FUSION facts

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A. DR. WILL PLANS FUSION RESEARCH.

Dr. Fritz Will, the new director of the National Cold Fusion Institute, has reviewed the status of the cold fusion work and states that his first priority is to find means to make the experiments reproducible on demand. The lack of ability among most researchers to precisely reproduce observed results is shared by nearly all researchers in the U.S., Japan, India, Bulgaria, and other places.

CURRENT STATUS OF COLD FUSION

As a background for further work, the current status of cold fusion was reviewed in the January 1990 report of the National Cold Fusion Institute and is summarized:

More than 20 research laboratories worldwide have confirmed one or more aspects of the Pons/Fleischmann cold fusion experiment that was first announced March 23, 1989. These reports include observations of low levels of excess heat for weeks and months, occasional large heat excursions lasting hours or days, and detection of other nuclear byproducts, specifically tritium and neutrons.

National Science Foundation Workshop The published conclusion of the 40 workshop scientists (16-18 Oct 1989) was: "These results (e.g. excess heat, tritium production, neutron emission) cannot be explained as a result of experimental artifacts, equipment error, or human errors."

Oak Ridge National Laboratory An official ORNL report No. ONRL/TM-11322, "A Preliminary Investigation of Cold Fusion by Electrolysis of Heavy Water", describes lengthy experiments in which excess heat, neutron emission, and tritium production are observed and reported.

Los Alamos National Laboratory officially reported on the production of tritium. The draft paper is: 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.]

Energy Research Advisory Board Cold Fusion Panel In spite of the denial by some panel members of most of the positive evidence for cold fusion (including the then unpublished reports from Oak Ridge), the panel still suggested: "modest support for carefully focused and cooperative experiments with the present funding system."

Division of Advanced Energy Projects of DoE. Dr. Ryszard Gajewski, Director, Division of Advanced Energy Projects, DOE, stated at the NSF/EPRI workshop that he could support cold fusion research projects. Soon thereafter, two million dollars were slashed from his fiscal 1990 funds so that he is now unable to fund any further cold fusion research in fiscal 1990.

U.S. UNIVERSITIES REPORTING POSITIVE RESULTS
Some of the U.S. researchers who have reported positive experimental results are the following:
Brigham Young University
Case Western Reserve University
University of Florida
University of Minnesota
University of Nebraska
Oregon State University

Stanford University
Texas A&M University (2 groups)
University of Utah (2 groups)

WORLD-WIDE POSITIVE RESULTS

Japanese Efforts Scientists at Hokkaido, Nagoya and Osaka Universities, among others, describe successful experiments, particularly large neutron emissions. The Wall Street Journal reports "200 Japanese scientists in 30 laboratories" working on cold fusion. Dr. Hideo Ikegami of Nagoya University's Institute for Fusion Science told The Wall Street Journal, "researchers in the United States are more interested in denying cold fusion, and in Japan we are interested in trying to observe cold fusion." Several positive publications have already been published by Japanese researchers and reported in this newsletter.

Bhabha Atomic Research Centre (BARC) As reported in a section of this newsletter, some 53 different scientists in twenty articles report on positive cold fusion results at BARC. As stated by Iyengar and Srinivasan, "Investigations of cold fusion phenomena at Trombay during April to September, 1989 have positively confirmed the occurrence of (d-d) fusion reactions in both electrolytic and gas-loaded Pd and Ti metal lattices at ambient temperatures". Several of the papers report on copious amounts of tritium being produced.

Other researchers in Bulgaria (Noninski's work reported in Fusion Facts, November 1989, page 14-15), Finland, Sri Lanka, China, Mexico, Brazil, Spain, Italy, Russia, and other countries are working on cold fusion. Papers are being received and reviewed from these sources (see below under More News from Abroad).

DR. WILL PLANS EXPANSION OF EFFORTS.

"At this point," Dr. Will emphasizes, "one does not have an understanding of the underlying phenomena. No one to the best of my knowledge, has been able to reproduce these phenomena at will." Dr. Will is working with the staff of the National Cold Fusion Institute to continue the parametric studies that are now underway. Some 32 cells have been placed in operation with sets of cells having difference parameters. Sixty-four more such cells are planned to allow further studies of important cell parameters according to a recent report from the Institute.

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B. NO NEUTRONS - NO COLD FUSION?
By Hal Fox

"Where are the neutrons?", is often the first technical question that a nuclear physicist would ask when hearing about cold fusion and excess heat. Physicists have been thoroughly schooled that when D + D fuse there is almost an equal probability that tritium or neutrons will be observed. The two expected nuclear reactions that are expected to be "equally branched" are:

$D + D \rightarrow {}^3He + n + energy$

$D + D \rightarrow T + p + energy$

A third reaction is rarely expected: $D + D \rightarrow {}^4He + energy$.

The "equal branching" is so ingrained in nuclear physics that a University department chairman, with his head in his hands, complained, "But if we don't find equal branching, then we will have to rewrite what we know about nuclear physics." [1].
Progress in science is seldom predictable and never comfortable. Iyengar observed in July 1989 the surprising fact that in a series of cold fusion experiments the measurements for tritium far exceeded the observed neutron events [2]. Iyengar also cited Oppenheimer and Philips [see note appended to 2] comments on the expected deuterium fusion under low-energy conditions. However, we physicists are not often found reading 1935 ancient history.
McNally [3] states: "Thus nuclear mass-energy resonance together
with other physics might account for the reactions observed by
Pons, Fleischmann, Jones, and others. Experimental and theoretical confirmation of this hypothesis is needed. Should
the results be favorable, the scientific study of other nuclear
resonances at `low temperature' and high density might be quite
promising, possibly ensuring `cold fusion' a valid place in
science."

Aspden [4] states: "I think it will interest your readers because I refer to ... a paper of mine ... in the Hadronic Journal [5]. I made it clear that there was a very good case for showing that the deuteron should not be seen as containing neutrons but rather should be seen as a transiently fluctuating proton-antiproton-electron-positron composition which assumes a neutral core with a satellite positron at times. ... In a host cathode conductor carrying electrons able to annihilate the satellite positron in the transient field state, we see that a deuteron can be disarmed, as it were, and so exposed to fusion with a nearby [or itinerant] deuteron when put in an excited state. Cold fusion can therefore be explained if only we wake up to the reality of the nature of the deuteron ..."

V. Guillemin [6] instructs us: "Material particles do not simply exist statically; they are centers of intense activity, of continual creation and annihilation. Every atom is a seat of such activity. In the nucleus there is a constant interplay of mesons, and the space around it is filled with swarms of virtual photons darting between the nucleus and the electrons."

T. Tijima et al [7] state: "In heavily deuterated palladium (approx. PdD) Pd atoms form a fcc lattice, while deuterium atoms sit in the octahedral positions to form a tight overall NaCl-type lattice (beta-phase) with the lattice constant d approx. equal to 4.08 Angstrom. **Deuterium would migrate itinerantly** from a cell to a cell under electrolysis driven by the applied voltage or the chemical potential in a fashion similar to superionic conductors. A palladium atom has ten d-shell electrons. We shall show that a deuterium atom in the Pd lattice exerts in effect an attractive electric potential in short distances (0.1 - 0.7 Angstrom) to another deuterium due to strong Coulomb correlation effects. Such an attractive electron potential between a pair of deuterons gives rise to a bound state for deuterons in equilibrium **and to a substantial reduction of the Coulomb barrier turning point for itinerant deuterons.** We shall show that such itinerant deuterons fuse with other deuteron nuclei in the dense electron system at a rate many tens of order of magnitude faster than that expected from a gaseous deuterium molecule."

Avid readers of theory papers will recall that the probability calculations for the fusing of deuterons deal with the deuterons trapped in the potential wells of the palladium (titanium) lattice between the Pd or Ti atoms. As Tijima properly observes (above), it is the hopping or "itinerant" deuterons that should be considered for fusion events. The end result is that the probability of fusion greatly increases.

Yeong E. Kim (Purdue) [8] states: "It is proposed that conventional theoretical estimates of the D-D fusion rate and branching ratio at low energies are arbitrary and may not be valid since they are based on an extrapolation of the reaction cross sections at higher energies (about 5 keV) to lower energies where no direct experimental tests and measurements exist, except the indirect measurements of Fleischmann, Pons, and Hawkins and others."

Yeong Kim [9] elaborates on the above comments: "Another significance of the experimental results of Beuhler et al [10] is that the reaction rate for 1b [neutron producing] appears to be substantially suppressed compared with that of reaction 1a [tritium producing] in their experiment, contrary to the conventional assumption of nearly equal rates...". Kim continues with important calculations in this paper and suggests some experimental tests.

A paper submitted to the First Annual Conference on Cold Fusion, Salt Lake City, Utah, March 27-30, 1990 by Robert A. Rice, Gary S. Chulick, Yeong E. Kim, and Jin-Hee Yoon (all from the Purdue Dept of Physics) contains the following comments in the Abstract: "Reaction rates from recent electrochemical fusion experiments have been found to be as many as 70 orders of magnitude larger than those obtained from simple calculations involving an extrapolated low-energy D-D cross section and a sharp velocity distribution. However, if an appropriate Maxwell-Boltzmann velocity distribution is used in place of the conventional sharp velocity distribution, it is seen that **the calculated reaction rate increases by as much as 50 to 60 orders of magnitude."**

As noted previously in this publication [11]: "The ease with which expected nuclear byproducts are produced in FPE are in the order of heat, tritium, and neutrons and the latter is most difficult to produce and measure."

CONCLUSIONS.

It is well understood by fusion researchers that neutrons are not expected to be produced in an electrochemical fusion cell with the same probability as tritium. **Experimental evidence is now overwhelming that tritium production can far exceed neutron production** in an electrochemical fusion cell. The extrapolation of the experimental results in high-energy physics is not valid for low energy physics. The expectations for equal branching of deuterium fusion has received comments and/or theoretical treatment in papers dating back to 1935.

Experimenters who base their criticism of cold fusion on the lack of neutron production have no valid case. However, because the observed events in solid-state fusion are not fully understood, it is prudent to monitor fusion cell experiments for neutron production as a safety precaution.

REFERENCES

[1] Personal communication June 1989.

[2] 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).]

[3] J. Rand McNally, Jr. in "On the Possibility for a Nuclear Mass-Energy Resonance in D + D Reactions at Low Energy", Fusion Technology, Vol 16, Sept 1989 p. 237ff.

[4] H. Aspden in a letter to M. Hecht of 21st Century Science and Technology, 8 Jan 1990. (Expected to be published in the Mar-April 1990 issue.)

[5] H. Aspden, "The Theoretical Nature of the Neutron and Deuteron", Hadronic Journal, Vol. 9, pp. 129-136, 31 July 1986.

[6] Victor Guillemin, The Story of Quantum Mechanics, Chas. Schibner Pub., New York, 1968 pp 180-181.

[7] T. Tajima (U. Texas-Austin), H. Iyetomi (Argonne National Laboratory), & S. Ichimaru (U. of Tokyo), "Influence of Attractive Interaction between Deuterons in Pd on Nuclear Fusion", Institute for Fusion Studies, The Univ. of Texas at Austin, Paper IFSR #369, April 1989.

[8] Yeong E. Kim (Purdue), "Comment on 'Cluster-Impact Fusion'", Unpublished paper PNTG-89-11.

[9] Yeong E. Kim (Purdue), "Nuclear Theory Hypotheses for 'Cold Fusion'", Invited talk presented at NSF/EPRI Workshop on Anomalous Effects in Deuterated Metals, Washington, D.C., October 16-18, 1989.

[10] R.J. Beuhler, G.Friedlander, and L. Friedman, Phys Rev. Lett. vol 63, pgs 1292 ff (1989).

[11] Staff, "Fusion Research Direction", Fusion Facts, Vol 1, No. 7, Jan 1990, pages 15-18.

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C. MORE NEWS FROM U.S.

FROM DEPT. OF PHYSICS, PURDUE UNIV.
CHAIN-REACTION IN PALLADIUM DEUTERIDE
(Courtesy of Dr. Yeong E. Kim)

Yeong E. Kim (Dept. of Physics, Purdue), "Neutron-Induced Photonuclear Chain Reaction Process in Palladium Deuteride", Unpublished paper PNTG-89-7, July 1989, 11 pages, 15 refs.

Abstract: Recently, it has been reported by Fleischmann, Pons, and Hawkins (FPH) that tritium production and excess heat generation above that due to the electrode reaction have been observed in their electrolysis experiments with a palladium cathode immersed in heavy water with 0.1M LiOD. The FPH effect cannot be explained by known single-step nuclear reactions such as deuterium-deuterium fusion, since the reaction cross-sections and rates are too small at room temperature. However, a combination of known nuclear reactions can form a set of closed chain reactions which can become self-sustaining at a critical stage under favorable conditions and geometries, as in the well-known case of neutron-induced fission chain reactions. In the paper, the FPH effect is described in terms of a chain-reaction process involving neutron-induced photonuclear chain reactions in palladium deuteride. Experimental evidence and tests of this chain-reaction hypothesis for the FPH are described.

HOT AND COLD FUSION WITH ELECTROLYSIS
(Courtesy of Dr. Yeong E. Kim)

Yeong E. Kim (Purdue), "Fission-induced Inertial Confinement Hot Fusion and Cold Fusion with Electrolysis", to be published in Laser Interaction and Related Plasma Phenomena, Volume 9, 24 refs.

Dr. Kim introduces the paper with the following: "Conventional theoretical estimates for deuterium-deuterium (D-D) fusion can not explain tritium production and excess heat generation above that due to the electrode reaction observed by Fleischmann, Pons, and Hawkins (FPH) and others in their electrolysis experiments with a palladium cathode immersed in heavy water (with 0.1M LiOD), since the estimated D-D fusion cross-sections and rates are too small at room temperature. Recent experimental results indicate that the extrapolation method is not valid at low energies. Plausible nuclear theory explanations are discussed. Experimental measurements of the D-D fusion cross-sections and branching ratios at very low energies are suggested. In order to explain the FPH effect, a surface reaction mechanism is proposed for the cold D-D fusion with electrolysis. Experimental tests of the proposed mechanism for cold fusion are discussed. Other nuclear reactions involving neutron-induced reaction processes, which may occur subsequent to and concurrent with the D-D fusion, are also discussed."
The paper also suggests the design of pellets for neutron-induced inertial confinement fission-fusion for large-scale power generation.

TRITIUM AND HELIUM PHOTODISINTEGRATION
(Courtesy of Dr. Yeong E. Kim)

D.J. Klepacki (Purdue), Y.E. Kim (Purdue), and R.A. Brandenburg (Univ. of Basel), "Two-Body Photodisintegration of ^{3}H and ^{3}He Near the Giant Resonance. I. Plant-Wave Approximation", Unpublished paper PNTG-89-8, August 1989, 50 pages, 149 refs.

Abstract: A concise survey of the current status of unpolarized two-body photodisintegration of the trinucleons in the region of the giant resonance [low-energy region is photon energy < 35 MeV] is presented. Also proposed is a method of including final state interactions (FSI) for calculations with non-separable two-nucleon potentials by way of the Faddeev T-operator. Calculations neglecting both FSI and M1 transitions are presented using the Reid Soft Core, Paris, and Bonn (OBEPQ) potentials. The results for ^{3}H photodisintegration using the Bonn potential appear to provide a satisfactory description of this reaction within the existing experimental uncertainties.

D-wave contributions to these reactions are not in agreement in the literature. The present results support an approximately 10±4% enhancement by D-waves to the cross sections. Furthermore, E2 contributions at a photon excitation energy of approx 12.5 MeV are found to be approximately 2% for ^{3}He (gamma,p)d and 0.1% for ^{3}H (gamma,n)d. Fore-aft asymmetry calculations indicate markedly different contributions from e1-E2 interference in a comparison of the ^{3}He and ^{3}H systems.

The conclusion states in part: "...In general, the results with the Bonn potential (employing the Siegert approximation) seem to produce the best overall description of the experimental data at this stage of calculation. This is especially true with the ^{3}H reactions where, however, the data either contain large uncertainties or are sparse. Additional measurements of ^{3}H reactions are badly needed in order to provide more stringent constraints upon the theoretical calculations. Such measurements would also eliminate the Coulomb effects which are present in the ^{3}He reactions.

"... The discrepancy among theoretical predictions of the photodisintegration reaction is most disconcerting. In particular, in this work the D-state contributions enhance the cross section by approximately 10±4% in accord with the results of references 109,112 but in disaccord with references 97, 102, and 104. ... It is encouraged that further calculations of the type presented here be made, so that these disturbing differences can be cleared up.

"... The formalism can also accommodate MEC and is expected to be valid for energies up to the pion production threshold. Beyond this Energy, Araki (ref 144) proposes modification (for a Faddeev formalism) which can incorporate relativistic invariance, isobar degrees of freedom, and even exotic channels due to the manifestation of explicit quark degrees of freedom. In the future, the present calculations are expected to be furthered along these lines."

VELOCITY DISTRIBUTION EFFECT ON COLD FUSION
(Courtesy of Dr. Yeong E. Kim)

Robert A. Rice, Gary S. Chulick, and Yeong E. Kim (all from Purdue), "The Effect of Velocity Distribution on Cold Deuterium-Deuterium Fusion", A paper submitted to the First Annual Conference on Cold Fusion, Salt Lake City, Utah, March 27-30, 1990.

Abstract: "Reaction rates from recent electrochemical fusion experiments have been found to be as many as 70 orders of magnitude larger than those obtained from simple calculations involving an extrapolated low-energy D-D cross section and a sharp velocity distribution. However, if an appropriate Maxwell-Boltzmann velocity distribution is used in place of the conventional sharp velocity distribution, it is seen that the calculated reaction rate increases by as much as 50 to 60 orders of magnitude. ..."

D-D FUSION AT LOW ENERGIES
(Courtesy of Dr. Yeong E. Kim)

Gary S. Chulick, Yeong E. Kim, and Robert A. Rice (all from Purdue), "Low Energy D-D Fusion Experimental Cross-Sections", A paper submitted to the First Annual Conference on Cold Fusion, Salt Lake City, Utah, March 27-30, 1990.

ABSTRACT: A major criticism of electrochemical fusion experiments has been that the extracted deuterium-deuterium (D-D) reaction rates from these experiments are 40-50 orders of magnitude larger than the calculated reaction rates. However, the reaction rate calculations are partly based on the assumption that the D-D reaction cross-section at extremely low energies (i.e., a few eV) is of correct form. Since the D-D cross-section has not been measured at energies below 2 keV (center-of-mass), it is naively assumed that the trends in the cross-section above that energy are automatically valid below that energy. Close examination of the available lowest energy D-D cross-section data, and the results of the recent Brookhaven cluster fusion experiment, which potentially allows us to extract the D-D cross-section down to the eV range, indicate that this assumption is not valid. The low energy cross-section (approx. 100 eV) appears to be 10-20 orders of magnitude larger and appears to behave differently than the cross-section at higher energies.

SURFACE REACTION MECHANISM FOR FUSION
(Courtesy of Dr. Yeong E. Kim)

Yeong E. Kim (Purdue), "Surface Reaction Mechanism for Cold Fusion with Electrolysis", A paper submitted to the First Annual Conference on Cold Fusion, Salt Lake City, Utah, March 27-30, 1990.

Abstract: A surface reaction mechanism is described for tritium production and excess heat generation above that due to the electrode reaction reported by Fleischmann, Pons, and Hawkins (FPH) and others in their electrolysis experiments. In the surface reaction mechanism, deuterium (D-D) fusion takes place in the surface zone of Pd cathode where whiskers of metal deuterides (PdD and/or LiD) are formed in electrolysis experiments. These whiskers are known to occupy the surface zone of approx. > 10 micrometer thickness, where most of D_2 and O_2 gases are formed from the dissociation of D_2O. Depending on electrolysis conditions, many spherical and hemispherical D_2 gas bubbles of varying sizes (radii ranging from few micrometers to a few millimeters) will be produced continuously in the surface whisker zone and will stay there for certain time durations before they move out of the electrolysis cell. Most of the D_2 gas bubbles in the surface whisker zone will have whiskers protruding into the bubbles creating field emission potentials around the tips of whiskers. The average potential in each D_2 bubble is expected to be approximately that of the applied potential of the electrolysis cell, but the electric field near the whisker tips can be several orders of magnitude larger than the average field, as is well known from field emission studies. Due to this electric field, D+ ions in the bubble will gain kinetic energies with a statistical distribution which depends on the bubble size and values of the varying electric field inside the bubble. When the applied potential is 1 to about 10 V, the average kinetic energy of the D+ ions in each bubble is expected to be 1 to about 10eV, which may be sufficient to achieve the observed reaction rates of 10^{-10} to about 10^{-23} per sec per D-D pair. Experimental tests of the proposed mechanism for cold fusion are discussed. Other nuclear reactions including neutron-induced reactions, which may occur subsequent to and concurrent with the D-D fusion during electrolysis, are also discussed.

INSTITUTE FOR FUSION STUDIES, U/TEXAS-AUSTIN

DEUTERON INTERACTION IN Pd
(Courtesy of Dr. Toshiki Tajima)

T. Tajima (U. Texas-Austin), H. Iyetomi (Argonne National Laboratory), & S. Ichimaru (U. of Tokyo), "Influence of Attractive Interaction between Deuterons in Pd on Nuclear Fusion", Institute for Fusion Studies, The Univ. of Texas at Austin, Paper IFSR #369, April 1989.

Abstract: It is shown that in a heavily deuterated palladium metal a pair of deuterons exhibit attractive interaction at short distance (approx. 0.1 to 0.7 Angstroms) due to strong Coulomb correlations in the ion-sphere model and due to the screening action of localized 4d electrons. This mechanism leads to enhanced thermonuclear reactions at room temperatures some 50 orders of magnitude faster than in a D_2 molecule. Characteristic signatures of predicted nuclear reactions are described.

SCREENING EFFECTS IN PdD_x
STATISTICAL-MECHANICAL THEORY
(Courtesy of Dr. Toshiki Tajima)

S. Ichimaru (U. of Tokyo), A. Nakano (U. of Tokyo), S. Ogata (U. of Tokyo), H. Iyetomi (Argonne National Laboratory), and T. Tajima (U. Texas-Austin), "Screening of the Hybridized 4d-1s Electrons in PdD_x and Nuclear Reaction Rates between Hydrogen Isotopes", Institute for Fusion Studies, The Univ. of Texas at Austin, Paper IFSR #376, June 1989, 15 refs.

Abstract: Screening action of the hybridized 4d-1s electrons in PdD_x is analyzed in the Fermi-Thomas approximation; charge-form factors for Pd and D are derived. The resulting D-D interaction is a sensitive function of both density x of the deuterons and energy levels $E_{1s}E_{15}$ of D-induced s-electron states; it exhibits an attractive part arising from interference between the 1s-screening electrons and strongly coupled (r_s approx 2) valence electrons. Nuclear reaction rates of hydrogen isotopes in Pd are calculated at various combinations of x and E13 by including D-D many-body effects through the ion-sphere potential; effects of fluctuations in x and/or E_{15} are discussed.

S. Ichimaru (U. of Tokyo), A. Nakano (U. of Tokyo), S. Ogata (U. of Tokyo), H. Iyetomi (U. of Tokyo), and T. Tajima (U. Texas-Austin), "Statistical-Mechanical Theory of Cold Nuclear Fusion in Metal Hydrides", Institute for Fusion Studies, The Univ. of Texas at Austin, Paper IFSR #379-R, Sept 1989, 25 refs.

Abstract: Screening action of the s-d hybridized electrons in PdH_x and TiH_x is analyzed in the Fermi-Thomas approximation. The resulting interaction between hydrogen exhibits an attractive part arising from interference between the H-induced s-electrons and the valence electrons. The screening potentials due to many-body effects between the electron-screened protons are examining through solution to the hypernetted-chain equations. The nuclear reaction rates between hydrogen isotopes are calculated at various temperatures by taking account of statistical-mechanical enhancements arising from the increment in the Coulombic chemical potential of a reacting pair before and after nuclear reaction. Remarkable isotopic and temperature-dependent effects are predicted.

MONTE CARLO SIMULATION STUDY
(Courtesy of Dr. Toshiki Tajima)

S. Ichimaru (U. of Tokyo), S. Ogata (U. of Tokyo), A. Nakano (U. of Tokyo), H. Iyetomi (U. of Tokyo), and T. Tajima (U.
Texas-Austin), "Monte Carlo Simulation Study of Short-Range Correlations Between Itinerant Hydrogen in Lattice Fields: Application to 'Cold Fusion'", Institute for Fusion Studies, The Univ. of Texas at Austin, Paper IFSR #397, Sept 1989, 15 refs.

Abstract: We perform Monte Carlo simulation study for short-range correlations between **itinerant hydrogen**, interacting mutually via electron-screened repulsive forces, in periodic and aperiodic (due to defects) lattice fields of metal hydrides. We find that the screening potentials and the resultant fusion rates depend extremely sensitively on microscopic details in the lattice fields, corroborating qualitatively the varied results in recent "cold fusion" experiments.

In the summary paragraph it is stated: "Finally we note in Table I an incredibly large reaction rate predicted for TiH_2 with defects [in the lattice structure] at T = 200 K."

UNIVERSITY OF DELAWARE
(Courtesy of Dr. Krzysztof Szalewicz)

FUSION RATES IN TITANIUM

Karl Sohlberg and Krzysztof Szalewicz (U/Delaware), "Fusion Rates for Deuterium in Titanium Clusters", Physics Lett A, in press. 25 pages, 31 refs.

Abstract: Ab initio Hartree-Fock self-consistent field calculations for hydrogen atoms in a titanium atom matrix have been performed. Computed potential energy surfaces for the deuterium motion are used to calculate fusion rates. These calculations suggest that no stable state of titanium deuteride exists with the small inter-deuteron distances required for measurable fusion rates.

Note: While admittedly a much more difficult calculation, it is hoped that the authors will consider the fusion probabilities between itinerant deuterium ions and deuterons imbedded in the titanium lattice. Experimental evidence exists for cold fusion in such an environment. See BARC papers, for example under News From India.

HELIUM IN PALLADIUM
(Courtesy of Dr. Sam Faile)

G.C. Abell, L.K. Matson, and R.H. Steinmeyer, "Helium release from aged palladium tritide", Physical Review B, Vol. 41, No. 2, pp 1220-1223 (January 15, 1990) 23 refs.

Summary: Experimental studies of helium release from aged PdT_x show that the helium-to-metal-atom ratio saturates at a value of He/Pd about 0.5 under conditions of ambient temperature storage. Below this value, very little helium release occurs. Thermal desorption experiments show that release from a sample with He/Pd about 0.3 requires temperatures in excess of about 600 K, while release from a sample with He/Pd about 0.02 requires temperatures in excess of at least 1300 K. These results are related to the question of the disposition of helium that would be produced by hypothetical reactions in a PdD_x electrode. The paper concludes: "... the present experimental results demonstrate that helium born within palladium hydride (H, D, or T) will certainly not escape into the external gas stream. ...Such trapped helium could easily be detected (down to levels of about 10^{10} atoms per gram of Pd) by mass spectrometric analysis of the Pd-electrode material.

EXCESS HEAT DIFFICULT TO EXPLAIN

K. Szalewicz (U.Del.), J.D. Morgan III (U.Del.), and H.J. Monkhorst (U.Fla.-Gainesville), "Fusion rates for Hydrogen isotopic molecules of relevance for 'cold fusion'", Physical Review A, Vol 40, No. 5, (Sept 1, 1989), pp 2824-2827, 20 ref.

Summary: In response to the recent announcements of evidence for room-temperature fusion in the electrolysis of D_2O, we have analyzed how the fusion rate depends on the reduced mass of the fusing nuclei, the effective mass of a 'heavy' electron, and the degree of vibrational excitation. Our results have been obtained both by accurately solving the Schrodinger equation for the hydrogen molecule and by using the WKB approximation. We find that in light of the reported d-d fusion rate, the excess heat in the experiment by Fleischmann, Pons, and Hawkins [1] is difficult to explain in terms of conventional nuclear processes.

Note: This paper asks, "...whether the crystal environment could open the channels for the radiationless reaction p + d --> ^{3}He (5.4 MeV) and d + d --> ^{4}He (196 keV) + mu (5.2 MeV)." The authors conclude that the probability of reaction through this channel is still relatively low. The conclusion is: "On the basis of our analysis we have concluded that the excess heat reported by Fleischmann, Pons, and Hawkins cannot be explained in terms of conventional nuclear processes."

[1] M. Fleischmann, S. Pons, and M. Hawkins, "Electrochemically induced nuclear fusion of deuterium." J. Electroanal. Chem., 261, pp 301-308, and erratum, 263, p187 (1989).

A NEGATIVE COLD FUSION TRIAL
(Courtesy of Dr. Samuel Faile)

S.H. Faller, R.W. Holloway, S.C. Lee, "Investigations of Cold Fusion in Heavy Water", J. Radioanal. Nucl. Chem. Letters, vol 137 No. 1, pp 9-16, (1989), 4 refs.

This paper was received 30 May 1989 and accepted 2 June 1989. The authors tried a variation of the Fleischmann-Pons-Hawkins experiment and found no nuclear byproducts. They used a hollow cylinder Pd cathode 6 cm. long by 3 mm. dia with about 1 mm wall thickness. The paper gives no details of any cathode preparation (an almost sure indication of imminent failure). The anode was iron, the electrolyte was NaOH later changed to LiOH by the introduction of LiC_2. Other experimenters have warned that carbon can contaminate the experiment ("Creating a Working Fusion Cell", Fusion Facts, Vol 1, No. 2, August 1989 pp 1-3).

FUSION: PRUDES OR SCIENTISTS?

"Fusion: Prudes or Scientists", The Plain Dealer, Friday Dec. 29, 1989, editorial.

This editorial includes the following: "The DOE panel wasn't even convinced that excess heat had been observed -- despite reported and unreported findings of this phenomenon from at least 16 teams of scientists, including two groups at the DOE-funded Oak Ridge National Laboratory in Tennessee and two groups at Case Western Reserve University here. The panel noted that 13 teams with published reports and 13 groups with unpublished findings had failed to find such results. The implication -- that since many more groups did not find excess heat than did, the results must be questionable -- is patently absurd."

After giving examples of hardening of the intellectual arteries, the article concludes: "Yet from this vantage point, it appears the tree is ripe for shaking. What prudes scientists have become if they **fail** to be intrigued by the unexplained. And how unlikely to find the answer if they fail to look.

A FAILED HATCHET JOB
(Courtesy of Marsha Freeman)

Ramtanu Maitra, "Cold Fusion: A Failed Hatchet Job", The New Federalist, Jan 19, 1990 page 11.

Article relates Prof. Russell M. Kulsrud's condemnation of cold fusion findings in his presentation at the 1989 International Conference on Plasma Physics held in New Delhi in late November. Dr. Kulsrud is affiliated with the Plasma Physics Laboratory at Princeton Univ. Dr. M. Srinivasan of Bhabha Atomic Research Centre (BARC), Tombay, India pointed out that while cold fusion may be dead at Princeton it is alive and well in India.

According to the article, Kulsrud stated, "There is definitely no energy generation of the order claimed by Pons and Fleischmann in their electrolysis of heavy water with palladium cathodes."
Kulsrud made it plain that he believes that Pons and Fleischmann made sloppy measurements. In contrast Dr. Srinivasan presented details of the BARC cold fusion experiments in which tritium generation was 100 million times more than the neutron
generation.

REINVENTING THE BATTERY
(Courtesy Avard Fairbanks)

"Reinventing the Battery", Popular Science, February 1990 page 23.

Fairbanks points out that this new LBL battery using uses a lithium anode and solid-state thin films and disulfide polymers as the anodes. Discharge releases electrons from the lithium and breaks the sulfur-sulfur bonds in the polymer. The opposite occurs during charge. Batteries operate at room temperature and have shown virtually no decrease in performance after 100 charge-discharge cycles. Fairbanks suggests these batteries as candidates for many fusion power systems.

LETTERS FROM READERS.

DEUTERON FUSION - NO NEUTRONS
Letter from Harold Aspden (Visiting Senior Research Fellow), Dept. of Electrical Engineering, The University, Southampton, England. (Dated Jan 8, Received Feb 1, 1990 after the article on neutrons and cold fusion was written.)

Dr. Aspden writes: "...in 1986 I published a paper in the Hadronic Journal concerning the neutron and the deuteron [1]. I pointed out that there were no neutrons in the deuteron. The neutron is only known in its free state when ejected by high energy action. More important, just as the neutron has a magnetic moment (though electrically neutral) as if it has an antiproton core for 22/23 of the time, so the deuteron has a magnetic moment which tells us that it too spends one seventh of its time as a neutral core with a satellite positron. The proof is the valid theoretical calculation of magnetic moment to part per million precision, as disclosed in the paper [1].

"You will see from this that deuteron fusion can occur under cold conditions with no neutron emission, if the deuterons come together whilst in their neutral phase. This [fusion] is aided by the annihilation of the positron by electron flow in a cathode conductor. My guess is that the top few layers of the cathode become saturated with tritons and protons and so arrest the fusion process after a while, so any practical implementation will need to reverse the anode-cathode current for short recovery periods to cleanse the surface."

[1] H. Aspden (Univ.-Southampton), "The theoretical nature of the neutron and the deuteron", Hadronic Journal Vol 9, No. 4, pages 129-136 (31 July 1986) 19 references.

NOTE: Aspden filed a patent for "Electrically Controlled Ion Fusion", UK Patent Application No. 8,908,571. The patent application was dated 15 April 1989. Ed.

DIFFUSION PROCESSES

Professor Valerij V. Bryksin is a co-author (with Prof. Harald Botger) of Hopping Conduction in Solids (Academic-Velag, Berlin, 1985). This book was reviewed briefly in Fusion Facts Vol 1. No. 5, Nov. 1989, page 13. The statement was made: "It is the opinion of the Editor that Bottger and Bryksin could provide some insights into the phenomena of charged particle conduction in palladium lattices." We have received a response to our letter to Prof. Bryskin which reads in part as follows:

"...I and my colleagues are interested in an investigation of the cold fusion which was first observed in the University of your state. Of course, I and my colleagues want to take part in studying the phenomena. A field of such an investigation is vast. Because of our specialization we are more interested in a cooperation on a theoretical investigation of diffusion and electrodiffusion of ions in crystalline lattices. We think that an investigation of diffusion processes taking into account a correlation between charged diffusible particles and a formation of D+D pairs is especially important. These processes in external electric fields (correlated electrodiffusion) are also of interest in connection with a recent communication from Japan where a reaction in the gas phase and at high electric field potential (about 12 KV) has been observed. The experiment reported a strong flash of neutron radiation. It seems to me that a study of ion movement in lattices taking into account the effect of the cathode surface is also important."

Address:
Prof. V. V. Bryksin,
Str. Karpinskogo 8, Flat 32
Leningrad, USSR
195256

NOTE: The book Hopping Conduction in Solids deals mainly with phenomena of electrons and semiconductors. However, Chapter V, "Recent Developments", contains reports of interesting developments that were added in proof in 1983. Chapter IV, "Classical Hopping Transport", deals with diffusive atomic motion. This subject became important in the study of superconductivity and will be of importance in learning more about cold fusion. The book includes 24 pages of references. We strongly urge our readers who share an interest in furthering the theory of cold fusion to communicate with Prof. Bryksin. Ed.

NEGATIVE PAPERS ON COLD FUSION

Fusion Facts has received three comments urging us to give more attention to negative results. With the plethora of positive results, we believe that authors reporting negative results while trying to replicate the Fleischmann-Pons-Hawkins experiment can only be embarrassed by further attention. Therefore, we try to contact such experimenters, send them information, and suggest other nearby successful researchers who can help. One of the best definitions of a scientific fact is "the close agreement of a series of observations of the same phenomena." The many observations by researchers from over 50 laboratories in over ten countries of the production of neutrons, and/or tritium, and/or excess heat in the heavy-water lithium-palladium electrochemical system have proven that cold fusion is a scientific fact. What has yet to be published is the methods by which the experiment can be replicated and achieve the precise same results at each try.

* * *

D. NEWS FROM INDIA

BARC COLLECTION OF PAPERS.
(Courtesy of Drs. Brophy and Guruswamy)

P.K. Iyengar and M. Srinivasan, Editors BARC Studies in Cold Fusion (April-September 1989), published by Govt. of India, Atomic Energy Commission, Bhabha Atomic Research Centre, Trombay, Bombay, India, BARC-1500, 1 Dec 1989, 20 articles.

The BARC collection reports on the extensive work accomplished at the Bhabha Atomic Research Centre that began immediately after the announcement by Fleischmann and Pons on March 23, 1989. The papers cover April through September 1990. Eleven papers report on various electrolytic cell experiments, four papers report on experiments in which titanium and palladium shapes are loaded with deuterium gas, and five papers are on theoretical considerations. The publisher/distributor is listed as the Bhabha Atomic Research Centre, Bombay. Originally the work on cold fusion in India was treated with some secrecy (press was not admitted to the first cold fusion meeting in India) but Dr. Iyengar has been quoted as favoring a free exchange of research results to more rapidly promote this new technology. We applaud Dr. Iyengar for his foresight.

The Conclusions of the work to date is summarized by Iyengar and Srinivasan as follows:

"Investigations of cold fusion phenomena carried out at Trombay during April to September 1989, **have positively confirmed** the occurrence of (d-d) fusion reactions in both electrolytic and gas loaded Pd and Ti metal lattice at ambient temperatures. Neutron emission has been observed at times even when the current to the electrolytic cell was switched off or in case of gas loaded Ti targets when no externally induced perturbation such as heating, cooling, evacuation etc was effected."

The main findings of the Trombay investigations are as follows:

1. Tritium is found 100 million times more than neutrons (averaged over a variety of experiments). Neutrons and tritium appear to be produced in the same time intervals.

2. Cold fusion in electrolytic cells begins after a charge of about one ampere-hour per sq. centimeter of palladium (or titanium). This is about equivalent to 0.6 ratio of D/Pd. However, one paper suggests that 0.8 may be a significant D/Pd ratio.

3. Once fusion reactions begin, the cathode produces about 100,000 neutrons and about 10^{14} tritium atoms per sq. cm. of cathode, regardless of the details of cell design.

4. Neutrons are emitted essentially singly with a Poisson distribution from both electrolytic and gas-loaded experiments.

5. About one-tenth to one-fourth of neutrons are generated in bunches of 100 or so neutrons in a 20 millisecond time period. Since it is unlikely that these neutron events are matched with a cascade production of 10^{10} atoms of tritium, the neutron bursts may be due to lattice cracking or a similar event.

6. The gas-loading of Ti and Pd together with the use of medical X-Ray film for self-photographing of the tritium decay is an elegant manner to show nuclear events. Spots of activity are highly localized with titanium but more diffuse with palladium.

7. The high probability for the tritium branch in d-d cold fusion would indicate processes of neutron transfer across the potential barrier. This mechanism has been discussed elsewhere:

[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) Ed.]

The BARC editors conclude: "If neutron transfer as envisaged by these authors does take place so easily, it may have many implications for the future of nuclear technology, for the deuterium nuclide might very well do the work which free neutrons do in present day fission reactors. In the context of the emerging energy production scenario, aneutronic nuclear reactions such as this may give rise to new nuclear technologies providing a cleaner energy source for the twenty-first century."

NOTE: Although the editors did mention excess heat as one of the observed byproducts of nuclear reactions, paper A-5 (Radhakrishnan et al, "Search for Electrochemically Caltalysed Fusion of Deuterons in Metal Lattice") has the following observation after listing the neutron and tritium nuclear reactions of d-d: "In the present work, the emission of neutrons, reasonably above the background level, and the build up of significant tritium activity in excess of the blank value, have been confirmed in four different electrolysis experiments. In certain experiments neither the evidence for significant neutron emission nor any appreciable build up of tritium activity has been observed. It is likely that in such cases charging was not sufficient for ensuring optimum loading of the lattice with deuterons for inducing fusion. However, it appears that in addition to reaction channels (2) and (3) [the neutron and tritium branches], the **possible occurrence of a non-emitting nuclear process cannot be precluded.**"

"This reaction can be written as Pd + D + D --> ^{4}He + Pd*, which implies that the lattice is excited to a higher energy level to conserve both momentum and energy. It is likely that during the subsequent lattice relaxation, the excess energy stored in the lattice is liberated as heat. This mechanism would lead to the formation and build up of helium inside the metal and can possibly account for the observed low yield of neutrons or tritium in certain experiments."

The following papers are included in "BARC Studies in Cold Fusion (April-September 1989)":

PART A. ELECTROLYTIC CELL EXPERIMENTS

A-1. M.S. Krishnan, S.K. Malhotra, D.G. Gaonkar, M. Srinivasan, S.K. Sikka, A Shyam, V. Chitra, T.S. Iyengar, and P.K. Iyengar, "Cold Fusion Experiments Using a Commercial Pd-Ni Electrolyser", 10 pages, 5 refs.

Two quotes are of interest: "...tritium production is much higher than the neutron yield, although in 'hot fusion' their probability is known to be approximately equal." "An important observation of this work is that 'spent' Pd electrodes seem to lose their capability to support cold fusion reactions as can be seen from a comparison of the results of RUN1 and RUN2."

A-2. M.G. Nayar, S.K. Mitra, P. Raghunathan, M.S. Krishnan, S.K. Malhotra, D.G. Gaonkar, S.K. Sikka, A Shyam, and V. Chitra, " Preliminary Results of Cold Fusion Studies Using a Five Module High Current Electrolytic Cell", 5 pages.

The conclusion states: "The electrolysis though carried out for limited periods only has shown conclusively that cold fusion occurs in this system also." The tritium/neutron ratio is reported to be about 1 billion to 1.

A-3. M.S. Krishnan, S.K. Malhotra, D.G. Gaonkar, M.G. Nayar, A. Shyam, and S.K. Sikka, "Observation of Cold Fusion in a Ti-SS Electrolytic Cell", 5 pages.

The conclusions state: "The results of the neutron and tritium measurements seem to strongly indicate that cold fusion occurs in the Ti-D system also. When compared with Pd-D systems where big neutron bursts are observed, in the present system the neutrons are produced at a low but more or less steady rate." It was observed that the Tritium/neutron ratio was about 10 million. Our American readers should note that PTFE stands for polytetrafluoroethylene and can be translated as Teflon.

A-4. A. Shyam, M. Srinivasan, S.B. Degwekar, and L.V. Kulkarni, "Multiplicity Distribution of Neutron Emission in Cold Fusion Experiments", 13 pages, 9 refs.

The conclusion states: "...in the light of the experimentally deduced neutron-to-tritium branching ratio of 10^{-8}, we are obliged to come to the intriguing conclusion that during bunched neutronic events upwards of 10^{10} fusion reactions occur in under 20 msec. As this appears very unlikely, the authors are inclined to believe that bunched neutronic events are not accompanied by tritium production with a yield of 10^8 and hence lattice cracking where the branching ratio is close to unity would appear to be the most plausible cause for bunched neutron emission."

A-5. T.P. Radhakrishnan, R. Sundaresan, J. Arunachalam, V. Sitarama Raju, R. Kalyanaraman, S. Gangadharan, and P.K. Iyengar, "Search for Electrochemically Catalysed Fusion of Deuterons in Metal Lattice", 11 pages, 5 refs.

The following quote is of interest: "The predominant process during d.c. polarisation is the electrolysis of D_2O and has been checked by measuring the volume of D_2 and O_2 mixture liberated in a fixed electrolysis time using a precision integral flow-meter and by gas chromatographic analysis of the composition of the gas mixture. As **excess heat** is liberated over and above electrolysis, it is clear that some other reactions are responsible for the excess enthalpy observed. Pauling ascribed the excess heat to the formation of palladium deuteride. However, Bockris and coworkers have shown that exothermic effects due to solution of D in Pd; recombination of D atoms; formation of D_2O etc. cannot account for the observed heat evolution. Normal chemical reactions cannot account for the generation of neutrons or the production of tritium during charging of Pd with deuterons. As has been pointed out by Fleischmann and Pons , the results can be rationalized and understood on the basis of cold fusion reactions occurring between deuterons in the Pd lattice as indicated ...". Paper then discusses the nuclear reactions of d + d. See in Note above following the list of conclusions. Ed.

A-6. T.P. Radhakrishnan, R. Sundaresan, S. Gangadharan, B.K. Sen, T.S. Murthy, "Tritium Generation during Electrolysis Experiment", 13 pages.

This experiment used a Pd cylinder 1 cm. in length and with a surface area of 6.37 sq. cm. The paper notes: "...around 1,000 hrs. there was a change in the cell behaviour. The bottom of the cell was shattered due to explosion. ... Before the explosion it was noticed that the cell temperature shot up from 71 deg C to 80 deg C and the bubbling rate was low."

"Metallographic examination of the palladium cathode ... which experienced an explosion showed an extensive twinning within the palladium grains with worm-like microstructure. This is suggestive of an intensive shock-wave impact on the metal."

A-7. G. Venkateswaran, P.N. Moorthy, K.S. Venhateswarlu, S.N. Guha, B. Yuvaraju, T. Datta, T.S. Iyengar, M.S. Panajkar, K.A. Rao, and Kamal Kishore, "Burst Neutron Emission and Tritium Generation from Palladium Cathode Electrolytically Loaded with Deuterium", 12 pages.

The paper includes the following comment: "The electrolytic cell design was optimised mainly with respect to observation of fusion products rather than the accurate measurement of excess heat output. This is because the quantity of heat required to raise the temperature of 1 gm of D_2O even by 1 K demands the occurrence of about 10^{13} fusions and hence heat measurement appears to be an insensitive method of confirming whether cold fusion occurs in the cathode or not."

These scientists from the Chemical Group and the Health Physics
Division, in their initial work did not expect to find lots of excess heat. They make the following observation: "In general very few groups have been able to reproduce the large heat output reported by Fleischmann et al and Mathews et al (Indian J. Tech. vol 27, No. 229, 1989). Even to match

a cooling rate of 0.1 K per minute in a cell of dimensions reported in the present paper it would require the occurrence of fusions at a steady rate of about 10^{10} per sec. ... hence there is no wonder that the excess heat output went undetected."

The paper concludes with: "...Energy production from cold fusion of deuterium in an electrolytically charged Pd matrix in a sustained manner may require more systematic exploration to identify the various parameters governing the occurrence of the process, not the least important among which is **the proper pretreatment of the electrode**.

A-8. H. Bose, L.H. Prabhu. S. Sankarnarayanan, R.S. Shetiya, N. Veeraraghavan, P.V. Joshi, T.S. Murthy, B.K. Sen, and K.G.B. Sharma, "Verification Studies in Electrochemically Induced Fusion of Deuterons in Palladium Cathodes", 10 pages.

This experiment used a 1 x 1 x 1 cm cube of palladium as cathode and platinum wire gauze as anode and lasted for seven weeks. The paper reports: "At the end of 1365 ampere-hours, current was changed to pulsing mode (... 0.5A for 1 sec followed by 2.5A for 11.5 sec) for about three hours and then to the cycle 0.5A for 1 second followed by 4.5A for 1.5 sec). The latter lasted for about ten minutes when an explosion occurred inside the cell resulting in the cell lid being thrown out with the electrode assembly."

Again reported: "When the Pd-D_2O main experiment was conducted in current pulsing mode with low heat sink temperature environment, the cell experienced a temperature transient of about 25 deg C over a period of 8 minutes. The cell had a mild explosion which dismantled the cell configuration. ...". "During seven weeks of electrolysis, the Pd-D_{20} cell experienced in all three explosions, two of which lifted the cell lid."

Data for heat measurements were taken and are provided. While excess heat was found, the measurements were deemed not to be of the quality that should be used to confirm excess heat. Ed.

A-9. T.S. Murthy, T.S. Iyengar, B.K. Sen, and T.B. Joseph, "Tritium Analysis of Samples Obtained from Various Electrolysis Experiments at BARC", 10 pages.

This report summarizes the methods by wich tritium content in various experimental samples was measured.

A-10. M.S. Krishnan, S.K. Malhotra, and S.K. Sadhukhan, "Material Balance of Tritium in the Electrolysis of Heavy Water", 8 pages, 6 refs.

The report states: "In this short note we have attempted to give a complete material balance of tritium escaping the system in the form of DT gas and also as DTO vapor.

Tritium produced in excess of what is predicted from this equation may be attributed to nuclear fusion reactions."

A-11. K. Annaji Rao, "Technique for Concentration of Helium in Electrolytic Gases for Cold Fusion Studies", 5 pages, 3 refs.

The paper states: "In order to concentrate the helium in the gas phase an experimental technique has been devised wherein D_2 and O_2 generated by electrolysis is catalytically recombined in situ facilitating gas collection over long periods of electrolysis. The results obtained by this techniques followed by gas chromatographic analysis are given in the paper."

The conclusions include: "Though all the released gas is contained and concentrated to a residual volume of 1 to 3 ml, no helium could be detected in all the experiments." No comments were made as to the possibility of the He being consumed by other nuclear reactions. [See also review of paper by Abell et al under C. (MORE NEWS FROM U.S.) Ed.]

PART B. D_2 GAS LOADING EXPERIMENTS

B-1. P. Raj, P. Suryanarayana, A. Sathyamoorthy, and T. Datta, "Search for Nuclear Fusion in Gas Phase Deuteriding of Titanium Metal", 4 pages, 4 refs.

The results included: "After a soaking time of about 20 minutes, sample temperature was raised gradually [from 77K], while simultaneous evacuation was started. Within about 15 min. the neutron counter registered an increase in count rate reaching a max 3900 (as compared to background counts of about 60)."

B-2. V.K. Shrikande and K.C. Mittal, "Deuteration of Machined Titanium Targets for Cold Fusion Experiments", 3 pages, 6 refs.

The paper contains the following: "It was noticed that targets could typically absorb about 10^{19} molecules of D_2 ... successful deuteration depends on various experimental factors ... Initial sandblasting of the targets for cleaning and roughening of the surface leads to better absorption of D_2. Impurity content (such as O_2, N_2 etc.) in D_2 should be <0.1%. Since the glass vacuum chamber is isolated from the pumping system during D_2 absorption, it is important that the vacuum chamber be lead tight. Small air leaks may contaminate the D_2."

B-3. R.K. Rout, M. Srinivasan, and A. Shyam, "Autoradiography of Deuterated Ti and Pd Targets for Spatially Resolved Detection of Tritium Produced by Cold Fusion", 4 pages, 5 refs.

The conclusions include: "The evidence presented in the paper seems to be indicative of cold fusion reactions occurring in some of the deuterium loaded titanium and palladium targets. It has not been possible to conclusively establish whether the fusion reactions occur during the deuteration process or subsequently. Also it is not clear whether the reactions occur in sporadic bursts or continuously. However one of the disc targets, which gave impressive spotty radiograph did give rise to a significant neutron burst which produced 10^6 neutrons over a period of 85 minutes."

B-4. M.S. Krishnan, S.K. Malhotra, D.G. Gaonkar, V.D. Nagvenkar, and H.K. Sadhukhan, "Evidence for Production of Tritium via Cold Fusion Reactions in Deuterium Gas Loaded Palladium", 5 pages, 5 refs.

In these experiments the deuteriated target palladium was kept in contact with distilled water for a few hours to extract the tritium by isotopic exchange into the water.

The conclusions include: "Gas loaded Pd samples have provided evidence for the first time of the presence of tritium, strongly suggesting the occurrence of cold fusion reactions. The Pd-D system does not require high pressure of D_2 gas and also no external perturbation is required to create non equilibrium conditions as suggested by De Ninno et al."

PART C. THEORETICAL PAPERS

C-1. R. Chidambaram and V.C. Sahni, "Materials Issues in he So-Called 'Cold Fusion' Experiments", 2 pages, 6 refs.

This paper from the Physics Group speculates that the excess heat observed by Fleischmann and Pons is due to deuteride formation. The final paragraph states: "To sum up, we feel that the neutronic signals reported to have been seen in some of the recent electrochemical experiments deserve to be viewed in the light of the materials science of palladium deuteride. Although, if it is finally confirmed, this so called 'cold fusion' would be physically very interesting, the possibility that it will lead to a significant new energy source appears doubtful at present."

This paper was published in "Current Science", June 5 1989 (Vol. 58, No. 11 pp 597-598). Not long after the article was written, there were results from BARC experiments that lead Dr. Iyengar, the Director, to state that cold fusion is a reality and not an artifact of experiment.

C-2. B.A. Dasanacharya and K.R. Rao, "Remarks on Cold Fusion", 2 pages 7 refs.

This paper makes some interesting comments about the large energy fluctuations that are normally found in materials. The conclusion states: "...we note that a number of known phenomena give evidence for the presence of large energy fluctuations of small number of atoms over short times and these may be considered as one of the possible modes for'starting' a cold fusion which would then be followed by more nuclear reactions involving the product of the first fusion reaction. Such fluctuations may vary considerably depending on the condition of the solid/experiments, like concentration gradient, field gradient, nearness to a transition etc."

C-3. S.N. Vaidya and Y.S. Mayya, "The Role of Combined Electron-Deuteron Screening in D-D Fusion in Metals", 4 pages, 9 refs.
The authors show that the combined effect of screening by
both the electron and the deuteron or by a deuterium molecule in the palladium lattice can raise the probability of fusion events to a range of values of 10^{-16} to 10^{-14} per second. These values lie within the range of values indicated by cold fusion experiments.

C-4. Swapan K. Ghosh, H.K. Sadhukhan, and Ashish K. Dhara, "A Theory of Cold Nuclear Fusion in Deuterium Loaded Palladium", 4 pages 18 refs.

Calculations by the authors show that the fusion rate per deuterium pair per sec is a strong function of the D/Pd ratio and ranges from 10^{-20} to 3.45×10^{-18} as the D/Pd varies from 0.5 to 1.2. The conclusion states: "...we emphasize that the screening mechanism due to quantum boson plasma can significantly enhance the cold fusion rate. However, due to extreme sensitivity of the predicted rate on the screening length, further studies incorporating the effect of temperature, non adiabatic degrees of freedom, non equilibrium conditions etc are in progress to confirm the role of the suggested mechanism in the observed cold fusion.

C-5. T.C. Kaushik, M. Srinivasan, and A. Shyam, "Fracture Phenomena in Crystalline Solids: A Brief Review in the Context of Cold Fusion", 3 pages, 22 refs.

This paper summarizes the literature concerning fusion events due to 'fracto-fusion'. The concluding paragraph states: "Meanwhile along with fusion signals, the detection of electric fields and related acoustic emission during cracking in the present type of cells or gas-loaded metals, should be able to indicate if the fracturing of metals because of deuterium loading is at least partially, if not completely, involved in the observed cold fusion phenomena."

NOTE: In the September 1989 issue of Fusion Facts, we cited from the TIMES OF INDIA the following: "Reportedly, some Indian scientists have determined that the current level of heat produced by cold fusion is sufficient to warrant further scaled-up experiments. Their studies indicate that the heat density from a power plant design is currently competitive with the heat density in a commercial coal-fired power plant." In view of this former newspaper article, the volume of papers from BARC is also of interest in what they do not, as yet, report. However, the papers provide some

excellent additional insight into the processes of cold fusion. In addition, the fact that one research facility in India has 53 scientists (the number of authors for the above papers) reporting on various aspects of
cold fusion is significant. Ed.

POSSIBLE FUSION MECHANISM
(Courtesy Ramtanu Maitra)

J.K. Bhattacharjee, L. Satpathy, and Y.R. Waghmare (Indian Inst of Tech, Kanpur), "A possible mechanism of cold fusion", Pramana - J. Physics, Vol. 32, No. 6, June 1989, pp L841-L844. 1 Ref.

Abstract: A possible mechanism for the occurrence of nuclear fusion at room temperature is presented. Neutralization of the positive charge of the deuteron nucleus by its orbiting electron due to large enhancement of effective mass results in the vanishing of the Coulomb barrier which facilitates fusion at room temperature.

An interesting comment from the paper: "It may be remembered that deuteron is a very loosely bound system with root mean square radius of 4.2 fm. Fifty per cent of the time the neutron and proton spend outside the range of the nuclear force." See also the letter from Aspden under Section C.

* * *

E. MORE NEWS FROM ABROAD

ENGLAND

THE SUPERGRAVITON AND FUSION
(Courtesy H. Aspden)

H. Aspden (Univ.-Southampton), "The supergraviton and its technological connection", Speculations in Science and Technology, Vol 12, No. 3, pages 179-186, 12 refs. [An appendix discussing applications to solid-state fusion was added in July 1989 while paper in proof form but inspired by the
Fleischmann-Pons-Hawkins announcement.]

Abstract: This paper shows how the 2.587 GeV graviton discussed in the first issue of Speculations in Science and Technology accounts for a supergraviton state of 95.18 GeV. This suggests a pairing of the 2.587 GeV graviton with the 92.6 ±1.7 GeV Z boson in a resonant response in certain molecular systems. Technological implications are discussed with emphasis on the "warm" superconductor phenomenon found in perovskite compositions having molecular masses that are integral multiples of 95.18 GeV c^{-2}.

The appendix states: "Note that these fusion experiments involve
the entry of light atoms (deuterium) into the body of an electrode composed of heavy atoms (palladium). The graviton inflow has to adjust to supergraviton form, because palladium has an atomic mass in excess of 102 mu."

"...Now suppose that a light atom of mass M mu can enter into molecular association with the heavy atom, bringing with it its graviton cluster. Indeed, for generality, suppose that n such light atoms form a union with the heavy atom. Then, the graviton resonance has to be such that A + nM is approx = 102.18 + 6.60
where nM is necessarily less than 6.60. If enough such resonant atoms can survive long enough to act in a concerted decay adjustment as the graviton clusters transform in supergraviton states, then conceivably there is sufficient transient energy involved in the background field fluctuation for fusion on the n light atoms to occur."

"... Ignoring fusion of hybrid combinations of light atoms, the
only possible nuclear reactions involving catalyst A in the
graviton-supergraviton transition are:

M=1 (hydrogen) A=106.78: only silver has the 107 isotope
M=2 (deuterium) A=104.78: only palladium has the 105 isotope
M=3 (tritium) A=102.78: only rhodium has the 103 isotope."

The appendix concludes: "The technological conclusion to be drawn from this simple analysis is that the supergraviton is involved in the Fleischmann and Pons discovery and that the fusion activity might well be enhanced if the palladium electrode used with deuterium electrolysis is enriched by the isotope 105. The 'cold fusion' catalytic stimulus of supergraviton resonance is further discussed in the author's UK Patent application."

NOTE: See also LETTERS FROM READERS under Section C. Ed.

GERMANY

LASER-INDUCED COLD FUSION?
(Courtesy of Dr. Samuel Faile)

Christoph Steinert, "Laser-Induced 'Semicold' Fusion", Fusion Technology, Vol. 17, Jan. 1990, pp 206-208, 5 refs.

Abstract: "The large high-energy lasers required for inertial fusion are at present beyond state of the art, and there are other problems (instability of the fuel target, suprathermal electrons, etc.) as well. Therefore, it is hoped that the energy requirement for inertial fusion can be reduced with the help of cold fusion, which takes place within the electrode material confining the fuel (avoiding instability problems). With the 'semicold fusion cell,' laser energy is transferred into the 'hot' part of the fuel, which is confined within the cathode in a cavity, and credit is taken from fast projectiles (tritium) stemming from the (t,p) branch of cold

fusion in the 'cold' metal lattice. The latter is the key to the model of a dynamic process for potential growth between the cold electrode and the hot confined fuel in the semicold fusion cell."

HUNGARY

FUSION TRIGGERED BY DIELECTRIC CONSTANT
(Courtesy of Dr. Samuel Faile)

C. Hargital (Hungarian Academy of Sciences), "Considerations on Cold Nuclear Fusion in Palladium", J. Radioanal. Nucl. Chem., Letters, Vol 137, No 1, pp 17-22, (1989), 4 refs.

Abstract: The possibilities for cold nuclear fusion in an electrochemical cell are discussed. It is suggested that the cold nuclear fusion can be triggered by rising the dielectric constant of the cathode material around a value of 20.

The paper states: "...It is found that under these conditions at electromotive force smaller than 1 volt, the fusion rate can exceed 1 per second whenever epsilon [the dielectric constant] is greater than 20 or so. This way, **cold nuclear fusion is not impossible in a Fleischmann-Pons cell**."

The final paragraph is important: "If this consideration on cold nuclear fusion is valid, that is, the continuum approximation for dielectric screening is justified for extremely small subatomic distances and there is really a metal-semiconductor transformation in the PdH_x system, the effects due to high dielectric permeabilities in the PdH_x should show up in all nuclear processes where the Coulomb barrier manifests itself. For example, the alpha-decay and the spontaneous fission of high atomic number nuclei must be catalyzed by the dielectric environment especially when the Coulomb barrier is extremely high. This can give further possibility to test these considerations."

PSEUDO-COMPRESSION OF D_2
(Courtesy of Dr. Samuel Faile)

G. Horanyi (Hungarian Academy of Sciences), "Some Basic Electrochemistry and the Cold Nuclear Fusion of Deuterium", J. Radioanal. Nucl. Chem., Letters, vol 137, No. 1, pp 23-26, (1989), 4 refs.

The abstract: "The role of electrochemistry in the discovery and interpretation of the alleged cold nuclear fusion is discussed."

The paper provides a mathematical discussion of the way in which the apparent closeness of deuterium atoms in a palladium lattice can be compared with a compression of D_2 in the gas phase (as suggested by Fleischmann, Pons, and Hawkins in their first paper). The author states: "The aim of the present paper is to show that a strict analysis of kinetic and equilibrium relationships for palladium electrodes implies that the calculation of pressures of 'astronomical magnitude' should be rejected."

FUSION IN Fe-Zr ALLOY?
(Courtesy of Dr. Samuel Faile)

E. Kuzmann, M. Varsanyi, L. Korecz, A. Vertes, T. Masumoto, F. Deak, A. Kiss, L. Kiss (Eotvos Univ., Budapest), "Investigation on the Possibility of Cold Nuclear Fusion in Fe-Zr Amorphous Alloy", J. Radioanal.Nucl.Chem.,Letters, Vold 137, No. 4., pp 243-250, (1989), 9 refs.

Abstract: "Neutron, gamma, and Mossbauer spectroscopy were used to study the possibility of cold nuclear fusion in $Fe_{90}Zr_{10}$ amorphous ribbon having high hydrogen absorbing ability. No significant changes in the neutron and in the gamma spectra were found at deuterization performed electrochemically at different cathodic potentials. The observed differences between the Mossbauer spectra of samples deuterized in air and in nitrogen atmosphere can be explained by decrease of deuterium uptake as well as by a small heat effect due to reaction of hydrogen with oxygen dissolved in water in the case of electrolysis carried out in air."

This Hungarian-Japanese effort used a thin ribbon in an electrolytic cell having a Na_2SO_4 electrolyte. The neutron, gamma, and Mossbauer spectroscopy did not give any clear indication of cold fusion.

The authors note that the lack of results in the very thin samples used in their experiment does not exclude the possibility of cold nuclear fusion in a bulk zirconium containing amorphous material.

ITALY AND EGYPT

IMPURITIES AND FUSION
(Courtesy of Ramtanu Maitra)

M. Vaselli, M.A. Harith (Cairo U.), V. Palleschi, G. Salvetti, and D.P. Singh (Istituto di Fisica Atomica E Molecolare-Pisa), "Screening Effect of Impurities in Metals: a Possible Explanation of the Process of Cold Nuclear Fusion", Il Nuovo Cimento, Vol 11 D, No. 6 (June 1989) pages 927-932, 10 ref.

Summary: The screening length of the deuterium ion by surrounding electrons in a palladium metal lattice, as estimated using two approaches -- viz. the Thomas-Fermi screening theory and the Debye screening theory for plasmas in metal -- is found to be less than the interatomic separation of ordinary hydrogen molecules. This has important implications for the possibility of cold nuclear fusion at room temperature, since slight fluctuations in equilibrium conditions may drive the deuterons to fuse together. The relative magnitudes of screening length for the cold nuclear fusion regime and classical hot nuclear regimes (inertial and magnetic confinement) reveal that in the former a comparatively smaller amount of energy is needed to overcome the repulsive Coulomb barrier between two deuterium ions.

SRI LANKA

LITHIUM-HELIUM FUSION

Kanapathipillai Murukesapilliai (Univ of Jaffna), "Ignition of Thermonuclear Fuels Utilising the Energy Liberated in $^6Li(n,T)^4He$ Reactions", Japanese Journal of Applied Physics, Vol 28, No. 8, Aug 1989 pp 1462-1467, 15 refs.

Abstract: $^6Li(n,T)^4He$ fusion reactions occur readily at room temperature and liberate 4.8 MeV per reaction. It is shown here that this energy can be utilized to ignite thermonuclear fusion fuels. The main fuel considered here is a mixture containing equal numbers of tritium and deuterium nuclei. Rate equations and their numerical solutions are presented. The solutions show that it is possible to ignite the D-T fuel with an initial charge containing equal numbers of ^6Li nuclei and neutrons. A brief sketch of a probable fusion reactor which would utilize the proposed heating scheme is also presented.
This paper has some interest in cold fusion because of the suggested Li + neutron reaction to produce tritium and helium. The role of Li in cold fusion cells has not been fully documented.

* * *

F. SHORT ARTICLES FROM AUTHORS

TRITIUM DANGERS
By Dr. Dennis Cravens, Vernon, Texas
Note: The author is a professor at Vernon Regional College.

Tritium is a heavy isotope of hydrogen. Its nucleus consists of one proton and two neutrons. Tritium is very rare in nature and it is estimated that only 11 grams of naturally-occurring tritium is in the entire atmosphere of the earth. Tritium has a half-life of only 12.28 years and radioactively beta decays. This decay means that tritium is relatively safe (low-level radiation) as long as it is outside a living being. If tritium enters the body it can cause considerable radiation damage.

Most of the tritium has been produced by placing a Li-6 containing material, such as LiF [U.S. Patent No. 3,079,317 (1963)] in a high neutron flux. Most of the U.S. production of tritium has been done at the Savannah River Project. Recently, the safety considerations have caused concern over the continued production of tritium at Savannah River. The site may be totally shut down at some future time.

The production of tritium has been the focus of some national security concern since the tritium can be used as part of the production of H-bombs. The concern is that as time goes by without the production of new tritium, the existing tritium stock will decay (losing one-half in each 12 years).

The original H-bomb designs made use of liquified deuterium and tritium to be used as "kindling". This kindling was to be placed around a U-235 core and served as the igniting match to supply great temperatures and pressures to start the fusion reaction. The use of lithium hydride (deuterated) avoids the use of refrigeration and reduces the complexities of the bomb design. The lithium-6 is fissioned by the neutrons from the uranium explosion to form tritium and helium-4. If tritium is used with the lithium hydride, as well as the deuterium, then there is a larger release of neutrons (called a U-bomb). The result is that the more abundant U-239 can be used as an outer shell to give even greater power. The result is a very powerful bomb with a minimum amount of costly U-235.

Cold fusion produces tritium as a byproduct. The result is that any nation that can construct an atomic bomb could also produce H-bombs or U-bombs with only a minimal amount of difficulty. The energy yield of even a "simple atomic bomb" is reported to be increased by simply allowing uranium embrittlement with tritium to increase the fast neutron release. The political difficulties of large-scale tritium production and availability is obvious.

Fusion has a higher available energy content per weight than does fission. In the fission of uranium only about 0.1 percent of the total energy (mc^2) is released. In fusion of hydrogen the amount is closer to 0.5 percent. This fact is the reason that much more energy is released during a thermonuclear explosion than during a pure fission bomb explosion. Tritium is a prime component of thermonuclear bombs.

Tritium has been produced from cold fusion cells. In fact, it is simpler to measure the tritium from a small cell than it is to set up a large cell that produces heat. The detection of <u>INCREASING</u> quantities of tritium (above that caused by continued electrolysis) is proof that nuclear events are taking place. Unfortunately, it is often hard to prove that tritium is being produced and not just being concentrated due to loss of deuterium. For example, tritium is retained by metals better than deuterium and deuterium is removed from isotopes of water faster than tritium. (This removal is due to the diffusion rates based on mass differences.) This fact makes measurements of tritium production more difficult than one might assume.

The best work to date is by K. Wolf and Packham at Texas A&M [1,2] and by Storms and Talcott [3] at Los Alamos.

Even these careful experiments must be examined closely. In any future experiments, the starting values of tritium in the water and rods must be tightly controlled. One key in such experiments is recombining any generated gas to improve the concentration of tritium that might otherwise be lost with the deuterium gas evolved from the cathode. Thin plastic containers should be avoided to prevent concentrating tritium due to the more rapid diffusion of deuterium from the system.

The use of recombination of tritium is important for other reasons. Tritium represents a health problem if it is allowed to enter living tissue. Although its beta decay is low energy and easily shielded, the tritium can be damaging to living organism when inside body cells. The tritium can be more easily handled by recombining the tritium into T_2O. All hydrogen isotopes diffuse easily through the smallest openings when they are free hydrogen gas. Water can be more easily contained.

The tritium can be recombined in a number of ways. These methods include "wettable catalysts" and heated platinum wires. Catalysts used in fuel cells seem to work well. I personally use heated platinum wires so that catalyst poisoning (due to S compounds in some electrolytes) is avoided. The important feature is to chemically combine the tritium so that it will not be in a volatile state which can diffuse into the local environment and breathed by the unwary experimenter. The recombined material should be returned to the cell or treated as a low-level radioactive liquid.

Perhaps some enterprising individual will offer to take any spent electrolytes and recombined water so that experimenters could have a place to dispose of such material. The materials collected could then be purified, the tritium removed, and the deuterium oxide (heavy water) be resold. We need to plan ahead as to how best to handle the tritium-containing byproducts before large and high-energy cells are placed into operation.

REFERENCES:

[1] 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.

[2] N.J.C. Packham, K.L. Wolf, J.C. Wass, R.C. Kainthla, and J.O'M Bockris (Texas A & M), "Production of Tritium From D2O
Electrolysis at a Palladium Cathode.", J. Electroanal. Chem. vol
270 (1989), pages 451-458.

[3] 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 fund in eleven cells.]

THERMAL EFFICIENCY AND AUTORADIOGRAPHY
By Dr. Dennis Cravens, Vernon, Texas

Note: The author is a professor at Vernon Regional College.

Very little information has been gathered as to the role of temperature within the cold fusion process. Yet the operating temperature of a cold fusion cell will likely play an important part in the ultimate utility of such devices. It is hoped, as reproducibility is improved, that more experimenters will investigate the temperature effects within the phenomenon. Most current electrochemical cold fusion experiments have been conducted at near room temperature. Some high pressure gas experiments have seen low levels of neutrons as deuterated metals or heavy water ices are heated from liquid nitrogen temperatures. There have been reports of tritium releases from electric spark induced exploded wires that have been loaded with deuterium. Photographs of some research cells would indicate that high pressures are being attempted but as yet no formal public announcements have been made. [See Note at end. Ed.]

The calorimetric studies normally use a large heat bath placed near room temperature (or slightly above). A small heat source warms the device and a record is kept as to how much energy it takes to keep the system at a given temperature. If a cell gives off heat then there is a decrease in the energy required by the small heat source to maintain the given temperature. For the system to work there should not be any unexpected or large losses of the heat bath into the environment. This process is why most heat baths in calorimetric studies work near room temperature. This fact is also why most experimentation has been conducted at room temperature.

Practical heat-generation devices should, however, be run at higher temperatures. There are several reasons for this choice. First and foremost are the thermodynamic restraints on any energy dynamo. The ultimate efficiency of any energy generating device is proportional to the difference between the working temperature (T1) and the rejection temperature (T2). For a Carnot cycle, the efficiency = 1 - T2/T1 (Temperatures in degrees Kelvin). The rejection temperature is basically the temperature of the local environment and cannot be easily controlled. The result is that the working temperature of the cells will ultimately dictate the efficiency of any energy generation applications for the device. Even if two cells produce the same net integrated energy, the cell with the greatest working temperature will ultimately generate the greatest USABLE energy. Working temperatures also effect the thermal motion of any deuterium within the host metal lattice. This will likely increase the success of deuterium in surmounting Coulombic barriers and crystal defects of the host metal lattice. It also increases populations of higher energy states. Bush [1] has calculated the power relation for Pd to be:

$$P(+) = \text{Summation} \exp(-Tn/T), \quad \text{where}$$
$$Tn = (2n+1)^2 (3.62 \text{ deg K}).$$

This factor Tn is the relative ratio of excess energy generation compared to the value at some very low temperature. For Pd this ratio is 3.99 at 293 K and is 5.70 at 600 K. Bush derives these values from the thermal population and wavelengths of deuterons of supposed energy levels set by the molecular geometry of the bound deuterium in the deuterated metal lattice.

These two effects (thermodynamic efficiencies and population statistics) would indicate that cells working at higher temperatures would give the greatest energy yields. There are also other factors that may decrease the net efficiency of a cell at higher temperatures. The prime factor is the deuterium/metal molar ratio. As the temperature goes up there is a tendency for hydrogen to leak out of the metal lattice sites. In other words, the deuterium diffuses more quickly when it and the metal are at higher temperatures. This effect has been used in hydrogen storage for automobiles. Hydrogen is first stored in a metal lattice then recovered as the temperature is raised.

One simple experiment that someone may wish to try is the use of autoradiography. It is possible to produce small-scale nuclear events by simply loading a metal disk with deuterium gas. When the disk is placed upon a photographic emulsion the nuclear activity exposes the film in the area where the nuclear events occur. The degree of exposure or fogging can be correlated to the nuclear activity in the sample. This technique is used in biological studies. It should be possible with simple materials to check the temperature effect of nuclear events within host metal lattices which are loaded with deuterium (Experimenters should be warned as to the change of film sensitivity with conditions, for example with temperature.) This film exposing technique offers the potential of rapid screening of various metal alloy ratios, metal crystal structure, and other experimental variables.

The following gives a possible experiment (not as yet performed to my knowledge) and how autoradiography can be employed. First a lithium palladium rod is made with a given molar ratio. The rod is then "cleaned" by using a "reverse current". That is, the rod is used as an anode in the electrochemical cell. The lithium is released from the rod more readily than the palladium leaving pore openings. As the rod is being "cleaned", it is slowly withdrawn from the electrolyte. The areas of the rod in the lower section will then have a greater depletion of its lithium. This process produces a rod with a range of Li/Pd molar ratios. This rod can then be loaded with deuterium. Once loaded, the rod can be withdrawn and placed within a photographic emulsion (such as an X-ray film). The emulsion or film may be affixed to the rod under pressure to prevent rapid loss of the deuterium and the film should be chemically isolated from the metal to prevent chemical effects from altering the emulsion. Separating the metal from the emulsion or film with a thin plastic film should be adequate.

After a suitable time, the photographic material can be removed and developed. Examination of the exposed film (suitably marked so that the spatial relationship of the film and the metal is retained) should provide spatially-related information as to the nuclear events. In this case, the film will be examined to determine the best Li/Pd ratio. The greater the fogging (or number of spotted events) the greater the chance that nuclear events are occurring in the corresponding alloy mixture.

It is hoped that autoradiography will help in studies of the process and aid in the selection of preferred materials and temperatures. An adventurous experimenter may want to try a photographic study of a working cell as viewed through a thin plastic window and thin thicknesses of electrolyte.

Note: During the same time period that we received this article from Dr. Cravens, we also received copies of the 20-article report from BARC. Several of the BARC articles are based on some experiments with deuterium-gas loaded metal lattices then exposed to X-Ray film. The Li/Pd experiment is an excellent suggestion. How could one perform a similar range of values with an Ag/Pd rod? Ed.

REFERENCES

[1] Dr. R.T. Bush (Cal State Polytech, Pomona), "A Transmission Resonance Model for Cold Fusion.", Presented at COLD FUSION - A STATUS REPORT session in conjunction with the ASME Winter Annual Meeting held in San Francisco, CA December 12, 1989. [This paper presents a resonance model for cold fusion and shows how the phenomenon is temperature dependent.]

SOME NOTES ON HYDRIDES.
By Dr. Samuel Faile, Cincinnati, Ohio.

The binary alloy ZrV_2 can absorb hydrogen isotopes up to a composition of $ZrV_2H_{2.9}$ and desorb hydrogen without significant pulverization [1]. The pure zirconium, according to Hurd [2] would have to be heated to a red heat to release the absorbed hydrogen: "The thermal dissociation of zirconium hydride is similar to that of titanium hydride, and the compound decomposes to hydrogen and metallic zirconium at a red heat". The question occurs, would the vanadium added to zirconium produce an alloy that would desorb the hydrogen at a lower temperature? If so, would the ZrV_2 binary alloy be a good candidate for a cathode in a fusion cell?

Shaw [3], page 102 shows the dissociation pressure isotherms for palladium hydride up to a ration of H/Pd of 0.6. To maintain a ratio of 0.4 for palladium hydride at 313 C requires about 28 atmospheres of pressure. As the temperature rises the isotherms appear to approach a limiting and lower H/Pd ratio. It would be of interest to understand how these curves would be changed under the electric field conditions of an electrochemical fusion cell.
In considering various binary alloys that may be candidates for use in cold fusion it is important to have an understanding of the phase diagrams. Massalski's book is a valuable resource for such phase diagrams [4].

REFERENCES

[1] N. Mitshishi, S. Fukada, H. Tokuda, T. Nawata, and Y. Takai (Dept. Nuc. Engr., Kyusha Univ., Fukuaka, Japan), "Absorption Breakthrough of Hydrogen Isotopes and Desorption in a Zirconium-Vanadium Particle Bed", Fusion Engineering Design, Vol 10, pp 343-347.

[2] Dallas T. Hurd, An Introduction to the Chemistry of the Hydrides, John Wiley and Sons, New York, 1952. [The synthesis and properties of many types of hydrides are discussed in this book. For example, pages 181-187 covers titanium, zirconium, and hafnium (the group IVA elements) and Vanadium, Niobium, and Tantalum (the group VA elements).]

[3] B. L. Shaw, Inorganic Hydrides, Pergamon Press, Oxford, 1967. [This book is a good introduction to the many hydride categories.]

[4] Thaddeus B. Massalski, Editor-in-Chief, Binary Alloy Phase Diagrams, Volume 2, Published by American Society for Metals, Metals Park, Ohio 44073, c1986

INDUCED CURRENTS IN Pd CATHODE.
By Andrew E. Huber, San Diego, Calif.

Note: Mr. Huber has spent years in analyzing circuits and systems for space application for possible failure modes. His insights may be of interest to researchers. One of the calorimeter structures appears to be based on the structure used by Huggins of Stanford. The interplay of electric/magnetic fields may play an important role in some observed fusion events. Ed.

The F-P circuit can be viewed as involving the following interrelated parameters:

1. The electric field(s) in the cathode, as defined by the battery connection(s).

2. Current densities in the cathode, as defined by the square-shaped (or hex-shaped as determined by the anode wire support) anode, the round cathode, the electric field(s) in the cathode, the voltage between anode and cathode, and the resistance of the electrolyte.

3. Magnetic fields in the cathode, due to the earth's magnetic field, the four (or more) external magnetic fields from the four (or more) faces of the anode, and four (or more) internally generated fields arising from higher incident surface current densities opposite the four (or more) corners of the square-shaped anode coil.

The isothermal calorimeter can be viewed as consisting of an anode cylinder, surrounded by three shells of (paramagnetic) aluminum, as demagnetizing the F-P circuit as follows:

1. The cylinder removes the regions of relatively higher incident current density, thereby removing the four (or more) internally generated magnetic fields.

2. The fields from the four (or more) faces of the square grid disappear.

3. The three aluminum shells provide a shunt magnetic path around the cathode for the earth's magnetic field, as well as for any magnetic fields from the anode.

The IHF calorimeter, larger in size than the F-P calorimeter, can be viewed as consisting of a solenoid wound anode, surrounded by one shell of aluminum, as demagnetizing the F-P circuit in a similar manner. The anode-cathode spacing (approx. 2 cm.) implies that the grid was made more nearly circular, thereby reducing the ratio of maximum to minimum incident surface current density. This would result in lower peak current densities and associated magnetic fields. The aluminum shell, as in the case of the isothermal calorimeter, provides a shunt path for the earth's magnetic field. The shell would also provide a shunt path for the solenoid field from the anode to cathode.

* * *

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