A Practical Guide to 'Free Energy' Devices

Part D9: Last updated: 16th May 2006 Author: Patrick J. Kelly

This document provides practical information on the construction of different types of electrolysers. This document is for information purposes only and should not be interpreted as encouragement to actually physically construct any of these devices. The gas produced by electrolysis is very dangerous and should you decide to experiment with it, you do so wholly at your own risk. The author of this document stresses that he is not recommending that you build any of these devices and he disclaims any responsibility whatsoever should you decide to do so against his advice.

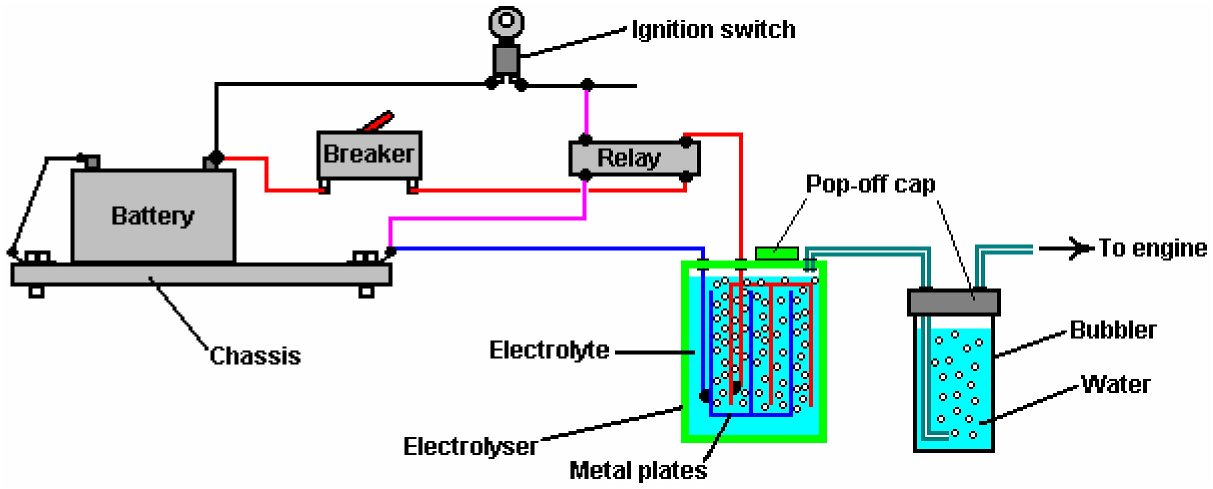
What is an Electrolyser?

An 'electrolyser' is a cell which breaks water down into hydrogen and oxygen gasses by passing an electric current through the water. The resulting gas is called 'hydroxy' gas, as it is a mixture of hydrogen and oxygen. Hydroxy gas is highly explosive, much more so than hydrogen on its own, and very much more dangerous than petrol vapour, burning at least 1,000 times faster. The slightest spark will set it off and exploding as little as a single cupful of hydroxy gas produces a bang so loud that it can cause permanent hearing damage.

Consequently, the most important information about electrolysers concerns the safety devices and techniques which must be used with them. The objectives are to keep the amount of hydroxy gas actually present in the system, to an absolute minimum, and to prevent any spark reaching the gas.

The question arises then, if these things are so dangerous, why do people want to construct them? The answer is that they are very useful. The output from a simple electrolyser can be mixed in with the air being drawn into the engine of a vehicle and the result is generally; much improved miles per gallon, much reduced pollution emissions, and the automatic removal of carbon deposits inside the engine, promoting longer engine life. The output from an advanced electrolyser can replace fuel oil altogether, but such an electrolyser is difficult to build and the exhaust system will rust, and the piston rings may also rust.

A simple electrolyser could be arranged like this:



While the physical arrangement can vary considerably, there are some essential safety features which need to be noted:

1. The electrolyser cell is not connected directly to the battery. Instead, its power comes via a relay which is operated by the ignition switch. This is important, as forgetting to switch off a directly wired electrolyser when the vehicle reaches its destination, leaves the generation of gas continuing while the vehicle is parked. This extra gas builds up and becomes a danger, while the battery is being run down without any benefit being gained. The relay connection makes the electrolyser switch-off automatic and while that sounds like a minor thing, it most definitely is not.

2. The electrical supply to the electrolyser then passes through a resettable circuit-breaker. This is also an important feature because, should any malfunction occur in the electrolyser cell which causes a continuously increasing current to be drawn (such as undue overheating of the cell), then the circuit breaker disconnects the link and prevents any serious problem arising. A light-emitting diode with a current limiting resistor of say, 680 ohms in series with it, can be wired directly across the contacts of the circuit breaker. The Light-Emitting Diode can be mounted on the dashboard. As the contacts are normally closed, they short-circuit the LED and so no light shows. If the circuit-breaker is tripped, then the LED will light up to show that the circuit-breaker has operated. The current through the LED is so low that the electrolyser is effectively switched off.

3. Both the electrolyser and the 'bubbler' have tightly fitting 'pop-off' caps. This is very important. If the hydroxy gas above the surface of the liquid were to be ignited and the unit were robustly sealed, then the pressure build up inside the unit would be very rapid and it would explode like a grenade. If however, 'pop-off' caps are installed, then as the pressure starts to build up, the cap is displaced, maintaining the integrity of the unit, and preventing excessive pressure build-up. Having said that, it is a major objective to avoid gas ignition in the first place.

4. The wires going to the plates inside the electrolyser are both connected well below the surface of the liquid. This is to avoid the possibility of a connection working loose with the vibration of the vehicle and causing a spark in the gas-filled region.

5. The volume above the surface of the liquid is kept as low as possible to minimise the size of an explosion in the unlikely event of one occurring in spite of all of the precautions. Some experimenters like to reduce the volume above the liquid surface by filling it with polystyrene 'beans'. I am not happy with that arrangement as polystyrene is a material with major electrostatic properties. Massive charges build up rapidly on polystyrene, and while the damp conditions inside the electrolyser are not particularly suitable to electrostatic sparks, I feel that the risk of explosion is greater with moving pieces of polystyrene inside the cell.

6. Finally, the hydroxy gas is passed through a 'bubbler' before being fed to the engine. A bubbler is just a tall and narrow container of water with the gas being fed into it near the bottom, and forced to rise through the water before continuing it's journey to the engine. If, for any reason, the gas in the pipe feeding the engine is ignited, then the gas above the water in the bubbler will be ignited. That will blow the cap off the bubbler, restrict the explosion to a small amount of gas, and the water column in the bubbler prevents the gas in the electrolyser from being ignited. People have suggested using flashback arrestors from gas-welding equipment but these are far too slow to work with hydroxy gas where the flame front moves at a thousand metres per second. So the best practice is to use one, or more, bubblers as they are easy to make and install and are very reliable.

Different Types of Electrolyser

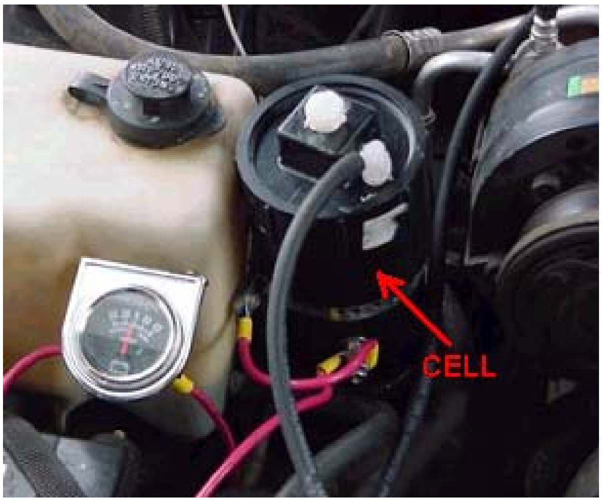
There are three main types of electrolyser:

1. 12 Volt Single Cell.
2. 12 Volt Series Cell.
3. High-Voltage Series Cell.

Each of these will be covered in detail in the remainder of this document. Certain principles apply to each type and will be covered after the three descriptions. These include the necessary surface area of each electrode, the 'conditioning' of the electrodes and dealing with bubbles.

12 Volt Single Cells

The most simple electrolyser to construct is the single cell version as shown above. This can use any size and shape of container which makes is convenient for mounting in the engine compartment of the vehicle. Many people opt for a cylindrical container as these are widely available and are easier to mount, possibly as shown here:



Finding space in the engine compartment is one of the more difficult tasks with European cars as their designs tend to pack the engine area tightly to reduce the size of the vehicle to a minimum.

The rate of gas production depends on a number of factors:

1. The liquid used for electrolysis. If distilled water is used, then almost no current will flow through the cell as distilled water has a very high resistance to current flow, and almost no gas will be produced. It is normal practice to add some other substance to the water to increase the rate of gas production.

   If salt is added to the water, the rate of electrolysis increases enormously. However, that is not a good choice of additive as the salt forms a corrosive mixture and Chlorine gas is produced along with the Hydrogen and Oxygen gasses. The same goes for battery acid; it does work but it is a very poor choice which causes practical problems over a period of time. Other additives will create the increase in gas production but have similar undesirable effects.

   Two additives stand out as being the best choices. The first is Sodium Hydroxide (chemical symbol $NaOH$), sometimes called 'lye'. The very best choice is Potassium Hydroxide (chemical symbol KOH) which is available in pellet form. Potassium Hydroxide acts as a catalyst in the process of electrolysis in that it promotes the gas production but does not get used up in the process.

2. The spacing of the electrode plates. The closer together the plates are placed, the greater the rate of gas production. There is a practical limit to this, as bubbles of gas formed between the plates have to be able to escape and rise to the surface. The optimum spacing is generally considered to be 3 mm or 1/8 inch, although some people prefer to have a 5 mm gap between the plates. These plates are typically made from 316 grade stainless steel.

3. The area of the electrode plates and the preparation of the plate surface. The greater the plate area, the greater the rate of gas production. Some of this effect may be due to the improvement in the chances of bubbles escaping from the plates and not blocking some of the plate area. It is recommended that each face of every electrode plate has an area of between two and four square inches (13 and 25 square centimetres) per amp of current flowing through the cell.

   The preparation of the surface of the plates has a major effect on the rate of gas production. A major improvement is achieved if both sides of each plate are sanded in a criss-cross pattern (this produces an increased surface area with thousands of microscopic peaks which help bubbles form and leave the plate). The plates are then assembled and immersed in the electrolyte solution for about three days. This creates a protective white coating on the surface of the plates which helps enhance the electrolysis. The plates are then rinsed off with distilled water and the cell is refilled with a fresh solution of electrolyte.

4. The current flowing through the cell. This is an absolutely key factor in gas production, and one of the most difficult to control accurately and economically. The greater the current, the greater the rate of gas production. The current is controlled by the concentration of Potassium Hydroxide in the electrolyte (water plus KOH) and the voltage across the cell. The voltage across the cell has limited effect as it reaches a maximum at just 1.24 volts. Up to that point, an increase in voltage causes an increase in gas production rate. Once the voltage gets over 1.24 volts, increasing it further produces no further increase in the rate of gas production.

   If the voltage is increased above 1.24 volts, the extra voltage goes to heat the electrolyte. This can be a slight advantage, but not much. Assume that the current through the cell is 10 amps. In that case, the power used to produce gas is 10 amps x 1.24 volts = 12.4 watts. When the engine is running, the voltage at the battery terminals will be about 13.8 volts as the alternator provides the extra voltage to drive current into the battery. The excess voltage applied to the cell is about 1.24 less than that, say 12.5 volts. The power which heats the electrolyte is about 12.5 volts x 10 amps = 125 watts. That is ten times the power being used to produce gas. This is very, very inefficient.

   However, the heating of the electrolyte is not a wholly bad thing as it drives a good deal of water vapour out of the electrolyte and this mixes with the gas and is fed to the engine. Injecting water mist into an engine increases its performance, improves both the power and miles per gallon, and it makes the engine run cooler, which improves the life of the engine. So the water vapour produced is not necessarily a bad thing, but it is an inefficient way of doing it.

   As the voltage applied to the cell is pretty much fixed, the current flow is controlled by the concentration of Potassium Hydroxide in the electrolyte and the plate area. Once the cell is built, the plate area is fixed, so the current is adjusted by controlling the amount of KOH added to the water.

   There is a slight limit to this, in that the gas production increases with KOH concentration until the concentration reaches 28% (by weight). After that point, any increase in the concentration produces a reduction in the rate of gas production. General practice is to have a fairly low concentration of KOH which is found by trial.

5. The temperature of the electrolyte. The hotter the electrolyte, the higher the current carried through it. This can be a snag. Suppose it is decided that the current through the cell is to be 10 amps and the electrolyte concentration adjusted to give that current when the engine is started. As time passes, the 125 watts of excess power drawn from the battery, heats the electrolyte, which in turn causes an increase in the current flowing through the cell, which causes even greater heating, which..... The result is positive feedback which causes a runaway temperature effect.

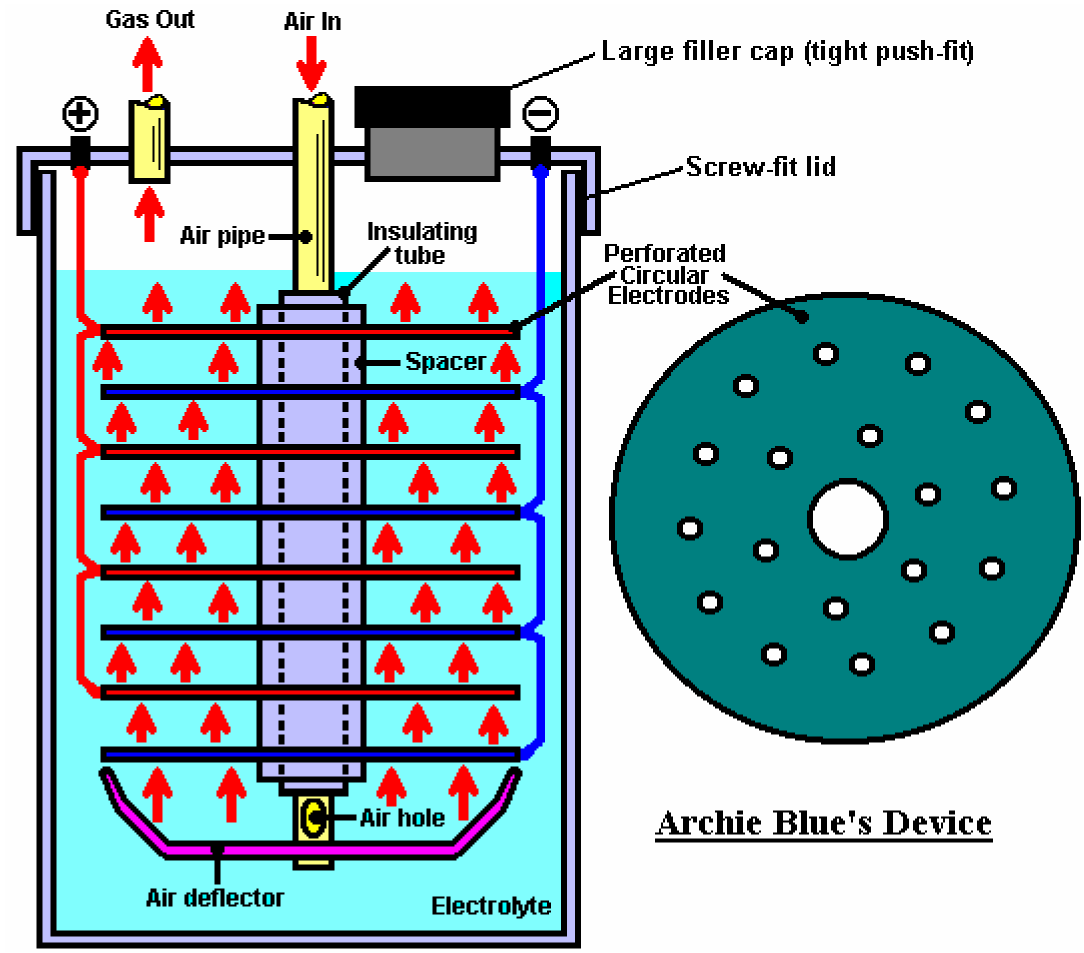
   This effect is aggravated by the water in the cell being used up as the vehicle drives along. This raises the concentration of the electrolyte because the amount of KOH remains the same while the amount of water reduces.

   There are different ways of dealing with this problem. One is to reduce the concentration of KOH so that the chosen current is only reached when the electrolyte has reached its maximum working temperature. This is a simple solution with the slight disadvantage that the gas production rate when starting is lower than it could be. However, the heating power is so high that it will not be long until the cell is operating at its maximum temperature.

   A different way to handle the problem is to use an electronic circuit to limit the current through the cell to the chosen value by dropping the voltage applied to the cell. This has the disadvantage that the extra power is being dissipated in the electronics which then has a heat problem. Also, this solution does not improve the overall efficiency of the process.

   The best way of all is to reduce the voltage applied to the cell by using more than one cell connected in a daisy-chain across the battery. With two cells, each will get about seven volts across it and the gas production will be doubled. If space in the engine compartment allows, a chain of six cells can be used which means each receives about two volts and the waste powers is reduced to some 10.6 watts per cell, while the gas production is six times higher. With the higher rate of gas production, it would probably be possible to reduce the chosen current flowing through the cell. Also, with six cells, the amount of water is six times greater and so there will be less concentrating of the electrolyte due to the water being used up. This is a “Series-Cell” arrangement.

6. The number of bubbles sticking to the surface of the electrode plates. This is generally considered to be a significant problem. Many methods have been used to deal with it. Some people use magnets, others pump the electrolyte around to dislodge the bubbles, others use buzzers to vibrate the plates and some pulse the voltage to the cell at just the right frequency to vibrate the cell. One of the best methods is to use the intake strokes of the engine to draw air through the cell (or cells). The most popular design for this was produced by Archie Blue and is shown here:



Archie Blue's Device

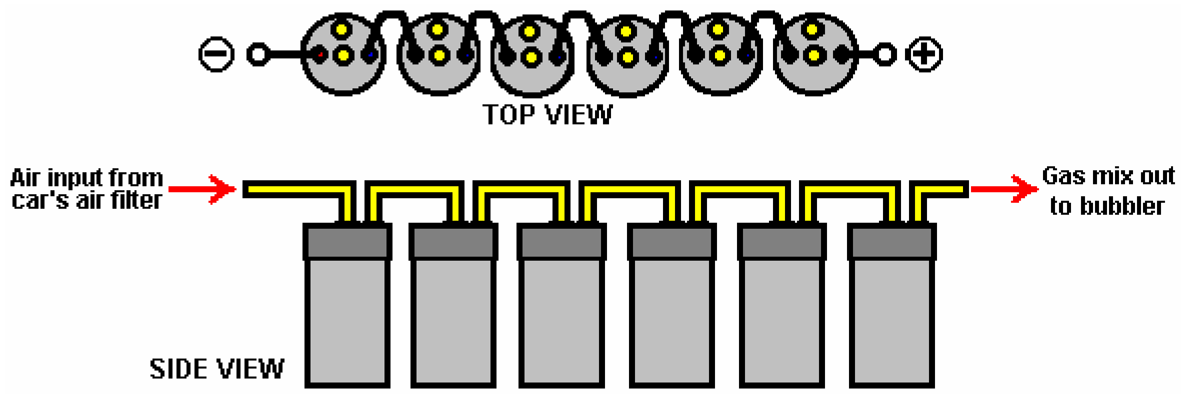
Here, a number of horizontal circular plates are mounted on a vertical pipe. They are insulated from the pipe and connected electrically into two sets of interleaved plates, one set connected to the battery plus and the other to the battery minus. Although shown fairly widely spaced in the diagram, the actual gap between the plates is normally from 5 mm to 9 mm. The plates are positioned so that the holes are not lined up and the air being drawn through the electrolyte has to zig-zag between the plates.

The air is drawn down through the pipe and exits through holes at the bottom. An air-deflector plate under the pipe helps channel the air up through the holes in the plates. The air being drawn up through the cell causes turbulence in the electrolyte and this helps to brush the gas bubbles off the plates and carry them up to the exit pipe in the cap of the cell.

The diagram shows a considerable gap between the metal discs and the inside of the housing cylinder. This is only to aid clarity when drawing the cell. In practice, the discs will be a close fit in the housing so as to enhance the air flow through the holes in the discs.

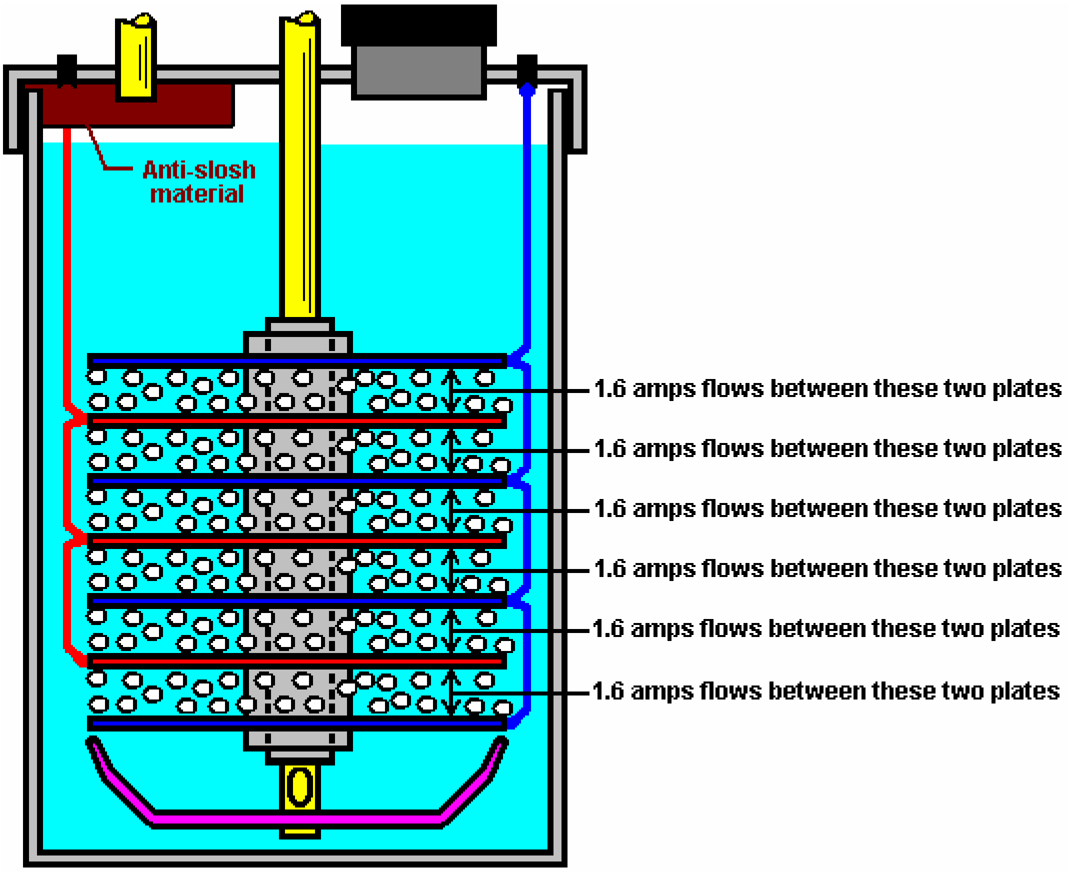
12 Volt Series Cells

If there is room in the engine compartment, then anything up to seven of these cells may be installed and connected in series across the battery. The pipework is daisy-chained from cell to cell so that the air drawn into the engine passes through each cell, picking up more and more gas on the way, as shown here:



The upper diagram shows the electrical connection between the cells while the lower diagram shows how the air/gas pipes are connected. While the cells are shown side by side in the diagram, they can be positioned in any convenient locations in the engine compartment. As the temperature in the engine compartment can be quite high, the cell housings need to be unaffected by high temperatures, which make some plastic containers unsuitable for this use.

The Archie Blue cell design is very neat and allows a very large electrode area if it is needed. If the discs were 3 inches (75 mm) in diameter, the central hole 3/4 inch (18 mm) in diameter, and there were 18 holes of 1/8 inch (3 mm) diameter, then the electrode area would be 6.4 square inches (41.3 sq. cm.). As we would like to have between two and four square inches of plate area per amp of current flowing through the plate surface, that means that each disc could carry anything from 6.4 / 4 = 1.6 amps to 6.4 / 2 = 3.2 amps. With a 10 amp current flow through the cell, and the air flow not shown, the gas production would look like this:



The volume of electrolyte contained in the cells of this type is considerable, so topping up the cells would not be an urgent matter. The picture above is expanded to give a better view. The actual gap between the plates will be about 5 mm or so, which means that the plate assembly shown above will only have a vertical height of about 1.5 inches (40 mm). The cell housing is likely to be eight or nine inches tall (200 mm) so the amount of electrolyte above the plates is considerable. The electrode area in this single cell electrolyser is about 6 x 6.4 = 38.4 square inches (248 sq. cm.).

For maximum gas output, this cell only needs 1.24 volts across it. If the vehicle alternator is connected across it, then it will be receiving about 13.8 volts. Only 1.24 volts is used to make gas, the rest goes to heat the electrolyte. If the concentration of the electrolyte is adjusted to give 10 amps flowing through the cell, then 1.24 volts x 10 amps = 12.4 watts will be used to produce gas, and (13.8 - 1.24) volts x 10 amps = 125.6 watts will just heat the electrolyte. To put that another way: less than 10% of the power taken from the alternator will be used to actually make gas.

If two of these cells were daisy-chained across the alternator supply, then 24.8 watts (18%) would go to make gas and the gas output would be doubled. With three cells 37.2 watts (36%) would make three times as much gas as a single cell. With six cells 74.4 watts would produce six times as much gas as a single cell but some 63 watts would still go to heat the electrolyte.

The Archie Blue electrolyser is an excellent design with many advantages, but to get optimum efficiency on 13.8 volts, it would require eleven cells wired in series. This is not a very practical arrangement although the gas volume would be high. If you use a sufficiently high number of electrolysis cells, it becomes possible to run the engine on the gas output alone.

High-Voltage Series Cells

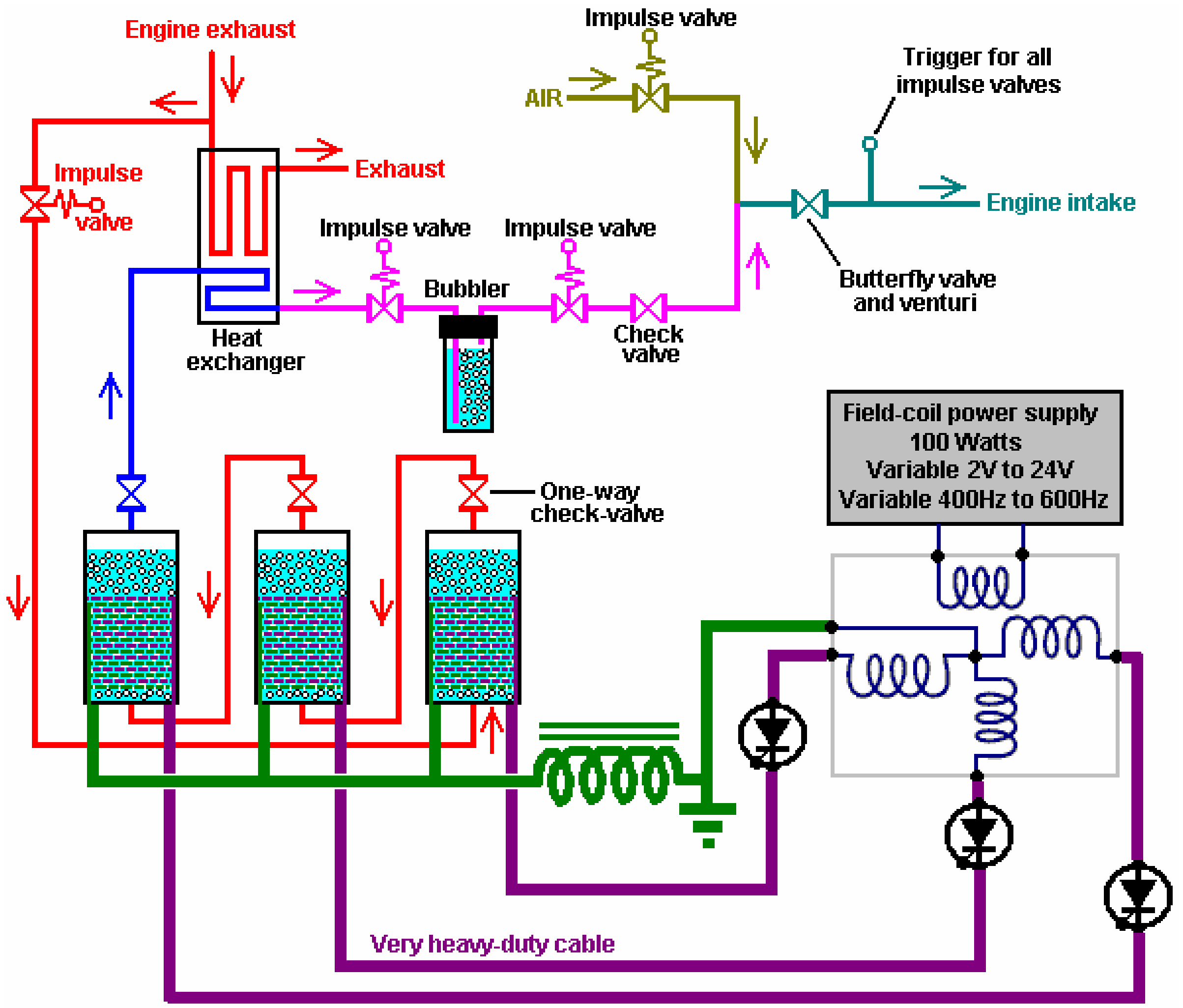
The electrolysers discussed above are used to improve the performance and efficiency of internal combustion engines running on fossil fuels. The optimum situation would be where the original fossil fuel can be dispensed with altogether and the engine run on water alone. This is not easy to do. It is not impossible to do. A few people have done it. The electrolyser described below is capable of running a suitable internal combustion engine. However, it should be understood that excluding fossil fuels altogether will definitely cause rust in the exhaust system and probably in some parts of the engine, such as the piston rings.

Not every engine is suitable for conversion as the current types which have computer control of the amount of fuel passed to the engine, the timing of the spark and which used oxygen sensors to determine how the fuel burn inside the engine is going, are not suitable unless the present ignition-control system is removed and replaced with a more simple variety. One reason for this is that hydroxy gas burns a thousand times faster than fossil fuel vapour does. Consequently, the spark inside the cylinder has to occur later in the cycle, definitely after Top Dead Centre and probably about twenty-five degrees after TDC. The most suitable vehicles are the older types with Capacitor Discharge ignition or types which have a contact-breaker in the ignition circuit. These types generally have the ability to manually adjust the timing to whatever setting is needed. Ideally, the engine will have a carburettor and fair amount of spare space in the engine compartment. These factors restrict the suitable vehicles very considerably. It would also be an advantage if the engine capacity were not particularly large, as the larger the engine, the larger the amount of hydroxy gas needed to run it.

To increase the amount of gas produced by a electrolyser, it is necessary to increase the current through the cells by a major amount or increase the number of cells in the electrolyser, or both.

Peter Lowrie has succeeded by increasing the current to where a clamp-ammeter shows between 800 and 900 amps flowing into each of his three Archie Blue style electrolysers. This produces enough hydroxy gas to run the engine and produce the electrical power for the electrolyser cells by driving an extra alternator. His design uses a marine alternator, driven by the engine, to apply pulses of electrical power to an electrolyser cell attached to each of the three alternator windings. Peter's design uses a heat exchanger to heat the gas coming from the electrolysers, before it is fed to the engine. The cascaded electrolyser cells are fed from the engine exhaust, with the volume controlled by an impulse valve. When the engine runs faster, the trigger impulses from the manifold vacuum increase in frequency, feeding more exhaust gas into the electrolysers.

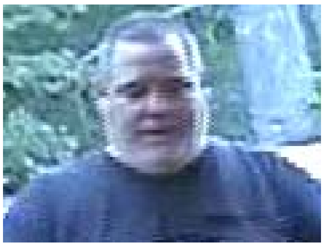
The hydroxy gas, mixed with Nitrous Oxide, Carbon Monoxide and Carbon Dioxide is heated and passed through a flashback arrestor bubbler, which has an impulse valve positioned on each side of it. The heated gas mix is then passed through a check valve and mixed with air, whose inflow is also controlled by an impulse valve. A final butterfly valve sets the flow to the engine intake, as shown here:



If the engine stalls, the trigger impulses to the impulse valves stop immediately and the electrolysis current stops as the alternator stops turning. The electrolysis cells are intended to run hot at about 85^0C. When the engine is started from cold, the pulsed voltage applied to the field coil of the alternator is set at 24 volts. When this increased power level starts to heat up the electrolyte in the cells, the voltage to the field coil is reduced progressively, until it reaches the 2 volt level, where very little power is taken up in heating the electrolyte.

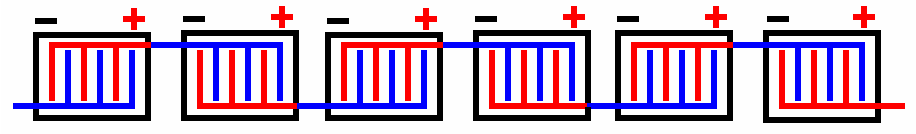
An electronic circuit (not shown) is arranged to fire the very powerful Silicon Controlled Rectifiers (SCRs or Thyristors) at the voltage peak of each output cycle for its electrolyser cell. The coil shown between the cells and the earth (engine chassis voltage) comes from an industrial 3-phase power supply. It is of very heavy construction to handle the very large current, made with insulated copper strip wound around a steel core. Each cell will have a controlled water-supply system as the water levels will fall rapidly due to the very large volume of hydroxy gas being produced.

It has been suggested that the circuit would be more efficient if the half-wave SCR circuit shown above were replaced with a full-wave arrangement. This has not been tried as yet, but a number of problems arise with that idea. Firstly, the cables carrying the current to the electrolyser cells, show a reading of 900 amps when a standard clamp-ammeter is placed around the cable. That is a very large current, requiring exceptionally large cables to carry it effectively. If a full-wave circuit is introduced, then the power dissipated in the cables will be doubled. This is liable to cause problems unless the already expensive cables are increased in size. Secondly, the frequency of the field coil electronics will be doubled as there will be twice as many voltage peaks per second, so the circuit timing components will need to be changed. Thirdly, the SCRs are already very expensive due to their very high current handling capacities. If full-wave operation is introduced, either there will need to be twice as many expensive SCRs, or Triacs of even higher specification will need to be used. Since the design works well in its present form, there does not appear to be any reason to modify it.



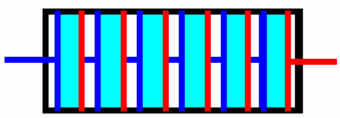
Bob Boyce achieves the increased gas production rate by using an electrolyser with a large number of cells in it. Sixty or seventy cells are used which means that a voltage of up to 1.24 x 70 = 86.8 volts is needed to power it to its maximum output. To get this higher voltage, he uses a 110 Volt inverter. An inverter is an electronic circuit which has a 12 Volt DC input and generates a 110 Volt AC output. These are readily available for purchase as they are used to run (US) mains equipment from car batteries. The output from the inverter is converted from Alternating Current to pulsing Direct Current by passing the output through four diodes in what is called a 'Diode Bridge'. These are readily available at very low cost and the smallest I have seen can handle up to 1000 Volts at currents of up to 35 Amps, which is far, far more than is needed for this type of electrolyser.

Obviously, it would not be practical to use seventy Archie Blue style cells daisy-chained together to act as the series-connected electrolyser cell. There would not be enough physical space in the engine compartment for that, so a different style of cell construction is needed. The view looking down on several separate electrolyser cells could be represented something like this:

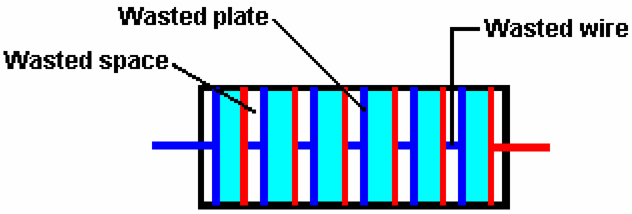


Top view of an electrolyser

Here the plus side of each cell is connected to the minus side of the next cell to provide a set of six interconnected cells acting in series. The current flowing through the electrolyser goes through each cell in turn and so each cell receives exactly the same current as the other cells. This is the same sort of arrangement as using six Archie Blue style cells in a daisy-chain. To reduce the physical size of the unit, it would be possible to construct the electrolyser as shown here:

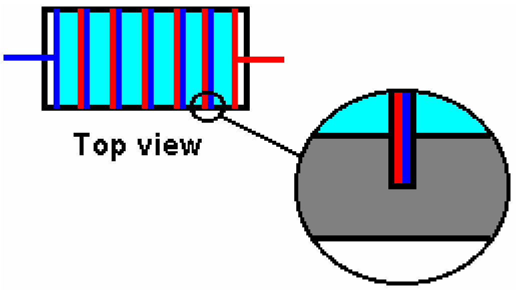


Top view

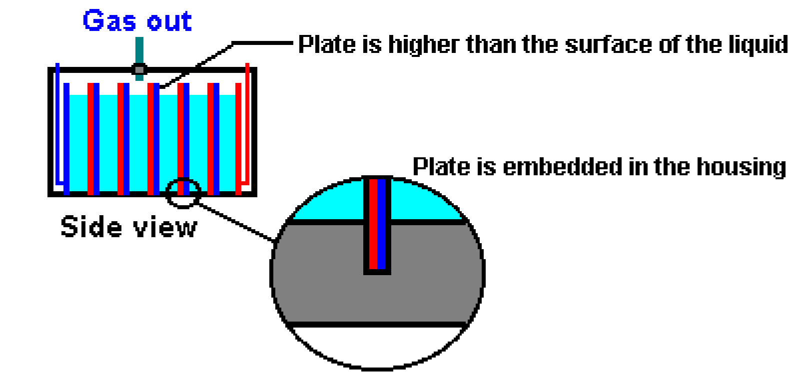


In this arrangement, the individual cells have just one positive plate and one negative plate. The plates slot into the sides of the housing so that the electrolyte is trapped between the plates and an air gap is formed between the plus plate of one cell and the minus plate of the next cell.

These air gaps are wasted space. They contribute nothing to the operation of the electrolyser. Each consists of a metal plate, a gap and a wire connection to the next metal plate. From an electrical point of view, the two metal plates at the opposite ends of these gaps, being connected by a wire link, are effectively the same plate (it is just a very thick, hollow plate). These air gaps might as well be eliminated which would save one metal plate and one wire link per cell. This can be difficult to visualise, but it produces an arrangement as shown here:



The only air gaps remaining are at the ends of the electrolyser. The plates in the middle are notionally touching each other. The positive plates are marked in red and the negative plates are shown in blue. In reality, there is only one metal plate between each cell and the next cell - the red and blue marking is only a notional device to try to make it easier to see that the diagram actually shows six separate cells in a single housing. They are separate cells **because** the metal electrode plates extend into the base and sides of the housing, thus isolating the six bodies of electrolyte from each other. It is very important that the different bodies of electrolyte are fully isolated from each other, otherwise the electrolyser will not act as a series-connected unit. The plates need to be a tight push-fit in grooves cut in the sides and base of the housing. The electrolyte level must always be below the top of the plates as shown here:



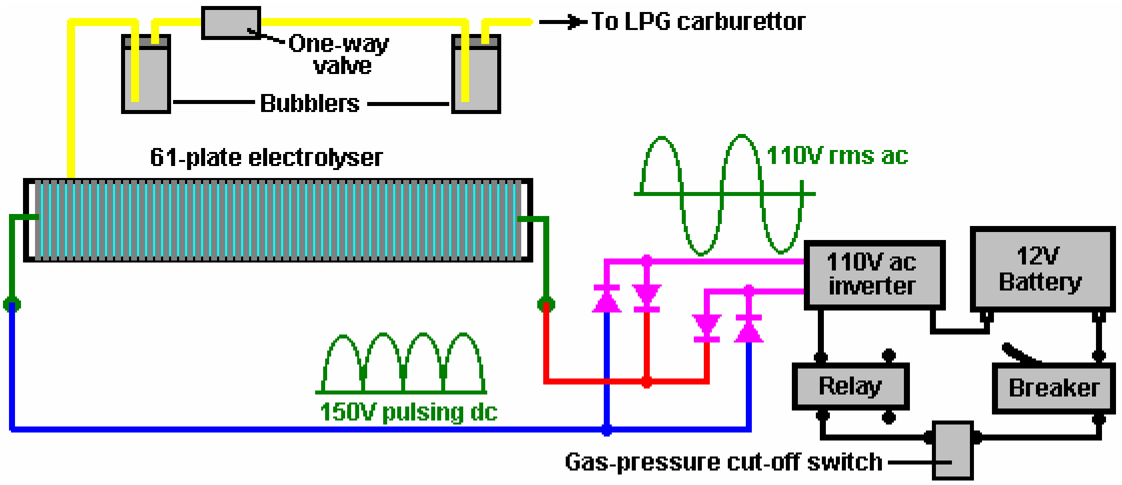
A seventy cell electrolyser built in this style will have seventy one metal plates and seventy separate bodies of electrolyte. In spite of these large numbers, the size of the overall unit does not have to be excessive. The spacing between the plates is set to, say, 3 mm (1/8 inch) and the plate thickness might be 16 gauge, so the width of any cell is not great.

The size of the plates may be determined by the space available in the engine compartment. If there is a large amount of spare space, then the plate size may be selected by allowing four square inches of area on both sides of each plate, per amp of current. Each side of every plate is in a different electrolysis cell so a 6-inch by 6-inch plate will have 36 square inches on each face and so would carry 36 / 4 = 9 amps of current. The choice of current is made by the builder of the electrolyser and it will be influenced by the size and cost of the inverter chosen to drive the electrolyser and the allowable current draw from the battery.

A 600 watt electrolyser would have an absolute maximum output current capacity of 600 watts / 110 Volts = 5.45 Amps. The inverter will run much better if not used at its maximum load all the time, so perhaps a current of 4 Amps might be used as the target current. At four square inches per amp, that indicates a plate area of 16 square inches (103 square centimetres), say 5” x 3.5” below the surface of the electrolyte. As the plates need to project above the surface of the electrolyte, a plate size of 5” x 4.5” (125 mm x 115 mm) would be practical. If the inverter is 80% efficient, then 25% more current goes into it than comes out of it (the remainder being wasted as heat). The power taken from the battery would then be 4 amps x 110 volts = 440 watts plus 25% = 550 watts. The current draw from the battery would be 550 watts / 13.8 volts, or about 40 amps. Bob Boyce recommends a 6” x 6” or larger plate size, but the size and shape of the spare space in the engine compartment would be a major consideration. It is essential that every item which contains hydroxy gas is located in the engine compartment. Under no circumstances should the electrolyser or bubbler be located in the passenger area of the vehicle, even if pop-off caps are provided and a second protective outer housing is provided, as the explosive force is so great that permanent hearing damage would be a serious danger.

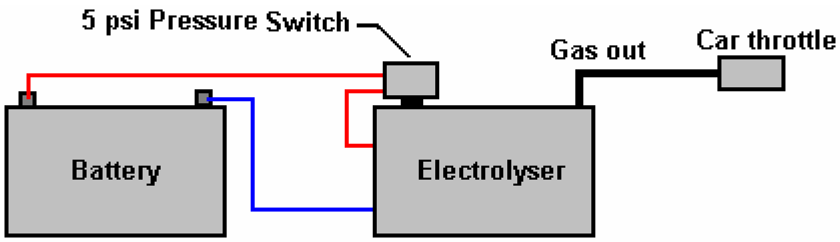
Here is what a housing of this type might look like:

The overall size of the housing is not excessive, and the chances of mounting it in an older design of vehicle is a realistic proposition. The inverter should be mounted securely, preferably in the stream of air drawn in to cool the radiator. Using a diode bridge produces the electrical arrangement shown here:



The one-way valve shown between the two bubblers, is to prevent the water in the bubbler mounted beside the electrolyser, being driven into the electrolyser in the event of an explosion in the bubbler mounted beside the engine.

The overall operation of this style of electrolyser is very much like taking gas from a pressurised cylinder via a pressure-regulator valve. The electrolyser has a pressure switch which disconnects the electrical supply from the electrolyser when the gas pressure in the electrolyser reaches five pounds per square inch:



When the vehicle is driving along, the electrolyser output goes straight to the engine via the butterfly valve in the vehicle throttle control. When the engine slows down and the gas required is far less, the gas pressure inside the electrolyser builds up. When the pressure reaches it pre-set value (usually 5 to 7 pounds per square inch), the pressure switch mounted on the electrolyser trips and disconnects the battery from the electrolyser, cutting off the electrolysis and preventing any further build up of pressure inside the electrolyser. Please note that, for clarity, the above diagram is just an outline sketch to illustrated the pressure switch operation, and the vital safety mechanisms for the system have not been shown.

It does not matter which direction the current flows through the electrolyser. Connecting the diode bridge is very straightforward as the two terminals which are connected to the inverter are marked with sine-wave symbols and the other terminals are marked with a + and - symbol respectively. Later in this document, Bob's custom electronics unit is shown which can split the water into gas much more effectively and at low voltage.

A serious issue with an electrolyser of this type is dealing with water loss. As the plates have to be spaced closely together and the since the electrolyte between the cells is effectively isolated from the electrolyte in the other cells, driving a mile down the road is liable to lower the water level by half an inch (say, one centimetre). It is essential to keep replacing the water which is used.

Two things have to be dealt with:

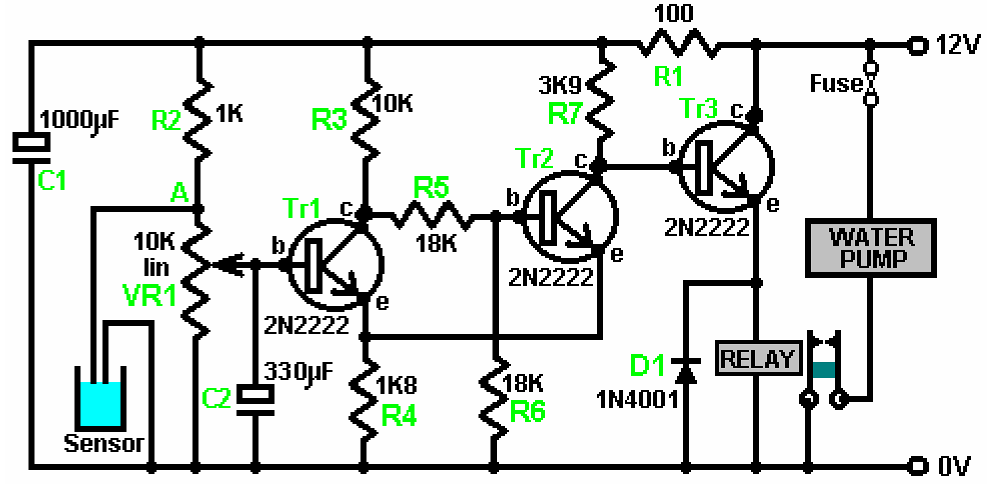
1. Sensing when the electrolyte level has fallen, and
2. Creating some device for getting extra water into each cell

Simple electronics provides the answer to sensing the level of the electrolyte, and a windscreen-washer water pump can be used to inject the additional water.

A sensor for the water in the cells can be on just one cell. If the water level of any one cell falls below the level in the other cells, then the gas produced in that cell will be slightly less than the other cells, so it will lose less water until the water levels match again. Also, Bob recommends cutting the slots which hold the plates, 3 thousandths of an inch (0.003" or 0.075 mm) larger than the actual thickness of the metal plates. This effectively blocks electrical leakage between adjacent cells but does allow a very gradual migration of water between the cells to help maintain an even water surface across the cell.

The water-level sensor can be just one stiff stainless steel wire run down each side of any cell. These wires should be insulated to make sure that They do not short-circuit to either (or both) of the plates on each side of them. They should be set so that their tips are at the intended surface level of the electrolyte.

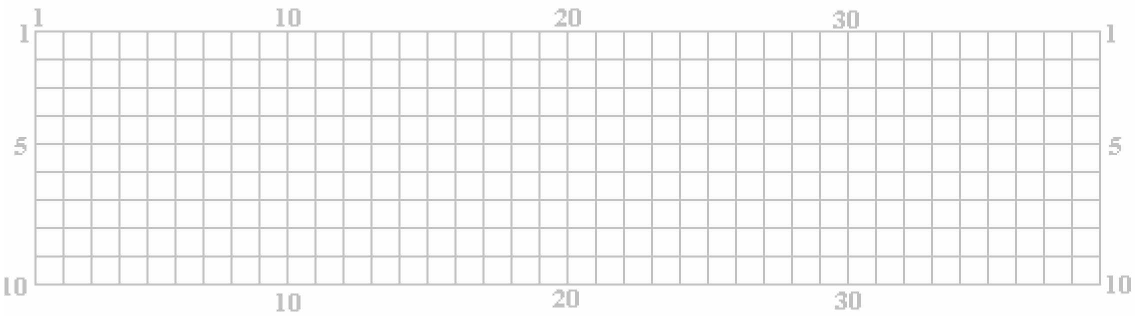
If the electrolyte level drops below the tip of the wire sensors, then the resistance between the wires will fall, indicating that more water is needed. This can switch the water pump on, which will raise the water level until the electrolyte level reaches the tip of the wire again. A possible circuit for doing this is shown here:



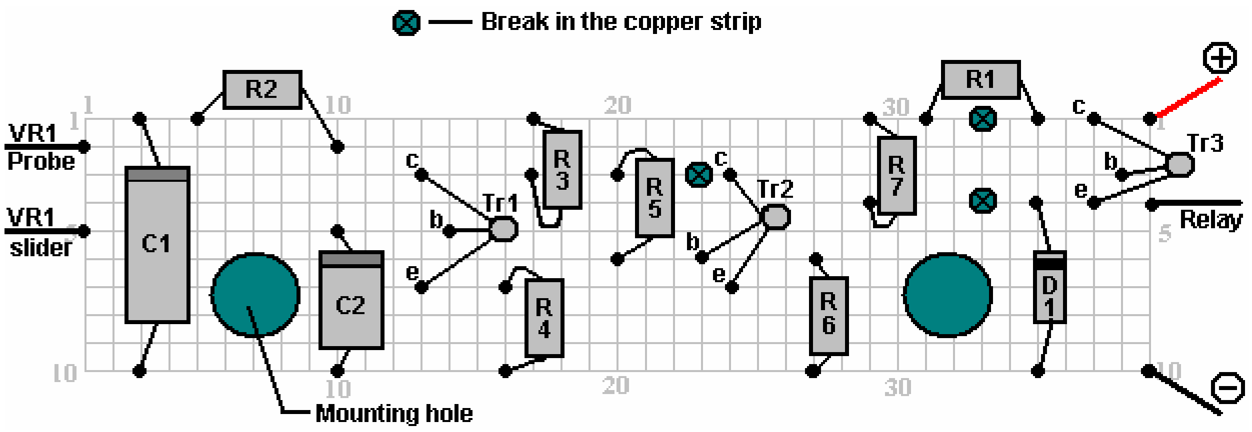
When the level of the electrolyte falls, the sensor wires come clear of the liquid and the voltage at point 'A' rises. Provided that this situation remains for a second or two, capacitor C2 charges up and the voltage on the base of transistor Tr1 rises, causing it to switch on. Transistors Tr1 and Tr2 are wired as a Schmitt trigger, so transistor Tr2 changes state rapidly, raising the voltage at its collector, and causing transistor Tr3 to power the relay on. The relay contacts switch the water pump on, which raises the level of the electrolyte until it reaches the sensor wires again. This flips the circuit back into its standby state, powering down the water pump. Resistor R1 feeds capacitor C1 to reduce the effects of variations of voltage reaching the sensor circuit. The components shown here are not critical and there must be at least twenty alternative designs for this circuit.

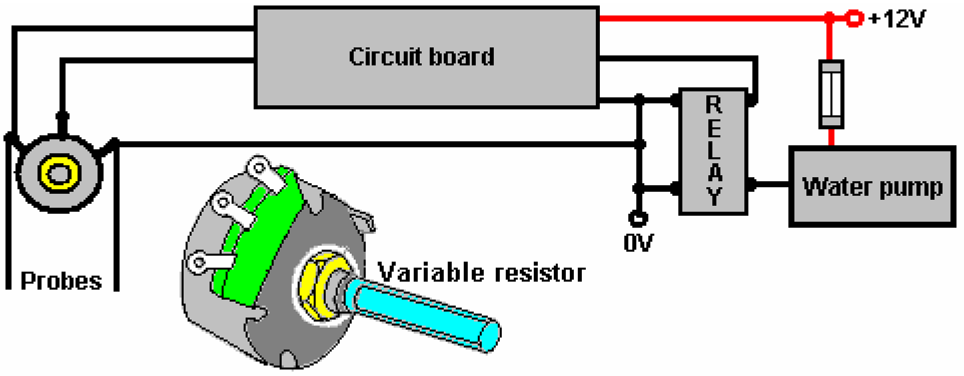
A possible physical layout for this circuit is shown here:

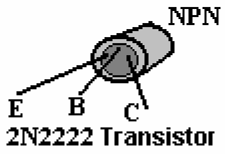
The build is based on using the standard 10-strip, 39-hole stripboard. For convenience in drawing, the holes are represented as the points where the lines cross in the diagram shown here:



The horizontal lines represent the copper strips and the intersections with the vertical lines represents the matrix of holes. Many different layouts could be used for this circuit, so the following diagram is only a suggestion:







Components:

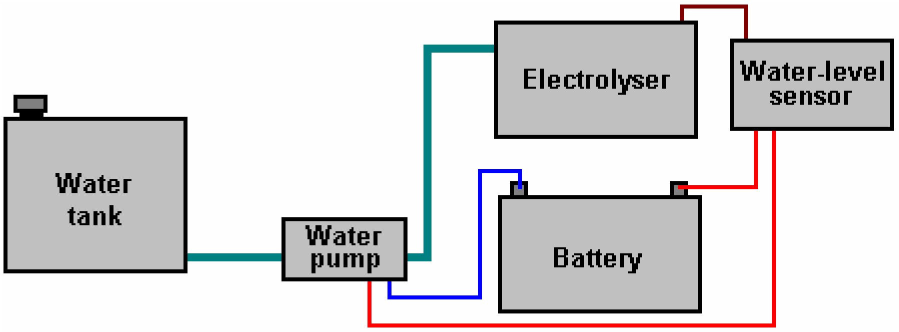
R1 100 ohms
R2 1,000 ohms
R3 10,000 ohms
R4 1,800 ohms
R5 18,000 ohms
R6 18,000 ohms
R7 3,900 ohms

C1 1000 microfarad 35 volt or higher
C2 330 microfarad 16 volt or higher

D1 1N4001 or similar 100 volt or higher 1 amp

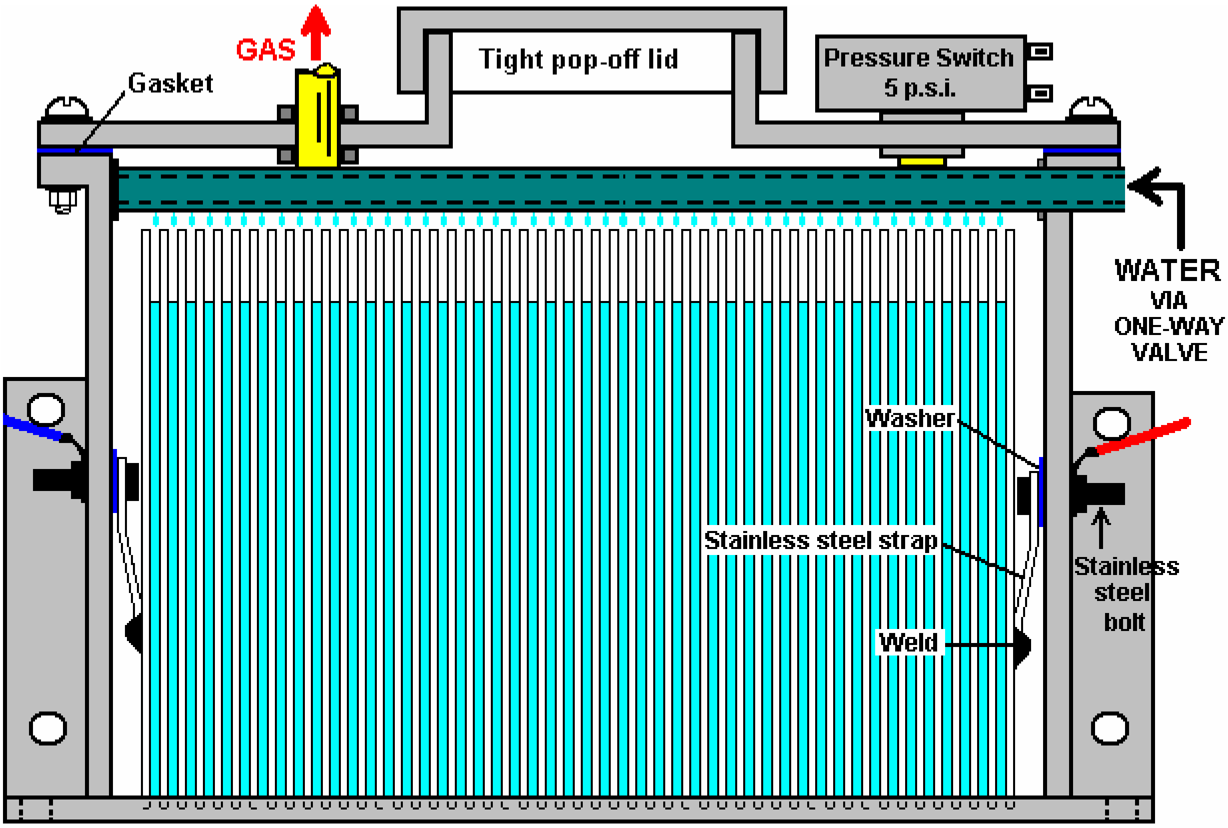
Tr1 to Tr3 2N2222 or 2N2222A or similar
40V, 800 mA, 500 mW, gain 100 - 300

In broad outline, then, the operation of the sensor and the water pump is as shown here:

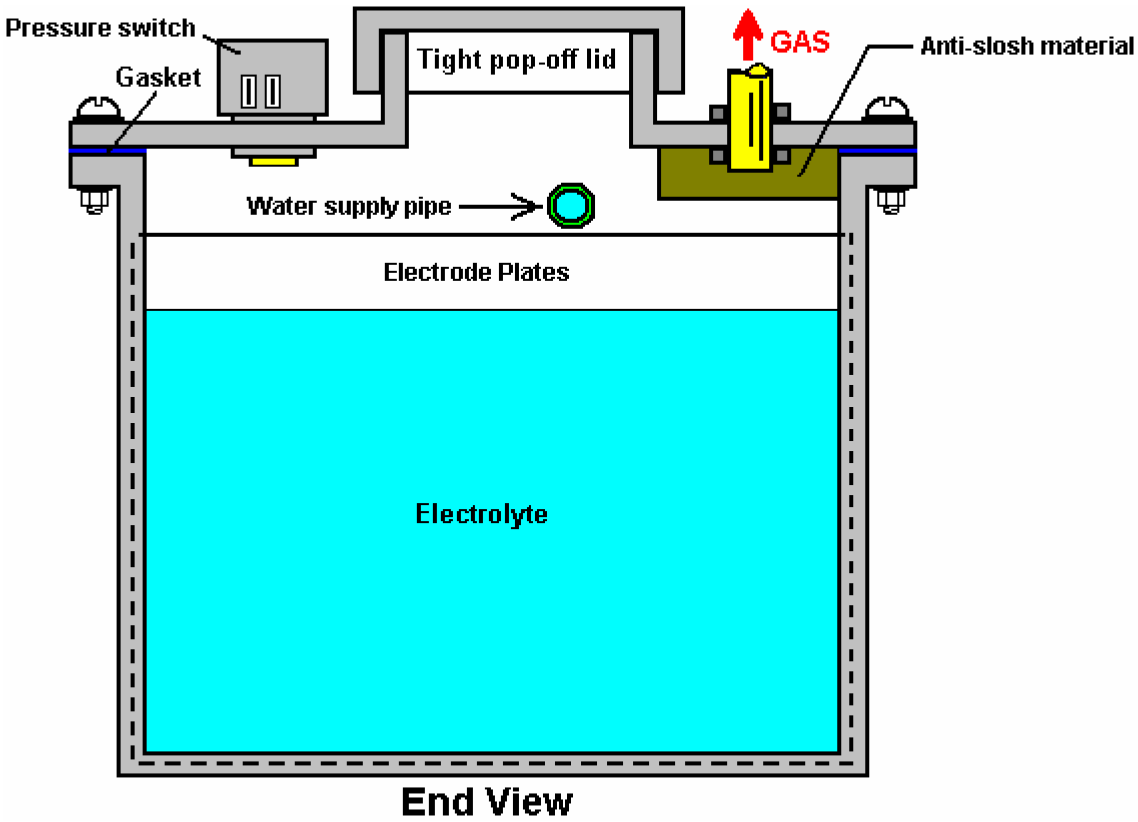


When the electrolyte level drops inside the electrolyser, the water-level sensor switches the water pump on and water is fed from the water tank into every cell inside the electrolyser simultaneously. When the level of the electrolyte returns to its normal level, the water-level sensor switches the water pump off again.

The method of introducing water to the cell calls for accurate construction. The technique involves using a pipe running above the plates in the cell. The pipe, which is fed by the water pump, is blanked off at one end. One tiny hole is drilled in the pipe, exactly above the centre of each cell. When the pump is operated, water flows through these identical holes, into each individual cell separately. The construction can be as shown here:



Side View



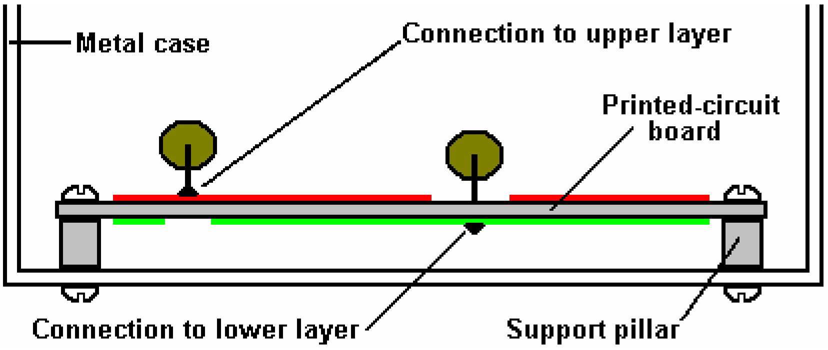
End View

As shown above, when the water pump is operating, the water is dispensed into the gaps between the electrode plates. The housing has to be sealed carefully against gas escaping, so all pipes and wires coming from it, need to go through sealed apertures. The water has to be injected with no possibility of gas escaping through the water pipe when water is not being pumped into the electrolyser. A pressure gauge which operates at five pounds per square inch is used to disconnect the electrical power to the unit to ensure that excessive pressure never builds up inside the unit.

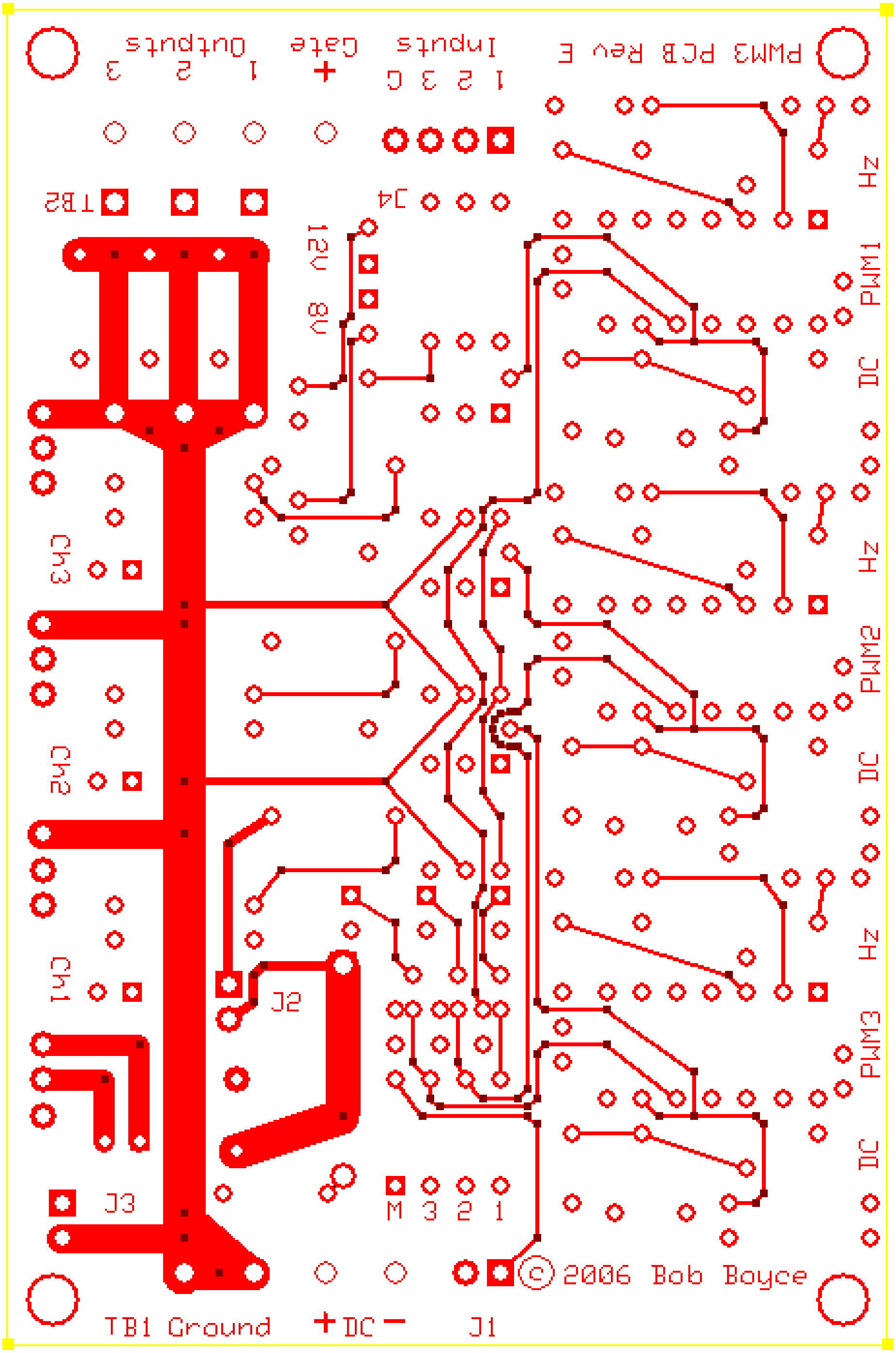
With an electrolyser of this kind, with narrow gaps between sizeable plates, shifting bubbles off the plates is important. An important technique is to alter the frequency of the inverter so that it makes the cell resonate. This can be done fairly easily with many inverters as all it entails is replacing one capacitor with one of a lower value and replacing one resistor with a variable resistor. Bob Boyce found that the rate of electrolysis increased considerably when the cell was resonated, and the frequency for his cell was in the 600 Hz to 900 Hz range. If you find this hard to understand, then may I suggest that you read through the step-by-step electronics tutorials which accompany this document. They are designed to be easy for a total beginner to understand and can take you to the level where you can read circuit diagrams, design circuits and build prototypes.

Custom Electronics

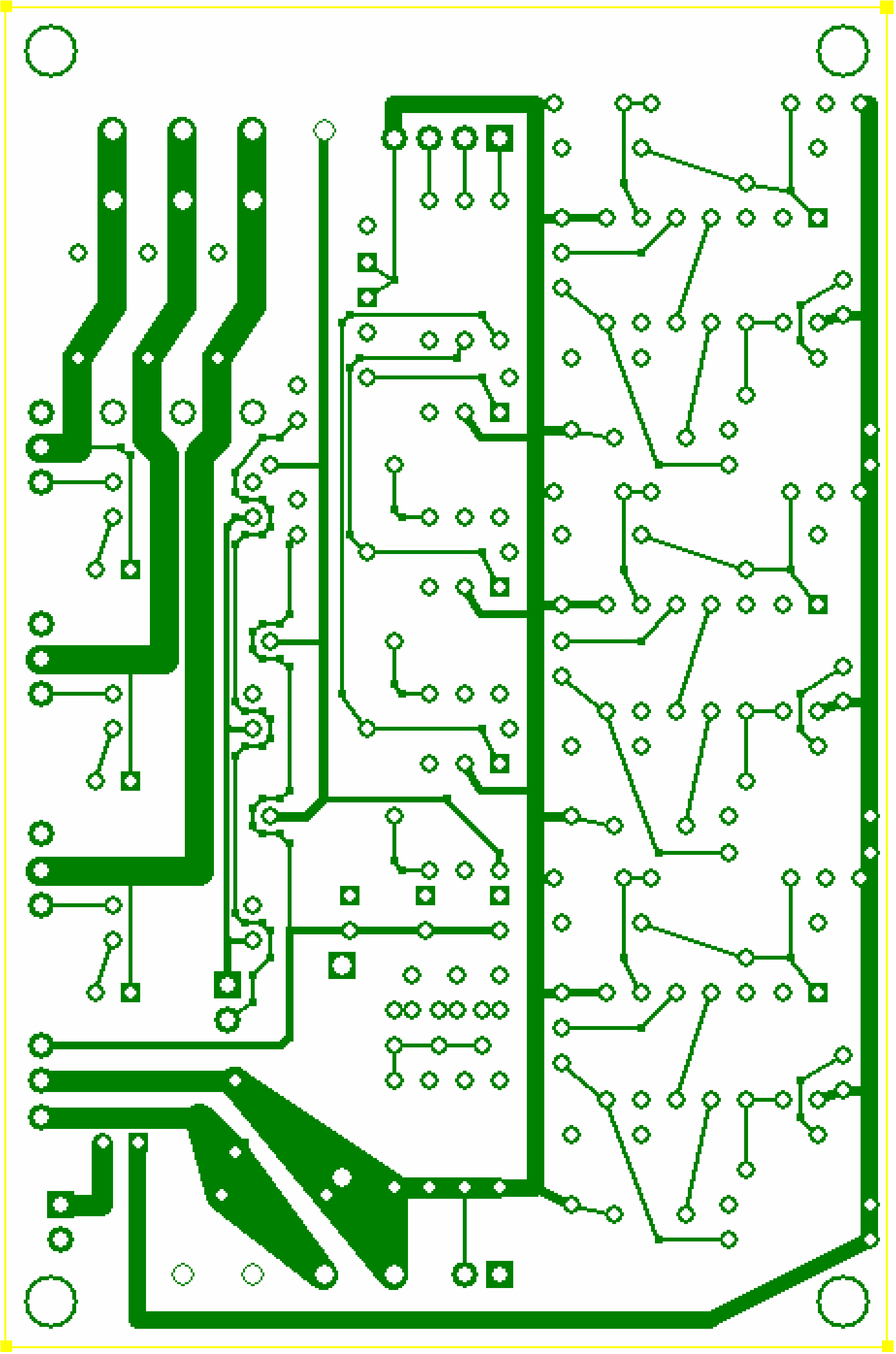
Bob Boyce has produced an electronics design which effectively reproduces Stan Meyer’s water-fracturing system, but at low voltage and with simple circuitry. His design is described here with his kind permission. This unit is built on a double-sided printed circuit board, where the connections to some components are made on the top of the board while other components are soldered to the tracks on the underside of the board:



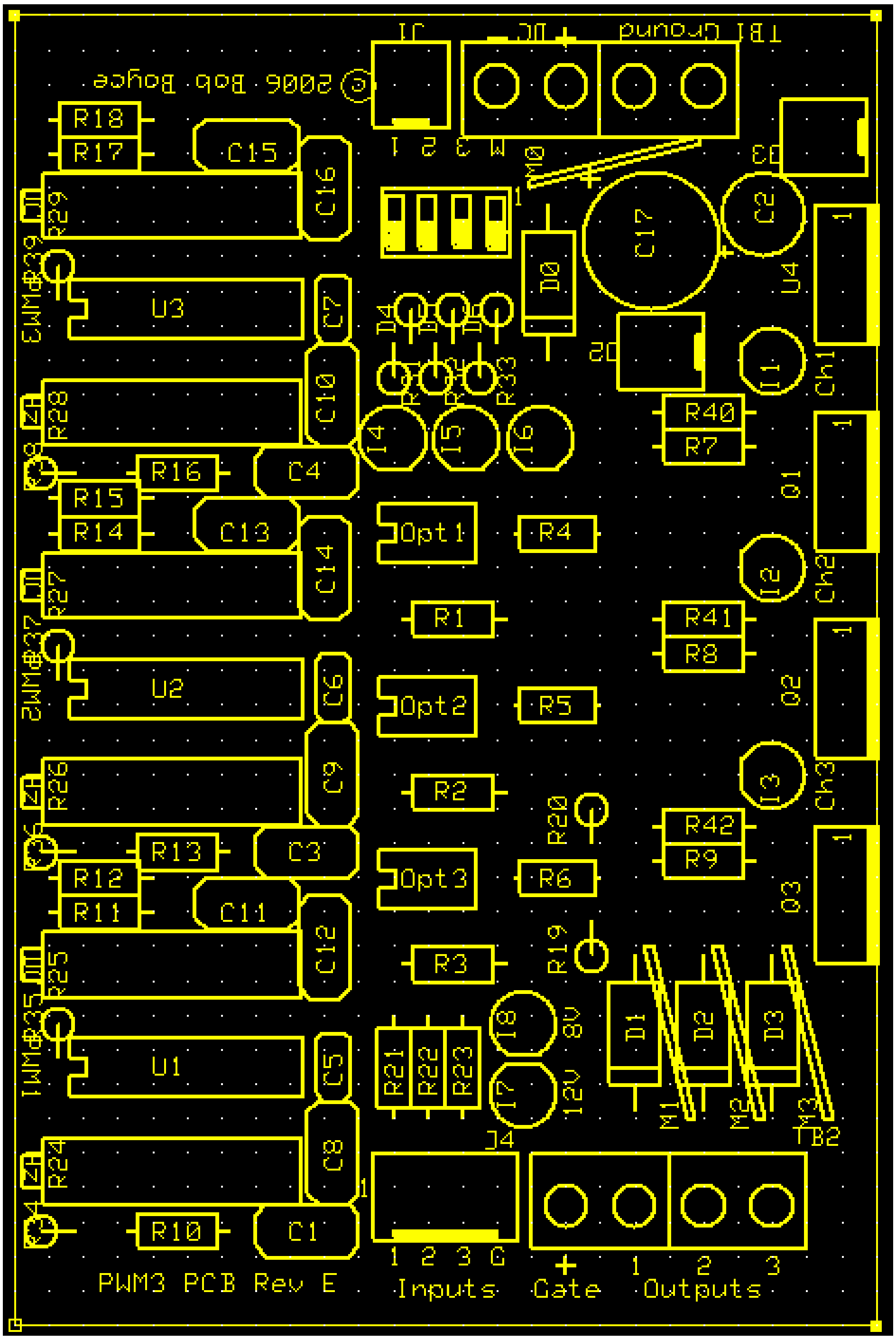
The etching pattern for the top of the board is:



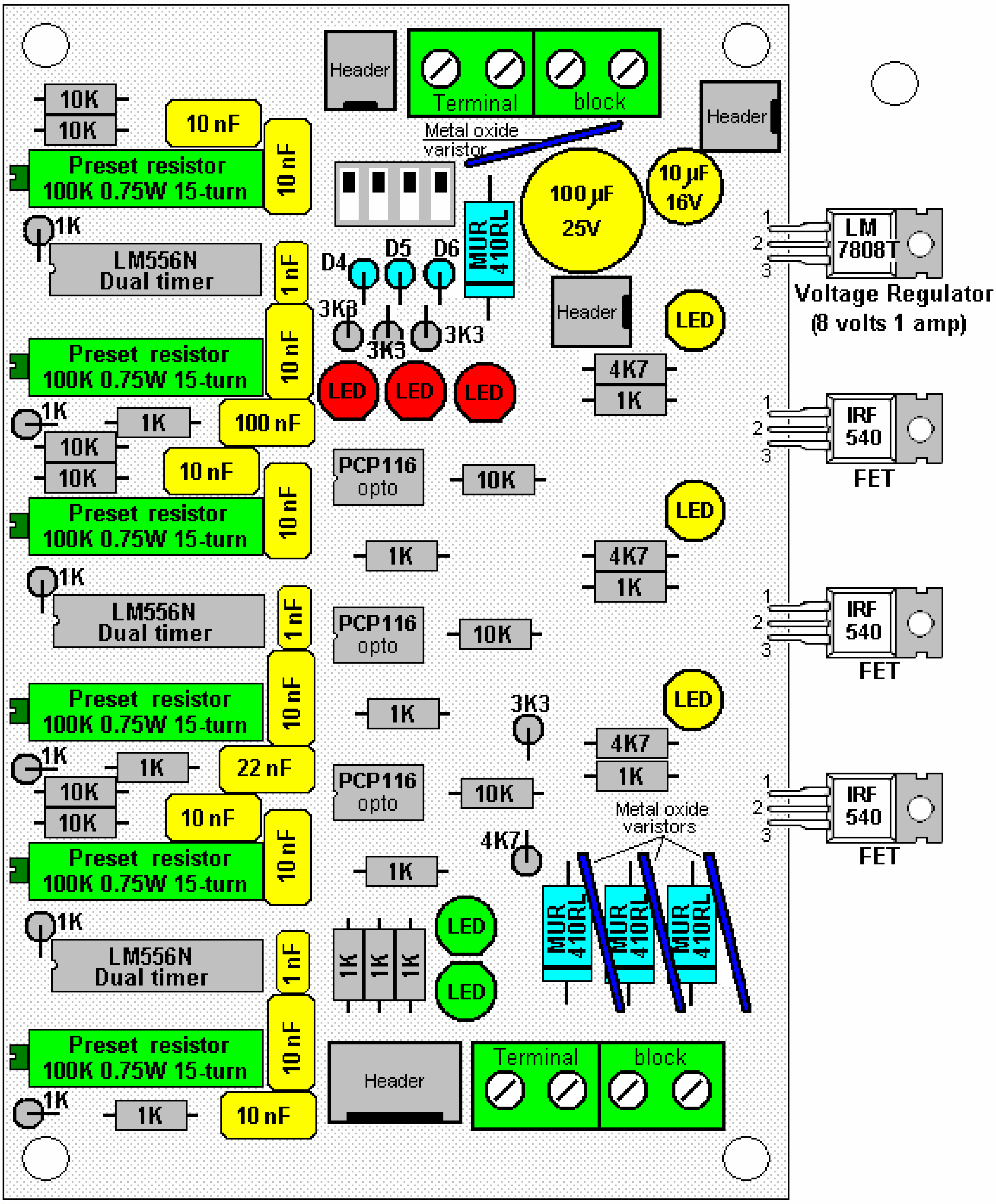
And the underside pattern is:



And the component layout is:



And an alternative view of the component layout is:



The Component list for this circuit board is:

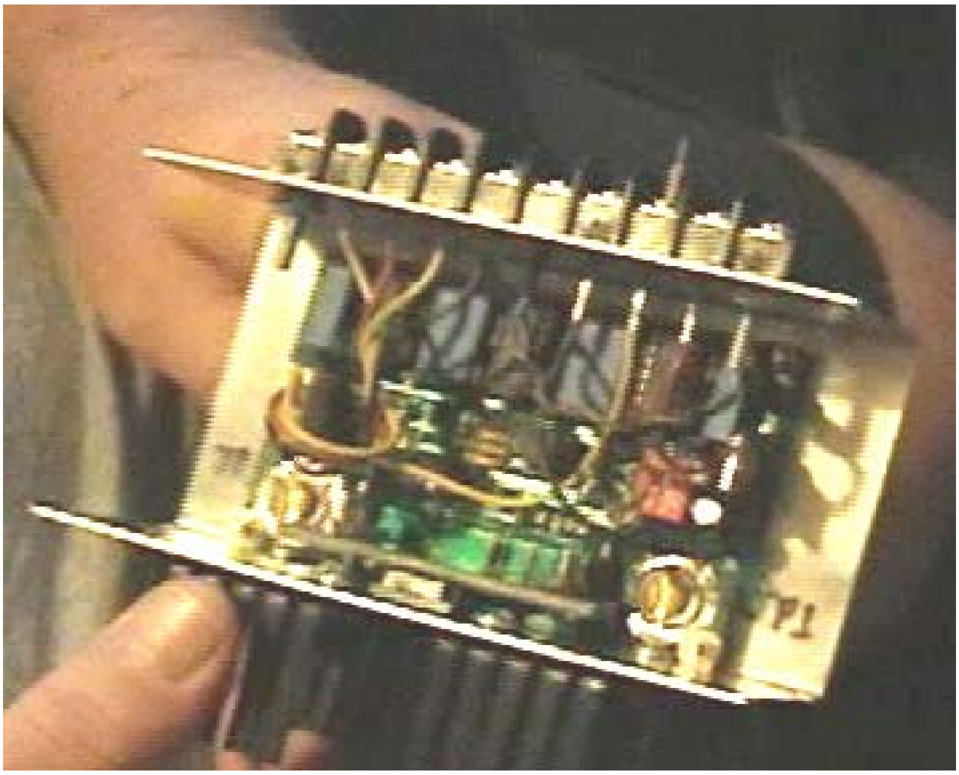
Item	Digi-Key Part Number	Description
C1	P3913-ND	Capacitor, High Stability, .01uF, 50V, 2%
C2	565-1303-ND	Capacitor, Electrolytic, 10uF, 16V, Radial
C3	P3917-ND	Capacitor, High Stability, .022uF, 50V, 2%
C4	P3925-ND	Capacitor, High Stability, .1uF, 50V, 2%
C5	BC1072CT-ND	Capacitor, Ceramic Disc, .001uF, 50V
C6	BC1072CT-ND	Capacitor, Ceramic Disc, .001uF, 50V
C7	BC1072CT-ND	Capacitor, Ceramic Disc, .001uF, 50V
C8	BC1078CT-ND	Capacitor, Ceramic Disc, .01uF, 50V
C9	BC1078CT-ND	Capacitor, Ceramic Disc, .01uF, 50V
C10	BC1078CT-ND	Capacitor, Ceramic Disc, .01uF, 50V
C11	BC1078CT-ND	Capacitor, Ceramic Disc, .01uF, 50V
C12	BC1078CT-ND	Capacitor, Ceramic Disc, .01uF, 50V
C13	BC1078CT-ND	Capacitor, Ceramic Disc, .01uF, 50V
C14	BC1078CT-ND	Capacitor, Ceramic Disc, .01uF, 50V
C15	BC1078CT-ND	Capacitor, Ceramic Disc, .01uF, 50V
C16	BC1078CT-ND	Capacitor, Ceramic Disc, .01uF, 50V
C17	565-1673-ND	Capacitor, Electrolytic, 100uF, 25V, Radial
D0	MUR410RLOSCT-ND	MUR410RL, Diode, Ultra Fast, 4A, 100V, Axial
D1	MUR410RLOSCT-ND	MUR410RL, Diode, Ultra Fast, 4A, 100V, Axial
D2	MUR410RLOSCT-ND	MUR410RL, Diode, Ultra Fast, 4A, 100V, Axial
D3	MUR410RLOSCT-ND	MUR410RL, Diode, Ultra Fast, 4A, 100V, Axial
D4	1N914-TPCT-ND	1N914 Switching Diode
D5	1N914-TPCT-ND	1N914 Switching Diode
D6	1N914-TPCT-ND	1N914 Switching Diode
I1	67-1058-ND	LED, T1, Amber
I2	67-1058-ND	LED, T1, Amber
I3	67-1058-ND	LED, T1, Amber
I4	67-1064-ND	LED, T1, Red
I5	67-1064-ND	LED, T1, Red
I6	67-1064-ND	LED, T1, Red
I7	67-1070-ND	LED, T1, Green
I8	67-1070-ND	LED, T1, Green
J1	WM8084-ND	Header, .100", 2 Position
J2	WM8084-ND	Header, .100", 2 Position
J3	WM8084-ND	Header, .100", 2 Position
J4	WM8086-ND	Header, .100", 4 Position
M1	495-1450-ND	Metal Oxide Varister - S14K14
M2	495-1450-ND	Metal Oxide Varister - S14K14
M3	495-1450-ND	Metal Oxide Varister - S14K14
M4	495-1450-ND	Metal Oxide Varister - S14K14
Opt1	67-1566-5-ND	Optocoupler, Lumex OCP-PCP116, 6 Pin DIP
Opt2	67-1566-5-ND	Optocoupler, Lumex OCP-PCP116, 6 Pin DIP
Opt3	67-1566-5-ND	Optocoupler, Lumex OCP-PCP116, 6 Pin DIP
Q1	IRF540ZPBF-ND	IRF540 Diode Protected HEXFET, TO-220
Q2	IRF540ZPBF-ND	IRF540 Diode Protected HEXFET, TO-220
Q3	IRF540ZPBF-ND	IRF540 Diode Protected HEXFET, TO-220
R1	1.0KQBK-ND	Resistor, 1k ohm, 1/4W, 5%
R2	1.0KQBK-ND	Resistor, 1k ohm, 1/4W, 5%
R3	1.0KQBK-ND	Resistor, 1k ohm, 1/4W, 5%
R4	10KQBK-ND	Resistor, 10k ohm, 1/4W, 5%
R5	10KQBK-ND	Resistor, 10k ohm, 1/4W, 5%
R6	10KQBK-ND	Resistor, 10k ohm, 1/4W, 5%
R7	1.0KQBK-ND	Resistor, 1k ohm, 1/4W, 5%
R8	1.0KQBK-ND	Resistor, 1k ohm, 1/4W, 5%
R9	1.0KQBK-ND	Resistor, 1k ohm, 1/4W, 5%
R10	1.0KQBK-ND	Resistor, 1k ohm, 1/4W, 5%

R11	10KQBK-ND	Resistor, 10k ohm, 1/4W, 5%
R12	10KQBK-ND	Resistor, 10k ohm, 1/4W, 5%
R13	1.0KQBK-ND	Resistor, 1k ohm, 1/4W, 5%
R14	10KQBK-ND	Resistor, 10k ohm, 1/4W, 5%
R15	10KQBK-ND	Resistor, 10k ohm, 1/4W, 5%
R16	1.0KQBK-ND	Resistor, 1k ohm, 1/4W, 5%
R17	10KQBK-ND	Resistor, 10k ohm, 1/4W, 5%
R18	10KQBK-ND	Resistor, 10k ohm, 1/4W, 5%
R19	4.7KQBK-ND	Resistor, 4.7k ohm, 1/4W, 5%
R20	3.3KQBK-ND	Resistor, 3.3k ohm, 1/4W, 5%
R21	1.0KQBK-ND	Resistor, 1k ohm, 1/4W, 5%
R22	1.0KQBK-ND	Resistor, 1k ohm, 1/4W, 5%
R23	1.0KQBK-ND	Resistor, 1k ohm, 1/4W, 5%
R24	3006P-104-ND	Resistor, Potentiometer, 15-turn CERMET, 100k ohm, 3/4W
R25	3006P-104-ND	Resistor, Potentiometer, 15-turn CERMET, 100k ohm, 3/4W
R26	3006P-104-ND	Resistor, Potentiometer, 15-turn CERMET, 100k ohm, 3/4W
R27	3006P-104-ND	Resistor, Potentiometer, 15-turn CERMET, 100k ohm, 3/4W
R28	3006P-104-ND	Resistor, Potentiometer, 15-turn CERMET, 100k ohm, 3/4W
R29	3006P-104-ND	Resistor, Potentiometer, 15-turn CERMET, 100k ohm, 3/4W
R30	-	None
R31	3.3KQBK-ND	Resistor, 3.3k ohm, 1/4W, 5%
R32	3.3KQBK-ND	Resistor, 3.3k ohm, 1/4W, 5%
R33	3.3KQBK-ND	Resistor, 3.3k ohm, 1/4W, 5%
R34	1.0KQBK-ND	Resistor, 1k ohm, 1/4W, 5%
R35	1.0KQBK-ND	Resistor, 1k ohm, 1/4W, 5%
R36	1.0KQBK-ND	Resistor, 1k ohm, 1/4W, 5%
R37	1.0KQBK-ND	Resistor, 1k ohm, 1/4W, 5%
R38	1.0KQBK-ND	Resistor, 1k ohm, 1/4W, 5%
R39	1.0KQBK-ND	Resistor, 1k ohm, 1/4W, 5%
R40	4.7KQBK-ND	Resistor, 4.7k ohm, 1/4W, 5%
R41	4.7KQBK-ND	Resistor, 4.7k ohm, 1/4W, 5%
R42	4.7KQBK-ND	Resistor, 4.7k ohm, 1/4W, 5%
SW1	CT2094LPST-ND	4PST Switch, 8 Pin DIP
TB1	ED1609-ND 2 Required	Terminal Block, .200", 2 position X 2
TB2	ED1609-ND 2 Required	Terminal Block, .200", 2 position X 2
U1	296-6504-5-ND	LM556N or similar Dual Timer IC, 14 Pin DIP
U2	296-6504-5-ND	LM556N or similar Dual Timer IC, 14 Pin DIP
U3	296-6504-5-ND	LM556N or similar Dual Timer IC, 14 Pin DIP
U4	497-1446-5-ND	7808T or LM7808, Voltage Reg. IC, 3 Terminal, 8V, 1 A, TO-220
Misc	AE8906-ND 3 Required	IC Socket, 6 Pin DIP, Soldertail
Misc	AE8914-ND 3 Required	IC Socket, 14 Pin DIP, Soldertail
Misc	4724K-ND 3 Required	TO-220 Mounting kit X 3 for Q1, Q2, & Q3. Not needed for U4.
Misc	A31697-ND Pack of 10	2 position .100" shunt block for shorting J1, J2, and J3

Functions:

J1	External PWM Master Disable, Short to Disable on-board PWMs 1-3
J2	Single Supply Enable, Short to Tie MOSFET Gate Supply TB3 to +DC
J3	Common Ground Enable, Short to Tie MOSFET Source to -DC
J4	Auxiliary TTL Inputs 1, 2, 3, & Gnd
SW1	1-3 = PWM Channel Disable 4 = PWM Master Disable
TB1	DC Power Input & MOSFET Source Ground
TB2	MOSFET Drain/PWM Outputs & MOSFET Gate Supply Input

The assembled unit looks like this:

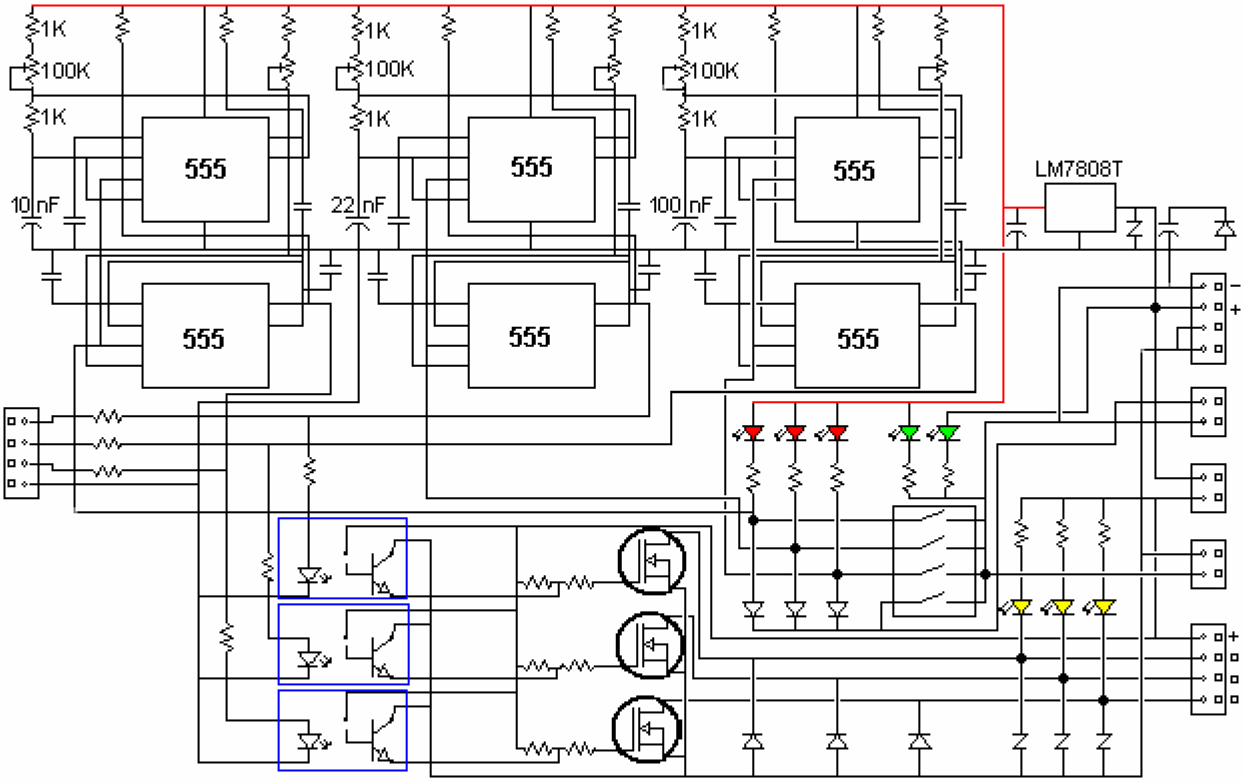


Component quantities are:

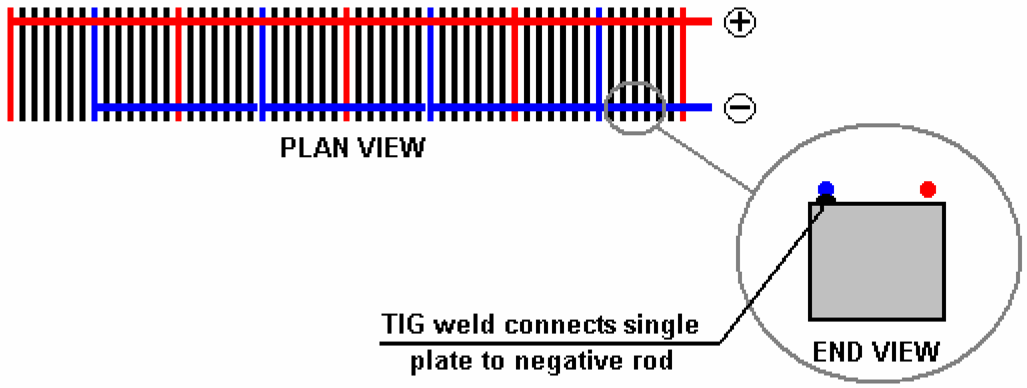
Quantity	Item
3	Capacitor, Ceramic Disc, .001uF, 50V
1	Capacitor, High Stability, .01uF, 50V, 2%
9	Capacitor, Ceramic Disc, .01uF, 50V
1	Capacitor, High Stability, .022uF, 50V, 2%
1	Capacitor, High Stability, .1uF, 50V, 2%
1	Capacitor, Electrolytic, 10uF, 16V, Radial
1	Capacitor, Electrolytic, 100uF, 25V, Radial
4	MUR410RL, Diode, Ultra Fast, 4A, 100V, Axial
3	1N914 Switching Diode
3	LED, T1, Amber
3	LED, T1, Red
2	LED, T1, Green
3	Header, .100", 2 Position
1	Header, .100", 4 Position
4	Metal Oxide Varister - S14K14
3	Optocoupler, Single Channel Photo IC, Lumex OCP-PCP116, 6 Pin DIP
3	IRF540 Diode Protected HEXFET, TO-220
18	Resistor, 1k ohm, 1/4W, 5%
9	Resistor, 10k ohm, 1/4W, 5%
4	Resistor, 3.3k ohm, 1/4W, 5%
4	Resistor, 4.7k ohm, 1/4W, 5%
6	Resistor, Potentiometer, 15-turn CERMET, 100k ohm, 3/4W
1	4PST Switch, 8 Pin DIP
2	Terminal Block, .200", 2 position X 2
3	LM556N or similar Dual Timer IC, 14 Pin DIP
1	7808T or LM7808, Voltage Regulator IC, 3 Terminal, 8V, 1 A, TO-220
3	IC Socket, 6 Pin DIP, Soldertail
3	IC Socket, 14 Pin DIP, Soldertail
3	TO-220 Mounting kit
Pack of 10	2 position .100" shunt blocks

This circuit operates by adding the outputs from three separate oscillators together to form a complex waveform. Each oscillator can also have its Mark/Space (ON/OFF) Ratio adjusted without altering the frequency of the oscillator.

The timing circuit is powered via an 8 volt voltage stabiliser chip which smoothes out any variations in the battery's supply voltage. Each generated signal is boosted in power by an FET transistor whose load goes directly to the battery/alternator power line. The output from each oscillator can be switched in or out of the final waveform:



There are two options for using this water-splitting module. The first way is to use a step-up transformer to raise the output voltage to about 150 volts and apply it to a sixty or seventy cell electrolyser as shown earlier in this document. The second way is to use a 1:1 ratio transformer to keep the voltage at 13.8 volts and alter the plate arrangement inside the electrolyser as shown here:



The plates are connected in sets of seven cells, giving nearly 2 volts per cell as the supply voltage is about 13.8 volts. The same number of cells are used but each set of seven series cells is connected in parallel to the next. Greater voltage flexibility can be had if a step-up transformer is used. The transformer used should be a torroidal type so that it operates efficiently when handling the higher frequencies generated by the oscillators. Please remember that the same safety requirements for pressure switch, bubblers, etc. still apply.

The difficulty with a water-fracturing system like this is that the unit needs to be adjusted to the resonant frequency of the electrolyser. Unfortunately, the resonant frequency changes as the electrolyte levels falls during use. The ideal situation is where the electronics unit is designed to detect the change in resonance frequency and adjusts itself accordingly. That type of unit is currently being designed and tested.

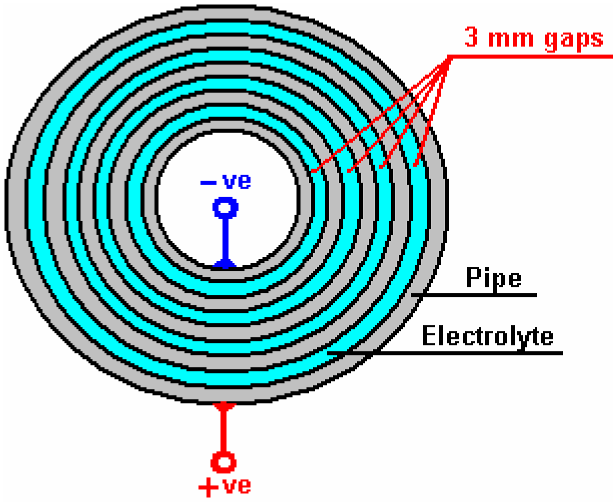
The circuit board was designed using the design software which can be downloaded free from http://www.expresspcb.com (who will make the board for you if you wish) and the data files which allow that program to specify the board and components can be found in the 'Files' section of the Yahoo 'hydroxy' Group. The electrolyser runs with a Potassium Hydroxide electrolyte and it should be remembered that the Potassium Hydroxide is only a catalyst and does not get consumed in the process, consequently, the electrolyser gets topped up with plain water. Adjust the concentration of the electrolyte to give about half an amp current at 8 volts. Bob's system is so very like that used by Stan Meyer that it might be expected that the unit should run on pure water. However, that is not so. If pure water were used then the system would need high voltage to achieve this rapid breakdown effect. With an electrolyte solution, the water-splitting takes place at much lower voltage. It should be remembered that Stan Meyer used 5 volts at 2 amps for his demonstration to Admiral Griffin at the British Admiralty, and the result was described as "large volumes of gas". Please remember that Potassium Hydroxide attacks 'Lexan' plastic but is ok with PVC and acrylic. Sodium Hydroxide (lye) can be used with Lexan.

Using Pipes as Electrolyser Electrodes

It is possible to use pipes as electrodes in an electrolyser but unless a very simple booster system is required, or a Joe Cell non-electrolysis fuel-less system is proposed, then there are some practical problems with this style of construction:

1. The spacing between the electrodes is difficult to control unless you make the pipes yourself.
2. The inner surfaces are difficult to condition.
3. The surface area changes rapidly with the change in diameter.

1. If you opt for commercially available pipes, the you are limited to the diameters and wall thicknesses available over the counter. Ideally, you want an arrangement like this:



Here, five pipes are used to create a four cell series-cell electrolyser. It would be quite an achievement to find a whole series of stainless steel pipes which have a 1/8 inch (3 mm) gap between the outer surface of each pipe and the inner surface of the next pipe. Ideally, seven pipes would be needed as a six-cell electrolyser is about minimum for efficient use with a car alternator producing 13.8 volts or so. If these pipes are available, then it is likely that they are only obtainable in long lengths, rather than the few inches of each pipe which will be needed for construction. This is not necessarily a problem in that the extra lengths will be available for other units or replacement electrodes should they become needed at a later date.

2. Gas production from any cell with stainless steel electrodes is improved significantly if the steel surface is conditioned. This is done by sanding the surface in a cross-hatch pattern and then soaking the electrode in the Hydroxide electrolyte for two or three days. The electrodes are then rinsed off with distilled water and new a electrolyte solution used. The sanding of the inner surface of each pipe becomes progressively more difficult as the pipe diameter reduces.

3. The surface area of the electrodes changes rapidly with the diameter of the pipe. The surface area of each pipe is directly proportional to its diameter. Double the diameter and the suffice area doubles. If the pipes are all the same length which is usually the case, then the innermost pipe has a very different surface area to the outermost pipe. Ideally, there should be between two square inches and four square inches of electrode surface (on each of the two faces of the electrode) for every amp of current flowing through the cell. With pipe electrodes, the current per square inch of surface varies considerably from pipe to pipe due to their different diameters. This is not an ideal arrangement.

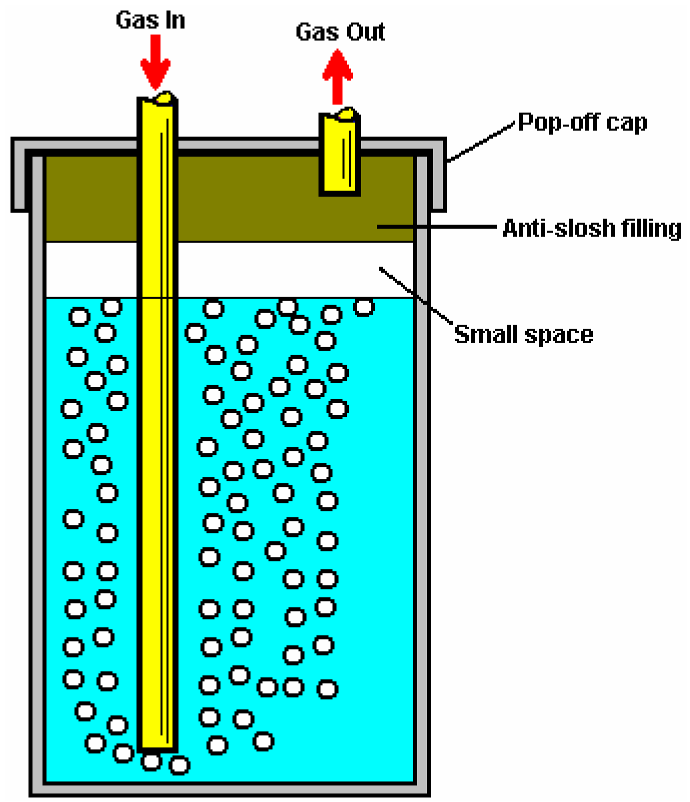
One other consideration which may be important is that the diameter of the electrode array increases by two 3 mm gaps plus 2 pipe wall thicknesses for every additional cell in the electrolyser. Effectively, both the width and the length of the unit increases in this way. With a rectangular series-cell as described earlier, the length increases by just half that amount for each additional cell, and the width does not alter. Also the current per square inch of electrode area stays fixed in a rectangular cell.

Practical Issues

No matter which variety of electrolyser cell is used, it is essential to put a bubbler between it and the engine intake. This is to prevent any accidental ignition of the gas reaching the electrolysis cell. Also, no electrolyser should be operated or tested indoors. This is because the gas is lighter than air so any leak of gas will cause the gas to collect on the ceiling where it can cause a major explosion when triggered by the slightest spark (such as is generated when a light switch is turned off). Hydrogen gas escapes very easily indeed as its atoms are very, very small and can get through any tiny crack. Testing electrolysers should be done outdoors.

I know it takes a great deal of restraint, but much better results will be produced from any electrolyser if the plates are conditioned before use. This requires the plates to be sanded in an 'X' pattern, using coarse sandpaper. This roughens the surface, creates minute peaks which help bubble formation, and increase the working surface area of each plate. The plates then need to be immersed in a solution of Potassium Hydroxide (KOH) and left there for about three days. This creates a white protective coating on the plate surfaces. The electrolyser then needs to be emptied and the plates rinsed off using distilled water and the electrolyser filled again with a new solution of electrolyte.

Using a bubbler is an absolutely vital safety measure. A typical bubbler looks like this:



Bubbler construction is very simple indeed. It can be any size or shape provided that the outlet of the entry tube has at least five inches (125 mm) of water above it. Plastic is a common choice for the material and fittings are easy to find. It is very important that good sealed joints are made where all pipes and wires enter any container which has hydroxy gas in it. This, of course, includes the bubbler.

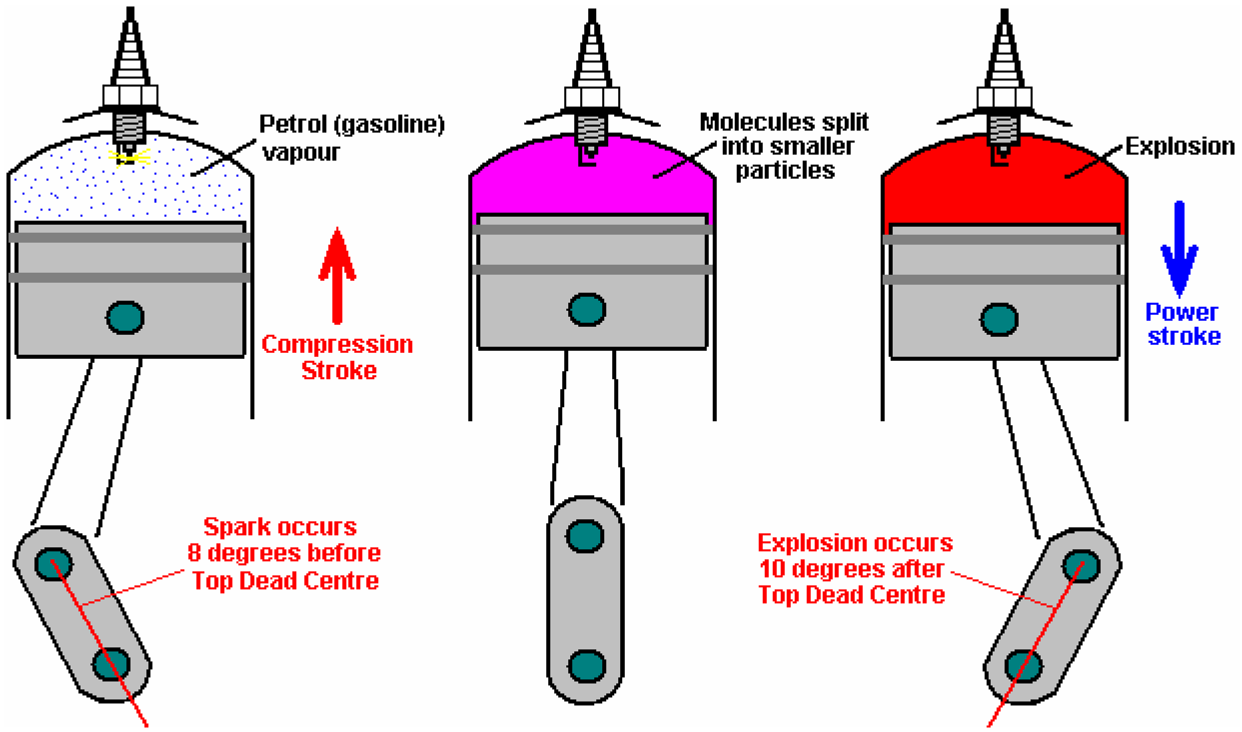
The anti-slosh filling in the cap is to prevent the water in the bubbler from splashing up into the exit pipe and being drawn into the engine. Various materials have been used for the filling including stainless steel wool and plastic pot scourers. The material needs to prevent, or at least minimise, any water passing through it, while at the same time allowing the gas to flow freely through it.

Let me stress again, that this document does NOT recommend that you actually build any of the items of equipment discussed here. The 'hydroxy' gas produced by electrolysis of water is extremely dangerous, explodes instantly and cannot be stored safely, so this document is strictly for information purposes only.

However, to understand the process more fully, the following details would need to be considered carefully if somebody decided to actually build one of these high-voltage series-cell devices.

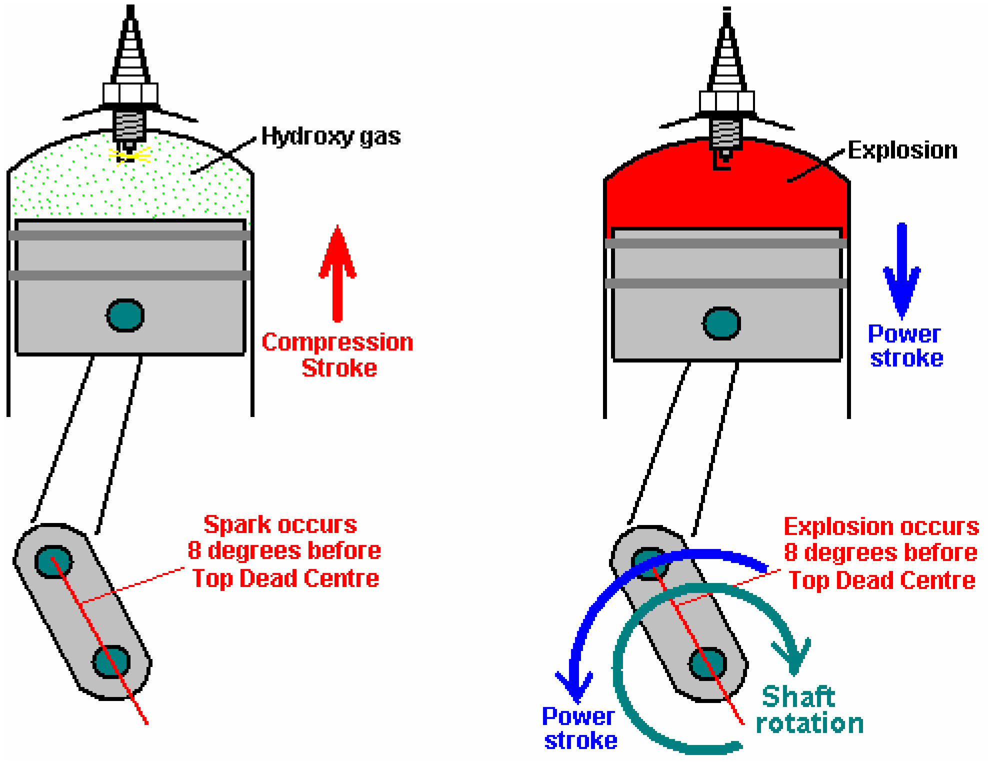
There is a considerable difference between a mixture of hydrogen and oxygen gasses ('hydroxy') and petroleum (gasoline) vapour. While they both can serve as fuel for an internal combustion engine, they have considerable differences. One major difference is that hydroxy gas burns ten times faster than petrol vapour. That would not be a problem if the engine was originally designed to burn hydroxy gas. However, most existing engines are arranged to operate on fossil fuels.

These hydrocarbon fuels have large molecules which do not burn fast enough to be efficient inside the cylinder of an engine. What happens is that for the first fraction of a second after the spark plug fires, the molecules inside the cylinder split up into much smaller particles, and then these smaller particles burn so fast that it can be described as an explosion:



Because of the delay needed for the conversion of the hydrocarbon molecules to smaller particles, the spark is arranged to occur before the Top Dead Centre point. While the molecules are splitting up, the piston passes its highest point and the crankshaft is some degrees **past** Top Dead Centre before the driving pressure is placed on the head of the piston. This driving force then reinforces the clockwise rotation of the crankshaft shown in the diagram above and the motor runs smoothly.

That will **not** happen if hydroxy gas is substituted for the petrol vapour. Hydroxy gas has very small molecule sizes which do not need any kind of breaking down and which burn instantly with explosive force. The result is as shown here:



Here, the explosion is almost instantaneous and the explosion attempts to force the piston **downwards**. Unfortunately, the crankshaft is trying to drive the piston **upwards** past the Top Dead Centre ('TDC') point, so the explosion will not help the engine run. Instead, the explosion will stop the crankshaft rotating, overload the crankshaft and connecting rod and produce excessive pressure on the wall of the cylinder.

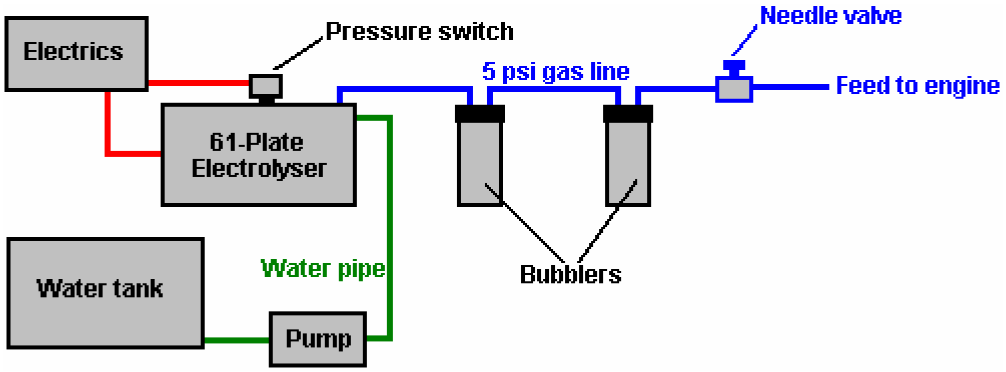
We do **not** want that to happen. The solution is to delay the spark until the piston has reached the position in its rotation where we want the explosion to take place - that is, in exactly the same place as it did when using petrol as a fuel.

In the example above, the spark would be retarded (delayed) from 8 degrees before TDC to 10 degrees after TDC, or 18 degrees overall. The spark is '**retarded'** because it needs to occur **later** in the rotation of the crankshaft. The amount of retardation may vary from engine to engine, but with hydroxy gas, the spark must never occur before TDC and it is preferable that the crankshaft has rotated some degrees past TDC so that most of the push from the piston goes to turn the crankshaft and as little as possible in compressing the crankshaft.

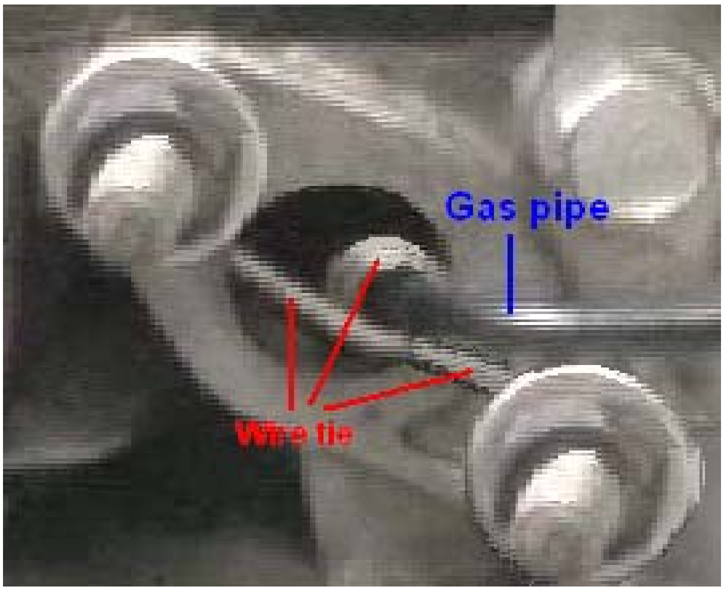
Rob McAllister has been running internal combustion engines on hydrogen and many mixtures of hydrogen and other fuels for forty years now. He advises anybody interested in implementing a system like this, to start with a single-cylinder engine of five horsepower or less. That way, the techniques are easily learnt and experience is gained in tuning a simple engine running on the new fuel. So, let us assume that we are going to convert a small generator engine. How do we go about it?

First, we obtain or supply of the new fuel. In this case, let us assume that we will produce hydroxy gas using a multi-cell high-voltage series electrolyser as described earlier. This unit has an electrical cut-off operated by a pressure switch which operates at say, five pounds per square inch. Assuming that the electrolyser is capable of producing a sufficient volume of gas, this is roughly equivalent to a hydrogen bottle with its pressure regulators.

In broad outline, the gas supply would look like this:



The physical connection to the engine is via a 6 mm (1/4 inch) stainless steel pipe, fitted with a standard knob-operated needle valve. The carburettor is removed altogether to allow maximum airflow into the engine, (or failing this, the throttle valve of the carburettor is opened wide and secured in that position). The stainless steel gas pipe has its diameter reduced further by the use of a nozzle with an internal diameter of 1 mm or so (1/16 inch or less), about the size of a hypodermic needle used by a vet. Hydroxy gas has very small molecules and will flow very freely through tiny openings. The nozzle tip is pushed close to the intake valve and the gas feed pipe is secured in place to ensure no movement:



When the engine is about to be started, the needle valve can be hand-adjusted to give a suitable level of gas flow to maintain tick-over, but before that can happen, the timing of the spark needs to be adjusted

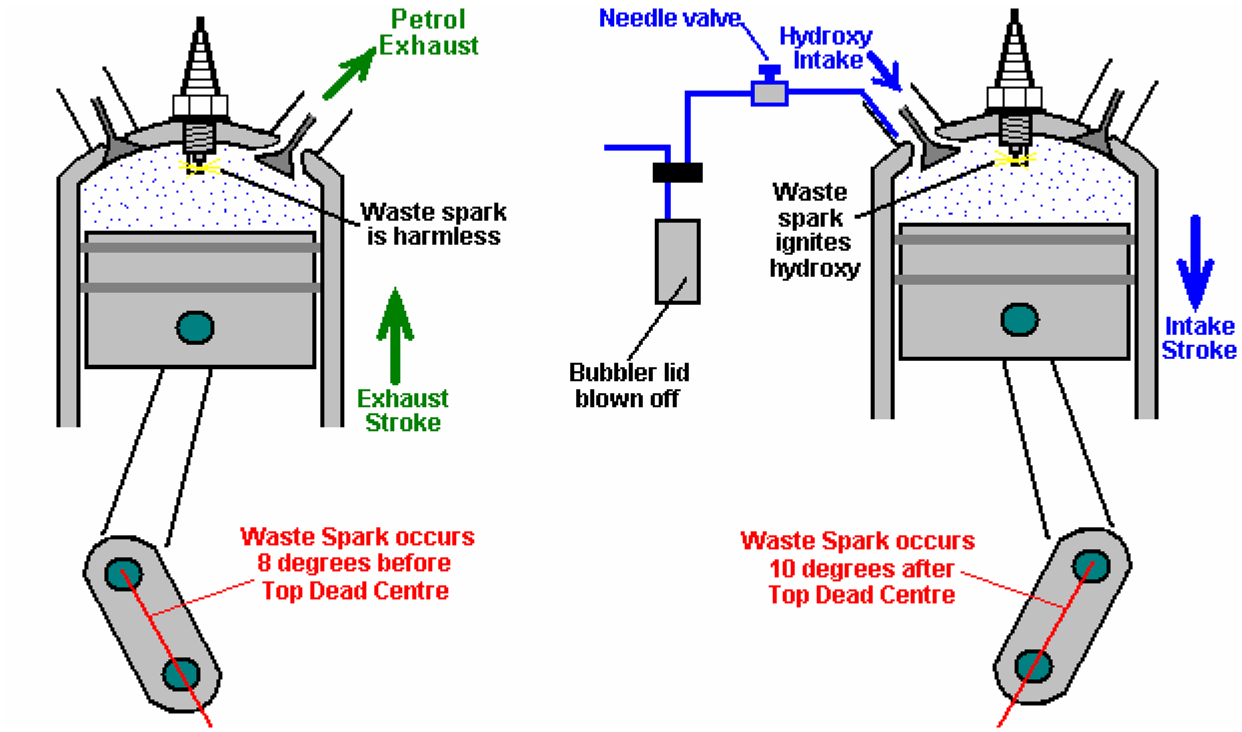
There are two main ways to adjust the timing. The first is mechanical, where an adjustment is made to the mechanism which triggers the spark. Some small engines may well not have a convenient way to adjust the timing by as much as is needed for this application. The second way is to delay the spark by an adjustable electronic circuit (for instance, an NE555 monostable driving a FET). This can either be built or bought ready made. One supplier which offers a dashboard-mounted manually controlled ready-built ignition delay unit is http://www.msdignition.com/1timingcontrols.htm and there are others.

Waste spark.

There is one other very important consideration with small engines and that is the way in which the spark is generated. With a four-stroke engine, the crankshaft rotates twice for every power stroke. The spark plug only needs to fire every second time the piston approaches its highest position in the cylinder. This is not particularly convenient for engine manufacturers, so some simplify matters by generating a spark on every revolution. The extra spark is not needed, contributes nothing to the operation of the engine and so is called the “waste spark”. The waste spark does not matter for an engine running on fossil fuel vapour, but it **does** matter very much if the fuel is switched to hydroxy gas.

As has been shown in the earlier diagrams, it is necessary to retard (delay) the spark by some eighteen degrees or so when using hydroxy gas, due to its very much faster ignition rate. Delaying the hydroxy fuel ignition point until after Top Dead Centre sorts out the situation in an entirely satisfactory manner for the Power Stroke of the engine. However, if the engine generates a spurious ‘waste spark’ that waste spark does cause a serious problem.

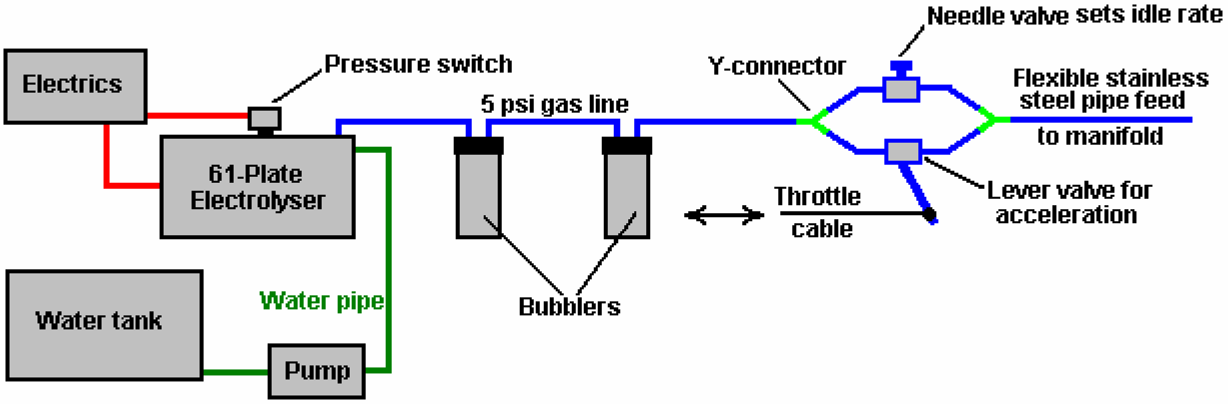
In the case of the fossil fuel, any waste spark will occur towards the end of the Exhaust Stroke and it will have no real effect (apart from wasting electrical power). In the case of the hydroxy fuel, the engine has completed the Exhaust Stroke, the outlet valve has closed, the intake valve has opened and the gas is being drawn through the open inlet valve into the cylinder in the Intake Stroke. At that instant, there is an open passage from the spark plug, through the cylinder, through the open intake valve, to the gas supply pipe and through it to the bubbler between the electrolyser and the engine. If a waste spark takes place, it **will** ignite the gas:



The gas ignition is highly likely if there is a waste spark in an engine using hydroxy fuel and (the necessary) retarded ignition. Trying to eliminate the unwanted spark by using a ‘divide-by-two’ electronic counter circuit is not likely to be successful unless there is some mechanically certain way of triggering the counter circuit at start-up. The best way of overcoming a waste spark, if the engine has one, is to use a 2:1 gearing arrangement on the output shaft of the motor and using the slower shaft to trigger the spark. Multi-cylinder engines do not have a waste spark.

Once some experience has been gained in operating a single cylinder engine on hydroxy gas, the move to a full-sized engine is not very difficult. Each cylinder of the large engine is pretty much the same as the small engine. Instead of running a small tube down the carburettor intake of each cylinder, it is more convenient and economic to use the existing intake manifold, leave the throttle wide open and run the hydroxy gas pipe into the manifold. A flexible stainless steel pipe section should be used to absorb the vibration of the engine relative to the electrolyser. Rob McAllister suggests using a knob-operated needle valve to set the idling speed to about 1,000 rpm and placing a throttle-operated lever valve in parallel with it for applying more power to the engine:

It is not immediately clear to me why this arrangement is recommended as the knob-operated needle valve use to set the idling rate appears to be redundant. There appears to be no particular reason why a screw adjustment could not be used on the lever valve linked to the accelerator pedal of the vehicle. If that were done, then the throttle screw could be used to set the idle rate and the screw locked in position. That way, the needle valve and two Y-connectors could be dispensed with. The only possible reason which suggests itself is that there is slightly less physical construction needed for the recommended way shown here:



One supplier of flexible tubing suitable for this sort of work is www.titeflexcommercial.com but there will be many others.

So if a vehicle were to be converted to run on hydroxy, what things need to be considered?

1. A suitable vehicle needs to be acquired. This would be an old vehicle which has Capacitor Discharge ignition, or the even earlier Contact-Breaker points ignition system. These types of electrical system allow the timing to be adjusted and do not attempt to feed more fuel into the engine if an exhaust gas sensor decided that the mix was not correct for standard fossil fuel operation. Ideally, the vehicle should have a good deal of spare space in the engine compartment, and if the objective is to run on water alone, then the lower the engine capacity the better. As the objective is to run on water alone, then it must be accepted that rust will occur in the exhaust system, and other ageing problems may well be encountered. For long vehicle life, the vehicle should be converted to run on natural gas ('LPG') and water mist injection should be considered so that the engine runs cooler to improve the life of the valves.

2. A decision needs to be made as to what size of electrolysis cell or cells will be used and secure mountings devised and constructed in the engine compartment, to allow robust installation of the additional devices to be placed there. As an inverter will be used, then if at all possible, it should be mounted in the airstream which is used to cool the radiator. The inverter will have an input of 12 volts DC an output of 110 volts AC in the range 600 to 800 watts. When this is bought, the size and type of mounting brackets will be seen and can be constructed and the inverter mounted in the vehicle. The construction of the remaining mounting platforms shows what dimensions can be used when constructing the electrolyser(s) and bubbler(s). It must be stressed that it is **absolutely vital** that no device containing hydroxy gas, be placed in the section of the vehicle where the driver and passengers sit.

   It is also **vital** that at least one bubbler is installed between the output of the electrolyser and the engine intake. It is highly advisable that both the electrolyser and the bubbler have pop-off caps so that in the unlikely event of accidental ignition of the gas contained in them, that the caps blow off, controlling the situation and limiting or eliminating any physical damage to the units. Being located in the engine compartment, the sound of any explosion will be considerably reduced before reaching the passenger area, and any electrolyte splashed around will not come into contact with people.

   Potassium Hydroxide is very corrosive and can cause serious burns. It produces considerable heat when dissolved in water and it will absorb moisture from the air. It must not be allowed to come into contact with skin and most especially, in either solid or liquid form, must not contact the eyes as serious eye damage is almost certain to occur. If either the solution or solid comes in contact with the eyes, the area of contact should immediately be flushed with running water for at least ten minutes and immediate medical help called. Any area of contact with skin should be washed in running water for at least ten minutes. If the skin reddens or appears damaged, seek medical aid. Any contaminated clothing should be removed. In the unlikely event of swallowing any, drink plenty of water and call for immediate medical help.

   Potassium hydroxide reacts strongly with most materials and should be handled very carefully. Safety glasses should be worn and rubber gloves used. Never mix Potassium Hydroxide with water in a glass container. If Potassium Hydroxide is to be dissolved in water, the liquid should be swirled around continuously to avoid hot spots developing.

3. Once the space in the engine compartment has been chosen and the mountings constructed, the size of the electrolyser and its plates can be chosen. Plexiglas is a good choice for the housing, provided that it is thick enough to allow slots to be cut in it to accept the stainless steel plates after they have been conditioned, say 1/2 inch (12 mm) thickness with slots 1/8 inch (3 mm) deep cut in it. This calls for accurate workmanship. If that is likely to be a problem, an alternative form of construction can be considered where narrow strips of 1/8 inch (3 mm) thick Plexiglas are cut and then attached to the inside of the housing, plate by plate, with the previous plates clamped in position. That way, the manufactured thickness generates the accurate spacing between the plates and the manufacturers glue bonds the strips into the walls and base of the housing, forming a watertight seal. The plates need to be conditioned before this is done as their thickness may be affected by the conditioning process. The plates need to fit tightly in position as they need to form watertight partitions across the inside of the housing. The housing should be arranged so that either the base or side project to provide robust mounting holes to take the bolts needed to fasten it to the bracing set up in the engine compartment.

4. The additional items for the electrolyser need to be installed: the pressure switch, water-level sensor wires, water-feed tube with its one-way valve, welded leads to the bolts leading out through the case, and the anti-slosh material, need to be installed.

5. The lid of the housing needs to be a tight fit and pressed into place so that it can act as a pop-off safety feature in the unlikely event of the gas in the cell being ignited. If this is not convenient, then an additional large-diameter tube and push-fit cap should be installed on the top of the unit to provide the same type of protection.

6. One or more bubblers need to be constructed and installed in the vehicle. Bob Boyce chose to use one bubbler close to the electrolyser (to catch any electrolyte vapour) and one close to the engine. He installed a one-way flow automatic valve between the two bubblers so that should the gas in the bubbler near the engine be ignited, then any pressure wave from the explosion would be trapped by the valve and prevent the water in the other bubbler being driven backwards into the electrolyser.

7. The water-level switch circuit is then built. The circuit shown here is only one suggestion out of many different ways of producing the required operation. Most electronic experts will prefer other circuit designs. It is in no way critical how this controller is built so long as it performs the task reliably and is easy and cheap to build. The relay shown in the circuit needs to have contacts capable of switching the current taken by the water pump to be used, and have a coil winding which lets it switch when a voltage of 10 volts is applied to it. The water pump chosen may well be a windscreen-washer pump.

8. The inverter output can now be rectified and the final wiring completed and tested. The relay which passes power to the electrolyser (via the pressure switch) should be an automotive type, rated at 12 volts nominal and with contact ratings of say, 30 amps and the circuit breaker can also have a trip value of 30 amps.

9. The electrolyte can now be mixed in a ceramic container, where the liquid is swirled around continuously until completely dissolved. A glass dropper or battery hydrometer can then be used to fill each of the inter-plate gaps to the chosen level. When the lid is positioned securely, the final testing can take place.

10. A plastic water tank can be positioned anywhere convenient in the vehicle and plastic piping run from it to the intake of the water pump.

11. When the initial testing has been carried out and the engine is ticking over satisfactorily, the inverter can be removed and modified. The modification will be slightly different for different types of inverter, but is likely to be fairly simple on nearly every inverter. If this turns out to be a confusing operation, then the help of an electronics expert can be called on, whether it be the local TV repair man, school physics teacher or university lecturer. Most technically minded people are usually more than willing to help out if asked.

12. The modified inverter is ten used to increase the gas output of the system by adjusting its output frequency very slowly until a major increase in gas production is achieved. The system should now be fully capable of running the vehicle on water.

***Materials*:**

Thick Plexiglas sheet, quantity determined by the chosen size of unit and the number of cells
Specialist adhesive specifically designed to bond Plexiglas sheets together
Stainless steel plates, 16 gauge 316-type, size and number determined by the chosen size of electrolyser
A short length of rigid PVC pipe to be used as the water-supply pipe inside the electrolyser
One or two plastic containers and piping from which to make one or two bubblers
Inverter: 12 volt DC input, 110 volt AC output, 600 watt to 800 watt rated
Rectifier bridge: 200 volt (or greater) 30 amp (or higher)
Two 12 volt relays with contacts rated at 30 amps
Gas pressure switch: 5 psi operating pressure, contacts rated at 30 amps
Water pump: windscreen washer type is usually suitable
Plastic water tank plus plastic piping to suit intake to the water pump
One-way valve for water-supply to the electrolyser
One-way valve if one is to be placed between two output bubblers.

Stripboard and components to make the water-level sensor unit
Heavy duty, insulated, stranded wire for connecting up the electrical circuit
Stainless steel wire and bolts for carrying the electrical connections out of the electrolyser housing
Metal strips and bolts from which to construct the various mountings in the engine space
A small amount of material to act as anti-slosh guards: stainless steel wool, plastic scourers, etc.

***Bob Boyce's Experiences*:**

Bob had an electronics business down in south Florida where he owned and sponsored a small boat-race team through his business, starting in 1988. He had a machine shop behind his business, where he did engine work. He worked on engines for other racers and a local minisub research outfit which was building surface-running drone type boats for the DEA. He delved into hydrogen research and started building small electrolysers using distilled water mixed with an electrolyte. He then resonated the plates to improve the efficiency of the units. He discovered that with the right frequencies, He was able to generate 'monatomic' Hydrogen and Oxygen rather than the more common 'diatomic' versions of these gasses. When the 'monatomic' gasses are burnt, they produce about four times the energy output produced by burning the more common diatomic version of these gasses.

About 4% of diatomic Hydrogen in air is needed to produce the same power as petrol, while slightly less than 1% of monatomic Hydrogen in air is needed for the same power. The only drawback is that when stored at pressure, monatomic hydrogen reverts to its more common diatomic form. To avoid this, the gas must be produced on-demand and used right away. Bob used modified Liquid Petroleum carburettors on the boat engines to let them run directly on the gas produced by his electrolysers. Bob also converted an old Chrysler car with a slant six-cylinder engine to run on the hydrogen set-up and tested it in his workshop. He replaced the factory ignition with a high energy dual coil system and added an optical pickup to the crankshaft at the oil pump drive tang to allow external ignition timing adjustment. He used Bosch Platinum series spark plugs.

Bob never published anything about what he was working on, and he always stated that his boats were running on hydrogen fuel, which was allowed. Many years later that he found that he had stumbled on was already discovered and known as "Browns Gas", and there were companies selling the equipment and plans to make it.

Bob's electrolyser is fairly simple to make but it requires a lot of plates made of 316 stainless steel able to withstand the more exotic electrolytes which are more efficient, a plastic box to contain the plates, 1/8" spacers to keep the rows of plates apart, the electrolyte, and an adjustable-frequency modified pseudo-sinewave inverter for the drive electronics. A total of 61 plates 6 inches square were used to give a large surface area. These had their surfaces scoured with coarse sandpaper in an "X" pattern to give a fine crosshatch grain which added fine sharp points to the surfaces.

This was found to improve the efficiency of the electrolysis. The box had two threaded ports, a small one for injecting replacement distilled water, and a larger one for extracting the vapour. Under the top cover was a piece of plastic matting to prevent sloshing. It is very important to keep the electrolyte level below the tops of the plates to prevent current bypassing any cells and creating excessive water vapour.

Bob placed a 5 **P**ounds per **S**quare **I**nch cut-off switch in a tee on the water injection port that shut the drive electronics down when the pressure in the unit hit 5 PSI. This allowed the unit to be able to supply on demand without building up too much pressure in low-demand situations. He built a bubbler from a large home cartridge type water-filter housing to prevent any backfire from travelling back up the gas feed pipe to the electrolyser. Without some sort of bubbler there is the risk of the electrolyser exploding if a flame front from the engine flows back to it.

The copper mesh screens designed for welding gasses will not work as hydrogen has a much higher flame propagation speed which passes straight through the copper mesh. The bubbler should be placed close to the engine so as to limit the amount of recombination of the gasses from monatomic to diatomic varieties. The hydroxy gas should be fed to the vapour portion of a **L**iquid **P**etroleum **G**as carburettor system. The carburettor will have to be modified for hydrogen use (different mixture rate than propane) and adjusted for best performance with the system running.

Bob found that the best electrolytes to use were Sodium Hydroxide (NaOH) and Potassium Hydroxide (KOH). While Sodium Hydroxide works well and is much easier to get ('Red Devil' lye found in most department stores) than the slightly more efficient Potassium Hydroxide. Whatever is used, be very careful what construction materials are used. Make absolutely sure that they are compatible with the chosen electrolyte (Plexiglas acrylic sheet was what Bob used). Never use glass containers for mixing or storing Potassium Hydroxide.

Bob never had the chance to drive the test Chrysler on the road with this system. Instead, he placed the rear end up on jack-stands and ran the engine under no-load conditions in drive just to test and tune the system and get an idea of how well the engine held up on the hydrogen fuel. The vehicle was run for a mileometer recorded distance of one thousand miles in this set-up with the hydrolysis being fully powered by the alternator of the vehicle. With the vehicle running at idle, the drive electronics consumed approximately 4 to 4.3 Amps @ 13.8 V DC. With the rear wheels off of the ground, and the engine running with the vehicle speedometer registering 60 mph, the drive electronics drew approximately 10.9 to 11.6 Amps @ 13.8 V DC.

The unit does not use "normal brute force" electrolysis when operating in high efficiency mode. It relies mainly on a chemical reaction that takes place between the electrolyte used and the metal plates, which is maintained by electrical energy applied and stimulated into higher efficiency by the application of multiple harmonic resonances which help to "tickle" the molecules apart. Multiple cells in series are used to lower the voltage per cell and limit the current flow in order to reduce the production of water vapour. It relies on the large surface area of the total number of cells to get the required volume of fuel vapour output.

In the first prototype of this design, Bob used a custom built controller/driver which allowed a lot of adjustment so that performance could be tested using different frequencies, voltages, and waveforms individually. The result was a pattern of 3 interwoven square waves rich in harmonics that produced optimum efficiency. When Bob had the basics figured out he realised that he could just replace the custom controller/driver unit with a modified inverter (much easier than building a unit from scratch). He experimented using a 300 watt pseudo-sine wave inverter that had been modified so the base frequency could be adjusted between 700 and 800 Hz. The stepped sine wave output was fed through a bridge rectifier which turned each stepped sine wave into two positive stepped half waves. Each of these half waves had 8 steps, so a single cycle was turned into 16 steps. The resulting output, while not consisting of intermixed square waves, was still rich in harmonics, and it was much easier to adjust to the point of resonance than trying to tune 3 separate frequencies.

The frequency range can change depending on the number of steps in the pseudo-sine wave of the inverter you choose since not all inverters are created equal. The desired effect is caused by the multiple harmonic resonances in the inverter output at higher frequencies. You will know when you hit resonance by the dramatic increase in gas output. The frequency does vary a bit depending on what electrolyte is used, the concentration of the electrolyte solution, the temperature of the electrolyte, water purity, etc.

Bear in mind that Bob’s electrolyser tank was large enough to hold 61 plates of 316 grade stainless steel which were 6" X 6" each, spaced 1/8" apart, to create 60 cells in series, with the 130 V DC power from the inverter, through the bridge rectifier, applied to the end plates only. That gave 4,320 square inches of surface area, plenty of surface area to produce enough fuel for a vehicle engine. The best electrolyte for efficiency was Potassium Hydroxide, and the electrolyte level must be kept below the tops of the plates to prevent any current from bypassing the plates and creating excess water vapour through heating. Distilled water was used to prevent contamination of the electrolyte which would result in reduced performance and efficiency.

The unit had 316 grade stainless steel wires welded to the tops of the end plates. The other ends of the wires were welded to 316-grade stainless steel bolts which passed through holes in the ends of the container, with rubber o-ring gaskets inside and out, located above the liquid level.

There was a PVC spray bar attached on the inside of the chamber to the water injection port with tiny holes drilled along its length on the underside to supply replacement water evenly to the cells when the water pump was switched on. A backflow-prevention valve on top of the tee was used to keep the gas from flowing back into the water lines. There was a mat of interwoven plastic fibres (air conditioner filter material) cut and fitted on top of the plates to help prevent sloshing. Do not use fibreglass mat, which could cause a severe reaction with some electrolytes, like Potassium Hydroxide.

It is very important to understand that unless an engine is originally designed for, or later modified for, running on vapour fuel such as Liquid Petroleum Gas (natural gas), that water mist injection be added. Unless the engine has the proper valves for vapour fuel, the stock valves will not survive for extended run times on vapour fuel of any kind without additional cooling of some sort. This is an issue of valve design by the vehicle manufacturers, not something detrimental because of hydroxy gas combustion. The manufacturers want to prevent their cars from being adapted to high mileage operation without adverse effects, so they designed the valves to fail if not cooled by excess raw fossil fuel.