US 20100133097A1

(19) **United States**
(12) **Patent Application Publication**
Fawcett et al.

(10) **Pub. No.: US 2010/0133097 A1**
(43) **Pub. Date: Jun. 3, 2010**

(54) **HYDROGEN RICH GAS GENERATOR**

(75) Inventors: **Timothy J. Fawcett**, Clearwater, FL (US); **Scott Marton**, Clearwater, FL (US)

Correspondence Address:
DENNIS G. LAPOINTE
LAPOINTE LAW GROUP, PL
PO BOX 1294
TARPON SPRINGS, FL 34688-1294 (US)

(73) Assignee: **HYDROGEN TECHNOLOGY APPLICATIONS, INC.**, Clearwater, FL (US)

(21) Appl. No.: **12/624,489**

(22) Filed: **Nov. 24, 2009**

Related U.S. Application Data

(60) Provisional application No. 61/118,705, filed on Dec. 1, 2008.

Publication Classification

(51) **Int. Cl.**
C25B 9/00 (2006.01)

(52) **U.S. Cl.** **204/275.1**

(57) **ABSTRACT**

A method of improving the efficiency of continuous water electrolysis processes to produce a hydrogen rich gas. Improved efficiency is realized by minimizing and/or eliminating wasted current, current that does not convert water to a hydrogen rich gas, attaining approximately 100% Faradic efficiency. This improvement in current or Faradic efficiency is attained by electrically isolating the electrolyte solution contained in each electrolysis cell as well as electrically isolating the electrolyte solution contained in each cell from the supply of electrolyte solution. This invention also improves the efficiency of water electrolysis processes through the utilization of electrodes coated with electrode specific nanomaterials, improving voltage efficiency at current densities exceeding 100 mA/cm^2. Overall efficiency improvements of about 20% have been obtained with the present invention over other hydrogen rich gas generators. The hydrogen rich gas produced by this invention is comprised of hydrogen, oxygen, and water.

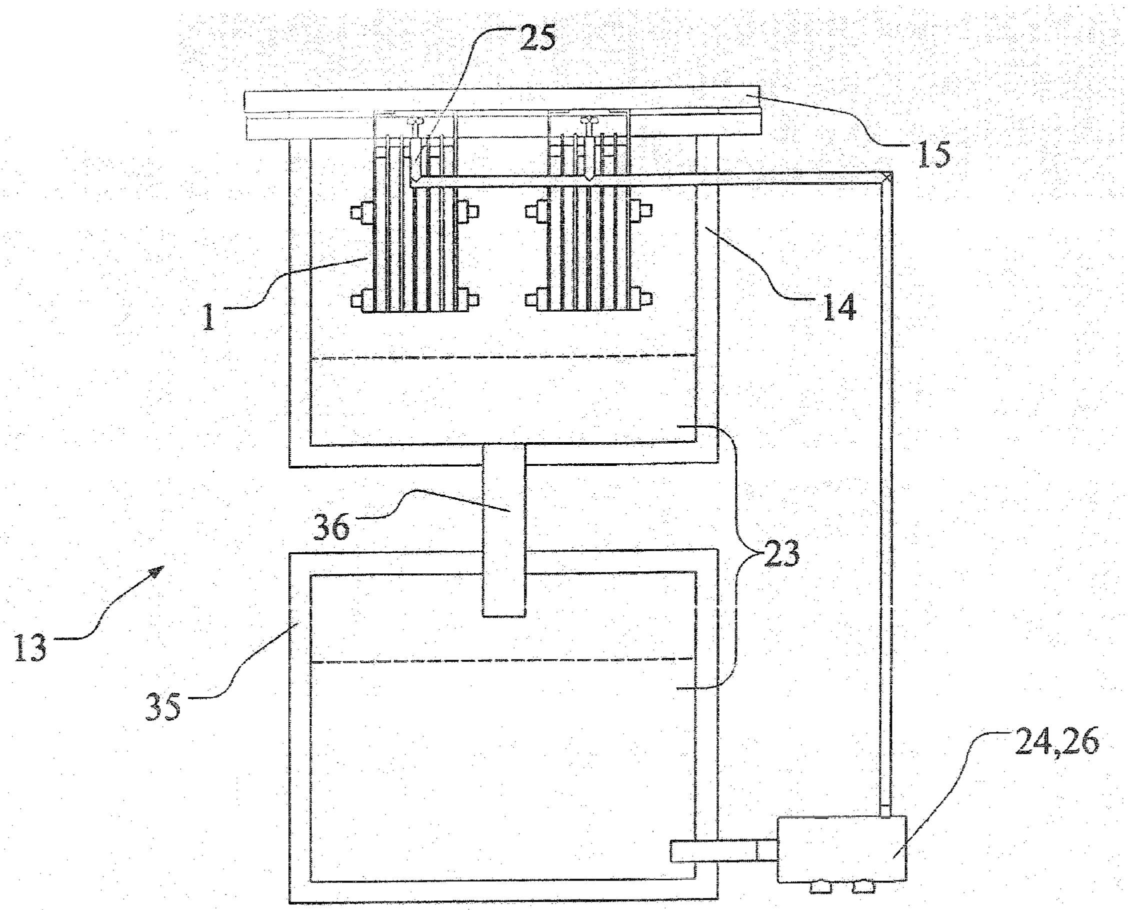


Fig. 1

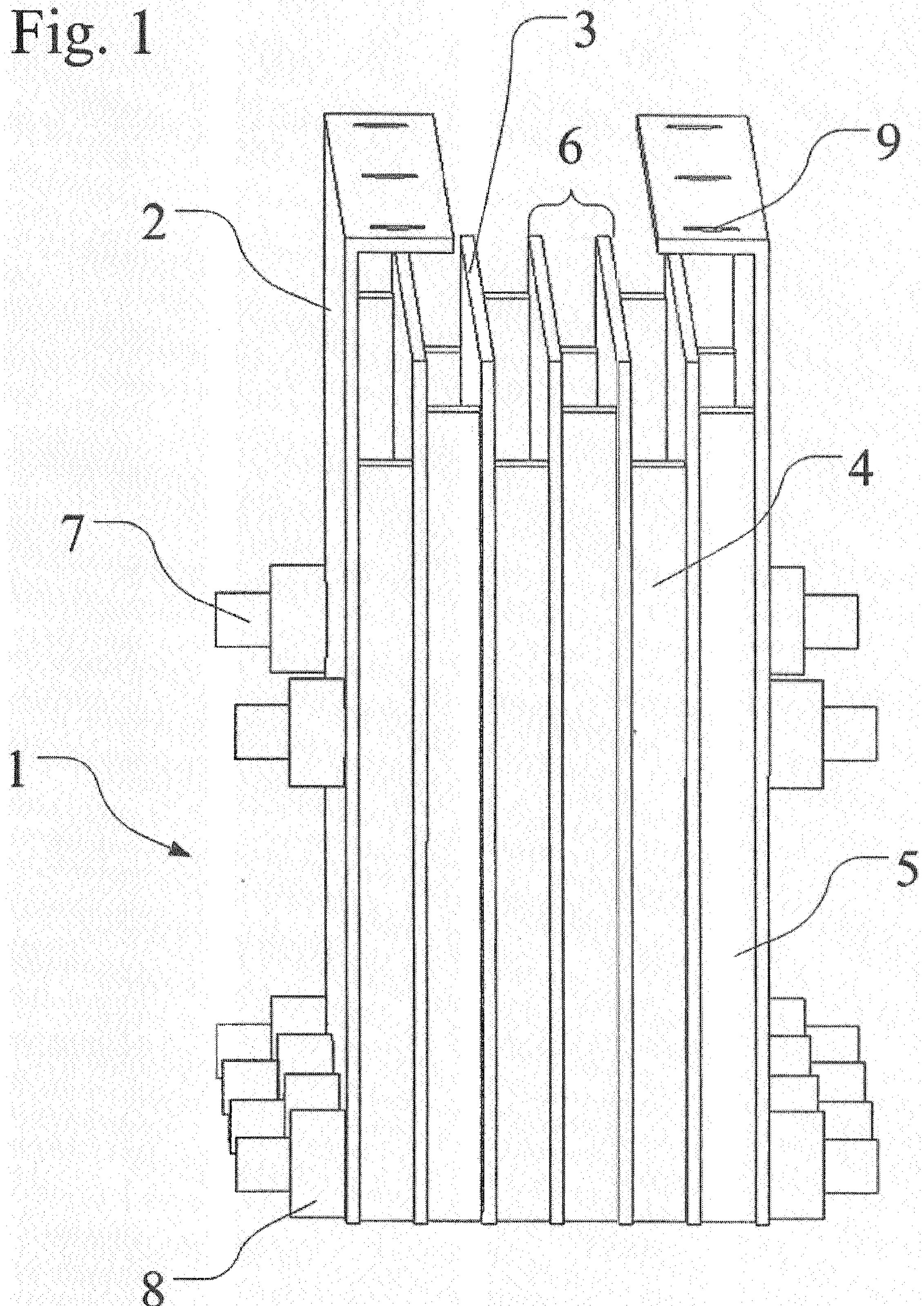
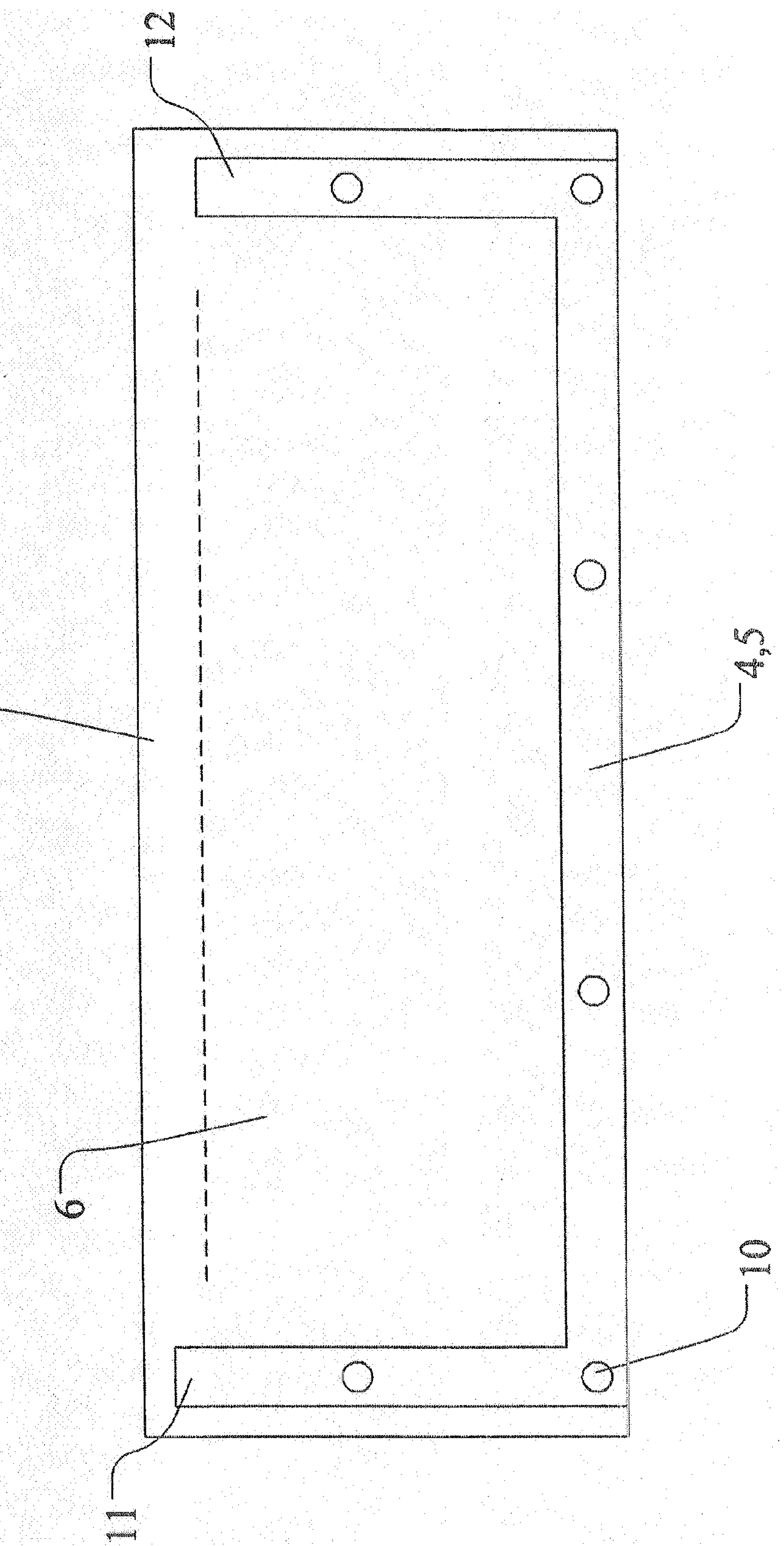


Fig. 2



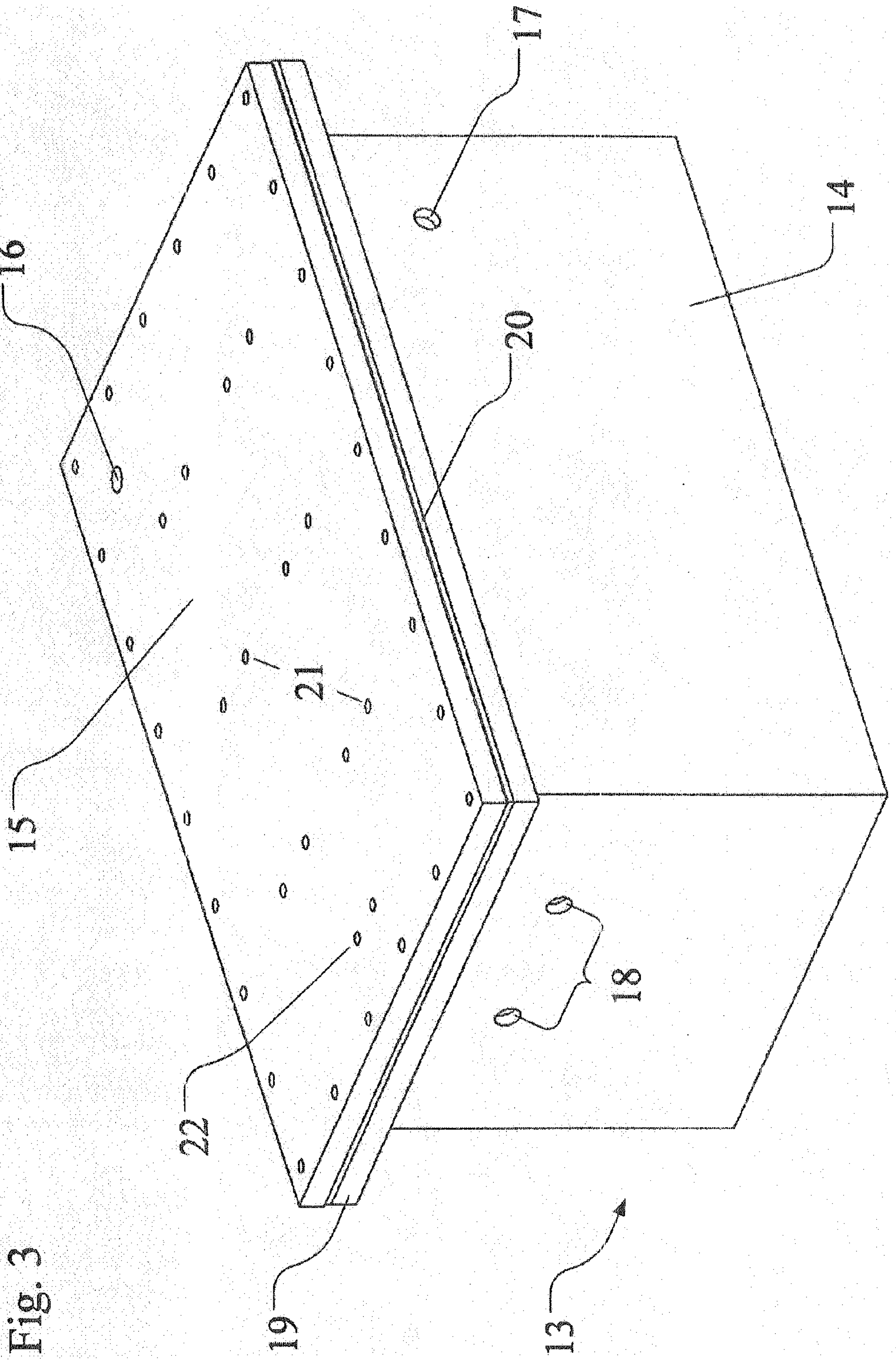


Fig. 3

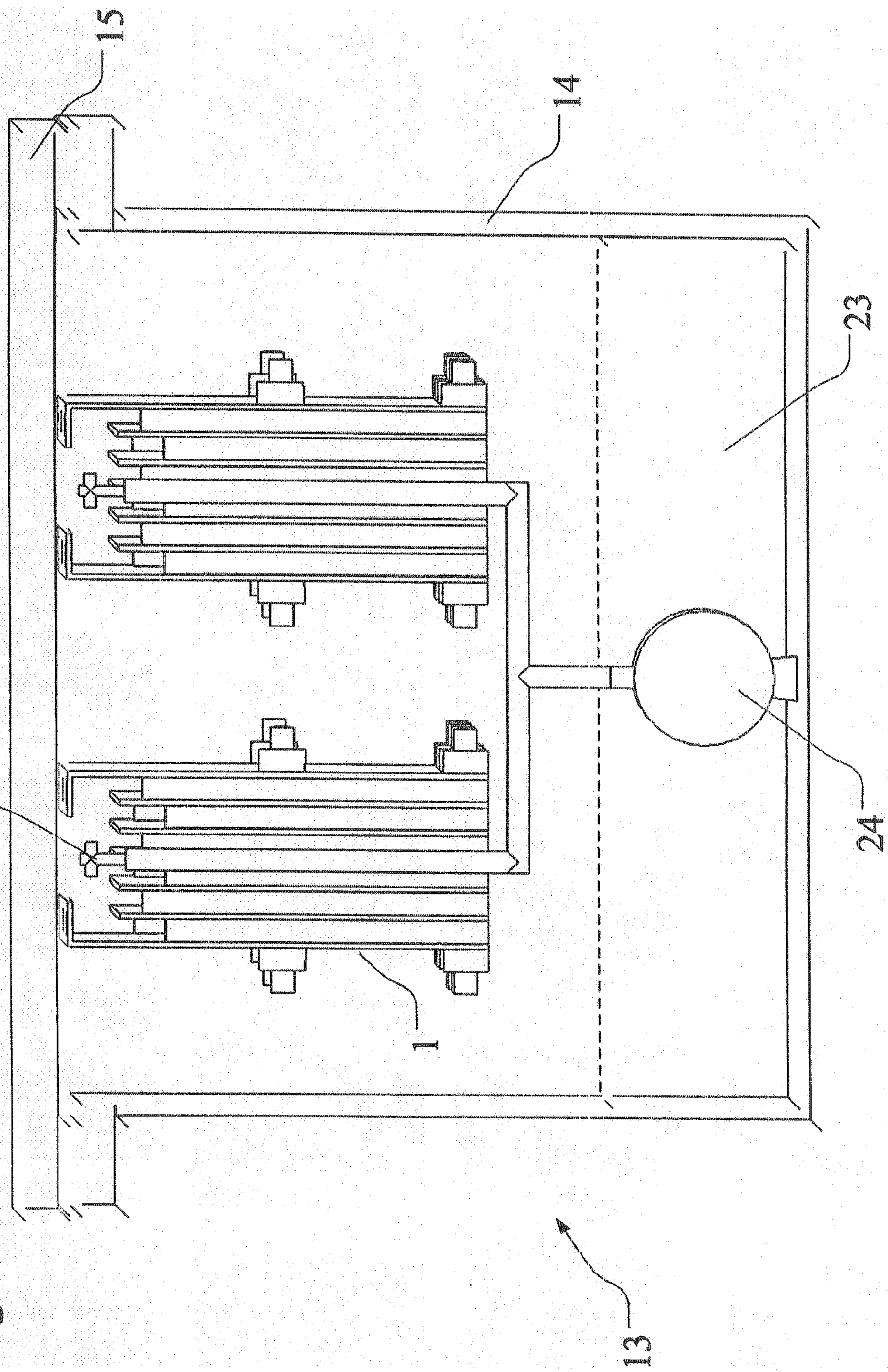


Fig. 4

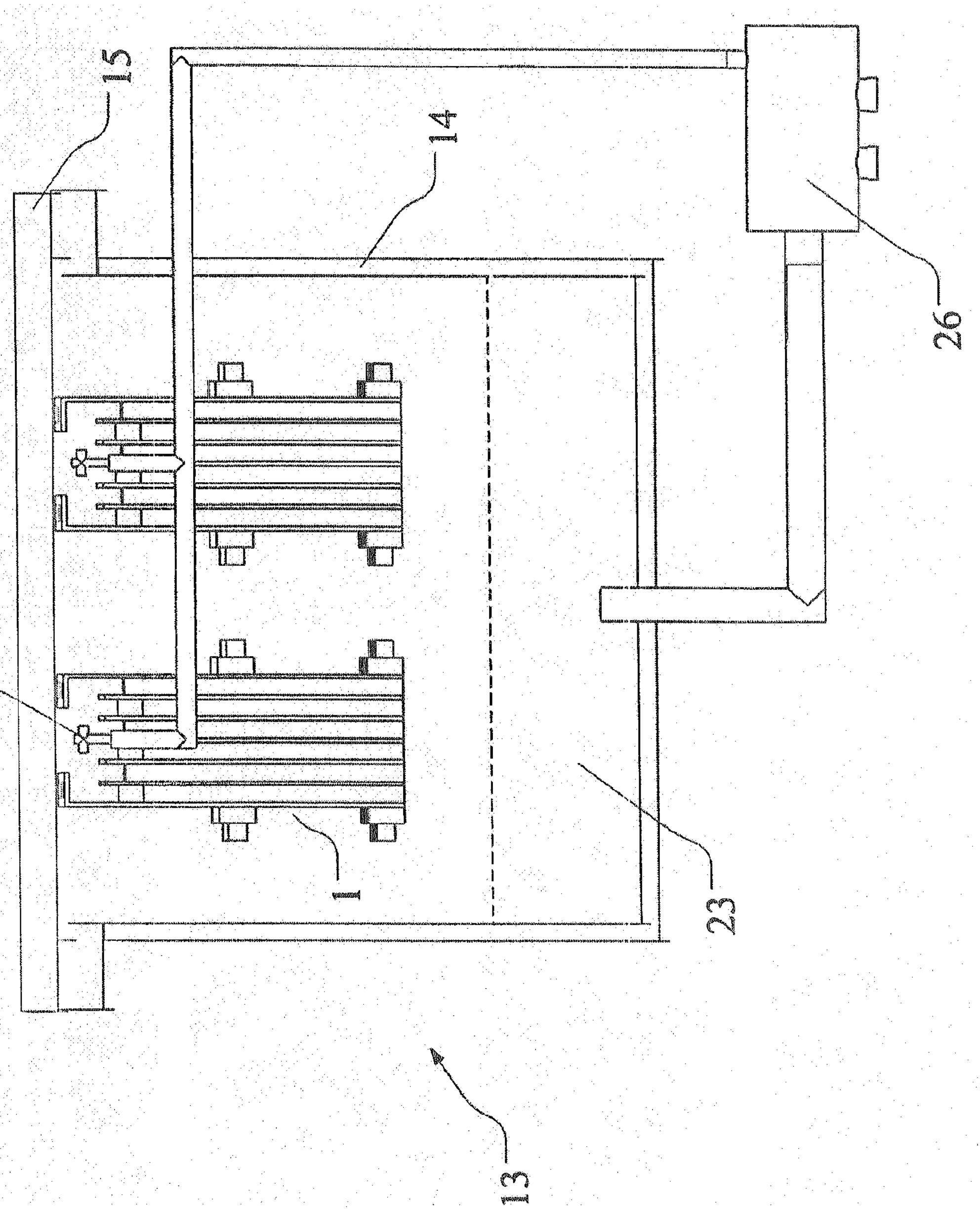


Fig. 5

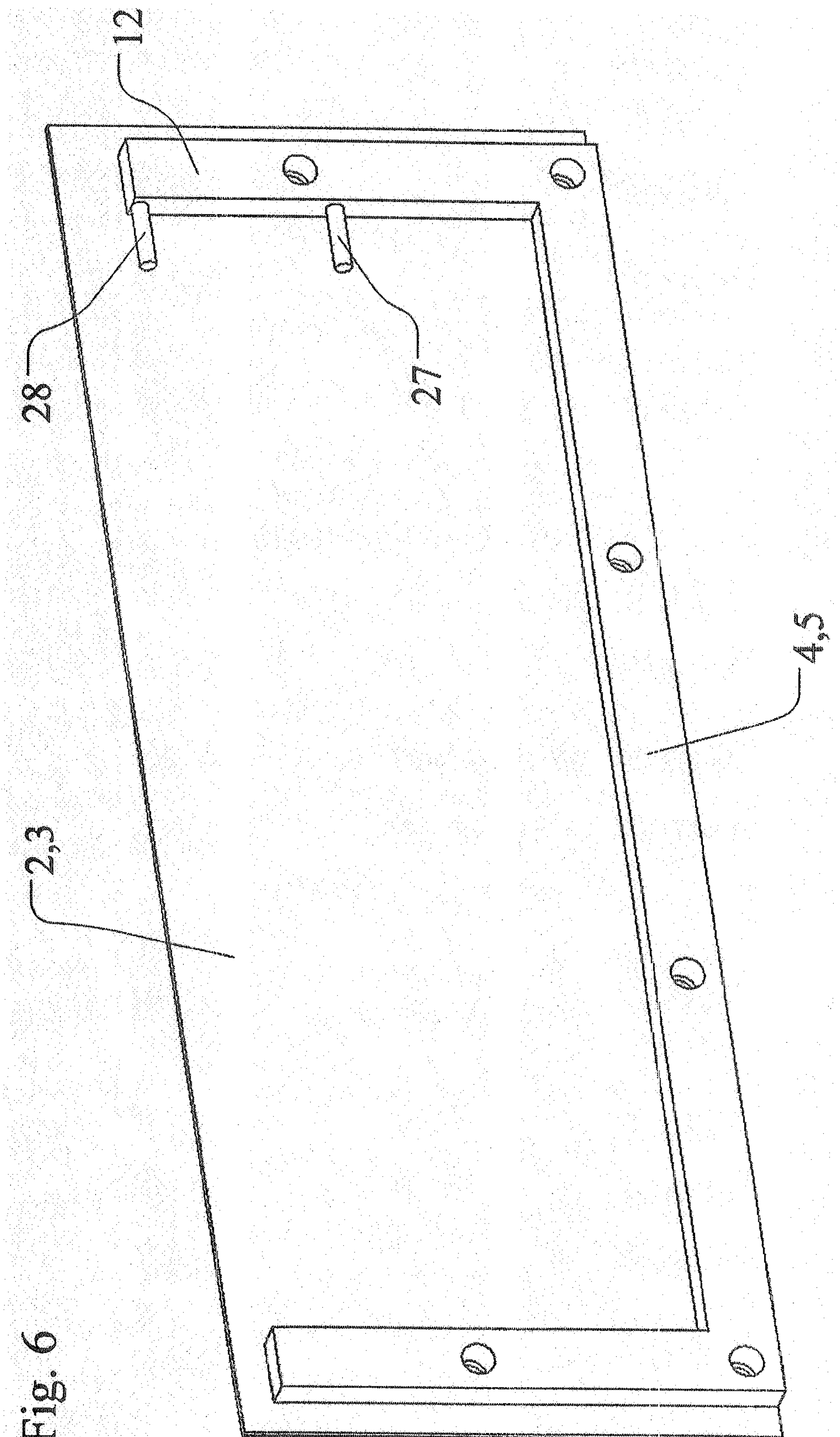


Fig. 6

Fig. 7

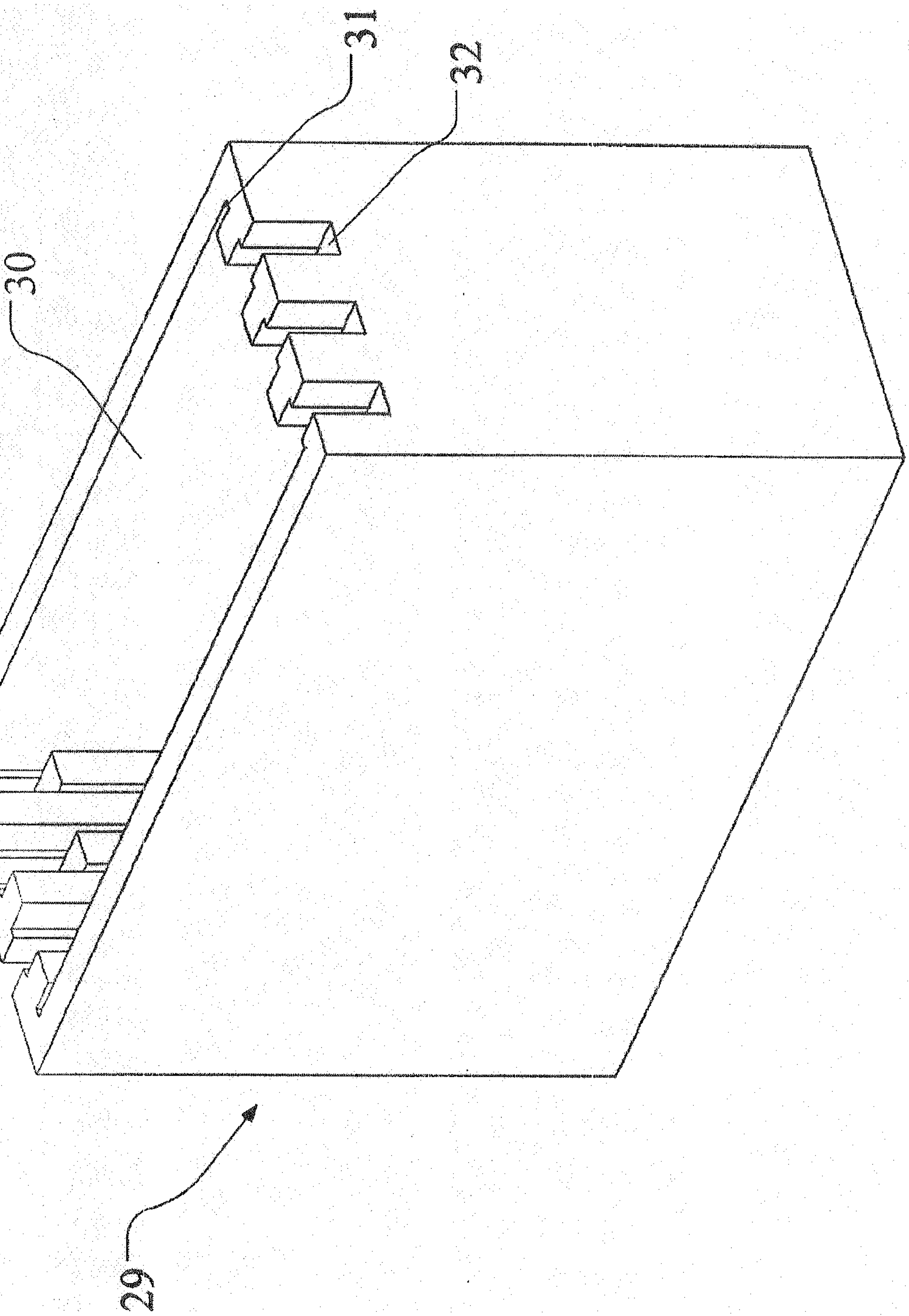


Fig. 8

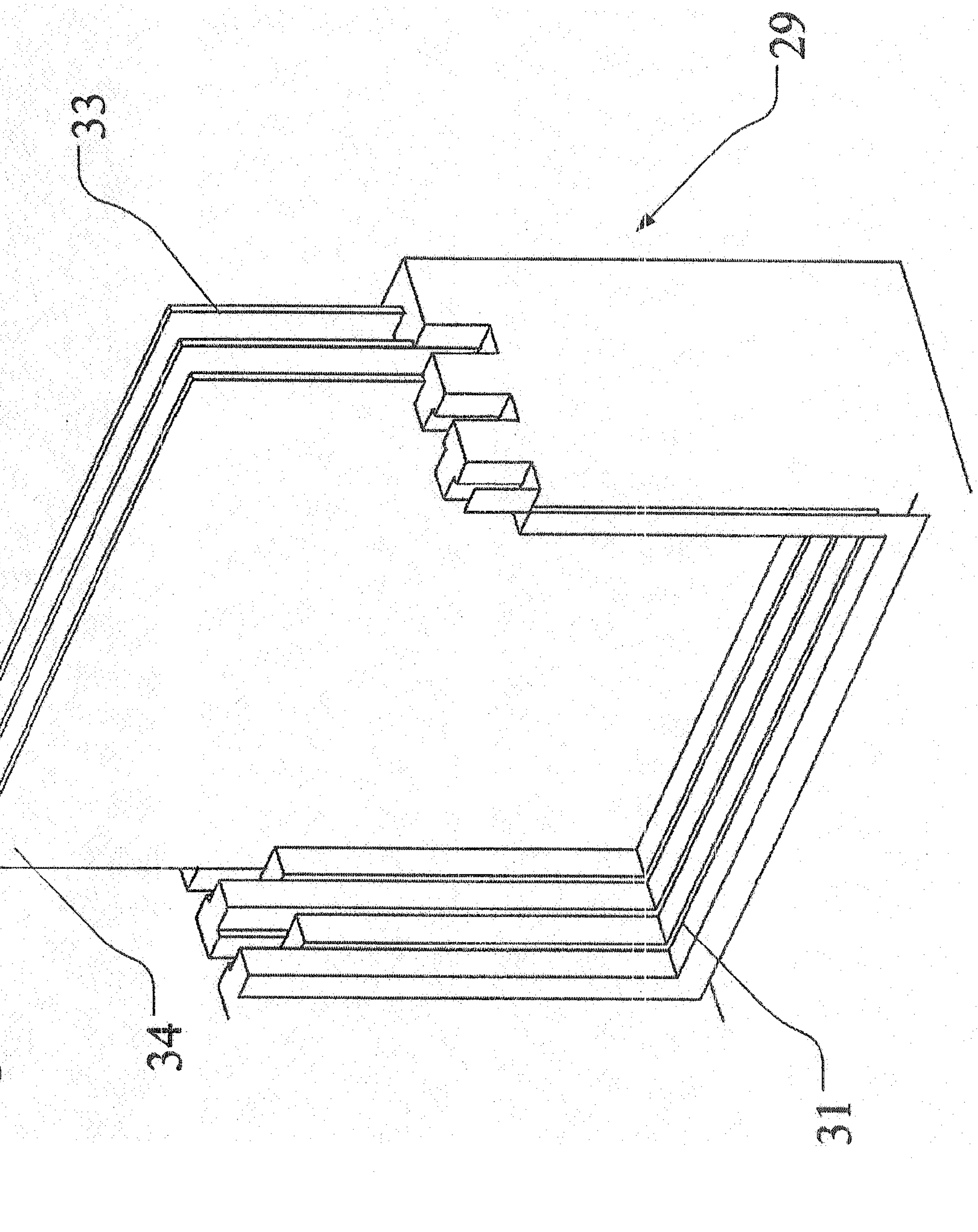
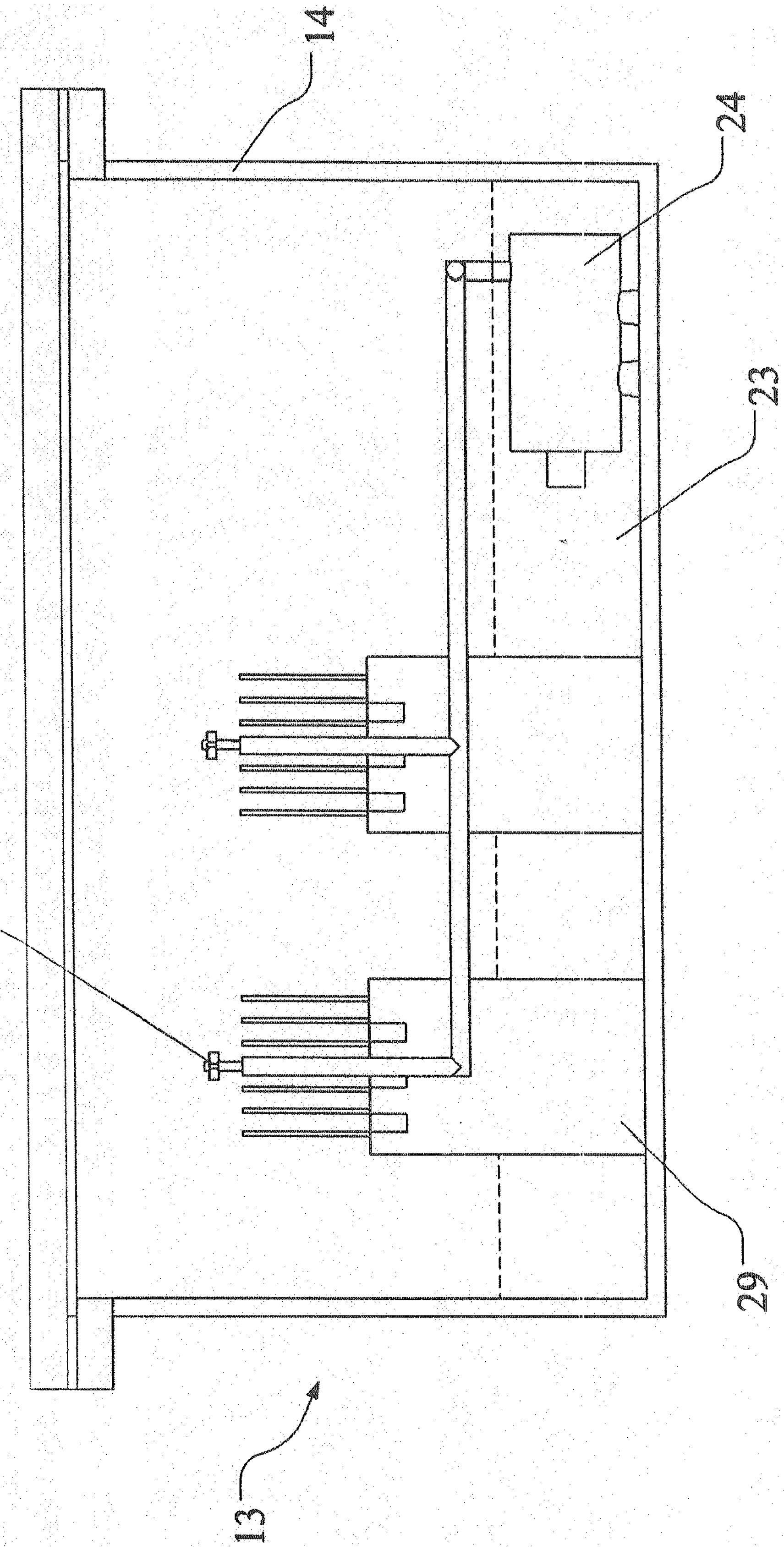


Fig. 9



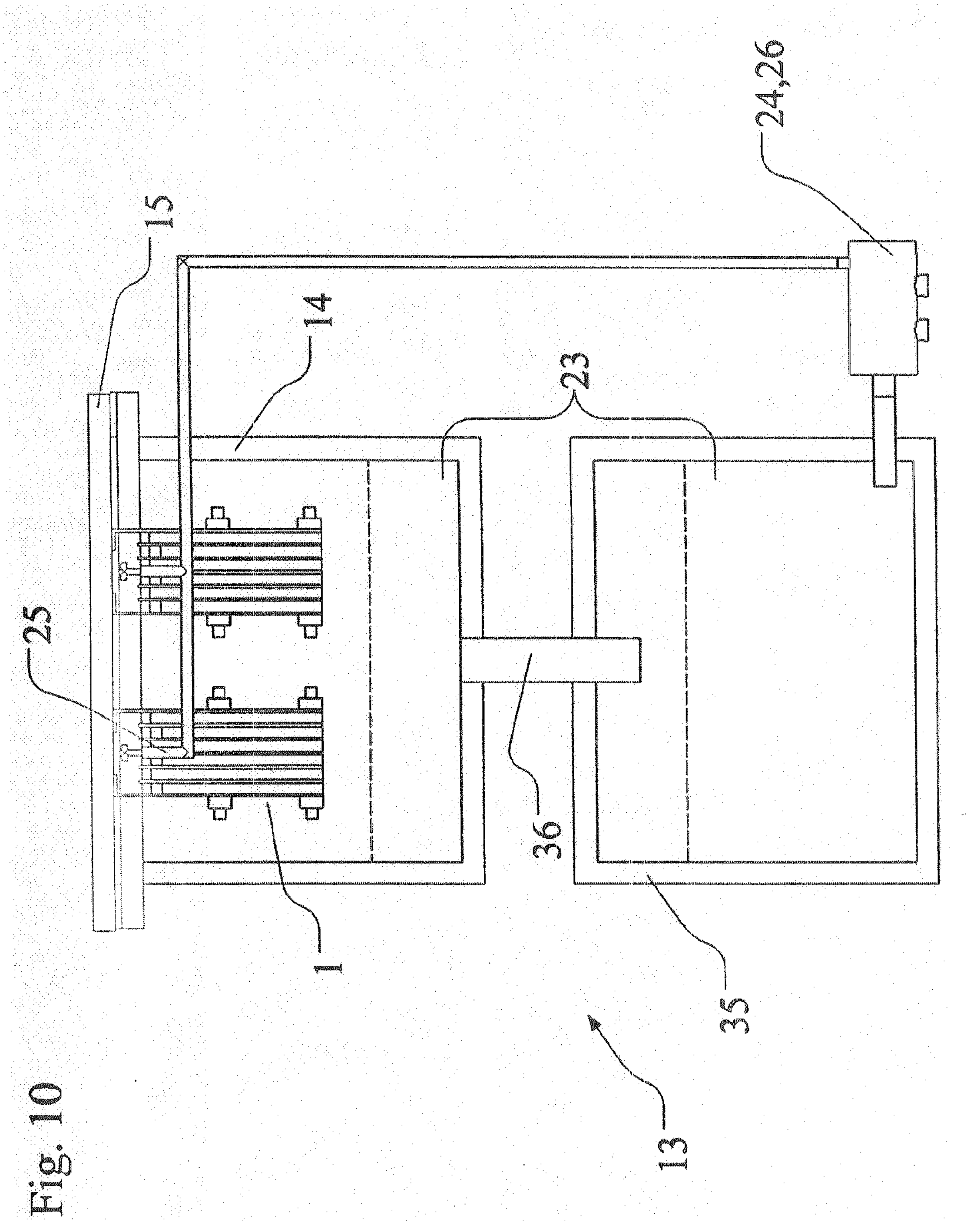


Fig. 10

HYDROGEN RICH GAS GENERATOR

RELATED APPLICATION

[0001] This application claims the benefit of U.S. provisional patent application No. 61/118,705 filed Dec. 1, 2008.

FIELD OF INVENTION

[0002] This invention relates to an improved method and related equipment/system for the continuous coincident generation of a hydrogen rich gas through water electrolysis.

SUMMARY OF INVENTION

[0003] This invention is a method and related equipment/system for improving the efficiency of continuous water electrolysis processes to produce a hydrogen rich gas.

[0004] This invention improves the efficiency of water electrolysis processes by minimizing and/or eliminating wasted current, current that does not convert water to a hydrogen rich gas, attaining approximately 100% Faradic efficiency. This improvement in current or Faradic efficiency is attained by electrically isolating the electrolyte solution contained in each electrolysis cell as well as electrically isolating the electrolyte solution contained in each cell from the supply of electrolyte solution. This invention also improves the efficiency of water electrolysis processes through the utilization of electrodes coated with electrode specific nanomaterials, improving voltage efficiency at current densities exceeding 100 mA/cm^2. The hydrogen rich gas produced by this invention is comprised of hydrogen, oxygen, and water. For optimum control of the hydrogen rich gas generator described in this invention, a constant current source should apply dc power to the primary electrodes.

[0005] Electrical isolation is attained by filling the cells with electrolyte solution from the electrolyte supply by means of a pump and a spray nozzle or other appropriate device, in which the volume between the nozzle and electrolyte surface in each cell does not form a contiguous stream. The absence of a contiguous stream electrically isolates the electrolyte solution in each cell from the supply of electrolyte solution. The electrolyte solution in a cell must not come in contiguous contact with the electrolyte solution in any other cell as to guarantee electrical isolation between the electrolyte solutions in adjacent cells.

[0006] The flow of electrolyte from the supply of electrolyte solution and the cells can either be pulsed or a continuous stream. In either case, any volume of electrolyte solution that exceeds the volume of the cell will overflow over the sides of the insulating cell separators and fall to the supply of electrolyte solution. With the electrolyzer assembly suspended from the top or lid of the electrolyzer and the surface of the supply of electrolyte solution not in contact with the bottom of the electrolyzer assembly, no contiguous stream will exist between the electrolyte solution overflowing from the cells and the supply of electrolyte solution. Thus, the electrolyte solution in the cells is again electrically isolated from the electrolyte solution in the supply. The absence of contiguous contact between the bottom of the electrolyzer assembly and the surface of the supply of electrolyte solution also provides electrical insulation.

[0007] In a preferred embodiment, the active area of the cathode (hydrogen producing) side of each electrode is coated with an appropriate catalytic material, improving the voltage efficiency of the hydrogen gas generator described in this invention by about 10%. The preferred catalytic material is a nanomaterial comprised of nickel and iron nanoparticles obtained from QuantumSphere Inc. of Santa Ana, Calif.

[0008] A hydrogen rich gas generator built according to the preferred embodiments of the present invention have shown an increase in current efficiency of about 10% over various operating conditions when compared to similar hydrogen rich gas generators such as that described in U.S. Pat. No. 7,191,737. That is an increase in current efficiency of about 10% combined with an increase in voltage efficiency of about 10% results in an increase in overall efficiency of about 20%.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] In the accompanying drawings.

[0010] FIG. **1** is a schematic representation of an electrolyzer assembly;

[0011] FIG. **2** is a schematic representation of an electrode and spacer for which an electrolyzer assembly is comprised;

[0012] FIG. **3** is a schematic representation of the exterior of a hydrogen rich gas generator;

[0013] FIG. **4** is a schematic representation of the longitudinal cross-section view of a hydrogen rich gas generator;

[0014] FIG. **5** is a schematic representation of the longitudinal cross-section view of an alternative embodiment of a hydrogen rich gas generator;

[0015] FIG. **6** is a schematic representation of an electrode and spacer including level sensors for which an electrolyzer assembly is comprised in an alternative embodiment;

[0016] FIG. **7** is a schematic representation of an electrode holder for an alternative electrolyzer assembly;

[0017] FIG. **8** is a schematic representation of an alternative electrolyzer assembly,

[0018] FIG. **9** is a schematic representation of the side cross-section view of a hydrogen rich generator comprised of an alternative electrolyzer assembly; and,

[0019] FIG. **10** is a schematic representation of the side cross-section view of a hydrogen rich generator comprised of an enclosure and separate electrolyzer tank arrangement.

DETAILED DESCRIPTION OF THE INVENTION

[0020] As described above, this invention is an improved method and related equipment/system for the continuous coincident generation of a hydrogen rich gas through water electrolysis. This invention improves the efficiency of water electrolysis processes by minimizing and/or eliminating wasted current, current that does not convert water to a hydrogen rich gas, attaining approximately 100% Faradic efficiency. This improvement in current or Faradic efficiency is attained by electrically isolating the electrolyte solution contained in each electrolysis cell as well as electrically isolating the electrolyte solution contained in each cell from the supply of electrolyte solution. This invention also improves the efficiency of water electrolysis processes through the utilization of electrodes coated with electrode specific nanomaterials, improving voltage efficiency at current densities exceeding 100 mA/cm^2. The hydrogen rich gas produced by this invention is comprised of hydrogen, oxygen, and water. For optimum control of the hydrogen rich gas generator described in this invention, a constant current source should apply dc power to the primary electrodes.

[0021] FIG. **1** presents an example of the longitudinal view an electrolyzer assembly **1** that will enable realization of the present inventive method. The electrolyzer assembly **1** is comprised of two primary electrodes **2** and zero or more secondary electrodes **3** composed of solid conductive material such as stainless steel or nickel. The primary electrodes **2** and/or secondary electrodes **3** are separated by U-shaped spacers **4**, **5** composed of insulating material such as nylon or poly(tetrafluoroethylene) (PTFE). A cell **6** of the electrolyzer assembly **1** is defined as the open volume between two primary electrodes **2**, a primary electrode **2** and a secondary electrode **3** or two secondary electrodes **3** that is exposed by the U-shaped spacer **4**, **5**. In a preferred embodiment, the height of one side of alternating spacers **4**, **5** is lower in order to allow the overflow of electrolyte solution from each cell **6** to exit the electrolyzer assembly **1** on alternating sides of the electrolyzer assembly **1**. The electrolyzer assembly **1** comprised of two primary electrodes **2**, zero or more secondary electrodes **3**, and spacers **4**, **5** are held together by an insulating clamp, fastener or other equivalent device. In a preferred embodiment, the electrolyzer assembly **1** comprised of two primary electrodes **2**, zero or more secondary electrodes **3**, and spacers **4**, **5** are held together by threaded rods **7** and nuts **8** composed of insulating material such as nylon of PTFE. In the preferred embodiment, the height of one side of the alternating spacers with the lower height **4** should be sufficiently low enough to ensure the electrolyte solution in one cell **6** does not come in contiguous contact with the electrolyte solution in any adjacent cells. The primary electrodes **2** also contain mounting holes **9** to facilitate mounting the electrolyzer assembly in the enclosure discussed below. The choice of material for the primary electrodes **2**, supplemental or secondary electrodes **3**, spacers **4**, **5**, threaded rods **7**, and nuts **8** as well as the number and location of the threaded rods **7** and nuts **8** should be sufficient to assure a sturdy electrolyzer assembly **1**. The choice of primary electrode **2**, secondary electrode **3**, and spacer **4**, **5** dimensions and thickness influence the voltage efficiency of the electrolyzer assembly **1**.

[0022] With reference to FIG. **2**, an example of the side view a U-shaped spacer **4**, **5** positioned next to a primary electrode **2** and/or secondary electrode **3** with multiple holes **10** in each spacer **4**, **5** and primary electrode **2** and/or secondary electrode **3** for the threaded rod **7** (not shown in FIG. **2**) described above. In the preferred embodiment, the width of the primary electrode **2** and/or secondary electrode **3** is slightly larger than the width of the spacer **4**, **5**, allowing the overflow of electrolyte solution from each cell **6** to be contained between the cell's respective electrodes. The area enclosed on three sides by the spacer **4**, **5** defines the surface area of the cell **6**. In the preferred embodiment, the height of both sides **11**, **12** of the spacer **4**, **5** are slightly lower than the height of the primary electrode **2** and/or secondary electrode **3**, preventing the overflow of electrolyte from one cell **6** to form contiguous contact with the electrolyte solution from an adjacent cell **6**. In the preferred embodiment, the height of one side **11** of the spacer **4**, **5** is slightly higher than the other side of the spacer **12**, allowing the overflow of electrolyte solution from a cell **6** to occur over the lower side **12** of the spacer **4**, **5**.

[0023] With reference to FIG. **3**, an example of an enclosed hydrogen rich gas generator **13** comprises an enclosure **14** with lid **15**, sealable electrolyte fill port **16**, sealable gas outlet port **17**, and zero or more sealable measurement ports **18**. In a preferred embodiment, the hydrogen rich gas generator **13** enclosure **14** is also comprised of a flange **19** and gasket **20** to facilitate sealing the lid **15** to the enclosure **14**. In a preferred embodiment, the lid **15** also contains holes **21** to mount one or more electrolyzer assemblies **1** (not shown in FIG. **3**) to the lid and provide electrical contact to the primary electrodes **2** (not shown in FIG. **3**) of each electrolyzer assembly **1**. Holes **22** in the lid **15** also provide electrical contact to the pump **24** (not shown in FIG. **3**) described below. Bolts, screws and/or other fasteners should be utilized in conjunction with suitable sealing washers with each hole **21** to mount the one or more electrolyzer assemblies **1** (not shown in FIG. **3**) to the lid as well as each hole **22** to provide electrical contact to the pump **24**. To generate the hydrogen rich gas, dc power is applied to the appropriate primary electrodes **2** (not shown in FIG. **3**) of one or more electrolyzer assemblies **1** (not shown in FIG. **3**), preferably with a constant current as opposed to a constant voltage.

[0024] FIG. **4** shows an example of the inside of an enclosed hydrogen rich gas generator **13** (longitudinal view), which comprises an enclosure **14**, means for containing an electrolute solution **23**, means for holding a supply of electrolyte solution **23**, submersible pump **24** submerged in the supply of electrolyte solution **23** and fluidly connected to one or more sprayers or similar devices **25** suited to deliver electrolyte solution from the supply of electrolyte solution **23** to all cells **6** (not numbered in FIG. **4**) of the one or more electrolyzer assemblies **1** suspended from the lid **15** of the enclosed hydrogen rich gas generator **13**. Examples of means for containing an electrolyte solution **23** and means for holding a supply of electrolyte solution **23** include but are not limited to the lower portion of the enclosure **14**, as shown in FIG. **4**, a separate electrolyte tank (not shown in FIG. **4**), or a combination thereof. The sprayers or similar devices **25** suited to deliver electrolyte solution to one or more electrolyzer assemblies **1** should be configured such that all cells **6** (not numbered in FIG. **4**) are continuously filled and no contiguous stream of electrolyte solution is formed between the electrolyte solution in any cell **6** (not numbered in FIG. **4**) in the one or more electrolyzer assemblies **1** and the outlet of the one or more sprayers or similar devices **25**. The absence of a contiguous stream between the electrolyte solution exiting the one or more sprayers or similar devices **24** described above eliminates the flow of electrical current from the electrolyte solution contained in one or more cells **6** (not numbered in FIG. **4**) of the one or more electrolyzer assemblies **1**, reducing the amount of current that does not participate in the generation of the hydrogen rich gas and thereby increasing the current or Faradic efficiency of the hydrogen rich gas generator **13**.

[0025] With reference to FIG. **5**, an alternative embodiment of a hydrogen rich gas generator **13** comprises an enclosure **14**, means for containing an electrolute solution **23**, means for holding a supply of electrolyte solution **23**, fluidly connected to the inlet of an external pump **26** whose outlet is fluidly connected to one or more sprayers or similar devices **25** suited to deliver electrolyte solution from the supply of electrolyte solution **23** to all cells **6** (not numbered in FIG. **5**) of the one or more electrolyzer assemblies **1** suspended from the lid **15** of the enclosed hydrogen rich gas generator **13**. Examples of means for containing an electrolyte solution **23** and means for holding a supply of electrolyte solution **23** include but are not limited to the lower portion of the enclosure **14**, as shown in FIG. **5**, a separate electrolyte tank (not shown in FIG. **5**), or a combination thereof. The sprayers or similar devices **25** suited to deliver electrolyte solution to one or more electrolyzer assemblies **1** should be configured such that all cells **6** (not numbered in FIG. **5**) are continuously filled and no contiguous stream of electrolyte solution is formed between the electrolyte solution in any cell **6** (not numbered in FIG. **5**) in the one or more electrolyzer assemblies **1** and the outlet of the one or more sprayers or similar devices **25**. The absence of a contiguous stream between the electrolyte solution exiting the one or more sprayers or similar devices **25** described above eliminates the flow of electrical current from the electrolyte solution contained in one or more cells **6** (not numbered in FIG. **5**) of the one or more electrolyzer assemblies **1**, reducing the amount of current that does not participate in the generation of the hydrogen rich gas and thereby increasing the current or Faradic efficiency of the hydrogen rich gas generator **13**.

[0026] FIG. **6** shows an alternative embodiment of the invention, which comprises the incorporation of a low level sensor **27** and a high level sensor **28** in one or more cells **6** (not numbered in FIG. **6**) of an electrolyzer assembly **1** suspended from the lower side **12** of one or more spacers **4**, **5**. The lower level sensor **27** and high level sensor **28** can connected to the electrical control of the pump (submersible **24**, external **26**) or a valve (not shown) fluidly connected to the pump **24**, **26** and the sprayers or similar devices **25** suited to deliver electrolyte solution to one or more electrolyzer assemblies **1**. With these connections, the lower level sensor **27** and high level sensor **28** can be used to power the pump **24**, **26** or valve (not shown in FIG. **6**) to fill each cell **6** with electrolyte solution when the level is low (low level sensor **27** activated) and to disconnect power to the pump **24**, **26** or valve (not shown in FIG. **6**) when the level is high (high level sensor **28** activated). This action of powering the pump **24**, **26** or a valve (not shown in FIG. **6**) would result in a pulse flow of electrolyte from the supply of electrolyte solution and the cells.

[0027] With reference to FIG. **7**, an example of an embodiment of an alternative electrolyzer assembly **29** comprises an insulating electrode holder **30** with slots for each electrode (primary and secondary) **31** and notches **32** between each electrode (primary and secondary) on alternating sides to allow electrolyte solution to overflow from each cell **6** (not shown in FIG. **7**) to the supply of electrolyte solution **23** (not shown in FIG. **7**). FIG. **8** shows a cutaway view of this alternative embodiment of an electrolyzer assembly **29** also comprises two primary electrodes **33** (only one shown), zero or more secondary electrodes **34** all of which are held in place by slots **32** on three sides. The two primary electrodes **33** (only one shown) and zero or more secondary electrodes **34** fit tightly into each notch **32** as to not allow any fluid contact between cells **6** (not numbered in FIG. **8**), eliminating the flow of electrical current from the electrolyte solution contained in one or more cells **6** (not numbered in FIG. **8**) to the electrolyte solution contained in any other cell **6** (not numbered in FIG. **8**) reducing the amount of current that does not participate in the generation of the hydrogen rich gas and thereby increasing the current or Faradic efficiency of the hydrogen rich gas generator **13** (not shown in FIG. **8**).

[0028] With reference to FIG. **9**, an example of an alternative embodiment of a hydrogen rich gas generator **13** comprises an enclosure **14**, one or more alternative electrolyzer assemblies **29**, means for containing an electrolute solution **23**, means for holding a supply of electrolyte solution **23**, submersible pump **24** submerged in the supply of electrolyte solution **23** and fluidly connected to one or more sprayers or similar devices **25** suited to deliver electrolyte solution from the supply of electrolyte solution **23** to all cells **6** (not numbered in FIG. **9**) of the one or more alternative electrolyzer assemblies **29** of the enclosed hydrogen rich gas generator **13**. Examples of means for containing an electrolyte solution **23** and means for holding a supply of electrolyte solution **23** include but are not limited to the lower portion of the enclosure **14**, as shown in FIG. **9**, a separate electrolyte tank (not shown in FIG. **9**), or a combination thereof. The height of the supply of electrolyte solution **23** must be lower than the height of the alternative electrolyzer assemblies **29** as well as the notches **32** (not numbered in FIG. **9**), allowing electrolyte solution to overflow from each cell **6** (not numbered in FIG. **9**) to the supply of electrolyte solution **23** without forming a contiguous stream. The sprayers or similar devices **25** suited to deliver electrolyte solution to one or more electrolyzer assemblies **1** should be configured such that all cells **6** are continuously filled and no contiguous stream of electrolyte solution is formed between the electrolyte solution in any cell **6** in the one or more electrolyzer assemblies **1** and the outlet of the one or more sprayers or similar devices **25**. The absence of a contiguous stream between the electrolyte solution exiting the one or more sprayers or similar devices **25** described above and between the electrolyte solution overflowing from each cell **6** (not numbered in FIG. **9**) and the supply of electrolyte solution **23** eliminates the flow of electrical current from the electrolyte solution contained in one or more cells **6** of the one or more alternative electrolyzer assemblies **29**, reducing the amount of current that does not participate in the generation of the hydrogen rich gas and thereby increasing the current or Faradic efficiency of the hydrogen rich gas generator **13**. Although the pump shown in FIG. **9** is submersible, it is understood that an equivalent structure is an external pump conceptually represented by the embodiment of FIG. **5**.

[0029] With reference to FIG. **10**, an alternative embodiment of a hydrogen rich gas generator **13** comprises an enclosure **14**, means for containing an electrolute solution **23**, means for holding a supply of electrolyte solution **23** is fluidly connected to the inlet of a submersible **24** or external pump **26** whose outlet is fluidly connected to one or more sprayers or similar devices **25** suited to deliver electrolyte solution from the supply of electrolyte solution **23** to all cells **6** (not numbered in FIG. **5**) of the one or more electrolyzer assemblies **1** suspended from the lid **15** of the enclosed hydrogen rich gas generator **13**. Examples of means for containing an electrolyte solution **23** and means for holding a supply of electrolyte solution **23** include but are not limited to the lower portion of the enclosure **14**, separate electrolyte tank **35**, or a combination of thereof. The enclosure **14** is fluidly connected to the separate electrolyte tank **35** such that the electrolyte overflowing from the one or more electrolyzer assemblies **1** flows without forming a contiguous stream of electrolyte solution to the bottom of the enclosure **14** which drains into the electrolyte tank **35** through one or more drain ports **36** fluidly connected to both the enclosure **14** and the electrolyte tank **35**. The sprayers or similar devices **25** suited to deliver electrolyte solution to one or more electrolyzer assemblies **1** should be configured such that all cells **6** (not numbered in FIG. **10**) are continuously filled and no contiguous stream of electrolyte solution is formed between the electrolyte solution in any cell **6** (not numbered in FIG. **10**) in the one or more electrolyzer assemblies **1** and the outlet of the one or more sprayers or similar devices **25**. The absence of a contiguous stream between the electrolyte solution exiting the one or more sprayers or similar devices **25** described above eliminates the flow of electrical current from the electrolyte solution contained in one or more cells **6** (not numbered in FIG.

10) of the one or more electrolyzer assemblies 1, reducing the amount of current that does not participate in the generation of the hydrogen rich gas and thereby increasing the current or Faradic efficiency of the hydrogen rich gas generator 13. It is understood that the use of a supply of electrolyte 23 contained in the enclosure 14, separate electrolyte tank 35, or a combination thereof can also be applied to the alternative embodiment described in FIG. 9.

[0030] A hydrogen rich gas generator built according to the preferred embodiments of the present invention have shown an increase in current efficiency of about 10% over various operating conditions when compared to similar hydrogen rich gas generators such as that described in U.S. Pat. No. 7,191,737, that is, an increase in current efficiency of about 10% combined with an increase in voltage efficiency of about 10% results in an increase in overall efficiency of about 20%.

[0031] It should be understood that the preceding is merely a detailed description of one or more embodiments of this invention and that numerous changes to the disclosed embodiments can be made in accordance with the disclosure herein without departing from the spirit and scope of the invention. The preceding description, therefore, is not meant to limit the scope of the invention. Rather, the scope of the invention is to be determined only by the appended claims and their equivalents.

What is claimed is:

1. An electrolyzer generator apparatus for making a hydrogen rich gas comprising hydrogen, oxygen and water, said apparatus comprising:

a generator enclosure comprising means for containing an electrolyte solution and a lid covering said enclosure, said enclosure configured to contain one or more electrolyzer assemblies, said enclosure further containing means for holding a supply of electrolyte solution wherein said electrolyte solution within said supply portion is physically separated from said one or more electrolyzer assemblies;

each of said one or more electrolyzer assemblies comprising two primary electrodes and zero or one or more secondary electrodes, each of said electrodes being made from a conductive material and separated from respective adjacent electrodes by an insulating material comprising an insulating separator constructed so as to allow an electrolyte solution used within said apparatus to overflow without mixing between adjacent cells formed between respective adjacent electrodes;

means for pumping said electrolyte solution from said supply portion to each of said one or more electrolyzer assemblies;

means for supplying a DC current circuit to said one or more electrolyzer assemblies; and

means for supplying electrical power to said means for pumping said electrolyte solution from said supply portion to each of said one or more electrolyzer assemblies.

2. The apparatus according to claim 1, wherein said means for containing an electrolyte solution is comprised of a lower portion of the generator enclosure.

3. The apparatus according to claim 1, wherein said means for containing an electrolyte solution is comprised of a separate electrolyte tank.

4. The apparatus according to claim 1, wherein said means for holding a supply of electrolyte solution is comprised of a lower portion of the generator enclosure.

5. The apparatus according to claim 1, wherein said means for holding a supply of electrolyte solution is comprised of a separate electrolyte tank.

6. The apparatus according to claim 1, wherein said insulating separators are configured to have alternating high and low heights between adjacent electrodes and between adjacent cells.

7. The apparatus according to claim 1, wherein said insulating separator separating said respective adjacent electrodes is U-shaped with one end being higher than an opposite end of said insulating separator.

8. The apparatus according to claim 1, wherein each of said one or more electrolyzer assemblies are removably attached to an underside of said lid and configured such that a bottom of said one or more electrolyzer assemblies is separated from a top level of said electrolyte solution within said supply portion.

9. The apparatus according to claim 1, wherein each of said one or more electrolyzer assemblies are disposed on a bottom of said housing such that said insulating material further physically separates said electrodes and cells within said one or more electrolyzer assemblies from said electrolyte solution within said supply portion.

10. The apparatus according to claim 1, wherein said electrodes are coated with electrode specific nanomaterials to improve voltage efficiencies at current densities exceeding 100 mA/cm^2.

11. The apparatus according to claim 1, wherein an active area of a hydrogen producing side of each electrode is coated with a catalytic material comprising nickel and iron nanoparticles.

12. The apparatus according to claim 1, wherein said means for pumping said electrolyte solution from said supply portion to each of said one or more electrolyzer assemblies comprises a submersible pump located within said supply portion or an external pump located outside said generator housing said submersible pump or external pump being in fluid communication with said electrolyzer assemblies.

13. The apparatus according to claim 1, wherein a flow from said supply portion of said electrolyte solution to said electrolyzer assemblies is a predetermined pulsed stream or a continuous stream of said electrolyte solution directed to each electrolyzer assembly.

14. The apparatus according to claim 1, wherein said means for supplying a DC current circuit to said one or more electrolyzer assemblies comprises a constant current source for supplying DC power to said primary electrodes.

15. The apparatus according to claim 8, wherein when said flow is pulsed stream, said apparatus further comprises a low level sensor between adjacent electrodes for activating said pulsed stream and a high level sensor between adjacent electrodes for stopping said flow of said pulsed stream.

* * * * *