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(54) Title: SYSTEMS, METHODS AND CELLS FOR PRODUCTION OF HYDROGEN FOR USE IN A COMBUSTION ENGINE

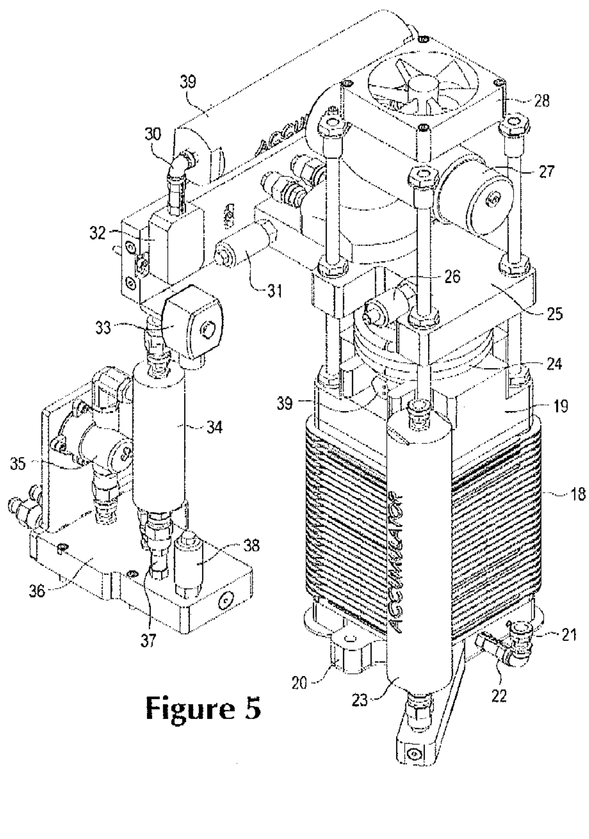

Figure 5

(57) Abstract: The system includes a housing, a voltage regulator coupled to the housing, the voltage regulator operable to increase an input voltage from a lower voltage to a higher operating voltage, a hydrogen-producing cell coupled to the voltage regulator comprising a senes of conical shaped electrodes, the hydrogen producing cell containing a mixture of water and an electrolyte, and operable to produce hydrogen when receiving the operating voltage from the voltage regulator, a fuel-mixing area coupled to the hydrogen-producing cell, the fuel-mixing area receiving a petroleum based fuel and hydrogen from the hydrogen-producing cell and producing a blended (hydrogenated) fuel by mixing the hydrogen and petroleum based fuel, the fuel-mixing area outputting the blended fuel to a fuel intake port of an internal combustion engine (ICE) With a distilled water-based fuel source, the system's chemistry and electrode design shapes are elements of an efficient method of hydrogen and oxygen fabrication.

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SYSTEMS, METHODS AND CELLS FOR PRODUCTION OF HYDROGEN FOR USE IN A COMBUSTION ENGINE

RELATED APPLICATIONS

[0001] The present application claims priority to US Provisional Patent Application Serial No. 61/273,418, entitled A SYSTEM AND METHOD FOR THE PRODUCTION OF HYDROGEN FOR THE USE IN A COMBUSTION ENGINE, filed August 3, 2009, the contents of which are hereby incorporated herein in their entirety by this reference.

TECHNICAL FIELD OF THE INVENTION

[0002] This invention relates to the field of the production of hydrogen through electrolysis of water and, more specifically to a system and method for the production of hydrogen for the use in a combustion engine.

BACKGROUND OF THE INVENTION

[0003] It is well known that hydrogen gas can be produced by passing a current through two or more conductive materials that are submerged in an electrically conductive liquid that is part distilled water and part conductive electrolytes. This electrolysis process fractures H_2O into its atomic elements of hydrogen and oxygen.

[0004] Much has been written on the use of HHO as an additive fuel source for internal combustion engines. In these writings, the HHO gas is discussed as an on-demand additive gas that is added to the air intake of the combustion engine. The additive gas (HHO) supposedly aids in the complete burn of the hydrocarbon fuels, increasing fuel economy and decreasing emissions.

[0005] The basic Brown's Gas Generator is an example of one device that uses electrolysis to create hydrogen and oxygen gases. The generator works by providing DC electricity to an anode and cathode immersed in an electrolyte solution. The generator comprises of a plurality of cells. Each cell produces an equal amount of HHO gas. The number of cells is dependent on the current and voltage supply available. Each cell produces HHO gas for every 1.5 volts applied to the electrode. Applying more than 1.5 volts only results in an increase in heat with no additional gas production.

[0006] Hydrogen generators, such as Brown's Gas Generator, have been suggested for use in conjunction with internal combustion engines such as those found in automobiles to increase gas mileage and decrease emissions. However, current implementations of hydrogen generators and internal combustion engines have several drawbacks.

[0007] For example, typical generators, produce only a small amount of hydrogen and oxygen, limiting the benefits of added hydrogen and oxygen preferably in the form of HHO. Also, present generators lack safety features to check for hydrogen leaks or hydrogen. This could result in a potentially dangerous situation if the hydrogen were ignited. Current systems also combine other design flaws such as flaws in the area of power management, heat management, low temperature management and the like. It is believed that injecting HHO or other hydrogen-based fuel into the air inlet of an internal combustion engine produces pre-detonation of the mixed fuel within the cylinder that lowers combustion efficiency in energy production. This lowered efficiency can be exacerbated by on-board computers typically found in modern vehicles such as automobiles.

SUMMARY OF THE INVENTION

[0008] It is desired to provide a hydrogen gas generator which produces hydrogen in a safe manner. Furthermore, the desirable features and characteristics of the present invention will be apparent from the subsequent detailed description and the appended claims, taken in conjunction with the accompanying drawings and the foregoing technical field and background.

[0009] In one embodiment of the present invention, a system is disclosed that improves on the HHO generation process in several areas. Each feature works with the others. Thus, the process of managing, blending, and delivering these fuels work with the benefits each has on the entire system. As will be discussed below, the invention provides many features and advantages over the prior art in the areas of generator shape, mounting, fluid dynamics, power management, heat management, hydrogen management and safety systems, petroleum blending with the hydrogen and oxygen vapors, electrolyte chemistry management and safety, leak detection, water delivery, freezing management, fuel tank design, electrode shape and gas production efficiencies, human interface, logic controls, circuitry, polarity flipping, data logging, experimentation, expanded fields of use, etc.

[0010] The hydrogen generator of the present invention provides an efficient and safe method of fabricating hydrogen and blending it with one or more petroleum-based fuels. These combustible fuels and methods of fabrication achieve improved fuel efficiency along with reduced emissions. The system of the present invention can use 12, 24, 36, or 48VDC power source supplied by the engine to which it is supplying power. With a distilled-water-based fuel source, the system's chemistry and electrode design shapes are important elements behind an efficient method of hydrogen and oxygen fabrication. The system efficiently fractures the H_2O fuel source and delivers it to the engine as a burnable fuel through a combustion engine's fuel intake port, rather than through its air intake port. The invented process of fracturing water provides a system that is safe and easy to maintain along with a high efficiency and reliability factor.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] The present invention will hereinafter be described in conjunction with the following drawing figures, wherein like numerals denote like elements, and:

[0012] FIG. 1 is a front view of an exemplary system for producing hydrogen in accordance with the teachings of the present invention;

[0013] FIG. 2 illustrates a back side of the system including a vertical mounting system in accordance with the teachings of the present invention;

[0014] FIG. 3 illustrates the system with vertical mounting system 8 removed from enclosure 1 in accordance with the teachings of the present invention;

[0015] FIG. 4 is a flow chart illustrating a simplified representation of the process in accordance with the teachings of the present invention;

[0016] FIG. 5 illustrates internal components of system used to move fluid and vapor gasses through the system in a safe reliable manner in accordance with the teachings of the present invention;

[0017] FIG. 6 is a cross section of the cell in accordance with the teachings of the present invention;

[0018] FIG. 7 is a view similar to FIG. 5 except that the view of FIG. 7 is a rotated view in accordance with the teachings of the present invention;

[0019] FIG. 8 illustrates an exemplary embodiment of the controls system side of the system in accordance with the teachings of the present invention;

[0020] FIG. 9 illustrates system with some of the sides removed for easier viewing of the components in accordance with the teachings of the present invention;

[0021] FIG. 10 illustrates the air flow that cools the system in accordance with the teachings of the present invention;

[0022] FIG. 11 describes the path that the fuel and hydrogen will take through the blending head in accordance with the teachings of the present invention;

[0023] FIGs. 12A and 12B are a side view and a front elevation (view) respectively of the fuel passing through the flow meter in accordance with the teachings of the present invention;

[0024] FIGs. 13A, 13B, and 13C respectively illustrate a top plan, side elevation, and isometric view of the static mixing sub assembly that is inserted in the blending head assembly in accordance with the teachings of the present invention;

[0025] FIG. 14 illustrates the electrode shape and components used in the system to isolate the reaction and increase the gas production in accordance with the teachings of the present invention;

[0026] FIG. 15 is a simplified cross-section of the cones, spacers & o-rings stacked on top of each other in accordance with the teachings of the present invention;

[0027] FIG. 16 is a simplified diagram of the fluid filling process in the cell in accordance with the teachings of the present invention;

[0028] FIG. 17 is a molecular diagram of an exemplary organic electrolyte, Methanesulfonic acid (MSA) in accordance with the teachings of the present invention;

[0029] FIG. 18 illustrates a simplified representation of the reaction illustrating how MSA works as an efficient electrolyte between each cell in accordance with the teachings of the present invention;

[0030] FIG. 19 illustrates a diesel molecule that is mostly a long chain of carbon atoms, with hydrogen atoms attached, and at one end, an ester functional group in accordance with the teachings of the present invention;

[0031] FIG. 20 illustrates how the small molecular size of hydrogen can be packed in open spaces in the long diesel chain to assist in a complete burn in accordance with the teachings of the present invention;

[0032] FIG. 21 illustrates the high speed flash point of each hydrogen molecule burning along the length of the petroleum molecule once introduced into the combustion engine in accordance with the teachings of the present invention;

[0033] FIG. 22 shows a simplified flow path that the generated HHO vapors take through the system and to the blending head in accordance with the teachings of the present invention;

[0034] FIG. 23 illustrates the vapor fluid dynamics of the valve system in accordance with the teachings of the present invention;

[0035] FIG. 24 describes the event that the logic uses to determine if there is a leak in accordance with the teachings of the present invention;

[0036] FIG. 25 illustrates a thermal pipe and a thermal pipe fitting in accordance with the teachings of the present invention;

[0037] FIG. 26 illustrates an exemplary embodiment of electrical circuitry used in the system in accordance with the teachings of the present invention;

[0038] FIG. 27 illustrates the system coupled by an input fuel line and an output fuel line in accordance with the teachings of the present invention;

[0039] FIG. 28 illustrates the use of the invented hydrogen oxygen (HHO) system in combination with a combustion engine in accordance with the teachings of the present invention;

[0040] FIG. 29 is a schematic side elevation illustrating a second embodiment of the invention in which the system is modular and its HHO splitter and operational controller functions are distributed for use with a larger engine requiring more HHO and/or with one or more smaller engines that are located remotely from the controller;

[0041] FIG. 30 is an enlarged, fragmentary isometric view illustrating a feeder port the modular system of FIG. 29;

[0042] FIG. 31 illustrates an auxiliary tank for chilling at least the splitter part of the system of FIG. 29;

[0043] FIG. 32 illustrates an enlarged, fragmentary side elevation of the splitter part of the system of FIG. 29;

[0044] FIGS. 33A, 33B, and 33C are flow diagrams respectively illustrating a fuel-cost-saving allocation and accounting method in accordance with another invented method; and

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0045] The following detailed description of the invention is merely exemplary in nature and is not intended to limit the invention or the application and uses of the invention. Furthermore, there is no intention to be bound by any theory presented in the preceding background of the invention or the following detailed description of the invention.

[0046] FIG. 1 is a front view of an exemplary system 100 for producing hydrogen in accordance with the teachings of the present invention. Illustrated in this view is the basic shape of one embodiment of the present invention which includes various features that provide mounting methods, interface to a fuel system, operator setup capabilities, and mechanical structures needed to secure and keep vital electronics dry, while providing the ability to cool the system under extreme weather conditions. The system 100 provides operator lights that identify to the end user in a simplified manner that the system 100 is operating properly or if the system 100 may need attention to a service issue.

[0047] System 100 includes an enclosure 1 that provides support and protection for the electronics and other components therein. In one exemplary embodiment, enclosure 1 is a sheet metal box. A warning light 2 is coupled to the enclosure 1. The warning light 2, in one embodiment, remains green when all systems are functioning properly, and it blinks when there is an error or fault condition. Enclosure 1 further includes a vented water-filling port 3 for adding water to the system. A power indicator light 4 provides an indication of power being delivered to the device. In one exemplary embodiment, power indicator light 4 is a company logo that turns on green when power is first delivered to the device.

[0048] Hurricane straps 5 hold the device down to a surface. Leveling feet 6 can be used to level out the system 100 and to prevent the crushing of a lower air intake and filter portion of the system 100. This will be explained in greater detail below. Fan cover 7 allows air to flow out of the system while blocking any water from penetrating it when used in an outdoor environment.

[0049] FIG. 2 illustrates a back side of the system 100 including a vertical mounting system 8. Also illustrated is a user interface 9, a window 10, input and output connections 11 and power input 12. Vertical mounting system 8 can be used to mount the system 100 to a vehicle, generator or other desired surface. User interface 9 provides information regarding the operation of the system to a user.

[0050] In accordance with one embodiment, window 10 is a clear window that can be used to visually confirm that the hydrogen and oxygen are mixing with conventional fossil fuel (e.g. petroleum or "petrol"). The input and output connections 11 introduce one or more fuels into the blending system and return a blended fuel, as will be discussed in greater detail below. In one embodiment, the fossil fuel is diesel gasoline. Power input 12 is used to provide power to system 100. In an exemplary embodiment, the power supply is a 12 volt direct current (VDC) power supply, although other power supplies, such as 12VDC, 24VDC, 36VDC, or 48VDC power supply can be used.

[0051] FIG. 3 illustrates the system 100 with vertical mounting system 8 removed from enclosure 1. The vertical mounting system 8 can be bolted onto a vertical structure, such as part of a vehicle or a diesel generator or similar structure, in order to mount the system into a static position relative, for example, to a vehicle. System 100 in accordance with one embodiment of the invention also includes International Standards Organization (ISO) standard DIN rails 13 which can be used to couple to vertical mounting system 8.

[0052] Vertical mounting system 8 includes a main plate 14, mounting holes 15, at least one mounting bar 16, and a spring-loaded feature 17. The main plate 14 is the main structural component. Mounting holes 15 are used to mount the vertical mounting system 8 onto a structure. Vertical mounting bar 16 opens the release features for the remainder of system 100 to snap on via DIN rails 13. Spring-loaded feature 17 can be pulled down to collapse the spring-loaded features that grip the DIN rails 13. A "tamper proof" screw (not pictured) can be inserted in this feature to tamper proof the system from being removed once installed.

[0053] The present invention utilizes a fluid comprising a known concentration of electrolytic chemicals. It also adds more distilled water as the water is fractured into its atomic elements of hydrogen and oxygen. As the hydrogen and oxygen are taken away during the electrolysis process, new water may be added to the system, e.g. to a large-capacity, tank that may form a part thereof, during a filling process.

[0054] In accordance with an alternative embodiment of the invention, a large external distilled water tank or other external source of water supply can be avoided. This is especially important in mobile applications such as vehicles, e.g. buses, trucks, boats, and cars. The alternative draws ambient air through an electrostatic air filter, condenses water from the air, and then distills the condensed water via a series of filters. Such a system for extracting distilled water from ambient air is available from Konia Australia Pty Ltd. Those of skill in the art will appreciate that other configurations for and methods of extracting water from ambient air and distilling the extracted water for use with the invented system are possible. Some such alternatives may require a local distilled water tank, but such acts only as a buffer in the supply chain (to ensure a continuous feed) rather than as an external source. Thus, alternatives to providing a large quantity of stored water near the water intake to the HHO separation device are contemplated and are within the spirit and scope of the invention.

[0055] Those of skill in the art will appreciate that the particular HHO production technique adds important advantages to the overall invented system. Conventional H_2 and O production is usually referred to as diatomic chemistry, i.e. it produces an oxygen atom and a hydrogen molecule. Instead, the invention uses an orthohydrogen chemistry to produce H, H, and O as three separate atoms in an atomic rather than molecular chemical form that promotes efficient blending with petrol and that elevates energy production in an internal combustion engine. Applicant does not intend to be bound to any theory of operation, however, and instead intends that the present invention is broad in scope in accordance with the appended claims.

[0056] Those of skill in the art will appreciate that the H_2O molecule has a 104.5 degree cleavage plane between each H atom and the shared O atom. It has been discovered that there is an optimal frequency at which cleavage is obtained for the water molecule. Thus, in accordance with one embodiment of the invention, a resonant-frequency cleavage approach emerges that involves a unique combination of a series-electrode-plates configuration in the hydrolysis chamber and excitation thereof by a DC voltage on either end of the series electrodes. In accordance with this alternative embodiment of the invention, a DC voltage is superimposed by one or more alternating current (AC) voltage waveforms that enhance H_2O molecule cleavage into the separate HHO atoms. The 104.5 degree cleavage plane mentioned above is believed to suggest the concurrent application of tri-frequency AC waveforms having a baseline frequency resonant and higher, harmonic frequencies thereof, e.g. those related to one another by powers of two.

[0057] FIG. 4 is a process flowchart illustrating a simplified representation of the invented fluid dynamics control. At block 402 the invented device receives power from the diesel or gasoline engine and initiates a homing sequence to ensure that the orthohydrogen splitter (including the electrodes 18 and a water-and-electrolyte-containing jacket) or cell is full of water. At block 404 power to the splitter is shut off while vital inputs are confirmed as being within satisfactory operating norms. At block 406 the vacuum pump is commanded to "pull" a nominal vacuum level on the splitter. At block 408 the vapor accumulator receives hydrogen/oxygen from the splitter during the vacuum process, and pressure builds to a predetermined level, e.g. 60psi, by operation of the one-way check valve.

[0058] At block 410 a cell electrolyte accumulator 23 delivers fluid to the electrodes 18 when operating pressures exceed a predetermined level, e.g. 20psi. At block 412 when the cell fluid accumulator 23 is empty, a vacuum pump 27 pulls water from the water source, e.g. a reservoir, to top off the splitter. At block 414 the electronic eye at the top of the cell 'sees' fluid when the vacuum has pulled all of the vapor out of the splitter, and the vacuum pump 27 is commanded to stop. At block 416 valve 1 opens on the vapor accumulator for a defined time, e.g. 5 seconds, and the positive hydrogen and oxygen pressures force excess fluid out of the splitter and back into the cell fluid accumulator 23. At block 418 power is turned onto the generator, and hydrogen and oxygen (HHO) are produced. Finally at block 420 valve 1 closes and valve 2 opens to permit vapors to flow to a mixing head or manifold 26 to blend the HHO with the petrol.

[0059] FIG. 5 illustrates internal components of system 100 used to move fluid and vapor gasses through the system in a safe reliable manner. As illustrated in FIG. 5, electrodes 18 comprise a plurality of electrodes that are stacked on top of each other in a vertical manner. Each of these electrodes is separated by spacers and o-rings. They are securely mounted together using threaded rods to prevent leakage of water thereinto. Top block 19 and a bottom plate 20 captures the electrodes 18 therebetween. Input 21 brings fluid in from the water fuel tank (not pictured in FIG. 5 but discussed in detail below). A one-way check valve 22, coupled to input 21, prevents hydrogen and oxygen from moving back into the fuel tank (not pictured). A cell fluid accumulator 23 stores and maintains the electrolyte concentration within the cell, allowing electrolyte density relative to the H_2O diluent to remain balanced and constant.

[0060] A vacuum pump 27 in one embodiment pulls a vacuum that results in the accumulator 23 releasing its volume into the electrodes 18 to flood the cell and to replace any water that has been "burned off" during the electrolysis process. A top plate 25 is fixed above top block 19 and electrodes 18, as shown in FIG. 5. A temperature probe 26 monitors the internal temperature of the electrodes 18, as will be discussed in further detail below. A fan 28 pulls air through the system. A vapor accumulator 29 stores pressurized gases during the filling process. A one-way check valve 30 creates pressure when the pump 27 turns on, thereby to pull in fluid and to fill the volume around the electrodes 18.

[0061] A pressure sensor 31 measures and monitors the cell internal operating pressure. A block 32 is located in the valve assembly that transfers the vapors out of the main gas manifold into the vapor accumulator 29. A main solenoid valve 33 is used to pressurize the system during the filling process. The valve 33 is normally in an open position. Once the splitter or cell is generating hydrogen, the valve 33 remains open. It is also used to check the entire system upstream from the mixing area for any hydrogen leakage. A pressure check is completed after the filling sequence is completed, as will be described by reference to FIGs. 4 and 27.

[0062] A buffer tank 34 is used to stage the hydrogen and oxygen prior to blending it with the fossil fuel, e.g. the petrol. A flow meter 35 monitors the fuel running through the system. In one exemplary embodiment, flow meter 35 has a clear viewing window 10 on the back side used to visually confirm that bubbles are mixing with the fuel. Mixing manifold 36 contains the static mixing head (not pictured in this figure) and sensors for multiple fuels. Another one-way check valve 37 prevents the fuel from back-feeding into the hydrogen and oxygen subsystem. This check valve 37 opens when the pressure created by the pump 27 exceeds the pressure on the incoming fuel lines. A mixing head pressure transducer 38 is used to measure the fuel pressure inside of the mixing and blending head. This transducer 38 determines an operating pressure required to blend the hydrogen and oxygen in with the petrol. A limit electric eye 39 monitors the fluid level when the pump pulls more water into the cell. This electric eye 39 is used to ensure that the pump does not pull fluid into the blending area or valve system. A coil 24 separates any vapors from the newly fractured hydrogen produced in the cell. This coil 24 also helps remove heat from the vapors prior to mixing with the petroleum.

[0063] FIG. 6 is a cross-sectional view of the cell in accordance with the teachings of the present invention. In one embodiment, the plurality of connected electrodes 18 can be considered a cell. As shown in FIG. 6, the conical shape of each electrode 18 lends itself to a higher surface area for needed for hydrogen production. The conical shape of each electrode 18 helps to support the release of heat from the reaction side of the cell to let the cell operate at higher powers as heat is a by-product of the electrolysis process.

[0064] FIG. 7 is a view similar to that of FIG. 5 except that the view of FIG. 7 is a rotated isometric view. In this view, a mixing area with the first fuel input line 58, a second fuel input line 57 and a first output line 55 for fuel blending can be seen. FIG. 7 illustrates the mixing and blending mechanism of the system and how the blending mechanism integrates with the vapor generation part of the system, as discussed previously. The underside of the assembly sits on a metal frame. A plastic insulator plate 41 prevents high voltage from jumping onto the frame.

[0065] FIG. 8 illustrates an exemplary embodiment of the controls system part of the system. This drawing illustrates the structural frame to clarify how the superstructure goes together with supporting electronics mounted to control the system. All sensors and devices used to measure, monitor and deliver the hydrogen to the fuel supply are designed to use one of 12VDC, 24VDC, 36VDC, or 48VDC. A separate high voltage side of the product uses a 220VAC power inverter to make hydrogen/oxygen generator side of the system turn on and off. A heating element is operatively coupled with the base plate to thaw out any frozen water when temperatures are below freezing, e.g. at certain latitudes or elevations and/or in certain climates or seasons. To extend the life of the electrodes 18 and minimize the amount of maintenance, a polarity switching device is provided using several high voltage relays that periodically reverse polarity of the electrodes 18.

[0066] The polarity-switching device can be conventional. But in accordance with one embodiment of the invention, polarity switching is done across the series-connected electrodes, as described above, and at a frequency or frequencies suitable to reduce or avoid athodic-layer build up of ionized free metal particles on one or the other of the electrode plate surfaces. For example, such can be relatively slow-periodic, e.g. minutes, hours, days or months. Alternatively, such polarity-switching can be relatively fast-periodic, e.g. several or hundreds or thousands of times per second. In accordance with one embodiment of the invention, the polarity switching frequency can be the same a the so-called resonant frequency at which molecular cleavage occurs. Thus a useful combination of high-frequency polarity switching and AC switching can be used to avoid electrode build up and to enhance the cleaving of water molecule into atomic HHO.

[0067] As seen in FIG. 8, a super-structure frame 42 mounts the system components together. Wire track 43 is used to organize wiring. In the event that a component needs to be replaced, prewired components can be pulled out and replacements pulled in. Master breaker switch 44 turns off the system power, such as in the event of an over-current draw. Master breaker switch 44 can also be used to service the device while in the field in order to shut down all power to the system. Current-limiting board 45 turns the high voltage to the cell electrodes 18 on and off. Current-switching relays 46 can be used to reverse ("flip") the polarity of the device. These relays are switched on and off from a digital controller, e.g. a programmable logic control (PLC) device, 47 or a suitable alternative such as an alternative logic array or special-purpose processor executing instructions stored in a memory, as is known.

[0068] Controller 47 controls the operation of the invented system including the intake, blending, out-take, monitoring, and user-interface subsystems described and illustrated herein. A power inverter 48 takes a lower-voltage DC to a higher-voltage AC level for the electrolysis process. In one embodiment, a nominal 12VDC input to inverter 48 (more precisely labeled "13 Volt" in FIG. 8, but not intended in any way as a contradiction or limitation to the scope of the invention) is changed to a nominal 230VAC output. Power switch 50 turns off the device when fluid in the cell is too low for safe and efficient operation. Logic expander 51 expands the programmable logic controls to provide additional channels for input and output data and command processing and/or control and/or monitoring, as will be discussed below by reference to FIGs. 26 and 27.

[0069] FIG. 9 illustrates system 100 with some of the sides removed for easier viewing of the internal components. In FIG. 9, fuel tank 52 is illustrated near the cell. The fuel tank 52 is hollow in the center and in one exemplary embodiment; the shape of fuel tank 52 lends itself well to cooling the cell as air is pulled from the bottom of the cell through the center of the fuel tank. As the air flow circulates around the cell, the cold water pulls the heat away from the cell through the fins that extend past the o-rings and spacers inside the cell stack. Fan 28 pulls the hot air from the center of the fuel tank around the cell. The vented water tank cap 3 permits operators to fill the tank with additional distilled water when needed. The cap 3 is vented to allow the vacuum process of filling the cell.

[0070] Those of skill in the art will appreciate that the system described herein produces heat. Thus, heat removal or venting or reuse becomes an important concern to operating the system efficiently and productively. Removal of heat from the system will be described below. Those of skill in the art will appreciate that alternative heat removal and/or venting mechanisms, within the spirit and scope of the invention, may be used.

[0071] FIG. 10 illustrates the air flow that cools the system by a plurality of bold arrows against an intentionally lighter background outline of the system. Fan 28 draws air through the enclosure hot air travels, around the cell. This air is cooled when it passes by the cool water in the fuel tank 52. A filter 54 is provided at the bottom of system 100.

[0072] FIG. 11 describes the path that the petrol and hydrogen and oxygen take through the blending head. In order to allow one or more fuels to be blended together there are two in-ports illustrated in this figure along with one out-line going out to the engine with the resulting blended fuel. The hydrogen and oxygen is introduced as the diesel or other petrol flows through the static mixing head. The purpose of the static mixing head is to send the blended fuels through a tortuous path without unduly restricting flow. This method of mixing lets the engine run even when the generator is not producing hydrogen. The tortuous path will be understood to be enforced by a particularly novel structure and alignment of circular, aligned plates each having plural openings therein. This novel structure will be described in detail below by reference to FIG. 13. Those of skill in the art will appreciate that a blended petrol-hydro-oxygen, fluid-gas mixture produced in accordance with the invention is believed to substantially raise the efficiency and productivity of the blended fuel in internal combustion engines.

[0073] FIGs. 12A and 12B respectively are side and front elevations showing the fuel passage through the flow meter 35. As seen in FIGs. 12A and 12B, the fuel moves in a vertical direction through the flow meter 35, the buffer tank 34, and the check valve 37 to provide a hydrogen/oxygen injection path. The hydrogen/oxygen blends with the fuel in the mixing manifold 36. As discussed previously, the window 10 can be used to visually confirm that the fuel is mixing with the hydrogen and oxygen and moving through the system. In accordance with the mixing manifold teachings herein, and descry bed in detail below by reference to FIG. 13, the blended HHO-diesel mixture is a cloudy but homogeneous fluid that can be injected immediately at the combustion phase through the fuel import valve of an internal combustion engine to great advantage. Mixing head pressure transducer 38 measures the fuel pressure inside of the mixing manifold. The system logic takes variable readings from this sensor and then through the PLC the programmed logic tells the main pump to turn up the pressure a defined amount, e.g. 10psi, higher than the pressure inside of the mixing manifold to create proper blending. These ratios can be established using the following formula:

$$(X=Y+10) \qquad (1),$$

wherein X= fossil fuel (petrol) pressure and Y=hydrogen/oxygen (HHO) gas pressure. Those of skill in the art will appreciate that alternative mixture formulae can be used, within the spirit and scope of the invention.

[0074] As the fuel converges from a first fuel line 57 and a second fuel line 58, the fuel then flows through the static mixer 59. Static mixer 59 blends the hydrogen and oxygen with the petroleum. The arrows in FIG. 12A illustrate how the fluid flows through the flow meter used to determine the proper blend of hydrogen to petroleum. One-way check valve 37 prevents hydrogen from being back fed into the buffer tank 35 from the mixing head. Mixed fuel output 55 is where the blended fuel exits the system 100. The injection point of the hydrogen is in the path that the petroll makes through the mixing head. This injection point is half way along the static mixing features. High turbulence is created due to the tortuous path that the petroleum makes through these features providing an opportunity for the hydrogen to blend at a higher than normal rate in the part of the mixing head.

[0075] FIG. 13 illustrates top, side and isometric views of the static mixing sub assembly 59 that is inserted in the blending head assembly. The arrows in the top view show the tortuous path that the petroleum and hydrogen must take to get to the other end of the sub assembly. The tortuous path is achieved as illustrated by the provision along a spindle 59a of plural, spaced-apart plates each having plural openings therein. In accordance with one embodiment of the invention, the interfering surface area of the plates is effectively doubled to increase blending by way of providing in each spaced-apart location double, orthogonally oriented plates 59b arranged in pairs, each plate having plural openings therein, as shown. This provides turbulence for blending fuels together to provide a mixed fuel. The petroleum that naturally flows to the engine from the fuel tank will not require power from the system in the event that the system is not running using the static mixing head. Therefore, if the system 100 is not running, the engine it is coupled to will receive fossil, e.g. diesel, fuel conventionally.

[0076] FIG. 14 is an exploded view of one of plural electrodes 18 used in the system to isolate the reaction and increase the gas production. Each electrode 18 is generally conical (e.g. frusto-conical) in shape, which lends itself well to high gas production through isolating the reactions to individual cells in a series cell design. The conical shape provides a high surface area in a small packaged area. Each electrode 18 includes a cone portion 60 and a base portion 63. In one embodiment, these portions are extruded from thin sheets of stainless steel to create the shape. The shape lends itself well to hydrogen production due to the higher surface area in this shape than would be present in a corresponding flat shape. In one exemplary embodiment, the diameter of the base of the cone is 4.461 inches and it rises at a 45 degree incline resulting in 43.34 square inches of surface area on the top and bottom side of the cone. The surface area of an identical electrode shape with a flat shape with a diameter of 4.46 inches is only 31.2 square inches. Thus, the advantageous increase in surface area is a surprisingly effective 38%.

[0077] A fluid entrance port 66 is formed upwardly and centrally of the frusto-conical electrode shape. Fluid entrance port 66 will be seen by reference below to FIG. 15 to form part of a heat sink when the air that is pulled through the assembly between the fuel tank and the cell stack. Spacer 61 is used as an electrical insulator between each cell. These features isolate the reaction between each cell and force the high voltage electricity to pass through the water/electrolyte compound used to create hydrogen in invented system 100 cell design. O-ring 62 is used to eliminate any leakage. Spacer 61 establishes how far the O-ring 62 collapses during assembly of the electrode stack. Rim 65 aligns the cones with the o-rings 62 and the spacers 61 for assembly purposes.

[0078] The conical shape of the electrodes 18 lends itself well to a water filling process. FIG. 15 is a simplified cross-section of the frusto-conical electrodes (showing only four such electrodes and corresponding parts for the sake of clarity), spacers and O-rings stacked on top of each other. All of these cells are compressed using four threaded rods with heavy top and bottom retainer plates. When a high voltage potential difference is presented between the top and bottom of the cell, each electrode takes on both a positive and negative polarity referred to herein as a bipolar condition, as shown. The compression of the O-ring and spacer doubles not only as a vapor and liquid barrier, it also acts as an electrical barrier with a central exit for newly formed gases to escape. Fluid entrance port 66 allows for the filling of water in the electrode assembly. The main pump pulls water into the cell using a vacuum process. As the vapors are removed, water is replaced. Once the water is topped off with an electronic eye in place, the pump stops, valves are opened in the gas manifold letting a pressurized vapors push the liquid out of the center entrance port 66 in FIGs. 14 and 15.

[0079] In the present invention, the series of cells produces maximum gas production while preventing the high voltage from "jumping" along any conductive materials such as plastic and or metal objects. The design takes into account that, if the cell is flooded in the center, gas production is diminished because the positive electrons attempt to follow a path of least resistance. The invented design evacuates this hole by forcing excess electrolytic solution into the cell accumulator.

[0080] FIG. 16 is a simplified diagram of the fluid-filling process for the cell. As the H_2O is burned off, the electrolyte remains between each cell. The logic as provided by the PLC determines the filling sequence to replenish the water-based HHO atomic mixture. Each time the generator is turned on, the filling sequence starts, and a timer counts down to determine when the cells are nearly empty. At a known time interval from the last filling sequence, the high voltage is turned off. The vacuum pump turns on, pulling any residual electrolytic solution from the cell accumulator into the cell. The electronic eye monitors the fluid as it rises above the top cell, and the pump continues to pull fluid into the cell structure. The topping-off process takes place with a one-way valve opening at the base of the water tank. That valve allows fluid to enter into the system, yet prevents hydrogen from escaping during the cell run time when the generator is producing the hydrogen and oxygen (HHO) mixture. The entire system generally runs a 40-60psi pressure to hold the extra electrolyte in the accumulator. As the pump pulls a vacuum, it pressurizes the vapor storage tank to 80psi for a short period of time to charge this tank. A one way check-valve allows the pump to hold pressure in the vapor storage tank. Once the fluid reaches the top of the cell, according to the electronic eye 39, the pump stops. The release valve opens, thereby allowing the pressurized charge to push any residual fluid from the center of the cell back down through the base manifold into the cell accumulator. The system is now charged at 40-60psi and is ready for hydrogen and oxygen (HHO) gas mixture production.

[0081] FIG. 17 is a molecular diagram of an exemplary organic electrolyte, methanesulfonic acid (MSA) or $H_2SO_3(CH_3)$, for use in the present invention. In trials, MSA has shown superior electrical conductivity and chemical stability. The chemical compound provides an excellent electrolyte for the disassociation of H_2O into hydrogen and oxygen using a very low amount of power. One advantage of MSA is that it is very stable. As a result, during the electrolysis process, as water is fractured into its elemental gasses the electrolyte itself stays readily active and available for continued operation. The principal benefits are that, as the water volume increases, the chemical balance can be restored by simply replenishing any lost water volume.

[0082] While it would be ideal if every electron that enters the cell were converted to an atom of hydrogen, that is not the case. In real world, this less-than-perfect electrical efficiency undesirably results in a heat gain. The MSA is stable at high temperatures resulting in a stable process. Additionally, the electrolysis process can impact electrolytes as well. MSA is stable under this electrochemical load as well. Comparable electrolytes, such as sodium hydroxide (NaOH) and potassium hydroxide (KOH) can provide similar results, but at substantially higher concentrations (up to a factor of 100 times) that result in unwanted side effects relative to health, safety and other environmental issues. These competing electrolytes are also the foundation chemistry for soaponification, and as such, they lead to a viscous, frothy film in the cell which can and does lead to electrical arcing, which undesirably electrically bypasses desirable hydrogen cell generation. Additionally, the surface tension of the molecule leads to a better 'wetting' of the electrode surface, which, in turn, yields a greater conversion of electrons to hydrogen and oxygen (i.e. leads to higher electrical efficiency) at lower electrolyte concentrations. To promote this reduced surface tension, each electrode is electro-polished prior to cell operation, to smooth out the surface of the electrode. The series electrode design brings in one rail of the high voltage to one side of the plate stack with the other rail of the high voltage power to the other end of the cell stack.

[0083] FIG. 18 illustrates a simplified representation of the reaction illustrating how MSA works as an efficient electrolyte between each cell. The organic nature of the compound provides benefit to the electrolyte, as the methyl group (CH_3) bonds to the sulfate component of the molecule and encourages the formation of intermediate compounds in the electrolysis that yields a higher concentration of hydrogen generation. With H_2SO_3. The methyl group (CH_3) having three hydrogen atoms bonded to it, exhibits a slight electropositive tendency. When in contact with a proximally natively charged electrode surface, the MSA orients itself with the methyl compound end in contact with or close proximity to the negatively charged electrode. This increases the cathodic film's ability to fracture the water into hydrogen. Conversely, the proximally positively charged electrode surface attracts the other end of the molecule which is slightly electronegative, creating a more favorable electro-chemical mechanism for the creation of oxygen.

[0084] As mentioned above, in order to promote a clean electrode, each electrode 18 of the cell should go through a periodic polarity reversal to clean the mineral film from the cathodic side of each cell electrode plate. In testing, it is observed that each side of each electrode plate either attracts a 'sludge' of minerals or tends to oxidize. This observation leads to the conclusion that each plate in the cell is acting on one side as a cathode, and on the other side of the same plate as an anode.

[0085] In accordance with one embodiment of the invention, the logic in the system controls reverses or flips the polarity of the cells each time it goes through a filling sequence. Surprisingly, is has been discovered that cathodic buildup occurs quickly in operation of the invented system. Indeed, empirical evidence suggests that buildup occurs in thirty or fewer minutes of operation. This is evidenced by a marked reduction in HHO production from the invented cell after approximately ten minutes. Indeed, a discernable reduction in output power attributable to cathodic buildup occurs in even less elapsed time. As a consequence, it is believed that a nominal minimum period for polarity reversal is approximately thirty minutes, a preferred minimum period for polarity reversal is approximately ten minutes, and a more preferred minimum period for polarity reversal is approximately five minutes.

[0086] It is believed and demonstrated that reversing the polarity of the series-electrodes' DC bias periodically and as often as once every five minutes avoids cathodic buildup and preserves high efficiency and generation of HHO and the resultantly high ICE output production and fossil fuel savings. Those of skill in the art will appreciate that other polarity-reversal periods and frequencies, whether above or below the periods described herein, are contemplated as being within the spirit and scope of the invention.

[0087] Electrolysis balancing increases the life of the electrodes while enhancing gas production with minimal corrosion, ion-contamination, and resultant cathodic buildup on the ion-attractive (relatively negatively charged) electrode plate surfaces. The invented system technology increases the flow of electrons, resulting in higher electro-chemical throughput. The MSA acts to promote conductivity of the cell. Therefore, the concentration of the MSA must be above a critical minimum, but is not limited on its upper end. The MSA concentration can be as small as approximately 1% by weight, determined primarily by the separation distance of the electrodes, and can be as large as approximately 10% by weight. One empirical result demonstrating the benefits of electrolyte concentration increase is that doubling the concentration resulted in a one liter/minute increase in HHO production and a commensurate reduction in power draw on the cell itself. It is believed that the closer the electrodes get to one another, the lower this concentration needs to be, so those of skill in the art will appreciate that there are other variables at play. Thus, tradeoffs are contemplated as being within the spirit and scope of the invention.

[0088] Notwithstanding the above, an important correlation between electrolyte concentration within the water has been discovered. It has been determined that a minimum concentration of approximately 1%, a more preferable concentration of approximately 2%, an even more preferable concentration of approximately 2.5%, and a most preferable concentration of approximately 4% or more substantially increases hydrogen production without substantially increasing cost. For example, by doubling the MSA concentration from approximately 2% to approximately 4% by weight in water, a 20% increase in HHO production has been measured and realized. Thus, those of skill in the art will appreciate that alternative but suitable electrolyte concentrations in water are contemplated as being within the spirit and scope of the invention.

[0089] As the generated hydrogen mixes with the long chain hydrocarbon in the internal combustion engine's combustion zone (e.g. cylinder), it is believed that this HHO-fossil fuel mixture aids in concurrently or simultaneously spreading the ignition/combustion process across the hydrocarbon chain. Thus, it is believed that combustion of the invented mixture 'arcs' and thus produces a quick "burn" along the hydrocarbon chain, rather than slowly "burning" down the hydrocarbon chain. This 'arc' or 'flash' promotes better or more thorough or more efficient burn in the combustion chamber resulting in increased power, lower carbon emissions and better fuel economy.

[0090] FIG. 19 illustrates a diesel molecule that is mostly a long chain of carbon atoms, with hydrogen atoms attached, and at one end, an ester functional group. It is believed that FIG. 19 is largely self-explanatory to those of skill in the art.

[0091] Conventional diesel fuel contains only approximately 45.5 mega-Joules/kilogram (MJ/kg) of energy, while hydrogen contains approximately 121 MJ/kg of energy. The octane number for diesel is only approximately 25 Research Octane Number (RON), while the octane number for hydrogen is 130 RON. The speed of the "burn" of hydrogen thus is more than approximately five times faster than the speed of the "burn" of diesel, resulting in a fuel blend that helps complete the slow burning diesel. In other words, it is believed that the hydrogen contribution of the HHO mixture greatly accelerates combustion when supplied at an internal combustion engine's fuel intake port without pre-detonation that results from prior art processes that involve adding (diatomic) hydrogen gas to the air intake port.

[0092] FIGS. 20 and 21 illustrate what is believed to be the electro-chemical mechanism and advantage of the invention. FIG. 20 illustrates how the small molecular size of hydrogen may, in accordance with the invention, "pack into" or otherwise fill open spaces or volumetric gaps in the long diesel chain to assist in a faster and more complete "burn." FIG. 21 schematically and dramatically illustrates the high-speed flash point of each hydrogen molecule burning along the length of the petroleum molecule once introduced into the fuel intake port of an internal combustion engine. Thus, the high turbulence created using the static mixing head creates a blended fuel that burns more completely and more quickly, resulting in reduced-fuel consumption (and thus higher cost savings) and lower emissions.

[0093] FIG. 22 shows a simplified flow path that the generated HHO vapors take through the system and to the blending head. Condensing coil 24 separates any excess water vapors that are created in the form of steam from the hydrogen and oxygen vapors. As the air flow, described previously by reference to FIG. 10, passes across the surface of the condensing coil, the hydrogen and oxygen pass along this circular path indicated by the arrow. The condensing effect of the cool air on the outside of the pipe create a mechanism for the water to drop back into the cell where further and more complete electrolysis occurs.

[0094] FIGs. 23A and 23B are partially cutaway front and side elevations of the system illustrating its fluid dynamics. As seen in these figures, the vacuum pump pulls the vapors out of the cell until the electronic eye (not shown for the sake of clarity) and operatively coupled controller (also not shown) commands it to stop. The vapors are stored in buffer tank 29. The pump (not shown) connected to the in-line 67 and to the out-line 68 then urges the vapors through the one-way check valve 37. A first valve 40a is normally closed and maintains pressure created by the vacuum pump. A second valve 40b is normally open, yet for this cell-filling event it is closed to prevent any pressure from leaving the internal system and bleeding into the petroleum line. Once the cell is full of fluid, the controller turns off the pump and then opens first valve 40a. This pressure works backwards through the in/out vapor manifold line back into the cell to urge excess fluid out of the center of the cells. This prepares the cell for operation by pressurizing the system with a positive pressure of 20-40psi. The controller then turns on the cell to begin making hydrogen/oxygen. As the pressure builds, the second valve 40b opens to urge fluid into the fluid mixing area.

[0095] First valve 40a identified in FIG. 22 is normally open. Second valve 40b is normally closed. This is the run-time position wherein the pressure created by the fracturing of water into hydrogen and oxygen forces the hydrogen pressure to overcome pressure at the blending head.

[0096] In order to provide proper fuel blending, the controller, typically in the form of instructions programmed on a PLC, is used to achieve a closed loop system that insures that the cell and the petroleum are able to blend properly as the engine demands a greater volume of the mixture of OOH and petrol. Thus, the logic processing within the controller ensures that adequate volumes of fuel are blended and mixed properly using pressures that can overcome the pressure of the petrol insure consistent blending. If staging pumps are used before the generator mixing head, the mixing head pressure sensor signals the controller that there is excessive pressure. The vacuum pump turns on and second valve 40b opens to pressurize the lines (downstream from the pump) that lead to the mixing head. The controller and its associated circuitry and interconnections provide a mechanism for overcoming high fuel-line pressure that exceeds a nominal 40psi operating pressure.

[0097] First valve 40a is normally open and used to let vapors move to the staging area in the buffer tank 29. The one-way check valve 37 is used to maintain pressure when the vacuum pump has evacuated the cell. The normally-closed second valve 40b maintains pressure of the vacuum pull from the cell, and then opens for a determinedly short time to remove the excess electrolyte from the cell.

[0098] Those of skill in the art will appreciate that hydrogen atoms are physically small, with a natural ability to leak through very small openings. Those of skill also will appreciate that the accumulation of hydrogen could lead to explosive results. Thus, primarily for safety reasons, the invented system is designed to be leak free. The system is designed with no hoses: instead it employs block manifolds machined or otherwise formed from aluminum (or a suitably rigid, durable, and virtually impenetrable material and or with a virtually impenetrable coating) that are able to prevent these tiny molecules from leaching into the atmosphere. However, the system does include some threaded fittings throughout the design that are susceptible to leaking. To prevent and/or halt such improbable leaks, the invented system's controller periodically checks to see that all fittings are able to hold a higher than nominal operating pressure. A so-called pressure check system closes first valve 40a so the gas production side of the system can increase pressure to a known value. Assuming that 40psi is the internal operating pressure, the check pressure can, for example, be 100-200% greater than that nominal operating pressure to provide the system with a wide safety margin.

[0099] FIG. 24 is a cutaway view illustrating the leak-detection mechanism and method. The leak-detection steps occur each time the system goes through a filling cycle, although within the spirit and scope of the invention is not so limited. Second valve 40b is opened while first valve 40a closes to prevent any leakage into the mixing head area. The power to the cell is turned on to create pressure. As the pressure increases, the power to the electrodes that create these vapors is turned off when the pressure reaches 80psi. The system waits twenty seconds to determine whether the pressure drops below 79psi. If there are no leaks, as determined by this wait step, then the system proceeds with HHO gas production. First valve 40a in FIG. 24 closes to maintain pressure on the entire electrolysis side of the system in order to check for leaks. Pressure sensor 31 monitors the system for a pressure drop or differential. The four-pronged arrow symbols in FIG. 24 represent the outward pressure vectors that impact all parts of the vapor paths.

[00100] As discussed previously, the system uses distilled water to operate. In the event that the ambient temperature drops below freezing (0°C or 32°F) the system controller "knows" that there is a possibility that the water is frozen. Thus, in accordance with one embodiment of the invention, when power is provided to the system, the controller first checks the ambient temperature to see if it is at or below freezing. If the ambient temperature is below freezing, then a relay turns on 230VAC power to the base manifold heater to thaw out any ice that may have built up in this water-transfer area. The system quick-disconnects all flow through such stainless steel fittings, e.g. by turning off the vacuum pump. As heat is transferred through the base plate, it passes through these fittings into the water tank area. The conducted heat thaws out the plumbing for the fluid to begin flowing. In accordance with one embodiment of the invention, this event occurs for fifteen minutes. Alternative timing scenarios of course are contemplated as being within the spirit and scope of the invention.

[00101] To thaw the fuel tank, a heating element is turned on at the base of the cell. In accordance with one embodiment of the invention, all of the couplings are metal and/or high temperature O-rings. The heater turns on until the thermostat reaches 40°F. This provides an operating window for the cell to start drawing water from the water tank. As the system begins to run, the internal heat of the system thaws the tank.

[00102] The system is configured to include a thermal pipe located inside the fuel tank. The thermal pipe includes gas charged with nitrogen. The heat that is created through the heater in the manifold transfers into the thermal pipe via suitable plumbing, thereby melting any frozen water. This thaws out a channel for liquid water to flow into the cell. Once water is flowing, the natural heat from the cell or electrodes will thaw out the rest of the water tank. FIG. 25 describes how the heat from the heater cartridge transfers into the water tank through the aluminum manifold up into the thermal pipe. Such a thermal pipe 73 and a thermal pipe fitting 74 are illustrated in FIG. 25. The holes in the fitting are able to take fluid in as the solid-phase frozen water melts into this heated metal assembly.

[00103] FIG. 26 illustrates an exemplary embodiment of electrical circuitry 200 used in the system 100. The electrical circuitry 200 includes the following 12/24/36/48VDC sensors used as input devices providing vital information to the smart-relay PLC control system for logic processing. Input devices include a cell pressure sensor (producing an analog output), a cell temperature monitor, a cell fluid level sensor used to tell the pump that the cell is full when pulling a vacuum, an accelerometer (e.g. 1.5G) shut down switch (airbag sensor), a fluid flow meter (mixing head--producing an analog output), a pressure sensor (mixing head--also producing an analog output), one or more current measuring devices used to calculate the amount of power being drawn, a touch screen display (user inputs and/or operating parameters and/or status indicators), a temperature transmitter, a fluid level high (water tank), a fluid level low (water tank), a 12/24/36/48VDC volt input power block (e.g. from a vehicle's main battery), and an auxiliary 230VAC power input block.

[00104] The electrical circuitry 200 includes the following as input devices which receive control information from the smart-relay controller or PLC control system. The input devices include inputs from the vacuum pump, current limiting board, first valve 40a (normally closed), second valve 40b (normally open), safety light, display backlight, touch display, cooling fan, heater cartridge (anti-freezing), ±230 VAC, and cell.

[00105] Also, the programmable logic control PLC relay and the PLC relay expansion module provide processing components to the electrical circuitry 200.

[00106] The controller or logic side of system includes self diagnostics that allow the hydrogen generator to run continuously while supporting proper blending of multiple fuels. FIG. 26 also may be seen to illustrate the logic flow of the system. The generally left side of the logic illustrates the cell filling sequence while the generally right side of the diagram illustrates the fluid blending sequence. Each is integral to the other. The fuel blending side of the logic includes sensor inputs, while the cell-filling sequence side has both inputs and outputs. To achieve optimal blending of the fuels, the pressure from the hydrogen and oxygen must overcome the back pressure from the fuel line. This is ensured by providing a separate sensor on the fuel blending side in accordance with a simple mathematical formula:

$$FP + 5 = OP \qquad 2),$$

wherein FP is fuel pressure and OP is operating pressure. The operating pressure is created by turning up the current going into the cell and/or by turning on the vacuum pump that pulls hydrogen out of the cell. Settings in the logic are established in accordance with one embodiment of the invention that will prevent the cell pressure from exceeding a predetermined cell pressure (CP) maximum. This maximum acts as a trigger point to force the pump to turn on or off to maintain the predetermined pressure.

[00107] FIG. 27 is a process flow diagram illustrating the initial homing sequences for the invented system. The process flow diagram is believed to be largely explanatory.

[00108] The diagram illustrates how system actions are determined depending on the temperature, pressure, state of the fuel tank and rate of petrol flow. FIG. 27 also illustrates the blending sequence. For example, if the temperature is above 180°F, the pressure is below 80psi, the fuel tank is full, and petrol is flowing, a starting sequence begins. Additionally, the fan is turned on, a voltage is sent to the cell, the cell pump is turned on until the cell is full, and then the cell is pressurized. This is done to initiate the production of hydrogen.

[00109] If the temperature is above 180°F or if the pressure is below 80psi, or if the fuel tank is low, steps are taken to correct those conditions.

[00110] On the blending (mixing) side, the petroleum pressure is tested to determine internal operating pressure and petrol flow rate. The flow rate is used to set the mixing pump speed, as illustrated.

[00111] FIG. 28 illustrates system 100 coupled by an input fuel line 280 and an output fuel line 281. Input fuel line 280 sips petrol from a diesel fuel (gas) tank 282 (An optional condenser/filter 283 can be used to extract distilled or purified water from ambient air, as described above.) Output fuel line 281 supplies fuel directly to an internal combustion engine 284. For example, output fuel line 281 feeds a fuel injector (not pictured) or other fuel intake port of the combustion engine. This approach has several advantages over current systems. For example, providing mixed fuel directly to the fuel injectors avoids problems with trying to add hydrogen directly to the manifold or air intake port. Hydrogen added to the manifold could be an explosive hazard. Moreover, as discussed at length above, adding hydrogen to the air intake port is believed to result in pre-detonation of the gas-fluid mixture within the internal combustion engine's cylinder, resulting not only in a safety hazard but also in decreased performance and higher petrol consumption.

[00112] Therefore, system 100 is designed to measure monitor and blend hydrogen with both diesel- and gasoline-based fuels, automatically to produce the proper volume of hydrogen needed for a determined engine size, automatically to turn the hydrogen on and off when pressures exceed limits set thresholds, automatically to turn the heater on when the temperature is below freezing, to manage the amount of distilled water and turn the generator on and off when the tanks run low, to diagnose that the generator does not have any pressure leakage, to automatically switch the polarity of the high voltage side (after the inverter), to provide the user with the ability to change variables, to measure current draw and to display the same and/or status and/or efficiency and/or condition and/or temperature and/or internal pressure and/or

fuel flow rate, and to provide a safety shut down sequence using an 12/24/36/48VDC air bag sensor.

[00113] FIG. 29 is a schematic side elevation illustrating a second embodiment of the invention in which the system is modular and its structures and functions are distributed use with a larger engine requiring more HHO and/or with one or more smaller engines that are remote from the HHO generation source. Larger engines tend to require more HHO production, which in turn tends undesirably to produce more heat. Moreover, one or more smaller engines distributed away from a central location, e.g. in a bus or other vehicular conveyance that has particular packaging requirements for retrofitting installation of the invented system, tend to have special spatial distribution requirements wherein parts of the system might be located near the gas tank, others might be located near the engine, and still others might be located elsewhere due to space constraints.

[00114] In its modular configuration, system 100' includes all of the elements of system 100 including a main controller 99 coupled to one or more so-called splitters 101 including corresponding internal mixing heads, sensors, electrode stacks, and gas lines (not shown for the sake of clarity) via one or more HHO lines 102 directing HHO from one or more splitters 101 to controller 99 and one or more metered water-electrolyte mixture ("water") lines 103 directing a metered electrolyte-water mixture from controller 99 to one or more splitters 101.

[00115] FIG. 30 is an enlarged, fragmentary isometric view illustrating a feeder port the modular system of FIG. 29. FIG. 30 is believed to be largely self-explanatory, and straightforwardly shows HHO line 102, "water" line 103, a temperature transducer/transmitter 104 and a pressure transducer/transmitter 105. Those of skill in the art will appreciate that temperature transducer/transmitter 104 and pressure transducer/transmitter 105 can be of conventional design.

[00116] FIG. 31 illustrates an auxiliary tank for chilling at least the splitter part of the system of FIG. 29. Those of skill in the art will appreciate that higher the hydrogen production load on the invented splitter, the higher the heat produced thereby. Thus those of skill will appreciate that a straightforward oil bath for submersion of the splitter therein is provided in accordance with one embodiment of the invention. The oil bath can be, for example, transmission oil such as that used to cool internal combustion engine (ICE)-equipped vehicles. The bath can be provided by substantially filling with oil 106 a substantially closed or sealed receptacle configured and dimensioned to receive the splitter 101 therein. Also shown in FIG. 31 are HHO lines 102 and "water" lines 103.

[00117] FIG. 32 illustrates an enlarged, fragmentary side elevation of the splitter part of the system of FIG. 29. Those of skill in the art will appreciate that very similar components and their function and cooperation are evident from the detailed description above. Briefly, the illustrated region of splitter 101 includes HHO line 102, "water" line 103, a tank 105 filled with a material such as oil capable of sinking heat, a series-connected and preferably cone-shaped, stacked, plurality of electrodes 107, a "water" channel 108 supplying the water and electrolyte mixture through a splitting region including the plurality of electrodes 107, and a corresponding channel 109 for out-taking HHO after the splitting of the "water" mixture.

[00118] FIGS. 33A, 33B, and 33C are flow diagrams respectively illustrating a fuel-cost-saving allocation, accounting, and billing method in accordance with another invented method.

[00119] This invented method involves the allocation of fuel savings among a hydrogen-generation-and-fuel-blending equipment supplier and a fuel consumer. The method includes establishing a fuel consumption baseline by monitoring fuel consumption without the blending equipment in operation; thereafter operating the blending equipment; establishing a fuel consumption level while the blending equipment is in operation; determining the difference between the baseline and the level; and allocating a consumption cost saving amount based upon the determined difference to the fuel consumer. The establishing step can be performed at pseudo-random time intervals by the blending equipment supplier.

[00120] FIGs. 33A, 33B, and 33C illustrate these basic steps under three different operational modalities based on fuel consumption location and mobility.

[00121] FIG. 33A illustrates the invented accounting method for a relatively stationary or fixed fuel consumer, e.g. an electrical generator installation, wherein network, e.g. Internet, communications are substantially continuous. Fuel readings are taken automatically by the system and logged to a distinct URL web address served by a proprietary server. The server retrieves consumption confirmation via the Internet and zeros out the system at the end of the billing period. An accounting program calculates the period fuel savings allocable to the hydrogenation in accordance with the invented system and sends the consumer (customer) and invoice, as shown. Thus, the invented accounting/billing method optionally further includes providing a web-based server configured automatically periodically to upload baseline and consumption-level data from the blending equipment.

[00122] FIG. 33B differs somewhat from FIG. 33A in that the fuel consumption is relatively fixed but the fuel consumer, e.g. a large marine, mining, farming irrigation pump engine that operates 24/7/365, is not network-connected. In this case an employee or agent of the hydrogenated fuel supplier manually visits the fuel consumption site and retrieves a logged memory stick from the system and replaces it with a blank one to be used for data acquisition until the next site visit. The data is logged via computer into the accounting package and the client receives an invoice for the fuel saving for the past period, which may or may not represent a fixed period of time. Thus, the invented allocation, accounting, and billing method optionally further includes providing a portable data storage device at the blending equipment, the device storing the baseline and consumption-level data from the blending equipment for periodic pick-up by service personnel.

[00123] FIG. 33C differs somewhat from FIG. 33A in that the fuel consumption is not stationary, e.g. it might be on a mobile vehicle (e.g. a bus, a truck, a train, etc.) that has widely variable fuel consumption and that is not always network-connected. In this case a cellular network is used instead and the fuel consumption data is obtained by the proprietary server during periods of time and in locations where cellular connectivity is established.

[00124] The method further includes optionally reporting the allocated cost saving the fuel consumer; invoicing the fuel consumer for the allocated cost saving and crediting the blending equipment supplier by the amount of the cost saving against the non-recurring cost of (manufacturing and) installing the blending equipment; and selectively discontinuing operation of the blending equipment in the event the fuel consumer fails to pay the amount of the invoicing within a defined time thereafter.

[00125] It has been discovered that relatively high-frequency polarity reversal avoids cathodic buildup on the electrode plates and boosts efficiency of HHO generation and ICE fossil fuel savings. Experimentation demonstrates that a measurable reduction in

HHO generation occurs as quickly as ten minutes after start up of the invented HHO cell. While applicants do not intend to be bound by any theory of operation of their invention, nevertheless it is believed that such reduced output after such a short interval is at least in part caused by cathodic buildup. Accordingly, it is believed that a preferred polarity reversal period or interval of less than approximately ten minutes, and more preferably as few as approximately five minutes is desired. Those of skill in the art will appreciate, however, that other polarity-reversal intervals or periods of time (perhaps as measure by their inverse, frequency) are contemplated as being within the spirit and scope of the invention.

[00126] Finally, those of skill in the art will appreciate that the invented method, system and apparatus described and illustrated herein may be implemented in software, firmware or hardware, or any suitable combination thereof. Preferably, the method system and apparatus are implemented in a combination of the three, for purposes of low cost and flexibility. Thus, those of skill in the art will appreciate that the method, system and apparatus of the invention may be implemented by a computer or microprocessor process in which instructions are executed, the instructions being stored for execution on a computer-readable medium and being executed by any suitable instruction processor.

[00127] While at least one exemplary embodiment has been presented in the foregoing detailed description of the invention, it should be appreciated that a vast number of variations exist. It should also be appreciated that the exemplary embodiment or exemplary embodiments are only examples, and are not intended to limit the scope, applicability, or configuration of the invention in any way. Rather, the foregoing detailed description will provide those skilled in the art with a convenient road map for implementing an exemplary embodiment of the invention, it being understood that various changes may be made in the function and arrangement of elements described in an exemplary embodiment without departing from the scope of the invention as set forth in the appended claims.

CLAIMS

1. A system for producing hydrogen comprising:

a housing;

a voltage regulator coupled to the housing, the voltage regulator operable to increase an input voltage from a lower voltage to a higher operating voltage;

a hydrogen-producing cell coupled to the voltage regulator comprises a series of conical shaped electrodes, the hydrogen producing cell containing a mixture of water and an electrolyte, the hydrogen producing cell operable to produce hydrogen when receiving the operating voltage from the voltage regulator;

a fuel-mixing area coupled to the hydrogen-producing cell, the fuel-mixing area receiving a petroleum based fuel and hydrogen from the hydrogen-producing cell and producing a blended fuel by mixing the hydrogen and petroleum based fuel, the fuel-mixing area outputting the blended fuel.

2. The system of claim 1, wherein the petroleum based fuel is received from a fuel tank coupled to the system.

3. The system of claim 1, wherein the blended fuel is outputted to a combustion engine coupled to the system.

4. The system of claim 1 further comprising:

a mixing window in the fuel mixing area for visual inspection of the mixing process.

5. The system of claim 1 further comprising:

a water source coupled to the hydrogen-producing cell for supplying water thereto.

6. The system of claim 5, wherein the water source includes a water reservoir.

7. The system of claim 6, wherein the water source includes a condenser for extracting water from ambient air to supply the water reservoir.

8. The system of claim 1, wherein the electrolyte includes methanesulfonic acid (MSA).

9. The system of claim 8, wherein the electrolyte includes MSA in a concentration of between approximately one percent and approximately ten percent by weight.

10. The system of claim 9, wherein the electrolyte includes MSA in a concentration of greater than approximately four percent by weight.

11. The system of claim 1 further comprising:

a voltage polarity-reversing circuit operatively coupled between the voltage regulator and the cell, the circuit configured to reverse the polarity of the operating voltage periodically in accordance with a defined timing interval.

12. The system of claim 11, wherein the defined timing interval is variable.

13. The system of claim 11, wherein the defined timing interval is less than approximately ten minutes.

14. The system of claim 13, wherein the defined timing interval is approximately five minutes.

15. A method of allocating fuel savings among a hydrogen-generation-and-fuel-blending equipment supplier and a fuel consumer, the method comprising:

a) establishing a fuel consumption baseline by monitoring fuel consumption without the blending equipment in operation; thereafter

b) operating the blending equipment;

c) establishing a fuel consumption level while the blending equipment is in operation;

d) determining the difference between the baseline and the level; and

e) allocating a consumption cost saving amount based upon the determined difference to the fuel consumer.

16. The method of claim 15 further comprising:

f) reporting the allocated cost saving to the fuel consumer.

17. The method of claim 16 which further comprises:

g) invoicing the fuel consumer for the allocated cost saving and crediting the blending equipment supplier by the amount of the cost saving against the non-recurring cost of installing the blending equipment.

18. The method of claim 17 which further comprises:

h) selectively discontinuing operation of the blending equipment in the event the fuel consumer fails to pay the amount of the invoicing within a defined time thereafter.

19. The method of claim 15, wherein the establishing step is performed at pseudo-random time intervals by the blending equipment supplier.

20. The method of claim 15 wherein the blending equipment is generally telecommunications-capable, which further comprises:

f) providing a web-based server configured automatically periodically to upload baseline and consumption-level data from the blending equipment.

21. The method of claim 15 wherein the blending equipment is generally telecommunications-incapable, the method further comprising:

f) providing a portable data storage device at the blending equipment, the device storing the baseline and consumption-level data from the blending equipment for periodic pick-up by service personnel.

22. A method of supplying hydrogenated fuel to an internal combustion engine, the method comprising:

first drawing a volume of water from a water source;

adding a volume of electrolyte to the volume of water to produce a water-electrolyte mixture;

flooding a splitter cell containing series-connected electrodes with a volume of the water-electrolyte mixture;

first energizing the splitter cell with direct current (DC) voltage to split the water-electrolyte mixture into a hydrogenated vapor;

second drawing a volume of fossil fuel from a fuel tank; and

blending the hydrogenated vapor with the volume of gas to produce a hydrogenated fuel.

23. The method of claim 22 further comprising:

supplying the hydrogenated fuel to a gas intake port of an internal combustion engine.

24. The method of claim 23 further comprising:

second energizing the splitter cell with an alternating current (AC) voltage applied thereto concurrent with the first energizing.

25. The method of claim 24, wherein the amplitude of the AC voltage is greater than the amplitude of the DC voltage.

26. The method of claim 25, wherein the first and second energizing are periodically polarity-reversed.

27. The method of claim 26, wherein the periodic polarity-reversal is at an interval of less than approximately ten minutes.

28. The method of claim 22 which further comprises:

condensing ambient air to extract water therefrom;

filtering the extracted water; and

conveying the filtered water to the water source.

29. The method of claim 22, wherein the blending includes urging the hydrogenated vapor and the fossil fuel through a conduit along a tortuous path.

30. A modular orthohydrogen fuel cell comprising:

a fossil-fuel source;

a water source;

an electrolyte source;

a power source;

a splitter including plural series-connected electrodes operatively connectable to an applied power, the splitter configured to fracture electrolyte-infused water molecules into individual hydrogen and oxygen atoms and to output the atoms as orthohydrogen (HHO) gas;

a blending mechanism configured to mix the HHO gas and the fossil fuel and to output a blend thereof to an internal combustion engine; and

a controller configured to control the intake of water from the water source and of electrolyte from the electrolyte source, selectively to provide an applied power from the power source to the splitter, and to operate the blending mechanism,

wherein at least the splitter and the controller are separated and operated remotely from one another, with water and HHO lines extending therebetween to operatively couple together the splitter and the controller.

31. The cell of claim 30 further comprising:

a receptacle configured to receive the splitter therein, the receptacle further configured to submerse the splitter in an oil bath, whereby the oil is operable as a heat sink for the splitter.

32. The cell of claim 30, wherein the electrodes are series-connected and the power is applied across the series-connected electrodes.

33. The cell of claim 30, wherein the electrodes are conical in shape.

34. The cell of claim 33, wherein the applied power includes a direct-current (DC) bias voltage and an alternating current (AC) excitation voltage superimposed thereon.

35. The cell of claim 34, wherein the excitation voltage is of greater amplitude than the bias voltage.

36. The cell of claim 35, wherein the frequency of the AC waveform is a multiple of the resonant frequency of a water molecule.

37. The cell of claim 36, wherein the AC waveform includes multiple frequency components that are multiples of the resonant frequency of a water molecule.

38. The cell of claim 37, wherein the controller is configured to control the intake of water from the water source and of electrolyte from the electrolyte source in a concentration of more than approximately two percent by weight electrolyte to water.

39. The cell of claim 38, wherein the controller is configured to control the intake of water from the water source and of electrolyte from the electrolyte source in a concentration of more than approximately four percent by weight electrolyte to water.

40. The cell of claim 39, wherein the water source includes a condenser for extracting water from ambient air.

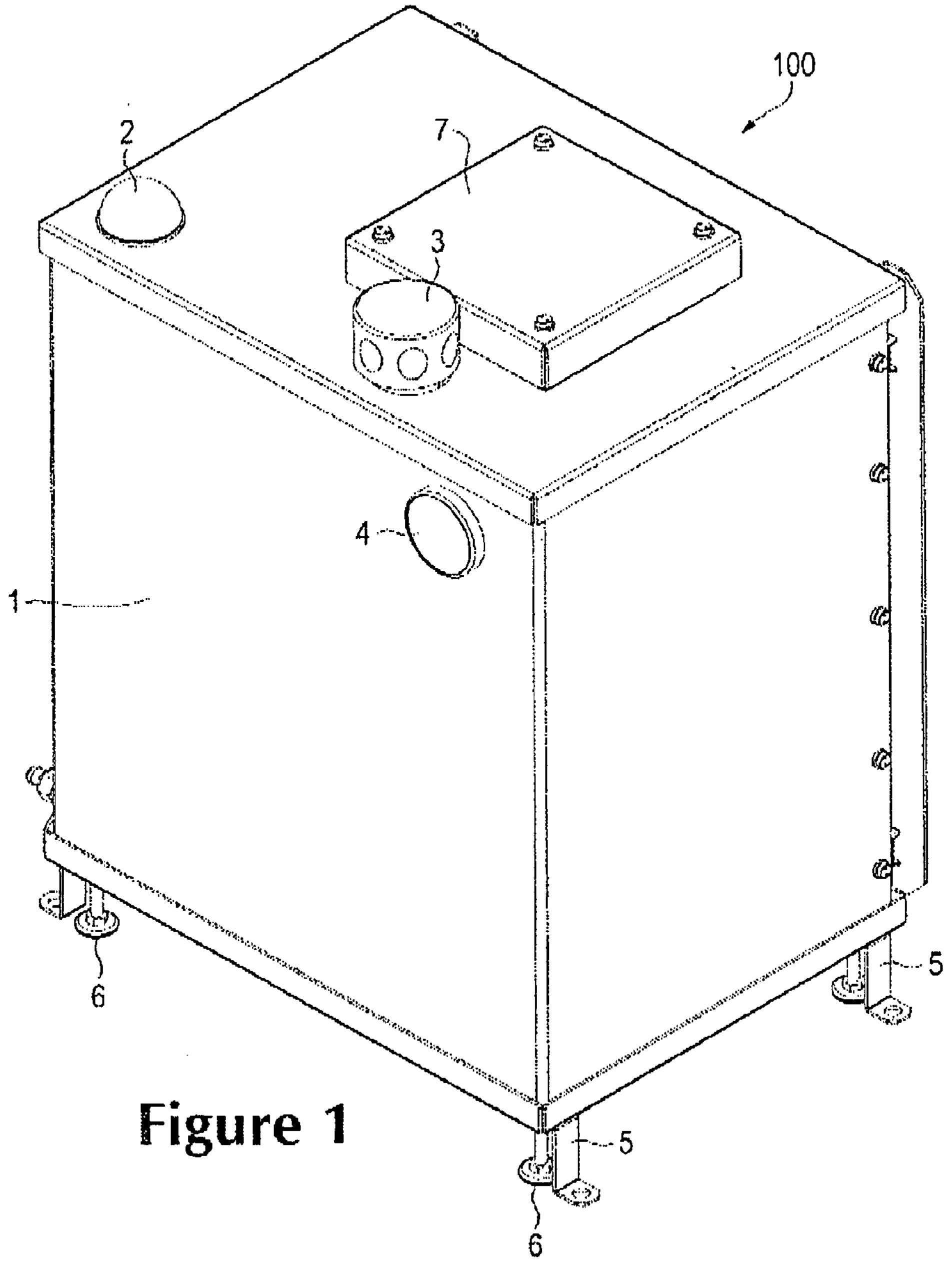


Figure 1

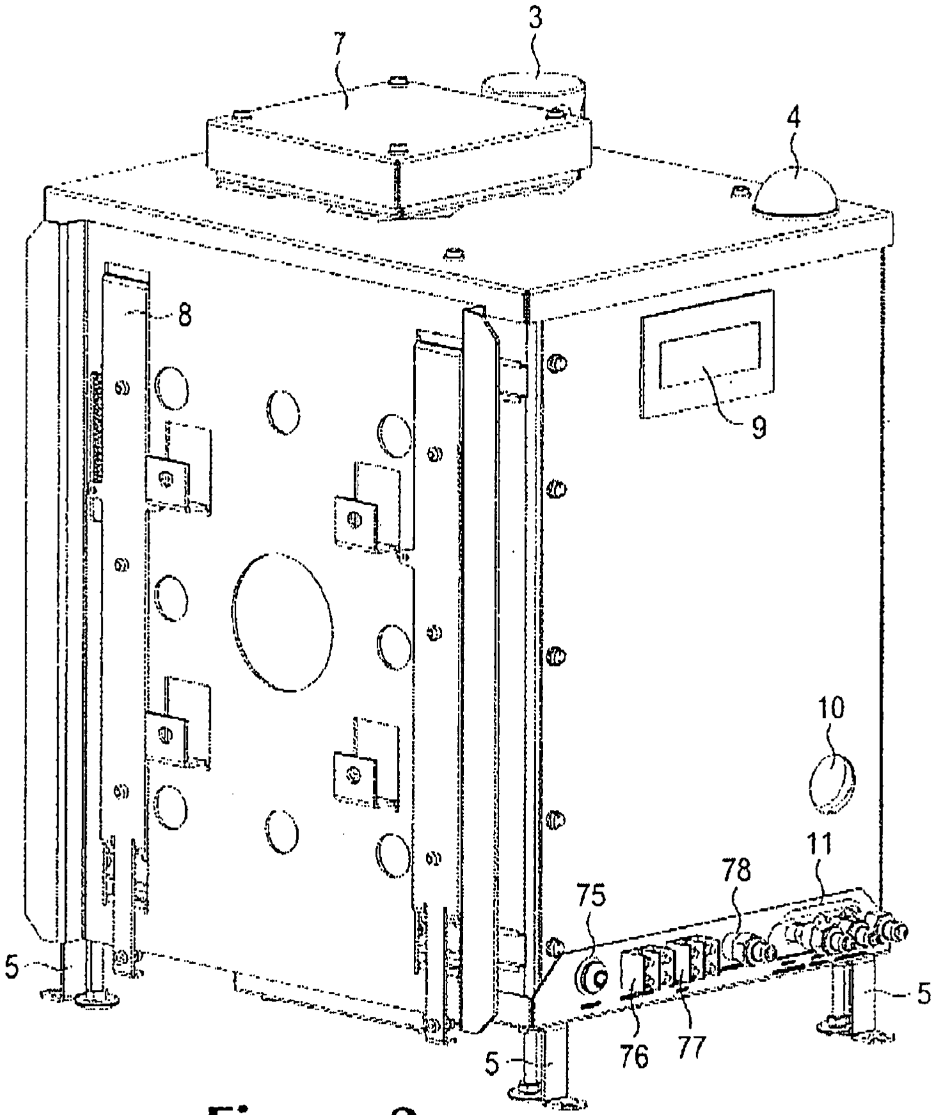


Figure 2

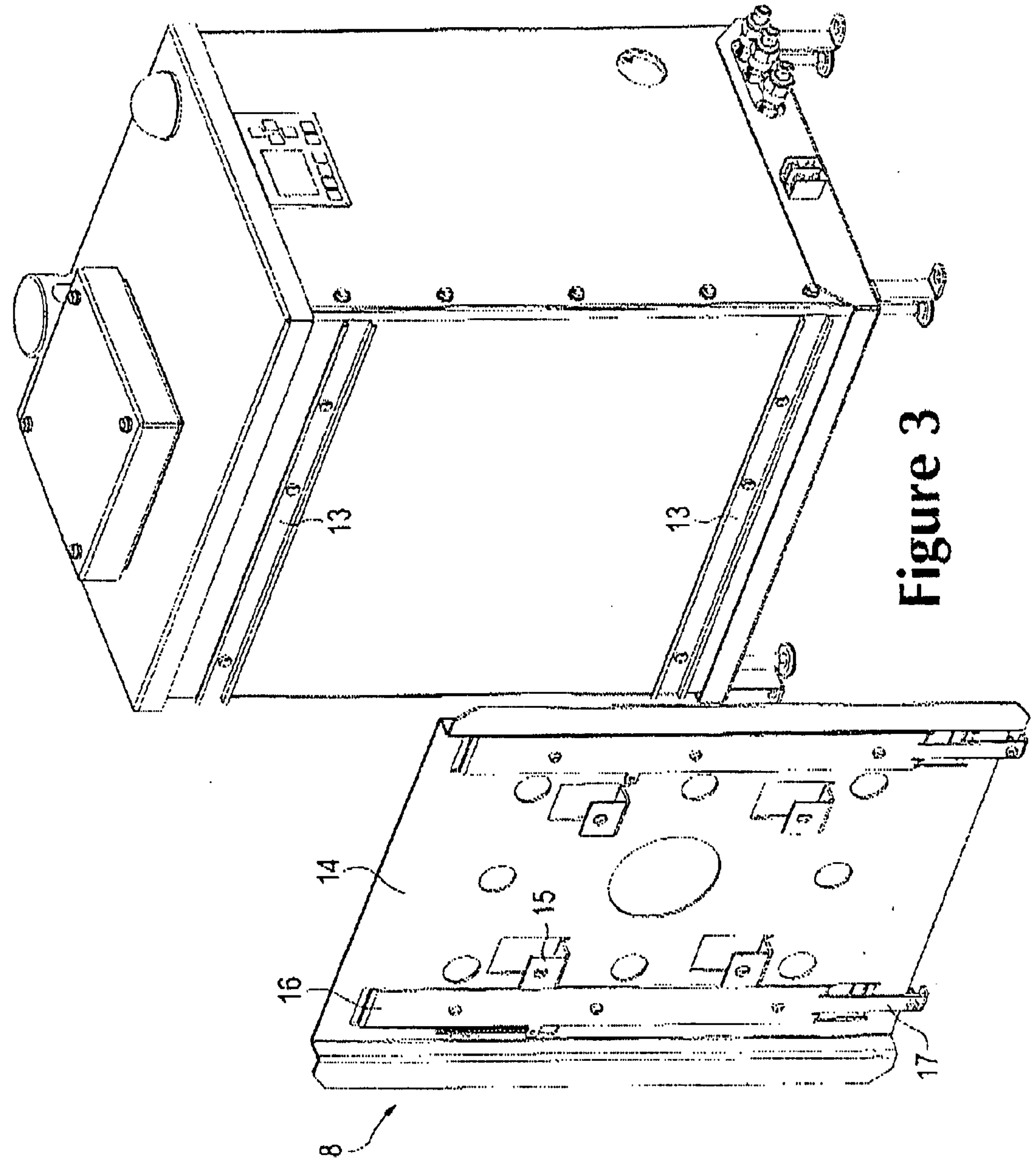


Figure 3

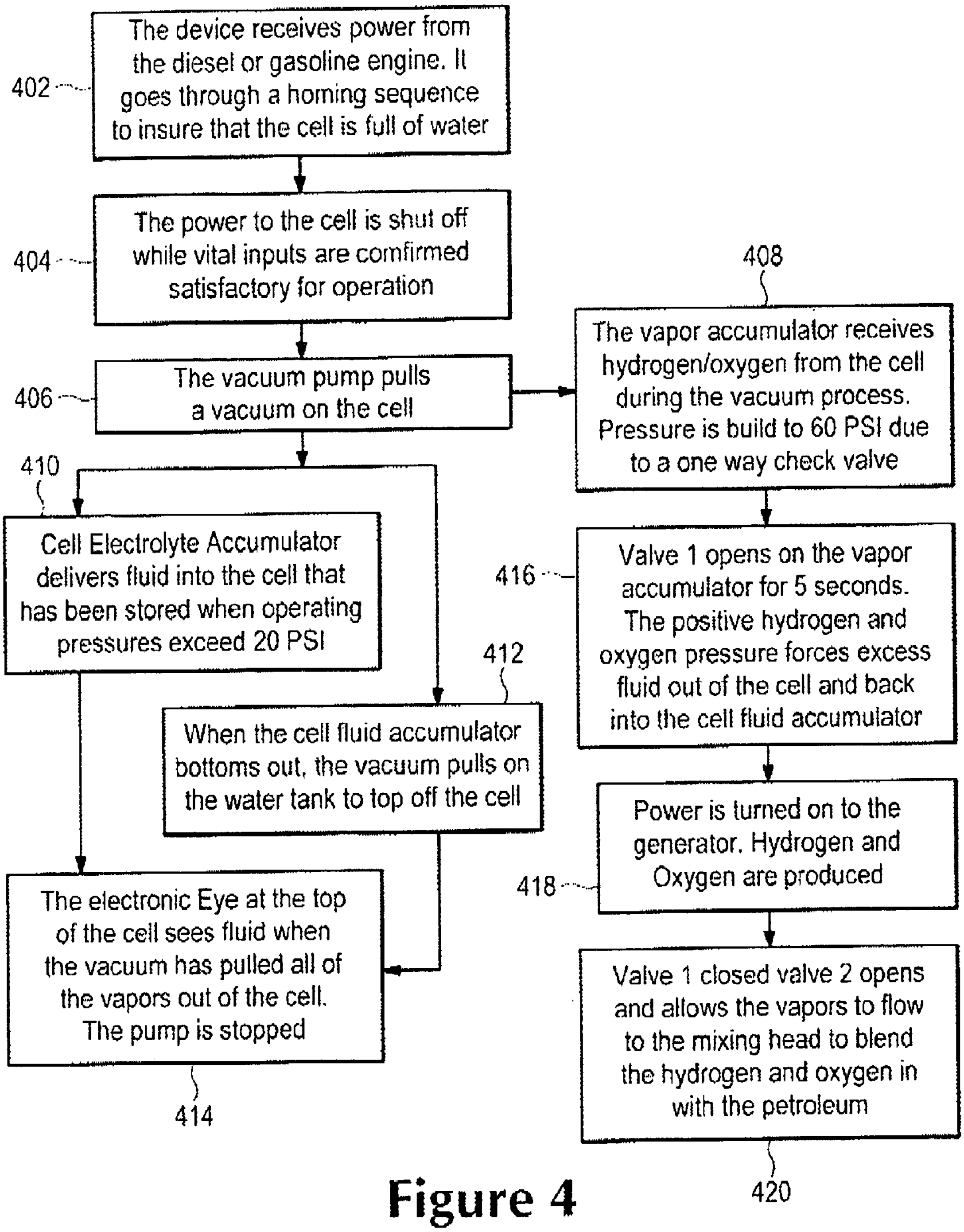

402
The device receives power from the diesel or gasoline engine. It goes through a homing sequence to insure that the cell is full of water
404
The power to the cell is shut off while vital inputs are comfirmed satisfactory for operation
406
The vacuum pump pulls a vacuum on the cell
408
The vapor accumulator receives hydrogen/oxygen from the cell during the vacuum process. Pressure is build to 60 PSI due to a one way check valve
410
Cell Electrolyte Accumulator delivers fluid into the cell that has been stored when operating pressures exceed 20 PSI
412
When the cell fluid accumulator bottoms out, the vacuum pulls on the water tank to top off the cell
416
Valve 1 opens on the vapor accumulator for 5 seconds. The positive hydrogen and oxygen pressure forces excess fluid out of the cell and back into the cell fluid accumulator
418
Power is turned on to the generator. Hydrogen and Oxygen are produced
The electronic Eye at the top of the cell sees fluid when the vacuum has pulled all of the vapors out of the cell. The pump is stopped
414
Valve 1 closed valve 2 opens and allows the vapors to flow to the mixing head to blend the hydrogen and oxygen in with the petroleum
420

Figure 4

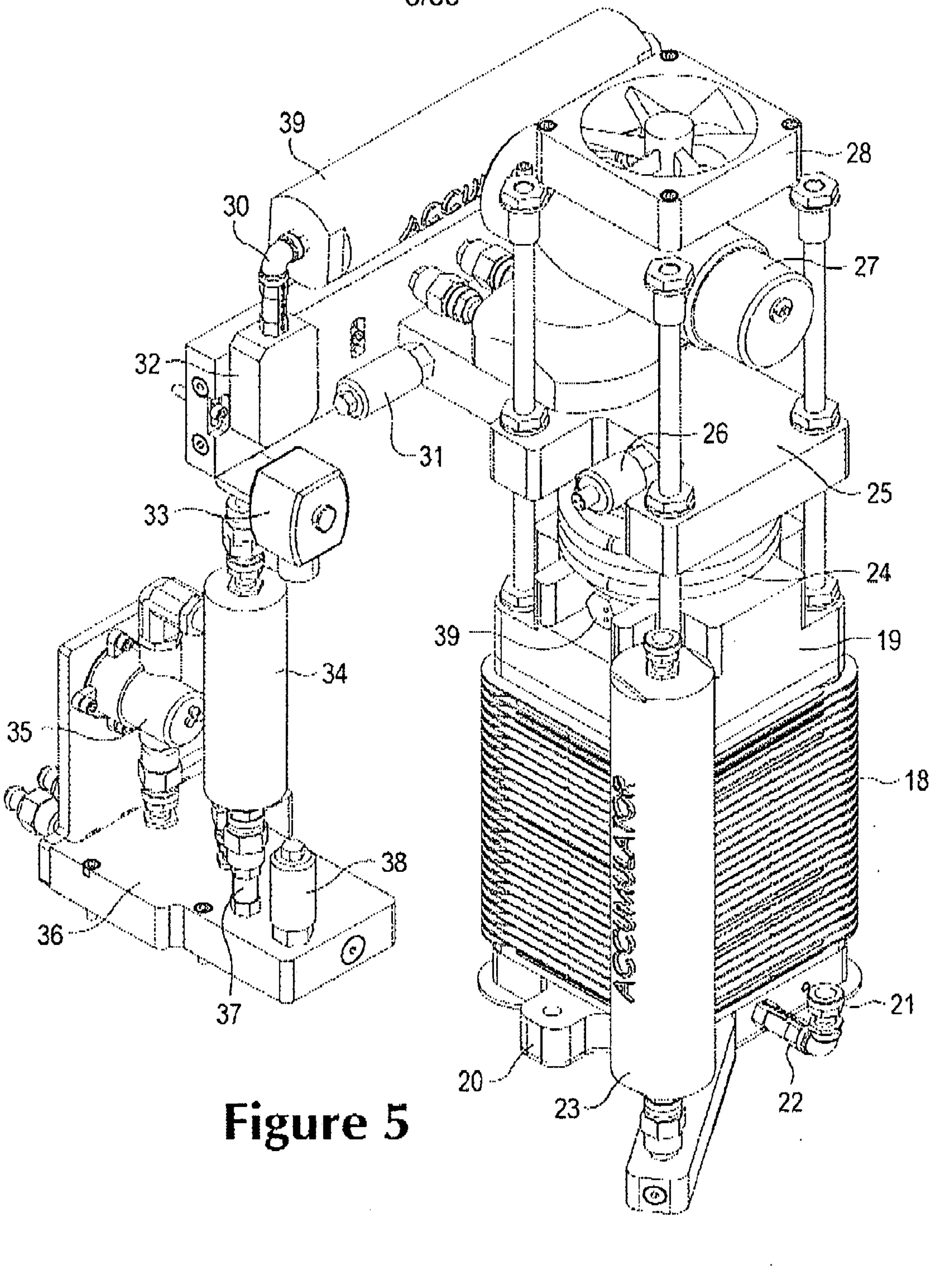


Figure 5

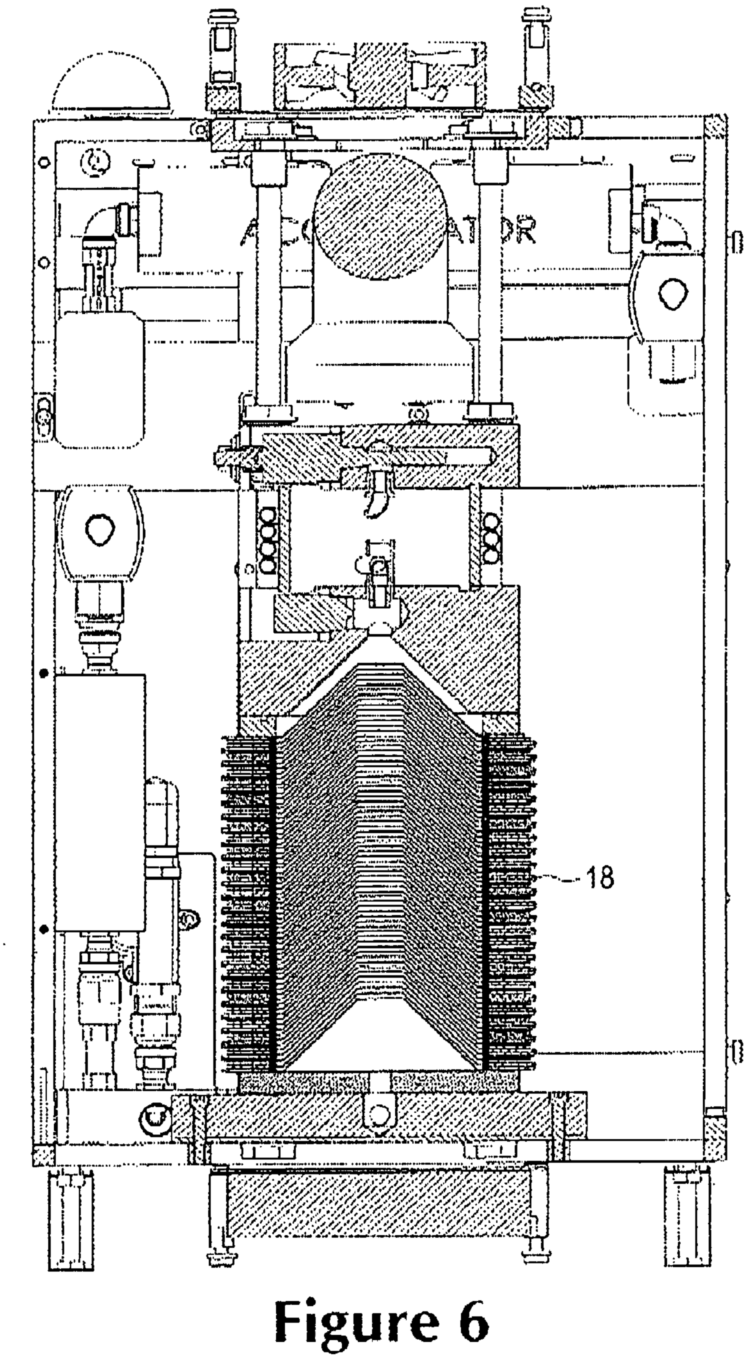


Figure 6

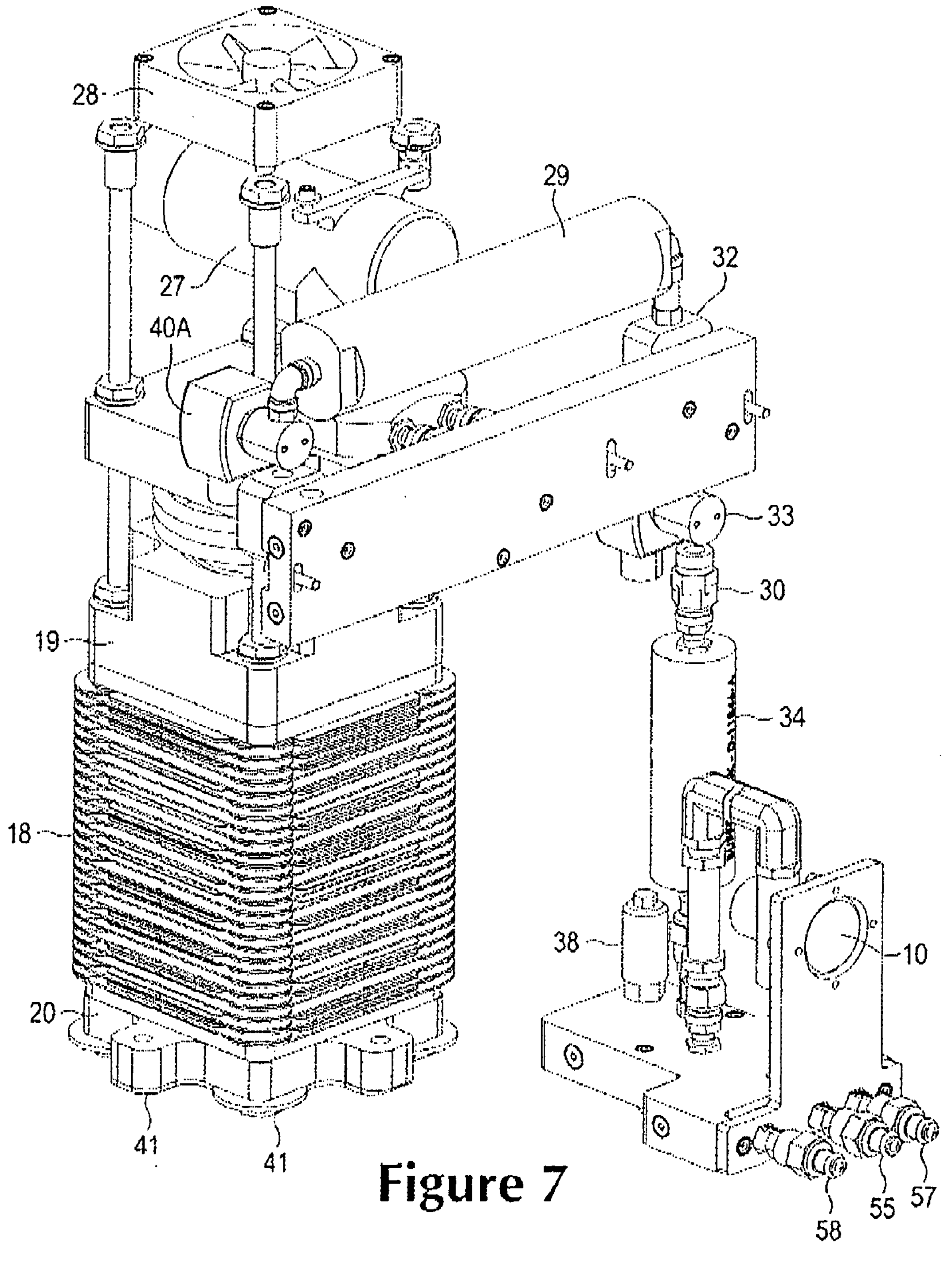


Figure 7

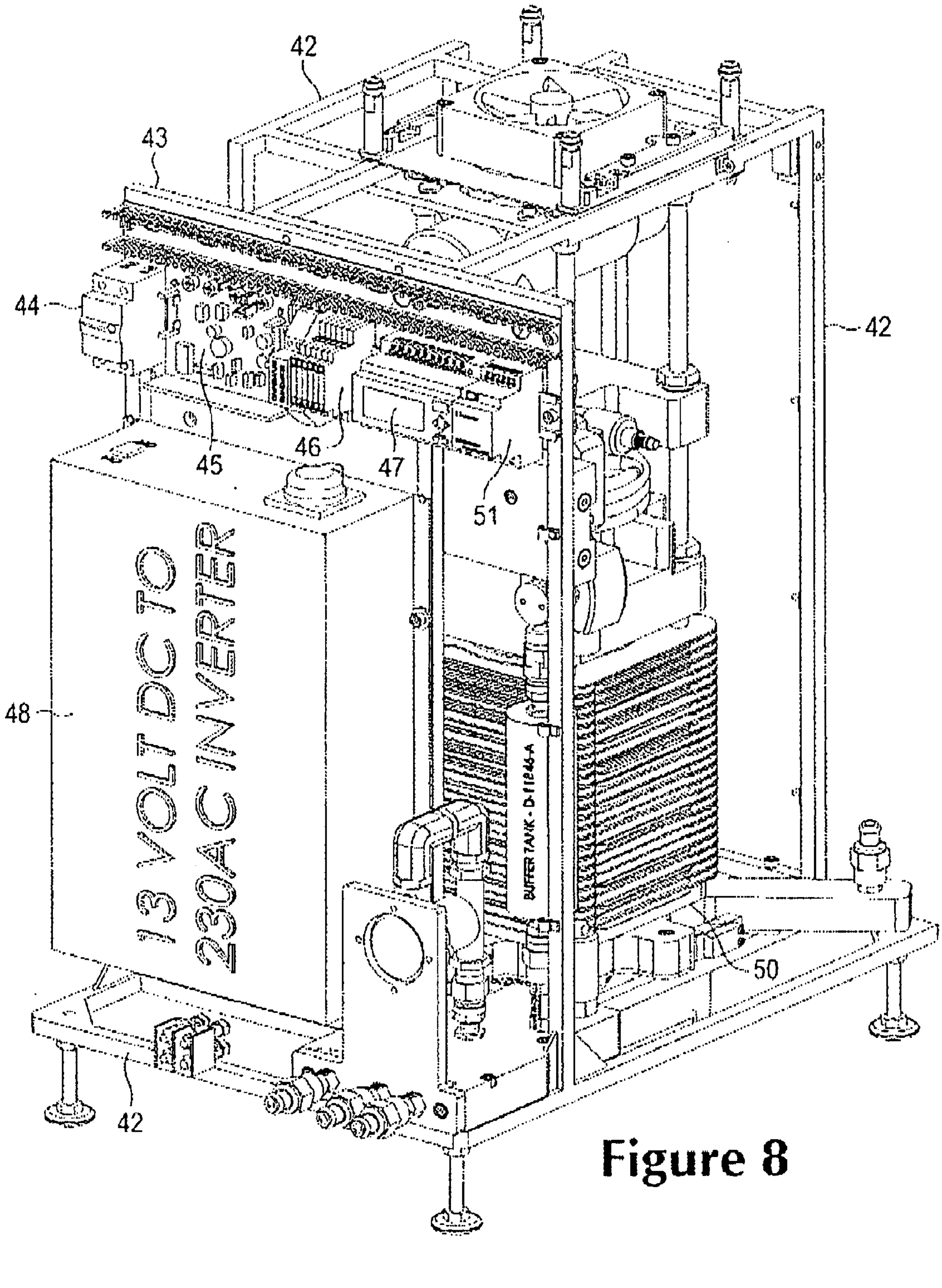

42
43
44
42
45
46
47
51
13 VOLT DC TO
230AC INVERTER
48
BUFFER TANK
50
42

Figure 8

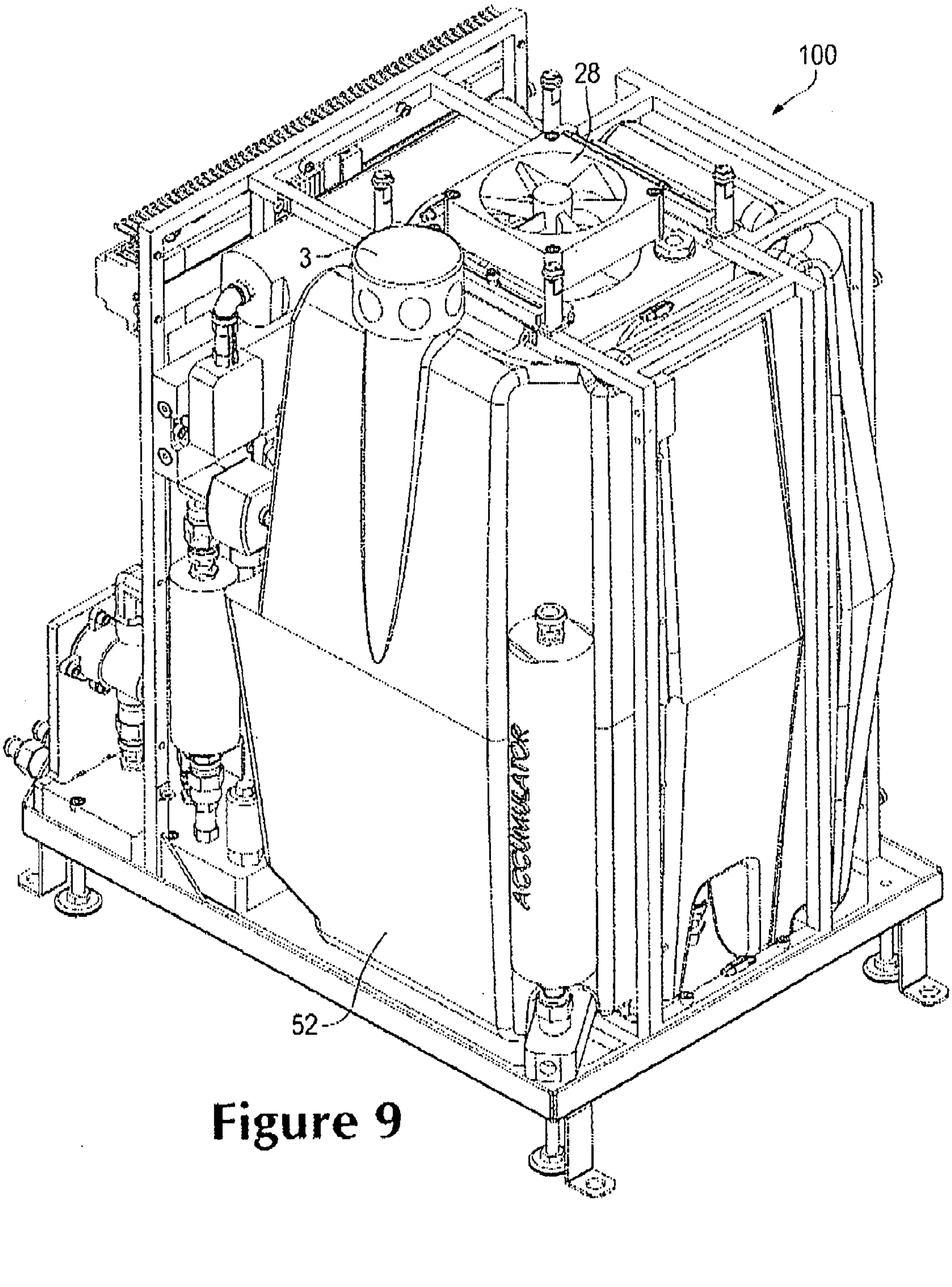


Figure 9

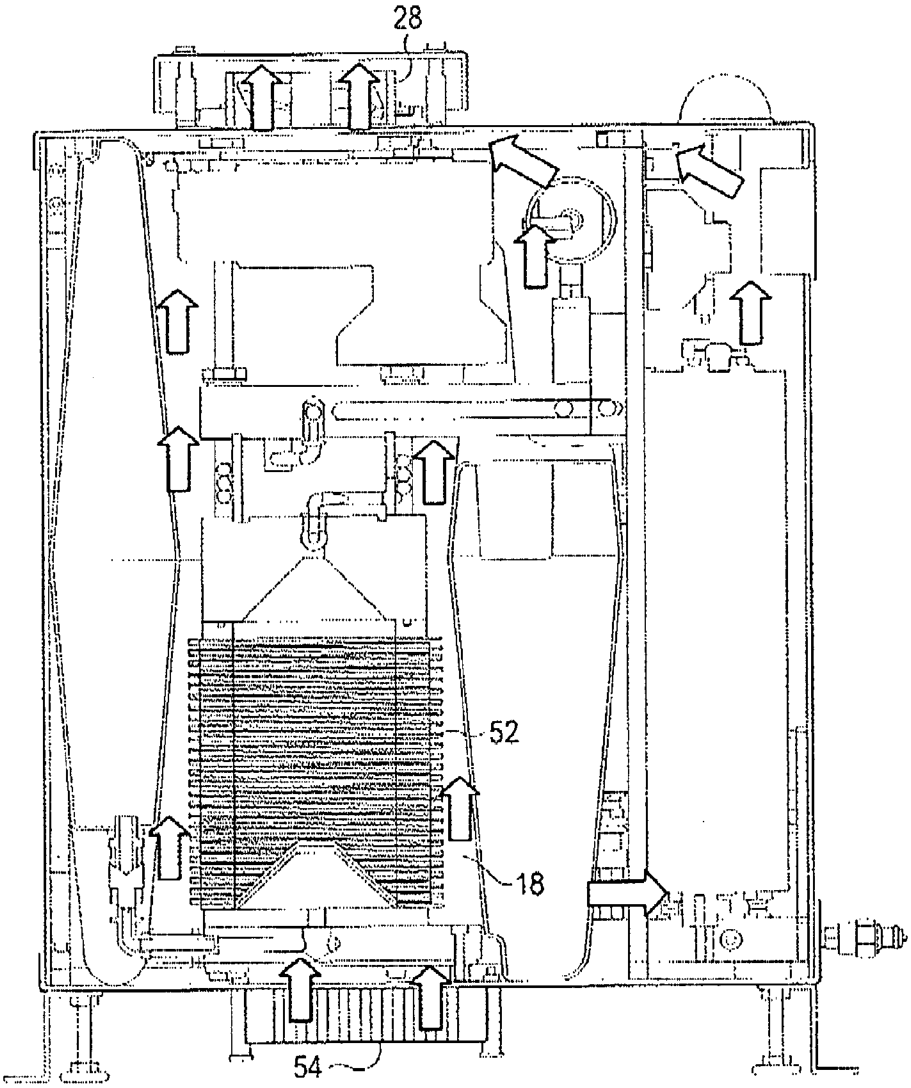


Figure 10

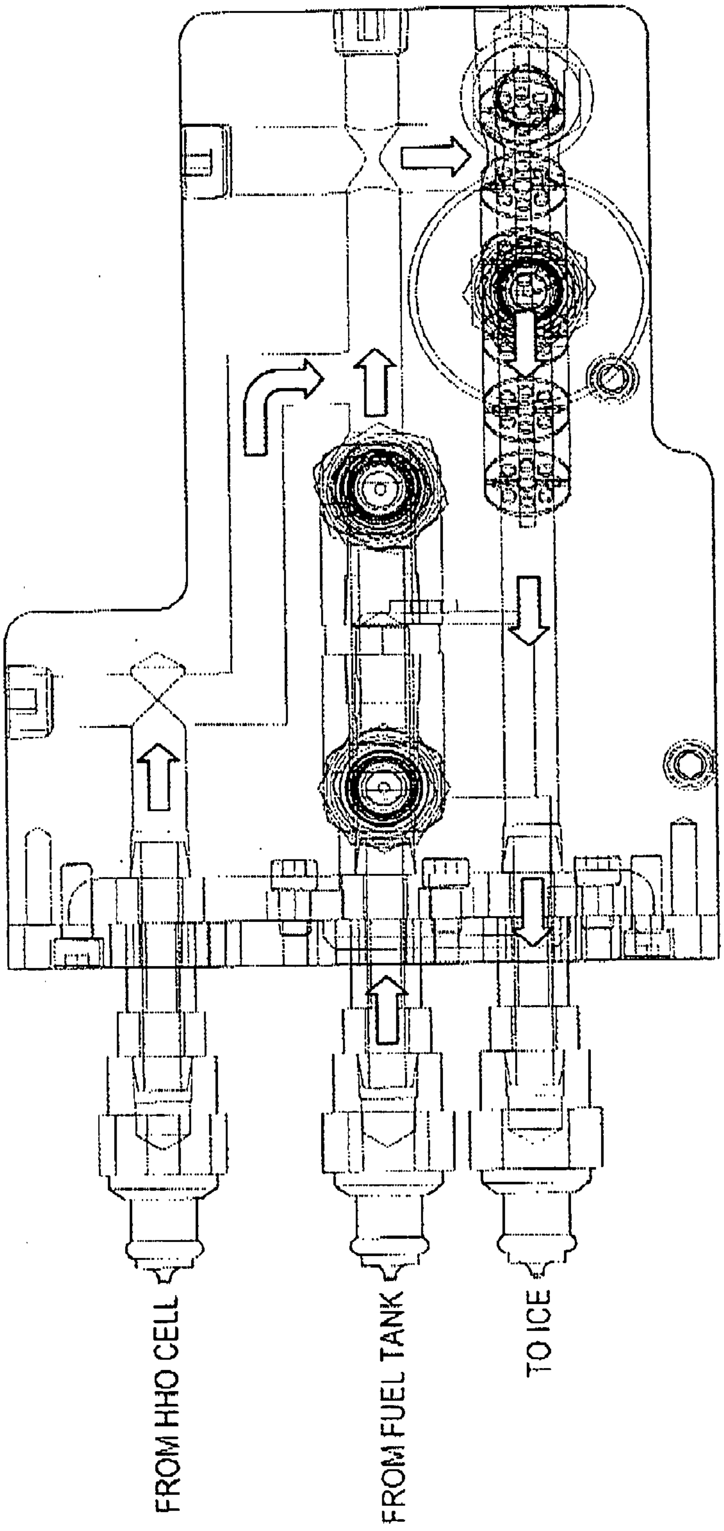


Figure 11

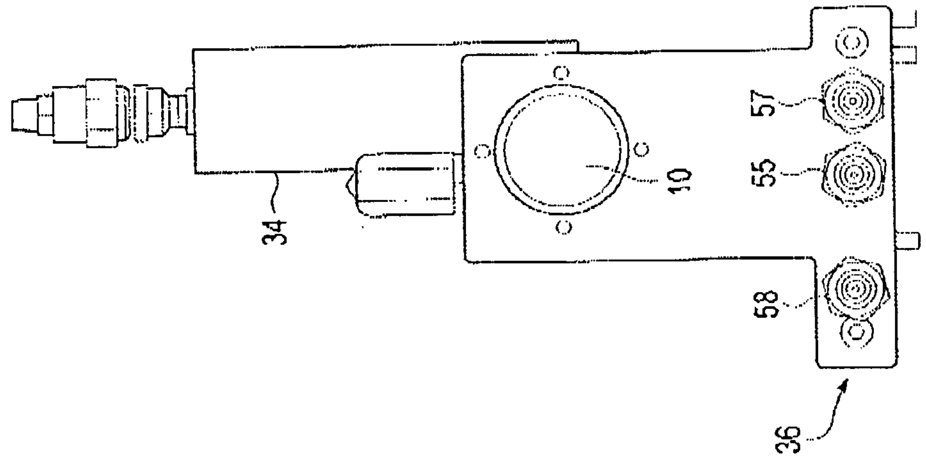


Figure 12B

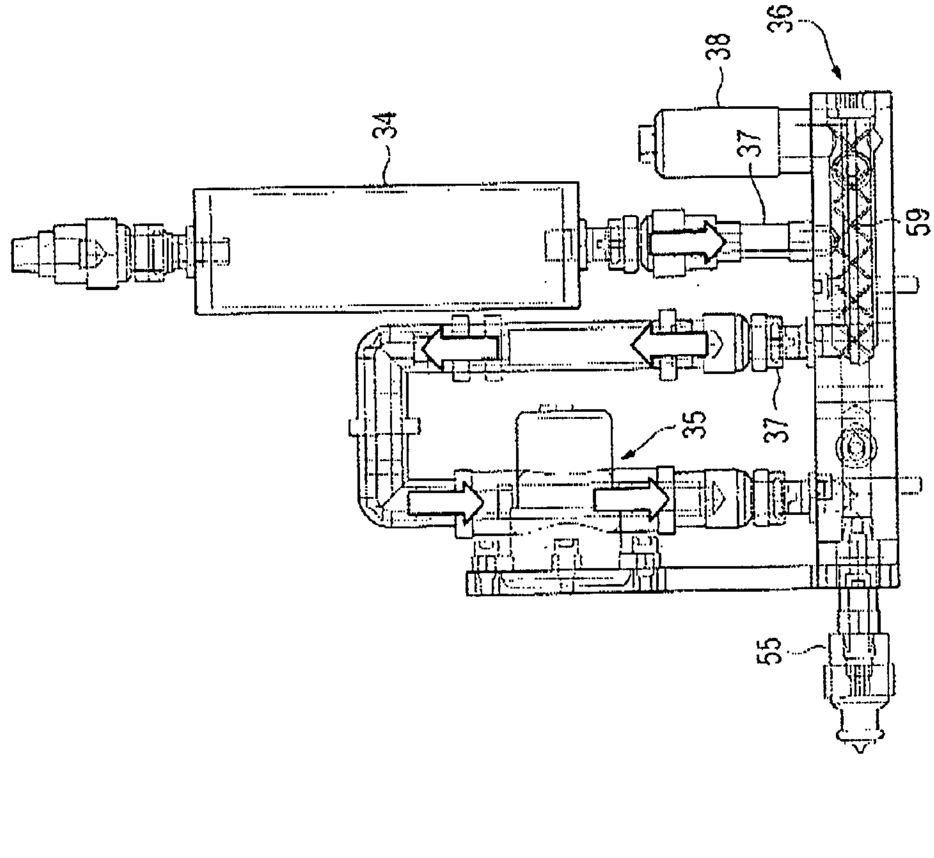


Figure 12A

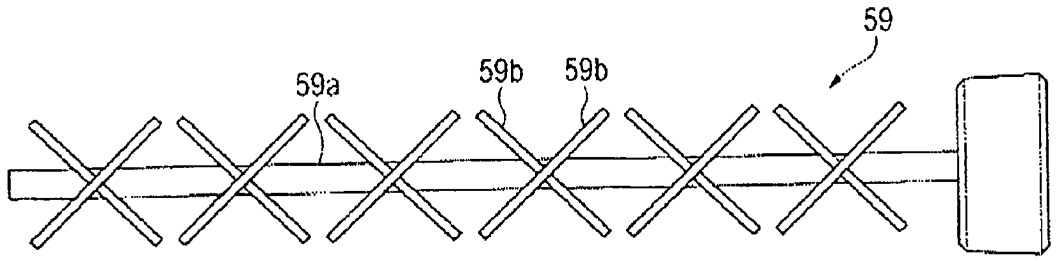


Figure 13A

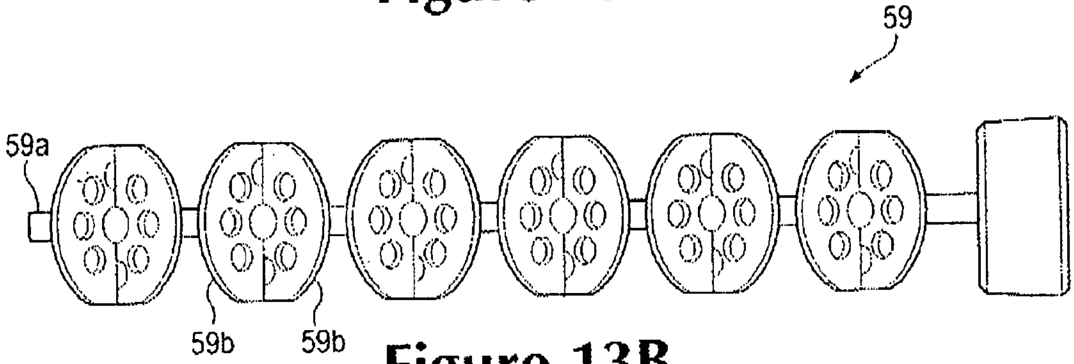


Figure 13B

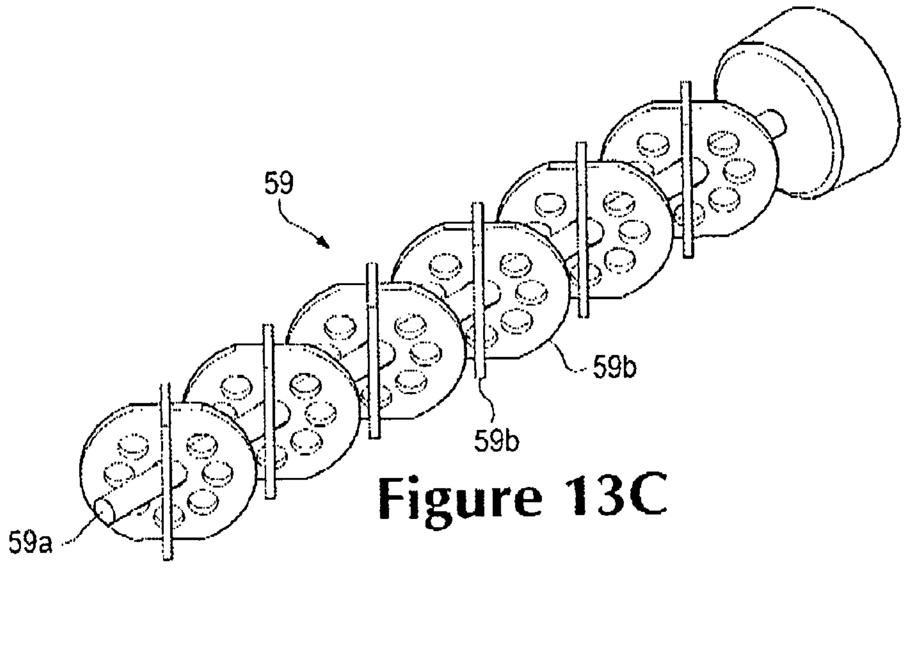


Figure 13C

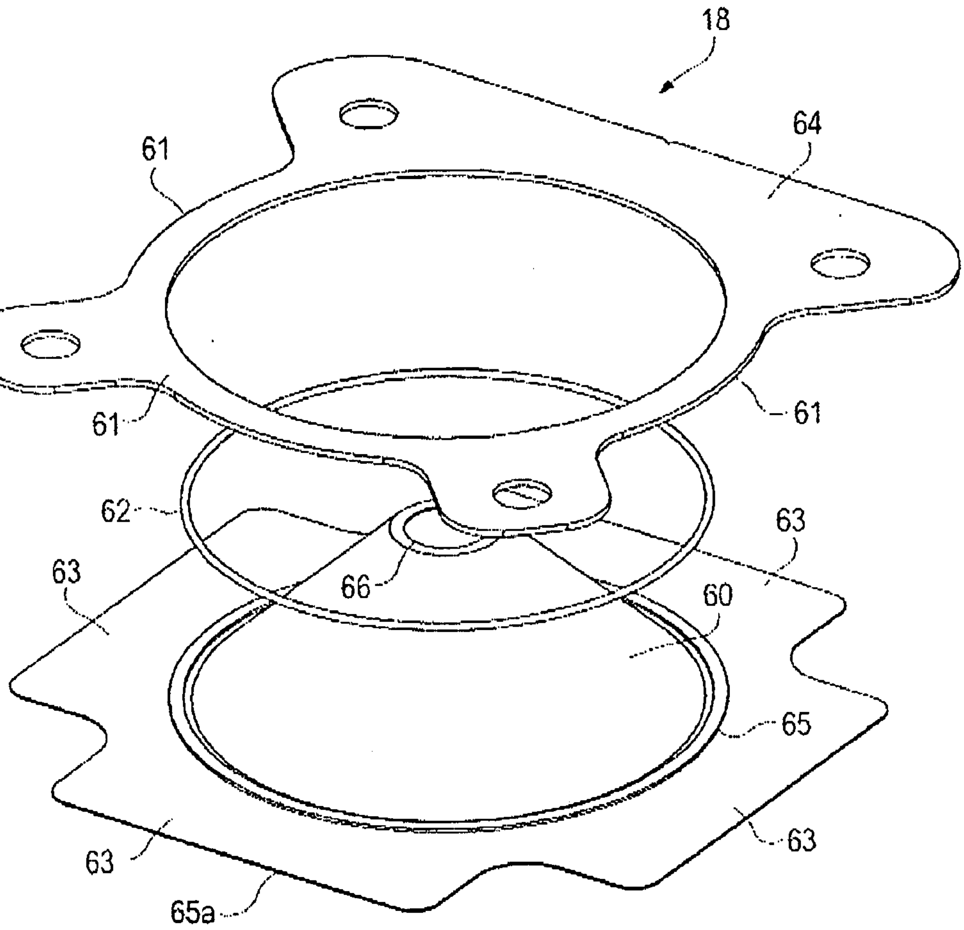


Figure 14

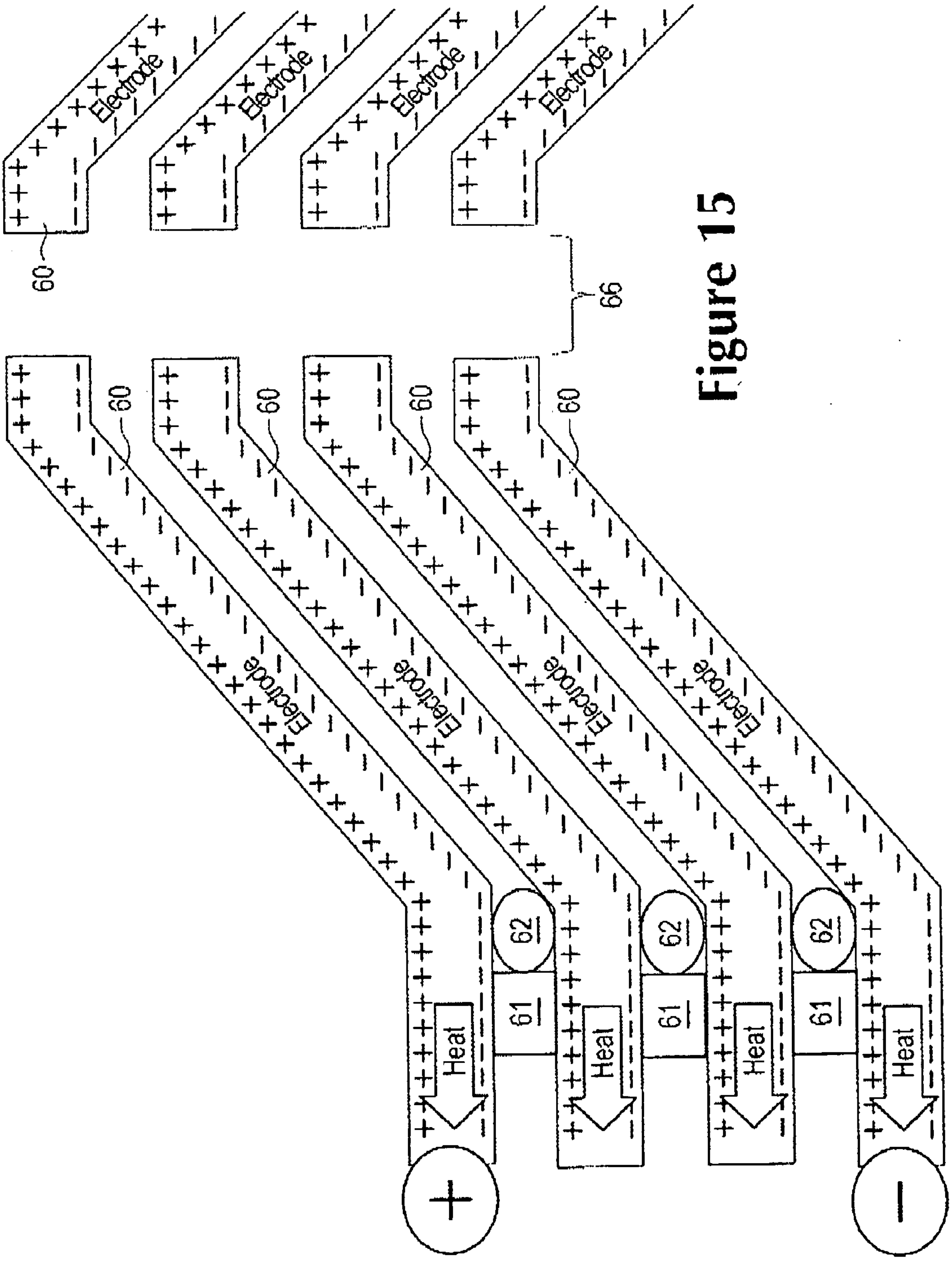


Figure 15

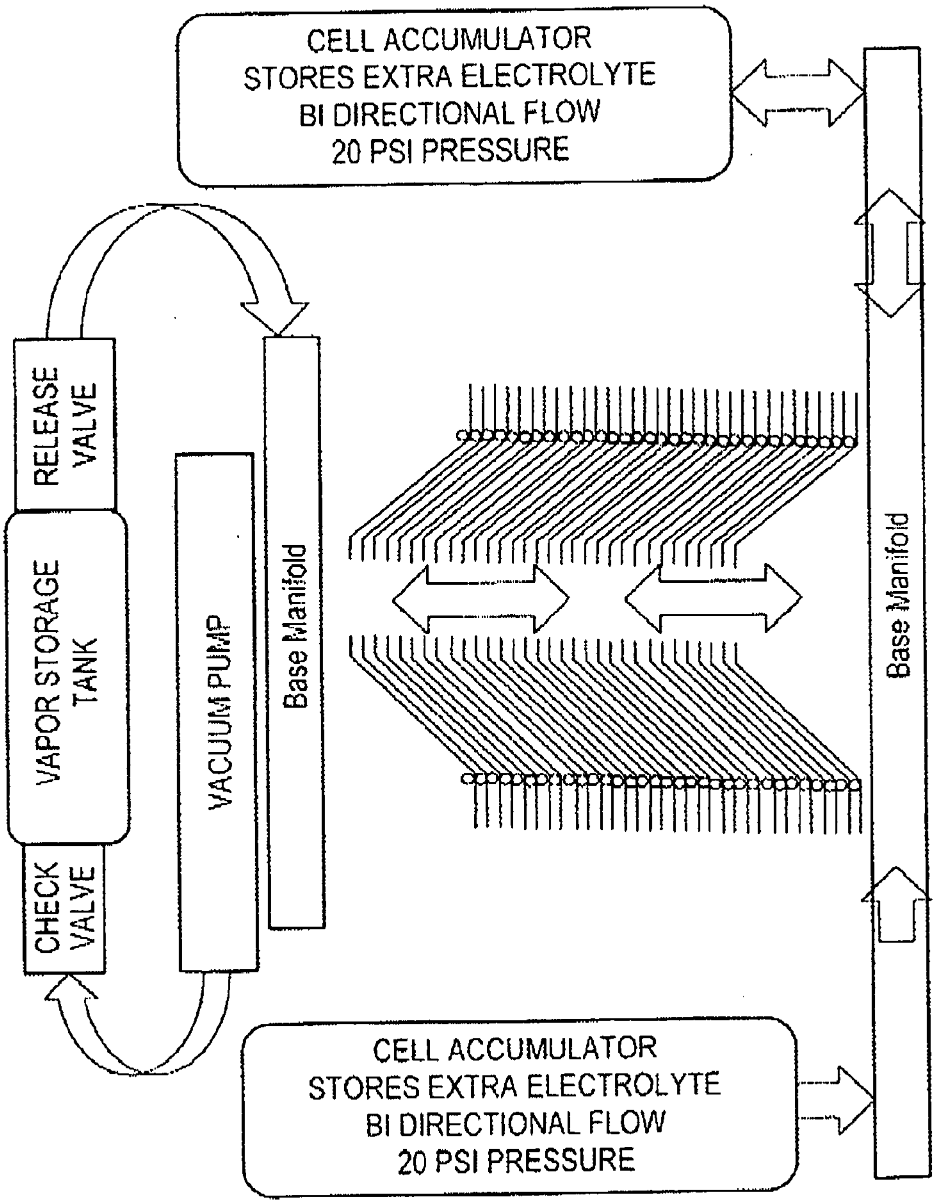

CELL ACCUMULATOR
STORES EXTRA ELECTROLYTE
BI DIRECTIONAL FLOW
20 PSI PRESSURE
RELEASE VALVE
VAPOR STORAGE TANK
CHECK VALVE
VACUUM PUMP
Base Manifold
Base Manifold
CELL ACCUMULATOR
STORES EXTRA ELECTROLYTE
BI DIRECTIONAL FLOW
20 PSI PRESSURE

Figure 16

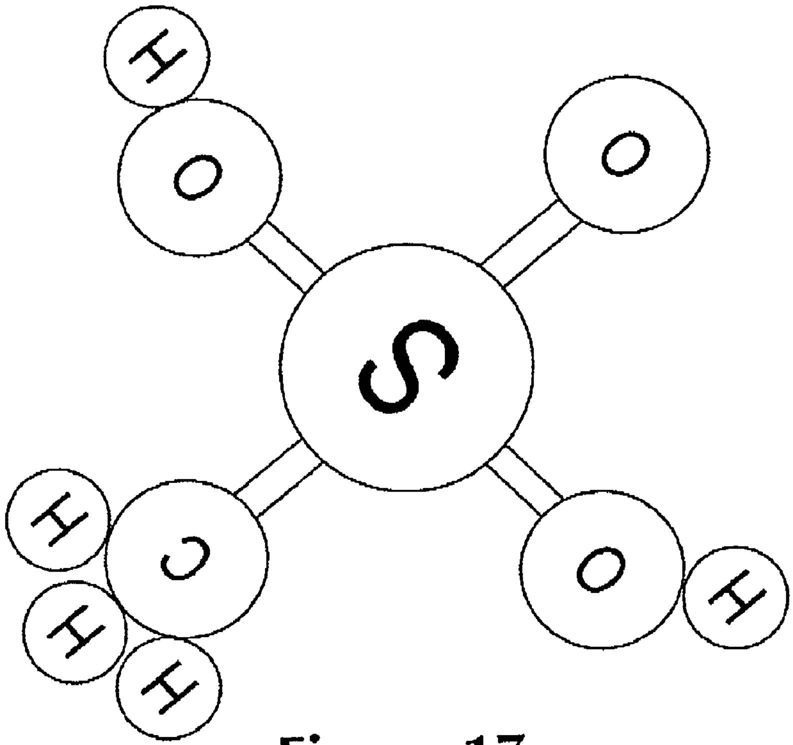


Figure 17

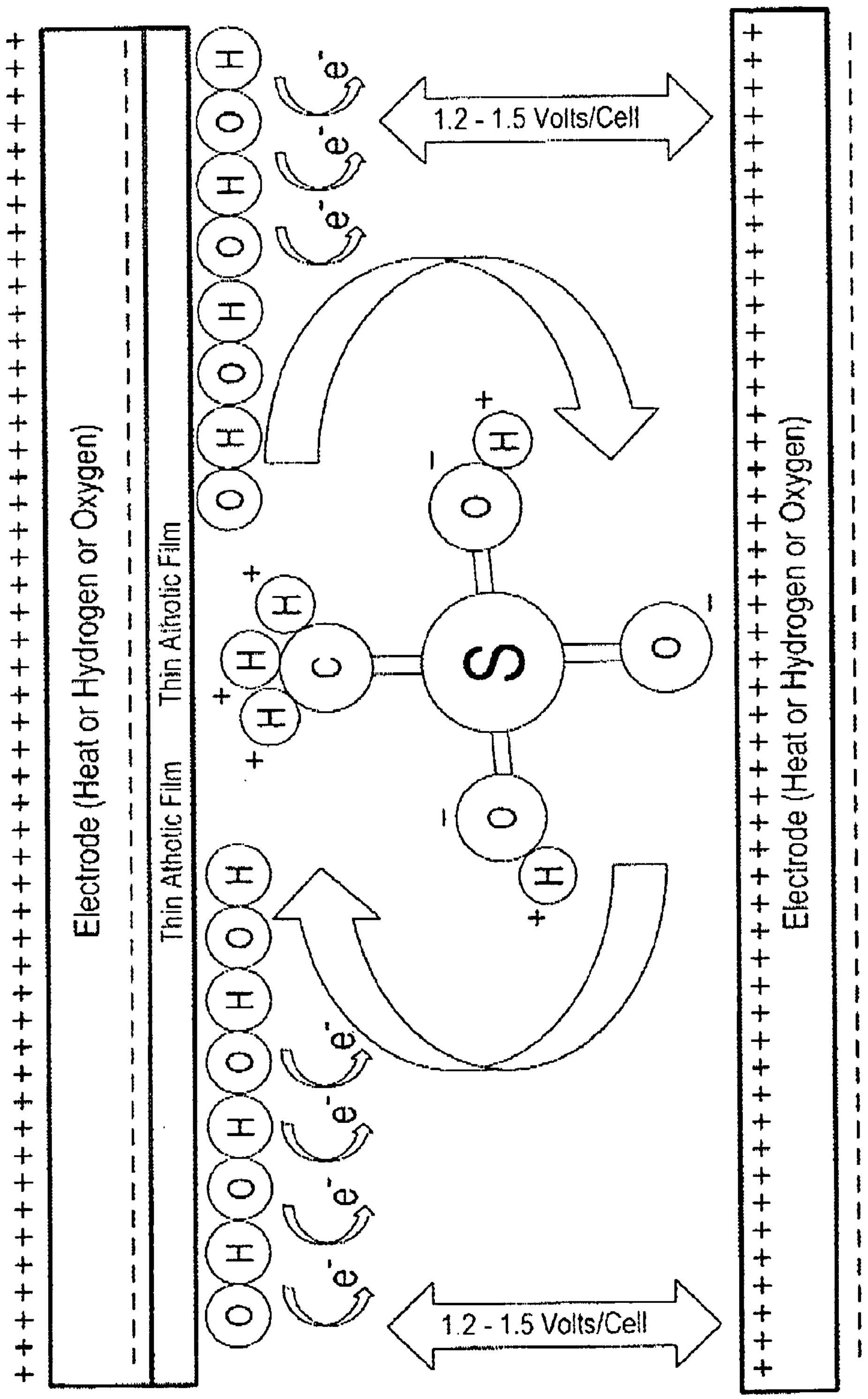
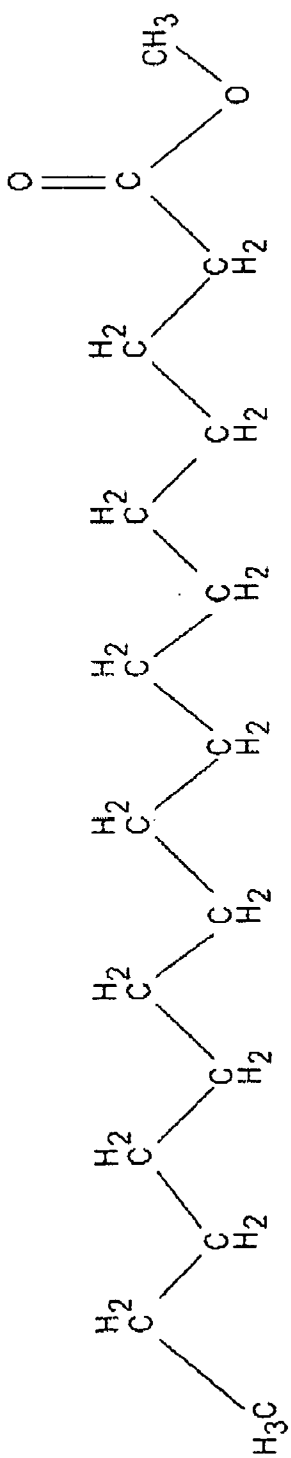
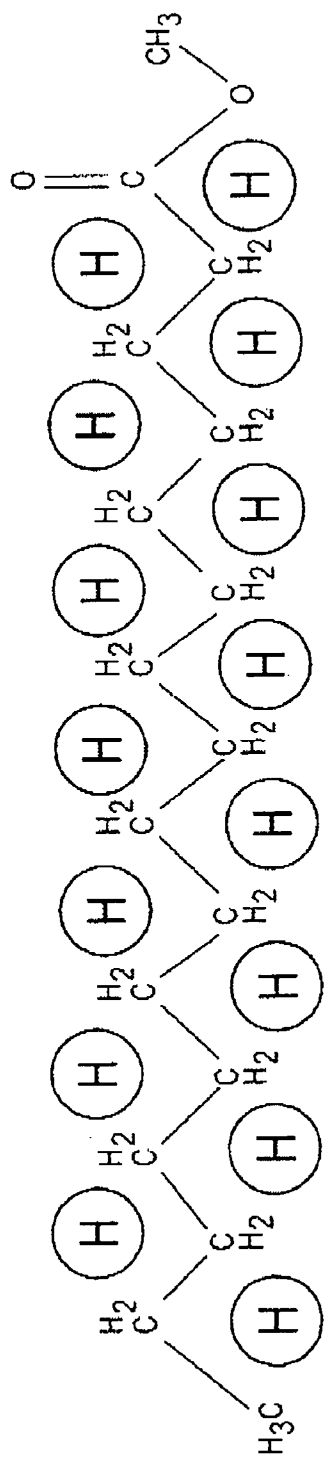

Electrode (Heat or Hydrogen or Oxygen)
Thin Athalic Film
Thin Athalic Film
1.2 - 1.5 Volts/Cell
1.2 - 1.5 Volts/Cell
Electrode (Heat or Hydrogen or Oxygen)

Figure 18



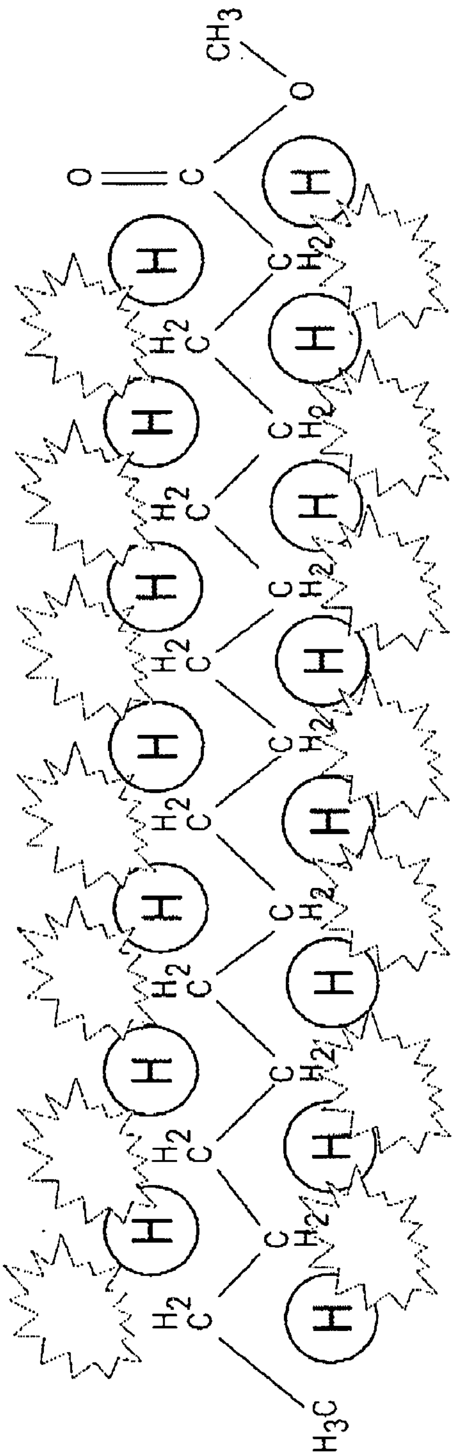
Diesel Molecule

Figure 19



Diesel Explosion with Hydrogen Molecules Blended

Figure 20



Diesel Explosion with Hydrogen Molecules Blended

Figure 21

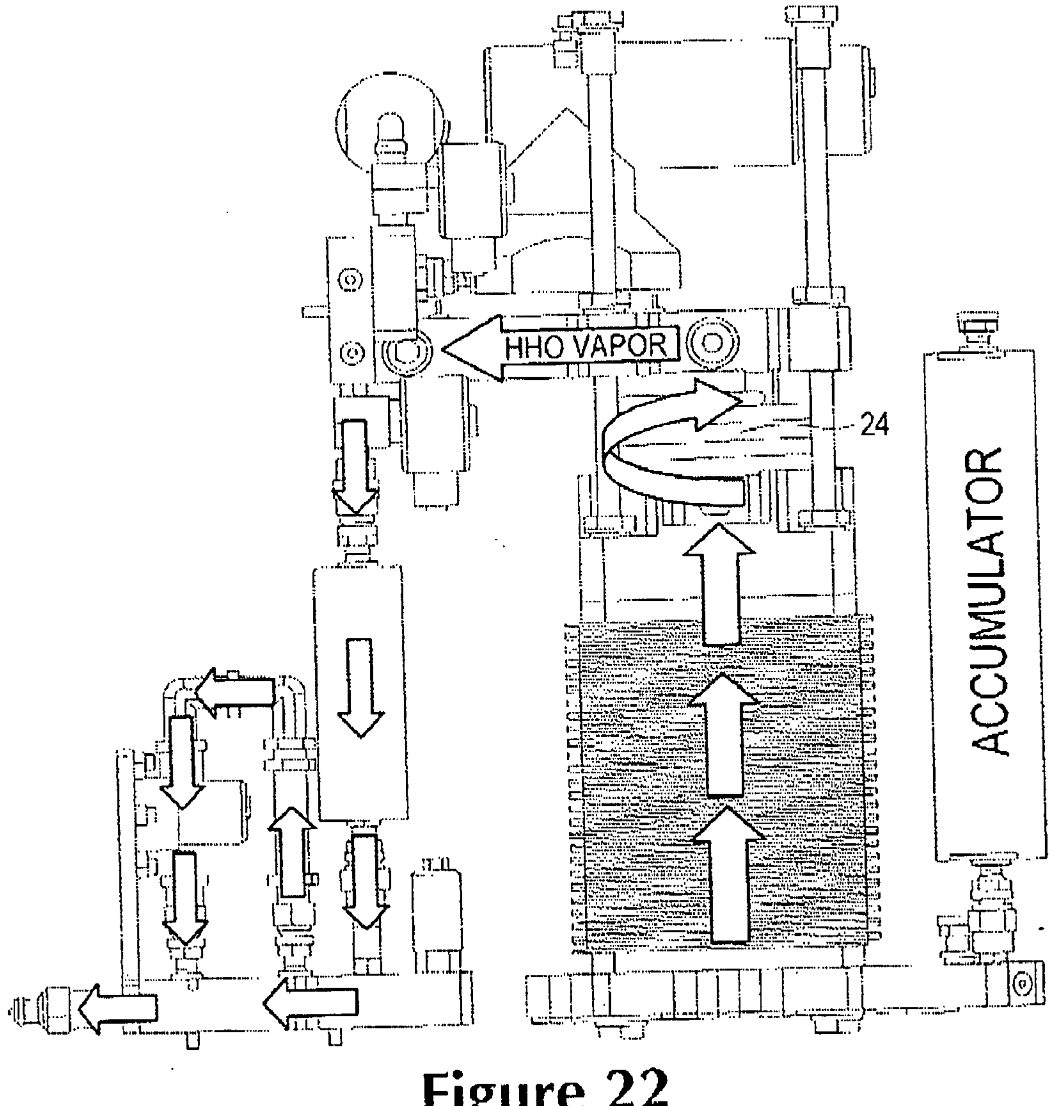


Figure 22

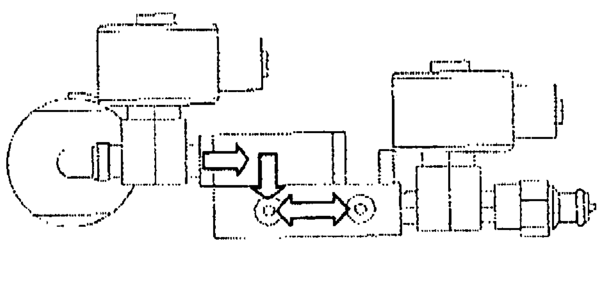


Figure 23B

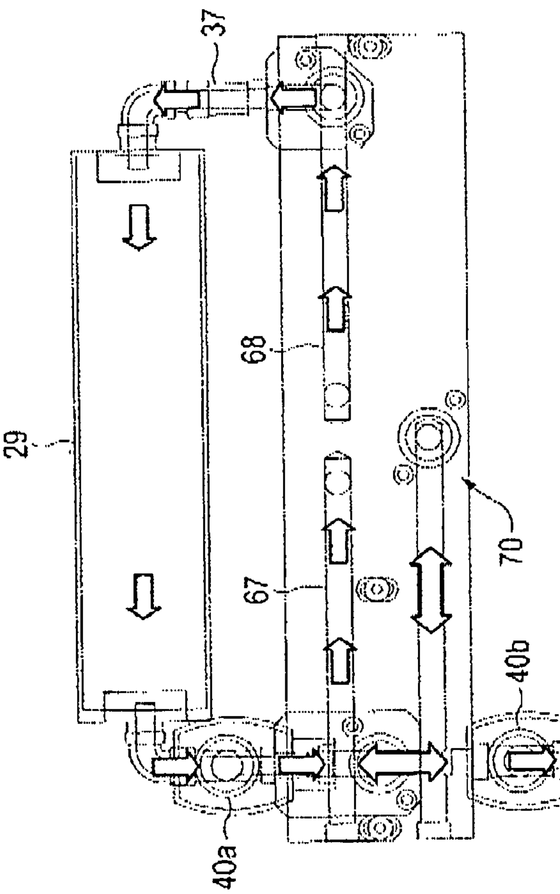


Figure 23A

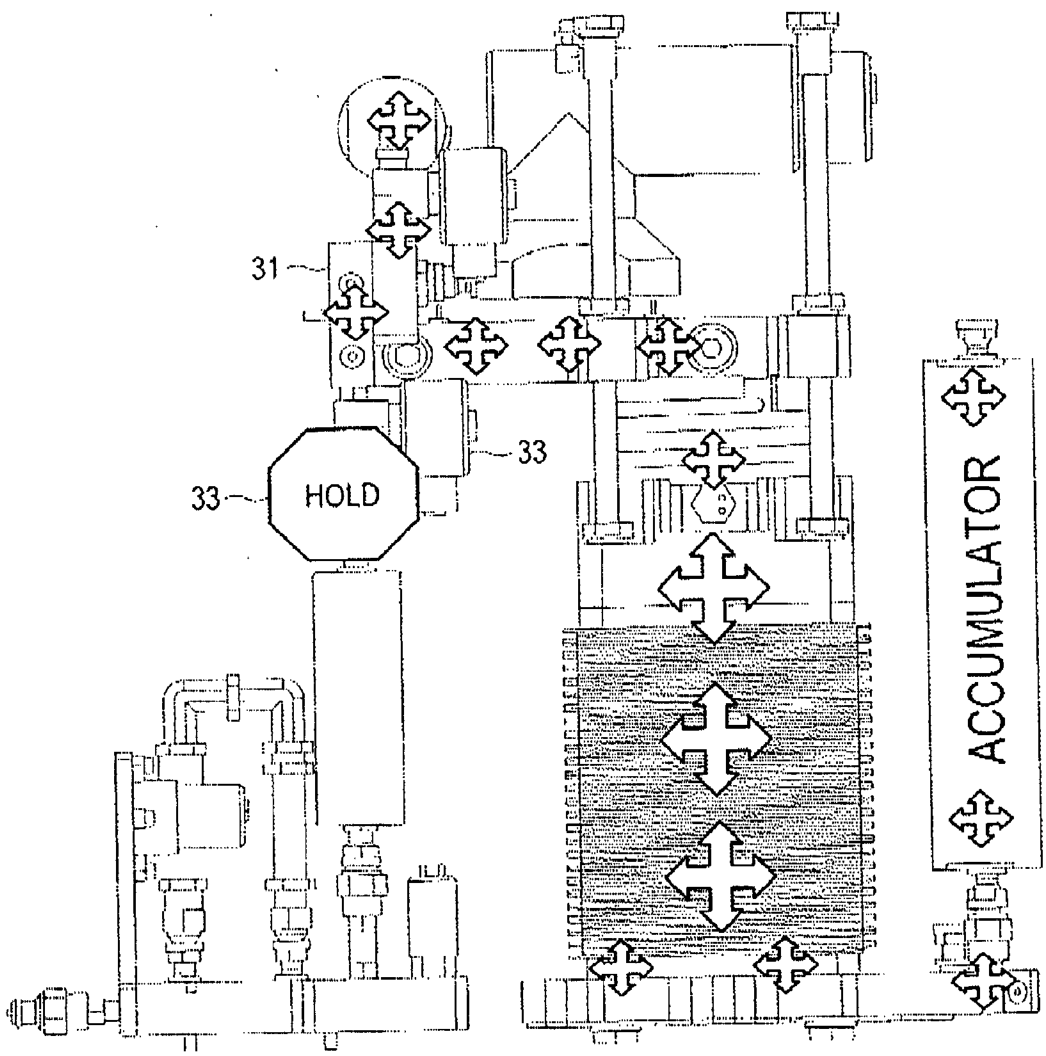


Figure 24

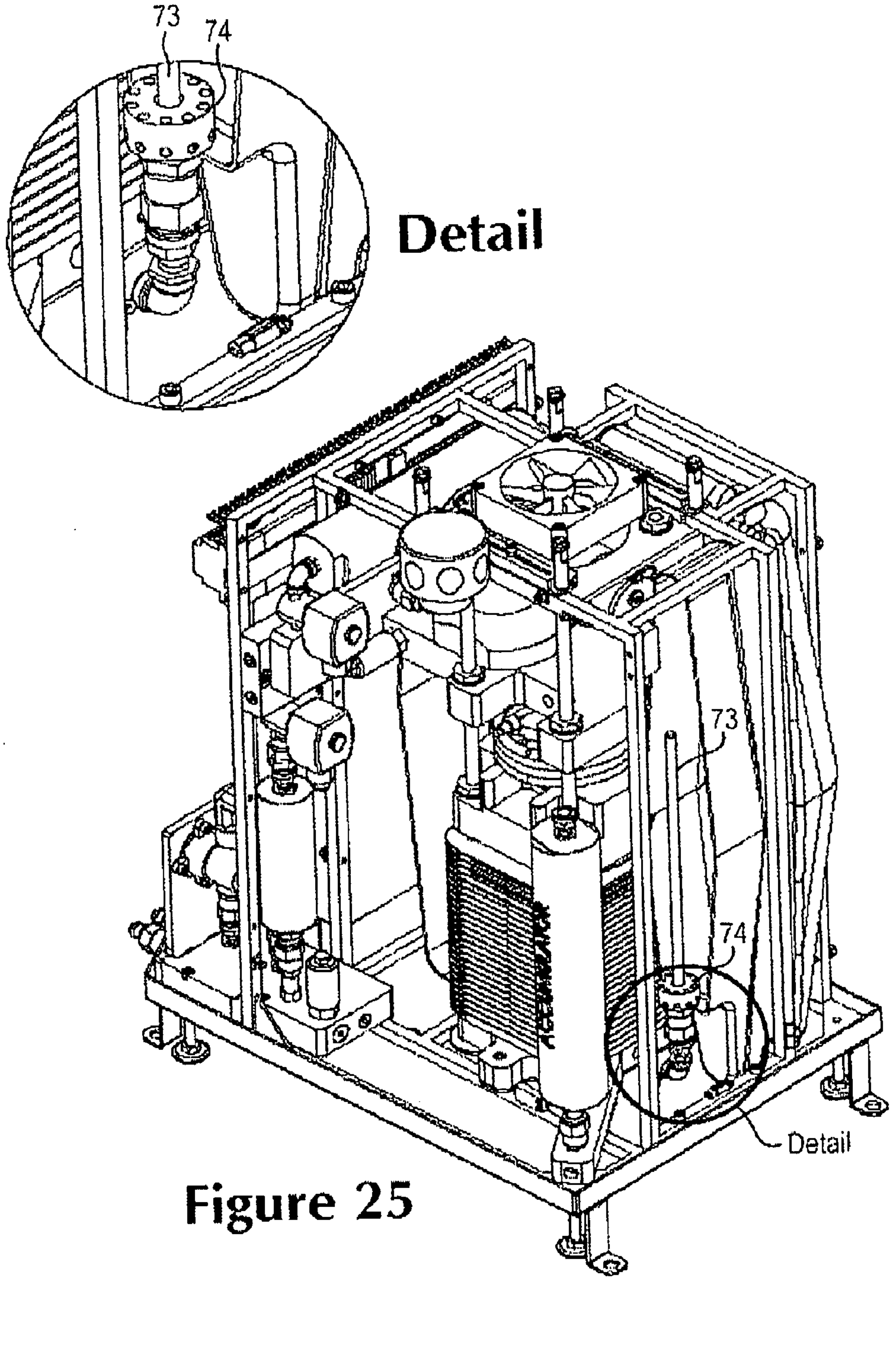


Figure 25

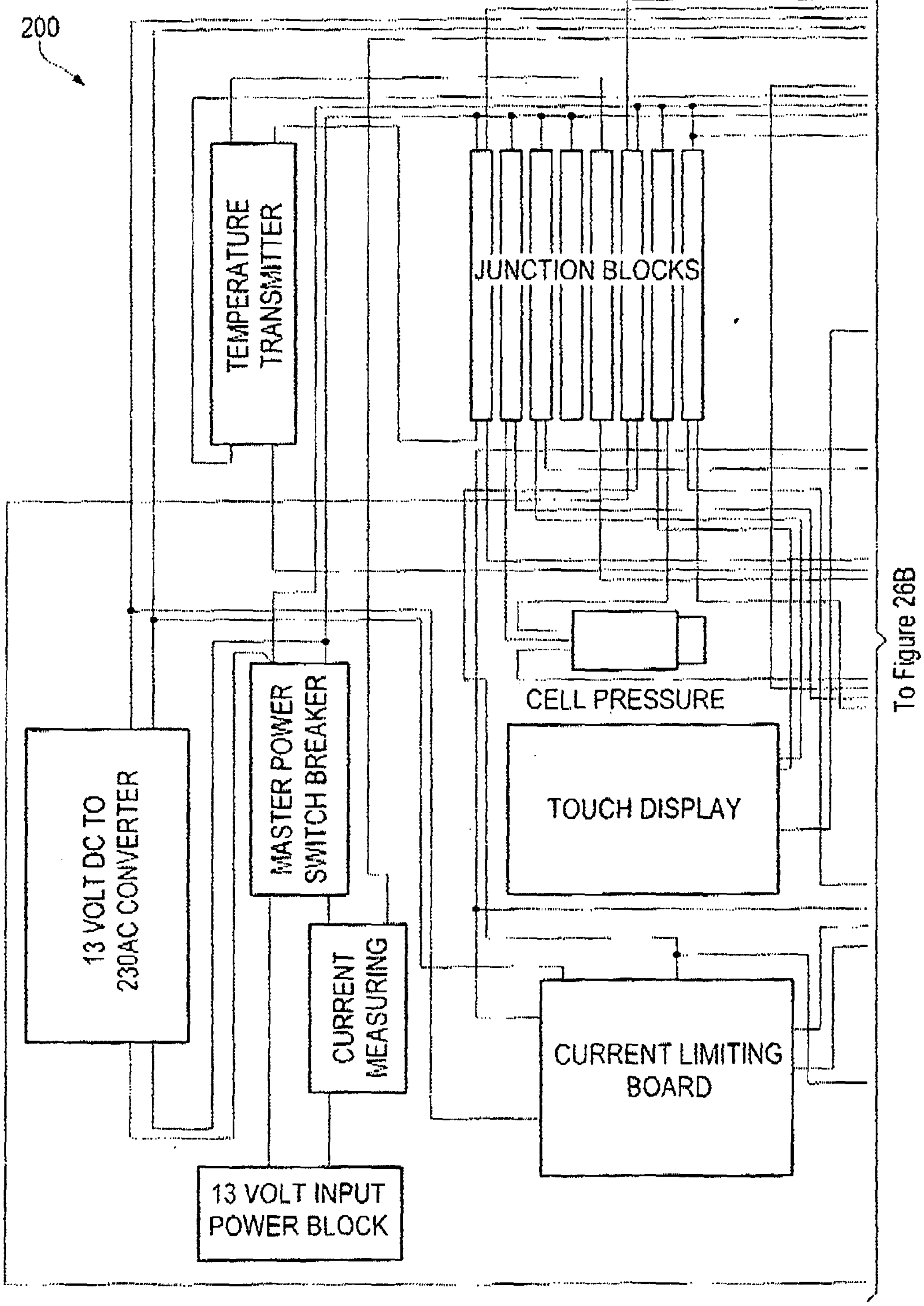

200
TEMPERATURE TRANSMITTER
JUNCTION BLOCKS
CELL PRESSURE
TOUCH DISPLAY
13 VOLT DC TO 230AC CONVERTER
MASTER POWER SWITCH BREAKER
CURRENT MEASURING
CURRENT LIMITING BOARD
13 VOLT INPUT POWER BLOCK
To Figure 26B

Figure 26A

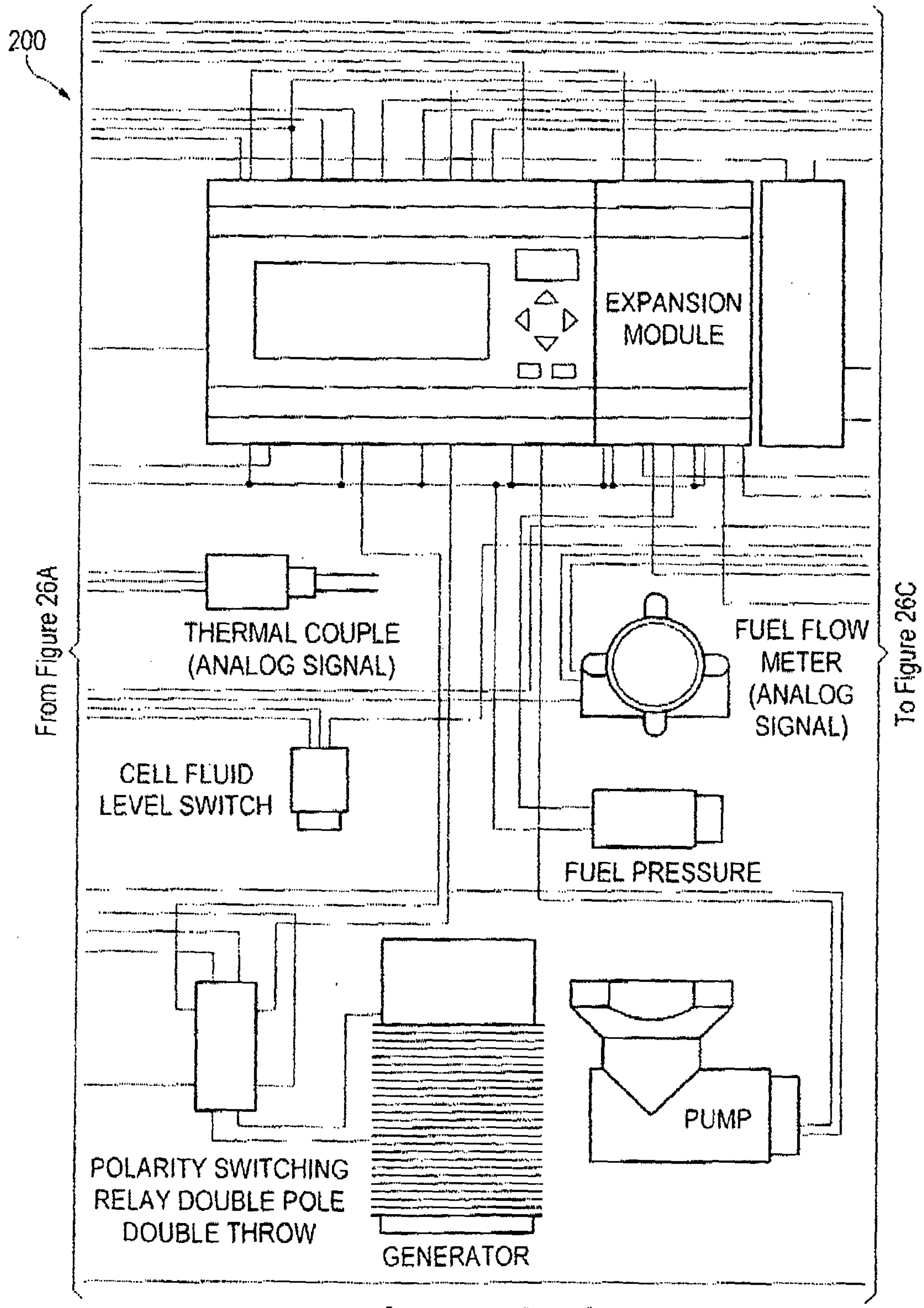

200
EXPANSION MODULE
From Figure 26A
To Figure 26C
THERMAL COUPLE (ANALOG SIGNAL)
FUEL FLOW METER (ANALOG SIGNAL)
CELL FLUID LEVEL SWITCH
FUEL PRESSURE
POLARITY SWITCHING RELAY DOUBLE POLE DOUBLE THROW
GENERATOR
PUMP

Figure 26B

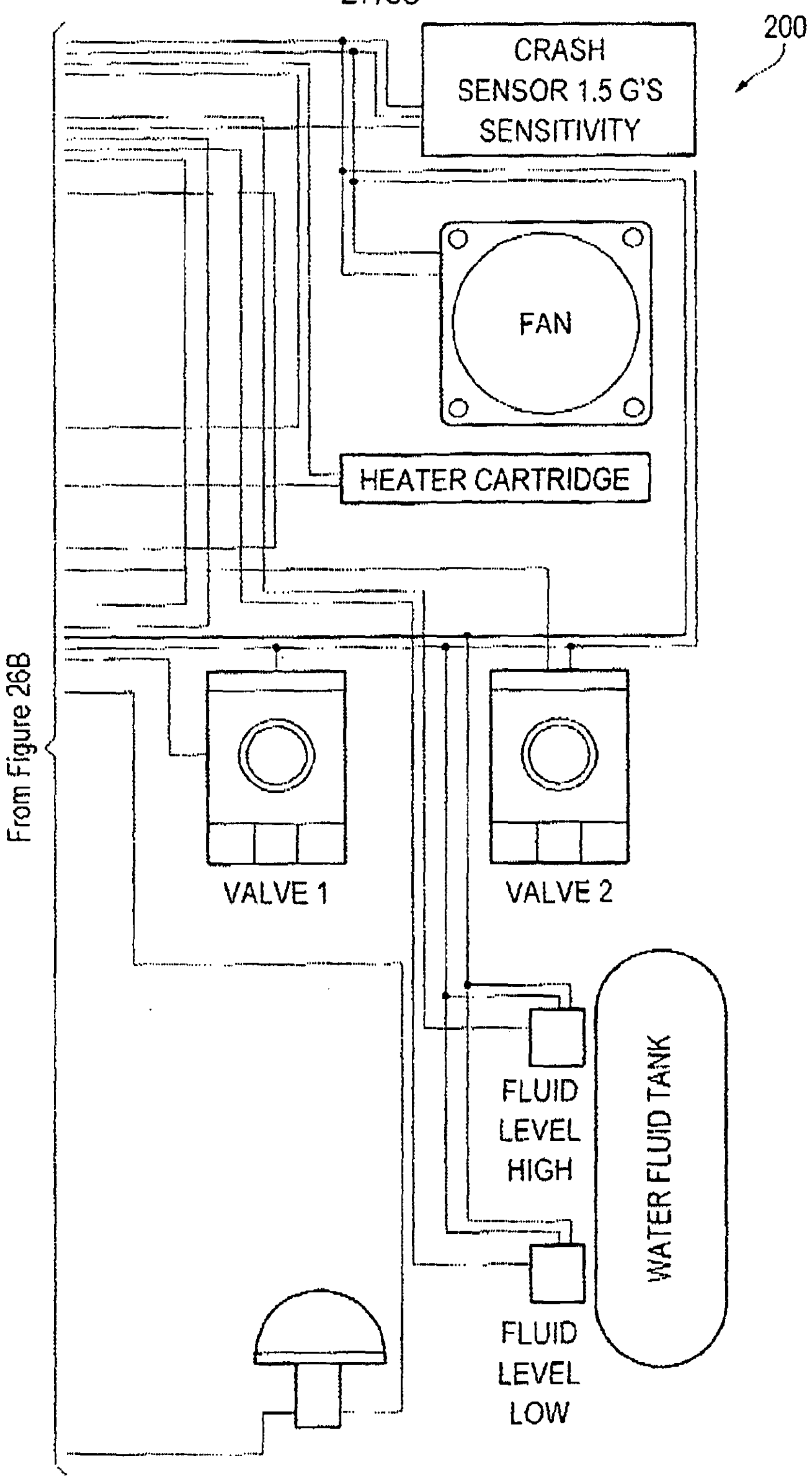

200
CRASH SENSOR 1.5 G'S SENSITIVITY
FAN
HEATER CARTRIDGE
From Figure 26B
VALVE 1
VALVE 2
FLUID LEVEL HIGH
WATER FLUID TANK
FLUID LEVEL LOW

Figure 26C

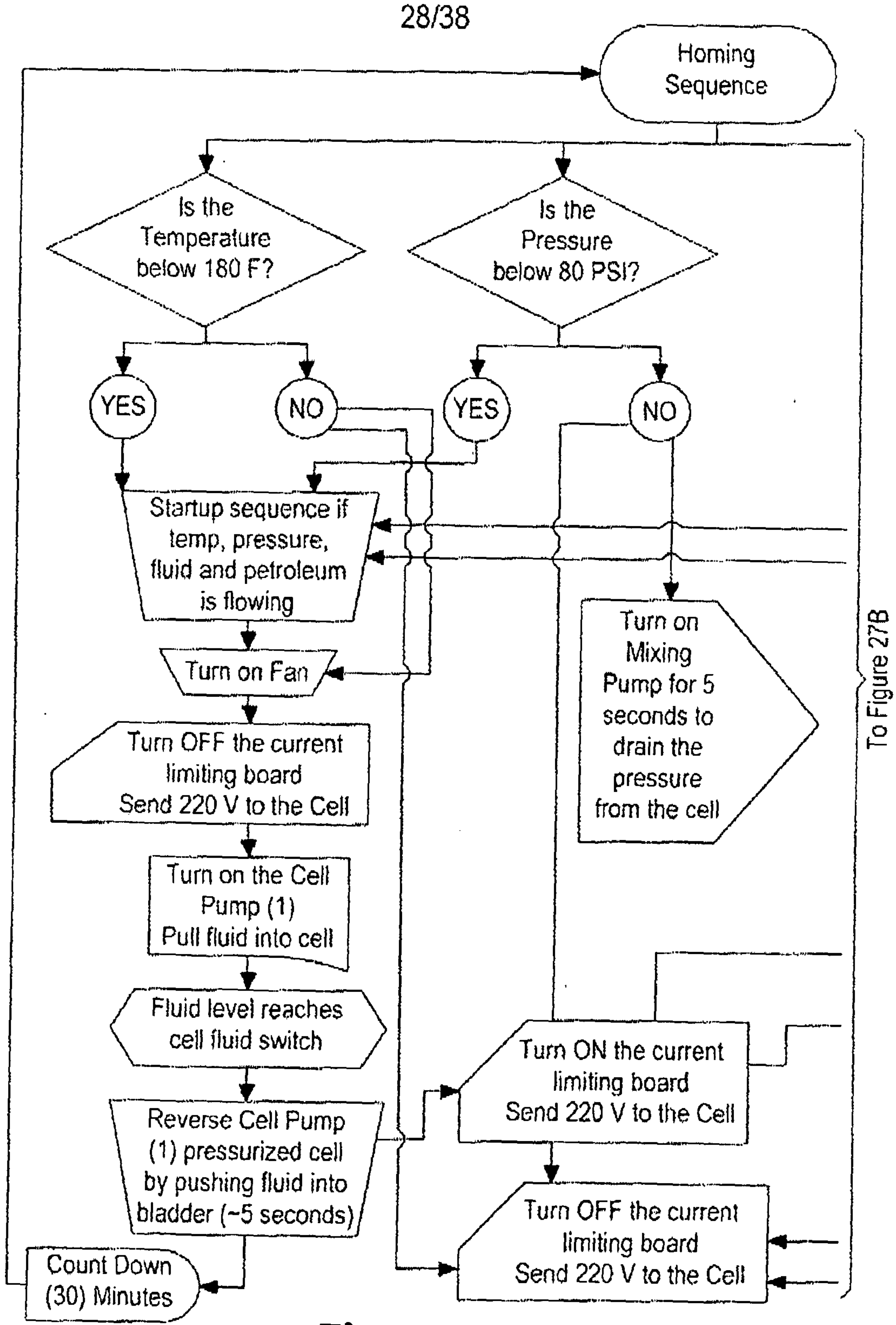

Homing Sequence
Is the Temperature below 180 F?
Is the Pressure below 80 PSI?
YES
NO
YES
NO
Startup sequence if temp, pressure, fluid and petroleum is flowing
Turn on Fan
Turn OFF the current limiting board Send 220 V to the Cell
Turn on the Cell Pump (1) Pull fluid into cell
Fluid level reaches cell fluid switch
Reverse Cell Pump (1) pressurized cell by pushing fluid into bladder (~5 seconds)
Count Down (30) Minutes
Turn on Mixing Pump for 5 seconds to drain the pressure from the cell
To Figure 27B
Turn ON the current limiting board Send 220 V to the Cell
Turn OFF the current limiting board Send 220 V to the Cell

Figure 27A

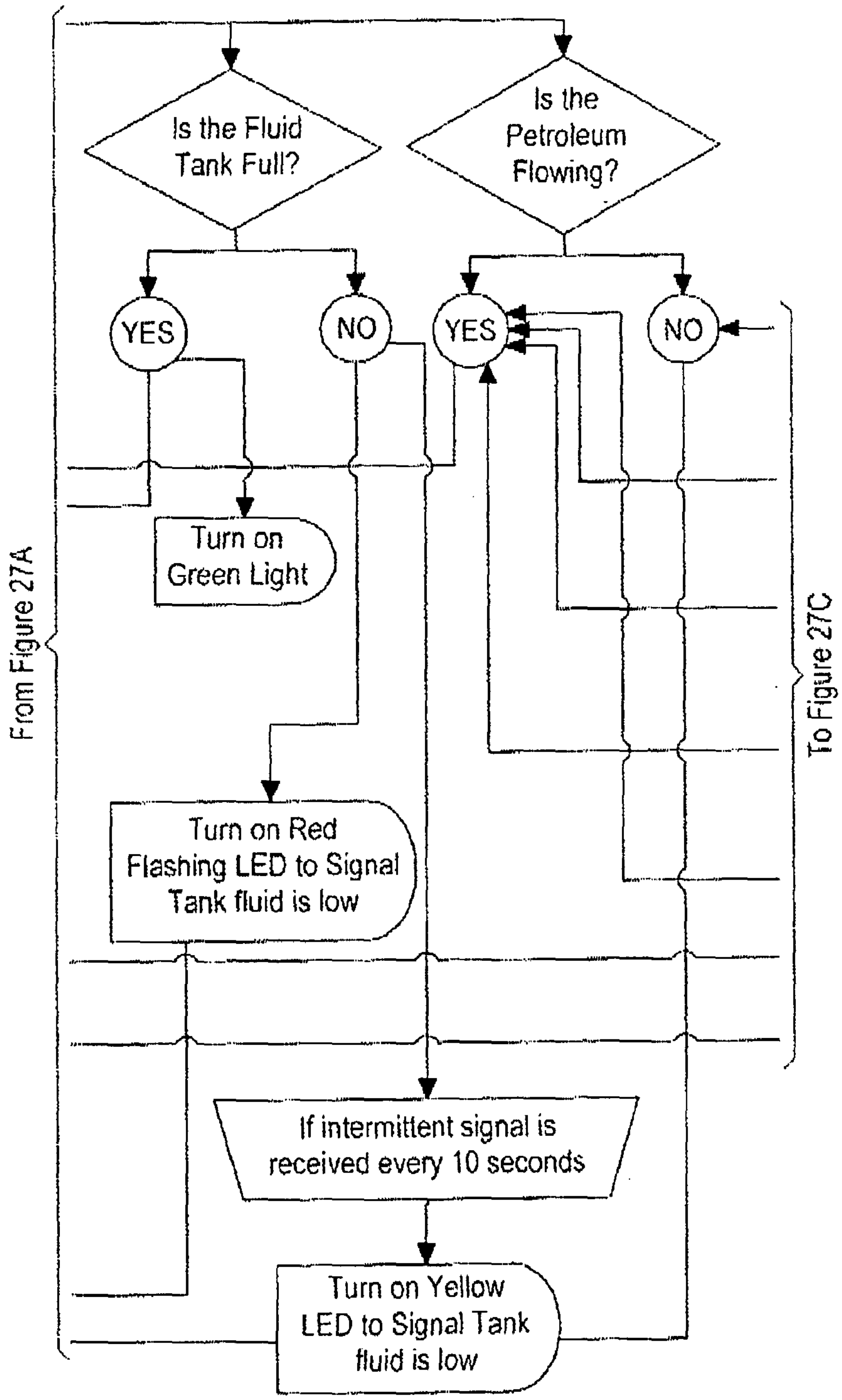

Is the Fluid Tank Full?
Is the Petroleum Flowing?
YES
NO
YES
NO
Turn on Green Light
From Figure 27A
To Figure 27C
Turn on Red Flashing LED to Signal Tank fluid is low
If intermittent signal is received every 10 seconds
Turn on Yellow LED to Signal Tank fluid is low

Figure 27B

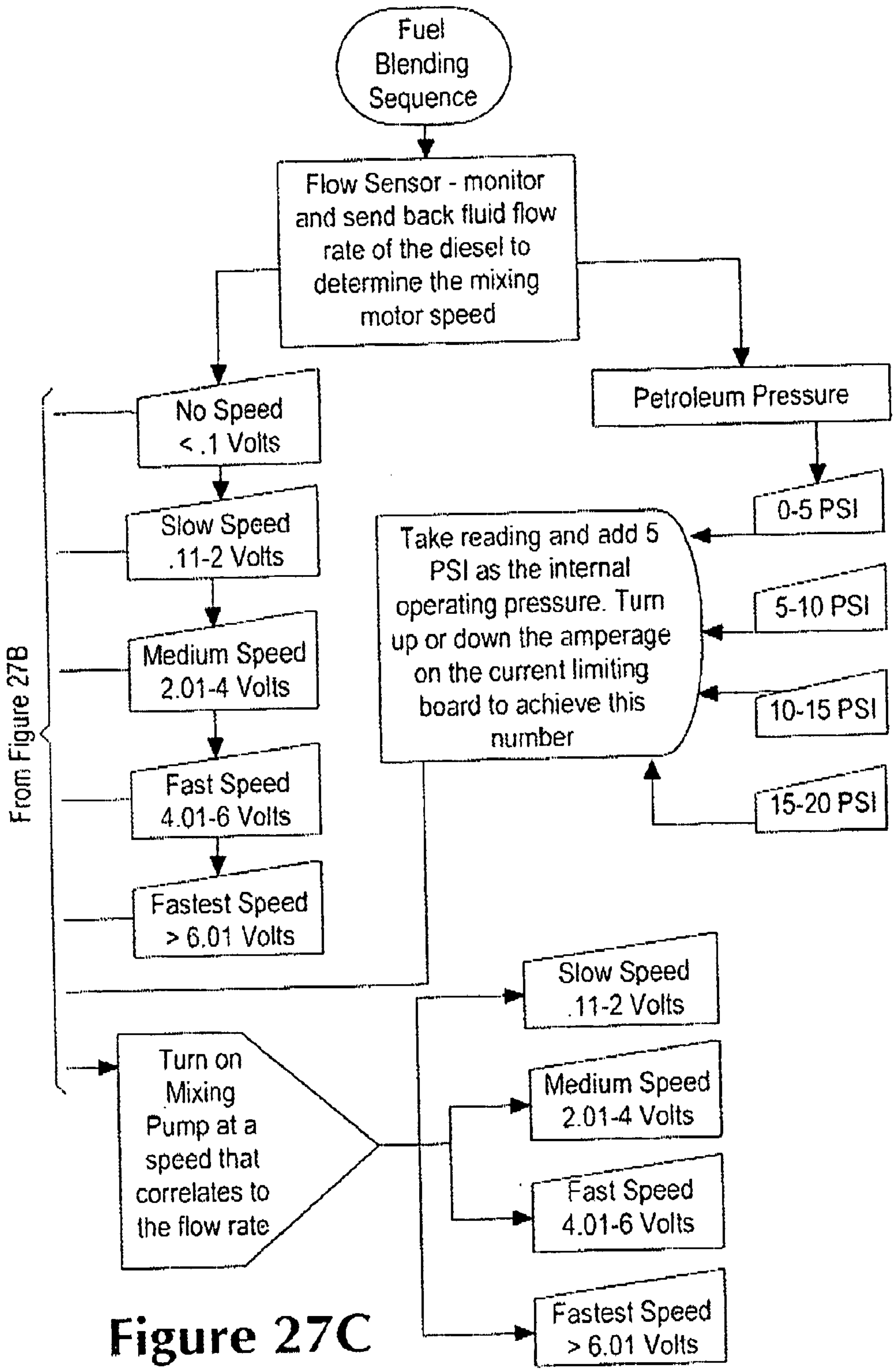

Fuel Blending Sequence
Flow Sensor - monitor and send back fluid flow rate of the diesel to determine the mixing motor speed
No Speed < .1 Volts
Slow Speed .11-2 Volts
Medium Speed 2.01-4 Volts
Fast Speed 4.01-6 Volts
Fastest Speed > 6.01 Volts
Petroleum Pressure
0-5 PSI
5-10 PSI
10-15 PSI
15-20 PSI
Take reading and add 5 PSI as the internal operating pressure. Turn up or down the amperage on the current limiting board to achieve this number
From Figure 27B
Turn on Mixing Pump at a speed that correlates to the flow rate
Slow Speed .11-2 Volts
Medium Speed 2.01-4 Volts
Fast Speed 4.01-6 Volts
Fastest Speed > 6.01 Volts

Figure 27C

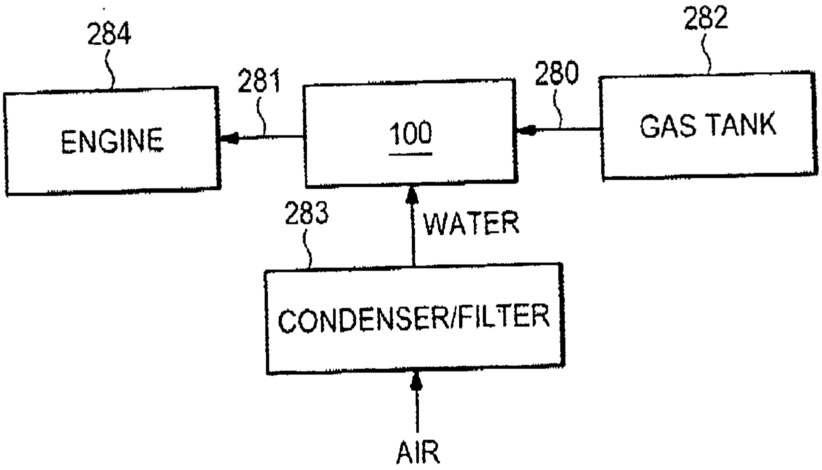

284
ENGINE
281
100
280
282
GAS TANK
283
WATER
CONDENSER/FILTER
AIR

Figure 28

32/38

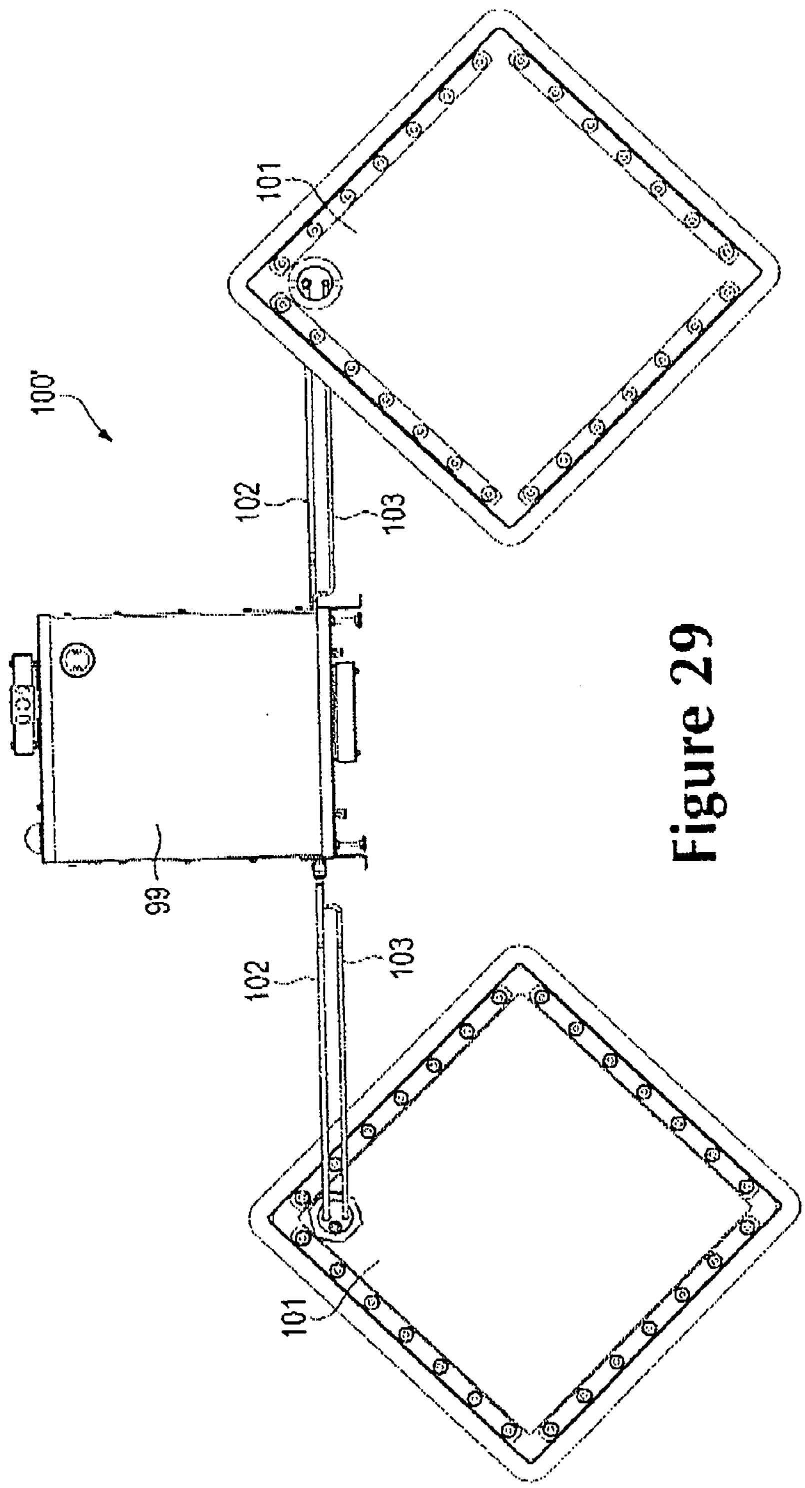


Figure 29

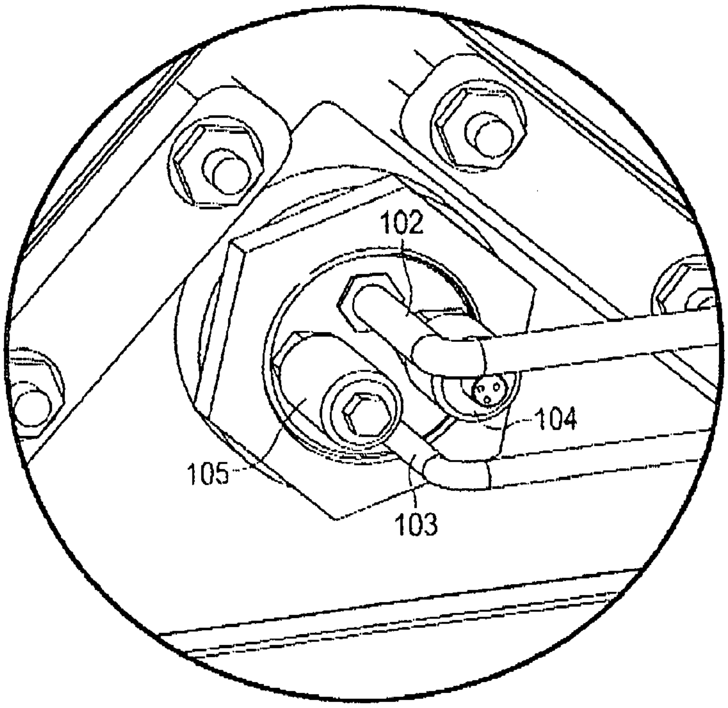


Figure 30

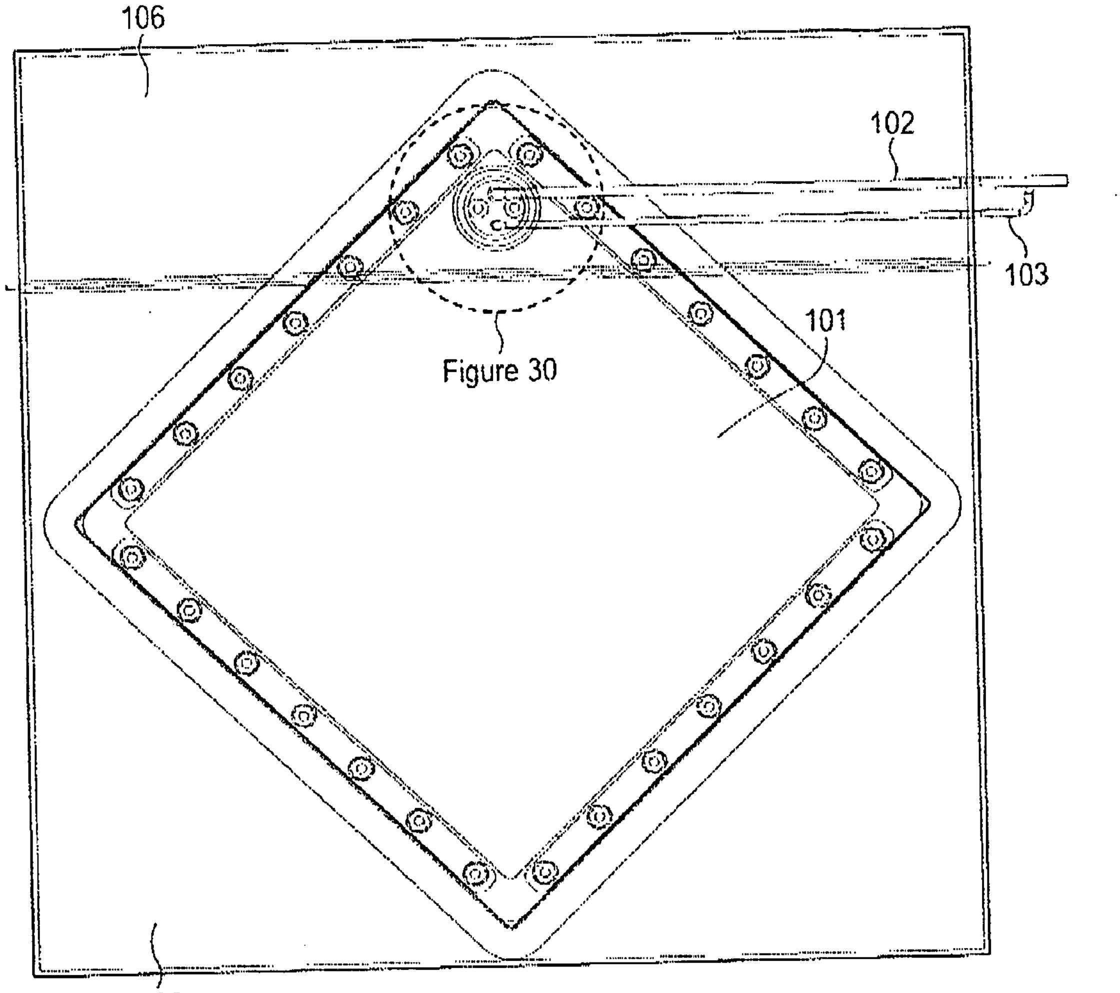


Figure 31

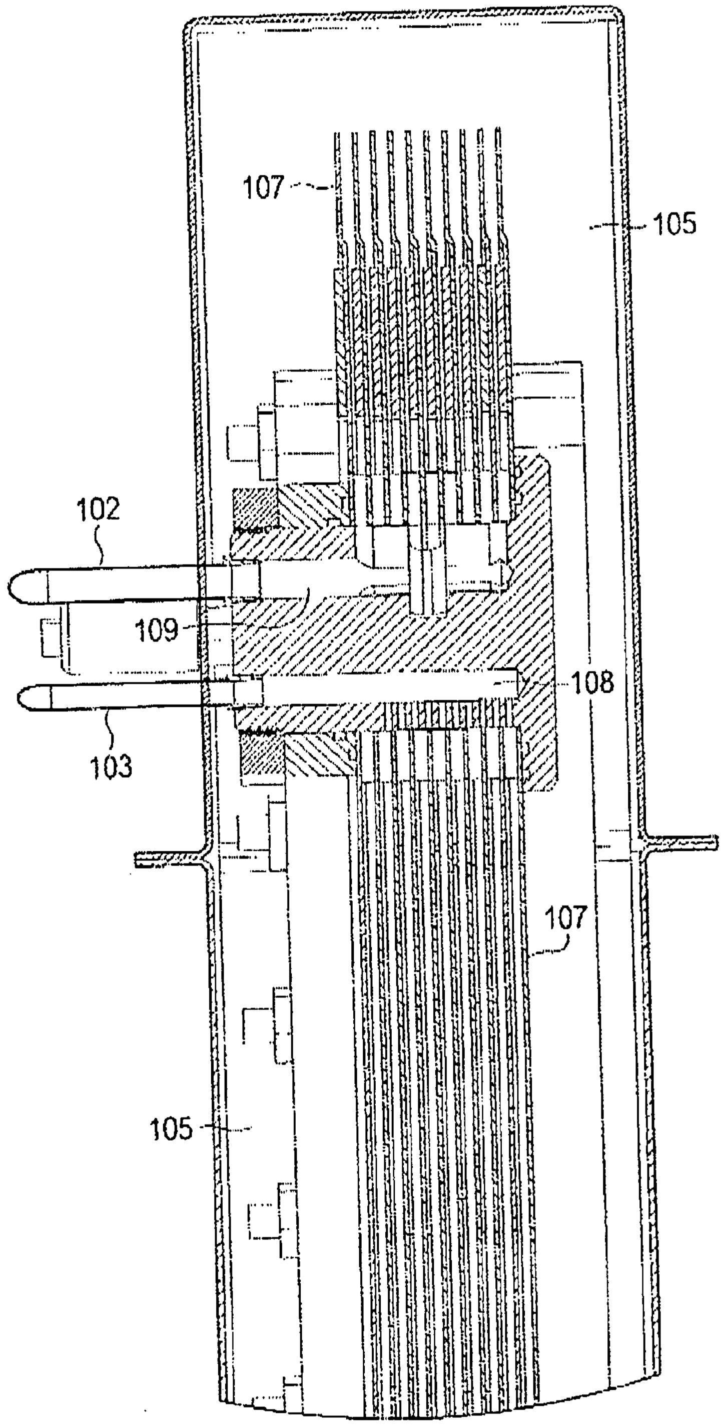


Figure 32

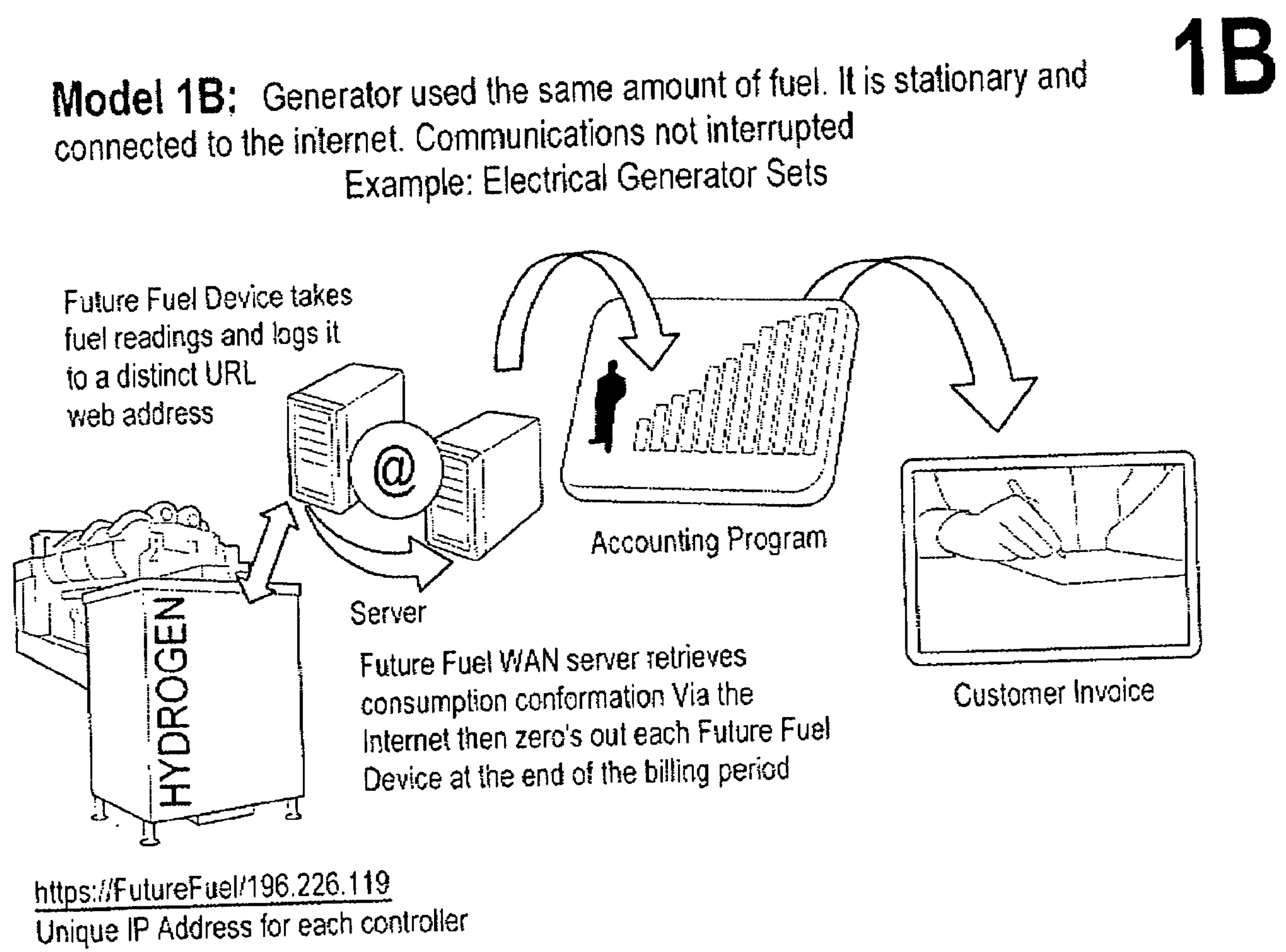

1B
Model 1B: Generator used the same amount of fuel. It is stationary and connected to the internet. Communications not interrupted
Example: Electrical Generator Sets
Future Fuel Device takes fuel readings and logs it to a distinct URL web address
@
HYDROGEN
Server
Accounting Program
Customer Invoice
Future Fuel WAN server retrieves consumption conformation Via the Internet then zero's out each Future Fuel Device at the end of the billing period
https://FutureFuel/196.226.119
Unique IP Address for each controller

Figure 33A

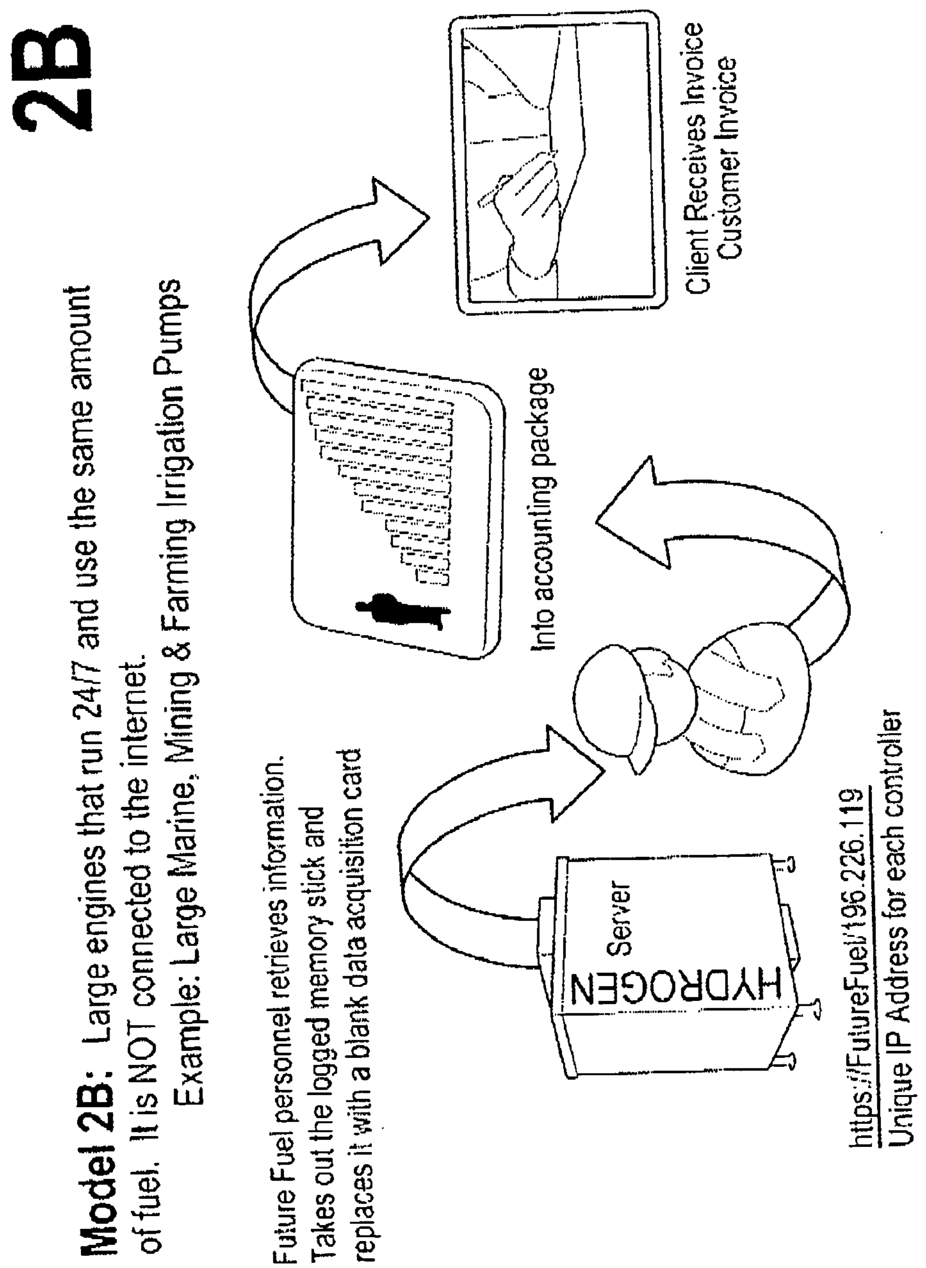

2B
Model 2B: Large engines that run 24/7 and use the same amount of fuel. It is NOT connected to the internet.
Example: Large Marine, Mining & Farming Irrigation Pumps
Future Fuel personnel retrieves information.
Takes out the logged memory stick and
replaces it with a blank data acquisition card
HYDROGEN
Server
https://FutureFuel/196.226.119
Unique IP Address for each controller
Into accounting package
Client Receives Invoice
Customer Invoice

Figure 33B

3B

Model 3B: The engine is not stationary. It is off and on frequently and fuel consumption varies. It is NOT connected to the internet all the time. Cellular networking solves communications issues

Example: Buses, Trucks, Trains

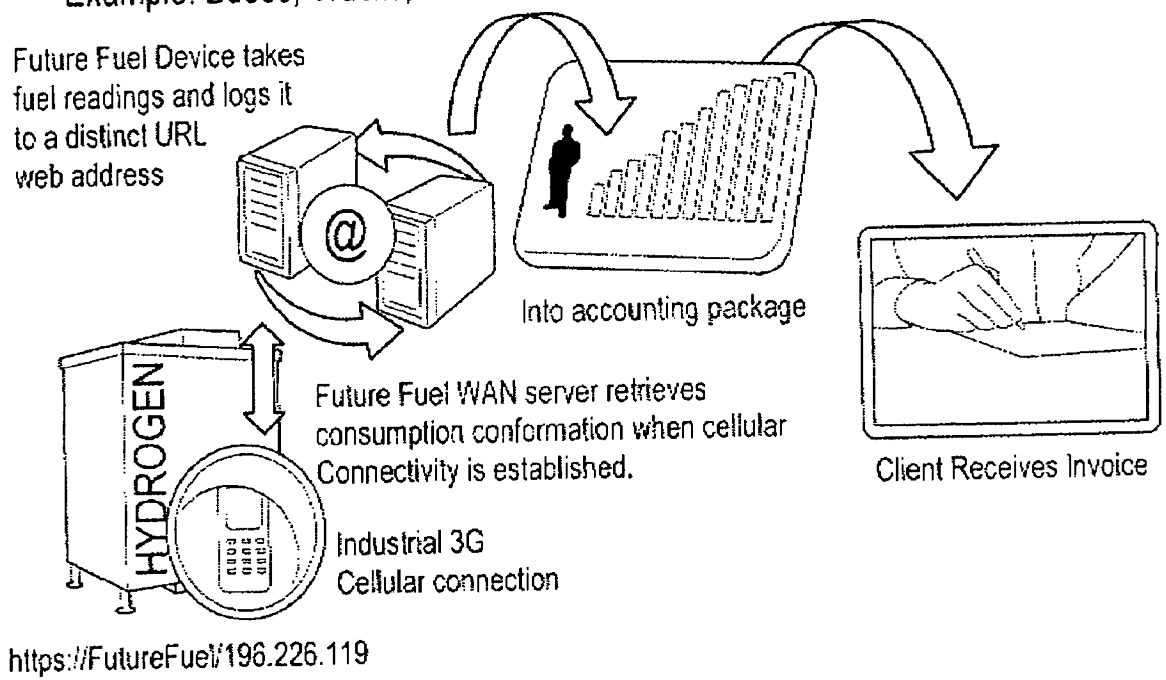


Figure 33C

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2009/006256

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - F02B 43/10 (2010.01)
USPC - 123/3
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8) - F02B 43/10 (2010.01)
USPC - 123/3

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
USPTO EAST System (US, USPG-PUB, EPO, DERWENT), PatBase

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2005/0258049 A1 (KLEIN) 24 November 2005 (24.11.2005) entire document	1-14
Y	US 2007/0181083 A1 (FULTON et al) 09 August 2007 (09.08.2007) entire document	1-14
Y	US 2003/0064260 A1 (ERDLE et al) 03 April 2003 (03.04.2003) entire document	7
Y	US 5,272,871 A (OSHIMA et al) 28 December 1993 (28.12.1993) entire document	8-10
Y	US 2004/0025807 A1 (JHETHAM) 12 February 2004 (12.02.2004) entire document	11-14
A	US 3,654,136 A (MILSOM) 04 April 1972 (04.04.1972) column 3, line 60 to column 4, line 6	1-14

☐ Further documents are listed in the continuation of Box C. ☐

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
02 April 2010	16 APR 2010

Name and mailing address of the ISA/US	Authorized officer:
Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2009/006256

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

See extra sheet.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
1-14

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

Continuation of Box III.

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I, claims 1-14, drawn to a system for producing hydrogen.
Group II, claims 15-21, drawn to a method of allocating fuel savings among a hydrogen-generation-and-fuel-blending equipment supplier and a fuel consumer.
Group III, claims 22-40, drawn to a method of supplying hydrogenated fuel to an internal combustion engine and a modular orthohydrogen fuel cell.

The inventions listed as Groups I, II and III do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: the special technical feature of the Group I invention: a system for producing hydrogen comprising a voltage regulator, a hydrogen producing cell and a fuel mixing area to mix petroleum and hydrogen and output a blended fuel as claimed therein is not present in the invention of Groups II or III. The special technical feature of the Group II invention: establishing a fuel consumption level and determining the difference between a baseline and the consumption level and allocating a consumption cost saving amount based upon the determined difference to a consumer as claimed therein is not present in the invention of Groups I or III. The special technical feature of the Group III invention: drawing water from a water source; adding electrolyte to the water; flooding a splitter cell with the water electrolyte mixture; energizing the splitter cell to split the mixture into a hydrogenated vapor; drawing fossil fuel from a fuel tank; blending the mixtures to form a hydrogenated fuel as claimed therein is not present in the invention of Groups I or II.

Groups I, II and III lack unity of invention because even though the inventions of these groups require the technical feature of blending a fossil fuel with hydrogen, this technical feature is not a special technical feature as it does not make a contribution over the prior art in view of US 3,654,136 A (MILSOM) column 3, line 60 to column 4, line 6.

Since none of the special technical features of the Group I, II or III inventions are found in more than one of the inventions, unity of invention is lacking.