FUSION facts

A Monthly Newsletter Providing Factual Reports On Cold Fusion Developments

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A. FUSION FACTS YEAR IN REVIEW

PONS, FLEISCHMANN HOPE FUSION FUROR WILL GIVE WAY TO SOLID NEW RESEARCH

(Reprinted from *Univ. of Utah REVIEW*, Vol 23, No 5, April/May 1990. By James C. Bapis, Review Writer.)

Two Utah chemists certain excess heat is nuclear. Buoyed by new verifications.

University of Utah chemists B. Stanley Pons and Martin Fleischmann, self-described "unrepentant" believers in their discovery of possible cold fusion, say the year-long controversy has slowed them from entering new pathways of research, but hasn't changed their minds about what they've found. "We feel this controversy has put us back at least a year in developing a tighter theoretical base," says Pons. "So far we've proved nothing additional in the whole year except we've confirmed over and over again what we've done."

On March 23, 1989, Pons and Fleischmann jolted the world of science with the announcement they had created nuclear fusion at room-temperature in a simple electrolytic cell. Their claim set in motion a protracted debate on the topic of cold fusion and a worldwide scramble to duplicate the experiment.

While some scientists resorted to jerry-built devices in the frenzy to duplicate what quickly became known as the Pons-Fleischmann "effect," others made use of the world's finest nuclear process monitoring equipment. Failures outnumbered successes in the race for replication.

Pons and Fleischmann are convinced the large amounts of excess heat they are regularly measuring in electrolytic cells is not the result of chemical reactions, but some kind of nuclear process at work. They made their discovery public after five years of experimentation in which they repeatedly rechecked their results and after submitting an article to a peer-reviewed journal.

"We are much more convinced now," says Pons about the findings. "If we were 99 percent sure, we are now 100 percent. We have made no mistakes in our calorimetric measurements. No one has ever convinced us that we made a mistake. We stand by that. As Martin says, we are 'unrepentant.'"

Some of Pons' cells have produced over 100 watts per cubic centimeter, or twice the energy output that he says one would expect in a water-cooled nuclear fission reactor.

The Dewar-type open systems cell he and Fleischmann use provide "very accurate values" of enthalpy, or heat output.
"We believe that more accurate values of heat outputs could not be derived by using more complex experimentation," according to the Pons-Fleischmann paper, which will be published in the July 1990 issue of the *Journal of Fusion Technology.*

"The rates of enthalpy produced during the 'bursts' are 17 times plateau levels and 40 times peak values of the total enthalpy input to the cells," their paper adds. "The cumulative excess enthalpy for the bursts...far exceeds the heat which could be generated from any conceivable chemical process."

Two other Pons-Fleischmann papers have also been accepted for publication in other journals. Fleischmann says that during the past year, because the cold fusion debate often reached a strident level, the two scientists were forced to spend less time on the innovative approaches to research for which they're known and more time on detail work.

"Neither Stan nor I ... especially enjoy 'i'-dotting and 't'-crossing," says Fleischmann. "We don't particularly enjoy working in great detail. We like more of the innovation aspect rather than the highly detailed work. It (the controversy) has compelled us to pay attention to the detail and so we do."

Despite the steadfast optimism of the two principal figures, the worldwide opinions of nuclear scientists, chemists, physicists, and engineers remain sharply divided over claims of cold fusion in a test-tube. After a six-month study, a special advisory board appointed by U.S. Department of Energy Secretary James Watkins recommended last November against approving special federal funding for cold fusion. The board concluded that the experiments in Utah and elsewhere presented "no convincing evidence to associate the reported anomalous heat with a nuclear process."

Cold fusion's biggest single boost came at the recent First Annual Conference on Cold Fusion sponsored by the University of Utah-affiliated National Cold Fusion Institute. At the three-day meeting, a string of scientists reported on successful experiments showing excess heat or the emission of nuclear particles or sometimes both.

Dr. Ernest B. Yeager of Case Western Reserve University appraised the conference as a "decisive turning point" in the history of cold fusion. Dr. John O. Bockris of Texas A&M said research has "passed the anecdotal stage". Dr. Robert A. Huggins of Stanford University said that if experimental results don't fit the theory, then theory must sometimes change. Dr. Giuliano Preparata of the University of Milan in Italy said that after months as a doubter he's convinced the reactions are "nuclear events". Utah's Gov. Norman Bangerter told fusioneers "we're with you all the way". And Nobel laureate Julian Schwinger of UCLA said "it is no longer possible to lightly dismiss the reality of cold fusion." But critics also had their say -- sometimes in conference sessions, sometimes speaking with reporters during breaks, sometimes hundreds and even thousands of miles away from the conference doors. Some who skipped the conference altogether resorted to ridicule and derision in dismissing fusion's relevance.

Appearing on network television, Robert Park, public affairs executive director of the American Physical Society, termed the Salt Lake gathering a "seance of a hardy band of remaining true believers." Only a few fusion skeptics chose to attend the proceedings.

Speaking from the floor at one of the sessions, Dr. Stephen Kellogg of the California Institute of Technology, reacted to the collective positive reports this way: "I would like to be Alice in Wonderland and accept so many impossible things before breakfast. I may be willing to accept one miracle, but what I see from this conference is that the various groups reporting positive results are at variance with each other. You can't all be right. Who among you is wrong?" [Note: Kellogg is one of the co-authors of a *Nature* article with data showing excess heat; [see Noninski's paper in section C of this issue. Ed.]

Pons and Fleischmann hope the results from the NCFI conference will provide seriously needed impetus for accelerated studies of the phenomena. Pons called the conference "fair and open." "The conference can do nothing but help science. I think it is now clear that there is something. If the atmosphere at this conference continues, it should move us along faster." He adds, however, that published attacks on cold fusion, such as those appearing in the British journal *Nature*, could hinder the pace of research. An editorial in the journal's March 29 issue bids "Farewell (not fond) to cold fusion," calling it a diminishing focus for professional belief.

Dr. Fritz G. Will, NCFI director and former senior research scientist at General Electric, says the meeting provided a "consensus" on the truth of heat production. He notes that the amounts of excess heat recorded in various experiments are too high to be attributed to chemical reactions. "Let us not be surprised that it will take theoreticians a long time before they will be able to come up with a self-consistent theory that explains the many multifaceted experimental results that have been presented," says Will.

He also confirmed that the institute, established last August with a $5 million appropriation from the state of Utah, recently received its first non-state funding, a $50,000 contribution from Utah Power & Light Co. Pons' and Fleischmann's findings, if proven correct, could turn conventional fusion theory inside out. At great expense, physicists have labored for years under the established theory that fusing atoms require heating to millions of degrees. Pons and Fleischmann believe they've found a simpler pathway, and at ambient conditions.

Dr. P.K. Iyengar, Director of India's Atomic Energy Commission, says he is convinced from research at the Bhabha Atomic Research Centre that "our results have conclusively established cold fusion does occur in deuterium-loaded palladium and titanium metal lattices." The Indian centre employs some 3,000 nuclear scientists. "Now that the effect has been established, the next step is to determine the ideal conditions under which you can multiply this event," says Iyengar. "By and large we have had success in 70 percent of our cells, which is a very high number." Pons has indicated an even higher success rate. Iyengar acknowledged, however, that the most important results from Bhabha may be the "surprisingly low" neutron yield ratio, on the order of one neutron per 100 million tritons. A triton is a nucleus of a tritium atom. He says these low neutron count rates relative to tritium levels defy conventional nuclear fusion theory and account for much of the skepticism in the physics community. "This branching ratio anomaly cannot be explained on the basis of our present understanding of fusion reactions," says Iyengar. But he thinks his research clearly shows, "there is a finite possibility that you can have an energy-producing source based on cold fusion." Researchers at the Indira Gandhi atomic centre have also reported positive results.

Scientists in both India and Japan have focused most of their cold fusion efforts on detecting neutrons, tritium, gamma rays and other subatomic particles because of their conviction that accurate heat flux measurements are extremely difficult to make.

Dr. Hideo Ikegami, Director of Nagoya University's Institute for Fusion Science, says 40 groups, including about 140 key personnel, assisted by staff and students, have been assigned to cold fusion experiments in Japan. He offered few specifics at the Utah conference on the Japanese studies, except to acknowledge "positive results" at some laboratories, particularly in excess neutron activity.

"So far the results are not as great as the very interesting results we heard at the Utah conference," says Ikegami. "I found (the reports) there very promising." He feels Japan's research is far too early in the development stage for definitive papers to be written. As a major energy importer, Japan operates an active fusion research program, especially in high-temperature fusion. Part of his country's interest in cold fusion is its potential for complementing and supporting much larger programs in hot fusion.

Any cold fusion process that inexpensively generates large amounts of tritium could have an enormous effect on studies in plasma physics, which is especially important in studies directed at moving thermonuclear fusion beyond the break-even point in energy output. Contemporary hot fusion research is focused on finding methods to contain a plasma (highly ionized gas) so that it yields more energy than required to raise the plasma to "ignition," the minimum temperature at which a hot fusion reaction occurs.

At Oak Ridge National Laboratory, Dr. Donald P. Hutchinson heads one of two hot-fusion groups who have turned their attention to cold fusion. Hutchinson doubts that the widespread and intensive scientific inquiries around the globe during the past year have yet shed much light on the true source of excess enthalpies variously reported.

"We've seen excess heat in our experiments, as others have in theirs. We have an anomaly, obviously. We have as much difficulty explaining that heat from a chemical standpoint as we do from a nuclear standpoint. But we see no nuclear signatures.

"It might be a nuclear event, but I'm not sure it's fusion. We are planning several new experiments to see whether the energy generated is on the surface of the rods or in the rods themselves and what might be the cause of the heat."

Another Oak Ridge scientist, Dr. Charles D. Scott, a research chemical engineer, says that he has simultaneously measured excess heat, neutrons and gamma rays in at least one closed system cell that recombines electrolytic gases. Excess heat production has been in the range of 5 to 10 percent.

"We've been able to initiate excess energy and maintain it for hundreds of hours, and our latest tests have also seen some increases in the neutron and gamma ray count rates. However, these levels of particles are at many levels of magnitude less than required to account for the excess energy by conventional nuclear theory," he says.

Neither Hutchinson nor Scott is ready to label their findings, nor those of any other scientists, as undeniable cold fusion. But Scott did tell a television interviewer that "our colleagues at the national laboratory believe the data we are reporting is credible scientific information."
Skeptics, such as Dr. John R. Huizenga, co-chairman of the now-dissolved U.S. Department of Energy advisory board on cold fusion, argue that the experiments reporting positive results show no consistent relationship between heat production and particle emissions.

Huizenga, professor of physics and chemistry at the University of Rochester, left the conference convinced that the DoE advisory board's report "still represents the best balance of exactly where things stand on cold fusion." He restated the board's conclusion that excess heat is insufficient to prove that the experimental cells are generating fusion reactions. "That argument (excess heat) is fallacious," he says. "It turns out that if nuclear fusion is really occurring there has to be a commensurate number of nuclear products. Unless people understand that, not much progress is going to be made."

Huizenga believes that one of the surest ways to resolve some of the larger differences among scientists is a collaboration on future projects between people reporting positive results and people reporting negative results.

"In our report, we suggested small amounts of funding for just such work. I'm not satisfied that's happened. I think that would be outstanding. It's the only way we're going to make progress in this field." He says that thus far no satisfactory evidence has emerged to indicate that the phenomena being reported will lead to any kind of new energy source.

Ninety percent of the researchers chasing the mystery of cold fusion are either not seeing positive results or only a "scattering" of positive results "because at low-current densities, it (the cell) can't decide whether to go or not to go," counters Pons.

"This is where the problem, I think, has been. All of our experiments show excess heat" at higher current levels. "When we take these cells up to high enough current, they all show positive heat. Scientific papers yet to be published will present evidence of neutron emissions", he adds.

Cold fusion experiments are also being run at other U.S. government laboratories. Results of the work of Edmund Storms and Carol Talcott of Los Alamos National Laboratory will also appear in the July issue of the *Journal of Fusion Technology.*

According to Storms, about 10 percent of the first 165 cells the two scientists operated produced tritium, mostly in relatively small amounts, in experiments using palladium cathodes and lithium deuteroxide electrolytes.

The Los Alamos studies have purposely avoided heat measurements, says Storms. "We adopted the philosophy that because the process is so irreproducible, a lot of variables need exploring and this can best be done least expensively by looking for evidence of tritium." He adds that because experimenters are rarely finding tritium and excess heat in the same cells, **fusion theorists should consider that separate processes are probably occurring.** "If we succeed in reproducing tritium (on demand) then we can begin looking for neutrons, and eventually for heat," says Storms, "we can detect even small amounts of tritium because we examine our cells once a day and have plenty of good statistics and controls running."

Dr. David Worledge, a physicist with the Electric Power Research Institute in California, says the conference convinced him that even in the face of higher quality experiments, evidence pointing toward the possibility of fusion reactions isn't retreating. "That's usually a sign of a real phenomenon," says Worledge. "I was encouraged by the quality of the presentations, although I don't believe the results...unequivocally prove the phenomena are real."

Worledge concluded his conference talk by showing an overhead view-graph entitled, "The Bottom Line," consisting of four "bullets" of information. The first bullet read, "Not Proved, Yea or Nay"; the second, "Don't Quit"; the third, "Don't Hold Your Breath"; and the last, "Do Science." "And I think we can see some decent quality scientific work being done," he said.

EPRI, a research consortium supported by utility companies, has provided some funding for cold fusion research. "The Holy Grail in the current research effort is finding at least one experiment that is truly reproducible," adds Worledge. "If not perfectly reproducible, then at least with a high enough success rate for independent laboratories to be able to follow the 'recipe' and get positive results." If the hurdle to reproducibility is cleared, new investigations are certain to begin on the metals most compatible with the fusion process and best able to withstand high electric currents without fracturing or losing their electrochemical properties.

University of Utah physicist Haven J. Bergeson will collaborate with Brigham Young University physicist Steven E. Jones on a study of how the neutron/tritium branching ratios in cold fusion cells (that generate positive effects) compare with conventional fusion theory.

Jones and Bergeson plan to operate their electrochemical cells underground, possibly in a mine in Park City, to block out neutrons caused by the constant bombardment of the earth by cosmic rays. Most cold fusion experiments claiming positive results report only small counts of neutrons relative to tritium. Conventional theory holds that the yields or branching ratios should be roughly the same.

Professor Jones also discounts excess heat as evidence of fusion. While heat values being reported may be accurate, "there is no evidence, whatsoever, that the heat is due to fusion. He admits he is "intrigued," however, by reports of tritium (which occurs only in traces in nature.)

Dr. Milton E. Wadsworth, Dean of the U of U College of Mines and Earth Sciences, says he is pleased with the cooperation and pooling of ideas that exists among researchers at NCFI. Wadsworth is one of America's highest honored metallurgists and a member of the National Academy of Engineering. "The relationship between our metallurgical group and the physical people headed by professor Bergeson, for example, is excellent. "We are collaborating very closely."

The exchange of information is beneficial to both groups. "A year ago everything was unsettled. Nobody knew where they were headed. Now we're seeing a quiet, steady evolution of science, the kind of effort that's going to produce important and revealing data."

Dr. Fritz Will adds that the hype that existed in the first few weeks and months after the Pons-Fleischmann announcement is over. Laboratories with no little or experience in electrochemistry were among those which had jumped into the research frenzy, hoping to duplicate the effect because of the potentially enormous economic and scientific implications. "But as time elapsed, and as many failed to find positive results, they ended their experiments, leaving the effort to some of the more established laboratories and to the scientists most seriously interested in the subject." Will says research is now in a "solid, gradual, and systematic" mode.

Wadsworth's team has shifted its primary focus away from heat measurements toward the search for cell start-and- stop capabilities. Another research objective is the possible role of material properties in touching off the elusive heat excursions and particle emissions. Last May, Wadsworth's group became the first on the University campus to independently confirm the kind of excess heat readings first reported in the Pons-Fleischmann experiments.

Dr. Gary M. Sandquist, professor of mechanical engineering at the University of Utah, says one of the many basic unanswered questions in the search for pathways to reproducible fusion at ambient conditions is a full understanding of the physical behavior of deuterons, the nuclei of deuterium atoms, in palladium and other potential "fusion catalyzing" metals.

In a search for answers, some fusion scientists have dusted off a 1935 paper by J. Robert Oppenheimer and M. Phillips, which describes the unusual behavior and interaction of deuterons with other nuclei. "Stripping" or removing neutrons from deuterons by particle acceleration provided scientists in the 1930's with an early source of neutrons for scientific research. "The Oppenheimer- Phillips model could possibly account for some of the unusual results in some fusion experiments, particularly the absence of significant neutron yields in electrochemical cells showing excess heat and in high-pressure gas experiments," says Sandquist.

"It's a nuclear process. We firmly believe this could only have a nuclear explanation", says Fleischmann. "We are convinced there are nuclear processes, but we are not convinced that it is fusion. That's the substance of what we've showed so far. Our position is exactly the same as it was last spring."

Fleischmann hopes that strife, if not disagreement, will now begin to subside so that the search for answers to cold fusion's validity can play itself out through careful and expanded scientific inquiry. "I hope it's the end of the beginning and not the beginning of the end. I hope that there is now a sufficiency of work which allows us to move forward to a comprehensive and rational design of new experiments. And I hope, in the end, that maybe something useful will come of it", says Fleischmann.

B. COLD FUSION SUCCESSES, ACHIEVEMENTS, AND PRIMARY SOURCES

The following scientists (principal investigators or authors) have reported positive results in cold fusion experiments as noted. Our sources of information are cited by last name. Scientists are listed alphabetically by last name.

1. Appleby (Texas A&M)
   Excess Heat: 19.3 W/cm^3; May 23, 89.

   Source: A.J. Appleby, S. Srinivasan, Y.J. Kim, O.J. Murphy, and C.R. Martin, "Evidence for Excess Heat Generation Rates During Electrolysis of D_2O in LiOD Using a Palladium Cathode - A Microcalorimetric Study", Workshop on Cold Fusion Phenomena, Santa Fe, NM, May 23-25, 1989.

2. Balding (Nytone Elec, UT)
   Excess Heat: 10%, April, 1989.

   Source: Personal communication 5/24/90

3. Bockris (Texas A&M)
   Excess Heat: 28% Peak, 20% Average; November, 1989.
   Tritium: $7.23x10^5$, $6x10^6$ dpm/ml; November, 1989.

   Source: J.O'M. Bockris in a presentation to attendees at the 13th Annual Utah Conference on Energy, Mining, and New Technology, U/U Sept 8, 1989 discussed the following: It is suggested that in the electrical field environment of a palladium deuteride lattice the nuclei of two adjacent deuterons will line up as follows: p - n : n - p. As a result of statistical tunneling the end result will be p - n - n : p where the p-n-n becomes the tritium nucleus and the p escapes.

4. Bush (Cal. Poly Univ.)
   Excess Heat: 30%; April 1989.

   Source: R.T. Bush (Cal. State Poly. U), "A Transmission Resonance Model for Cold Fusion" Presented at ASME Conference, San Francisco, Dec. 10-15, 1989, and personal communication.

5. Claytor (Los Alamos National Laboratory)
   Tritium: 1,000 x background; May 5, 1989. Larger amounts of 10^8-10^9 dpm, February, 1990.
   Neutrons: 9,000 neutrons /hr high, 4 or 5 neutrons per hour low; April 12, 1989.

   Source: Personal Communication, May 24, 1990 and July 31, 1990.

6. Criddle (U of Ottawa)
   Excess Heat: Initial burst 23.8%; June 20, 1989.

   Sources: Personal Communication on May 22, 1990 and letter on June 5, 1990. E.E. Criddle (U of Ottawa), "Exploratory Experiments Concerning Anomalous Thermal Effects In The Palladium-Deuterium System". 176th Electrochemical Society Meeting - Cold Fusion Session, 19-21, October 1989, Hollywood, Florida.

7. Faler (Idaho State U.)
   Neutrons: .003 n/sec above background; March, 1990

   Source: Personal Communication on May 24, 1990.

8. Hall (Novatek)
   Excess Heat: High 16.3%, Average 5.35%, July 18 & 19, 1989

   Source: H. T. Hall, (Novatek), "Observation of Excess Heat Production During Electrolysis of LiOD-D_2O solution on a Palladium Cathode", August 22, 1989 unpublished technical papers.

9. Huggins (Stanford)
   Excess Heat: 18% max. steady; November, 1989.

   Source: A. Belzner, U. Bischler, S. Crouch-Baker, R.M Gur, E. Lucier, M. Schreiber, and R.A. Huggins, untitled invited paper presented by Huggins at the Workshop on Cold Fusion Phenomena, Santa Fe, NM, May 23-25, 1989. Also presentation at ASME conference, San Francisco, Dec. 10-15, 1989, and personal communication.

10. Hutchinson (Oak Ridge Nat'l Lab.)
    Excess Heat: 5%; May, 1989. 20%; December, 1989.

    Sources: Personal Communication, May 23, 1990. D.P. Hutchinson, C.A. Bennett, R.K. Richards, V. Bullock, IV and G.L. Powell, "Initial Calorimetry Experiments in the Physics Division at ORNL, *Proceedings of the First Annual Conference on Cold Fusion"*, Salt Lake City, UT, March 28-31, 1990.

11. Iyengar, Srinivasan, Venkakeswaren (BARC, India)
    Tritium: 78 dpm/ml; December, 1989.
    Neutrons: 112.5 n/min; December, 1989.

    Source: P. K. Iyengar (BARC - Trombay, India) in "Cold Fusion Results in BARC Experiments" (Fifth International Conference on Emerging Nuclear Energy Systems, Karlsruhe, July 3-6, 1989) states in his summary: "The very high probability for the tritium branch in cold (d-d) fusion reactions would indicate processes of neutron transfer across the potential barrier as postulated by Oppenheimer over half a century ago and elaborated on more recently by Rand McNally..." [See Oppenheimer and Philips, Note on the Transmutation Function for Deuterons. Phys Rev 48, 500 (1935).]

P.K. Iyengar and M. Srinivasan (Editors), BARC Studies in Cold Fusion (April - September 1989), Bhabha Atomic Research Centre, Trombay, India, December 1989. [A collection of twenty papers showing positive results in the scientific replication of the Fleischmann/Pons work.]

12. Jones (Brigham Young Univ., UT)
Neutrons: .169 neutrons per sec; May 27, 1986. .06 neutrons per sec (energy spectrum also measured); Apr 19, 1989.
Source: J. Rafelski & S.E. Jones, Scientific American, 267, pp 84-89, (July 1987). S.E. Jones, E.P. Palmer, J.B. Czirr, D.L. Decker, G.L. Jensen, J.M. Horne, S.F. Taylor, and J. Rafelski, "Observation of cold nuclear fusion in condensed matter.", *Nature*, 338, pp 737-740 (1989).

13. Liebert (U of Hawaii)
Excess Heat: 600% to 1200% , using high temperature molten system; Oct., 1989.

Source: Personal Communication, May 24, 1990.

14. Matsumoto (Hokkaido U.) Using ordinary light water.
Neutrons: A little above background; November 13, 1989, using ordinary light water.

Source: Takaaki Matsumoto, "Cold Fusion Observed with Ordianry Water", *Fusion Tech.*, Vol 17, pp 490-1, Mar. 1990.

15. McBreen (Brookhaven Nat'l Lab)
Excess Heat: Unknown; September, 1989.
Tritium: 7×10^3 dps/ml; April 22-23, 1989.

Source: Personal communication, May 23, 1990, and June 12, 1990. James McBreen, (Dept of Applied Science Brookhaven Nat'l Lab), "Absorption of Electrolytic Hydrogen and Deuterium by Pd: The Effect of Cyanide Adsorption".

16. Menlove (Los Alamos National Laboratory)
Neutrons: .01-.1 n/s random events; April, 1989.

Source: Personal communication, May 25, 1990. H.O. Menlove (LANL), "High Sensitivity Measurements of Neutron Emission from Ti Metal in Pressurized D_2 Gas" *Proceedings of the First Annual Conference on Cold Fusion"*, Salt Lake City, UT, March 28-31, 1990.

17. Miles (Naval Weapons Center)
Excess Heat: Average 17%; Sept 1989, 10%; Nov, 1989, 8%; March 1990. Peaks were 30%, 15%, & 15%.

Source: M.H. Miles, (Naval Weapons Center), "Electrochemical Calorimetric Studies of the Cold Fusion Effect", *Proceedidngs of the First Annual Conference on Cold Fusion"*, Salt Lake City, UT, March 28-31, 1990

18. Noninski (Sofia, Bulgaria)
Excess Heat: >20%; ten experiments, May, 1989. Range 1.6 to over 40 W/cm^3 of Pd.

Source: V.C. Noninski and C.I. Noninski (LEPGER, Sofia, Bulgaria), "Determination of the Excess Energy Obtained During the Electrolysis of Heavy Water.", submitted to *J. Electroanal. Chem.* (Copy mailed to Fusion Facts, October 25, 1989). Personal communication.

19. Oriani (U of Minnesota)
Excess Heat: 5-20%; July, 1989.

Source: Personal Communication, May 24, 1990.

20. Pons & Fleischmann (U of UT)
Excess Heat: 53% burst; March 13, 1989.
Tritium: $4.2x10^5$ dpm/ml; March 1989.
Neutrons: Above background; March 1989.

Source: M. Fleischmann, S. Pons, and M. Hawkins, "Electrochemically induced nuclear fusion of deuterium." *J. Electroanal. Chem.*, 261, pp 301-308, and erratum, 263, p 187 (1989).

21. Sanchez (U. Madrid, Spain)
Tritium: Ave. 1080 to 1230 dpm/ml per hour. Single burst, 4557; June 9, 1989.
Neutrons: 6.7 /hr average; June 9, 1989.

Source: C. Sanchez, J. Sevilla, B. Escarpizo, F.J. Fernandez, and J. Canizares, "Nuclear Products Detection during Electrolysis of Heavy Water with Ti and Pt Electrodes.", *Solid State Communications*, Vol. 71, No. 12, pp 1039-1043, 1989. [Authors use a Ti cathode, Pt anode, heavy water with Li_2SO_4 as an electrolyte. After a charging time of about five days, bursts of neutrons are recorded followed by an increase in tritium measurements. The conclusion states: "...the observations reported are compatible with the existence of cold fusion processes. However, the underlying theoretical mechanism is still unknown. The process has an incubation period of about five days and we have not yet been able to pinpoint the exact conditions under which it occurs. Although the threefold type of observations leave little doubt as to the existence of the phenomena, reproducibility still remains poor."]

22. Santhanam (Tata Inst, India)
Excess Heat: w/Pd 48%, w/Ti 17.6%; April 25, 1989.
Tritium: 48% above background with Pd; April 25, 1989.

Source: As reported earlier in the September, 1989 issue of *FUSION FACTS*, an article in *The Indian Post* (May 7, 1989) by Michael Neri reports the following: "Dr. K.S. V. Santhanam, head of the chemical physics department at TIFR (Tata Institute of Fundamental Research, Bombay), said, `We also read the first reports of the experiment in the newspapers and decided to attempt it immediately but changed two important parameters of the Utah experiment -- titanium in place of palladium and simple sodium chloride for lithium.' On the TIFR;s third attempt (they wrecked two temperature measuring thyristors while trying), a phenomenal temperature rise of 1 degree C per minute was recorded."

23. Schoessow (U of Florida)
Excess Heat: >20%; July 1989.
Tritium: 50,000 dpm/ml; April 1989.

Source: Personal communication, May 25, 1990.

24. Scott (ORNL)
Excess Heat: 50% spontaneous, 5-10% ave.; May 5-9, 1989.
Tritium: 3000 dpm/ml; July 1989.

Source: C.D. Scott, J.E. Morchek, E. Newman, T.C. Scott, G.E. Michaels, and M. Petek (Oak Ridge National Laboratory), "A Preliminary Investigation of Cold Fusion by Electrolysis of Heavy Water.", presented at COLD FUSION - A STATUS REPORT session in conjunction with the ASME Winter Annual Meeting held in San Francisco, CA, December 12, 1989. (Oak Ridge National Laboratory Publication ORNL/TM-11322 available from NTIS, Dept of Commerce, 5285 Port Royal Rd., Springfield, VA 22161.)

25. Storms & Talcott (Los Alamos National Laboratory)
Tritium: 1.5 to 80 times starting concentrations; Dec. 1989

Edmund Storms and Carol Talcott (Nuclear Materials Div, LASL), "Electrolytic Tritium Production", Paper LAUR:89-4138, Draft Released Dec. 1989, 19 pages, 23 refs. [Abstract: 53 electrolytic cells of various configurations and electrode compositions have been examined for tritium production. Significant tritium has been found in eleven cells.]

26. Tanigucho (OPRRT, Japan)
Neutrons: 5 times background; July 19, 1989.

Source: Ryoichi Taniguchi, (Osaka Prefecture Radiation Research Institute), "Detection of Charged Particles Emitted by Electrolytically Induced Cold Nuclear Fusion", *Japanese Journal of Applied Physics*, Nov. 9, 1989, Vol 28, No 11.

27. Wada (Nagoya U, Japan)
Neutrons: $2x10^4$ times background; August 9, 1989.

Source: Nobuhiko Wada and Kunihide Nishizawa (Nagoya Univ), "Nuclear Fusion in Solid", *Japanese Journal of Applied Physics*, Vol 28, No 11, November 1989, pp L2017-L2020, 3 refs., in English.

28. Wadsworth (U of Utah)
Excess Heat: 50% in burst; May, 1989.

Source: Personal communication, also in Deseret News article.

29. Wolf (Texas A&M)
Tritium: 10^8 dpm/ml; May 1989.
Neutrons: 100 n/min; January 1990.

Sources: K.L. Wolf, N.J.C. Packham, D.R. Lawson, J. Shoemaker, F. Cheng, and J.C. Wass (Texas A & M), "Neutron Emission and the Tritium Content Associated with Deuterium Loaded Palladium and Titanium Metals.", *Proceedings of the Workshop on Cold Fusion Phenomena*, May 23-25, 1989, Santa Fe, NM.
Personal Communication: June 1990.

31. Yeager (Case Western)
Excess Heat: 5-10%; June 1989.
Tritium: 100 dpm/ml; June 1989. Source: Personal communication: 5/25/90

NOTE: Many other scientists have reported positive results in replicating the FPE. As we obtain copies of their papers or answers to our letters, we will add their time and successes to our charts and source references.

NOTE: *FUSION FACTS* wishes to thank Dr. Fritz Will (National Cold Fusion Institute) and his staff and Dr. Edmund Storms (LANL) for sharing their lists of cold fusion successes.

THE FOLLOWING THREE CHARTS DEPICT THE DEGREE OF SUCCESS AND THE TIME PERIOD AT WHICH SUCH SUCCESS WAS ACHIEVED. CHARTS FOR EXCESS ENERGY, NEUTRON EMISSION, AND TRITIUM PRODUCTION FOLLOW:

CHART OF EXCESS ENERGY

```
    |
    | <-- % Above Break Even

1200 <                          600-1200
 600 >                         (Liebert)
    <                         high temp
    |                         molten system.
 60 |                           Verbal report, no
    |                         published data
    |  53
 50 |  (Pons)   50sp
    |        (Scott&Wadsworth)
    |
    |     48Pd
 40 |     (Santhanam)
    |
    |
 30 |     30                  30pk
    |   (Bush)  24            (Miles)   28pk/20av
    |       (Criddle)  >20              (Bockris)
    |       >20   (Schoessow)
 20 |        (Noninski)         20
    |                     (Hutchinson)
    |
    |   17.6 Ti      16.3 h     17 ave     18
 15 |     (Santhanam)    (Hall)     (Miles)    (Huggins) 15 pk
    |                                   (Miles)
    |
    |                       10 ave
 10 |              5-20              (Miles)
    | (Balding) 5-10   (Oriani)
    |         (Yeager)                        8 ave
    |      5-10su     5.35 av                   (Miles)
  5 |       (Scott)    (Hall)
    |        5 (Hutchinson)
    |                                1-2
    |      19.3W/cm^3 of Pd                    (Droege)
    |      (Appleby)
    |
Break|
Even |
    |________________________________________________________________

      Mr   Ap   My   Jn   Jl   Au   Sp   Oc   No   Dc   Jn   Fb   Mr
     1989                                   1990
```

The following scientists reported excess heat but the time & amounts were not available: Byelorussian State U, Cai, DeMaria, Gozzi, Kishan, Kuzmin, McBreen, McKubre, Milikan, Ohta, Riley, and Werth.

LEGEND: av=average; h=high; pk=peak; sp=spontaneous; su=sustained; Ti=titanium cathode; >=greater than.

NOTE: All experiments used palladium unless otherwise noted.

CHART OF NEUTRON EMISSION

```
 15 |  <-- Neutrons Per Second
    |
    |            12.6
    |             (Sanchez)
 10 |                   10.98
    |                  (Wada)
    |
    |                  5 x bg (Taniguchi)
  5 |
    |                          2.0
    |      2.5 hi          (Iyengar, Srinivasan,          |    (Claytor)      & Venkakeswaren) 1.66
  1 | .169                         (Wolf)
    | (Jones)    .06sp
    | May '86   (Jones)                  .003
    |                             (Faler)
    |      .01-.1
    |      (Menlove)
    |
    |     .00138 lw           above bg
Back |      (Claytor)            using light water
Ground|                       (Matsumoto)
    |
    |
    |______________________________________________________________________
    May   Mr  Ap   My   Jn   Jl   Au   Sp  Oc  No  Dc  Jn  Fb  Mr         986  1989                 1990
```

The following scientists measured neutrons above background.
Detailed reports being sought: Alquasmi, Bertin, Blanco, Cai, Celani, DeMaria, Gozzi, Jorne, Kishan, Kuzmin, Mathews, Milikan, Mizzuno, Palamalai, Raghaven, Sanchez, Santhanam, Scaramuzze, Tanigucho, Zelensky.

LEGEND
hi=high
lw=low
sp=energy spectrum measured
bg=background level

Note: Experiments used both palladium and titanium. Many of the neutron-producing experiments used gas-loading, others used electrochemical cells.

CHART OF TRITIUM PRODUCTION

```
      |  <-- Counts per minute per ml.
10^10 |
      |
      |
10^9  |
      |                       10^8 - 10^9
      |                       (Claytor)
10^8  |       10^8
      |      (Wolf)       10^7 - 10^8
      |                (Iyengar & Srinivasan)
10^7  |
      |  6x10^6
      | (Bockris)
10^6  |
      |
      |  4.2x10^5
10^5  |      (Pons & Fleischmann)
      |
      |  5x10^4 (Schoessow)
10^4  |   7x10^3         3X10^3(Scott)
      | (McBreen)      1.2x10^3
      |             (Sanchez)
10^3  |        10^3
      |      (Claytor)
      |
10^2  |           10^2
      |          (Yeager)
      |
10^1  |
      |                   1.5 to 80 x background
      |                   (Storms & Talcott)
      | 48% above backgrd
      |  (Sanathanam)
      |
Break |
 Even |
      |
      |____________________________________________________________

        Ap  My  Jn  Jl  Au  Sp  Oc  No  Dc  Jn  Fb  Mr
        1989                            1990
```

The following scientists reported tritium production. Detailed reports are being sought: Alquasami, Cherepin, Gozzi, Kuzmin, McKubre, Morales, Riley, Scaramuzzi, Seminozhenko, Zelenskiy.

NOTE: Nearly all tritium production used Pd.

NOTE TO READERS: Please call or write Fusion Facts for additions or changes to these charts. Phone (801) 583-6232 or Fax (801) 272-3344. Thanks. Ed.

C. FUSION NEWS FROM THE U.S.

NAVAL RESEARCH LAB - DEUTERON SPACING

B.I. Dunlap, D.W. Brenner, R.C. Mowrey, J.W. Mintmire, and C.T. White (Naval Res Lab), "Linear combination of Gaussian-type-orbitals-local-density-functional cluster studies of D-D interactions in titanium and palladium", *Phys Rev.* B, Vol 41, No 14, pp 9683-9687, 33 refs., 15 May, 1990.

ABSTRACT

Linear combination of Gaussian-type orbitals (LCGTO) - local-density-functional (LDF) cluster calculations give the interaction energy of two deuterium atoms in the interstices of titanium and palladium. Octahedral and tetrahedral interstices of the face-centered-cubic (fcc) lattice are modeled by six and four metal atoms, respectively. No short equilibrium separations, compared to the gas-phase equilibrium separation, are found even when expansion of the lattice and loading with additional deuterium and metal atoms are considered. The deuteron affinities of these clusters are in accord with the experimental site preference.

CONCLUSION

The effective interaction between deuterons in both interstices in both Pd and Ti is found to be more repulsive than in free molecular D_2. Along directions of least repulsion in all four interstices both deuterons repel each other out of the interstitial volume. In this work, the above conclusion has been tested in three new ways. First, two different LDF's agree in predicting this repulsive interaction. Second, we have considered the fact that both lattices expand as they absorb deuterium. Expanding the titanium lattice gives more room for the deuterium atoms to push each other further apart. Third, loading the expanded lattice with spectator deuterium atoms also does not squeeze two deuterium atoms together. Combined with our earlier work that included empirical potentials and ab initio calculations, we believe it unlikely that any theoretical approach to this problem would find a stable static configuration that could squeeze two deuterons even as close as they are in the free D_2 molecule.

COMMENTS

The authors may want to consider the probability for a "hopping" or itinerant deuteron to fuse with or come closer to a deuteron trapped in the lattice. It does not appear fruitful to expect "trapped" deuterons to fuse. The wave rather than the particle approach may be a more fruitful view of deuterons (or protons) traveling or hopping in a metal lattice.

COLD FUSION POWER PLANT -REUTER

Andrew Stern (Chicago), "Utah Researchers Aiming for Small 'Cold Fusion' Power Plant", Reuter News Wire 24 April 1990.

This news report stated: CHICAGO, REUTER - Building a small-scale "cold fusion" power plant by the end of the year is the goal of the research team that claimed to achieve nuclear fusion at room temperature just over a year ago, the scientist overseeing the research said Tuesday.

Dr. James Brophy, vice president of the University of Utah research institute formed to study the as yet unexplained process, said the sharp criticism directed toward chemists Stanley Pons and Martin Fleischmann has softened. The model power plant would thin the ranks of skeptics, he said.

"Pons and Fleischmann have hopes of building a 100-watt power plant by the end of the year that they can turn on and off at will." Brophy said at a conference of the nation's utility executives and engineers. "I think they might be a little premature (regarding the timing), but I'm not going to criticize them,"" he said.

There have been dozens of attempts at the University of Utah and in laboratories around the world to reproduce the simple experiment. Some researchers have declared the experiment was a fraud while others said some type of low-level nuclear fusion had taken place.

The scientists working in Utah caused an uproar last March when they first reported discovering a simple experiment that created more energy than it consumed. The result held open the possibility that a source of pollution-free and unlimited energy had been found.

Nuclear fusion, the force that powers the sun, occurs when atoms are fused together rather than broken apart, as they are in nuclear reactors. But fusion research, up until the Utah experiment, concentrated on achieving it at extremely high temperatures like those found in the sun.

Scientists researching room temperature fusion have observed sustained emissions of energy up to 40 times the amount of energy consumed in the experiment, Brophy said. The surges have lasted for hours or even days but then ceased for no apparent reason, leaving scientists baffled, he said.

Pons and Fleischmann hope to be able to control the process, and are experimenting with putting the elements under pressure, Brophy said.

For now, the cold fusion researchers have attained the equivalent of boiling water, he said, but someday there may be fusion-powered homes, cars, and space vehicles.

The university's research institute has been funded by a $5 million grant from the state of Utah, but Brophy said several companies have offered to join the project, which could in turn encourage federal funding.

COLD FUSION - NEW PHYSICS

Hal Fox, "Understanding Cold Fusion As a New Physical Principle", *21st Century Science and Technology,* Spring 1990, pp 14-15, 4 refs.

COMMENTS

Fox discusses eight major stumbling blocks that have prevented many traditional scientists from recognizing the reality of cold fusion. Fox pleads for more exchange of information among researchers as fast as new discoveries are made.

AT STANFORD FUSION WORKS

K.L. Zondervan, "Cold Fusion Works At Stanford University!", *21st Century Science and Technology,* Spring 1990, pp 16-22.

One of the first researchers to announce that he had replicated the Fleischmann-Pons cold fusion effect (anomalous heat) was Dr. Robert A. Huggins of Stanford University's Solid-state Ionics Laboratory. 21st Century staff reports on an interview with Prof. Huggins. One of the most interesting observations by Dr. Huggins was in response to the question about the difficulty of replication, "Might other labs have difficulty in this regard?". Huggins responded, "I think they could do it if they chose to. ... But if you talk to people like Nate Hoffman (at Rockwell International Corp.) who has looked at the materials used by various people and looked at what shows up on the surfaces after they've been treated in various different environments, you find that there's a tremendous variation, and it's not surprising that the behavior should be very different. And, also, some of the people who have reported negative results, have, we believe, been running their experiments in ways that are not in the regime in which we would expect to see excess power."

The article ends with the following quote from Professor Huggins, **"I believe that anybody who feels that the whole thing is an experimental artifact has got his head in the sand."**

TRITIUM AND EXCESS HEAT AT TAM

Marjorie Hecht, "'Something' is Producing Tritium and Excess Heat", *21st Century Science and Technology,* Spring 1990, pp 23-27.

Marjorie Hecht interviews Dr. Nigel Packham who is part of the cold fusion team at Texas A&M. Packham reports on a cell that is producing both tritium and excess heat. The tritium accounts for about 1/1000th of the excess heat. Packham points out some small differences between his cell construction that is producing copious amounts of tritium and the cell construction at the National Cold Fusion Institute in which less tritium is being produced. Packham also points out the current difficulty of obtaining funds to continue with cold fusion research. He stresses that the difficulty in getting results takes a lots of careful work plus a degree of patience. Packham also cites the use of nickel for the anode (with palladium as the cathode) that appears to favor the production of tritium. The amount of tritium produced has been measured at 10,000 to one million times the background tritium levels.

COMMENTS

One factual observation that is common to nearly all of the cold fusion experiments is the skilled attention to fine details in order to replicate observed effects. The problem is that scientists are still finding out some of the factors that cause or block the onset of cold fusion. While this issue of *Fusion Facts* was in preparation, we received word from Dr. Wolf that there had been some tritium found in at least one of the Pd samples similar to those used in the tritium-generating cells. Dr. Wolf stated that the amount was much below the amount of tritium that had been produced but was a surprise and a concern. *The Wall Street Journal* was followed by the *New York Times* in making a big story out of this rather minor finding. One scientist was reported by the *New York Times* as proclaiming this event being the last nail driven into the cold fusion coffin. Some are anxious to bury cold fusion. Stay tuned for latest developments. Ed.

IMPURE PALLADIUM RODS AT TAM

Jerry Bishop, "Scientist Says 'Cold Fusion' Tests May Have Had Some Impure Rods", *Wall Street Journal*, June 7, 1990.

COMMENTS

Bishop reports that Kevin Wolf, a physicist in the Cyclotron Lab at Texas A&M, reports that at least some of the palladium rods used in cold fusion experiments might have been contaminated with tritium. The important statement, accurately relayed by Bishop (but subsequently greatly distorted by other publications) is the following:

"The surprising discovery is likely to add new confusion and controversy to the cold fusion work, although scientists said it doesn't undermine other evidence that some kind of strange phenomenon is occurring in various cold fusion experiments.

"... In the past year, as many as two dozen laboratories have reported finding tritium in their cold fusion experiments that wasn't present at the beginning of the experiments."

"...All the tritium-contaminated pieces, he said, came originally from Hoover & Strong, Inc., a metals processor in Richmond, VA."

Bishop reports the following from Dr. Bockris at TAM:
"...' I've been thinking about it for two days.' he said. But, he added, 'I haven't changed my mind.' that the tritium in his experiments is coming from some kind of nuclear reaction. He explained that he and others [at TAM] had pondered some 'worst case' scenarios involving tritium-contaminated palladium and none of the scenarios produced as much tritium as he has found in his experiments."

It is unlikely that tritium within a palladium rod immersed in an electrochemical cell (designed to force deuterium into the cell) could provide a means by which the tritium would leave the palladium and enter the cell electrolyte. In other words, it is not expected that a palladium rod loaded with tritium and maintained as the cathode in a cell could unload its tritium into the electrolyte.

Bishop was right in suggesting that this report could add new confusion to the cold fusion discussion. This report has elicited such comments as "this is the last nail to be driven in the cold fusion coffin". Immature or prejudiced scientists will be quick to leap on this finding as destroying credibility in cold fusion. Mature scientists will seek to determine how much effect the small amount of tritium found in the palladium would have on the end measurements of tritium. Ed.

MIT TECH TALK

Eugene F. Mallove (MIT News Office), "One Year Later. The Cold Fusion Mystery Continues", *MIT Tech Talk*, Vol 34, No 27, Wed. April 11, 1990.

COMMENTS

Dr. Mallove attended the First Annual Cold Fusion Conference at Salt Lake City and reported on some of the findings. Mallove quotes Dr. Petrasso (who also attended the conference), "I believe the claims of excess heat as directly attributable to nuclear fusion processes are still without substance."

Mallove correctly observes: "One of the most annoying factors in the experimental work, many would agree, is the lack of reproducibility at will of many of the results. They can be duplicated, but still not in every case. Some researchers require runs with many cells before getting an observed effect in some cells, others see effects more consistently."

Mallove continues, "An indication of why this may be happening was provided in numerous electron microscope views of palladium electrodes taken before and after operation. Researchers provided ample evidence that the surfaces of the rods are of great physical and chemical complexity. There are thoughts that the effects, if any, may occur in peculiar localized regions."

Mallove also quotes *Nature's* comment by Dr. David Lindley, "What was reprehensible a year ago has become absurd....Would a measure of unrestrained mockery, even a little unqualified vituperation have speeded cold fusion's demise?".

Mallove also gave Fleischmann and Pons' retort: "If Lindley doesn't have the time to come now to Utah to gather information first hand, then why doesn't he at least have the sense to use that well-known shortcut of establishing the scientific credentials of the believers and non-believers, namely the Citation Index?".

NATURE

"Cold Fusion Gets the Cold Shoulder", *Business Week*, April 9, 1990, page 51.

This short article notes the irony of the publication by *Nature* of a negative article just in time for the First Annual Cold Fusion Conference in Salt Lake City, Utah. Article quotes Solomon as stating, "We didn't see the tiniest peep of any **known** fusion reaction."

A REVIEW OF METAL FORMING
(Courtesy of Dr. Samuel Faile)

Margaret Hunt (Assoc. Ed.), "Casting About for New Applications", *Materials Engineering*, May 1990, pp 33-37.

ABSTRACT

Automotive and aerospace casting applications are increasing in number as new processes and alloys offer closer tolerances and improved properties at reduced costs.

COMMENTS

This article summarizes the state of the art in practical metal casting technologies. Some of the newer techniques may be applicable to forming fusion cell components or parts. New methods of vacuum-assisted casting can form thin webs even using stainless steels or form single-crystal castings.

TITANIUM CASTING FACILITY
(Courtesy of Dr. Sam Faile)

"Total Capability in Titanium Investment Casting", *Metallurgic*, Vol 56, No 4, April 1990, pp 189-190.

ABSTRACT

This article focuses on the Howmet Corporations's metal-to-finished part capability in the production of lightweight, rugged and corrosion-resistant titanium investment castings, primarily for aircraft engine and airframe applications and for medical implants. The corporations's high technology equipment and processing

facilities reflect the current state-of-the-art worldwide in advanced precision casting for this material.

COMMENTS

Metallurgic is a British publication but the article features the Howmet Corporation of Greenwich, CT.

HOT EARTH BY COLD FUSION?
(Courtesy of Dr. Sam Faile)
Steve Nadis, "This Place is Really Hot, Dude", *OMNI*, June 1990, p 40.

COMMENTS

For scientists considering the effect of geologic fusion on the sub-surface earth's heat this report on the "much hotter than expected" forecast of earth's molten core may be of interest. Article cites work of Raymond Jeanloz at the University of California - Berkeley concluding that the earth's core is hotter than the face of the sun - about 12,000 degrees.

FICTION: OVER FLAT MOUNTAIN
(Courtesy of Dr. Samuel Faile) Terry Bisson, "OVER FLAT MOUNTAIN", *OMNI*, June 1990, pp 48-87.

One of the first fiction stories in which cold fusion is mentioned - earth deformation.

LETTERS FROM READERS
EXCESS HEAT TAPERS OFF

Ernie Criddle, Principal Investigator of Cold Fusion, Centre Scientifique et Technologique en Electrochimie, University of Ottawa, May 29, 1990.

In response to our query, Criddle submitted the following letter: "...We achieved excess heat from an electrochemical cell (O.2M LiOD in D_2O) using a 6.35 mm dia. x 2 cm. Pd rod as cathode and Pt anode as described in the attached paper [1].... Our experiment started on April 21, 1989; it was shut down from 24 to 27 April and then re-started. Excess heat appeared on June 20, 1989 (day 46 of the run). For the first 46 days cell heating amounted to 5.36 deg C/watt for the 187.5 mA x (3.981 volt - 1.54 volt gas evolution correction) input energy. After a brief current interruption on day 46, cell heating amounted to 6.64 °C/watt at the same cell current and voltage. The difference of 1.28 °C/watt was a 23.8% increase. A second current interruption on day 52 resulted in a very small loss of heating. The excess heating tapered off to almost nothing by day 61 after 15 days of excess heating. The average excess heat was therefore about 24% tapering to nothing in 15 days. Our original observations compared heating in a D_2O cell with heating in an H_2O cell. Bockris's comments following the Electrochemical Society meeting suggested that heating out/heating in would provide a more valid observation for comparison with others so I re-calculated results and use this data for the excess quoted above."

COMMENTS

Discussions and papers on successful cold fusion experiments are showing more evidence that the excess heat can, in several cases, change dramatically with time. Since the report that ^{6}Li decreases with respect to ^{7}Li in the electrolyte of a working cell, there is speculation that a lithium nuclear reaction with deuterium may be responsible for the decrease in excess heat as the ^{6}Li is expended. However, ref [1] data, while showing some small change in ^{6}Li to ^{7}Li ratio, does not support the decrease in excess heat as a function of ^{6}Li decrease.

[1] W.A. Adams, E.E. Criddle, and V.S. Donepudi (U of Ottawa), "Exploratory Experiments Concerning Anomalous Thermal Effects in the Palladium-Deuterium System", paper presented at 176th Electrochemical Society Meeting, Cold Fusion Session: 19-20 October 1989, Hollywood, Florida.

CRIDDLE AND TRITIUM - CORRECTION
In a letter on June 5, 1990 to Dr. Edmund K. Storms (LANL), Criddle adds the following information:

"...That experiment [see above] did not analyze exhaust gases for tritium. Tritium levels in the electrolyte almost doubled during 14 weeks as expected by the evolution of deuterium from heavy water. We did <u>not</u> establish that tritium had formed at all so any thoughts about tritium formation and run down according to the recent findings of others would be pure speculation.

We have almost completed a second experiment in which we recombined and saved exhaust gases but we did not measure cell heating. Tritium analyses are pending so I cannot comment on whether our techniques have produced tritium or not."

FUSION FACTS apologizes for the error in our May issue in which we credited Ernie Criddle's team with producing tritium in excess of that concentrated by electrolysis. Ed.]

PITS DESTROY EXCESS HEAT
Note from Dr. Samuel Faile

"In a telephone discussion with Dr. Yeager of Case Western Reserve, he said that pits in the palladium cathode can kill the cold fusion reactions. Large visible pits are a problem. Small pits or voids smaller than those that can be seen by an optical microscope can also prevent a cold fusion reaction. Perhaps this insight is an explanation of why some electrodes never produce excess heat even though others with an identical composition produce excess heat."

* * * * * * * * * * * * * * * *

D. FUSION NEWS FROM ABROAD

CANADA - NO d-t FUSION
Courtesy of Dr. Samuel Faile

J.R. Southon, J.W. Stark, J.S. Vogel, and J.C. Waggington (McMaster U. Hamilton, Ontario), "Upper limit for neutron emission from cold d-t fusion", *Physical Review C*, Vol 41, No 5, pp R1899-1900, May 1990, 11 refs.

ABSTRACT

Reports that fusion of hydrogen isotopes may occur at room temperature during the electrolysis of D_2O led us to investigate possible d-t fusion reactions in an electrolysis cell with a tritiated Ti cathode. A search for 14-MeV neutrons from this reaction, using an NE213 scintillator detector and pulse-shape discrimination techniques, showed no significant deviations from background levels. We derive an upper limit of 10^{-23} per second for the fusion rate per d-t pair.

COMMENTS

In the final paragraph the authors note: "It should be noted, however, that attempts to duplicate the earlier d-d experiments revealed no statistically significant neutron fluxes above background. Either the earlier results are in error, or reaction rates for cold fusion processes (including d-t) may depend critically on subtle differences in experimental conditions."

FROM CHINA
THEORY - NON-EQUILIBRIUM PROCESSES
Courtesy of Dr. Samuel Faile

By Dr. Shang-Xian, Jin, Yi-bing, Ding, Yong-zhen, Liu, Bai-lu, Wu, and De-cheng, Yao (Dept. of Physics, Graduate School, Academia Sinica, Beijing, China), "Rate of Cold Nuclear Fusion of Deuterium in Palladium", *Chinese Physics Letters*, January, 1990.

ABSTRACT

Possible mechanisms of deuteron-deuteron fusion during electrolytic infusion of deuterons into metallic palladium electrodes are studied and rough estimations of the fusion rate are made. The deuteron ions in the palladium lattice form a strong coupled plasma in which there is a strong screening effect induced by correlations between ions. Our calculation shows that the effect enhances the fusion rate by a factor of $\sim10^{106}$ for the equilibrium deuteron system and of $\sim10^{34}$ for a deuteron molecule in the palladium at room temperature and atmospheric pressure. However, the total fusion rate, which is $\sim10^{-134}$ cm^{-3} sec^{-1} and $\sim10^{-40}$ sec^{-1} respectively in the above situation, are still very small and cannot reach the level which can be measured experimentally. Therefore, any positive result of cold D-D fusion in palladium, if it could be measured in some experiments, can only by caused by some non-equilibrium processes in which some relatively high energy and/or high density regions of deuterons are locally produced.

SUMMARY

The deuterium ions absorbed by the palladium cathode during the electrolytic process of heavy water form a strong-coupled plasma in which there is a strong screening effects induced by correlations between ions. Since the effects reduce the barrier of Coulomb potential, the rate of D-D fusion is substantially increased. Our calculations show, however, that the total rate of nuclear fusion at normal temperature and pressure is still very small and could not reach the level which are experimentally measurable. A considerable rate of fusion could, therefore, be produced only by some non-equilibrium processes in which some relatively high energy and/or very high density region of deuterium ions are locally produced. Lattice defect, some special lattice structure by impurities and plasma instabilities, etc., may be the causes of the non-equilibrium processes.

NEWS FROM INDIA
(Courtesy of Subbiah Arunachalam)

S. Arunachalam, "Cold Fusion - Hot on the Trail", *Economic Times*, New Delhi, May 23, 1990, 1 page.

COMMENTS

Arunachalam (Editor of *Indian Journal of Technology*) reports on Dr. Iyengar's (Director of BARC, Trombay, India) visit to Salt Lake City and attendance at the First Annual Cold Fusion Conference. The article cites Iyengar comments on the unpredictable behavior of cold fusion - "For him [Iyengar] it is just another natural phenomena to be explored and understood". He is also critical of *Nature* for not having accepted the Pons-Fleischmann paper which was later submitted to the *Journal of Electroanalytical Chemistry*.

INDIA - NEUTRON BURSTS
(Courtesy of S. Arunachalam)

Bikash Sinha, Y.P. Viyogi, S. Chattopadhyaya, M.R. Dutta Mazumdar, B.S.N. Murthy, G. Muthukrishnam, T. Bandyopadhyaya, M.D. Trivedi, D. Ghosh, & D.K. Srivastava (BARC), and P. Sen (Saha Inst. of Nucl. Phys, Calcutta), "Observation of Neutron Bursts in Electrolysis of Heavy Water", *Indian Journal of Technology*, Vol 27, June 1989, pp 275-277, 3 refs.

ABSTRACT

In an attempt to create conditions for the occurrence of cold fusion of deuterium, we have observed bursts of neutrons in the electrolysis of heavy water using

both palladium and titanium as cathodes. The bursts are several times above background, last for about five minutes and are aperiodic.

COMMENTS

These experiments used Pd foil or Ti rod and a small amount of sodium chloride in the heavy water. Three levels of current were used, 15, 30, and 40 mA/cm^2. No bursts of neutrons were observed at the lower current. At least four bursts of neutrons at 4 to 6 times background were recorded. A gradual rise in temperature was noted (up to 53 deg C for Pd and 40 deg C for Ti).

ITALY - LATTICE COLLAPSE MODEL
Courtesy of Dr. Samuel Faile

E. Tabet, and A. Tenenbaum (Lab. Fis. Inst. Rome), "Nuclear reactions from lattice collapse in a cold fusion model", *Physics Letters* A, Vol 144, No 6-7, 1990, pp 301-305.

ABSTRACT

A model is proposed which accounts for cold fusion processes on the basis of a lattice collapse, induced in a deuterated metal by a thermodynamic instability. A deuteron drag phenomenon enhances the nuclear reaction yield. The neutron emission is given as a function of thermodynamics parameters of the metal-deuteride system.

JAPAN - ON-OFF EFFECT
Courtesy of Dr. Samuel Faile

Y. Arata and Y.C. Zhang (Osaka U.), "'Cold' fusion caused by a weak 'on-off effect'", *Proc. Japan Academy*, Series B, Vol 66, No 2, pp 33-36, in Engl.

ABSTRACT

A substantial on-off effect was discovered in a Pd cathode during continuous electrolysis of D_2O. The temperature of the Pd is brought past the boiling point of the electrolyte to greater than 110 deg C, resulting in an explosive release of D_2 from the cathode surface (off effect) in an endothermic reaction. When the Pd cathode is cooled to 80 deg C, there is a rapid absorption of D_2 (on effect) in an exothermic reaction, and the Pd temperature rises. The cycle can repeat, generating a strong spontaneous on-off effect. The phenomenon was used to produce an intense cold fusion reaction with observations of neutrons.

FROM JAPAN
ABSORPTION OF HYDROGEN ISOTOPES
Courtesy of Dr. Samuel Faile

N. Mitshuishi, S. Fukada, and N. Tanimura (Kyushu University, Japan), "Absorption Breakthrough of Hydrogen Isotopes In Inert Gas Mixture and Desorption Characteristics with Zr-Ni Alloy Particle Bed", *Journal of the Less-Common Metals*, Vol 123, 1986, pp 65-74.

SUMMARY

A metal particle packed bed is one of the most effective methods for the selective recovery of hydrogen isotopes in an inert gas such as argon or helium. An effective and convenient alloy might be Zr-Ni. Zr-Ni particles, 80-120 mesh, were packed in a column 20 mm in diameter, through which H_2-Ar or H_2-D_2-Ar gas mixtures at 50 °C. The absorption characteristics were obtained, and the desorption rates of the hydrogen isotopes for the alloy were also obtained in flowing argon gas at 400, 600 and 800 °C. It was found that the absorption and desorption rates are very fast, large amounts can be absorbed, and the activation of the Zr-Ni alloy should serve as a good absorbent of the hydrogen isotopes, including tritium, at room temperature.

CONCLUSIONS

Studies on the selective absorption and desorption of hydrogen isotopes were carried out using H_2-Ar and H_2-D_2-Ar gas mixtures flowing through a Zr-Ni particle bed at 50 °C under around one atmosphere pressure. The results obtained are as follows.

(1) The Zr-Ni can absorb comparatively large amounts of hydrogen isotopes at around room temperature. The rates of the absorption and the desorption are very fast, and the activation of the Zr-Ni is very easy. Therefore it may be used as an absorbent of the hydrogen isotopes at around room temperature. It will also be a promising technique for a recovery system of the hydrogen isotopes such as tritium at room temperature.

(2) The apparent equilibrium amounts of absorption obtained from the experimental breakthrough curves have a tendency to decrease slightly with an increase of the gas flow rates. It was found that the equilibrium amounts of absorption at u = 0 extrapolating the experimental data or the apparent amounts were expressed against hydrogen concentration by a power type isotherm.

(3) No isotope effect was found on the hydrogen isotopes in the experiments using H_2 and D_2 gases. Therefore the experimental results obtained may be applicable to the engineering design of tritium handling facilities.

COMMENTS

The data reported in this paper may have some relevance in the selection of alloys for experimental work in cold fusion - especially after we solve the problems with the present use of Pd as a cathode. Ed.

FROM JAPAN
PARTICLE BED ABSORPTION OF HYDROGEN
Courtesy of Dr. Sam Faile
By Nobuo Mitsuishi, Satoshi Fukada and Katsuya Kuroiwa (Dept. of Nuclear Engineering, Kyushu University, Japan), "Selective Absorption of Hydrogen Isotopes In An Inert Gas In A Zirconium Particle Bed", *Journal of Less-Common Metals*, Vol 113, 1985, pp 23-31.

The selective absorption and recovery of hydrogen isotopes in an inert gas at 400 °C and their desorption at 800 °C were experimentally investigated using a zirconium particle packed bed. The gases used were H_2-Ar, D_2-Ar and H_2-D_2-Ar mixtures. The absorption rates of the hydrogen isotopes were found to be fast enough for this absorption method to be used as a hydrogen recovery process in the fuel cycle of a fusion reactor. The length of the absorption zone for D_2 in the zirconium bed is about twice that for H_2. The hydrogen isotopes in the H_2-D_2-Ar mixture break through in the sequence D_2, HD and H_2. This is believed to be because the absorption rate and solubility of H_2 are greater than those of D_2. The experimental results for the desorption of hydrogen isotopes are described fairly well by Fick's diffusion equation for a zirconium particle.

CONCLUSIONS

The selective absorption and desorption of hydrogen isotopes in an inert gas were experimentally investigated using a zirconium particle packed bed. The results obtained are as follows.

(1) The rate of hydrogen absorption in a zirconium bed is very fast under the experimental conditions employed in this work (particle size, 100 - 120 mesh; superficial velocity of the gas, 1.6 - 2.75 cm s^{-1}; temperatures, 400 °C). The hydrogen absorption zone is very short and the rate controlling step of hydrogen absorption is considered to be hydrogen diffusion in the zirconium particles.

(2) The capacity coefficient of H_2 in a zirconium packed bed is about twice that of D_2.

(3) If H_2 and D_2 gases flow through a zirconium particle bed, the breakthrough of D_2 gas occurs first followed by HD and H_2.

(4) The experimental data for hydrogen isotope desorption at 800 °C are described by a solution of Fick's diffusion equation.

(5) The residual amount of hydrogen isotopes in the bed approximately zero and the bed can easily be regenerated.

FROM JAPAN
ABSORPTION & DESORPTION OF HYDROGEN
Courtesy of Dr. Sam Faile

By N. Mitsuishi, S. Fukada, H. Tokuda, T. Nawata and Y. Takai (Dept. of Nuclear Engineering, Kyushu University, Japan), "Absorption Breakthrough of Hydrogen Isotopes and Desorption In A Zirconium-Vanadium Particle Bed", *Fusion Engineering and Design*, Vol 10, 1989, pp 343-347.

ABSTRACT

Selective absorption of hydrogen isotopes in an inert gas such as helium or argon is an important operation in the fuel cycle of a D-T fusion reactor. A process utilizing a zirconium-vanadium particle bed was investigated experimentally and numerically as one of the most effective methods for hydrogen isotope absorption. The diffusion equation in the solid and the material balance equation in the bed were computed simultaneously. It was found that the numerical results are in good agreement with experimental data for various bed conditions. The hydrogen concentration at the outlet of the bed were less than 1 ppm and ZrV_2 can absorb comparatively large amounts of hydrogen (the maximum amount of this work is $ZrV_2H_{2.9}$). Apparently no significant pulverization occurred and the rates of absorption and desorption were reproduced regardless of the number of cycles. The absorption and deabsorption rates of hydrogen isotopes were found to be fast enough for this method to be used as a hydrogen recovery process in the fuel cycles of the fusion reactor.

CONCLUSIONS

The selective absorption and desorption of hydrogen in an inert gas were investigated experimentally and numerically using a zirconium-vanadium particle.
The results obtained are as follows:

(1) The ZrV_2 can absorb comparatively large amounts of hydrogen (to maximum amount of this work is $ZrV_2H_{2.9}$ at 200°C).

(2) The hydrogen concentration at the outlet of the bed were less than 1 ppm.

(3) Since the particle temperature increases because of heat generation from hydrogen absorption, the diffusion resistance in the solid decreases.

(4) For almost complete hydrogen desorption, a temperature of more than 600 °C is required. However, large amounts of hydrogen can desorb at a temperature of even less than 400 °C.

NETHERLANDS - A REVIEW
Courtesy of Dr. Samuel Faile

J.A. Goedkoop, "Cold Nuclear Fusion in Condensed Matter?", *Energiespectrum*, Vol 13, No 6, 1989, pp 156-162.

The author presents a review of cold fusion with 12 references on the theory and the latest developments in cold fusion.

FROM POLAND
RESISTANCE & METAL DEUTERIDES
Courtesy of Dr. Sam Faile

S.M. Filipek, A.W. Szafranski, M. Warsza and S. Majchrazak (Polish Academy of Sciences), "Isotopic Effects in Ni-Si-H(D) and Ni-V-H(D) systems". *J of Less Common Metals*, Vol 158, 1990, pp 177-189, 36 refs.

SUMMARY

The electrical resistance and thermoelectric power of Ni-Si and Ni-V f.c.c. alloys were measured in situ at 298 K as a function of the pressure of gaseous deuterium up to about 2.0 GPa(D_2). The derived relationships were used to compare hydride/deuteride formation and decomposition pressures for both systems involving earlier measurements concerning hydrogen. The unusual behavior of thermopower in the Ni-V-H(D) system has been interpreted in terms of virtual bound states. Low-temperature resistance measurements and the X-rays structural analysis have been performed on samples saturated with deuterium (hydrogen) in high-pressure conditions. It was found that H/D dissolved in the Ni-V alloys induces Kondo behavior.

COMMENTS

This paper has a tie to cold fusion as noted by the authors: "Recently the importance of investigations of metal-deuterium systems has been accentuated because of the discussions about the possibility of cold nuclear fusion as reported in ref. 24."

RUSSIA - ANALYZED AND REJECTED
Courtesy of Dr. Samuel Faile

V.I. Gol'danskii & F.I. Dalidchik (N.N. Semenov Inst. Chem. Phys), "On The Possibilities Of Cold Enhancement Of Nuclear Fusion", *Physics Letters B*, Vol 234, No 4, 1990, pp 465-468.

ABSTRACT

Various possibilities of chemical and nuclear enhancement of nuclear fusion at ordinary temperatures are analyzed and rejected. Only the mechanism of acceleration by strong microelectric fields formed by the sudden disruption of solid matrixes (not treated in this paper) still does not seem to be excluded.

E. SHORT ARTICLES FROM AUTHORS
OBSERVATION OF EXCESS ENERGY IS THE ESSENCE OF FLEISCHMANN-PONS EFFECT
By Dr. V.C. Noninski
Laboratory LEPGER, Sofia, Bulgaria

As it is widely known, numerous laboratories throughout the world are studying the remarkable discovery made by Professors Fleischmann and Pons at the University of Utah [1] - production in a simple electrochemical way of energy which is in excess of the breakeven amount. The phenomenon is so unexpected and unexplainable from the chemical point of view that the discoverers quite ingeniously looked for the explanation in other fields of science. And, indeed, a possibility for an explanation was found in terms of one or more nuclear reaction processes. Moreover, the fact that nuclear reactions can take place at ambient temperatures (cold fusion) was noticed even before the Fleischmann and Pons' finding [2,3], but no exceeding of the breakeven energy was inferred in those papers. Therefore, the problem has two aspects - first, there is a novel unexplained experimental fact of great significance for science, and second, the attempts to explain that fact.

This situation is not new for science. The twentieth century Physics was shaken to it very foundations with discoveries that were unexplainable from the then available knowledge. These experimental findings include:

1. The experimentally found Wien's displacement law and the impossibility to apply the classical Raleigh and Jeans' formula for short wavelengths in the ultraviolet ("ultraviolet catastrophe").

2. The photoelectric effect (Einstein, 1905).

3. Demonstration of the wave properties of electrons (Davison and Germer, 1927). And others.

It was the problems with experimental findings that made Planck assume his famous finite, rather than classical infinite, energy gap (E = h nu) separating the energies of various groups of oscillators which marked the beginning of Quantum Mechanics.

The long history of science teaches us that the primary efforts when a new phenomenon is discovered experimentally should be directed towards carrying out precise, strictly designed, up to the requirements of the modern science, experiments, combined with thorough discussion of the obtained results to exclude any trivial effects. Verifying the reality of existence of the claimed phenomenon logically leads to attempts for its explanation. As it was noted, the important new phenomenon under discussion here is the existence of excess energy during the electrolysis of D_2O with Pd cathode. The search for neutrons, gamma-ray emissions, and even products of a nuclear reaction (newly-produced chemical elements) falls mainly with the subject of explanation of the said phenomenon. Such a search is very important to be carried out, but has only a complementary significance at present. Attempts to exchange the roles of the new, important phenomenon with its explanation and start studying it with the explanation and theoretical considerations based on the available knowledge puts the cart before the horse.

In this article, we discuss one experimental approach for studying the said phenomenon, in which the published article claimed negative results in the measurement of excess enthalpy, and we shall show that a more thorough analysis of the experimental data leads to the opposite conclusion, specifically that excess enthalpy has virtually been produced [4] and is comparable with that observed by Fleishchmann and Pons [1]. This discussion is a part of a large commentary submitted to the journal *Nature* on August 30, 1989.

Part I.

Let us express the Newtons' law of cooling in the following form:

$(dT/dt)K = P = AK(T_{cell} - T_{bath}) = AQ$ (1)

where K is the heat capacity of the calorimeter, P is the power input into the calorimeter (output from the calorimeter to the bath), t is the time, A is the Newton's cooling constant, T_{cell} is the temperature of the calorimeter, T_{bath} is the temperature of the constant temperature bath and Q is the quantity of heat necessary for the increase of the temperature of the calorimeter from T_{bath} to T_{cell}.
Equation (1) can be written in the following form:

$P/A = Q$ (2)

Since at a given P the quantity Q has a strictly defined value at a given heat capacity K of the system the Newtons's cooling constant A = P/Q has also only one value, strictly defined by these two quantities (P and Q). As is seen from equation (2) this constancy of A is a strict requirement - the left-hand side of equation (2) represents the input energy while the right-hand side of equation (2) represents the produced energy. From equation (2) is seen that the violation of the constancy of A in the case when the whole produced heat is absorbed by the calorimeter (i.e. there are no uncontrolled heat losses) contradicts with the law of conservation of energy.

The constancy of the Newton's cooling constant A requires respectively that the quantity heating coefficient = $(T_{cell} - T_{bath})/P = 1/AK$ (3) should also have a constant value at the given conditions -this heating coefficient (hc) is the true hc for the given K. Establishing different values of the hc at one and the same K is equivalent to establishing that either there are uncontrolled heat losses or that there is an unknown additional source of heat inside the calorimeter. Of course, simultaneous action of both causes is possible. Evidently, in the first case when there are uncontrolled heat losses a lower temperature difference $T_{cell} - T_{bath}$ = delta T will be observed than is the true delta T, corresponding to the true hc. Thus, the hc of the calorimeter, having a given heat capacity K, which in this case will be a seeming hc, according to equation (3) will be of a lower value than the true hc.

A diametrically opposite change of the hc will be observed if the cause for this changes is some additional source of energy for which no account is being taken during the experimental investigations. In this case a greater temperature difference delta T will be observed than the difference corresponding to the true hc and for the seeming hc at the given K according to equation (3) -- a value will be obtained which is greater than the value of the true hc. If both causes for the changing of hc are acting simultaneously then the two changes of delta T, being opposite, will partially or entirely compensate each other.

According to the above reasoning for the constancy of A, respectively of the hc, if in these two cases (of opposite changes of the values of these quantities) no attention is paid for the causes of the change and/or if these causes are ignored one can fall in contradiction with the law of the conservation of energy.

Part II.

We shall apply the consideration from Part I to the experimental results given in reference [4]. In Table 3 of reference [4], two sets of data are presented of which data set b is obtained from experiments using H_2O and no additional source of energy can be supposed to exist.

Since the experiments with H_2O are considered as control experiments, as the authors assume, it should be supposed that they are carried out at conditions exactly similar to the conditions during the electrolysis of D_2O (data set a). It is assumed that the data in both set a and set b was obtained using the same calorimeter dewar. It is also assumed that the disposition of the thermistor relative to the resistor were the same.

Therefore, the value of the Newtons's cooling constant, A, in both data sets a and b of Table 3 in ref [4] should be essentially one and the same. As it concerns the heat capacity of the calorimeter, K, its value should be a little greater for the experiments with D_2O because the density and specific heat of D_2O is higher than H_2O. Therefore, according to equation (3) the mean value of the heating coefficient during the electrolysis of D_2O, b_{D2O}, should be a little lower than that of H_2O, b_{H2O}.

From Table 3 in ref [4] it is seen, however, that the mean value of b_{D2O} = 15.3 °C/W is not lower but is higher than the mean value of b_{H2O} = 12.5 °C/W. Evidently, the deviations from the mean value of the hc values referring to H_2O (not more than 6%) give information for the error limits during the investigations.

Note that the deviations from the mean value of the hc values referring to D_2O in Table 3 and from Figure 3 of ref [4] are significantly greater, that is, these deviations are significantly outside the error limits.

If the comparative study of the hc in both cases is carried out correctly, this difference between b_{D2O} and b_{H2O} cannot be explained otherwise than with the acceptance that in addition to a mean input power during the electrolysis of D_2O (PD_2O), some mean value of excess power (P_{exc}) has been added. If we accept, for the sake of simplicity, that b_{D2O} is not lower but is equal to b_{H2O} then according to equation (3), after taking into account P_{exc} the following expression will be obtained:

delta T_{D2O} / (P_{D2O} + P_{exc}) = 12.5 °C/W. (4)

By taking into account that according to the data in Table 3 of reference [4] the mean value of the T_{D2O} = (T_{cell} - T_{bath}) $_{D2O}$ = 7.76 °C and that the mean value of P_{D2O} = 0.508 W from equation (4) it is obtained that P_{exc} = 0.113 W. Or taking into account the volume of the Pd cathode (0.073 cm^3) for the mean excess specified power, $P_{exc(sp)}$ = 1.55 W per cu cm is obtained. This value practically coincides with the value for the excess specific power of 1.57 W per cu cm obtained in reference [1]. The conditions of the two experiments [1] and [4] were approximately the same, that is, a Pd electrode of 0.2 cm diameter x 10 cm long and at a current density of 64 mA per sq cm.

However, the above derived facts - that in reality, the heating constant for D_2O is less than the heating constant for H_2O = 12.5 °C/W (for ref [4]). **The conclusion must be therefore, that according to equation (4) an even greater value for excess power ($P_{exc(sp)}$) must exist than the value cited in reference [1].**

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COMMENTS

We are indebted to Dr. Noninski for his careful analysis of the calorimetric data submitted by Lewis et al. We trust that *Nature* will print the analysis submitted to them by Drs. Noninski and extend suitable apologies to their readers. Ed.

NEW PARTICLES NEEDED?

NEW PARTICLES BASED ON YUKAWA-HEISENBERG CONCEPTS?
By Dr. Samuel P. Faile, May 29, 1990

Starting back in the thirties there were various suggestions for a particle that caused the nuclear force that bound the nucleons (protons and neutrons) together. The suggestion of Heisenberg involving electron and positron exchange between nucleons was found to be too small by a factor of 10^{14}. Yukawa suggested a heavier particle that had a mass consistent with the requirements of the uncertainty principle.

Across a range of 1.7 femtometers one obtains a mass of about 2.1 x 10^{-28} Kg. (using the formula mass = h/rc where h is Planck's constant, r is the radius across which the force operates, and c is the speed of light). The particle discovered was close to the predicted mass of about 230 times the rest mass of the electron. This particle, the pion, has a mass of about 270 times that of the electron. The pion is a composite particle composed of a quark and an antiquark which results from the residual strong force operating between nucleons. The virtual pions which are constantly being formed and being destroyed according to the uncertainty principle bind the nucleons together in a nucleus.

For speculations involving cold fusion, it appears that a particle resulting from some form of the strong force rather than just the electromagnetic force of electrons and positrons would be a better basis for a theory. If not a residue of the strong force, it should at least carry a component that modifies the strong force such as a residue effect from the weak force. Perhaps Dr. Matsumoto's particle fits the bill. According to Matsumoto's report in the May issue of *FUSION FACTS* [1], the ITON particle consists of an electron and a positron and a neutrino.

The particle which could have a rest mass of a few electron masses may (according to calculations made by the author) operate at 100 times the radius of the nuclear binding force or further especially if its influence is more one-dimensional (like a string) as contrasted to three-dimensional. According to T. Matsumoto, the ITON particle would favor the fusion of atoms in dense clusters. The ITON particle would carry off much of the energy of fusion (according to the "NATTOH" model) and deposit the energy over the lattice while avoiding the emission of hard radiation such as that produced by positron-electron annihilation reactions.

If Matsumoto's model is a reasonable approach to reality, then it is suggested that the ITON may decay in the metal lattice by capturing an electron which causes a transformation where an energetic beta ray and a neutrino are released as products. Hagelstein's theory involves the enhancement of the weak interaction. If Matsumoto's particle carries the weak interaction there may be some common ground between the theories where Hagelstein's coherent interactions augment the ITON's inter-nuclear effects. In any event, for authoritative insights, a waiting period is needed. I received today a letter from Dr. Matsumoto dated May 21, 1990 where he said the reprint of his paper, "Prediction of New Particle Emission on Cold Fusion", would not be released until a journal had accepted the article for publication.

It is suggested that both Matsumoto's and Hagelstein's theories be adapted for lithium in addition to the hydrogen isotopes. There is the possibility that the energy released in cold-fusion reactions largely involves the lithium nucleus. Some books of interest on the background for theories in modern physics are: *Concepts of Modern Physics*, 4th Edition, by Arthur Beiser, McGraw-Hill, c 1987. This book covers the "meson theory of nuclear forces" (see pages 433 ff). The second book is *Modern Elementary Particle Physics*, by Gordon Kane, Addision-Wesley, c 1987. On page 8 of this second book is listed the "free" quark masses and constituent quark mass which differ greatly from each other. Many "standard theory" concepts are covered in these books. These concepts often involve counter-intuitive insights.

REFERENCES

[1] Staff, "Japan: Progress Using the NATTOH Model", *Fusion Facts*, Vol 1, No 11, page 15, includes five references printed in or submitted to *Fusion Technology*.

COLD FUSION RESEARCH PROBLEMS

By Hal Fox, Editor-in-Chief

WHERE ARE THE NUCLEAR BY-PRODUCTS?

At least 65 scientists in ten or more countries have found evidence for nuclear reactions occurring in a metal lattice of palladium or titanium when used with deuterium gas or heavy water. [See section B, this issue of FF.] However, there is not an agreement among scientists as to the precise nuclear reaction or reactions that are occurring. There is no agreement as to whether the reactions are surface or bulk or both.

Experimentalists have repeatedly demonstrated that neutrons and tritium are produced using Pd or Ti and have published their results in peer-reviewed scientific journals. At the same time other scientific journals (also peer-reviewed) have adopted a policy that is more-or-less opposed to cold fusion and as a result these journals prefer to publish negative findings. Chief among the journals that prefer negative articles on cold fusion is *Nature*. Because of the prestige in Europe of *Nature* there have been several scientific teams who have been "talked out of" working in cold fusion by prestigious scientists who were tutored by the negative articles printed in *Nature*.

The problem is that the rates of production of either neutrons or tritium or both fail to account for the amount of excess heat that is being generated within (or on) the metal lattice. Classical physics has little or no evidence of nuclear reactions that can produce heat without some particles or gamma rays being produced.

POSSIBLE ELECTROCHEMICAL NUCLEAR REACTIONS

Under the proper experimental conditions, within a specific type of palladium metal lattice (crystal structure) and in the presence of lithium and heavy water, the deuterium atoms may periodically fuse and the resulting energy show up as heat in the palladium electrode [1]. The nuclear reactions are not fully understood nor controlled. The following known or suspected nuclear reactions are being investigated or proposed:

1. Deuterium + deuterium --> ^{3}He + neutron + energy.
2. Deuterium + deuterium --> tritium + proton + energy.

3. Deuterium + deuterium --> ^{4}He + energy.

4. ^{6}Li + deuterium --> 2 ^{4}He + energy.

5. Proton + proton --> deuterium + energy.

The first two have been previously observed in hot fusion experiments in almost equal numbers (equal branching ratio). The third reaction has been previously observed only at very low rates of occurrence and is controversial. The fourth reaction is expected to occur at the surface of the Pd cathode. The fifth reaction is lately being proposed. Experiments are now being designed to measure the production of both neutrons and protons to help in directly measuring the branching ratios of reactions 1 and 2. Assume that both reactions 3 and 4 are occurring. Note that with reaction 3 the ^4He would be expected to be trapped in the Pd lattice. In reaction 4 the ^4He could be expected to be released into the stream of evolved deuterium bubbling from the Pd cathode. The ^4He atoms are the "ashes" of the nuclear reactions 3 and 4. However, there have been few reported successes in making consistent measurements for the production of ^4He in either the evolved gases or by melting the Pd and measuring the released gases. Part of the problem is the scarcity of mass spectrometry equipment that can distinguish among such combinations as HT, D_2, ^3He, and ^4He.

Reaction 4 has only recently received sufficient attention. Natural lithium (according to the Handbook of Chemistry and Physics) is composed of 7.4% ^6Li and 93.6% of ^7Li. It has been reported that the ^6Li is depleted with respect to the ^7Li [2].

Reaction 5 has been proposed by Hagelstein [3] and in an article by John N. White (to be published in the next issue of FF)

If this reaction is predominant then it would explain the lack of neutrons and the presence of low level (soft) X-Rays that have been reported by researchers at the National Cold Fusion Institute [4].

BYPRODUCTS SUMMARY

The most promising research direction appears to be to confirm the emission of soft X-Rays from a fusion electro-chemical cell to help confirm reaction 5. In addition, researchers should closely monitor the isotopic ratio of ^6Li to ^7Li to confirm nuclear reaction 4.

THE PROBLEM OF DIMINISHING RETURNS

There is some experimental evidence [5] that fresh or early experimental results (after proper Pd loading) give higher excess heat than do later results. This observation could be explained if the following were true:

1. That nuclear reaction 4 is one of two or more reactions, and

2. If the depletion of ^6Li reduced the level of nuclear reaction 4 due to the scarcity of ^6Li.

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[3] Dr. Peter L. Hagelstein (MIT), "Status Report on Coherent Fusion Theory", *Proceedings of The First Annual Conference on Cold Fusion*, March 28-31, 1990, University of Utah Research Park, Salt Lake City, Utah.

[4] Personal communication. First observations have been cited to the news media. Confirmation has not been announced.

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F. COMING CONFERENCES ON COLD FUSION

45th ANNUAL CALORIMETRY CONFERENCE
(Courtesy of Prof. Jonathan Phillips)

Dr. Phillips writes: "We hope you will consider participating in the Application of Calorimetry to Electrochemical Processes session of the 45th Annual Calorimetry Conference. The conference will be held from July 22-27, 1990 at the University of Michigan in Ann Arbor. A lot of the controversy has arisen because of poor understanding of the calorimetric technique. In fact, the time is ripe to bring people together to discuss the new calorimetric technology as well as current and "potential" applications of that technology!"

A LITTLE LATE BUT:
TITLE AND ABSTRACT SHOULD BE SENT TO:

Prof. Ron D. Weir, Dept. of Chem and Chem Engr'g.
Royal Military College of Canada
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ANOMALOUS NUCLEAR EFFECTS IN DEUTERIUM/SOLID SYSTEM.

Sponsored by EPRI, BYU, Japanese National Institute for Fusion Studies, and U.S. DoE. Conference will be held at BYU, Provo, UT, Oct. 22 - 24, 1990. Interested attendees and contributors should send expressions of interest by or soon after June 20, 1990 to:
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Phone 801/378-4851 (Nuclear Fusion Conf.)
Abstracts should be sent to:
Professor Steven Jones
BYU Dept. of Physics
176 E.S.C., Provo, UT 84602

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