Pulsed Electrolysis Apparatus and Method of Using Same

FIELD OF THE INVENTION

The present invention relates generally to electrolysis systems.

BACKGROUND OF THE INVENTION

Fossil fuels, in particular oil, coal and natural gas, represent the primary sources of energy in today's world. Unfortunately in a world of rapidly increasing energy needs, dependence on any energy source of finite size and limited regional availability has dire consequences for the world's economy. In particular, as a country's need for energy increases, so does its vulnerability to disruption in the supply of that energy source. Additionally, as fossil fuels are the largest single source of carbon dioxide emissions, a greenhouse gas, continued reliance on such fuels can be expected to lead to continued global warming. Accordingly it is imperative that alternative, clean and renewable energy sources be developed that can replace fossil fuels.

Hydrogen-based fuel is currently one of the leading contenders to replace fossil fuel. There are a number of techniques that can be used to produce hydrogen, although the primary technique is by steam reforming natural gas. In this process thermal energy is used to react natural gas with steam, creating hydrogen and carbon dioxide. This process is well developed, but due to its reliance on fossil fuels and the release of carbon dioxide during production, it does not alleviate the need for fossil fuels nor does it lower the environmental impact of its use over that of traditional fossil fuels. Other, less developed hydrogen producing techniques include (i) biomass fermentation in which methane fermentation of high moisture content biomass creates fuel gas, a small portion of which is hydrogen; (ii) biological water splitting in which certain photosynthetic microbes produce hydrogen from water during their metabolic activities; (iii) photoelectrochemical processes using either soluble metal complexes as a catalyst or semiconducting electrodes in a photochemical cell; (iv) thermochemical water splitting using chemicals such as bromine or iodine, assisted by heat, to split water molecules; (v) thermolysis in which concentrated solar energy is used to

generate temperatures high enough to split methane into hydrogen and carbon; and (vi) electrolysis.

Electrolysis as a means of producing hydrogen has been known and used for over 80 years. In general, electrolysis of water uses two electrodes separated by an ion conducting electrolyte. During the process hydrogen is produced at the cathode and oxygen is produced at the anode, the two reaction areas separated by an ion conducting diaphragm. Electricity is required to drive the process. An alternative to conventional electrolysis is high temperature electrolysis, also known as steam electrolysis. This process uses heat, for example produced by a solar concentrator, as a portion of the energy required to cause the needed reaction. Although lowering the electrical consumption of the process is desirable, this process has proven difficult to implement due to the tendency of the hydrogen and oxygen to recombine at the technique's high operating temperatures.

A high temperature heat source, for example a geothermal source, can also be used as a replacement for fossil fuel. In such systems the heat source raises the temperature of water sufficiently to produce steam, the steam driving a turbine generator which, in turn, produces electricity. Alternately the heat source can raise the temperature of a liquid that has a lower boiling temperature than water, such as isopentane, which can also be used to drive a turbine generator. Alternately the heat source can be used as a fossil fuel replacement for non-electrical applications, such as heating buildings.

Although a variety of alternatives to fossil fuels in addition to hydrogen and geothermal sources have been devised, to date none of them have proven acceptable for a variety of reasons ranging from cost to environmental impact to availability. Accordingly, what is needed is a new energy source, or a more efficient form of a current alternative energy source, that can effectively replace fossil fuels without requiring an overly complex distribution system. The present invention provides such a system and method of use.

SUMMARY OF THE INVENTION

The present invention provides an electrolysis system and method of using same. In addition to an electrolysis tank and a membrane separating the tank into two regions, the system includes at least one pair of pulsed high voltage electrodes. The system

also includes metal barrier members interposed between the electrolysis tank membrane and the high voltage electrodes.

Preferably the high voltage pulses occur at a frequency between 50 Hz and 1 MHz, and more preferably between 100 Hz and 10 kHz, and with a pulse duration of between 10 nanoseconds and 0.5 seconds. The high voltage electrodes are fabricated from any of a variety of materials, although preferably the electrode material is selected from the group consisting of steel, nickel, copper, iron, stainless steel, cobalt, manganese, zinc, titanium, platinum, palladium, carbon, graphite, carbon-graphite, and alloys thereof. The electrodes can utilize any of a variety of surface shapes, with each pair of electrodes, i.e., the cathode and anode of each pair, being either positioned parallel to one another or not parallel to one another.

In at least one embodiment of the invention, the membrane separating the electrolysis tank into two regions is comprised of polypropylene.

In at least one embodiment of the invention, the electrolysis tank is filled with water and a concentration of electrolyte in the water of between 0.05 and 10 percent by weight. Preferably potassium hydroxide is used as the electrolyte.

A further understanding of the nature and advantages of the present invention may be realized by reference to the remaining portions of the specification and the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is an illustration of an exemplary embodiment of the invention;

Fig. 2 is an illustration of an alternate exemplary embodiment utilizing multiple metal members per tank region;

Fig. 3 is an illustration of an alternate exemplary embodiment utilizing multiple pairs of high voltage electrodes;

Fig. 4 is an illustration of an alternate exemplary embodiment utilizing multiple metal members per tank region and multiple pairs of high voltage electrodes;

Fig. 5 is an illustration of an alternate exemplary embodiment utilizing a vertical cylindrical tank;

Fig. 6 is an illustration of an alternate exemplary embodiment utilizing a horizontal cylindrical tank;

Fig. 7 is an illustration of an alternate exemplary embodiment utilizing a horizontal cylindrical tank and a separation membrane running lengthwise in the tank;

Fig. 8 is an illustration of one mode of operation;

Fig. 9 is an illustration of an alternate mode of operation that includes initial process optimization steps;

Fig. 10 is an illustration of an alternate, and preferred, mode of operation in which the process undergoes continuous optimization;

Fig. 11 is a block diagram illustrating the preferred optimization control system; and

Fig. 12 is a top, cross-sectional view of the embodiment shown in Fig. 1.

DESCRIPTION OF THE SPECIFIC EMBODIMENTS

Fig. 1 is an illustration of an exemplary embodiment of the invention. Electrolysis system 100 includes a tank 101 comprised of a non-conductive material, the size of the tank depending primarily upon the desired output of the system as well as the dimensions of the electrodes contained within the tank. Although tank 101 is shown as having a rectangular shape, it will be appreciated that the invention is not so limited and that tank 101 can utilize other shapes, for example cylindrical, square, irregularly-shaped, etc. Tank 101 is substantially filled with liquid 103. In at least one preferred embodiment, liquid 103 is comprised of water with an electrolyte, the electrolyte being either an acid electrolyte or a base electrolyte. Exemplary electrolytes include potassium hydroxide and sodium hydroxide. The term "water" as used herein refers to water (H_2O), deuterated water (deuterium oxide or D_2O), tritiated water (tritium oxide or T_2O), semiheavy water (HDO), heavy oxygen water ($H_2{}^{18}O$ or $H_2{}^{17}O$) or any other water containing an isotope of either hydrogen or oxygen, either singly or in any combination thereof (for example, a combination of H_2O and D_2O).

Within liquid 103 is an electrolyte, the electrolyte used to achieve the desired level of conductivity within the water. A preferred electrolyte is potassium hydroxide, although the invention is not limited to this specific electrolyte. For example, sodium hydroxide can also be used. Although a typical electrolysis system, for example one designed to decompose water into hydrogen and oxygen gases, will utilize relatively high

concentrations of electrolyte, the present invention has been found to work best with relatively low electrolyte concentrations, thereby maintaining a relatively high initial water resistivity. Preferably the water resistivity prior to the addition of an electrolyte is on the order of 1 to 28 megohms. Preferably the concentration of electrolyte is in the range of 0.05 percent to 10 percent by weight, more preferably the concentration of electrolyte is in the range of 0.05 percent to 2.0 percent by weight, and still more preferably the concentration of electrolyte is in the range of 0.1 percent to 0.5 percent by weight.

Separating tank 101 into two regions is a membrane 105. Membrane 105 permits ion/electron exchange between the two regions of tank 101 while keeping separate the oxygen and hydrogen bubbles produced during electrolysis. Maintaining separate hydrogen and oxygen gas regions is important not only as a means of allowing the collection of pure hydrogen gas and pure oxygen gas, but also as a means of minimizing the risk of explosions due to the inadvertent recombination of the two gases. Exemplary materials for membrane 105 include, but are not limited to, polypropylene, tetrafluoroethylene, asbestos, etc. In at least one preferred embodiment, membrane 105 is 25 microns thick and comprised of polypropylene.

As noted herein, the present system is capable of generating considerable heat. Accordingly, system components such as tank 101 and membrane 105 that are expected to be subjected to the heat generated by the system must be fabricated from suitable materials and designed to indefinitely accommodate the intended operating temperatures as well as the internal tank pressure. For example, in at least one preferred embodiment the system is designed to operate at a temperature of approximately 90° C at standard pressure. In an alternate exemplary embodiment, the system is designed to operate at elevated temperatures (e.g., 100° C to 150° C) and at sufficient pressure to prevent boiling of liquid 103. In yet another alternate exemplary embodiment, the system is designed to operate at even higher temperatures (e.g., 200° C to 350° C) and higher pressures (e.g., sufficient to prevent boiling). Accordingly, it will be understood that the choice of materials (e.g., for tank 101 and membrane 105) and the design of the system (e.g., tank wall thicknesses, fittings, etc.) will vary, depending upon the intended system operational parameters (primarily temperature and pressure).

Other standard features of electrolysis tank 101 are gas outlets 107 and 109. As hydrogen gas is produced at the cathode and oxygen gas is produced at the anode, in the exemplary embodiment shown in Fig. 1 oxygen gas will exit tank 101 through outlet 107 while hydrogen gas will exit through outlet 109. Replenishment of the electrolyte containing water is preferably through a separate conduit, for example conduit 111. In at least one embodiment of the invention, another conduit 113 is used to remove water from the system. If desired, a single conduit can be used for both water removal and replenishment. It will be appreciated that the system can either be periodically refilled or water and electrolyte can be continuously added at a very slow rate during system operation.

The electrolysis system of the invention uses electrodes comprised of one or more electrode pairs with each electrode pair including at least one cathode (i.e., a cathode coupled electrode) and at least one anode (i.e., an anode coupled electrode). All cathodes are kept in one region of tank 101 while all anodes are kept in the other tank region, the two tank regions separated by membrane 105.

A single pair of electrodes 115/117 is provided in the embodiment illustrated in Fig. 1, the electrodes being coupled to a high voltage source 119. Although not required, in at least one preferred embodiment the individual electrodes of each pair of electrodes are parallel to one another. Thus, for example, the face of electrode 115 is parallel to the face of electrode 117.

Interposed between each high voltage electrode and membrane 105 is a metal member which has been found by the inventor to significantly improve the output efficiency of the system. In one preferred embodiment, electrodes 115/117 and members 121/123 are comprised of nickel. In another preferred embodiment, electrodes 115/117 and members 121/123 are comprised of stainless steel. It should be appreciated, however, that other materials can be used and that the same material does not have to be used for both the electrodes and the metal members. Additionally, the same material does not have to be used for both the anode(s) and the cathode(s). In addition to nickel and steel, other exemplary materials that can be used for the electrodes and members include, but are not limited to, copper, iron, cobalt, manganese, zinc, titanium, platinum, palladium, carbon, graphite, carbon-graphite, and alloys of these materials. Preferably the surface area of the faces of

members 121 and 123 is a large percentage of the cross-sectional area of tank 101, typically on the order of at least 40 percent of the cross-sectional area of tank 101, and often between approximately 70 percent and 90 percent of the cross-sectional area of tank 101. Preferably the separation between members 121 and 123 is between 2 millimeters and 15 centimeters.

Electrodes 115/117 are positioned outside of the planes containing members 121 and 123. In other words, the separation distance between electrodes 115 and 117 is greater than the separation distance between members 121 and 123 and members 121 and 123 are positioned between the high voltage electrodes. The surface area of the high voltage electrodes may be larger, smaller or the same size as the surface area of the metal members.

Typically the voltage applied to high voltage electrodes 115/117 by source 119 is within the range of 50 volts to 50 kilovolts, and preferably within the range of 100 volts to 5 kilovolts. Rather than continually apply voltage to the electrodes, source 119 is pulsed, preferably at a frequency of between 50 Hz and 1 MHz, and more preferably at a frequency of between 100 Hz and 10 kHz. The pulse width (i.e., pulse duration) is preferably between 0.01 and 75 percent of the time period defined by the frequency, and more preferably between 1 and 50 percent of the time period defined by the frequency. Thus, for example, for a frequency of 150 Hz, the pulse duration is preferably in the range of 0.67 microseconds to 5 milliseconds, and more preferably in the range of 66.7 microseconds to 3.3 milliseconds. Alternately, for example, for a frequency of 1 kHz, the pulse duration is preferably in the range of 0.1 microseconds to 0.75 milliseconds, and more preferably in the range of 10 microseconds to 0.5 milliseconds. The frequency and/or pulse duration can be changed during system operation, thus allowing the system output efficiency to be continually optimized. Although voltage source 119 can include internal pulsing means, preferably an external pulse generator 125 controls a high voltage switch 127 which, in turn, controls the output of voltage source 119.

As described herein, the electrolysis process of the invention generates considerable heat. It will be appreciated that if the system is allowed to become too hot, the fluid within tank 101 will begin to boil. Additionally, other components such as membrane 105 may be susceptible to heat damage. Accordingly the system can be turned off and allowed to cool when the temperature exceeds a preset value, for example using a control

system coupled to a thermocouple or other heat monitor which triggers the control system when the system (or tank fluid) exceeds the preset value. A more efficient, and preferred, approach uses means which actively cool the system to maintain the temperature within an acceptable range. In at least one preferred embodiment, the cooling system does not allow the temperature to exceed 90° C. Although it will be appreciated that the invention is not limited to a specific type of cooling system or a specific implementation of the cooling system, in at least one embodimcnt tank 101 is surrounded by a coolant conduit 129, portions of which are shown in Figs. 1-7. Within coolant conduit 129 is a heat transfer medium, for example water. Coolant conduit 129 can either surround a portion of the electrolysis tank as shown, or be contained within the electrolysis tank, or be integrated within the walls of the electrolysis tank. The coolant pump and refrigeration system is not shown in the figures as cooling systems are well known by those of skill in the art.

As will be appreciated by those of skill in the art, there are numerous minor variations of the system described herein and shown in Fig. 1 that will function substantially the same as the disclosed system. As previously noted, alternate configurations can utilize differently sized/shaped tanks, different electrolytic solutions, and a variety of different electrode/metal member configurations and materials. Additionally the system can utilize a range of input powers, frequencies and pulse widths (i.e., pulse duration). In general, the exact configuration depends upon the desired output as well as available space and power. Figs. 2-7 illustrate a few alternate configurations, including the use of multiple metal members per tank region (i.e., Fig. 2), multiple pairs of high voltage electrodes (i.e., Fig. 3), multiple metal members per tank region and multiple pairs of high voltage electrodes (e.g., Fig. 4), vertical cylindrical tanks (e.g., Fig. 5), and horizontal cylindrical tanks (e.g., Figs. 6 and 7).

Fig. 2 illustrates an alternate embodiment of the system shown in Fig. 1, the alternate configuration replacing single metal member 121 with four metal members 201-204 and replacing single metal member 123 with four metal members 205-208.

Fig. 3 illustrates an alternate embodiment of the system shown in Fig. 1, the alternate configuration replacing high voltage electrode 115 with three high voltage

electrodes 301-303 and replacing high voltage electrode 117 with three high voltage electrodes 305-307.

Fig. 4 illustrates an alternate embodiment of the system shown in Fig. 1, the alternate configuration replacing single metal member 121 with four metal members 401-404, replacing single metal member 123 with four metal members 405-408, replacing high voltage electrode 115 with three high voltage electrodes 409-411 and replacing high voltage electrode 117 with three high voltage electrodes 413-415.

Fig. 5 illustrates an alternate embodiment of the system shown in Fig. 1, the alternate configuration replacing tank 101 with a vertically configured cylindrical tank 501.

Fig. 6 illustrates an alternate embodiment of the system shown in Fig. 1, the alternate configuration replacing tank 101 with a horizontally configured cylindrical tank 601, replacing membrane 105 with an appropriately shaped membrane 603, replacing metal members 121/123 with shaped metal members 605/606 and replacing high voltage electrodes 115/117 with shaped high voltage electrodes 607/608.

Fig. 7 illustrates an alternate embodiment of the system shown in Fig. 1, the alternate configuration replacing tank 101 with a horizontally configured cylindrical tank 701 which utilizes a lengthwise membrane 703. Additionally, metal members 121/123 are replaced by metal members 705/706 and high voltage electrodes 115/117 are replaced with high voltage electrodes 707/708.

As previously noted, the present electrolysis system can be used to generate hydrogen gas and oxygen gas. The primary use, however, of the present configuration is as a means of generating heat.

In one set of tests that illustrate the heat generation capabilities of the electrolysis system of the invention, a cylindrical chamber configured as shown in Fig. 5 was used. The tank was 125 centimeters high with an inside diameter of 44 centimeters and an outside diameter of 50 centimeters. The tank contained 175 liters of water, the water including a potassium hydroxide (KOH) electrolyte at a concentration of 0.1 % by weight. The metal members, i.e., members 121/123 in Fig. 5, were 75 centimeters by 30 centimeters by 0.5 centimeters and had a separation distance of approximately 10 centimeters. The high voltage electrodes, i.e., electrodes 115/117 in Fig. 5, were 3 centimeters by 2.5 centimeters

by 0.5 centimeters and had a separation distance of approximately 32 centimeters. The high voltage electrodes and the metal members were fabricated from stainless steel. The pulse frequency was maintained at 150 Hz and the pulse duration was initially set to 250 microseconds and gradually lowered to 200 microseconds during the course of a 2 hour run. The high voltage supply was set to 910 volts, drawing a current of between 2.21 and 2.45 amps. The initial temperature was 30° C and monitored continuously with a pair of thermocouples, one in each side of the tank. After conclusion of the 2 hour run, the temperature of the tank fluid had increased to 60° C.

The inventor has found a direct correlation between the size of the high voltage electrodes and the heat production efficiency of the electrolysis apparatus of the invention, the greater the electrode size the higher the heat production efficiency. For example in another test, the high voltage electrodes of the previous test were replaced with larger electrodes, the larger electrodes measuring 9.5 centimeters by 5 centimeters by 0.5 centimeters, thus providing approximately 6.3 times the surface area of the previous high voltage electrodes. The larger electrodes, still operating at a voltage of 910 volts, drew a current of between 1.6 and 1.94 amps. Although the pulse frequency was still maintained at 150 Hz, the pulse duration was lowered from an initial setting of 90 microseconds to 25 microseconds. All other operating parameters were the same as in the previous test. In this test, during the course of a 6 hour run, the temperature of the tank fluid increased from 23° C to 68° C. Given the shorter pulses and the lower current, this test with the larger high voltage electrodes exhibited a heat production efficiency approximately 3 times that exhibited in the previous test.

It should be understood that the present invention can be operated in a number of modes, the primary difference between modes being the degree of process optimization used during operation. For example, Fig. 8 illustrates one method of operation requiring minimal optimization. As illustrated, initially the electrolysis tank is filled with water (step 801). The level of water in the tank preferably just covers the top of the electrodes although the process can also be run with even more water filling the tank. The electrolyte can either be mixed into the water prior to filling the tank or after the tank is filled. The frequency of the pulse generator is then set (step 803) as well as the pulse duration (step 805), the pulse

generator controlling the output pulse frequency/duration for the high voltage supply. The initial voltage settings for the high voltage power supply (e.g., source 119) is also set (step 807), although it will be appreciated that the order of set-up is clearly not critical to the electrolysis process. Once set-up is complete, electrolysis is initiated (step 809) and continues (step 811) until process termination is desired (step 813).

The above sequence of processing steps works best once the operational parameters have been optimized for a specific system configuration since the system configuration will impact the heat production efficiency of the process and therefore the system output. Exemplary system configuration parameters that affect the optimal electrolysis settings include tank size, quantity of water, type and/or quality of water, electrolyte composition, electrolyte concentration, pressure, electrode size, electrode composition, electrode shape, electrode separation, high voltage setting, pulse frequency and pulse duration.

Fig. 9 illustrates an alternate procedure appropriate for use with new, untested system configurations, the approach providing optimization steps. Initially the tank is filled (step 901) and initial settings for pulse frequency (step 903), pulse duration (step 905) and high voltage supply output (step 907) are made. Typically the initial settings are based on previous settings that have been optimized for a similarly configured system. For example, assuming that the new configuration was the same as a previous configuration except for the composition of the electrodes, a reasonable initial set-up would be the optimized set-up from the previous configuration.

After the initial set-up is completed, electrolysis is initiated (step 909) and the output of the system is monitored (step 911). Thus, for example, assuming that the system is to be optimized for heat production, the rate of temperature increase would be monitored in step 911. System optimization can begin immediately or the system can be allowed to run for an initial period of time (step 913) prior to optimization. As step 913 is optional, it is shown in phantom. The initial period of operation can be based on achieving a predetermined temperature or a different criteria can be used. Alternately the initial period of time can simply be a predetermined time period, for example 30 minutes.

After the initial time period is exceeded, assuming that the selected approach uses step 913, the system output is monitored (step 915) while optimizing each of the operational parameters. Although the order of parameter optimization is not critical, in at least one preferred embodiment the first parameter to be optimized is pulse duration (step 917) followed by the optimization of the pulse frequency (step 918). Then the voltage of the high voltage supply is optimized (step 919). In this embodiment after optimization is complete, based on system performance, the electrolysis process is allowed to continue (step 921) without further optimization until the process is halted, step 923. In another, and preferred, alternative approach illustrated in Fig. 10, optimization steps 917-919 are performed continuously throughout the electrolysis process until electrolysis is suspended. Alternately a subset of steps 917-919 can be performed continuously throughout the electrolysis process.

The optimization process described relative to Figs. 9 and 10 can be performed manually. In the preferred embodiment, however, the system and the optimization of the system are controlled via computer as illustrated in the block diagram of Fig. 11. As shown, computer 1101 receives system performance data from monitor 1103. For example, monitor 1103 can monitor the temperature of the fluid within the tank, thus allowing absolute temperature and the rate of temperature change to be monitored and/or determined. Using this information computer 1101 varies the output of high voltage source 1105 and the frequency and pulse duration generated by pulse generator 1107 in order to optimize the output of the system as previously described.

As previously described, preferably the electrodes are flat and arranged such that the flat electrodes faces are parallel to one another. This is illustrated in Fig. 12 which is a top, cross-sectional view of the electrode configuration of the system illustrated in Fig. 1. It should be appreciated that such a configuration is not a requirement of the invention. For example, some or all of the electrodes can utilize curved surfaces and/or be arranged in a non-parallel geometry.

As will be understood by those familiar with the art, the present invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. Accordingly, the disclosures and descriptions herein are intended to

be illustrative, but not limiting, of the scope of the invention which is set forth in the following claims.

WHAT IS CLAIMED IS:

1. An electrolysis system comprising:

an electrolysis tank;

a membrane separating said electrolysis tank into a first region and a second region, wherein said membrane restricts hydrogen gas flow and oxygen gas flow between said first and second regions;

at least one pair of high voltage electrodes contained within said electrolysis tank, wherein each pair of said at least one pair of high voltage electrodes includes an anode and a cathode, wherein said anodes of said at least one pair of high voltage electrodes are contained within said first region, and wherein said cathodes of said at least one pair of high voltage electrodes are contained within said second region;

a plurality of metal members contained within said electrolysis tank, wherein at least a first metal member of said plurality of metal members is contained within said first region and interposed between said anode of said at least one pair of high voltage electrodes and said membrane, and wherein at least a second metal member of said plurality of metal members is contained within said second region and interposed between said cathode of said at least one pair of high voltage electrodes and said membrane;

a high voltage source electrically connected to said at least one pair of high voltage electrodes; and

means for pulsing said high voltage source voltage at a specific frequency and with a specific pulse duration.

2. The electrolysis system of claim 1, further comprising means for cooling said electrolysis system.

3. The electrolysis system of claim 2, wherein said cooling means is comprised of a conduit containing a heat transfer medium, wherein a portion of said conduit is in thermal communication with at least a portion of said electrolysis tank.

4. The electrolysis system of claim 3, wherein said portion of said conduit surrounds at least a portion of said electrolysis tank.

5. The electrolysis system of claim 3, wherein said portion of said conduit is contained within said electrolysis tank.

6. The electrolysis system of claim 3, wherein said portion of said conduit is integrated within a portion of a wall comprising said electrolysis tank.

7. The electrolysis system of claim 3, wherein said heat transfer medium is comprised of water.

8. The electrolysis system of claim 1, wherein said pulsing means comprises a pulse generator coupled to said high voltage source.

9. The electrolysis system of claim 8, wherein said pulse generator is integrated within said high voltage source.

10. The electrolysis system of claim 1, wherein said pulsing means comprises a pulse generator coupled to a high voltage switch, wherein said high voltage switch is coupled to said high voltage source.

11. The electrolysis system of claim 1, wherein each high voltage anode of said at least one pair of high voltage electrodes is comprised of a first material and each high voltage cathode of said at least one pair of high voltage electrodes is comprised of a second material, and wherein said first and second materials are selected from the group consisting of steel, nickel, copper, iron, stainless steel, cobalt, manganese, zinc, titanium, platinum, palladium, carbon, graphite, carbon-graphite, and alloys of steel, nickel, copper, iron, stainless steel, cobalt, manganese, zinc, titanium, platinum, palladium, carbon, graphite, and carbon-graphite, and wherein each metal member of said plurality of metal members is comprised of a third material selected from the group consisting of steel, nickel, copper, iron,

stainless steel, cobalt, manganese, zinc, titanium, platinum, palladium, and alloys of steel, nickel, copper, iron, stainless steel, cobalt, manganese, zinc, titanium, platinum, palladium.

12. The electrolysis system of claim 1, further comprising a liquid within said electrolysis tank.

13. The electrolysis system of claim 13, wherein said liquid includes at least one of water, deuterated water, tritiated water, semiheavy water, heavy oxygen water, water containing an isotope of hydrogen, or water containing an isotope of oxygen.

14. The electrolysis system of claim 13, further comprising an electrolyte within said liquid, said electrolyte having a concentration of between 0.05 and 10.0 percent by weight.

15. The electrolysis system of claim 13, further comprising an electrolyte within said liquid, said electrolyte having a concentration of between 0.05 and 2.0 percent by weight.

16. The electrolysis system of claim 13, further comprising an electrolyte within said liquid, said electrolyte having a concentration of between 0.1 and 0.5 percent by weight.

17. The electrolysis system of claim 13, further comprising an electrolyte within said liquid, said electrolyte comprised of potassium hydroxide.

18. The electrolysis system of claim 1, wherein an output voltage corresponding to said high voltage source is between 50 volts and 50 kilovolts.

19. The electrolysis system of claim 1, wherein an output voltage corresponding to said high voltage source is between 100 volts and 5 kilovolts.

20. The electrolysis system of claim 1, wherein the electrodes of each pair of said at least one pair of high voltage electrodes are positioned parallel to one another.

21. The electrolysis system of claim 1, wherein said specific frequency is between 50 Hz and 1 MHz.

22. The electrolysis system of claim 1, wherein said specific pulse duration is between 0.01 and 75 percent of a time period defined by said specific frequency.

23. The electrolysis system of claim 1, wherein said specific pulse duration is between 1 and 50 percent of a time period defined by said specific frequency.

24. A method of operating an electrolysis system comprising the steps of:

filling an electrolysis tank with a liquid;

positioning at least one pair of high voltage electrodes within said electrolysis tank, wherein each pair of said at least one pair of high voltage electrodes includes at least one high voltage cathode electrode and at least one high voltage anode electrode, wherein each high voltage cathode electrode is positioned within a first region of said electrolysis tank and each high voltage anode electrode is positioned within a second region of said electrolysis tank, said first and second regions of said electrolysis tank separated by a membrane;

positioning a plurality of metal members within said electrolysis tank, said metal member positioning step further comprising the steps of:

positioning at least a first metal member of said plurality of metal members within said first region between said at least one high voltage cathode electrode and said membrane; and

positioning at least a second metal member of said plurality of metal members within said second region between said at least one high voltage anode electrode and said membrane; and

applying a high voltage to said at least one pair of high voltage electrodes, said applying step further comprising the step of pulsing said high voltage applied to said at least one pair of high voltage electrodes at a first frequency and with a first pulse duration.

25. The method of claim 24, further comprising the step of selecting said liquid from the group consisting of water, deuterated water, tritiated water, semiheavy water,

heavy oxygen water, water containing an isotope of hydrogen, or water containing an isotope of oxygen.

26. The method of claim 24, further comprising the step of adding an electrolyte to said liquid.

27. The method of claim 26, further comprising the step of selecting a concentration of said electrolyte to be within a range of 0.05 and 10.0 percent by weight.

28. The method of claim 26, further comprising the step of selecting a concentration of said electrolyte to be within a range of 0.05 and 2.0 percent by weight.

29. The method of claim 26, further comprising the step of selecting a concentration of said electrolyte to be within a range of 0.1 and 0.5 percent by weight.

30. The method of claim 24, further comprising the steps of:

fabricating said at least one high voltage cathode electrode of said at least one pair of high voltage electrodes from a first material;

fabricating said at least one high voltage anode electrode of said at least one pair of high voltage electrodes from a second material;

fabricating said plurality of metal members from a third material;

selecting said first material, second and third materials from the group consisting of steel, nickel, copper, iron, stainless steel, cobalt, manganese, zinc, titanium, platinum, palladium, carbon, graphite, carbon-graphite, and alloys of steel, nickel, copper, iron, stainless steel, cobalt, manganese, zinc, titanium, platinum, palladium, carbon, graphite, and carbon-graphite.

31. The method of claim 24, further comprising the step of selecting said high voltage within the range of 50 volts to 50 kilovolts.

32. The method of claim 24, further comprising the step of selecting said high voltage within the range of 100 volts to 5 kilovolts.

33. The method of claim 24, further comprising the step of selecting said first frequency to be within the range of 50 Hz and 1 MHz.

34. The method of claim 24, further comprising the step of selecting said first pulse duration to be between 0.01 and 75 percent of a time period defined by said first frequency.

35. The method of claim 24, further comprising the step of selecting said first pulse duration to be between 1 and 50 percent of a time period defined by said first frequency.

36. The method of claim 24, further comprising the steps of:

monitoring an output parameter of said electrolysis system; and

optimizing an operational parameter of said electrolysis system in response to said monitored output parameter.

37. The method of claim 36, further comprising the step of selecting said high voltage as said operational parameter.

38. The method of claim 36, further comprising the step of selecting said first frequency as said operational parameter.

39. The method of claim 36, further comprising the step of selecting said first pulse duration as said operational parameter.

40. The method of claim 36, further comprising the step of selecting heat generation as said output parameter.

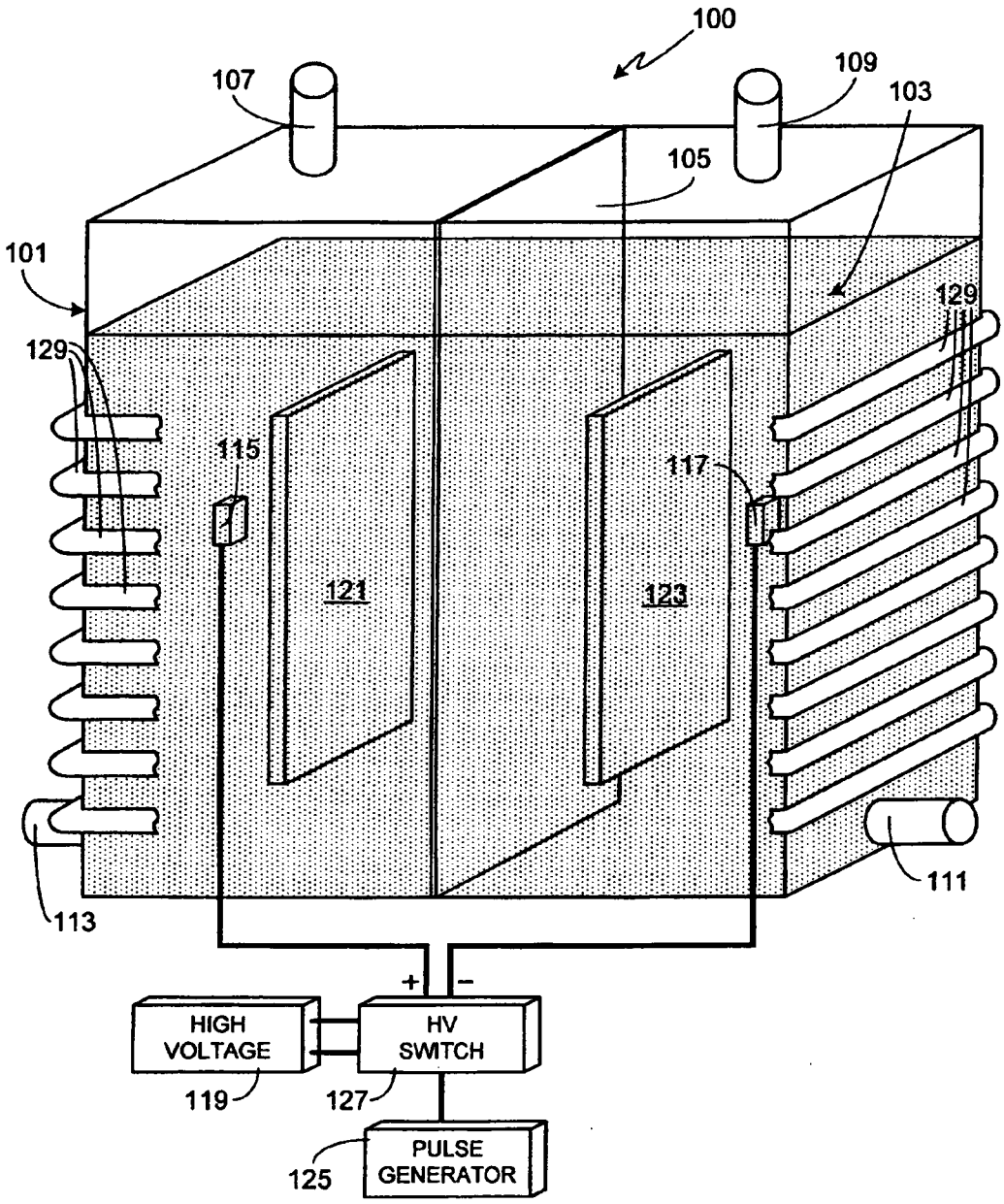
41. The method of claim 36, further comprising the step of selecting hydrogen generation as said output parameter.

42. The method of claim 36, further comprising the step of operating said electrolysis system for an initial period of time prior to performing said optimizing step.

43. The method of claim 36, further comprising the step of achieving a preset value for said output parameter prior to performing said optimizing step.

44. The method of claim 36, wherein said optimizing step is performed repeatedly.

45. The method of claim 36, wherein said optimizing step is automated.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HIGH VOLTAGE
HV SWITCH
119
127
PULSE GENERATOR
125

FIG. 1

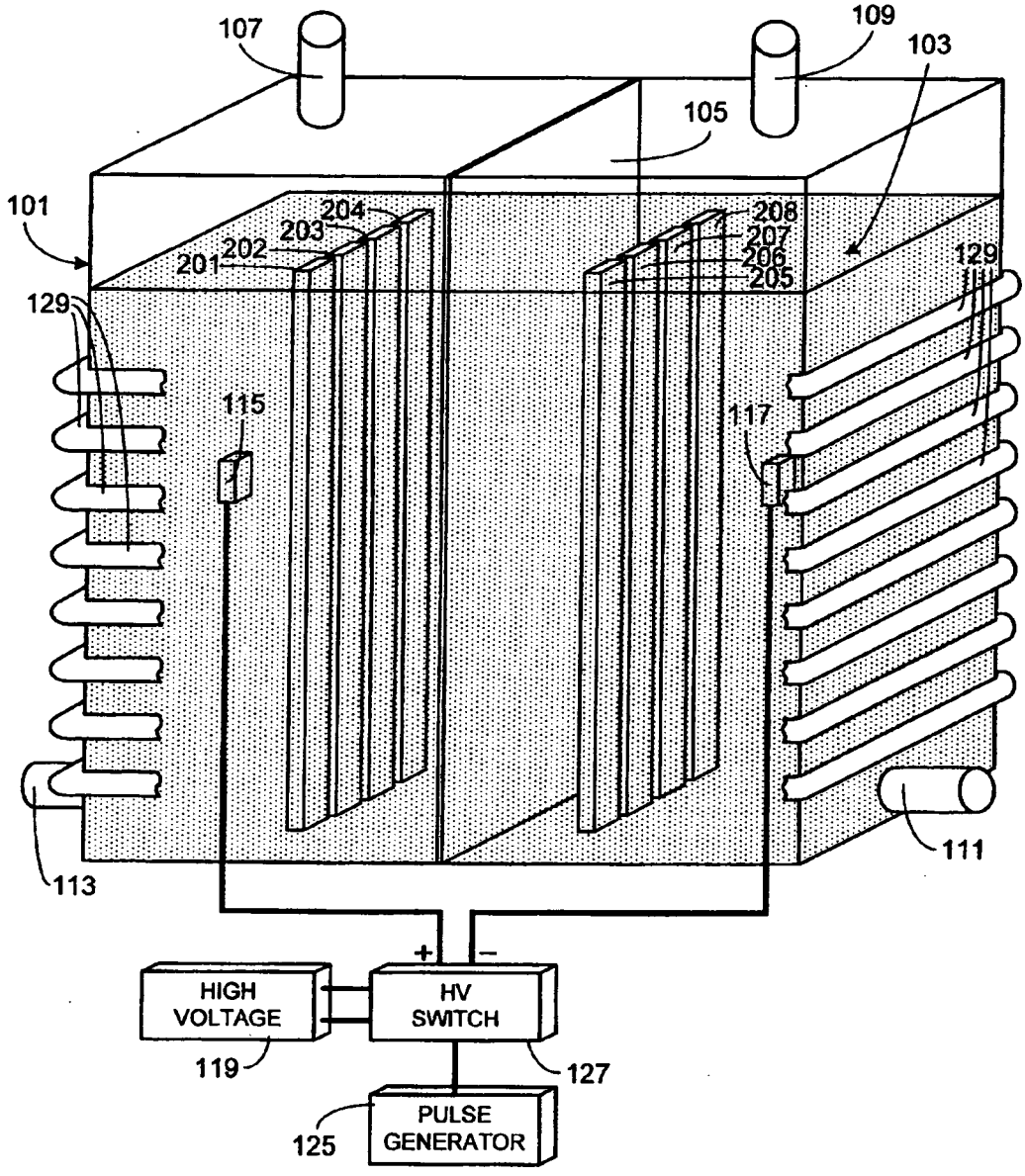
107
109
103
105
101
204
203
202
201
208
207
206
205
129
129
115
117
111
113
+
−
HIGH VOLTAGE
HV SWITCH
119
127
PULSE GENERATOR
125

FIG. 2

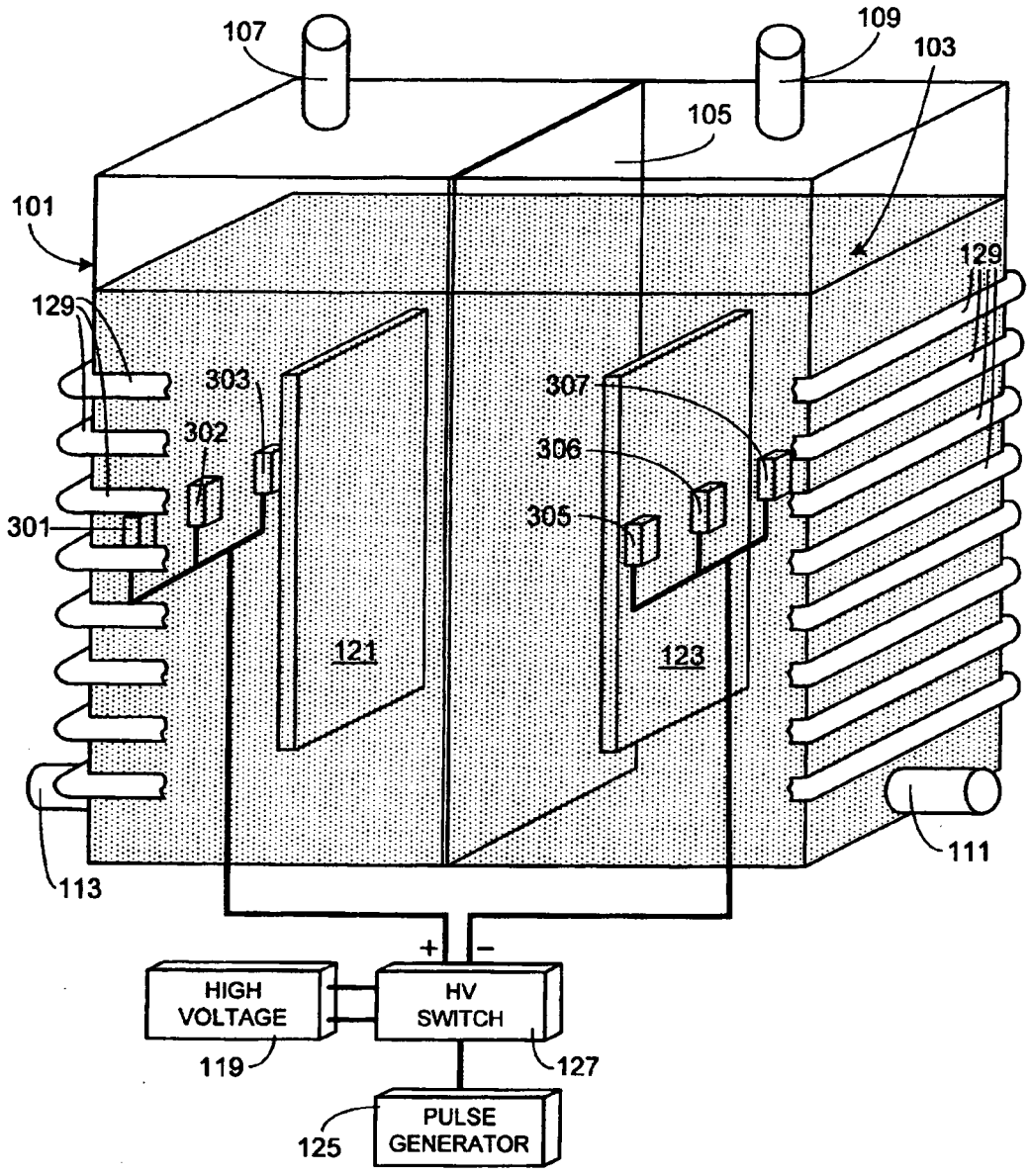
107
109
103
105
101
129
129
303
302
301
307
306
305
121
123
111
113
+
−
HIGH VOLTAGE
HV SWITCH
119
127
PULSE GENERATOR
125

FIG. 3

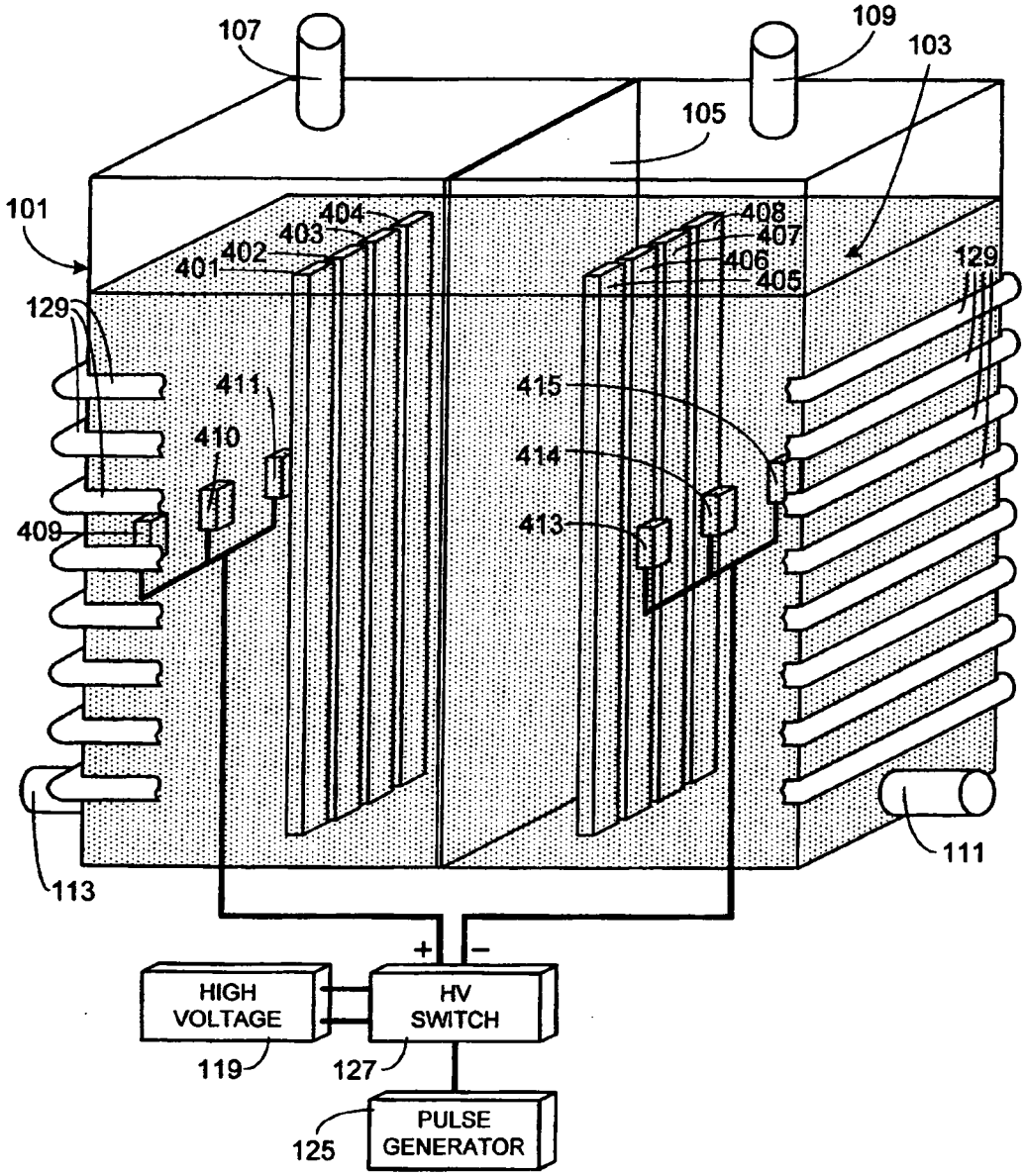
107
109
103
105
101
404
403
402
401
408
407
406
405
129
129
411
410
409
415
414
413
111
113
+
−
HIGH VOLTAGE
HV SWITCH
119
127
PULSE GENERATOR
125

FIG. 4

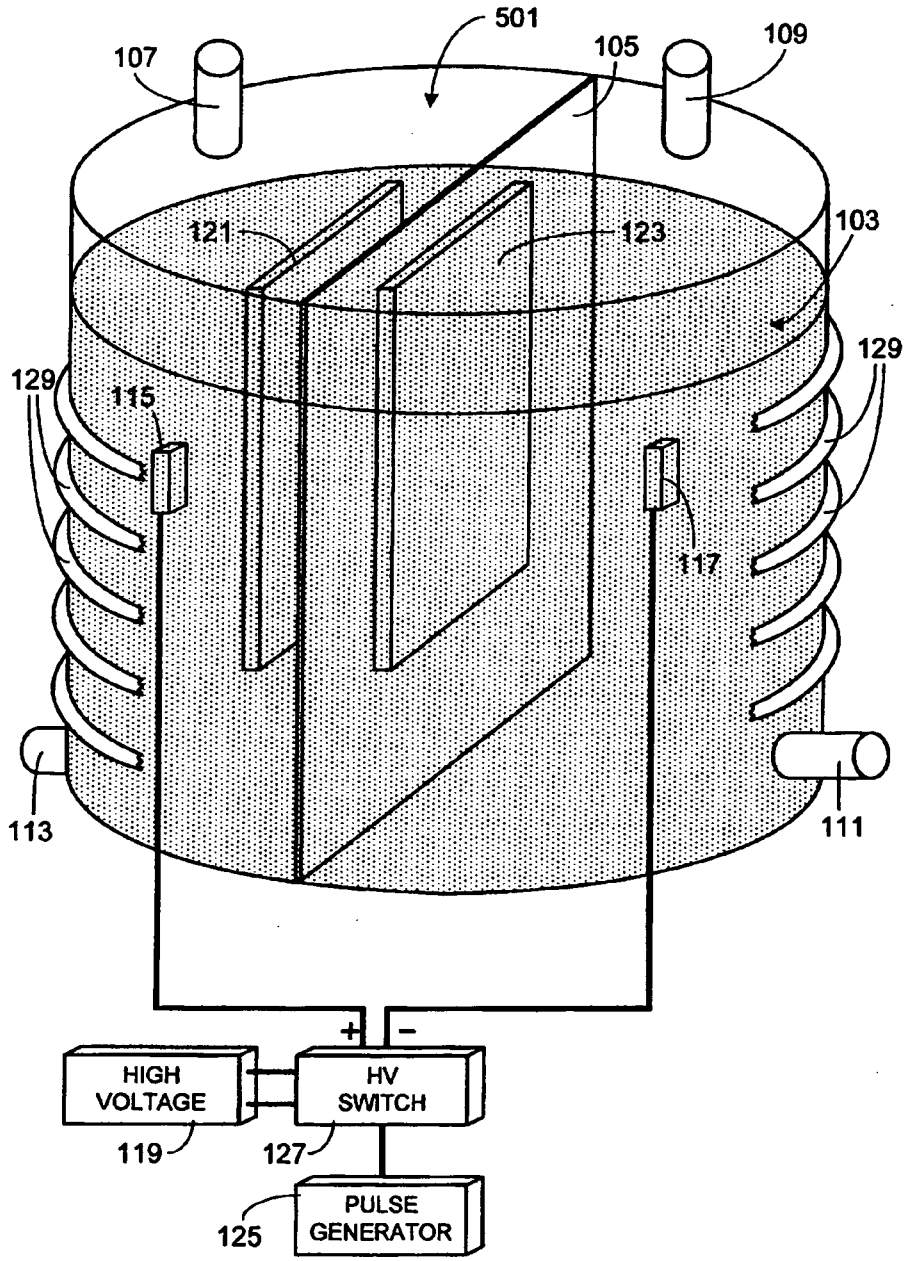
501
107
105
109
121
123
103
129
129
115
117
113
111
+
−
HIGH VOLTAGE
HV SWITCH
119
127
PULSE GENERATOR
125

FIG. 5

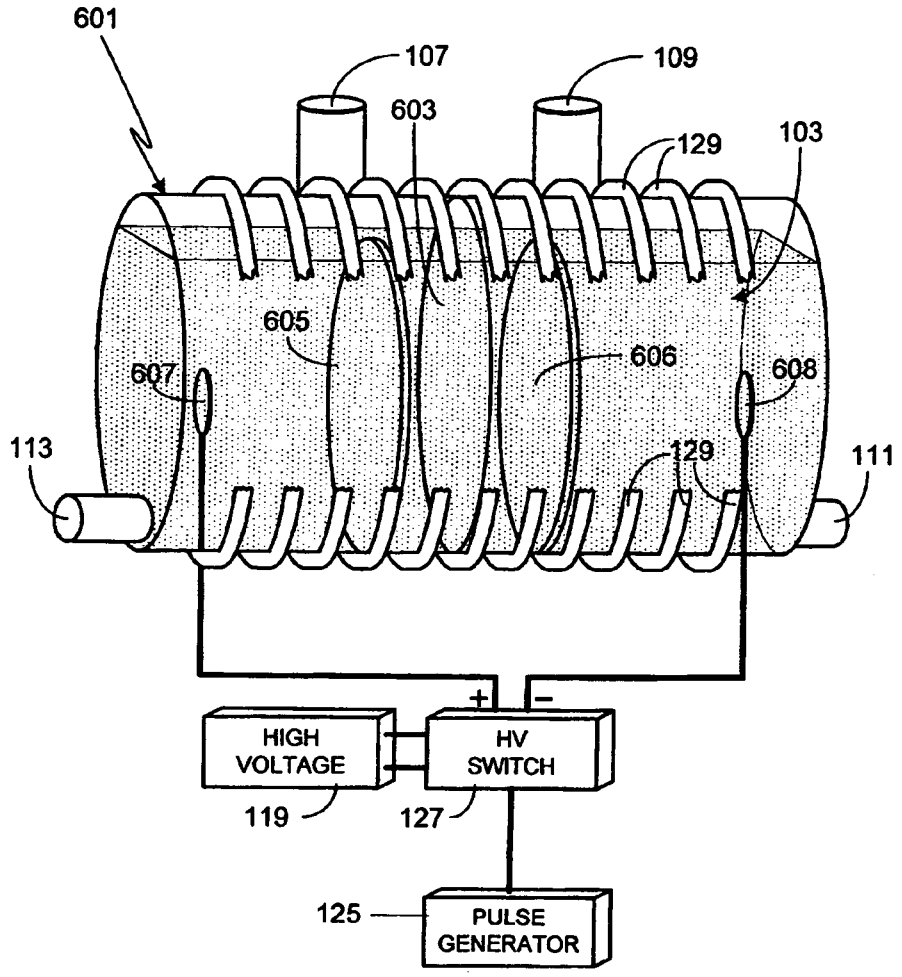
601
107
109
603
129
103
605
606
607
608
113
129
111
+
−
HIGH VOLTAGE
HV SWITCH
119
127
125
PULSE GENERATOR

FIG. 6

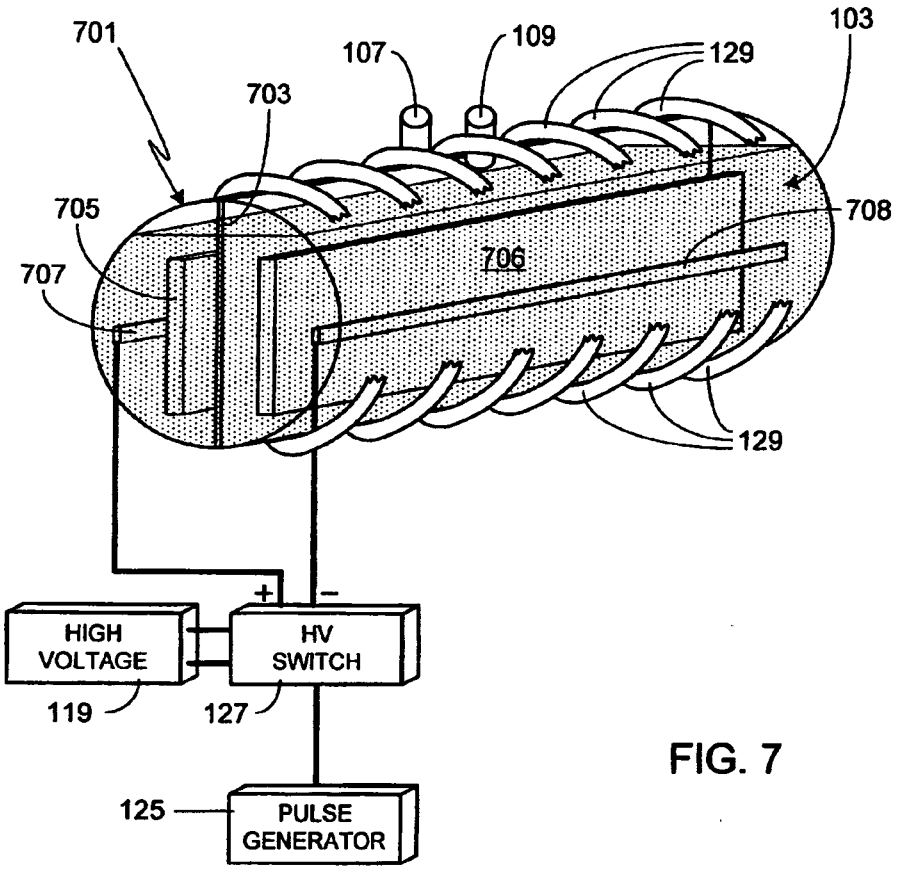
701
703
107
109
129
103
705
708
707
706
129
+
−
HIGH VOLTAGE
HV SWITCH
119
127
125
PULSE GENERATOR

FIG. 7

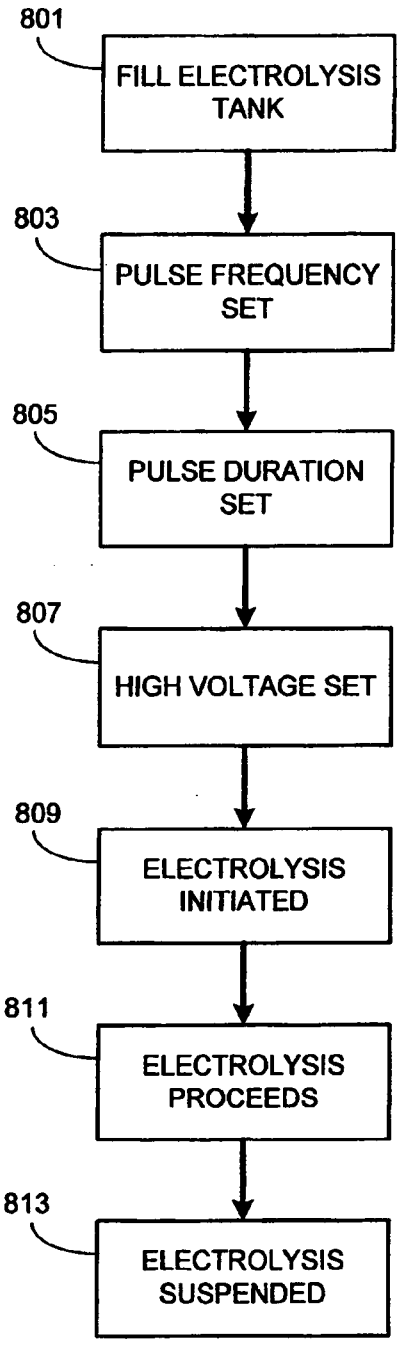
801
FILL ELECTROLYSIS TANK
803
PULSE FREQUENCY SET
805
PULSE DURATION SET
807
HIGH VOLTAGE SET
809
ELECTROLYSIS INITIATED
811
ELECTROLYSIS PROCEEDS
813
ELECTROLYSIS SUSPENDED

FIG. 8

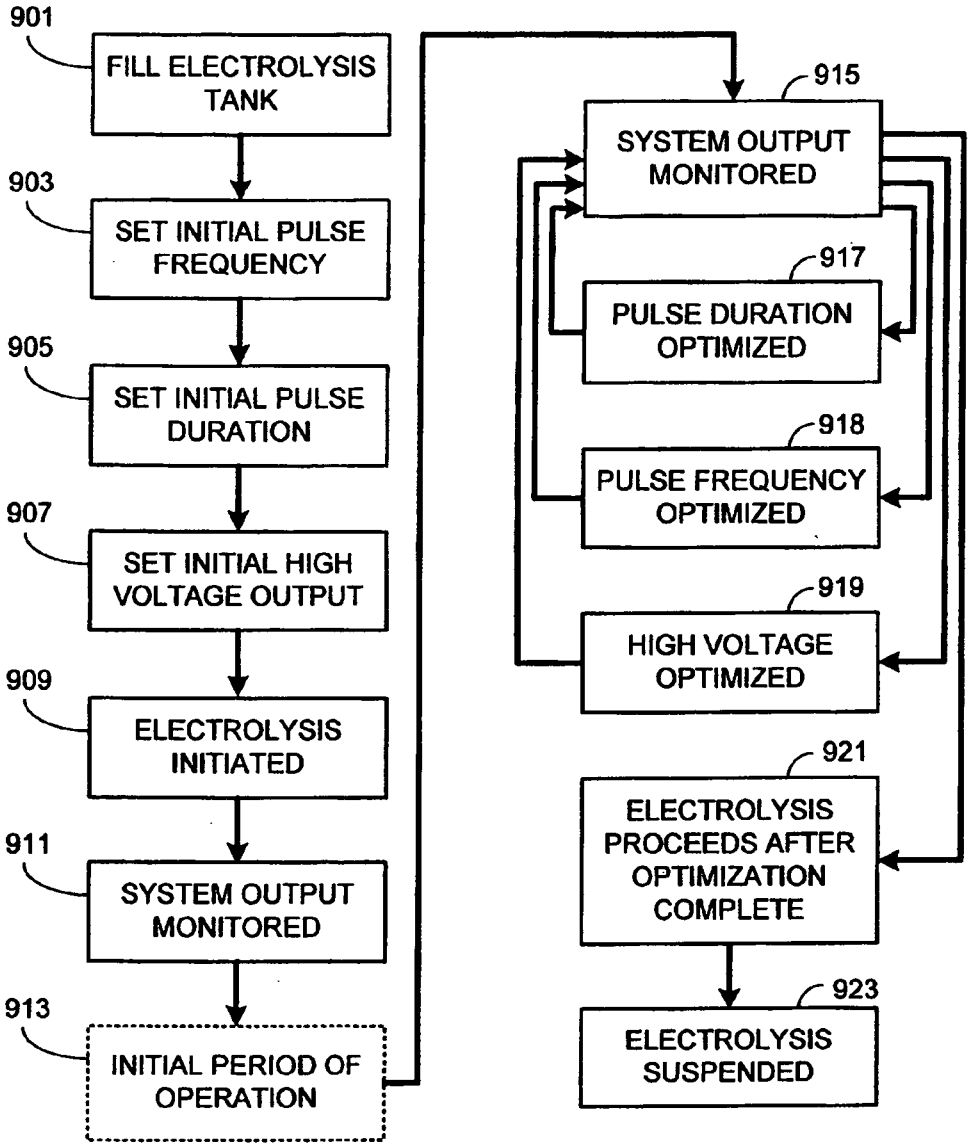
901
FILL ELECTROLYSIS TANK
903
SET INITIAL PULSE FREQUENCY
905
SET INITIAL PULSE DURATION
907
SET INITIAL HIGH VOLTAGE OUTPUT
909
ELECTROLYSIS INITIATED
911
SYSTEM OUTPUT MONITORED
913
INITIAL PERIOD OF OPERATION
915
SYSTEM OUTPUT MONITORED
917
PULSE DURATION OPTIMIZED
918
PULSE FREQUENCY OPTIMIZED
919
HIGH VOLTAGE OPTIMIZED
921
ELECTROLYSIS PROCEEDS AFTER OPTIMIZATION COMPLETE
923
ELECTROLYSIS SUSPENDED

FIG. 9

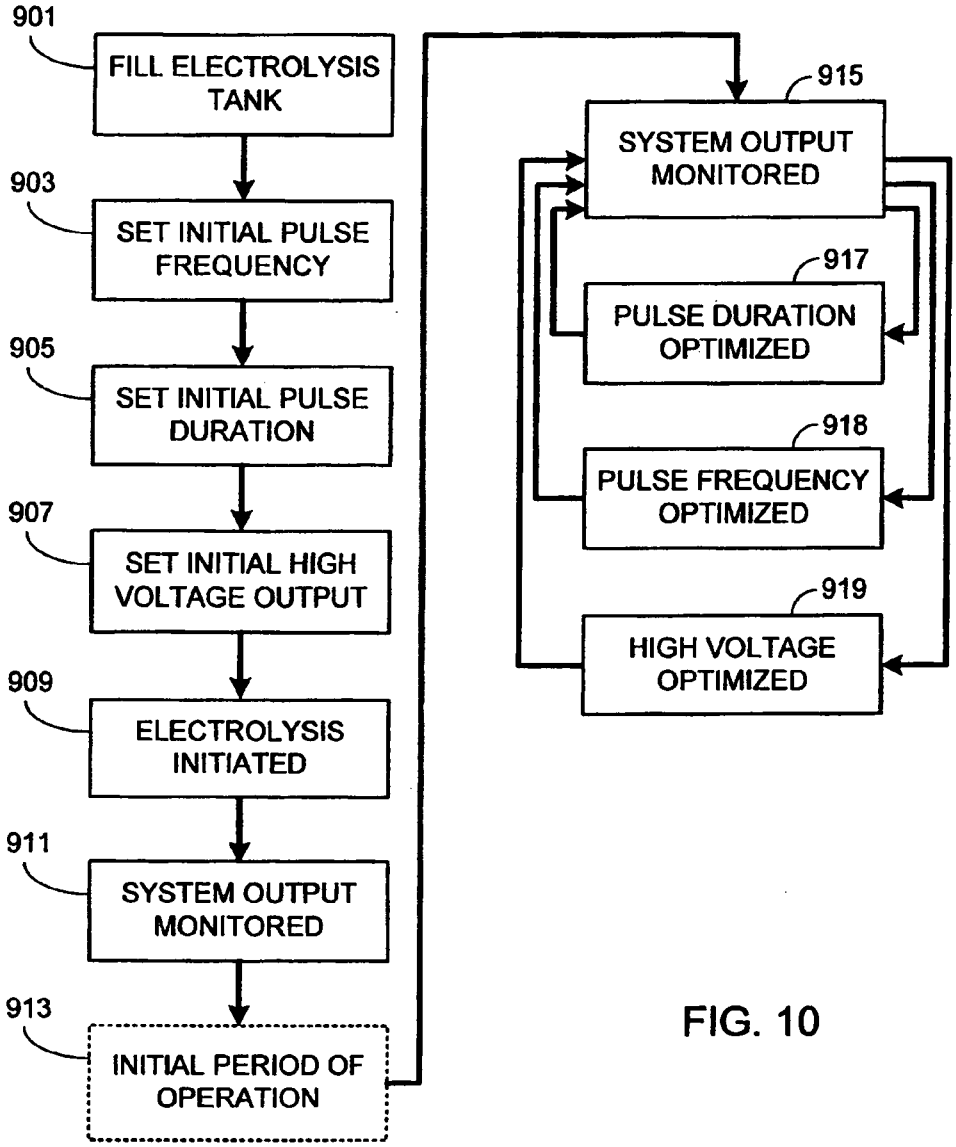
901
FILL ELECTROLYSIS TANK
903
SET INITIAL PULSE FREQUENCY
905
SET INITIAL PULSE DURATION
907
SET INITIAL HIGH VOLTAGE OUTPUT
909
ELECTROLYSIS INITIATED
911
SYSTEM OUTPUT MONITORED
913
INITIAL PERIOD OF OPERATION
915
SYSTEM OUTPUT MONITORED
917
PULSE DURATION OPTIMIZED
918
PULSE FREQUENCY OPTIMIZED
919
HIGH VOLTAGE OPTIMIZED

FIG. 10

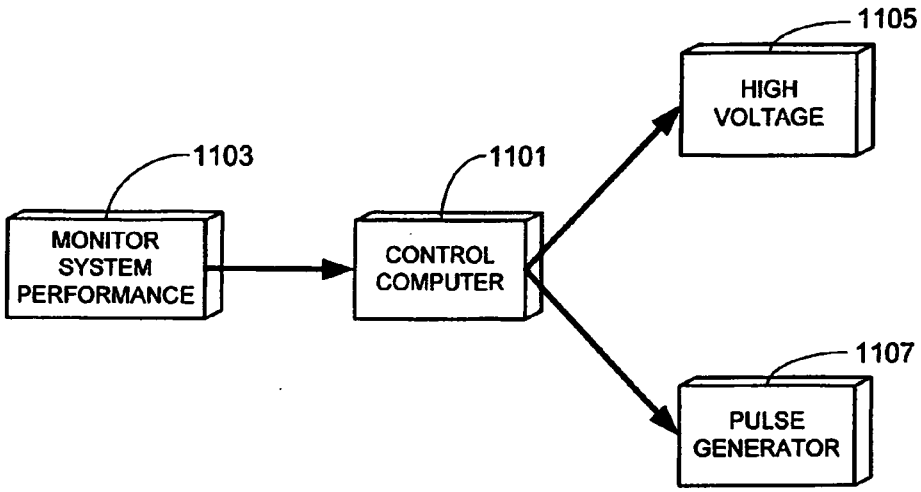
1105
HIGH VOLTAGE
1103
1101
MONITOR SYSTEM PERFORMANCE
CONTROL COMPUTER
1107
PULSE GENERATOR

FIG. 11

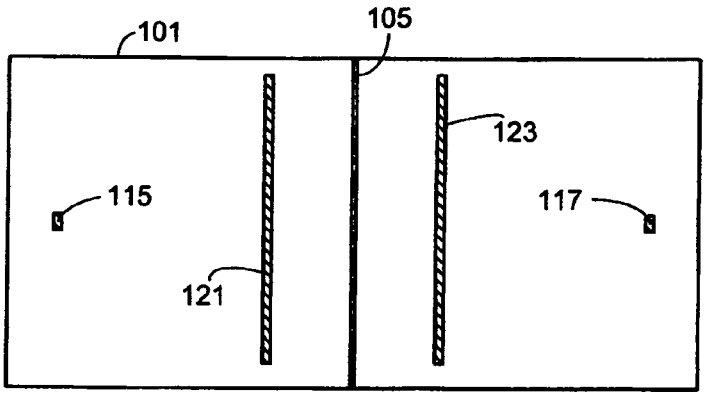

FIG. 12