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(56) Documents Cited:  
**WO 2013/069164 A1 US 20130105307 A1**  
**US 20070080071 A1**  
**AU2013101077**  
Prior use of cgon Hydrogen on Demand system on or  
around 13/08/2012 (<http://www.cgon.co.uk/#!/portfolio/cy2z>)

(58) Field of Search:  
Other: **EPODOC, WPI**

(54) Title of the Invention: **Improvements in or relating to hydrogen fuel generators**  
Abstract Title: **Hydrogen Fuel Generator**

(57) A hydrogen generator for use with an internal combustion engine in which the hydrogen is generated via electrolysis of water( $H_2O$ ) or potassium hydroxide( $KOH$ ). The device comprises a water tight container which houses the electrolyte and the plurality of cathodes and anodes. The anode is preferably made from titanium which is then coated with either platinum oxide or a mixture of metal oxides. The cathode is made of pure titanium. The anode and cathode are preferably made in the shape of threaded bars. The electrodes are secured within the plastic housing using titanium nuts and washers. The titanium used throughout the hydrogen generator is preferably Grade 2 or lower.

An injection system, for a wet or dry cell hydrogen fuel generator for an internal combustion engine, including means for raising the ambient temperature of air drawn through an air intake is also claimed.

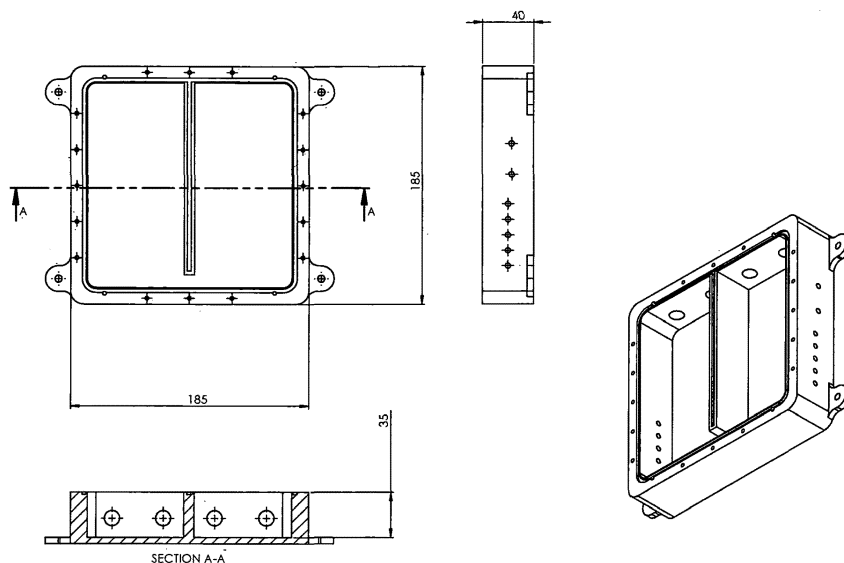


FIGURE 1

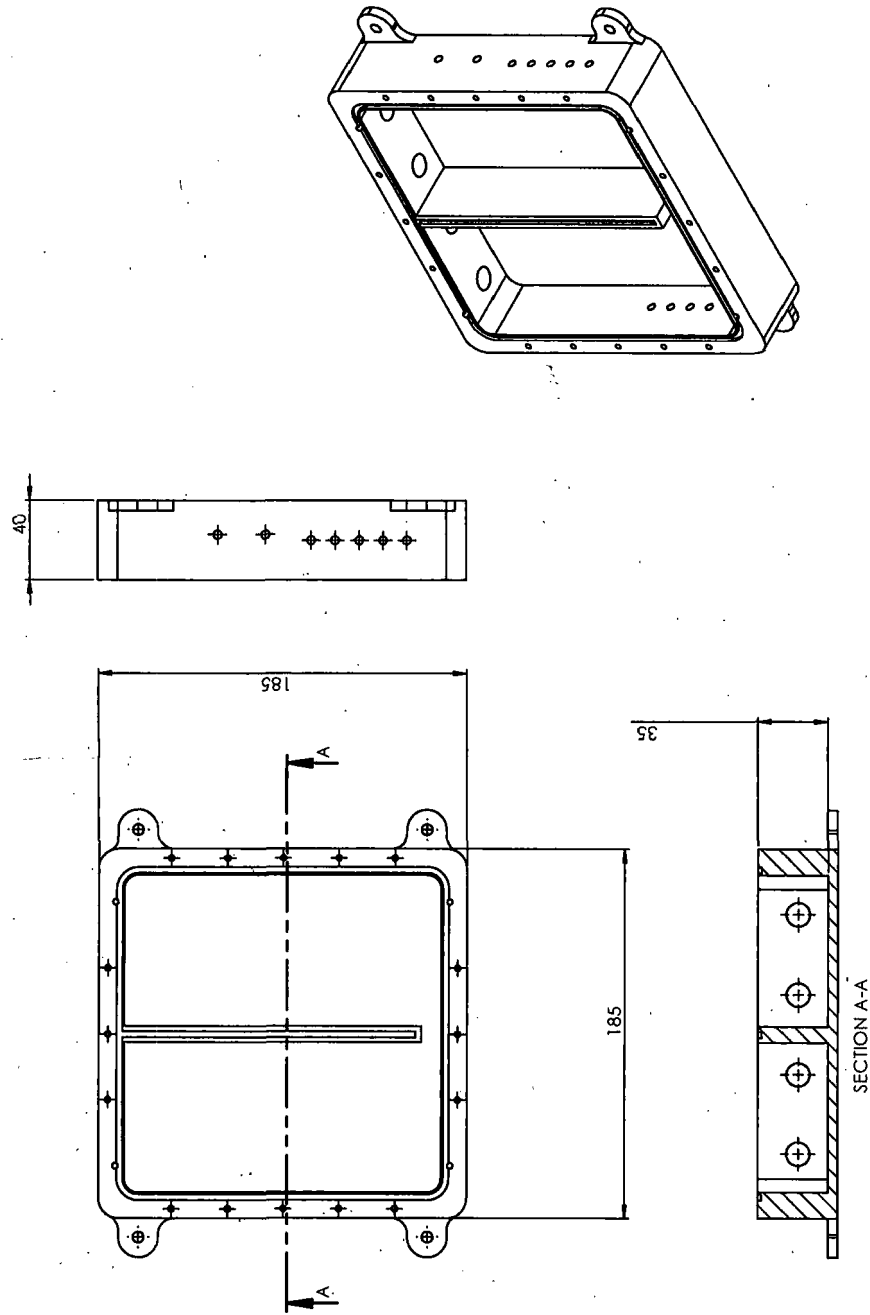
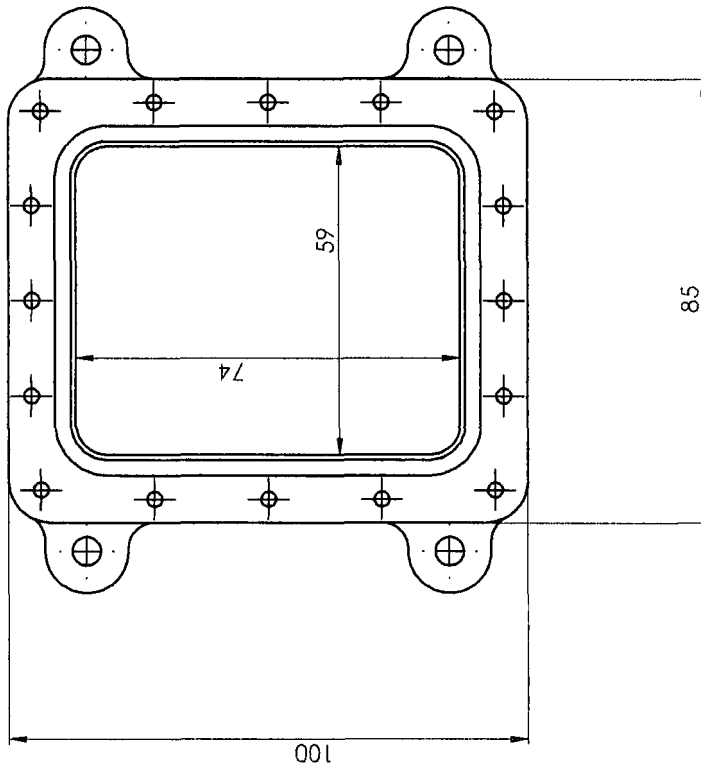
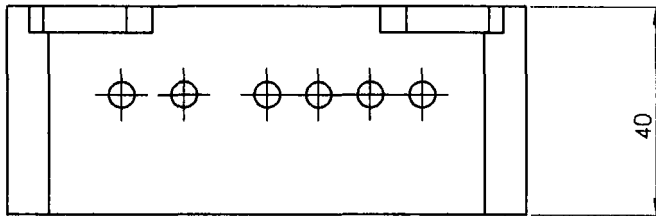
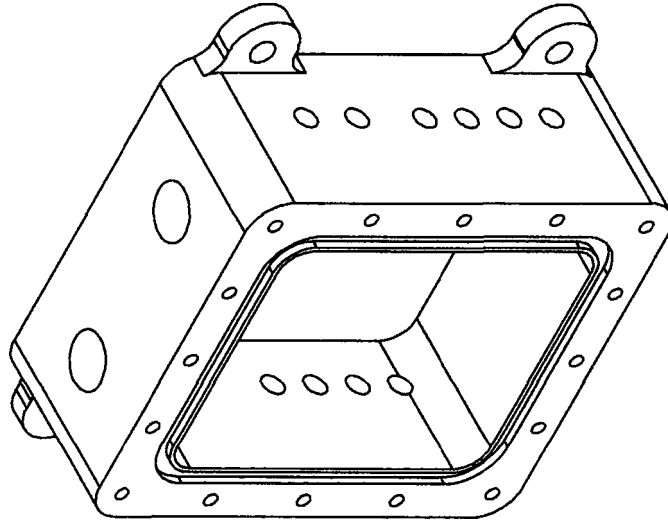


FIGURE 1



FILE 2

## **IMPROVEMENTS IN OR RELATING TO HYDROGEN FUEL GENERATORS**

The present invention relates to a hydrogen fuel generator and particularly to a wet cell hydrogen fuel generator for an internal combustion engine.

5 It is known to use a mixture of hydrogen and conventional hydrocarbon fuel in an internal combustion engine in a process known as hydrogen fuel enhancement.

Current research suggests that the introduction of hydrogen and oxygen into an internal combustion engine has the potential to produce lower emissions and higher thermal efficiency leading to better fuel economy. Lower emissions can be achieved as the Hydrogen and Oxygen assists the fossil fuel used to "burn" more efficiently. There are several reasons for this advantage, including: 1. excess oxygen oxidises unburned hydrocarbons and carbon monoxide; 2. excess oxygen lowers the peak combustion temperatures which inhibits the formation of oxides of nitrogen; 3. the lower combustion temperatures increase the mixture's specific heat ratio by decreasing the net dissociation losses; and 4. as the specific heat ratio increases the cycle thermal efficiency also increases.

One way in which hydrogen and oxygen for this purpose can be produced is through the electrolysis of water which causes decomposition of the water ( $H_2O$ ) into oxygen ( $O$ ) and hydrogen gas ( $H_2$ ) due to the electric current passed through the water.

20 The basic principle of water electrolysis is that an electrical power source is connected to two electrodes: a negatively charged cathode and a positively charged anode. The electrodes are placed in water and an electric current is passed through the water. At the negatively charged cathode a reduction reaction takes place with electrons from the cathode being given to hydrogen cat-ions to form hydrogen gas. At the positively charged anode an oxidation reaction occurs generating oxygen gas and giving 25 electrons to the cathode to complete the circuit.

Electrolysis of pure water requires excess energy in the form of over potential to overcome various activation barriers. Without the excess energy the electrolysis of pure water occurs very slowly if at all. Pure water has an electrical conductivity about one millionth that of seawater. Therefore the efficacy of electrolysis is usually increased 30 through the addition of an electrolyte (such as a salt, acid or base) and sometimes through the use of electrocatalysts.

Stainless steel electrodes can be employed as a cathode or anode, or both, in a wet cell or dry cell design hydrogen generators. However, it has been found that

stainless steel leaches Hexavalent Chromium (Cr(VI)) during the electrolysis process. Hexavalent Chromium is carcinogenic, and causes the decomposition of Ortho-hydrogen to Para-hydrogen, which is the case for stainless steel anodes and/or cathodes (Statuary Instrument 2008 No 37 The Restriction of the use of Certain Hazardous  
5 Substances in Electrical and Electronic Equipment regulations 2008). The following invention complies with the Statuary Instrument, as well as the RoHS (Restriction of Hazardous Substances) Guidelines on the production and deposal of Hexavalent Chromium.

The present invention seeks to address the problems with known hydrogen  
10 generators and avoid the production of Hexavalent Chromium.

According to a first aspect of the present invention there is provided a wet cell or dry cell hydrogen fuel generator for an internal combustion engine, comprising a container for receiving an electrolyte, at least one anode and at least one cathode for causing electrolysis of water in the electrolyte, wherein the at least one anode comprises  
15 an oxidation-resistant metal.

The generator unit may be provided as an automobile or internal combustion, hydrogen and Oxygen fuel enhancement system.

The at least one cathode may additionally comprise an oxidation-resistant metal, and may be coated or uncoated.

20 According to one embodiment, the at least one anode comprises a metal substrate with an oxidation-resistant coating.

The metal from which the at least one anode and/or at least one cathode is individually formed may be the same or different.

The oxidation-resistant metal may be any suitable electrically conductive, corrosion or leaching resistant material, such as titanium, a mixed metal oxide (MMO)  
25 or Platinum Oxide, or alloys thereof. By 'alloys' in this sense, it is intended to mean titanium coated with the MMO or Platinum Oxide.

Examples of materials which may be used for the at least one anode and/or at least one cathode as part of the present invention include, but are not limited to, titanium  
30 coated with a ruthenium-iridium MMO, titanium coated with an iridium-tantalum MMO, or titanium coated with a suitable single metal oxide, such as a ruthenium oxide or a platinum oxide. These are more typically used as the anode, but cannot also be used as the cathode.

According to one embodiment of the invention, one of the anode and cathode is pure titanium, while the other is MMO or Platinum Oxide coated titanium. Typically, the MMO or Platinum Oxide coated titanium constitutes the anode.

Such oxidation-resistant metals do not leach Hexavalent Chromium, and are  
5 therefore much safer.

The generator may use electricity from a vehicle battery to split water ( $H_2O$ ) into its component gases: Hydrogen and Oxygen. Typically, this occurs in a 2:1 atomic ratio of  $2 H_2 + O_2$  which are the same proportion as water. The resulting gas: Oxy-hydrogen is also referred to as HHO or Brown's gas. This gas is three times more powerful than  
10 normal petrol or diesel, yet it burns with the chemical stability of water. All this takes place under controlled circumstances in the combustion chamber. Besides improved fuel economy, other benefits may include increased torque and a smoother, quieter engine operation. The vehicle may also produce cleaner emissions. In other embodiments a separate power supply, such as a battery or solar generator, is provided.

15 Oxy-hydrogen will combust when brought to its auto-ignition temperature. For a stoichiometric mixture at normal atmospheric pressure, auto-ignition occurs at about  $570\text{ }^{\circ}\text{C}$  ( $1065\text{ }^{\circ}\text{F}$ ). [2] The minimum energy required to ignite such a mixture with a spark is about 0.02 mill joules. At normal temperature and pressure, oxy-hydrogen can burn when it is between about 4% and 94% hydrogen by volume.

20 When ignited, the gas mixture converts to water vapour and releases energy, which sustains the reaction: 241.8 kJ of energy (LHV) for every mole of  $H_2$  burned. The amount of heat energy evolved is independent of the mode of combustion, but the temperature of the flame varies. The maximum temperature of about  $2800\text{ }^{\circ}\text{C}$  is achieved with a pure stoichiometric mixture, about 700 degrees hotter than a hydrogen  
25 flame in air. When either of the gases is mixed in excess of this ratio, or when mixed with an inert gas, like nitrogen, the heat must spread throughout a greater quantity of matter and the temperature will be lower.

Engine Fuel management is also needed to achieve the fuel reducing and emission reducing properties, this is achieved by adjusting the ECU (Electronic Control  
30 Unit) software to compensate for the additional fuel in the shape of hydrogen and oxygen being introduced, on the air inlet side of the combustion engine this is a must for most modern day Petrol or Diesel fuelled internal combustion engines.

The at least one anode and/or at least one cathode may comprise titanium and/or MMO or Platinum Oxide. Titanium cathodes produce 'Ortho-hydrogen' which provides twice the combustion power of 'Para-hydrogen', therefore giving a much higher combustion ratio. Because the titanium does not leach chromium or Hexavalent chromium, the Ortho-hydrogen is not decomposed to Para-hydrogen, which is the case for stainless steel anodes and cathodes.

Alternatively, the at least one anode and/or at least one cathode may comprise MMO or Platinum Oxide, which is extremely resistant to oxidation during electrolysis. Either or both of the electrodes may comprise MMO or Platinum Oxide as a layer or coating on a metal substrate.

The at least one anode may comprise a metal substrate with an oxidation-resistant coating, such as MMO or Platinum Oxide.

The at least one anode may comprise a Titanium substrate and a passivation inhibiting coating, such as MMO or Platinum Oxide. By inhibiting passivation, the titanium anode retains its ability to function.

The at least one anode and/or at least one cathode may be formed, for example, as threaded rods. The at least one anode and or at least one cathode may be threaded to increase the surface area and aid the production of Ortho-hydrogen and oxygen.

In embodiments where titanium is used, the titanium may typically be Grade 2 or higher, although lower grade titanium can also be used.

Examples of the constituents of electrolytes which may be used include, but are not limited to:

- distilled water

- Potassium hydroxide (KOH)

The present invention is configured and designed to use low amperes to achieve the Hydrogen and oxygen production, thus not demanding any high levels of electricity and not putting high levels of amperage demand on the vehicle's alternator or electrical system. In use, the amperage draw of the generator may be less than 5 amps, for example in the range of 700 mA to 3 amps or even less.

According to a second aspect there is provided an internal combustion engine fitted with a hydrogen generator as defined hereinabove.

The hydrogen fuel cell produces hydrogen and oxygen gases which are introduced to the internal combustion engine, for example into the air intake, thus vastly improving the efficiency of the engine to improve the fuel consumption and emission levels normally seen in a particular fossil fuel engine.

5           Hydrogen systems can be configured to produce HHO gas on-demand either (a) through an on/off switch or (b) for as long as a vehicle's engine is running. This HHO produced can then be channelled through the intake manifold into the combustion chamber to mix with petrol/diesel/LPG. By doing so, the combustion rate of the fuel is greatly enhanced, and burns cleanly and completely.

10           In some embodiments no Hydrogen is stored, only being produced when the vehicle's ignition switch is on or engine running. Vehicles which store gas come under the vehicle special order regulations (VSO). Embodiments which do not store gas are exempt.

          The system may be fuse-link protected and fitted with a temperature monitor  
15       which will cut the power to the system if the temperature of the atmosphere rises to 70°C, this is an extra safety device in case of very hot weather and hold ups in busy traffic.

          An in-dash switch with, for example, a green (Hydrogen) LED allowing for total driver control may be provided.

20           When hydrogen is produced via a hydrogen fuel cell or an external hydrogen supply the hydrogen is injected into the path of the incoming air from the air filter box or assembly. Normally this is downstream of the MAF sensor (Mass Air Flow) Sensor or IAT sensor (Intake Air Temperature) Sensor.

          An IAT sensor is fitted to an air inlet manifold of an internal combustion engine  
25       and measures ambient air temperature that the engine draws when running at idle or at speed. It measures temperature and converts the temperature reading to an electrical resistance which is sent to the vehicles ECU (Electronic Control Unit), which in turn controls fuel delivery to the engine. When the ambient temperature is low, e.g. around 2.0 – 3.0°C, the air is more dense which causes the ECU to introduce more fuel and in  
30       effect making a more rich air to fuel mixture. When the ambient temperature rises to



around 12.0 – 15.0°C and above, the air becomes less dense, which in turn tells the ECU to decrease the fuel delivery, in effect leaning out the air to fuel mixture at the optimum temperature, while the air inlet manifold should be kept between 12.0– 15.0°C.

When hydrogen and oxygen is introduced downstream of the IAT sensor there is  
5 no control over the temperature of the two gases. So in cold or cooler climates e.g. winter time, the hydrogen and oxygen is allowed to become denser or more compressed thus reducing the volume of the two gases and reducing the hydrogen effect on an internal combustion engine.

In warmer climates or summer time the hydrogen and oxygen becomes less  
10 dense, which allows the hydrogen and oxygen to increase in volume which allows the hydrogen and oxygen to expand thus increasing the fuel consumption of the internal combustion engine further.

The present application addresses the problems in hydrogen and oxygen injection in cool or cold ambient temperatures.

15 According to an alternative aspect of the present invention there is provided an injection system for a wet or dry cell hydrogen generator for an internal combustion engine as defined hereinabove, the system comprising means for artificially raising the ambient temperature of air drawn through an air intake upstream of an intake temperature sensor.

20 The present invention achieves this by heating the ambient air temperature, for example to a minimum of 13°C and above. This can be done by installing a heater, for example a 12v DC electrical heater or a solar-powered heater, internal or external to the air inlet manifold upstream of the IAT/MAF sensor. This will increase the air temperature within the manifold and warm up the injected hydrogen and oxygen,  
25 allowing it to become less dense and expand in volume. As the engine runs, the warm air and hydrogen and oxygen will be sucked into the combustion chamber and increase the fuel efficiency.

By installing the heater upstream of the IAT/MAF sensor this will have a “leaning out” effect on the engine, as the IAT/MAF sensor will decrease resistance as it

senses the warmer air and sends the signal to the ECU to reduce fuel and allowing the hydrogen to take full effect, thus increasing fuel efficiency even further.

The heater can be controlled by a bi-metallic thermostat for automatic control or it can be adjusted manually. The heater installed will be activated only when the ambient outside air temperature drops below about 13°C. The heater will not be required in high temperature environments that average above about 13°C.

The injection system of the present invention may be used in combination with the hydrogen generator of the present invention, although it may be equally applicable to other hydrogen generators.

The invention will now be described further by way of example with reference to the following examples and figures which are intended to be illustrative only and in no way limiting upon the scope of the invention. In Figures 1-2, the features of this embodiment and variants thereof are as follows:

Figure 1 shows a titanium hydrogen fuel separator generator size and layout.

Figure 2 show front and side schematic drawings of the titanium hydrogen fuel generator.

As can be seen in Figures 1 and 2, the hydrogen fuel generators 1 and 2 encompassed by the invention are provided in a water tight container of various sizes and shapes made of plastic, or any other suitable material, which is used to house the anode and cathode design as well as the electrolyte used in the process. The casing may be a robust polyurethane casing, while the front covering 10 may be a clear Perspex.

The anodes and cathodes can be protruding from the side of the generators 1 and 2. The anode is made of a Grade 2 Titanium coated with an MMO or Platinum Oxide, and may come in various lengths and sizes with a threaded bar design. The threaded bar design is used as a unique way of creating Oxygen for low amperage draw. The cathode is made of pure titanium and can also have a threaded bar design.

The electrodes are secured in place within the plastic housing by Titanium Grade 2 Nuts and washers. Various amperage rated insulated or non-insulated wire is

used to connect the cathode in series from ground. Wire, stainless steel, or any other suitable material, is used to connect the anode and cathode to the external power supply to the cell. Also, various sized plastics screw head covers are provided on the Anode and Cathode side to eliminate any short circuit.

5           A bi-metallic thermostat 14 N/C 70-80°C is used to control the temperature of the electrolyte within the fuel cell to a maximum temperature which is below the boiling point of the electrolyte, and preferably around 70°C. There is a fuse link with various amperage, rated fuses and an anti-splash cover which connects through the bi-metallic thermostat to supply positive 12V DC power to the anodes, thus creating a thermal  
10       automatic power switch.

Various sized plastic/metal elbows seals and backing nuts are used for the delivery of the Hydrogen and Oxygen from the fuel cell to the vehicle's air intake via a 6 - 10mm braided hose 16 or similar connection.

The cell can be topped up with electrolyte via a filler cap 18 or in some cases a  
15       header tank when the level drops below operating parameters.

A pressure release valve 20 fitted to the top of the hydrogen generator will open if an explosion takes place with in the hydrogen generator. It is installed as an added safety feature and is set to open upon detection of a 1-2 psi rise in pressure with in the hydrogen fuel generator Figure 1.

20           The Grade 2 Titanium/MMO or Platinum Oxide coated electrodes are comprised of a high surface area MMO or Platinum Oxide coating coated on a pure titanium substrate. This electrode design allows for a unit that is comprised of one or a multitude of electrodes dependent on vehicle application. The various Anode and Cathode designs are unique in many ways. First of all, they create zero corrosion, so no rust enters the  
25       engine. No dirty water in the hydrogen generator means limited maintenance or product maintenance. This means less time spent monitoring the device.

The MMO or Platinum Oxide coating offers a surface area that is over 30 times that of stainless steel. The Titanium/MMO or Platinum Oxide coated anodes produce 'Ortho-hydrogen' which is twice the combustion power of 'Para-hydrogen' there for  
30       giving a much higher combustion ratios in respect to the combustion engine. Less metal

equates to less heat, and less energy loss with traditional large multi plate high amperage designs. This also allows for far less water usage. The design requires refilling far less than current systems. Size is also an important consideration, especially when trying to install a unit in any late model vehicle. The present Hydrogen cells vary  
5 in size, including both smaller as well as larger units, the latter of which can hold a multitude of electrodes.

Other advantages which can be achieved by the present invention include the following:

10 It can significantly increase the miles per gallon (MPG) achieved by a car engine.

It can improve thermal efficiency and works on all of diesel, petrol and liquid petroleum gas (LPG) engines.

It will significantly increase performance/efficiency of diesel vehicles using biodiesel/vegetable oil.

15 It lowers carbon monoxide emissions from the engine.

An immediate increase in performance which results in more torque, which in turn means less revs are employed, which in turn means that less fuel is consumed.

It can easily be transferred from vehicle to vehicle, and is not a permanent fit.

It increases torque so you can change into top gear faster with lower revs.

20 It reduces engine noise, allows for smoother gear changes, thus extending the lifespan of the engine.

There is no hydrocarbon build-up and less frequent oil changes are required.

It is of course to be understood that the present invention is not intended to be restricted to the foregoing examples which are described by way of example only.

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## CLAIMS

1. A wet or dry cell hydrogen fuel generator for an internal combustion engine, comprising a container for receiving electrolyte, at least one anode and at least one cathode for causing electrolysis of water in the electrolyte, in which the at least one anode comprises an oxidation-resistant metal.
2. A generator as claimed in Claim 1, in which the at least one cathode is also formed from an oxidation-resistant metal.
3. A generator as claimed in Claim 1, wherein the oxidation-resistant metal comprises titanium and/or a mixed metal oxide or Platinum Oxide.
4. A generator as claimed in any preceding claim, in which the at least one anode comprises a metal substrate with an oxidation-resistant coating.
5. A generator as claimed in Claim 4, wherein the metal substrate comprises titanium and the oxidation-resistant metal comprises a mixed metal oxide or Platinum Oxide.
6. A generator as claimed in Claim 1, in which the anode comprises a titanium substrate and a passivation inhibiting coating.
7. A generator as claimed in any preceding claim, in which the at least one cathode is uncoated.
8. A generator as claimed in any preceding claim, in which the at least one anode and/or at least one cathode are threaded.
9. A generator as claimed in any of claims 3-8, in which the titanium is Grade 2 or lower.
10. A generator as claimed in any preceding claim, in which the electrolyte comprises of distilled water and or potassium hydroxide.
11. A generator as claimed in any preceding claim in which, in use, the amperage draw of the generator is less than 3 amps.

12. A generator as claimed in any preceding claim, in which, in use, the amperage draw of the generator is less than 700 milli amps in use.
13. A generator as claimed in any of claims 1-11, in which, in use, the amperage draw of the generator is in the range of 700 milli amps to 3 amps and above.
- 5 14. A generator substantially as hereinbefore described with reference to, and as shown in, the accompanying drawings.
15. An Internal combustion engine fitted with a generator as claimed in any preceding claim.
- 10 16. An injection system for a wet or dry cell hydrogen fuel generator for an internal combustion engine according to any of claims 1-15, the system comprising means for artificially raising the ambient temperature of air drawn through an air intake upstream of an intake temperature sensor.
17. A system as claimed in claim 16, in which hydrogen is injected downstream of the temperature sensor.
- 15 18. An injection system substantially as hereinbefore described with reference to, and as shown in, the accompanying drawings.
19. An internal combustion engine fitted with a system or combination according to claim 16 or claim 17.

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**Application No:** GB1311736.1

**Examiner:** Mr Samir Miah

**Claims searched:** 1-15

**Date of search:** 13 January 2015

## Patents Act 1977: Search Report under Section 17

### Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1-15	US2013/105307 A1 PAVLOVIC - Whole document relevant
X	1-7, 9-10 & 13-15	US2007/080071 A1 PERRY - Whole document relevant
X	1-7 & 9-15	WO2013/069164 A1 HOSOKAWA et al - See English language abstracts
X	1-7, 10, 13 & 15	AU2013101077 A4 SHINDE - Whole document relevant
X	1 at least	Prior use of cgon Hydrogen on Demand system on or around 13/08/2012 ( <a href="http://www.cgon.co.uk/#!portfolio/cy2z">http://www.cgon.co.uk/#!portfolio/cy2z</a> ) See the web page section entitled 'Kia Sedona 3.0 Diesel 2008' and accompanying MOT Exhaust Emissions Test Results at <a href="http://www.cgon.co.uk/#!portfolio/cy2z">http://www.cgon.co.uk/#!portfolio/cy2z</a>

### Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

### Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC<sup>X</sup> :

Worldwide search of patent documents classified in the following areas of the IPC

The following online and other databases have been used in the preparation of this search report

EPODOC, WPI



**International Classification:**

<b>Subclass</b>	<b>Subgroup</b>	<b>Valid From</b>
C25B	0001/04	01/01/2006