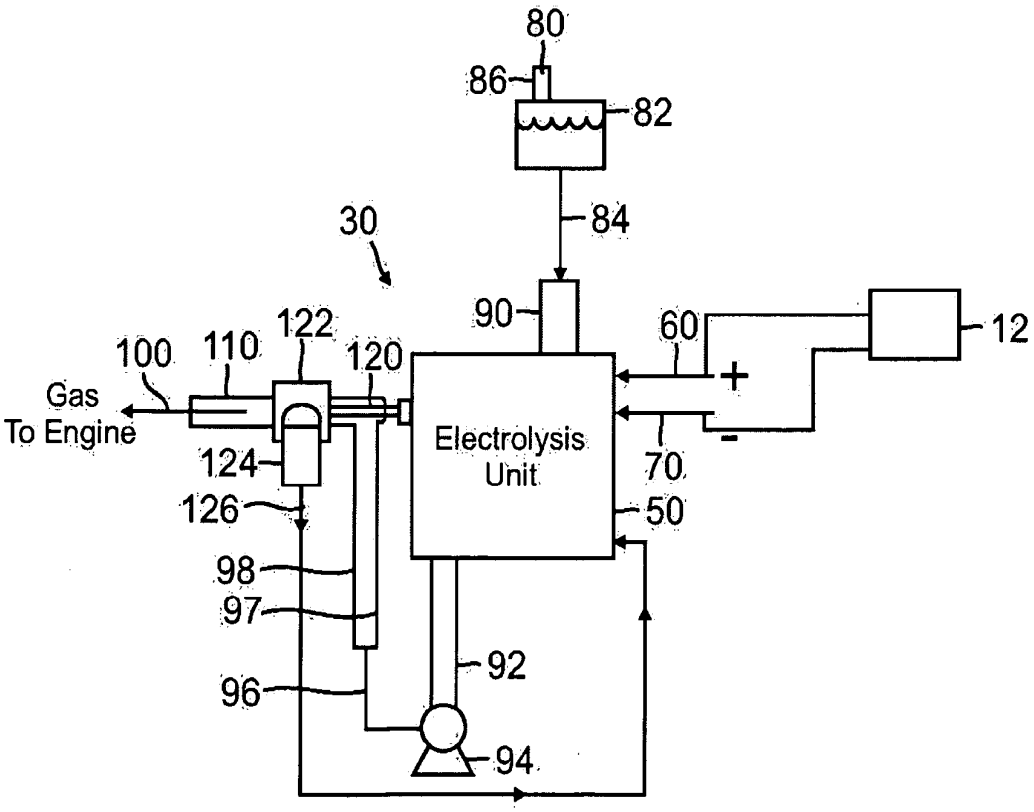
(57) **ABSTRACT**

The present invention provides a method and apparatus for electrolysis-based generation of hydrogen and oxygen to enhance combustion. A hydrogen generating apparatus comprises an electrolysis cell, the electrolysis cell electrically connected to a power source, an outlet for directing effluent gases from the electrolysis cell, and a scrubber for using a scrubbing medium to remove contaminants from the effluent gas flow. In another option, a first mesh electrode may be situated within the electrolysis cell and electrically connected to a power source, a second mesh electrode may be situated within the electrolysis cell and electrically connected to the power source, and a membrane may be situated between the first mesh electrode and the second mesh electrode which may be immersed within the aqueous solution.



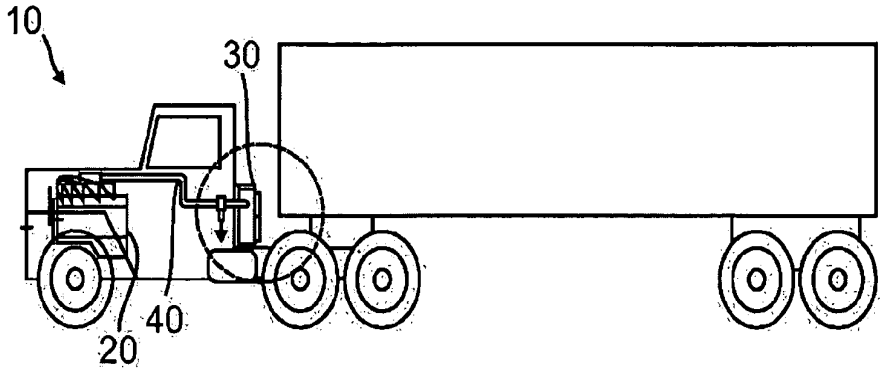

10
30
40
20

FIG. 1

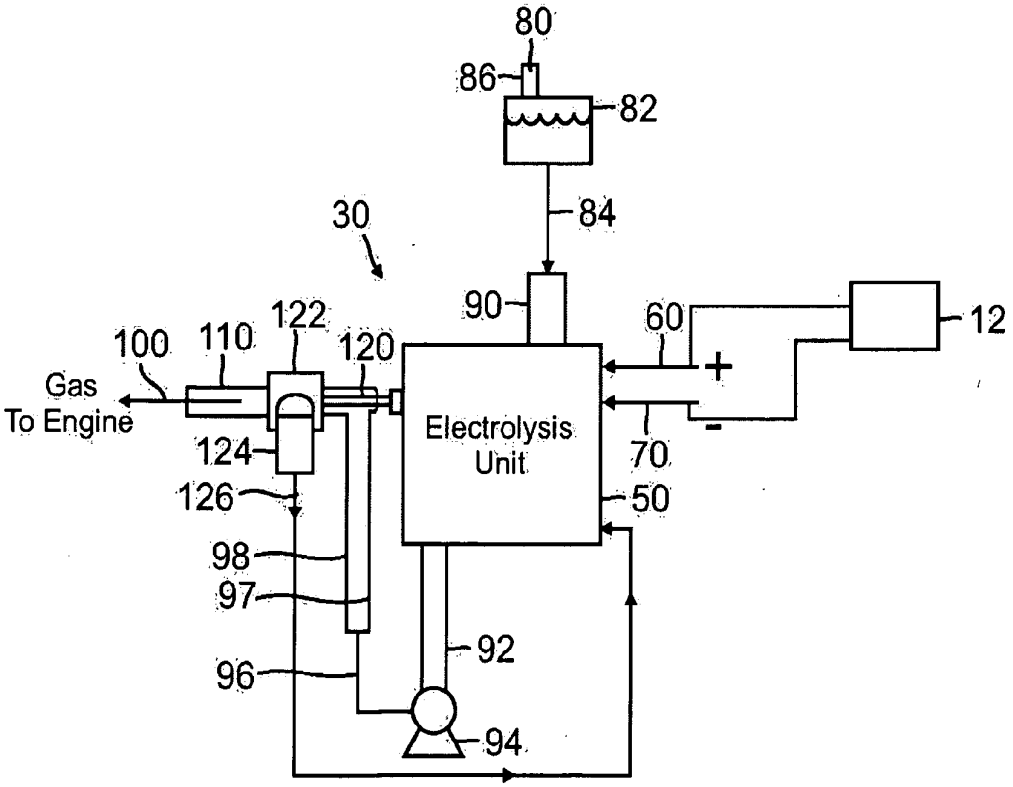

80
86
82
84
30
90
60
12
100
110
122
120
Gas
To Engine
Electrolysis
Unit
124
70
126
50
98
97
92
96
94

FIG. 2

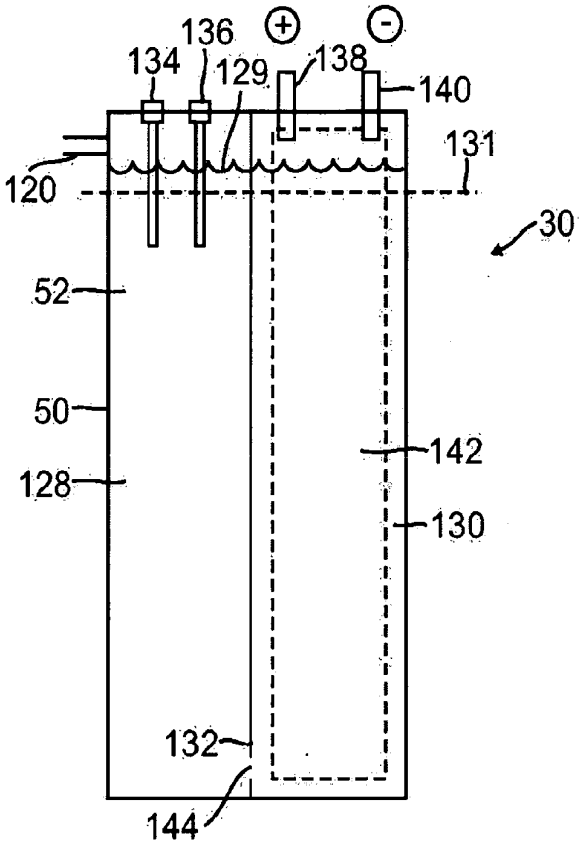

136
134
129
138
140
131
120
30
52
50
142
128
130
132
144

FIG. 3

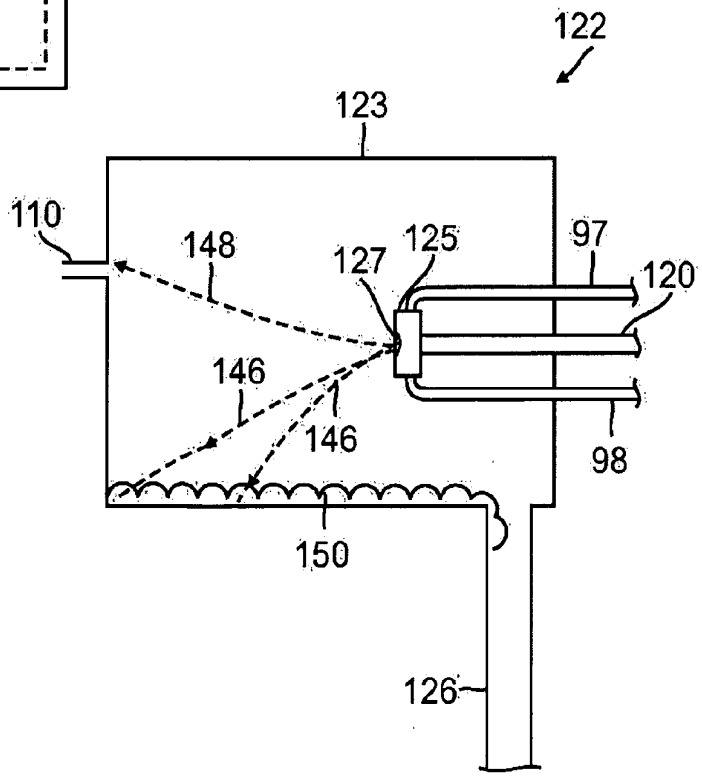

122
123
110
148
127
125
97
120
146
146
98
150
126

FIG. 4

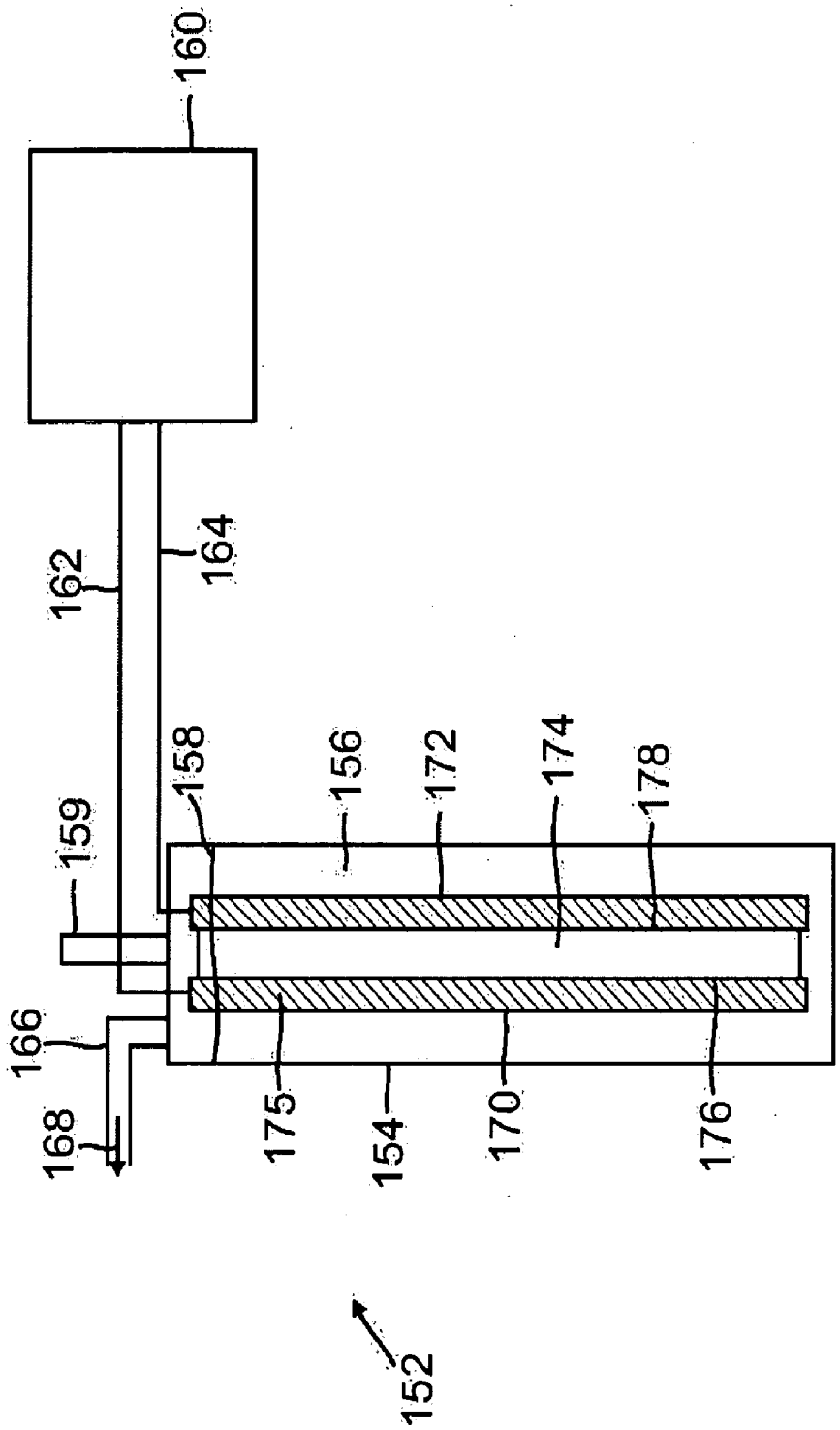


FIG. 5

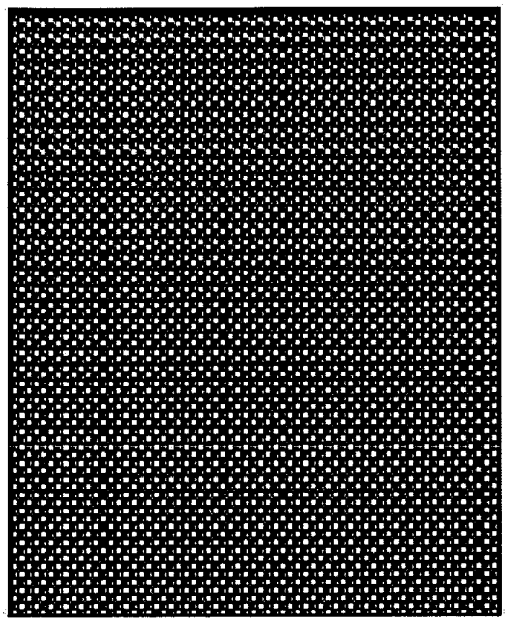


FIG. 7

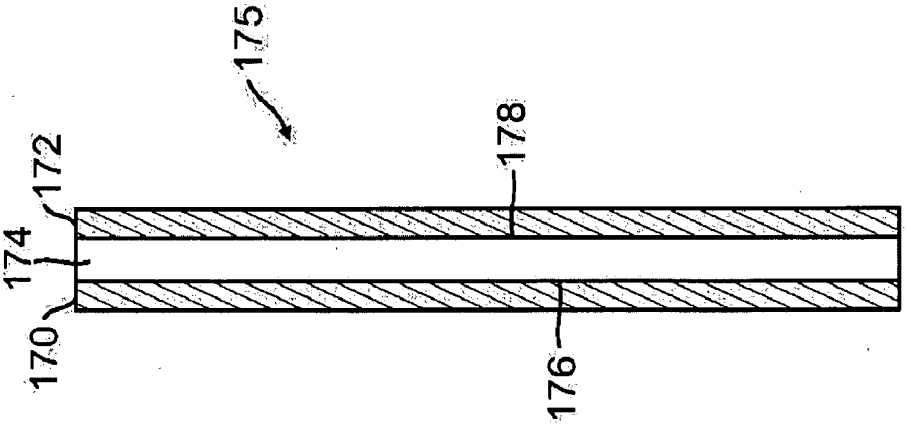


FIG. 6

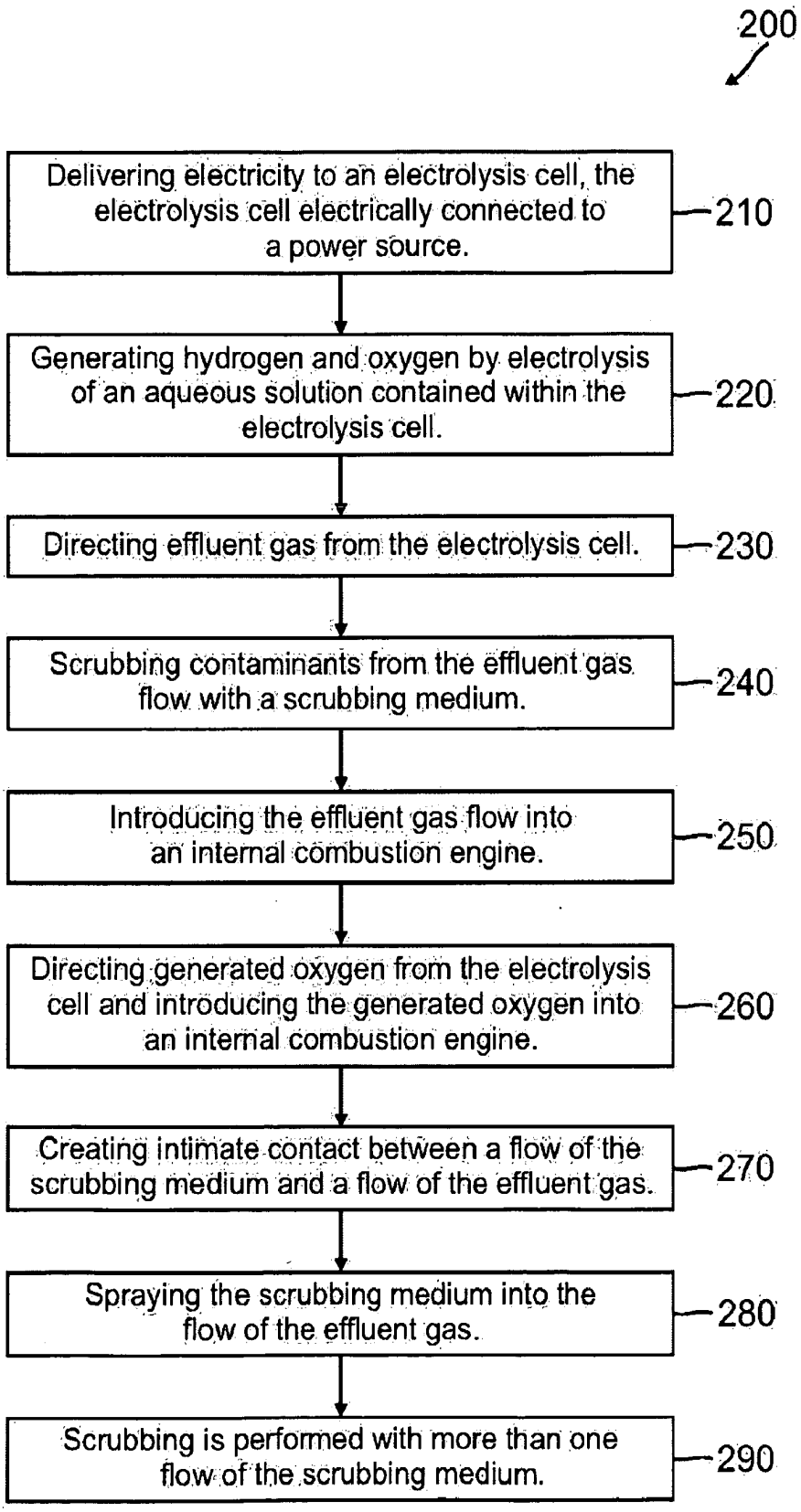

200
Delivering electricity to an electrolysis cell, the electrolysis cell electrically connected to a power source.
210
Generating hydrogen and oxygen by electrolysis of an aqueous solution contained within the electrolysis cell.
220
Directing effluent gas from the electrolysis cell.
230
Scrubbing contaminants from the effluent gas flow with a scrubbing medium.
240
Introducing the effluent gas flow into an internal combustion engine.
250
Directing generated oxygen from the electrolysis cell and introducing the generated oxygen into an internal combustion engine.
260
Creating intimate contact between a flow of the scrubbing medium and a flow of the effluent gas.
270
Spraying the scrubbing medium into the flow of the effluent gas.
280
Scrubbing is performed with more than one flow of the scrubbing medium.
290

FIG. 8

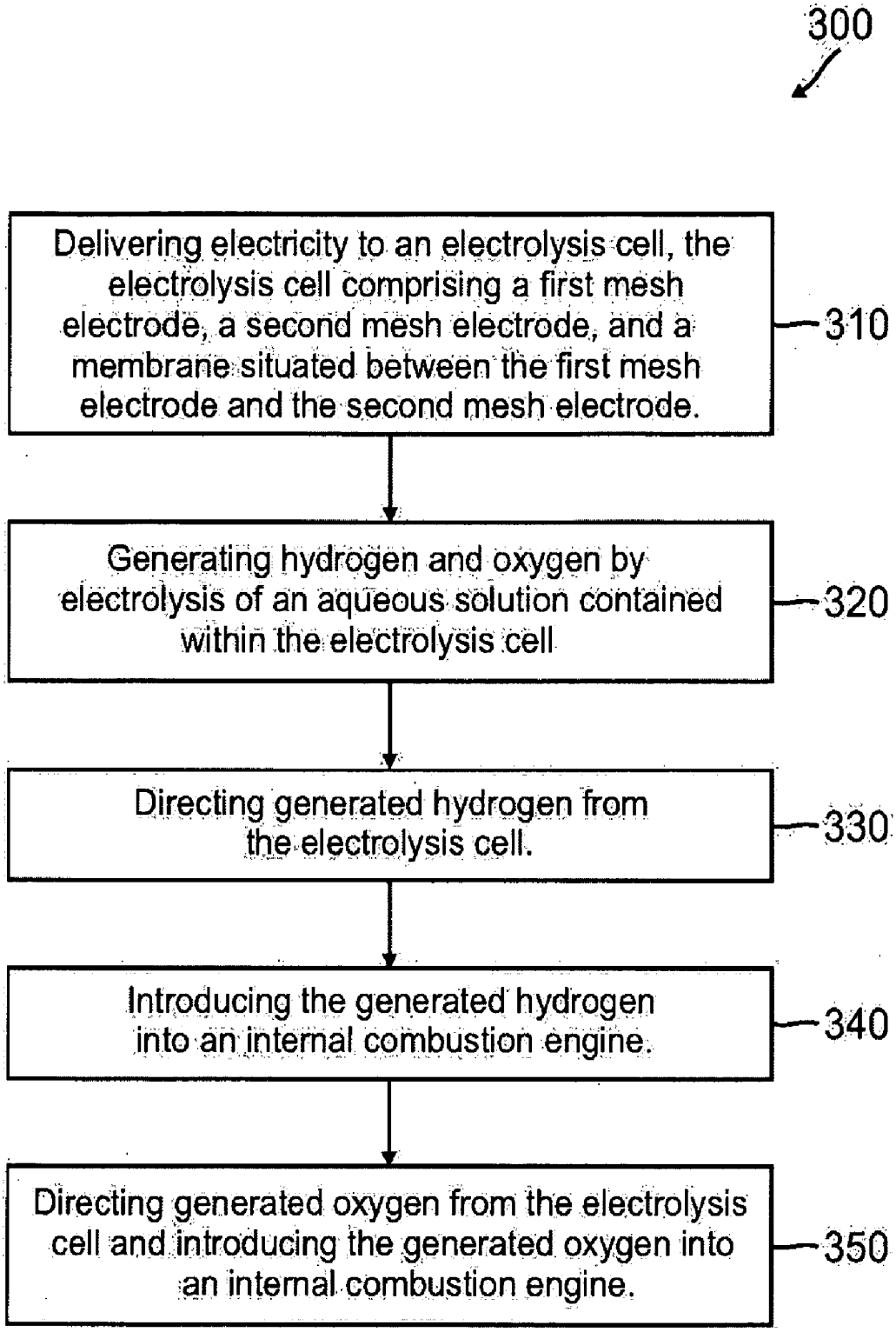

300
Delivering electricity to an electrolysis cell, the electrolysis cell comprising a first mesh electrode, a second mesh electrode, and a membrane situated between the first mesh electrode and the second mesh electrode.
310
Generating hydrogen and oxygen by electrolysis of an aqueous solution contained within the electrolysis cell
320
Directing generated hydrogen from the electrolysis cell.
330
Introducing the generated hydrogen into an internal combustion engine.
340
Directing generated oxygen from the electrolysis cell and introducing the generated oxygen into an internal combustion engine.
350

FIG. 9

METHOD AND APPARATUS FOR ELECTOLYSIS-ASSISTED GENERATION OF HYDROGEN

BACKGROUND OF THE INVENTION

[0001] The present invention relates generally to the generation of hydrogen and/or oxygen, and, more particularly, to an electrolysis cell for supplying gaseous fuel additives to enhance combustion in a combustion engine. The present invention also may be used to generate hydrogen and/or oxygen to be stored for use as a fuel or other purpose.

[0002] Electrolysis is a well-known process whereby an electric current is passed through an aqueous solution. The electric current splits the water molecules, releasing hydrogen and oxygen gasses which may be directed to the air intake of an engine.

[0003] Hydrogen may be mixed with gasoline vapor and air to enhance the efficiency of internal combustion engines. When the mixture of such gases ignites, the hydrogen distributed throughout the mixture burns first and contributes to an optimum combination of the remaining vaporized fuel.

[0004] Often, electrolysis to produce hydrogen and/or oxygen from water uses a basic electrolyte, such as a 20-30% aqueous solution of potassium hydroxide (KOH). A disadvantage of such a method of electrolysis is environmental contamination. KOH can be present in the fuel/air mixture, leading to KOH and KOH by-products being dumped into the atmosphere via engine exhaust. Additionally, KOH is caustic, unnecessarily damaging engine components and even degrading the electrodes used in the electrolysis apparatus.

[0005] Thus it would be advantageous to use a method of apparatus to generate hydrogen and/or oxygen that minimizes contamination by KOH or any other harmful substance.

[0006] As can be seen, there is a need for an improved apparatus and methods for generating hydrogen and/or oxygen for enhancing combustion, for example, a method that effectively and efficiently removes KOH from effluent gases or a method that uses water without KOH.

SUMMARY OF THE INVENTION

[0007] In one aspect of the present invention, a hydrogen generating apparatus comprises an electrolysis cell, the electrolysis cell electrically connected to a power source; an outlet for directing effluent gases from the electrolysis cell, the electrolysis cell containing an electrolysis zone and a reservoir zone, an aqueous solution stored within the electrolysis cell, and a mesh electrode situated within the electrolysis zone.

[0008] In another aspect of the present invention, a method for generating hydrogen comprises delivering electricity to an electrolysis cell, the electrolysis cell comprising a first mesh electrode, separating the electrolysis cell into an electrolysis zone, and a reservoir zone, generating hydrogen and oxygen by electrolysis of an aqueous solution contained within the electrolysis zone, directing generated hydrogen from the electrolysis cell, and introducing the generated hydrogen into an internal combustion engine.

[0009] In a further aspect of the present invention, a hydrogen generating apparatus comprises a cylindrical electrolysis cell, the electrolysis cell electrically connected to a power source, the electrolysis cell comprising an electrolysis pack, the electrolysis pack comprising a electrolysis zone and a reservoir zone, a separator situated between the electrolysis zone and the reservoir zone, an aqueous solution stored within the electrolysis zone and the reservoir zone, a first mesh electrode situated within the electrolysis zone, an inlet for refilling aqueous solution into the electrolysis cell, and an outlet for directing effluent gases from the electrolysis cell.

[0010] In yet another aspect of the present invention, a hydrogen generating apparatus comprises an electrolysis cell, the electrolysis cell electrically connected to a power source; an outlet for directing effluent gas flow from the electrolysis cell; an aqueous solution stored within the electrolysis cell; and a scrubber for using a scrubbing medium to remove contaminants from the effluent gas flow.

[0011] In still another aspect of the present invention, a method for generating hydrogen comprises delivering electricity to an electrolysis cell, the electrolysis cell electrically connected to a power source; generating hydrogen and oxygen by electrolysis of an aqueous solution contained within the electrolysis cell; directing effluent gas flow from the electrolysis cell; scrubbing contaminants from the effluent gas flow with a scrubbing medium; and introducing the effluent gas flow into an internal combustion engine.

[0012] In a still further aspect of the present invention, a hydrogen generating apparatus comprises an electrolysis cell; an aqueous solution stored within the electrolysis cell; a first mesh electrode situated within the electrolysis cell and electrically connected to a power source; a second mesh electrode situated within the electrolysis cell and electrically connected to the power source; a membrane situated between the first mesh electrode and the second mesh electrode and immersed within the aqueous solution; an inlet for refilling aqueous solution into the electrolysis cell; and an outlet for directing effluent gases from the electrolysis cell to the engine.

[0013] What is needed is an efficient method of electrolytic hydrogen generation for enhancing internal combustion without releasing caustic chemicals, such as potassium hydroxide to avoid excessive waste, improve the environment, and provide a low maintenance system.

[0014] These and other aspects, objects, features and advantages of the present invention, are specifically set forth in, or will become apparent from, the following detailed description of an exemplary embodiment of the invention when read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] FIG. **1** is a plan view of a vehicle using a hydrogen generating apparatus, according to an embodiment of the present invention;

[0016] FIG. **2** is a plan view of the hydrogen generating apparatus of FIG. **1**;

[0017] FIG. **3** is a view, in section, of an electrolysis cell, according to another embodiment of the present invention;

[0018] FIG. **4** is a view, in section, of a scrubber for removing contaminants in effluent gas, according to yet another embodiment of the present invention;

[0019] FIG. **5** is a view, in section, of an electrolysis cell, according to yet another embodiment of the present invention;

[0020] FIG. **6** is a view, in section of electrode material, with a membrane, according to an embodiment of the present invention;

[0021] FIG. **7** is an elevation view of mesh material for an electrode, according to an embodiment of the present invention;

[0022] FIG. **8** is a flow diagram of a method for generating hydrogen, according to still another embodiment of the present invention; and

[0023] FIG. **9** is a flow diagram of another method for generating hydrogen, according to a still further embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0024] The following detailed description is of the best currently contemplated modes of carrying out the invention. The description is not to be taken in a limiting sense, but is made merely for the purpose of illustrating the general principles of the invention, since the scope of the invention is best defined by the appended claims.

[0025] The present invention involves admixing hydrogen and/or oxygen into a fuel/air mixture to enhance combustion. The present invention will be described below using the example of a diesel-fueled truck. However, it should be understood that the present invention is also useful for other applications needing enhanced combustion, such as passenger automobiles, heavy equipment, buses, locomotives, marine engines, military vehicles, aircraft, spacecraft, power generation turbines, stationary generators, and the like. The present invention may also be used to produce hydrogen and/or oxygen to be used as fuel or fuel additives.

[0026] The present invention avoids polluting the environment with caustic substances, like KOH, which also may corrode engine parts and other apparatuses. For example, one or more mesh electrodes, membrane electrodes, or mesh electrodes combined with membrane electrodes may be used to efficiently and effectively break water into hydrogen and oxygen for enhancing combustion. The electrodes may be constructed of suitable metals, such as stainless steel, nickel, platinum, palladium, and alloys thereof. Also, the electrodes may be constructed of durable materials with coatings of suitable metals, such as nickel, platinum, palladium, and alloys thereof. In another example, electrolyte components, like KOH, may be removed from effluent gas flows by scrubbing with a scrubbing medium, such as the electrolyte itself.

[0027] Referring now to the drawings, wherein like reference numerals designate identical or corresponding parts throughout several views, which are not necessarily drawn to scale, and more particularly referring to FIG. **1**, the present invention provides a hydrogen generating apparatus **30** mounted on a vehicle (such as a diesel tractor-trailer type) **10** having an engine **20**. A gas intake tube **40** may be in fluid communication between the hydrogen generating apparatus **30** and the engine **20**, such that effluent gas from the hydrogen generating apparatus **30** may be directed to the engine **20**.

[0028] FIG. **2** is a plan view of the hydrogen generating apparatus **30** of FIG. **1**. A power supply **12**, such as an automotive battery, may be used to provide electrical current through positive pathway **60** and negative pathway **70**, to operate electrolysis within an electrolysis cell **50**. Water and/or electrolyte solution (such as an aqueous solution of calcium hydroxide, sodium hydroxide, potassium hydroxide, mixtures thereof, and the like) **80** may be fed into the electrolysis cell **50** via conduit **84** and/or inlet **90**. A reservoir **82** may be used for accumulation and/or overflow of electrolyte solution **80**, which may be fed via inlet **86**. The electrolysis cell **50** produces hydrogen and oxygen. Hydrogen, oxygen, or both hydrogen and oxygen may be ported out of the electrolysis cell **50** via a gas conduit **120**.

[0029] The electrolyte solution **80** may exit the electrolysis cell **50** through an electrolyte bleed **92**. A flow of the electrolyte solution **80** may be pumped onward and travel through an electrolyte flow tube **96**. It may be desirable to split the flow of electrolyte solution **80** into more than one flows, such as a first electrolyte flow **97** and a second electrolyte flow **98**. A scrubber **122** may be used for scrubbing contaminants from the effluent gas flow (such as hydrogen and/or oxygen) with a scrubbing medium, perhaps with an aqueous solution, such as the electrolyte solution **80**. An electrolyte recycle conduit **126** may serve for delivering the scrubbing medium to the electrolysis cell **50**. For example, recovered scrubbing medium, such as recovered electrolyte solution, may flow through a recycle outlet **124** for travel through the electrolyte recycle conduit **126** for recirculation into the electrolysis cell **50**. Gas flow (containing hydrogen, oxygen, and/or mixtures thereof) may continue via an outlet **110** as gaseous effluent **100**. The gaseous effluent **100** may be mixed into a fuel/air mixture for combustion in an engine (such as engine **20** as shown in FIG. **1**).

[0030] The gaseous effluent **100** may be sent to storage for future use as a fuel or other uses. For example, a facility may use the present invention to generate and accumulate hydrogen, oxygen, and/or mixtures thereof to supply passenger automobiles, industrial equipment, buses, locomotives, marine engines, military vehicles, aircraft, spacecraft, power generation turbines, stationary generators, and the like.

[0031] FIG. **3** is a view, in section, of a hydrogen generating apparatus **30**, according to another embodiment of the present invention. The hydrogen generating apparatus **30** may comprise an electrolysis cell **50**. A separator **132** may be used to divide or separate the electrolysis cell **50** into a reservoir zone **128** and an electrolysis zone **130**. An electrolyte **52** is contained within the electrolysis cell **30**. The electrolyte **52** may be present in the reservoir zone **128** and/or the electrolysis zone **130**. The electrolyte **52** may reach an electrolyte level **129**, which may be greater than, less than, or equal to a predetermined refill level **131** wherein whenever the electrolyte level **129** is at the predetermined refill level **131**, the electrolysis cell **50** is able to operate for a minimum operating period. A level indicator **134** may be used to monitor electrolyte level **129** in relation to the predetermined refill level **131**.

[0032] The electrolyte **52** may be an aqueous solution, water, or any other suitable electrolyte for generating hydrogen and/or oxygen. An electrolysis pack **142** may be situated within the electrolysis zone **130**. The electrolysis pack **142** may have therein a first electrode **138** and a second electrode **140**.

[0033] A port **144** may be used to permit electrolyte flow between the reservoir zone **128** and the electrolysis zone **130**. A temperature indicator **136** may be used to detect the temperature of the electrolyte **52**.

[0034] A scrubber **122** (such as the scrubber described above regarding FIG. **2**) is shown in FIG. **4**, according to yet another embodiment of the present invention. The scrubber **122** may comprise a scrubber housing **123** wherein a scrubbing medium may be used to remove contaminants from a gas flow. The contaminants (such as entrained KOH) may be removed by creating intimate contact between one or more flows of the scrubbing medium and a flow of the effluent gas (such as spraying the scrubbing medium into the flow of the effluent gas). Scrubbing may be performed with more than one flow of the scrubbing medium. For example, one or more electrolyte flows **97**, **98** may be sprayed into the flow of the

effluent gas traveling within gas conduit **120**. The scrubbing medium may a flow of the aqueous solution used as an electrolyte solution **80** in electrolysis cell **50** (shown in FIGS. **2** and **3**). The direction of flow of the scrubbing medium may be cross-current to the direction of flow of the effluent gas.

[0035] The scrubber **122** may comprise a scrubbing nozzle **125** for creating intimate contact between a flow of the scrubbing medium and a flow of the effluent gas. The flow of the scrubbing medium may be sprayed into the flow of the effluent gas. The direction of flow of the scrubbing medium may be cross-current to the direction of flow of the effluent gas. For example, the direction of flow of the scrubbing medium may be substantially perpendicular (such as from about 70 degrees to about 110 degrees) to the direction of flow of the effluent gas. After the liquid and gaseous flows merge in the scrubbing nozzle **125**, residue **146** (such as KOH) may exit the scrubbing nozzle **125** via a scrubbing orifice **127** for collection at the bottom of the scrubber housing **123**. Stripped gas, may exit through the scrubbing orifice **127**, depleted of residue **146**, may travel through outlet **110** as gaseous effluent **100**. As recovered solution **150** accumulates within the scrubber housing **123**, electrolyte solution may be recovered via an electrolyte recycle conduit **126** for recycle into the electrolysis cell **50** (shown in FIGS. **2** and **3**).

[0036] An electrolysis cell **152** in FIG. **5** is an example of an electrolysis cell that may be suitable for the present invention, especially when it is desirable to avoid using KOH or other caustic substances for electrolysis. The electrolysis cell **152** is capable of electrolysis using only water (such as distilled water) as an aqueous solution, as the membrane, along with charged members, effects separation of the aqueous solution into hydrogen and oxygen.

[0037] The electrolysis cell **152** may comprise a container **154** for holding aqueous solution **156** (such as water) and an inlet **159** for refilling aqueous solution **156** into the electrolysis cell **152**. The electrolysis cell **152** may have a solution level **158** wherein the aqueous solution **156** sufficient to perform electrolysis. The container **154** may be made of any suitable, durable, inert material, such as polymer-based materials. The container **154** may be in any suitable shape, such as a rectangular box, a cylinder, a conical shape, or any other suitable shape.

[0038] Electrical charge may be supplied by a power source **160** (such as a battery). The electrical charges may be supplied along current feeds **162**, **164** to a first mesh electrode **170** and a second mesh electrode **172**. The first mesh electrode **170** and the second mesh electrode **172** may be situated within the electrolysis cell **152** and electrically connected to the power source **160**. A membrane **174** may be situated between the first mesh electrode **170** and the second mesh electrode **172** and immersed within the aqueous solution **156**.

[0039] A gas outlet **166** may serve for directing gas effluent **168** (such as gas flow containing hydrogen, oxygen, or mixtures thereof) from the electrolysis cell **152** to be used, such as for intake in an engine or storage for future use.

[0040] The membrane **174** causes oxygen and hydrogen to separate from liquid water when the membrane **174** is situated between charged plates, such as first mesh electrode **170** (such as an anode for producing oxygen) and second mesh electrode **172** (such as a cathode for producing hydrogen) to form a membrane electrode assembly **175**. The membrane **174** may be of the type that is used in PEM (proton exchange membrane) systems. For example, the membrane **174** may be an ion-exchange membrane, such as a perfluorosulfonic cation-exchange membrane, Nafion, commercially available from DuPont. The membrane **174** may act as a catalyst for the separation of water into oxygen and hydrogen.

[0041] The mesh electrodes **170**, **172** may be made from one or more portions of durable materials, such as carbon steel, stainless steel, polymer, nickel, platinum, palladium, ruthenium, iridium, manganese, cobalt, chromium, and the like. As shown in FIG. **6**, the membrane electrode assembly **175** may comprise the membrane **174** sandwiched between porous mesh electrodes **170**,**172**. The membrane **174** may have a first side **176** and a second side **178**. The membrane **174** may comprise an active coating on the first side **176** and/or the second side **178**, such as in a binary membrane system. The active coating may serve to enhance electrolysis. The first mesh electrode **170** may have a different composition from the second mesh electrode **172**. For example, first side **176** may contain suitable substances, such as copper, platinum, nickel, palladium, and alloys thereof. Second side **178** may contain suitable substances, such as copper, platinum, nickel, palladium, and alloys thereof. Sides **176**,**178** may be treated by coating with the aforementioned substances and/or impregnating with the aforementioned substances. In one manner, powdered platinum, in solution, may be impregnated into the surface of one or more sides **176**,**178** of the membrane **174**.

[0042] Exemplary mesh material **180** is shown in FIG. **7**. As alternative to porous mesh material, electrodes **170**,**172** may comprise titanium fiber or slivered titanium (or other suitable metal). For example, titanium foil may be shredded, pressed onto a board or sheet, heat treated, and further processed to obtain an electrode material with large sum total active surface area or great porosity.

[0043] The present invention may provide a method **200** for generating hydrogen and/or oxygen, as shown in FIG. **8**. The method **200** of generating hydrogen and/or oxygen does not necessarily occur in the sequence expressly presented herein or in FIG. **8**. In fact, the method of the present invention may be practiced in any sequence of steps. The method **200** may comprise a step **210** delivering electricity to an electrolysis cell, the electrolysis cell electrically connected to a power source. A step **220** may comprise generating hydrogen and oxygen by electrolysis of an aqueous solution (such as water or KOH solution) contained within the electrolysis cell. Another step **230** may comprise directing effluent gas from the electrolysis cell. A further step **240** may comprise scrubbing contaminants from the effluent gas flow with a scrubbing medium (such as the aqueous solution). Introducing the effluent gas flow into an internal combustion engine may comprise step **250**. A step **260** may comprise directing generated oxygen from the electrolysis cell and introducing the generated oxygen into an internal combustion engine. Creating intimate contact between a flow of the scrubbing medium (such as water or the aqueous solution) and a flow of the effluent gas may comprise a step **270**. A step **280** may comprise spraying the scrubbing medium into the flow of the effluent gas. A step **290** may comprise scrubbing with more than one flow of the scrubbing medium.

[0044] It can be seen in FIG. **9** that the present invention also provides a method **300** for generating hydrogen, for example, for an internal combustion engine. The method **300** of generating hydrogen and/or oxygen does not necessarily occur in the sequence expressly presented herein or in FIG. **9**. In fact, the method of the present invention may be practiced in any sequence of steps. The method **300** may comprise a

step **310** of delivering electricity to an electrolysis cell, the electrolysis cell comprising a first mesh electrode, a second mesh electrode, and a membrane situated between the first mesh electrode and the second mesh electrode. A step **320** may comprise generating hydrogen and oxygen by electrolysis of an aqueous solution contained within the electrolysis cell. The method **300** may also comprise a step **330** of directing generated hydrogen from the electrolysis cell. Another step **340** may comprise Introducing the generated hydrogen into an internal combustion engine. In step **350**, the method **300** may comprise directing generated oxygen from the electrolysis cell and introducing the generated oxygen into an internal combustion engine.

[0045] The method **300** for generating hydrogen may also comprise a feature wherein the electrolysis cell has a predetermined refill level wherein the aqueous solution at the predetermined refill level enables the electrolysis cell to operate for a minimum operating period.

[0046] It should be understood, of course, that the foregoing relates to exemplary embodiments of the invention and that modifications may be made without departing from the spirit and scope of the invention as set forth in the following claims.

[0047] Furthermore, a method may be performed in one or more sequences other than the sequence presented expressly herein.

I claim:

1. A hydrogen generating apparatus, comprising:
an electrolysis cell, the electrolysis cell electrically connected to a power source;
an outlet for directing effluent gas flow from the electrolysis cell;
an aqueous solution stored within the electrolysis cell; and
a scrubber for using a scrubbing medium to remove contaminants from the effluent gas flow.

2. The hydrogen generating apparatus of claim **1**, wherein the scrubber comprises a scrubbing nozzle for creating intimate contact between a flow of the scrubbing medium and a flow of the effluent gas.

3. The hydrogen generating apparatus of claim **2**, wherein the flow of the scrubbing medium is sprayed into the flow of the effluent gas.

4. The hydrogen generating apparatus of claim **3**, wherein the direction of flow of the scrubbing medium is cross-current to the direction of flow of the effluent gas.

5. The hydrogen generating apparatus of claim **4**, wherein the direction of flow of the scrubbing medium is substantially perpendicular to the direction of flow of the effluent gas.

6. The hydrogen generating apparatus of claim **1**, wherein the scrubbing medium is a flow of the aqueous solution.

7. The hydrogen generating apparatus of claim **2**, comprising more than one flow of scrubbing medium.

8. The hydrogen generating apparatus of claim **1**, further comprising an electrolyte recycle conduit for delivering the scrubbing medium to the electrolysis cell.

9. A method for generating hydrogen, comprising:
delivering electricity to an electrolysis cell, the electrolysis cell electrically connected to a power source;
generating hydrogen and oxygen by electrolysis of an aqueous solution contained within the electrolysis cell;
directing effluent gas flow from the electrolysis cell;
scrubbing contaminants from the effluent gas flow with a scrubbing medium; and
introducing the effluent gas flow into an internal combustion engine.

10. The method for generating hydrogen of claim **9**, further comprising directing generated oxygen from the electrolysis cell and introducing the generated oxygen into an internal combustion engine.

11. The method for generating hydrogen of claim **9**, further comprising creating intimate contact between a flow of the scrubbing medium and a flow of the effluent gas.

12. The method for generating hydrogen of claim **11**, further comprising spraying the scrubbing medium into the flow of the effluent gas.

13. The method for generating hydrogen of claim **11**, wherein the direction of flow of the scrubbing medium is cross-current to the direction of flow of the effluent gas.

14. The method for generating hydrogen of claim **11**, wherein the scrubbing is performed with more than one flow of the scrubbing medium.

15. The method for generating hydrogen of claim **9**, wherein the scrubbing medium is a flow of the aqueous solution.

16. The method for generating hydrogen of claim **9**, wherein the electrolysis cell has a predetermined refill level wherein the aqueous solution at the predetermined refill level enables the electrolysis cell to operate for a minimum operating period.

17. A hydrogen generating apparatus, comprising:
an electrolysis cell;
an aqueous solution stored within the electrolysis cell;
a first mesh electrode situated within the electrolysis cell and electrically connected to a power source;
a second mesh electrode situated within the electrolysis cell and electrically connected to the power source;
a membrane situated between the first mesh electrode and the second mesh electrode and immersed within the aqueous solution;
an inlet for refilling aqueous solution into the electrolysis cell; and
an outlet for directing effluent gases from the electrolysis cell to the engine.

18. The hydrogen generating apparatus of claim **17**, wherein the first membrane is coated on one side with a substance in the group consisting of nickel, platinum, titanium, and alloys thereof.

19. The hydrogen generating apparatus of claim **17**, wherein the electrolysis cell has a predetermined refill level wherein the aqueous solution at the predetermined refill level enables the electrolysis cell to operate for a minimum operating period.

* * * * *