The Rebirth of Cold Fusion: Real Science, Real Hope, Real Energy

Here is the first chapter from the book: Krivit, S. and N. Winocur, *The Rebirth of Cold Fusion: Real Science, Real Hope, Real Energy*. 2004: Pacific Oaks Press. For more information about this book, or to purchase a copy, please see:

http://newenergytimes.com/v2/books/RebirthofColdFusion/AboutTRCF.shtml

Part One

GLOBAL ENERGY,

GLOBAL CONCERNS

CHAPTER ONE

Cold Fusion Basics

In simple terms, cold fusion is a scientific phenomenon that occurs in a room-temperature experimental arrangement and produces nuclear energy, in the form of heat, without harmful radiation.

Cold fusion flies in the face of 70 years of accepted hot fusion and atomic theory that states that fusion can occur only under extreme, multimillion-degree temperatures. While cold fusion experiments show every indication of some sort of fusion or, perhaps, some other as-yet-unexplained process, the debate is not really about fusion *per se*, which is accepted. The debate, rather, is about whether fusion is possible in this new "cold" method.

Cold fusion appears embarrassingly simple when compared to hot fusion. Many nuclear physicists cannot conceive that a cell, which is no larger than an adult hand, can exhibit a single spark of nuclear energy. However, as any solid-state physicist will attest, many things can happen at the sub-atomic level inside atoms. In essence, the microscopic surface of the palladium metal, along with an as-yet-theorized determining factor, appears to provide the proper "squeeze," if you will, to allow deuterium nuclei to fuse.

Fusion's Fuel: Ocean Water

For decades, scientists in both the hot and cold fusion fields have hoped that fusion finally will solve the world's energy problems. If fusion power becomes commercially viable, it has the potential to fulfill the world's energy needs, using ocean water as fuel, safely, without greenhouse gasses or nuclear waste.

Most fusion experiments use a form of hydrogen known as deuterium for fuel. Deuterium atoms (Figure 1-1) are considered isotopes of hydrogen, because they have the same single proton that hydrogen does, but they also have one extra neutron.

In cold fusion experiments, deuterium may be used in a liquid or gaseous form. As a liquid, deuterium takes the form of D_2O, or more commonly, "heavy water," because it is 10 percent heavier than normal water. In the gas form, deuterium is noted as D_2. Cold fusion reactions also require and occur in the presence of a metal, typically palladium but sometimes titanium or nickel.

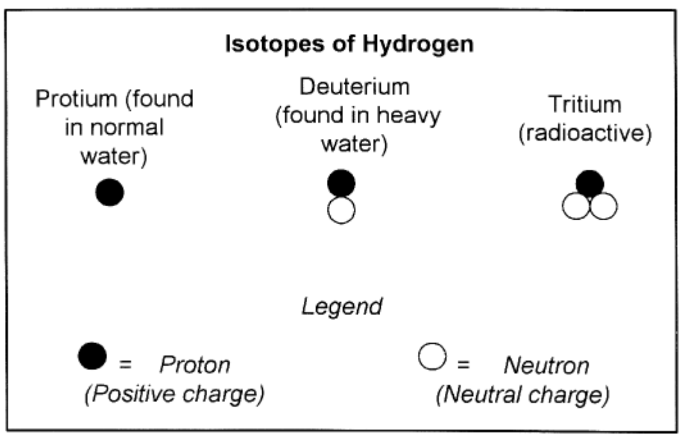

Figure 1-1. Isotopes of Hydrogen: Protium, Deuterium & Tritium

Deuterium is naturally abundant in ocean water. With the vastness of the oceans, nature may, in fact, have given humankind an enduring supply of fuel that may be the most powerful and versatile source of energy ever known.

When Steve Nelson, now with the U.S. Naval Research Laboratory, was a nuclear astrophysics Ph.D. candidate at Duke University, he performed a calculation which shows that the impact of deuterium extraction from ocean water, for the purpose of generating fusion energy for the entire world's energy consumption, would lower the ocean surface only by one millimeter after several thousand years. Considering even the engineering inefficiencies and losses present in any power generation system, Earth’s oceans have enough deuterium to last centuries.[1]

Electrolysis

One of the most common methods used to perform cold fusion experiments is that of electrolysis. Electrolysis is the process of passing an electrical current through a liquid, such as normal water (H_2O), and separating the hydrogen atoms from the oxygen atoms. In the case of heavy water (D_2O), deuterium atoms are separated from the oxygen atoms.

The basic cold fusion experiment is performed either in a small glass beaker, 250 milliliters in size, or in a narrow test tube, which can range from 20 to 100 milliliters in size. The difference in equipment varies based on the different methods of heat measurement employed.

In terms of its physical configuration and mechanical complexity, the apparatus is far less complex than the hot fusion apparatus. But a cold fusion electrolytic experiment is infinitely complex, deceptively so, on a smaller scale. Scientists must contend with a multitude of electrical, chemical, material science, metallurgical and time variables that all occur within the palladium cathode and the cell.

In the basic electrolytic cell, (Figure 1-2) an electrical circuit is made between the two poles of a battery and passed through a solution of liquid in a glass container. Two pieces of metal, or wires, are inserted into the container, one attached to the positive battery terminal, the other to the negative terminal.

Because pure water does not conduct electricity, the addition of salts to the liquid allows the electricity to flow through the solution, from one rod to the other. Lithium, in the form of LiOD, is a common salt used, as is potassium, in the form of K_2CO_3.

In a classical cold fusion electrolytic cell, platinum is usually connected to the positive terminal, palladium is usually connected to the negative terminal of the power source, and the heavy water solution is separated into its elemental components, deuterium and oxygen, by flow of current.

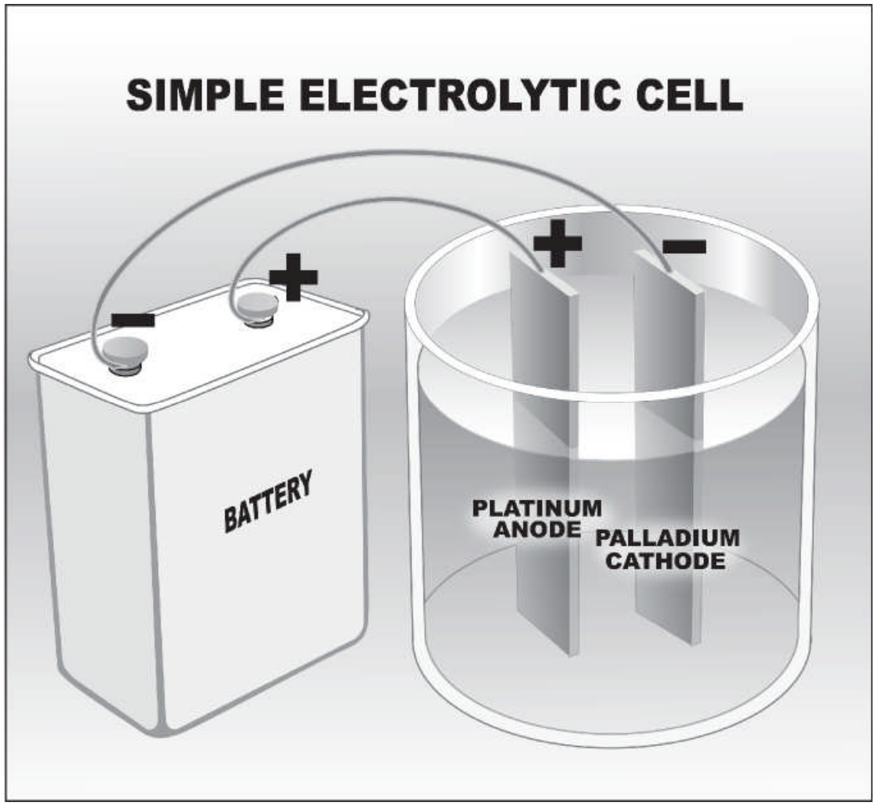

Figure 1-2. Simple Electrolytic Cell. (Drawing by Craig Erlick)

Calorimetry

The key effect that scientists seek in cold fusion experiments is the generation of large amounts of heat. This is the predominant reaction product from cold fusion and the most important for any potential commercial viability. The instrument to detect the presence of heat generation from cold fusion experiments is a calorimeter. A calorimeter measures heat. Just as a light bulb gives off heat when a current is passed through its filament, so does an electrolytic cell give off heat when current is passed through it. There are several types of calorimeters.

The critical piece in the cold fusion electrolytic experiment is the cathode. This is generally thought to be the site of the energy production, and it is submerged inside the cell. The energy emerges from the reaction between the metal cathode and the gaseous deuterium as heat, which in turn, causes the surrounding liquid to heat up. In order to measure the energy coming from the cell, one must be able to measure accurately this heat coming from the cell. This is the purpose of precision calorimetry.

Calorimetry is a complicated process and requires explicit skill and training. Generally, it is taught only in the field of physical chemistry, and even then, the occasions to use it are rare. Calorimetry is seldom taught in physics classes because physicists normally don't use calorimetry. This will turn out to be a major stumbling block for skeptical physicists trying to make sense of cold fusion.

The three types of calorimeters are isoperibolic, envelope-type, and mass-flow. Each has its strengths and weaknesses, but all require specialized skill. Figure 1-3 depicts the concept of the mass-flow type of calorimeter. The calorimeter surrounds the electrolytic cell in an independent jacket of water, much like the water that cools one's car engine. The water is made to flow continuously around the cold fusion cell. An electronic thermometer (thermistor) constantly measures the temperature going into the calorimeter, and another thermistor measures the water as it departs the calorimeter. The difference between these two readings and the flow rate of the surrounding water gives the amount of heat, or energy, being generated by the cell.

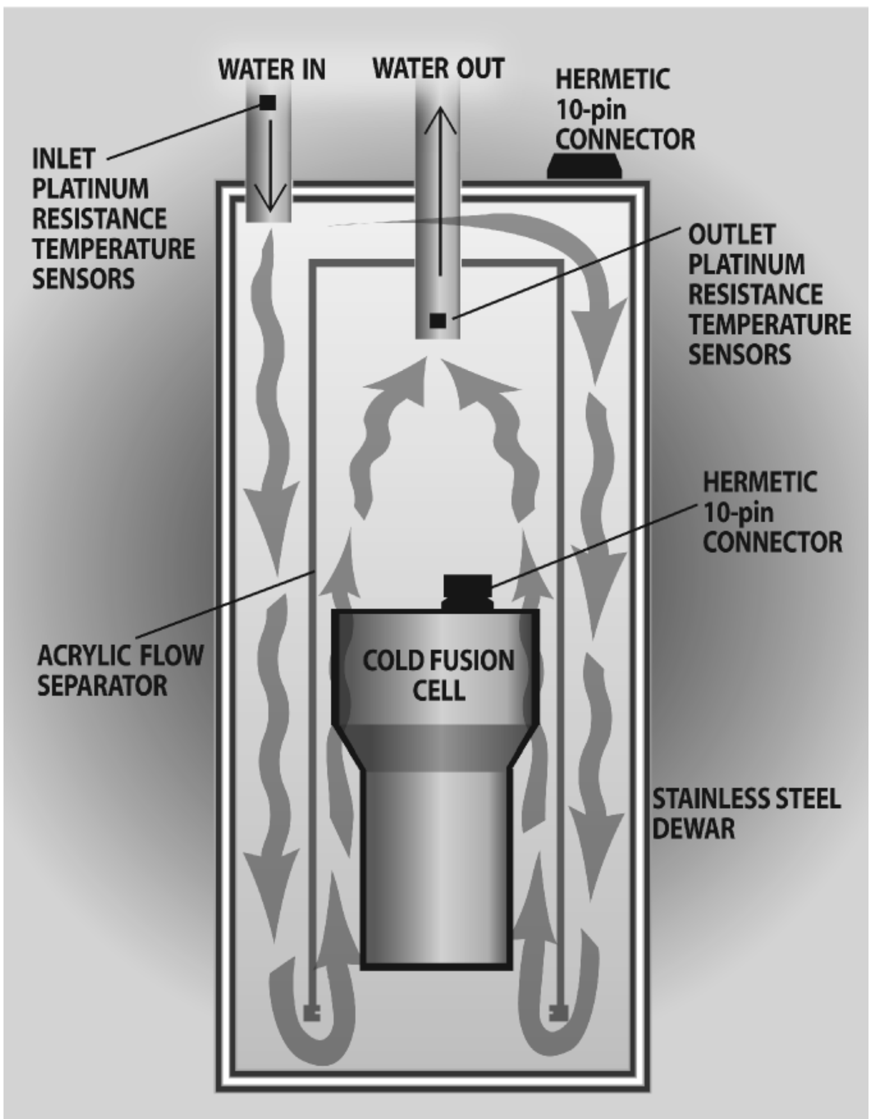

Figure1-3. SRI International-type Flow Calorimeter surrounding cold fusion cell. (Drawing by Craig Erlick)

Excess Heat

A fundamental principle in electrochemistry is that, when one places a certain amount of electrical energy through an electrolytic cell, one expects to get a commensurate amount of heat to come out of the cell.

For those who are mathematically inclined, this is represented in the following manner. If "Q" represents the amount of heat, "V" is the voltage, "I" is the current, and "t" is time, then $Q=V*I*t$.

In a standard electrolytic cell, the amount of energy coming out of the system is normally straightforward to calculate, using the above formula.

However, what Fleischmann and Pons discovered was that, in their cold fusion cell, Q, the amount of heat energy coming out of the cell, was much larger than it should have been based on any chemical reaction. An excessive amount of heat was coming from the experiment. It did not, in any way, match the amount of electrical energy going in plus other accounted-for energy losses! And this, in a nutshell, was their fundamental historic discovery: Something within the cell was releasing a new, "hitherto unknown" (Fleischmann-Pons) source of potential energy. In cold fusion research, this is the most important aspect of the phenomenon and is known by the term "excess heat."

How Cold Fusion Works

Figure 1-4 displays one of the most widely accepted models of the deuterium-deuterium cold fusion reaction. The nuclei (the center part of each atom) of two deuterium atoms, comprising a proton and neutron each, join together to form one helium-4 atom. Large amounts of heat also are given off as a result of the reaction.

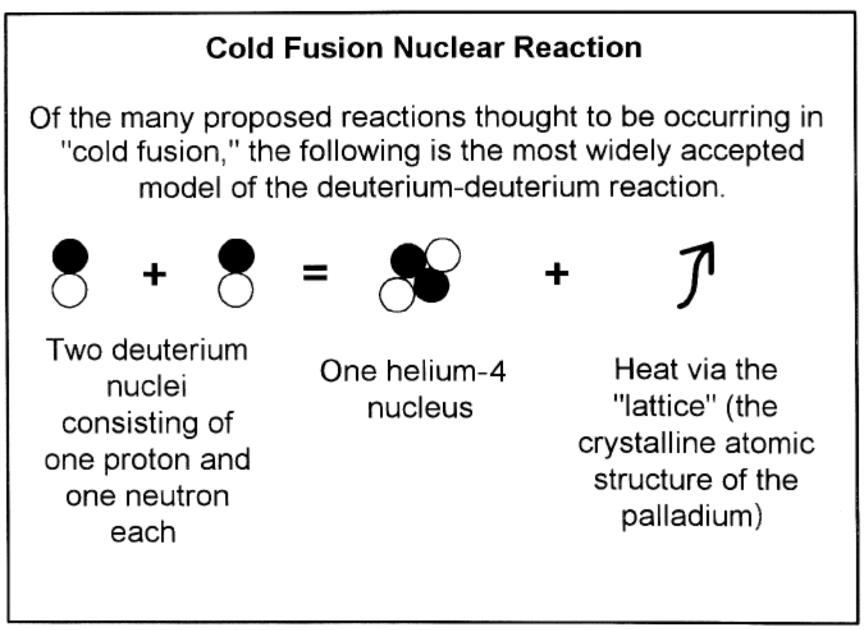

Figure 1-4. One Proposed Cold Fusion Nuclear Reaction

In contrast, *hot fusion's* normal byproducts are helium-3, tritium, and deadly neutron emissions. Only on rare occasions does helium-4, with its accompanying deadly gamma ray, appear in hot fusion. The results are, interestingly, almost reversed between hot and cold fusion, though both yield relatively large amounts of heat energy.

If the atomic masses of each proton/neutron pair are calculated, they equal slightly more than the atomic mass of the single helium-4 atom. This is where the liberated energy comes into the equation.

The difference in mass is accounted for by the portion of matter (deuterium) that has been converted into energy, which subsequently releases large amounts of heat. This heat is conveyed through the atoms of the palladium. The change in mass and subsequent conversion to energy are in accordance with Einstein's equation $E=mc^2$ and the law of conservation of mass-energy.

While many have claimed that cold fusion, once commercialized, will be an inexpensive source of energy, this may be somewhat optimistic. Certainly, deuterium, sold at retail for $1.00 per gram (much less in large quantities) is far less expensive as a nuclear fuel than uranium. However, "too cheap to meter," the catchphrase of nuclear fission plants, still rings in our ears. Dr. Edmund Storms, a radiochemist retired from the U.S. Los Alamos National Laboratory, said, "it's fair to say that the raw material is going to be cheaper than uranium, but we don't yet know how to make this work at a commercial level, and the costs for cold fusion power plants are a big unknown." [2]

Storms, who spent many years at Los Alamos working on nuclear energy systems for the space program, anticipates that cold fusion power plants, which likely will be small localized units, won't "have the safety problems which are inherent in nuclear fission plants." His reasoning, as discussed earlier, is that cold fusion appears to lack harmful radiation and radioactive waste and naturally will be simpler to build, far simpler than any hot fusion plant. "It's uncertain as to whether it would be less expensive than oil, but the raw material [deuterium] is certainly available in virtually unlimited quantities," Storms said.

Low Energy Nuclear Reactions (LENR)

A newer term has been adopted in recent years to classify a very broad set of experimental phenomena, which includes not only the classical heat-producing *cold fusion* experiments but also other interesting and anomalous reactions.

LENR refers to a variety of reactions that also occur in the presence of hydrogen- and deuterium-absorbing metals like palladium.

The cold fusion field is also known by other names and acronyms: CANR (Chemically Assisted Nuclear Reactions), CF (Cold Fusion), CNF (Cold Nuclear Fusion). CMNS (Condensed Matter Nuclear Science) also is evolving as the more scientific description for the entire field.

Readers wishing to see a more technical explanation of cold fusion will find "The Cold Fusion Effect: A Technical Explanation" at the end of Part Three.