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Back to the Future

The Fleischmann-Pons Effect in 1994

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Abstract

From its initial public announcement on 23 March 1989, the Fleischmann-Pons Effect (FPE) has been attributed to:

- nuclear fusion
- nuclear fission
- exotic chemistry
- some previously unidentified law of nature
- instrumental error.

Highly public as well as private efforts were made in 1989 to decide if an FPE existed and if so, what caused it. This paper reevaluates some of the factual bases for the scientific and management judgments of 1989 with the advantage of what has been learned after four years of worldwide experimentation and analysis. We conclude that there is an FPE and its signature is heat. Data existed in 1989 that could have lead to this conclusion. The source of the excess heat is still not understood. Scientific progress was not made through this debate, which was largely uninformed by appropriate experimentation, and patent considerations may have played a determining role in the scientific progress associated with the FPE.

Introduction

The extraordinary nature of the scientific claim made by Fleischmann and Pons [1](FP) immediately set off a flurry of both scientific as well as managerial activity. Starting with the University of Utah press conference on 23 March 1989 through the end of 1989, scientists and their sponsoring governmental and private employers struggled to decide the validity of the claims. By November 1989 the overwhelming official and popular judgement in most of the world was that there was no validity to the FP claims. Despite this, the “cold fusion” saga lives on and a non-scientific cottage industry continues to churn out “explanations” for the “facts” of the “cold fusion” saga. Strikingly absent from most of these explanations is any examination of the raw experimental data collected before December 1989, which presumably were the primary source of “fact” for determining the validity of the FPE.

The focus of our analytical efforts has been and continues to be the soundness of the 1989 conclusions concerning FPE validity. At the Second International Conference on Cold Fusion at Como, Italy one of us (WNH) reported his analysis for the State of Utah of some early Fleischmann and Pons experimental data. Some of our reconstruction and analysis of Harwell Laboratory’s[2] isoperibolic calorimetry was reported in the Proceedings of the Third International Conference on Cold Fusion at Nagoya, Japan3. We have gained access to other sets of raw data from the 1989-90 period and have also benefited from retrospective analysis efforts undertaken and published in the past years[4-6].

Inevitably in “scientific archeological” expeditions such as ours, a perspective evolves which was not available either to those who did the experiments or to those who immediately tried to draw implications from the results. This paper addresses, with benefit of hindsight, what might have been in 1989 had we known then what we know now. Or, as our title suggests, how might 1989 have turned out if we had had the benefit of these “future” four years of understanding?

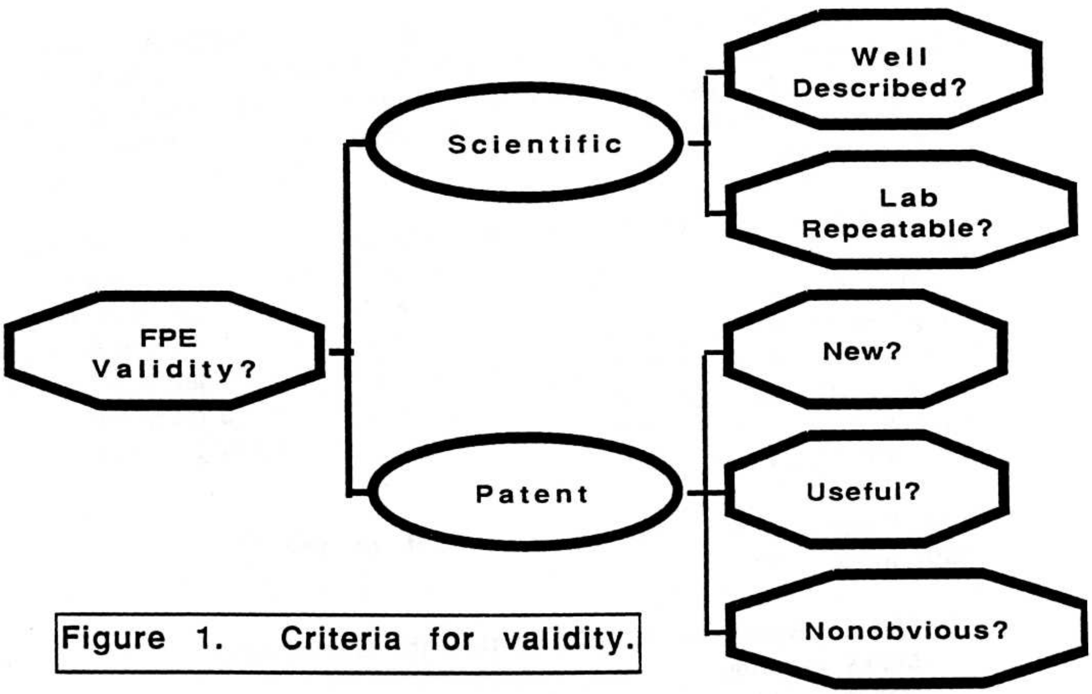

Figure 1. Criteria for validity.

FP Effect Validity - What is meant?

There are two sets of criteria that have been in play from the beginning -the scientific criteria and those associated with patents. It was commonly ***assumed,*** particularly since the FPE was presented in a public press conference, that the most important criteria were those of science, yet a careful examination of what was made available in 1989 suggests that patent criteria were primary. Although there is a relationship between the two they are not the same and have quite different requirements, (see Figure 1) Broadly speaking the scientific community has no secrets while the technological and commercial communities depend on secrecy or controlled access to information to derive competitive advantage. The United States Constitution created a monopolistic property right for inventors and the price to inventors was “public disclosure” of their invention. Thus, an inventor has no incentive to *publicly* describe his invention until such time as a patent is issued, further, the procedures for getting a patent in the United States assume secrecy from the time of application until issuance.

To receive a patent an inventor must have produced something that is “New” and “Useful”. Two hundred years of court cases and legislation have tried to grapple with what these words mean. “Newness” has been so difficult to define that an additional criteria “Nonobviousness” found its way into the law in 1952. Today an invention is “New” if there is no prior invention which conflicts with the “new invention”; and, if it wasn’t obvious to a “Person having ordinary skill *in the art”* - Mr. *Phosita,* in the legal jargon. The “Usefulness” criteria is the juncture of the scientific and patent criteria. An invention can be Useful only if it can operate to perform its intended task, thus, an invention that violates the laws of nature can’t operate—hence it can’t be useful.

The scientific validity criteria in Figure 1 serve different needs in science. If a phenomena is “well described” then scientists can use each other’s experiences without always having to repeat them, i.e., a good “theory” compactly represents and extends limited experience. Absent good “theory” the scientist must go back to the laboratory to find out what was “really meant”. If he can’t perform your experiment, i.e., repeat it, then he can’t have confidence that he knows what your claimed phenomena are.

To the extent there was any official application of “scientific” criteria to the FPE it started with the commissioning on 24 April 1989 by the Secretary of Energy, James D. Watkins, of a special assessment by the Energy Research Advisory Board (ERAB)?. The ERAB assessment team was to be formed and an interim report provided by 31 July 1989 with a final report by 15 November 1989. A fuller, non-bureaucratic discussion of the workings and reasoning of the ERAB team and the meaning of their report is given in Huizenga[8].

Cold Fusion Patentability Assessment of the U.S. Patent and Trademark Office

In his Annual Report for Fiscal Year 1992 the Commissioner of Patents and Trademarks reported:

> **Emerging Technology - Cold Fusion**
>
> Although cold fusion has been the subject of much skepticism in the scientific community, it continues to be an active area of research in the United States and other countries. Since the concept of cold fusion has come into recent prominence, over 200 applications mentioning it have been filed at the USPTO. The USPTO has not issued a patent for any application claiming cold fusion or claiming a process relying on cold fusion. These applications have been routinely rejected under 35 U.S.C. 101 and/or 35 U.S.C. 112.

The basic position of the USPTO in making its rejections seems to be:

(1) The inventions can’t be useful because the scientific community, particularly as summarized by the ERAB assessment team, has established that there is no “cold fusion”, (35 U.S.C. 101);

(2) Because there is no FPE, it is “impossible in any specification to describe the claimed invention in a manner which is enabling to one who is skilled in the art. That is, no inventor is capable of writing an enabling description. (35 U.S.C. 112).

The USPTO may also be rejecting applications using a third argument:

(3) Any claims by the inventors for new apparatus and methods are already to be found in the prior electrochemical art. Thus, all the claims of the inventors are “obvious” being a mere repetition of prior invention of electrochemists or other Mr. Phosita. As with (1) and (2) above this logic depends upon the non-existence of an FPE. If there is an FPE it would be a surprising result and thus this foundation for rejection would not stand.(35 U.S.C 102(exact duplication) or 35 U.S.C. 103(obvious extension)).

Reprise of Some Experimental Evidence of 1989 for the FPE

The following table lists papers based on data collected in 1989. They are used to illustrate various features of the evidence produced but not necessarily available in 1989. Each set of work is briefly discussed in the labeled paragraphs that follow.

Experiment-Reported	Exp. Start	Finished	Excess	± (Power)
FP[1] - 10 Apr 89	NA	March 89	KJ- MJ	NA
Lewis, et al.[10] - 17 Aug 89	early Apr 89	early May 89	zero	±6% P_{input}
Williams, et al.2 -23 Nov 89	mid-Mar 89	late July 89	zero	various
• 16 FPH calorimeters	17-26 Apr 89	29 May 89	inconclusive	±5-10% of P_{input}
• 1 Isothermal calorimeter	17 Apr 89	25 July 89	zero	< 1% P_{input}
Amoco[12] -19 March 1990	Apr 89	18 Dec 89	50KJ	< 1% P_{input}
• Trial cell 0	Apr 89	June 89	KJ	NA
• Trial cell 1	June 89	Aug 89	KJ	NA
• Closed, flow cell 2	24 Oct 89	18 Dec 89	>50KJ	±0.001W

Fleischmann and Pons (FP). First, the FPE was described in a "preliminary note"[1] that is a remarkably dense 7 pages and extraordinary for its claims. It was written in one afternoon and to expedite publication the authors never saw the final galley proofs. It provided very few details about the design of the electrochemical ceils or other information to educate experimenters in the subtlety of the experiment. In particular, the duration of an experimental cycle and other crucial information was not published in the scientific literature until FP's paper[9] was submitted 21 December 1989. Note that FP had completed a patent application, which remains publicly unavailable to this day, prior to submission of their "preliminary note"[1] - which had been received by the Journal of Electroanalytical Chemistry on 13 March 1989 and in revised form 22 March 1989, all prior to the press conference.

Lewis, et al, CalTech. Lewis, et al[10] attempted replication of the FP experiment but lacked detailed information about FP's experimental design. The California Institute of Technology Summer 1989 alumni magazine *Engineering & Science* [11] contains the most detailed published description of the design of the calorimeters and procedures used by Lewis, et al[6]. It is not possible using the published record to do an accurate comparative analysis of these attempted replications of the FP experiments. It appears that the Lewis group never had an experimental cycle longer than 18 days. Further, the quality and maturity of their calorimeters, their experimental design, and the analysis of their results make their published work of historical but not scientific interest in establishing or rejecting the FPE. It is also worth noting that Lewis, et al were highly visible[11] in the popular press and were subjected to and major participants in the pressures of the intense public relations firestorm that had started on 23 March 1989.

Williams et al, [2] Harwell. By reputation in the scientific community Williams, et al2 at Harwell in England conducted the most careful and complete replication trials of the FPE heat experiments. Their "replication" of the FP experiments using their sixteen Fleischmann-Pons-Hawkins (FPH) calorimeters represented a very good first effort to explore the parameters of electrode size, effects of light and heavy water, different electrolytes, and extended measurement cycle times. The FPH cells were operated for over 40 days throughout which period the experimental team was under great pressure to complete the experiments, produce conclusions and ultimately provide a written report. This pressure produced an immature understanding of the error characteristics of their FPH cells. A second calorimeter, the isothermal or so-called plutonium calorimeter, was also set up to measure heat produced in an electrolytic cell of design radically different than those of FP. Although much has been made of the measurement accuracy of this isothermal calorimeter, there was only one such instrument in existence and the detailed behavior of the installed electrochemical cell was never researched. For example, the cell potentials in this cell seem unaccountably low for the operating current densities used, particularly when compared to the geometry and electrolyte of their FPH cells. As with Lewis, et al., the Harwell group operated under extreme public scrutiny and had little opportunity to revisit and reanalyze and mature their instruments or procedures.

Amoco[12] , Non-public report of internal 1989 work. In March 1993 the Research Department of the Amoco Production Company provided us with a copy of their internal report of work on the FPE they performed in 1989. Unlike most other research groups trying to do science under the glare of publicity, the Amoco team was able in 1989 to complete three iterations of experimentation, learning in each iteration how to improve and mature their experimental instruments and designs. The result of their 24 Oct-18 Dec 1989 experiment showed that an FPE experiment in a closed, flow calorimeter produced unaccountably large steady levels of heat, as well as bursts of heat, at magnitudes 100 to 1000 times greater than instrumental error. The cumulative net gain in energy was in excess of 50KJ. Further, the tritium level in the electrolyte at experiment start was 2.5 ± 1.0 pcurie/mL, while at the end of the experiment this had increased to 7.4 ±1.1 pcurie/mL; these results were achieved in a closed calorimeter. A complete material accounting was carried out for the water, palladium and lithium and essentially no materials were consumed during the experiment. They note that had the experiment been terminated in less than one month they would have failed to see the FPE. We are urging Amoco to submit this work for publication in a scientific journal.

Summary and Observations

With the cooperation of Fleischmann & Pons, Harwell, Amoco and the State of Utah's National Cold Fusion Institute, we have obtained raw experimental data from FPE experiments performed in 1989. A dispassionate and more leisurely analysis of that data shows that additional, useful information can be extracted from these early data sets. Results of our analyses will be published elsewhere. The 1989 conclusions and assertions about instrumental accuracy, presence or absence of anomalous levels of heat, and the failed appreciation of the subtle nature of these experiments can be seen in hindsight.

As observed by the Amoco researchers, patience was crucial to the success of their experiments. In retrospect, the CalTech and Harwell teams failed to produce "persons having ordinary skill in the art". They did not have the "teachings" of the FPE contained in the Utah patent applications, nor did they spend the time to understand the subtleties of the FPE experiments.

Attaining the level of skill to become a Mr. Phosita for the FPE in 1989 now seems beyond the reach of a group conducting crash experimentation in the full glare of public scrutiny. The pressure to perform produced:

- experimental cycles that were too short—CalTech;
- experimental cycles too lacking in guidance about the experiment being replicated—all experimenters, since the FP preliminary note[1] was hurriedly produced and short on information for a new field;
- experiments too visible to produce mature, considered scientific judgment - ERAB panel which had an impossible set of deadlines and no established FPE facts, and the CalTech and Harwell teams which operated at full tilt for a short period without adequate contemplation time.

The 1989 attempts by the ERAB and other public review groups to discern the "facts" of the FPE demonstrates how weak a process advisory panels can be when faced with masses of "preliminary notes", strict reporting deadlines, anecdotal evidence from laboratory visits where experiments are not actually in progress, and where debate is more informed by passion than laboratory experience.

Based upon our evaluation of the 1989 experimental data sets made available to us, we conclude:

- There is a Fleischmann-Pons Effect.
- The experimental signature of the FPE is heat.

Further, we observe that:

- Refinements of the 1989 FPE experiments are producing experimental protocols and instruments that meet the most stringent demands of science and possibly those of the patent system.
- Today, there is no “explanation” for the FPE, but from a patent perspective - it simply doesn’t matter, so long as the inventions perform as claimed.

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