Title: COMBUSTION-ENHANCING-GAS DELIVERY SYSTEM AND FLOW CONTROL

Abstract: A system for delivering combustion-enhancing gases to an engine, the system comprising: an electrolysis cell for generating combustion-enhancing gases, and an engine conduit; a flow regulator; a pressure sensor to sense the pressure level in the cell; wherein the valve is configured to be openable independent of the pressure differential across the valve.

Published:
— with international search report

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.
FIELD OF THE INVENTION
This invention relates to the general field of combustion engines, and more particularly to the use of combustion-enhancing gases with internal combustion engines.

BACKGROUND OF THE INVENTION
Because the internal combustion engine is dependent upon the burning of non-renewable fossil fuels, there have been various attempts to create engines that do not run on non-renewable fuels. Attempts have also been made to create engines which run partially on fossil-fuels, but which are supplemented with other fuels whose long-term supply is understood to be more assured. One example of such technology is the class of devices which generate hydrogen and oxygen by means of the electrolysis of water. Typically, with these devices, the hydrogen from the electrolysis, or alternatively, the hydrogen/oxygen mix, is fed into the internal combustion engine. In some cases, it is intended that the hydrogen/oxygen mix will serve as the sole fuel for the engine. In other cases, the hydrogen/oxygen mix is fed into the internal combustion engine as a supplement to diesel fuel or gasoline, in order to improve the efficiency of the combustion process and to reduce the use of fossil fuels. An example of such a device is found in U.S. Patent no. 6,896,789 ("Ross").

These devices for generating combustion-enhancing gases, and feeding them to an internal combustion engine, are equipped with a variety of different mechanisms for feeding the gases into the engine. In Ross, an electrolysis device is disclosed, which includes a water reservoir, an electrolysis cell containing electrodes for generating the combustion-enhancing gases, and a conduit leading from the electrolysis cell to the
engine. The conduit includes a flow regulator in the form of a check valve, which regulates the flow of combustion-enhancing gases to the engine. The flow regulator is typically set at a pressure that is towards an upper end of the range of pressures at the engine intake. An example of a commonly acceptable check valve value is 20 psi.

Thus, when the Ross device is activated, the internal pressure of the electrolysis cell builds behind the check valve until it reaches a pressure 20 psi greater than the pressure at the engine intake. Then, the check valve opens, and combustion-enhancing gases begin to flow to the engine.

In this configuration, if the pressure at the engine intake rises, gas flow will be blocked by the check valve until the system returns to a state in which the internal electrolysis cell pressure exceeds the intake pressure by 20 psi. The system could return to this state by the intake pressure going down, or by the internal electrolysis cell pressure continuing to build, or a combination of both. In any event, it will be appreciated that in the Ross device, gas flow is usually blocked each time the engine intake pressure rises, and is not restored until the system reaches a state in which the internal electrolysis cell pressure exceeds the intake pressure by twenty pounds.

It will further be appreciated that, it is during periods of rapidly increasing intake pressure that the combustion-enhancing gases are most needed, as such periods typically coincide with increasing RPM, increasing load conditions (e.g. going up a hill), or increasing throttle positions. In the Ross system, it is at these times that gas flow will be temporarily blocked.

Also, in a typical electrolysis cell for generating combustion-enhancing gases, the electrodes generate an electric current within a mixture of an electrolyte (e.g. KOH) and water. The water is electrolyzed to produce hydrogen and oxygen, and a substantial amount of heat is also generated. The result of this process is that the hydrogen/oxygen mixture often carries with it electrolyte vapour and water vapour. This can be problematic,
because water vapour being fed to the engine can interfere with combustion, and electrolyte vapour may damage the engine.

SUMMARY OF THE INVENTION

Therefore, what is desired or a system wherein water vapour and electrolyte vapour are adequately scrubbed from the combustion-enhancing gases, or a system wherein combustion-enhancing gases are more likely to be available to the engine at times of increased engine load. Therefore, according to one aspect of the invention, there is provided a system for delivering combustion-enhancing gases to an engine, the system comprising:

- an electrolysis cell for generating combustion-enhancing gases, and a conduit configured and positioned to carry the gases to the engine;
- a flow regulator, the flow regulator comprising (1) a valve configured and positioned to control the flow of the gases from the cell to the engine, and (2) a controller operatively connected to the valve and configured to control the flow rate of gases through the valve by selective opening and closing thereof;
- a pressure sensor, operatively connected to the controller, the sensor being configured to sense the pressure level in the cell, the controller being configured to read the sensor;
- wherein the valve is configured to be openable independent of the pressure differential across the valve.

Optionally, the engine has, associated therewith, a maximum operating pressure at an intake, and the controller is configured to control the flow rate so as to maintain a cell pressure at a predetermined pressure range in normal operation, and at least a portion of the range includes a pressure value less than 20 pounds per square inch more than the maximum operation pressure at the intake.
Optionally, at least a portion of the range includes a pressure value less than 10 pounds per square inch more than the maximum operation pressure at the intake. Optionally, at least a portion of the range includes a pressure value less than 5 pounds per square inch more than the maximum operating pressure at the intake. Optionally, the flow rate is controlled by pulse width modulation. Optionally, the valve comprises a solenoid valve. Optionally, the valve comprises an injector-type valve. Optionally, the predetermined pressure range comprises a range of 10 pounds per square inch. Optionally, the system further comprises a second sensor, operatively connected to the controller, configured and positioned to sense the pressure at the intake. Optionally, the controller is operatively connected to the engine to receive engine load information. Optionally, the controller is configured to increase, in response to sharp engine load increases, the flow of gases to the engine such that the cell pressure falls below the predetermined pressure range, but not below the pressure at the intake. Optionally, the system further includes a variable power supply for supplying power to the cell, the controller being programmed to cause the variable power supply to increase, in response to sharp engine load increases, the power being supplied to the cell, whereby a production rate of combustion-enhancing gases is increased. Optionally, the system further includes an ignition sensor operatively connected to the cell and to the engine, the cell being configured to remain in an off state unless ignition is sensed. Optionally, the ignition sensor includes a ripple sensor for sensing alternator noise on the engine power line. Optionally, the ignition sensor includes a vibration sensor for sensing vibration associated with engine ignition. Optionally, the cell is configured to remain in an off state unless both the ripple sensor and vibration sensor indicate ignition. Optionally, the controller is operatively connected to the cell and programmed to control the operation of the cell. Optionally, the controller is an electronic controller. Optionally, the controller is a microprocessor-based controller.
According to another aspect of the invention, there is provided a combustion-enhancing gas delivery kit for use in association with an intake conduit carrying air to an internal combustion engine, the kit comprising a tap having an input and an output and being configured to be installed on the conduit with the input positioned to receive combustion-enhancing gases from a source thereof and with the output positioned within the conduit and spaced substantially within the walls of the conduit, whereby the gases are released into the conduit at a point of relatively high turbulence of the air to facilitate mixing of the gases and the air. Optionally, the output is positioned at or near the centre of the conduit. Optionally, the kit further comprises at least one turbulence-increasing fin, configured to be installed within the conduit downstream the output, for facilitating the mixing of the gases with the air.

According to another aspect of the invention, there is provided a system for delivering combustion-enhancing gases to an engine, the system comprising:

an electrolysis cell for generating combustion-enhancing gases;

a reservoir, operatively connected to the cell, for holding water to replenish the electrolysis cell;

a gas flow path configured and positioned to receive gases generated by the cell and deliver the gases to water in the reservoir;

a gas delivery path configured and positioned to receive gases delivered by the gas flow path and deliver the gases to the engine.

Optionally, the system includes a fill flow path for carrying water from the reservoir to the cell, an injector for controlling the flow of the gases through the gas delivery path to the engine, and a selectively openable first purge flow path for purging the gases in the cell to the atmosphere; and, the cell, reservoir and fill flow path are configured so that when the injector is closed and first purge flow path opened, a pressure differential between the reservoir and cell is created to drive water from the reservoir through the fill
flow path into the cell. Optionally, the fill flow path includes a check valve. Optionally, the check valve has a value of approximately 8 psi. Optionally, the injector is configured to restrict flow of gases to build pressure in the reservoir to a predetermined fill pressure prior to said injector being closed and first purge flow path opened. Optionally, the system includes a fill flow path for carrying water from the reservoir to the cell, an injector for controlling the flow of the gases through the gas delivery path to the engine, and a selectively openable first purge flow path for purging the gases in the cell to the atmosphere; and, the cell, reservoir and fill flow path are configured so that when the first purge flow path is opened, a pressure differential between the reservoir and cell is created to drive water from the reservoir through the fill flow path into the cell. Optionally, the cell includes a sensor, operatively connected to the injector and first purge flow path, for sensing that the cell is full. Optionally, the injector is programmed to open, and wherein the first purge flow path is configured to close, when the cell is full. Optionally, the system includes a bypass gas delivery path configured to deliver gases to the engine while bypassing the water in the reservoir, the system further including a fill flow path for carrying water from the reservoir to the cell, the cell, reservoir and bypass gas delivery path being configured so that, when the flow of gases through the gas delivery path is prevented, and the bypass gas delivery path opened, a pressure differential is created between the cell and the reservoir to drive water from the reservoir to the cell through the fill flow path. Optionally, the fill flow path overlaps with the gas flow path. Optionally, the system includes an injector configured to control the flow of gases along the bypass gas delivery path. Optionally, the injector is configured to adjust the flow of gases through the bypass gas delivery path to adjust the pressure differential, whereby the pressure differential can be increased by greater flow of gases through the bypass gas delivery system. Optionally, the system further includes a sensor for sensing an electrolyte level within the cell, and a controller, operatively connected to the sensor, for
causing the flow of gases through the gas delivery path to be prevented, and for opening the bypass gas delivery path. Optionally, the system further includes one or more valves operatively connected to the controller, and wherein the controller is configured to cause the flow of gases through the gas delivery path to be prevented, and to open the bypass delivery path, by changing a state of the one or more valves. Optionally, the controller is configured to halt filling of the cell when a full condition is present.

BRIEF DESCRIPTION OF THE DRAWINGS

Reference will now be made, by way of example only, to preferred embodiments of the invention as illustrated in the attached figures.

Figure 1 is a schematic diagram of a system for delivering combustion enhancing gases;

Figure 2 is a schematic diagram of an assembled combustion-enhancing gas delivery kit;

Figures 3A-C are schematic diagrams showing a flow control for a system for delivering combustion-enhancing gases; and

Figures 4A-C are schematic diagrams showing an alternative flow control for a system for delivering combustion-enhancing gases.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to Figure 1, the device 10 includes an electrolysis cell 12 for generating combustion-enhancing gases, which cell 12 comprises an electrolysis zone 16 and a gas collection zone 26. Preferably, the combustion-enhancing gases comprise hydrogen and oxygen generated by subject water to electrolysis within the cell 12. Within the zone 16 are positioned electrodes 18, at least partly immersed in electrolyte 20. When the electrodes 18 are energized, water within the electrolyte 20 is electrolyzed to produce hydrogen and oxygen shown as the mixture of combustion-enhancing gases 22.
conduit 24 is operatively connected to the gas collection zone 26, within which the combustion-enhancing gases 22 are located after they are generated and they emerge from the electrolyte 20. The conduit 24 is configured and positioned to carry the gases to the engine. The device 10 also includes a water reservoir for re-filling the cell 12 with water.

Mounted on the conduit 24 is a valve 28 configured and positioned to control the flow of combustion-enhancing gases from the cell 12 to the engine. The controller 30 is operatively connected to the valve 28 and configured to control the flow rate of gases through the valve 28. The controller 30 preferably controls the flow rate by controlling the opening and closing of the valve 28. Together, the controller 30 and valve 28 comprise a flow regulator 32 for regulating the flow of gases from the cell 12 to the engine. The conduit 24 continues from the valve 28 to the engine intake 34. Thus, the gases flow from the device 10 from the engine intake 34, and are fed to the engine to enhance combustion.

It will be appreciated that the invention comprehends other forms of flow regulator besides the preferred form described above. What is important is that the rate of flow of combustion-enhancing gases from the cell 12 to the engine intake 34 be controlled.

The controller 30 is preferably operatively connected to a pressure sensor 36 configured and positioned to sense the pressure level within the electrolysis zone 16, and to another pressure sensor 36 configured and positioned to measure the pressure at the engine intake 34. The controller 30 is preferably configured to read the sensors 36 at the intake 34 and the cell 12.

The controller 30 is operatively connected to the valve 28 in order to control the flow of combustion-enhancing gases to the engine. Preferably, the flow of gases through the valve 28 is controlled by pulse width modulation (PWM). In PWM, the controller 30 controls the amount of time that the valve 28 is opened. This time is referred to as the pulse width. Typically, the valve 28 will have, as part of its specification from the manufacturer, a maximum
number of times per second that it should be opened to ensure proper operation. For example, a typical solenoid valve that could be used in this application would have a specified period of 333 milliseconds corresponding to a maximum frequency of 3 cycles per second. What this means is that, for proper performance, the solenoid should not be opened more than once every 333 milliseconds, or three times per second.

Using this type of solenoid 28 as an example, it can be seen that, for each 333 millisecond space of time, the solenoid can be left open for some percentage of that time, and can be closed for some percentage of that time. Thus, within each 333 millisecond period, to allow more gas to flow, the controller keeps the solenoid open for a greater proportion of the period, and then closes the solenoid and keeps it closed for the remainder of the period. To reduce the amount of gas that flows, the controller keeps the solenoid open for a smaller proportion of the period, and then closes the solenoid and keeps it closed for the remainder of the period. It will be appreciated that, to allow maximum gas flow, the solenoid can simply be held open through the entire period. Similarly, if, in exceptional circumstances, it is desired to block gas flow entirely, the solenoid can be kept closed by the controller for the entire period.

It will be appreciated that PWM can be used with other types of valves, such as, for example, injector-type valves. Solenoid valves and injector-type valves each have advantages in this application. For example, injector-type valves typically operate by means of a mechanical seat and low-mass movable closure, while solenoids typically employ a diaphragm that uses a rocking action to open and close the ports of the valve. It has been found that injector-type valves typically have a shorter response time, and the flow of gases can therefore be more precisely controlled, because the shorter response time allows for the valve to be either fully open or fully closed for a greater percentage of the operating time.

On the other hand, it has been found that solenoids are more gas-tight, so that when the solenoid is in its closed position, less gas leaks through the
valve. Furthermore, the gases flowing through the valve 28 in this application typically contain some KOH residue. It has been found that many solenoids are, beneficially, resistant to clogging because of KOH residue.

Thus, it will be appreciated that the preferred form of the invention comprehends various types of valves 28. What is important is that the valve 28 be configured to be openable independent of the pressure differential across the valve 28. What this means is that the valve 28 should be openable by the controller regardless of whether the pressure difference between the input of the valve and the output is positive or negative. This is to be contrasted with a check valve. In a check valve, the pressure at the input must be higher than the pressure at the output for the valve to open (e.g. for a 20 p.s.i. check valve, the pressure must be 20 p.s.i. higher at the input for the valve to open). Thus, with a check valve, if the engine intake pressure rises suddenly, gas flow to the engine will be immediately blocked because the pressure difference across the valve would fall below the level needed to make the valve open. By contrast, the valve 38 of the present invention is openable independent of the pressure differential across the valve 28. This feature allows gases to be delivered to the engine at times when they are most needed, and makes it less likely that gas flow will be blocked at these times.

Those skilled in the art will appreciate that the invention comprehends various forms of flow regulators 32. What is important is that the flow regulator 32 be configured so that it selectively allows and blocks (partially or completely) the flow of combustion enhancing gases to the engine.

It will also be appreciated that, besides the preferred PWM method described above, the invention comprehends other modes of controlling gas flow. For example, instead of PWM, gas flow can be controlled by using a valve in which opening the valve to a greater extent causes more gas to flow, and opening the valve to a lesser extent causes less gas to flow. This is in contrast with, for example, the preferred valve 28, which, in the PWM application, is either fully open or fully closed. Other modes of gas flow control are also
What is important is that the invention include a gas delivery apparatus which controls the flow of gases, preferably being configured so that gas flow is not blocked when the demand for the gases increases.

The controller 30 is preferably operatively connected to a pressure sensor 36 within the zone 26 of the cell 12. This sensor 36 provides feedback data as to the pressure within the cell 12 resulting from the build up of combustion-enhancing gases within the cell 12. The controller 30 is also preferably operatively connected to a sensor 36 at the intake 34. This sensor 36 provides feedback as to the pressure at the intake.

Preferably, the controller 30 controls gas flow as described above in order to maintain the pressure in the zone 26 approximately at a predetermined pressure. Preferably, this predetermined pressure is selected to be above the maximum intake pressure. Thus, if the pressure within the zone 26 begins to rise above the predetermined pressure, the controller will respond by causing a higher rate of gas flow to the engine as described above. This will result in a lowering of the pressure in the zone 26. Similarly, if the pressure in the zone 26 moves below the predetermined pressure, the controller responds by restricting the flow of gases to the intake 34, thus causing an increase in the pressure in the zone 26 toward the predetermined pressure.

For any particular engine, the pressure at the intake 34 will vary within a range. It will be appreciated that it is preferred for the predetermined pressure to be selected at a point above the maximum engine intake pressure. For gases to flow from the zone 26 to the intake 34, the pressure at the intake 34 must be lower than the pressure in the zone 26. If the pressure at the intake 34 is higher than the pressure in the zone 26, the combustion-enhancing gases will be blocked from flowing to the engine. It will be appreciated that, when the engine is idling, the pressure at the engine intake will typically be at within a lower portion of its range. By contrast, when the engine RPM increase, and when the demand for engine power increases, the engine intake pressure will be higher. It is desirable to ensure that gas flow to the intake 34 is not blocked,
particularly when engine power demands have increased. Thus, the predetermined pressure is selected to be above the maximum operating pressure of the intake, so that gas will never be blocked. Furthermore, it is preferable that the predetermined pressure be high enough above the maximum operating pressure of the intake 34, so that, even when the intake is at that maximum operating pressure, there is still significant gas flow from the cell to the intake 34, the flow being driven by a substantial pressure difference therebetween.

On the other hand, it is desirable that the predetermined pressure not be too high above the maximum engine intake pressure. There are two reasons for this. First, it is desirable that the predetermined pressure be reached as soon as is practicable after the cell begins operating. The higher the predetermined pressure, the longer it will take for the cell to reach the predetermined pressure. Furthermore, it will be appreciated that the higher the predetermined pressure, the greater the stress on the components within the cell.

Furthermore, it will be appreciated that the predetermined pressure preferably constitutes a range of pressures. The reason for this is that maintaining a specific nominal pressure would require very precise, and thus very expensive, control hardware and software. It has been found that using a pressure range as the predetermined pressure is effective.

Most preferably, the range of the predetermined pressure is selected so that at least a portion of the range is less than 5 p.s.i. above the maximum operating pressure at the intake 34. It has also been found that the system will function effectively if a portion of the range is less than 10 p.s.i. above the maximum intake pressure, or even less than 20 p.s.i. above the the maximum intake pressure. It has also been found that the system functions effectively when that predetermined pressure comprises a range of 10 p.s.i. (e.g. the predetermined pressure is the range of 50-60 p.s.i.). It has been found that at this predetermined pressure, combustion-enhancing gases flow freely to the
engine. However, the cell components are not unduly stressed, nor does it take unduly long for the predetermined pressure to be reached. Nevertheless, it will be appreciated that the predetermined pressure may take a form different than the preferred form described above.

In another aspect of the invention, the controller 30 also receives pressure feedback data from the sensor 36 at the intake 34, thus providing a connection between the controller 30 and the engine to allow the controller 30 to receive information about the engine load. It will be appreciated that the pressure at the intake 34 typically rises as engine RPM rises. In turn, engine RPM usually rises in response to the driver's depressing the accelerator in order to increase engine power output. As stated above, in such circumstances, it is desirable to ensure that the flow of combustion-enhancing gases is not blocked. Furthermore, it is also desirable to actually increase the flow of combustion-enhancing gases to help meet the increased demand for engine power output.

Thus, preferably, the power supply 17 is a variable power supply and is operatively connected to the controller 30. As explained above, the controller 30 is preferably configured to receive intake pressure data from the sensor 36 at the intake 34. When that data show a rise in pressure that is sharp and long enough to indicate that a substantial and sustained demand for additional engine power exists, the controller 30 is configured to cause the variable power supply 17 to deliver additional power to the cell 12, thus increasing the rate of combustion-enhancing gas production. As a result, in response to a greater demand for engine power output, combustion-enhancing gases are produced at a greater rate to satisfy that demand.

In the event that the demand for engine power is subsequently reduced (indicated by a reduction in engine RPM and a reduction in the pressure at the intake 34), the controller is preferably configured to reduce the rate of gas production accordingly by adjusting the variable power supply.
In one alternative configuration, the controller 30 is programmed to allow, in specific, pre-determined situations, a rate of gas flow high enough to reduce the pressure in the cell 12 below its predetermined pressure. These situations include sharp engine load increases. Thus, for example, when the RPM of the engine rise sharply (thus raising the pressure at the intake 34 sharply), this indicates a sharply increased demand for engine power (i.e. a sharply increased engine load). In this alternative embodiment, the controller 30 is configured to increase gas flow to the intake 34 in response to a sharp increase in engine power demand, even if the increase in gas flow causes the cell pressure to fall below the predetermined pressure. This feature may be implemented where it is desirable to provide additional gas promptly to the intake 34 in response to increased engine power demands. It will be appreciated by those skilled in the art that increased power demands are sometimes temporary, but that it is desirable to meet those demands promptly. For example, a truck driver may need additional power to climb a small hill. In such a scenario, the only useful way to deliver additional engine power is to provide increased flow of combustion-enhancing gases immediately. If the increased flow of gases is delayed, the truck will have finished climbing the hill (and the increased demand will have disappeared), by the time the gas flow is increased.

Thus, the controller 30 can increase gas flow, even if the cell pressure will fall below the pre-determined pressure. This is because it is likely, in such a scenario, that the demand for engine power will recede before the cell pressure falls so low that gas flow to the intake 34 is blocked.

Furthermore, it will be appreciated that, in the preferred device 10, the controller 30 receives data regarding both the cell pressure and the intake pressure. Thus, once the cell pressure has fallen below the predetermined pressure, the controller 30 can be programmed to keep track of the difference between the cell pressure and the intake pressure. As the two values approach one another (i.e. as the cell pressure drops due to increased gas flow), the rate of gas flow can again be slowed to slow or reverse the pressure drop within the
cell 12, and preferably, the controller 30 can prevent the pressure in the cell 12 from falling below the intake pressure.

It will also be appreciated that the need to temporarily allow cell pressure to fall below the predetermined pressure will almost never result in gas flow to the intake 34 being blocked (i.e. the cell pressure falling below the engine intake pressure). This is because, in the preferred form of the invention, the controller 30 also activates the variable power supply 17 to increase gas production in response to an increase in engine power demand, particularly when that increase in demand is likely to be substantial. This increase in gas production will tend to raise the pressure within the cell 12. Thus, even if the pressure in the cell 12 has been allowed to temporarily fall below the predetermined pressure, the increased gas production will tend to raise the pressure back up toward the predetermined pressure.

Preferably, the system includes an ignition sensor 38 operatively connected to the cell 12 and the engine. The cell 12 is preferably configured to remain in an off state unless ignition is sensed. Most preferably, the operative connection between the cell 12 and the sensor 38 is achieved via the operative connection between the controller 30 and the engine ignition sensor 38. It will be appreciated that it is desirable that the device 10 begin operating immediately upon the engine starting to run. However, it is also very desirable that the device 10 not operate unless the engine is running, because of safety concerns, and because operating when the engine is off is wasteful of combustion-enhancing gases.

Thus, preferably, the ignition sensor 38 includes two different types of sensing capability. First, the sensor 38 preferably includes a ripple sensor 40 operatively connected to the engine's 12-volt power line and configured to sense electrical engine ripple on that power line that results from alternator noise. Second, the sensor 38 preferably includes a vibration sensor 42 for sensing the vibration that is generated by the ignition of the engine. The controller 30, which controls the operation of the device 10, is preferably
configured to switch the device 10 on only if both sensors 40, 42 in the ignition sensing means 38 indicate that the engine is on. This substantially reduces the likelihood of the device 10 being operated when the engine is not running. In addition, it will be appreciated that this method of sensing ignition is not intrusive, in the sense that complex and intrusive connections to the engine are not required. Rather, the sensing is done passively and non-intrusively.

It will be appreciated that other types of ignition sensors are also comprehended by the invention. What is preferred is that the device 10 only operate if at least two different sensors indicate that the engine is on.

 Preferably, the controller 30 will be programmable. Most preferably, the controller 30 is a microprocessor-based electronic controller that is, inter alia, operatively connected to the cell 12, sensors 36, valve 28 and power supply 17 to control their operation. This allows the predetermined pressure to be changed between uses of the device 10 if desired. For example, the device 10 may be transferred from one engine to another, in which case it may be desired to change the predetermined pressure to reflect the new operating conditions of the device 10. Also, adjusting the predetermined pressure might be required to improve the performance of the device 10.

Similarly, the specific response of the controller 30 to various situations (e.g. the increase or decrease of gas production, and the increase or decrease of gas flow at the solenoid 28) are also programmable. Thus, the rates of change of gas flow or gas production can be varied by changing the programming of the controller 30.

 Preferably, the controller 30 will include a memory that allows it to store data regarding the operation of the engine in association with which the device 10 operates. In other words, the controller 30 is configured to "learn" the operation profile of the engine. This allows the controller 30 to determine whether certain events, particularly in relation to engine pressure, tend to happen in repetitive sequences. Having this information, the controller 30 can
react appropriately to certain events, including changes of pressure, associated with the engine.

Also, preferably, the controller 30 will have associated therewith a data-log which records certain useful data. For example, the data may include average cell running pressure, so that maintenance personnel can determine if the cell is running properly. Similarly, the log may include data on how long it takes the cell to reach the predetermined pressure, and how steep the increase in pressure is. Such data is useful in determining whether there are gas leaks in the system. Another possible type of data is the number of pulses that the injector has received (i.e. how many times the solenoid or injector-type valve has opened and closed). This allows the user to keep track of the mean time between failures (MTBF). Also, the log can record the voltage and current provided by the power supply, with such data being useful for diagnosing various problems.

In the preferred embodiment of the invention, two valves 28 are redundantly provided in the device 10. Preferably, they are connected in series along the conduit 24. One of the valves is held open while the other is opened and closed by the controller 30. It will be appreciated that valves can malfunction from time to time. By having two valves 28 on the conduit 24, it is possible to continue using the device 10 even when one of the valves is malfunctioning.

Referring now to Figure 2, an engine inlet pipe 44 is shown. It will be appreciated that the gases from the device 10 are fed into the engine via the conduit 24. It is desirable that the combustion-enhancing gases be well mixed into the air that is used as a combustion input to the engine, because more complete mixing leads to more even, more consistent combustion. To ensure that the gases are well mixed with the air, a kit is preferably provided for installation on the engine. The kit comprises a tap 46 having an input and an output, and being installed in the intake conduit 44 which receives the gases from the conduit 24. The input of tap 46 is positioned to receive the gases from
the source thereof (preferably, the cell 12 via the conduit 24). Preferably, the output of tap 46 is positioned within the conduit 44 and spaced substantially from the walls thereof so that the gases are released into the conduit 44 at a point of relatively high turbulence of the air to facilitate mixing of the gases and the air. Most preferably, the output of the tap 46 is positioned at or near the centre of the conduit 44. It will be appreciated by those skilled in the art that the speed and turbulence of air flow is greater at or near the center of the conduit 44 than at the walls thereof. Thus, delivering the gases into the conduit 44 close to the center thereof, and/or spaced substantially from the walls thereof, will ensure that the gases are more effectively mixed into the air in the conduit 44. In addition, one or more turbulence-increasing fins 48, configured to be installed within the conduit downstream the output, create additional turbulence in the air of the pipe 44, thus facilitating the mixing of the combustion-enhancing gases from the device 10 into the air of the engine intake conduit 44.

Figures 3A-C disclose a schematic diagram of a cell flow control system for the device 10 described herein. The device as shown in Figures 3A-C includes an electrolysis cell 60, for generating combustion-enhancing gases and a reservoir 62, operatively connected to the cell 60, for holding water to replenish the cell 60. The apparatus further includes a gas output hose 64 having check valve C1 thereon, with the outlet of the gas output hose 64 being positioned within the water of the refill tank 62. The input of the hose 64 is positioned to receive the combustion-enhancing gases generated by the cell 60. The apparatus further includes a refill hose 66, having a check valve C2 mounted thereon within the water of the tank 62. The refill hose 66 extends from the bottom of the refill tank 62 to the bottom of the electrolysis cell 60, which electrolysis cell 60 is filled with an electrolyte such as KOH. The conduit 66 with check valve C2 thereon functions as a fill flow path for carrying water from the reservoir 62 to the cell. It will be appreciated, however, that the invention comprehends other forms of fill flow path. What is important is that the fill flow path function to carry water from the reservoir 62 to the cell.
The device further includes a purge conduit 68, having a two-port valve V1A thereon. Thus, when the valve V1A is open, flow through the conduit 68 is permitted. When the valve V1A is closed, flow through the conduit 68 is blocked. The purge conduit 68 connects the gas space above the electrolyte in the cell 60 with the atmosphere. Thus, the purge conduit 68, including valve V1A, functions as a selectively openable first purge flow path for purging the gases in the cell 60 to atmosphere. It will be appreciated, however, that other forms of selectively openable first purge flow paths are comprehended by the invention.

The apparatus further includes a second purge conduit 70, having two-port valve V2A thereon. When valve V2A is open, flow through the conduit 70 is permitted, and when it is closed, flow through the conduit 70 is blocked. The conduit 70 connects the gas space in the cell 60 with the atmosphere.

The apparatus further includes an injector hose 72 which connects the gas space above the water in reservoir 62 to the injector 74. Combustion-enhancing gases are carried away to the engine from the injector 74 (which injector preferably includes value 28, operated by controller 30) by an engine conduit 76.

It will be appreciated that the conduit 64 described above acts as a gas flow path, configured and positioned to receive gases generated by the cell and deliver the gases to the water in the reservoir 62. Those skilled in the art will appreciate that the other forms of gas flow path are comprehended by the invention, including, without limitation, gas flow paths consisting of more than one conduit. What is important is that the gas flow conduit be configured and positioned to receive gases generated by the cell and deliver the gases to the water in the reservoir 62.

It will also be appreciated that conduits 72 and 76, and the injector 74, function as a gas delivery path configured and positioned to receive gases delivered by the gas flow path and deliver the gases to the engine. The injector 74, in the preferred embodiment, controls the flow of gases through the gas
delivery path. Those skilled in the art will appreciate that other forms of gas delivery path are comprehended by the invention, including, without limitation, gas delivery paths comprising multiple conduits and valves.

As explained above, in normal operation, the device preferably operates at a predetermined pressure. In the preferred embodiment, the predetermined pressure is a pressure range within which lies a nominal pressure. So, for example, if the nominal pressure is 55 psi, the predetermined pressure maybe, say, 50-60 psi. Thus, the predetermined pressure is maintained by the system's increasing the pressure if it falls to 50 psi, and decreasing the pressure if it rises to 60 psi. Using hysteresis, the approximate nominal pressure of 55 pounds is maintained.

Typically, when the engine is turned on, the cell 60 begins producing combustion-enhancing gases. At this point, the injector 74 is preferably closed, to allow the production of gases to build pressure within the system. It will be appreciated that it is preferable for the injector 74 to begin delivering gas to the engine prior to the predetermined pressure being reached, if possible. This is preferred because engine performance will be enhanced sooner if combustion-enhancing gases are delivered sooner. Thus, for example, a minimum injection pressure may be programmed into the controller 30, so that the injector 74 begins delivering gas to the engine before the predetermined pressure is reached. In the present example, this minimum injection pressure could be, say, 30 psi. In this way, the operator of the vehicle only has to wait until the 30 psi pressure is reached before combustion-enhancing gases are delivered to the engine. It will be appreciated, however, that until the predetermined pressure is reached, the flow of combustion-enhancing gas being delivered to the engine will be restricted (but not blocked), in order to ensure that the pressure continues to build to the predetermined pressure.

In normal operation (see Figure 3B), combustion-enhancing gases produced in the cell 60 travel through the hose 64, which functions as the gas flow path. C1 is preferably a 1 psi check valve which is overcome when the
pressure on the input side of C1 exceeds the pressure on the output side of C1 by one psi. The combustion-enhancing gases are then bubbled through the water in the reservoir 62, and are carried via the conduit 72 to the injector 74. The gases that were bubbled through the water are thus carried by the gas delivery path to the engine.

It will be appreciated that combustion-enhancing gases produced in the cell 60 typically have mixed into it some water vapour and KOH vapour. Bubbling the combustion-enhancing gases produced in the cell 60 through the water of the reservoir 62 is beneficial, because residual KOH, as well as excess moisture that was being carried in the gases, are removed by, and left in, the water of the reservoir 62. It will be appreciated that H2O and KOH vapour in the combustion-enhancing gases can interfere with combustion and create safety concerns. Since the reservoir 62 will be used to refill the cell 60, this system of scrubbing the gases in the water of the reservoir 62 is efficient, as the wasting of KOH and water is substantially reduced. Furthermore, the water and KOH that are scrubbed from the combustion-enhancing gases need not be manually delivered to the reservoir 62, but are automatically delivered thereto.

In Figure 3A, the power-off state of the device is shown. In this state, the injector 74 is closed, and no combustion-enhancing gases are delivered to the engine, as the engine is not on. Valves V1A and V2A are both open. Thus, gases that have bubbled up through the water in the tank 62 do not move along the conduit 72, because that conduit is blocked by the injector 74. Rather, those gases are carried back to the cell 60 via the conduit 70 and the valve V2A. The valve V1A is also open, so that any gases in the cell 60 (including such gases that have flowed through the conduit 70) are carried, via the valve V1A and the conduit 68, to the atmosphere. This permits a safe purging of the combustion-enhancing gases.

Preferably, the controller is programmed so that if residual pressure is sensed in the cell after V1A and V2A are opened, the injector can be opened for a period of time to vent gases from the system. It will be appreciated that
if V1A and V2A are open, and a residual pressure continues to exist in the system, it is probably the result of V1A having failed, or the conduit 68 being blocked in some other way.

Figure 3B shows the system in normal operation. In normal operation, V1A and V2A are both closed. Gases are produced in the cell 60, and travel through the conduit 64 to the check valve C1. When the check valve C1 is overcome, the gases are released into the water of the tank 62, and bubble up to the surface. Because conduit 70 is blocked by V2A, the gases continue along conduit 72, into the injector 74, from which they are delivered to the engine by a conduit 76.

Figure 3C shows the apparatus in fill mode. As will be described more particularly below, the cell 60, reservoir 62 and fill flow path are configured so that when the injector 74 is closed and the first purge flow path is opened, a pressure differential between the reservoir and cell is created to drive water from the reservoir through the fill flow path into the cell 60. In the system, there will typically be a sensor, operatively connected to the injector 74 and first purge flow path (preferably via controller 30), that senses whether the KOH level in the cell 60 is at its optimal level. Once the KOH falls below its optimal level, the system is programmed to switch to fill mode.

In fill mode, the system is programmed to operate as follows. First, the injector 74 is configured to restrict (but, preferably, not to fully block) the flow of combustion-enhancing gases so as to build the pressure in the reservoir 62 to a predetermined fill pressure, preferably greater than the predetermined pressure. In the illustrative embodiment described here, an appropriate fill pressure would be 65 psi. Once the fill pressure is reached, V1A, having previously been closed, is opened to vent the space above the electrolyte in the cell 60 to atmosphere, thus reducing its pressure to zero. Valve V2A remains closed. At this point, the injector 74 may be closed completely, though filling can be performed with the injector permitting a flow of gases, as it did while the pressure was building to the predetermined fill pressure. This creates a
pressure differential, equivalent to the fill pressure, between the reservoir 62 and the cell 60. The result is that water in the reservoir 62 is driven through the conduit 66 and into the cell 60 to replenish the cell 60.

Typically, the check valve C2 on the conduit 66 is set at approximately 8 psi, and must be overcome for the water to travel from the tank 62 to the cell 60. The check valve C2 is useful in case there are any minor pressure differences between the tank 62 and cell 60. Because the check valve C2 is set at 8 pounds, no water will flow from the tank 62 to the cell 60 through conduit 66 unless there is at least 8 psi of difference between the pressure in the tank 62 and the pressure in the cell 60.

To return the device to normal operation, V1A is closed again, and the injector 74 opens and/or increases the flow rate of combustion-enhancing gases to reduce the pressure from the fill pressure to the predetermined pressure. It will be appreciated that, preferably, the valves of the device are operated, programmably and automatically, by the controller 30.

It will be appreciated that, as filling progresses, and the water moves from the tank 62 to the cell 60, the pressure in the tank 62 will progressively decrease. Preferably, the system is programmed so that the system will move from fill mode to normal operation when any one of the following conditions is met: (1) the pressure in the tank 62 reaches the lower end of the predetermined pressure; (2) the level sensor in the cell 60 indicates that the electrolyte is at the optimal fill level; (3) the level sensor in the cell 60 indicates that the cell 60 is in an undesired state (e.g. overflow, sensor failure); or (4) none of the above conditions is met within a predetermined time period (typically two seconds).

It will be appreciated that the fourth condition is used because a component, such as a valve or port, may fail or be stuck. Also, it will be appreciated that the system may or may not be equipped with a level sensor for the tank 62. In the absence of such a level sensor, the failure to achieve one of the first three conditions within the specified time period may be the result of the water tank being empty. Thus, preferably, the fill process is repeated a predetermined
number of times (N times), or until the optimal electrolyte fill level is achieved. If no abnormal conditions are sensed within the system, and N filling cycles have been completed, the system will assume that the tank 62 is empty, and alert the operator of the vehicle to the low water level condition.

Figures 4A-C show a second, preferred, embodiment of the cell flow control system. In the flow control configuration shown in Figures 4A-C, there are included three valves shown as V1B, V2B, and V3B. Each of these valves is a 3-way valve. V1B has two possible states. Either port A is connected to port B, with port C being blocked, or port A is connected to port C, with port B being blocked. Similarly, V2B has two possible states: either port D is connected to port E, with port F being blocked, or port D is connected to port F, with port E being blocked. Finally, in V3B, there are two possible states: either ports G and H are connected, with port I being blocked, or ports G and I are connected, with port H being blocked.

In the system as shown in Figures 4A-C, a gas collection conduit 80 runs from the gas collection area above the electrolyte in the cell 60 to port A of V1B. An atmosphere conduit 82 connects port B of V1B to the atmosphere. Thus, conduits 80 and 82 and valve V1B function as a fi. Running from port C of V1B to a position within the water of the tank 62 is a scrubbing conduit 84. The conduit 84 has a perforated end section 86, which includes multiple perforations for bubbling combustion-enhancing gases from the cell 60 through the water of the tank 62. This delivery of the combustion-enhancing gases through the water of the tank 62 is done for the reasons given above regarding the system shown in Figures 3A-C.

A multi-purpose conduit 88 extends from the gas collection area of the cell 60 and is connected to both port E of V2B and port I of V3B. An injector conduit 90 connects the injector 74 with port G of V3B, and an engine conduit 76 connects the injector 74 with the engine. A scrubbed gas conduit 92 receives gases scrubbed through the water of the tank 62 and carries them to port D of V2B. Connector conduit 94 connects port F of V2B and port H of V3B.
In the power-off state (Figure 4A), V1B is configured so that ports A and B are connected. V2B is configured so that ports D and E are connected. V3B is configured so that ports G and H are connected. The injector 74 is closed. In this configuration, gas in the cell 60 above the electrolyte travels through conduits 80 and 82 to atmosphere. Meanwhile, gas above the water in the tank 62 travels through conduits 92, 88, 80, and 82 to atmosphere. Just as with the cell flow control of Figures 3A-C, if V1B is unexpectedly blocked, as a last resort, the injector 74 can be opened to purge the combustion-enhancing gases from the system.

In normal operation (Figure 4B), V1B is configured so that ports A and C are connected; V2B is configured so that ports D and F are connected; and V3B is configured so that ports H and G and connected. In this configuration, gas is generated in the cell 60, and travels through the conduit 80 and conduit 84 to perforated portion 86, wherefrom the combustion-enhancing gases bubble through the water in the tank 62 and into the conduit 92. From there, the combustion-enhancing gases travel through ports D and F, conduit 94, ports H and G, conduit 90 and injector 74, to the engine conduit 76.

Thus, it will be appreciated that, in the embodiment shown in Figures 4A-C, conduit 80, valve V1B and conduit 84 function as the gas flow path. Conduit 92, valve V2B, conduit 94, valve V3B, injector 74 and conduit 76 function as the gas delivery path.

To fill the cell 60 with water from the tank 62 (i.e. fill mode; see Figure 4C), V3B is switched so that ports G and I are connected, and port H is blocked. In this configuration, gas now travels from the cell 60 via conduit 88, through ports I and G, and conduit 90, to the injector 74. Thus, in fill mode, the combustion-enhancing gases do not enter the injector 74 via the tank 62, but rather, the tank 62 is bypassed. Thus, conduit 88, valve V3B, injector 74, and conduit 76 function as a bypass gas delivery path configured to deliver gases to the engine while bypassing reservoir 62. It will be appreciated that other forms of bypass gas delivery path are comprehended by the invention. What
is important is that the gas be delivered to the engine while bypassing the water
of reservoir 62. As a result, the pressure remains stable in the tank 62, but is
progressively reduced in the cell 60 as gases flow through conduit 88, to the
injector 74 and to the engine. Specifically, the injector 74 permits an amount
of gas flow that will progressively reduce the pressure in cell 60. As the
pressure drops in the cell 60 relative to the tank 62, water is forced through the
perforated end 86, which is immersed in the water of the tank 62, through the
conduit 84, ports C and A, and conduit 80, into the cell 60. Thus, it will be
appreciated that conduit 84 acts to carry combustion-enhancing gases to the
engine during normal operation, but acts to deliver water from the tank 62 to the
cell 60 when the system is in fill mode. Thus, conduit 84 is a two-way conduit.
It will also be appreciated that conduit 84, valve V1B and conduit 80 function as
a fill flow path for carrying water from the reservoir 62 to the cell 60.

Thus, it will be appreciated that the cell 60, reservoir 62 and bypass gas
delivery path are configured so that when the flow of gases through the gas
delivery path is prevented, and the bypass gas delivery path opened, a
pressure differential is created between the cell 60 and the reservoir 62 to drive
water from the reservoir 62 to the cell 60 through the fill flow path.

It will be appreciated that, in the preferred embodiment shown in Figures
4A-C, there are two ways to control the rate of filling. The first is to control the
rate at which gas flows through the injector 74 when the system is in fill mode.
The slower the rate of flow through the injector 74, the more gradual the filling
will be, as the pressure difference between the tank 62 and cell 60 will increase
more gradually. Another approach is to toggle V3B from a configuration in
which ports G and H are connected, to a configuration in which ports G and I
are connected. Toggling V3B back and forth between these two connections
controls the fill rate, because filling will only take place when ports G and I are
connected.

It will be appreciated that this cell flow control system has a number of
advantages over the prior art, and over the configuration disclosed above in
Figures 3A-C. First, check valves are not required in the configuration of Figure 4. This is advantageous because check valves have a tendency to fail often enough so that their use can drive up the cost and frequency of maintenance. Second, filling using the cell flow configuration of Figure 4 can be done more gradually than the filling of the configuration shown in Figure 3. In the system of Figure 3, when fill mode commences, there is an instantaneous pressure difference between the tank 62 and cell 60 of 5-15 psi. Thus, the water will tend to flow with substantial force from the tank 62 to the cell 60, thus stressing the relevant conduits. By contrast, the cell flow control of Figure 4 causes a pressure difference to develop gradually, with the result that the water flow between the tank 62 and cell 60 is less forceful and less stressful to the relevant components.

With respect to the cell flow control shown in Figure 4, the conditions for ending the fill cycle are preferably the same as those described for the system of Figure 3. Similarly, the repetition of N filling cycles is preferably performed under the same conditions as described in respect of the system of Figure 3.

Regarding the system illustrated by example in Figures 1, 3 and 4, as discussed above, the system preferably operates at the predetermined pressure. In one embodiment, when the system is activated, the predetermined pressure is reached by keeping the valve 28 (or injector 74) closed until the pressure in the cell builds to the predetermined pressure. The result of this, however, is that no combustion-enhancing gases are delivered to the engine until the predetermined pressure is reached. Therefore, alternatively, gases may begin to be delivered to the engine before the predetermined pressure is reached. In the preferred form of this alternative embodiment, the controller 30 is configured to open the valve 28 at a predetermined injection pressure so that combustion-enhancing gases flow to the engine. Until the predetermined pressure is reached, the flow rate of the gases after the injection pressure is reached is restricted, i.e. less gas is permitted by the controller 30 and valve 28 to flow through the valve 28, than is produced by the electrolysis cell, so that the
pressure continues to build toward the predetermined pressure. Once the predetermined pressure is reached, the flow rate of combustion enhancing gases is controlled to maintain the predetermined pressure.

It will be appreciated that the injection pressure should be selected to balance two competing factors. On the one hand, if the injection pressure is selected to be high, then it will take too long for the engine to start receiving any combustion-enhancing gases. On the other hand, if the injection pressure is too low, it will take the system longer to reach the predetermined pressure. It has been found that, in the embodiment in which the predetermined pressure is 50-60 p.s.i., an injection pressure of 30 p.s.i. provides adequate performance.

It will be appreciated by those skilled in the art that the foregoing description was in respect of preferred embodiments and that various alterations and modifications are possible within the broad scope of the appended claims without departing from the spirit of the invention.
THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A system for delivering combustion-enhancing gases to an engine, the system comprising:
   - an electrolysis cell for generating combustion-enhancing gases, and a conduit configured and positioned to carry the gases to the engine;
   - a flow regulator, the flow regulator comprising (1) a valve configured and positioned to control the flow of the gases from the cell to the engine, and (2) a controller operatively connected to the valve and configured to control the flow rate of gases through the valve by selective opening and closing thereof;
   - a pressure sensor, operatively connected to the controller, the sensor being configured to sense the pressure level in the cell, the controller being configured to read the sensor;
   wherein the valve is configured to be openable independent of the pressure differential across the valve.

2. A system as claimed in claim 1, wherein the engine has, associated therewith, a maximum operating pressure at an intake, and wherein the controller is configured to control the flow rate so as to maintain a cell pressure at a predetermined pressure range in normal operation, and wherein at least a portion of the range includes a pressure value less than 20 pounds per square inch more than the maximum operation pressure at the intake.

3. A system as claimed in claim 2, wherein at least a portion of the range includes a pressure value less than 10 pounds per square inch more than the maximum operation pressure at the intake.
4. A system as claimed in claim 3, wherein at least a portion of the range includes a pressure value less than 5 pounds per square inch more than the maximum operating pressure at the intake.

5. A system as claimed in claim 1, 2, 3 or 4, wherein the flow rate is controlled by pulse width modulation.

6. A system as claimed in claim 1 or claim 5, wherein the valve comprises a solenoid valve.

7. A system as claimed in claim 1 or claim 5, wherein the valve comprises an injector-type valve.

8. A system as claimed in claims 1, 2, 3 or 4, wherein the predetermined pressure range comprises a range of 10 pounds per square inch.

9. A system as claimed in claim 1, 2, or 5, wherein the system further comprises a second sensor, operatively connected to the controller, configured and positioned to sense the pressure at the intake.

10. A system as claimed as claim 9, wherein the controller is operatively connected to the engine to receive engine load information.

11. A system as claimed in claim 10, wherein the controller is configured to increase, in response to sharp engine load increases, the flow of gases to the engine such that the cell pressure falls below the predetermined pressure range, but not below the pressure at the intake.

12. A system as claimed in claim 11, the system further including a variable power supply for supplying power to the cell, the controller being programmed
to cause the variable power supply to increase, in response to sharp engine load increases, the power being supplied to the cell, whereby a production rate of combustion-enhancing gases is increased.

13. A system as claimed in claim 1, 2, 3 or 4, wherein the system further includes an ignition sensor operatively connected to the cell and to the engine, the cell being configured to remain in an off state unless ignition is sensed.

14. A system as claimed in claim 13, wherein the ignition sensor includes a ripple sensor for sensing alternator noise on the engine power line.

15. A system as claimed in claim 13, wherein the ignition sensor includes a vibration sensor for sensing vibration associated with engine ignition.

16. A system as claimed in claim 14, wherein the ignition sensor includes a vibration sensor for sensing vibration associated with engine ignition, and wherein the cell is configured to remain in an off state unless both the ripple sensor and vibration sensor indicate ignition.

17. A system as claimed in claim 1 or claim 13, wherein the controller is operatively connected to the cell and programmed to control the operation of the cell.

18. A system as claimed in claim 1, 13 or 17, wherein the controller is an electronic controller.

19. A system as claimed in claim 18, wherein the controller is a microprocessor-based controller.
20. A combustion-enhancing gas delivery kit for use in association with an intake conduit carrying air to an internal combustion engine, the kit comprising a tap having an input and an output and being configured to be installed on the conduit with the input positioned to receive combustion-enhancing gases from a source thereof and with the output positioned within the conduit and spaced substantially within the walls of the conduit, whereby the gases are released into the conduit at a point of relatively high turbulence of the air to facilitate mixing of the gases and the air.

21. A kit as claimed in claim 20, wherein the output is positioned at or near the centre of the conduit.

22. A kit as claimed in claim 20 or 21, wherein the kit further comprises at least one turbulence-increasing fin, configured to be installed within the conduit downstream the output, for facilitating the mixing of the gases with the air.

23. A system for delivering combustion-enhancing gases to an engine, the system comprising:
   - an electrolysis cell for generating combustion-enhancing gases;
   - a reservoir, operatively connected to the cell, for holding water to replenish the electrolysis cell;
   - a gas flow path configured and positioned to receive gases generated by the cell and deliver the gases to water in the reservoir;
   - a gas delivery path configured and positioned to receive gases delivered by the gas flow path and deliver the gases to the engine.

24. A system as claimed in claim 23, wherein the system includes a fill flow path for carrying water from the reservoir to the cell, an injector for controlling the flow of the gases through the gas delivery path to the engine, and a
selectively openable first purge flow path for purging the gases in the cell to the atmosphere;

and wherein the cell, reservoir and fill flow path are configured so that when the injector is closed and first purge flow path opened, a pressure differential between the reservoir and cell is created to drive water from the reservoir through the fill flow path into the cell.

25. A system as claimed in claim 24, wherein the fill flow path includes a check valve.

26. A system as claimed in claim 25, wherein the check valve has a value of approximately 8 psi.

27. A system as claimed in claim 24, wherein the injector is configured to restrict flow of gases to build pressure in the reservoir to a predetermined fill pressure prior to said injector being closed and first purge flow path opened.

28. A system as claimed in claim 23, wherein the system includes a fill flow path for carrying water from the reservoir to the cell, an injector for controlling the flow of the gases through the gas delivery path to the engine, and a selectively openable first purge flow path for purging the gases in the cell to the atmosphere;

and wherein the cell, reservoir and fill flow path are configured so that when the first purge flow path is opened, a pressure differential between the reservoir and cell is created to drive water from the reservoir through the fill flow path into the cell.

29. A system as claimed in claim 24 or claim 28, wherein the cell includes a sensor, operatively connected to the injector and first purge flow path, for sensing that the cell is full.
30. A system as claimed in claim 29, wherein the injector is programmed to
open, and wherein the first purge flow path is configured to close, when the cell
is full.

31. A system as claimed in claim 23, wherein the system includes a bypass
gas delivery path configured to deliver gases to the engine while bypassing the
water in the reservoir, the system further including a fill flow path for carrying
water from the reservoir to the cell, the cell, reservoir and bypass gas delivery
path being configured so that, when the flow of gases through the gas delivery
path is prevented, and the bypass gas delivery path opened, a pressure
differential is created between the cell and the reservoir to drive water from the
reservoir to the cell through the fill flow path.

32. A system as claimed in claim 31, wherein the fill flow path overlaps with
the gas flow path.

33. A system as claimed in claim 31 or 32, wherein the system includes an
injector configured to control the flow of gases along the bypass gas delivery
path.

34. A system as claimed in claim 33, wherein the injector is configured to
adjust the flow of gases through the bypass gas delivery path to adjust the
pressure differential, whereby the pressure differential can be increased by
greater flow of gases through the bypass gas delivery system.

35. A system as claimed in claim 31, wherein the system further includes a
sensor for sensing an electrolyte level within the cell, and a controller,
operatively connected to the sensor, for causing the flow of gases through the
gas delivery path to be prevented, and for opening the bypass gas delivery path.

36. A system as claimed in claim 35, wherein the system further includes one or more valves operatively connected to the controller, and wherein the controller is configured to cause the flow of gases through the gas delivery path to be prevented, and to open the bypass delivery path, by changing a state of the one or more valves.

37. A system as claimed in claim 36, wherein the controller is configured to halt filling of the cell when a full condition is present.
INTERNATIONAL SEARCH REPORT

International application No
PCT/CA2006/001397

A CLASSIFICATION OF SUBJECT MATTER
IPC F02M 25/12 (2006 01) , F02B 43/10 (2006 01) , C25B 1/04 (2006 01) , F02M 21/02 (2006 01)
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)
According to International Patent Classification (IPC) or to both national classification and IPC

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

Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used)
Delphion, Esp@cenet, Canadian Patent Database, using keywords electrolyte*, engine, water, tank, flow, combustion, vehicle, gas, hydrogen

C DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category*</th>
<th>Citation of document, with indication, where appropriate, of the relevant</th>
<th>Relevant to claim No</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>US5394852 (MCALISTER) 07 March 1995 (07 03 1995)</td>
<td>1-19</td>
</tr>
<tr>
<td></td>
<td><em>whole document</em></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>US4368696 (REINHARDT) 18 January 1983 (18 01 1983)</td>
<td>20,21</td>
</tr>
<tr>
<td></td>
<td><em>column 3, lines 22-45</em></td>
<td>22</td>
</tr>
<tr>
<td></td>
<td><em>whole document</em></td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>WO 02/42621 A1 (CUMMING) 30 May 2002 (30 05 2002)</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td><em>Figure 2</em></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>whole document</em></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>US4023545 (MOSHER et al) 17 May 1977 (17 05 1977)</td>
<td>1-37</td>
</tr>
<tr>
<td></td>
<td><em>whole document</em></td>
<td></td>
</tr>
</tbody>
</table>

[ ] Further documents are listed in the continuation of Box C [X] See patent family annex

* 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

Date of the actual completion of the international search
10 October 2006 (10 10 2006)

Date of mailing of the international search report
31 October 2006 (31-10-2006)

Name and mailing address of the ISA/CA
Canadian Intellectual Property Office
Place du Portage, C114 - 1st Floor, Box PCT
50 Victoria Street
Gatineau, Quebec K1A 0C9
Facsimile No 001(819)953-2476

Authorized officer
Arthur Gary Grant (819) 953-9698

Form PCT/ISA/210 (second sheet) (April 2005)
<table>
<thead>
<tr>
<th>Document Cited in Search Report</th>
<th>Family Member</th>
<th>Publication Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>US6756140</td>
<td>2004-06-29</td>
</tr>
<tr>
<td></td>
<td>US6155212</td>
<td>2000-12-05</td>
</tr>
<tr>
<td></td>
<td>US5453085</td>
<td>1995-09-26</td>
</tr>
<tr>
<td></td>
<td>US5394852</td>
<td>1995-03-07</td>
</tr>
<tr>
<td></td>
<td>US5343699</td>
<td>1994-09-06</td>
</tr>
<tr>
<td></td>
<td>EP0793772A4</td>
<td>1997-09-10</td>
</tr>
<tr>
<td></td>
<td>EP0793772A1</td>
<td>1997-09-10</td>
</tr>
<tr>
<td>US4368696</td>
<td>no family</td>
<td></td>
</tr>
<tr>
<td>US6896789 B2</td>
<td>WO02099260A1</td>
<td>2002-12-12</td>
</tr>
<tr>
<td></td>
<td>US20050199509A1</td>
<td>2005-09-15</td>
</tr>
<tr>
<td></td>
<td>US20020179454A1</td>
<td>2002-12-05</td>
</tr>
<tr>
<td></td>
<td>US6896789</td>
<td>2005-05-24</td>
</tr>
<tr>
<td></td>
<td>PL0367483A1</td>
<td>2005-02-21</td>
</tr>
<tr>
<td></td>
<td>MX3011145A</td>
<td>2004-10-28</td>
</tr>
<tr>
<td></td>
<td>JP2004528512T2</td>
<td>2004-09-16</td>
</tr>
<tr>
<td></td>
<td>IL0159176A0</td>
<td>2004-06-01</td>
</tr>
<tr>
<td></td>
<td>HU0401459AB</td>
<td>2004-10-28</td>
</tr>
<tr>
<td></td>
<td>EP1397583A1</td>
<td>2004-03-17</td>
</tr>
<tr>
<td></td>
<td>CN1535353A</td>
<td>2004-10-06</td>
</tr>
<tr>
<td></td>
<td>CA2349508C</td>
<td>2004-06-29</td>
</tr>
<tr>
<td></td>
<td>CA2349508AA</td>
<td>2002-12-04</td>
</tr>
<tr>
<td></td>
<td>US20040025809A1</td>
<td>2004-02-12</td>
</tr>
<tr>
<td></td>
<td>US6912977</td>
<td>2005-07-05</td>
</tr>
<tr>
<td></td>
<td>CA2429993AA</td>
<td>2002-05-30</td>
</tr>
<tr>
<td></td>
<td>AU20001695A4</td>
<td>2000-12-21</td>
</tr>
<tr>
<td></td>
<td>AU223294A5</td>
<td>2002-06-03</td>
</tr>
<tr>
<td>US4773981</td>
<td>US4802335</td>
<td>1989-02-07</td>
</tr>
<tr>
<td></td>
<td>US4791896</td>
<td>1988-12-20</td>
</tr>
<tr>
<td></td>
<td>US4781729</td>
<td>1988-11-01</td>
</tr>
<tr>
<td></td>
<td>US4779576</td>
<td>1988-10-25</td>
</tr>
<tr>
<td></td>
<td>US4774810</td>
<td>1988-10-04</td>
</tr>
<tr>
<td></td>
<td>US4773981</td>
<td>1988-09-27</td>
</tr>
<tr>
<td></td>
<td>US4484444</td>
<td>1984-11-27</td>
</tr>
<tr>
<td></td>
<td>CN1016426B</td>
<td>1992-04-29</td>
</tr>
<tr>
<td>US4023545</td>
<td>no family</td>
<td></td>
</tr>
<tr>
<td></td>
<td>US6446597B1</td>
<td>2002-09-10</td>
</tr>
<tr>
<td></td>
<td>US6446597</td>
<td>2002-09-10</td>
</tr>
</tbody>
</table>