CIRCUIT CELLAR ONLINE

THE MAGAZINE FOR COMPUTER APPLICATIONS

Circuit Cellar Online offers articles illustrating creative solutions and unique applications through complete projects, practical tutorials, and useful design techniques.

RESOURCE LINKS

A Guide to online information about:

Fuel Cells and Radioisotope Heater Units

by *Bob Paddock*

In the 1970s there was a television series called Barnie Miller that dealt with a New York police precinct. The episode I remember the most is one in which an employee is charged with theft of trade secrets. During the questioning the fellow says he invented "The Perfect Battery", one that never goes dead. He was caught removing his own research from the company premises because the company was going to "lose it" instead of bring it to the world.

The company lawyer wanted to press charges to the fullest extent of the law until Capt. Miller explained that the data the suspect had on him when arrested would have to be impounded and kept for evidence in the trial.

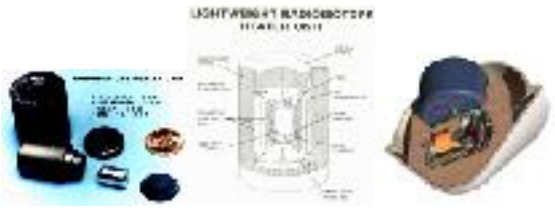
The company lawyer could not have this so he dropped all charges. The company lawyer escorted the employee out of the building leaving the viewer to wonder about his long term health....

In theory, a perfect battery could be had if one could be made that had zero internal resistance, no one that I know of has yet brought such a thing to market. The next best thing to zero internal resistance is probably some type of High Temperature Superconducting Material

(NIST). [The NIST WWW High Temperature Superconductors database (WebHTS) provides evaluated thermal, mechanical, and superconducting property data for oxide superconductors.]

Next in line for the perfect battery title, in the sense that it has a extremely long life, is the Radioisotope Heater Unit (RHU) which consists of a thermoelectric thermopile made of plutonium dioxide (mostly plutonium-238) in a ceramic form of the material that minimizes environmental problems. The heat from the RHU is converted to electricity with a thermoelectric converter made of Bismuth-Telluride. The thermoelectric converter charges LiTiS2 rechargeable AA cells. This combination has been dubbed "The Powerstick".

The following images may be expanded to show more detail by clicking on them.



While the Powerstick can produce 42 mW at 15VDC at the start of its life and still be producing 37 mW at 14VDC after 10 years of operation, the use of plutonium dioxide fuel makes it less than politically correct, at best, and a downright environmental danger at the worst. This takes us to the next most likely candidate for the perfect battery—the Fuel Cell, because tabletop fusion is not yet out of the experimental stage. [there seems to be two versions of the PowerStick as one talks about 15VDC and another talks about 28VDC at the start of life.]

Reference:

DEPARTMENT OF ENERGY FACTS: Radioisotope Heater Units (RHUs)

A.B. Chmielewski, R. Ewell, R. Bennett and W. Nesmith, The Powerstick Development (pdf), Orlando, FL, July 31-Aug. 4, 1995, AIAA Energy.

Aeronautics and Space Report of the President Fiscal Year 1995 Executive Summary Department of Energy (DoE).

Micro Thermal Power Source (MTPS).

Project Summary for Proposal Number: 960064 Project Title: POWER GENERATOR FOR PLANETARY MISSIONS.

Miniature Radioisotope Power Source JPL New Technology Report NPO-19339, NASA Tech Brief Vol. 19, No. 9, Item #25, september 1995.

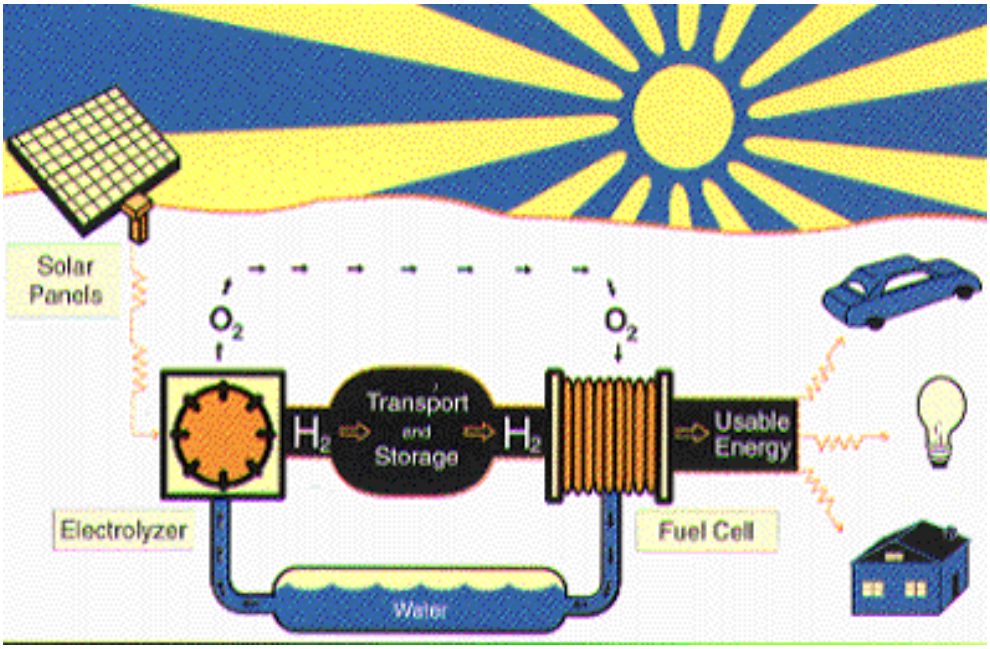
The History of Fuel Cells begins with Sir William Grove. Grove, now called the "Father of the Fuel Cell," completed experiments on the

electrolysis of water in 1839. He reasoned that this process of adding electricity to separate water should be reversible, where the formation of water would produce electricity.

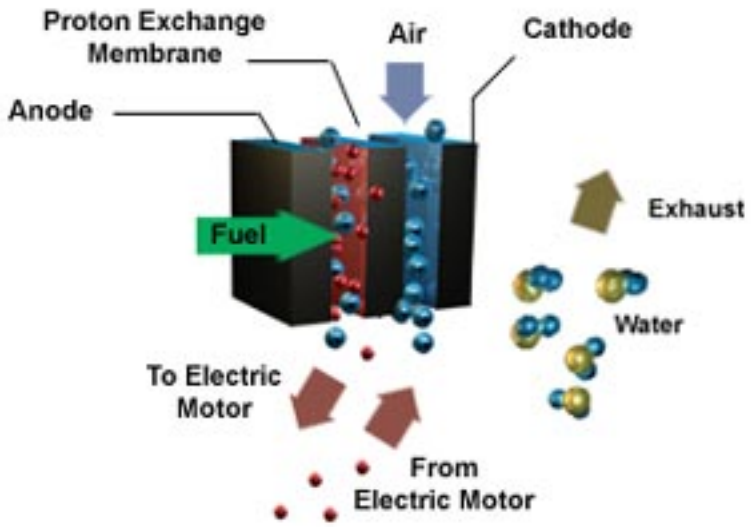
More on the history of the Fuel Cell.

Rather than try to explain the operation of a Polymer Electrolyte Membrane (PEM) Fuel Cell, the most common type today, the Animation done by H Power shows with pictures far better than what I can with words. [Some people refer to the PEM as a Proton Electrolyte Membrane.]

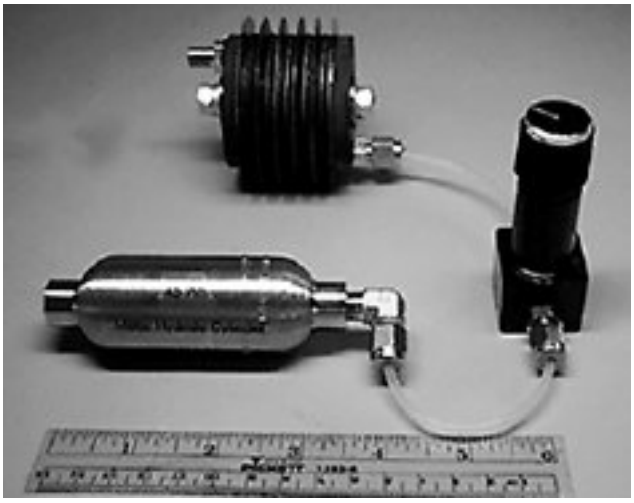
A different Animated PEM Fuel Cell by Schatz Energy Research Center (SERC) can be seen as well. Also check out their FAQ and their Proton Exchange Membrane Fuel Cell page. They also cover What is the Solar Hydrogen Cycle and Why is it Important.



The National Fuel Cell Resource Center has an extensive list of links to Fuel Cell related sites as well as some interesting pictures and information:



How PEM Fuel Cells Work by Ballard Power Systems is also quite informative.



Air-breathing PEM Fuel Cell stack with metal hydride H2 storage canister and pressure regulator. PEM Fuel Cells have now been developed which rely on ambient air pressure for oxygen and on its own water generation for humidification.

Answers to Frequently Asked Questions about Fuel Cells can be found at http://www.fuelcells.org/.

Fuel Cells: A Primer is meant to introduce everyone to the wonders of the Fuel Cell. The most common question is now what is the difference between a Fuel Cell and a battery?

> Shell gives the answer as "Fuel Cells and batteries are similar as they both deliver electrical power from a chemical reaction. However, in a battery, the chemical reactants are stored within the battery, are used up during the reaction and the battery must be recharged or thrown away. In a Fuel Cell, the reactants are stored externally to the Fuel Cell, so it will keep producing electricity as long

as reactants (fuels) are delivered to the Fuel Cell. Therefore a Fuel Cell vehicle is refueled instead of recharged."

The next most common thought on most minds is that Fuel Cells are a technology that is off in the distant future. Would it surprise you to know that you can buy Fuel Cells that range from 8W to 200kW off the shelf today?

A subtle but significant feature of Fuel Cells is that they leave lower detection infrared and acoustic signatures (fingerprints) because they are both silent and vibration free under ideal operating conditions.

Don Lancaster's "It's a Gas" Hydrogen Library should not be missed.

Just in case your chemistry is a bit rusty you might want to check out:

Chemical Elements.com
An Online, Interactive Periodic Table of the Elements

Andy Archer's Hydrogen as Energy Storage page gives options on the ways to store Hydrogen as well as The Pros and Cons of Hydrogen Storage.

A Fuel Cell Education Kit which includes the PEM Fuel Cell with a power output of at least is at least 3.5 W, .5 V, 7 A is available from Info Tech. [If someone can tell me how to get such a high current up to some more practical voltage like +12V, I would like to know.]

ElectroChem offers a wide range of Fuel Cell assemblies to serve your needs. They have a variety of Polymer Electrolyte Membrane single cells, and a Phosphoric Acid/Direct Methanol Fuel Cell. They also offer different stacks for your power and testing requirements. Be sure to take a look at the Portable Demonstration Unit.

Electro-Chem-Technic

Electro-Chem-Technic manufactures and sells low cost, small, Fuel Cells, mainly for schools, colleges, and universities. The objective is to make known the basic principles of Fuel Cell technology.

The Hydrocell "Starter Cell", has all the components to get you going with your own Fuel Cell experimentation. Don't miss their Hydrocell Fuel Cell Picture Gallery.

REB Research & Consulting, Useful Hydrogen, Fuel Cell and Renewable Energy Links should be checked out. REBR&C is a source of Hydrogen Purifiers, Membrane Reactors and Hydrogen Separations

Consulting.

You may be wondering what type of fuel a Fuel Cell uses, and how practical is this fuel to get? High-efficiency, low-emission Fuel Cell systems can run on gasoline, ethanol and other fuels.

In a major automotive research breakthrough, a government-industry team announced that for the first time, Fuel Cells using gasoline as the fuel have been demonstrated for automotive use, leading the way for high-mileage, low-emission electric vehicles that can be refueled at existing gas stations.

Being able to use the existing infrastructure is the first step on the way to a new hydrogen-based economy.

The United States Council for Automotive Research (USCAR) is an umbrella research organization for DaimlerChrysler, Ford, and General Motors, and was formed in 1992 to further strengthen the technology base of the domestic auto industry through cooperative, pre-competitive research.

http://www.drivingthefuture.org/ covers several other aspects and players of the Fuel Cell partnership for vehicles.

While the change to a hydrogen-based system for transportation is sure to have the largest impact on the environment, of more interest to Circuit Cellar readers are things like how to power your lap top or cell phone.

Micro-Fuel Cells from Manhattan Scientific, Inc. (MSI) are expected to drive a digital cellular telephone on standby for 6 months as opposed to 2 weeks with lithium ion batteries. In addition, the Micro Fuel Cell will, when developed, provide 1 week of talk time instead of the current 5 hours that lithium ion battery-powered cell phones now provide.

MSI's FAQ covers subjects such as why they chose to run the Micro-Fuel Cells from Methanol. Methanol was selected as the fuel because of its availability in the form of windshield washer fluid which is methanol and water.

U.S. Patent No. 4,673,624 Fuel Cell, June 16, 1987.

U.S. Patent No. 5,482,568 Micro Mirror Photovoltaic Cell, January 9, 1996.

U.S. Patent No. 5,631,099 Surface Replica Fuel Cell, May 20, 1997.

U.S. Patent No. 5,759,712 Surface Replica Fuel Cell for Micro Fuel Cell Electrical Power Pack, June 2, 1998.

Hydrogenics Corporation is a leading designer and systems integrator of Fuel Cell technology.

If you think that PEM type Fuel Cells are the only kind then think again. The FUEL CELL COMMERCIALIZATION GROUP is a first-of-its-kind

organization with the mission of commercialing carbonate Fuel Cells for power generation.

Fuel Cell Technologies Ltd. designs, develops, and manufactures a wide range of Fuel Cell and metal-air semi-Fuel Cell systems and components. Their expertise lies in the design, development, and supply of aluminum-oxygen power sources for underwater vehicles, integrated power systems for remote applications, zinc air rechargeable batteries and alkaline Fuel Cells.

The Fuel Cell page of Dr. Anthony Kucernak, Lecturer in Physical Chemistry, gives a comparison of the various operating parameters for different types of Fuel Cells.

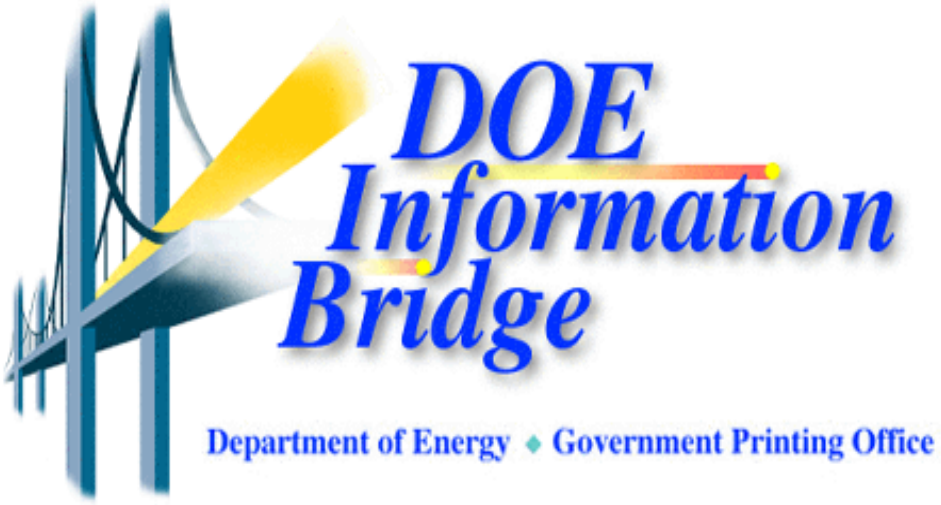
The World Fuel Cell Council was founded as a non-profit association in 1991 by a number of Fuel Cell manufacturers and material suppliers. The objective of the Council is to promote the most rapid commercialization of this benign technology worldwide.

The purpose of the Small-Scale Fuel Cell Group (SFCCG, Inc.) is to promote the commercialization of marketable residential, small commercial, and small industrial Fuel Cells.

Energy Partners, L.C. is a company dedicated to the development and commercialization of proton exchange membrane (PEM) fuel cells.

If you wish to stay informed on what is happening in the areas of Hydrogen and Fuel Cells then you'll find The Hydrogen & Fuel Cell Letter of interest.

While the standard search engines return may links to Fuel Cell technologies, the most advanced data can only be found in databases such as those at Los Alamos National Laboratory or the DOE Information Bridge.



Because some of these search links expire just moments after use, you may need to do the search yourself, by searching for "de96011453", or "de96000554", at the DOE Information Bridge. Also unless you go to the DOE Information Bridge home page and set a cookie that says what format you want your information to be in, you will get no place on this site, and these links will not work, it also forces you to use a browser that handles JavaScript.

Title:

Proceedings of the Fuel Cells `95 review meeting. 222p. (CONF-950886--:). Order Number DE96000554. Source: OSTI; NTIS; GPO Dep.

[This is the mother lode of technical data, coming in as a whopping 16-MB PDF file, if that is the format that you select. You can look at the individual pages before you download it if you like.]

Abstract:

This document contains papers presented at the Fuel Cells '95 review meeting. Topics included solid oxide Fuel Cells; DOE's transportation program; ARPA advanced Fuel Cell development; molten carbonate Fuel Cells; and papers presented at a poster session. Individual papers have been processed separately for the U.S. DOE databases.

Title:

Lean-burn hydrogen spark-ignited engines: the mechanical equivalent to the fuel cell. 23p. DOE Contract W-7405-ENG-48. (CONF-961017--9:). Order Number DE96011453. Source: OSTI; NTIS; GPO Dep.

Abstract:

Fuel Cells are considered the ideal power source for future vehicles, due to their high efficiency and low emissions. However, extensive use of Fuel Cells in light-duty vehicles is likely to be years away, due to their high manufacturing cost. Hydrogen-fueled, spark-ignited, homogeneous-charge engines offer a near-term alternative to Fuel Cells. Hydrogen in a spark-ignited engine can be burned at very low

equivalence ratios, so that NO[sub x] emissions can be reduced to less than 10 ppm without catalyst. HC and CO emissions may result from oxidation of engine oil, but by proper design are negligible (a few ppm). Lean operation also results in increased indicated efficiency due to the thermodynamic properties of the gaseous mixture contained in the cylinder. The high effective octane number of hydrogen allows the use of a high compression ratio, further increasing engine efficiency. In this paper, a simplified engine model is used for predicting hydrogen engine efficiency and emissions. The model uses basic thermodynamic equations for the compression and expansion processes, along with an empirical correlation for heat transfer, to predict engine indicated efficiency. A friction correlation and a supercharger/turbocharger model are then used to calculate brake thermal efficiency. The model is validated with many of 1345 experimental points obtained in a recent evaluation of a hydrogen research engine. The experimental data are used to adjust the empirical constants in the heat release rate and heat transfer correlation. The adjusted engine model predicts pressure traces, indicated efficiency and NO, emissions with good accuracy over the range of speed, equivalence ratio, and manifold pressure.

The Office of Transportation Technologies (OTT) information gateway is also a good place to find Fuel Cell info. OTT is part of the DOE's Office of Energy Efficiency and Renewable Energy.

Some last minute updates as the page goes to press:

Lab-designed Fuel Cell Tutorial available online, from Los Alamos Laboratories (LANL).

http://www.analyticpower.com
http://www.avistacorp.com
http://www.northwestpower.com
http://www.plugpower.com

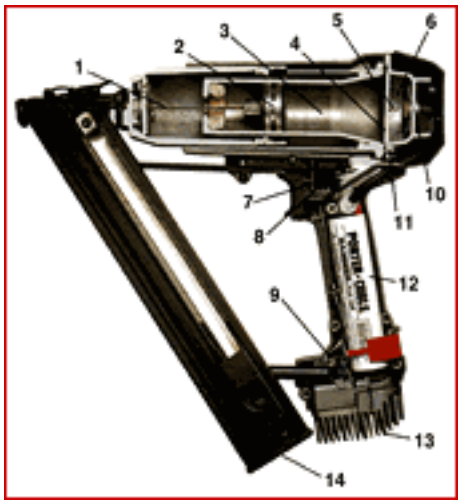
The DOE has selected four companies to start down a new research path toward a dramatic reduction in the cost of fuel cells, since they are one of the cleanest and most efficient ways to generate electricity.

Secretary of Energy Bill Richardson announced that McDermott Technology Inc., Alliance, Ohio, Allied Signal Inc., Torrance, Calif., NexTech Materials Ltd., Worthington, Ohio, and Technology Management Inc., Cleveland, Ohio, have been chosen to begin developing basic designs and manufacturing processes for a new generation of ultra-low-cost Fuel Cells.

The companies will investigate several alternative approaches to manufacturing all solid-state ceramic components and fabricating them into future Fuel Cell power plants.

The DOE has a new Introduction To Fuel Cells page up now, covering the different types of Cells.

If you find Fuel Cells fascinating and are tired of your current job you might want to look up International Battery Technology, Inc. (IBT). IBT is a small business, dedicated to the recruitment and placement of battery, Fuel Cell, and other chemical power source professionals on a world-wide basis. Their HOT LINKS have some interesting destinations as well.



While Porter Cable's Bammer has nothing to do with Fuel Cells I thought it was a interesting application of a battery-free technology. A Piezo ignition system generates a spark causing a gas to expand to give a impulse to drive a nail.

Those of you who look to the more speculative areas of science will find that there are some unconventional ways of separating hydrogen and oxygen from water. Do these work? Only time will tell.

HTGR Thermochemical Water Splitting for Hydrogen Production, from the Gas Research Institute (GRI).

Summary: In this investigation of thermochemical water splitting using the high-temperature gas-cooled reactor (HTGR) as a heat source, corrosion test data were obtained to identify materials of construction compatible with HIx environments.

From some other sources: A chemical research group has discovered a new way to extract hydrogen from water. It is different from current methods, and is based on the interaction of a Molybdenum (Mo) compound.

Another catalyst-based method comes from BlackLight Power, Inc., who believe they have developed a new method (the BlackLight Process) for generating thermal energy for heating and electrical power generation, and a vast class of new compositions of matter.

Sonoluminescence. Doing a search on Don Lancaster's *The Guru's Lair for Sonoluminescence* yields some interesting things.

Ultrasonic to generate oxygen.

The next step in energy production, engines and lighting.

Verification of frequency to produce etheric force from water.

Original water gas discovery.

"Resonance of water molecules at high amplitudes could possibly explode the hydrogen/oxygen bond! In a chamber filled with water, this could be disastrous, possibly leading to a chain reaction! So take every possible precaution if you choose to experiment with sonics!" See A Breakthrough to New Free Energy Sources.

Are Fuel Cells the last word in energy? Probably not as there is always something new coming along. For example, Entropy Systems claims that their new Entropy Engines have better efficiencies than Fuel Cells. See U.S. Patents # 5,547,341 & 5,765,387.

A cautionary note: some of the Fuel Cell sites I visited were more interested in talking about their stock than their technology. Investors are cautioned that all forward-looking statements involve risks and uncertainties, including, without limitation, product development delays, changing environmental regulations, the ability to attract and retain business partners, future levels of government funding, competition from other Fuel Cell manufacturers, competition from other advanced-power technologies, competition from existing power technologies, evolving markets for generating electricity and power for transportation vehicles, the ability to provide the capital required for product development, operations and marketing, and year 2000 readiness. These factors should be considered carefully and readers should not place undue reliance on information provided here. Personally, if I can't buy one today I would not invest in one. I also think there is going to be a patent war over some of these technologies, will the winner be the company you invested in?

If you would like to add any information on this topic or request a specific topic to be covered, contact Bob Paddock.
