FUSION facts

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ASME HOSTS SPECIAL COLD FUSION UPDATE SESSION PRESENTATIONS FROM ORNL, BUSH, AND HAGELSTEIN

CONTENTS DECEMBER ISSUE

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A. ASME COLD FUSION UPDATE

The American Society of Mechanical Engineers is to be congratulated for hosting COLD FUSION - A STATUS REPORT session in conjunction with the ASME Winter Annual Meeting held in San Francisco, CA December 12, 1989. This session on cold fusion is probably the most important public presentation of papers that has been given. The session was organized and chaired by two scientists from Oak Ridge National Laboratories, A. R. Sadlowe and Gordon E. Michaels.

"Evaluation and Verification of Cold Fusion", by Gary M. Sandquist (U of Utah) and Vern C. Rogers (Rogers and Assoc. Engr'g Corp. SLC, Utah).

Vern Rogers set the stage for the session by reviewing the experimental work that has been reported in replicating the F-P Effect. Extensive lists were presented of those laboratories that have successfully replicated one or more of the results of the Fleischmann-Pons cold-fusion experiment. More laboratories are being added to the success list every week from many parts of the world. The article lists 18 laboratories that measured excess heat; 14 laboratories that found neutrons above background; and 11 laboratories that measured tritium.

"A Preliminary Investigation of Cold Fusion by Electrolysis of Heavy Water. by C.D. Scott, J.E. Mrochek, E. Newman, T.C. Scott, G.E. Michaels, and M. Petek (Oak Ridge National Laboratory Publication ORNL/TM-11322 available from NTIS, Dept of Commerce, 5285 Port Royal Rd., Springfield, VA. 22161.)

The importance of this paper, presented by Dr. Gordon E. Michaels, is that it is the first publicly released information from a DOE-funded national laboratory.

Dr. Michaels reported the experimental efforts found using both open- and closed-system electrolysis using palladium rods about 0.55 cm in diameter by 8 cm long. Due to the size of the rods, excess heat was not recorded until after several hundred hours of operation. One of the charts shows the excess heat during the last 500 hours of experiment CF-3.

Figure 14 of the paper shows the electrolyte tritium content during the first 40 days (text and chart labeled "d", Title labeled "h") of Test CF-3. Tritium levels rose dramatically for the first measurement (day 2) and drops from this 25 times background level over the next 20 days. (Bockris of Texas A&M has reported a similar phenomena. Tritium apparently being consumed in other nuclear reactions? Ed.)

Neutrons were measured at somewhat above the background rate. At one point the neutron count was 3 1/2 standard deviations above background. On two other occasions, the neutron count rate exceeded the average values by three standard deviations.
The excess heat measured was usually in the range of 5% to 15%; however, during one 12-hour period excess heat up to 50% was measured. During this time the experimental uncertainty was calculated to be 3% to 5%.

The conclusions of the paper state: "Preliminary tests of the electrolysis of D_2O utilizing LiOD electrolytes and palladium electrodes have not confirmed the "cold fusion" phenomena. However, there have been several apparently anomalous neutron count rates, one unexplained 25-fold increase in tritium, and periods of many hours of apparent excess energy. None of these results has been precisely reproduced, nor can they be explained by conventional nuclear or chemical theory.

"Recent Stanford Work on Excess Heat Generation During Electrochemical Insertion of Deuterium into Palladium." by Dr. Robert A. Huggins (Stanford University).

Dr. Huggins reported on his continuing experimental efforts (interrupted briefly by an earthquake) in which he uses specially prepared coin-shaped palladium metal. Huggins stated that over 40 MJoules of heat per mole of Palladium had been measured in one cell and the test was still running. This amount of heat computes to about 8.5 watts per cubic cm of metal. Compare this figure to 50 watts per cubic cm of core in a large nuclear power plant.
Dr. Huggins has an excellent presentation on closed fusion cell calorimetry. We will try to get an abbreviated article from him on this subject for our readers.
With the careful preparation of the palladium, Dr. Huggins appears to obtain consistent results with no large bursts of energy but with identifiable "micro bursts". No neutrons appear to be produced by his experimental procedures, therefore, they no longer monitor for neutrons. Future work will emphasis going to higher temperatures.

"A Transmission Resonance Model for Cold Fusion", by Dr. R. T. Bush, California State Polytechnic University, Pomona, CA.

Dr. Bush bases his "scenario" or theory on a suggestion by Leaf Turner (1989, Letter to Editor, Physics Today, pp 140-141). Turner suggested that cold fusion may involve transmission resonances for deuterons diffusing through a periodic array of wells formed by an array of deuteron-occupied wells. Bush's paper discusses in detail the conditions under which wave-like deuterons can achieve the transmission resonance. At resonance the probability of fusion is greatly increased.

The conditions for resonance are shown to be temperature sensitive. One test for the theory is the explanation of neutrons being emitted by deuterated titanium at -30 deg. C. It is of considerable interest that the calculations from the theory predict this observed phenomenon.

Calculations for other temperatures (of the metal lattice) are given for both titanium and palladium. Experimenters should be able to use this theory and the calculations in fusion cell experiments. It is expected that the theory will quickly be validated or modified with new data.

A postscript to the paper shows how the theory explains the importance of lithium in the fusion cell. It is shown, by the theory, that at temperatures near 20 and 103 deg C for lithium 6 and temperatures near 20 and 98 deg C for lithium 7 that the following nuclear reaction may be important:

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

The energy would be about 22.4 MeV for lithium 6. The author notes that failing to find ^{4}He should not be taken as critical to the experiment. Others have suggested that ^{4}He would be depleted by other nuclear processes.

"Coherent Fusion Theory." by Dr. Peter L. Hagelstein, M.I.T.

Although this paper searches for a "new mechanism", the theory presented is based on basic and known principles of physics. Dr. Hagelstein states "The basic premise of the theory is that off-resonant coupling between two fusing nucleons and a macroscopic system can occur through the electromagnetic interaction. An example of such a virtual fusion reaction is ^{a}He + ^{b}He ---> $^{a+b}$He
For example, a proton and a deuteron can fuse conventionally to ^{3}He following the emission of a 5.5 MeV gamma. If instead a low energy photon is exchanged, ^{3}He is still created, but only in a virtual sense. ... exothermic incoherent reaction pathways exist for most of the virtual fusion products."

Hagelstein goes on to develop a model in which the reaction dynamics of a class of fusion reactions can be analyzed. The model is developed by the use of semiclassical field model expressed in Hamiltonian equations. Each step of the model is rigorously developed. The mathematical steps proceed to a semiclassical Hamiltonian diagonalization in Part III.

Part IV considers the Lattice Dynamics of the model and considers the mathematical terms of the criterion that must be met for exothermic virtual fusion reactions to occur. Hagelstein states "This constraint appears to be quite severe, and it is not obvious that it can be met without substantial enhancements in tunneling. (Perhaps the Bush approach can provide an explanation of conditions in which tunneling is enhanced).

Part V considers the mathematics for the combined nuclear and lattice system. This presentation is followed in Part VI by the mathematics for a "Driven Coupled Nuclear-Lattice System". An examination of the terms in the resulting equations leads to the following statement "... it appears difficult to produce substantial observable effects without enhancements of the tunneling probability."

In Part VI Hagelstein discusses Nonlinearities and Strong Driving Terms. In this effort, the author states that this discussion must be viewed as the beginning of a larger and possibly involved effort. The reader must appreciate the rigor with which Hagelstein is developing his model. With a few cycles between experimental data and model corrections, it is expected that this model will contribute substantially to the development of cold fusion and a better understanding of the complex reactions that are being reported.

In the Summary and Conclusions in Part VIII of the paper, the author provides us with a discussion of the needs to be met and/or the outcomes of the model including the following:

1. The need for enhancement of tunneling may be overcome by a two-step beta/fusion reaction involving an intermediate neutron.

2. A connection is made between laser physics and the fusion problem.

3. Electromagnetic interaction may promote fusion events.

To those readers who can manipulate Hamiltonian equations, we highly recommend this work. We also recommend that you study this paper and share your ideas with the author.
NOTE: The above papers can be obtained from ASME, 345 E. 47 Street, New York, N.Y. 10017. The codes are Bush -- 89-WA/TS-3; Sandquist & Rogers -- 89-WS/TS-2; and Hagelstein -- 89-WA.TS-4. Copies are available for 15 months after the date of the meeting (12/12/89).

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B. MORE NEWS FROM U.S.

FORTHCOMING TECHNICAL PAPERS.

K.B. Whaley (U. of Cal. Berkeley), "Boson Dynamics of Deuterium in Metals.", Proceedings of the NSF-EPRI Workshop on Anomalous Effects in Deuterated Materials, Washington D.C., October 1989 (in press).

K.B. Whaley (U. of Cal. Berkeley), "Boson Enhancement of Finite Temperature Coherent Dynamics for Deuterium in Metals.", Physical Review B, to appear February 1990.

Drs. Scott and Talcot Chubb, Naval Research Laboratory, will be forwarding copies of their presentation given at the NSF-EPRI Workshop as soon as the current publication review is completed.

"Report of the Cold Fusion Panel.", A Report of the Energy Research Advisory Board to the Department of Energy, November 1989. In printing. [The letter by John W. Landis, Chairman of the Energy Research Advisory Board to the Secretary of Energy, James D. Watkins contains the following: "On November 8, the full Board reviewed the conclusions and recommendations drafted by the Panel and, after making only minor revisions, approved the report unanimously." The report contains the following Summary of Tritium Results: "Some experiments have reported the production of tritium with electrolytic cells. The experiments in which excess tritium is reported have not been reproducible by other groups. These measurements are also inconsistent with the measured neutrons on the same sample. Most of the experiments to date report no production of excess tritium. Additional investigations are desirable to clarify the origin of the excess tritium that is occasionally observed."]

Editor's Note: We have been assured that both the Cold Fusion Panel and the Energy Research Advisory Board had full access to the Oak Ridge reports and to the reports on tritium by scientists at Texas A&M. Members of both groups are still struggling with plasma physics and are apparently unaware that nuclear reactions in metal lattices do not follow plasma physics.

PUBLISHED TECHNICAL PAPERS - ARTICLES

Harry DeBell, (Aurora, CO), "Cold Fusion, Emerging Technology.", TESLA 89, The International Tesla Society's <u>Journal of Power and Resonance</u>, Vol. 5, No. 3, Jul/Aug/Sept 1989, pages 5-7. [DeBell cites physicist Ed Cecil (Colorado School of Mines as saying, "They have been telling us that you have to run the experiment for days. We can do it in 12 hours in a much more controlled way than the Utah approach with a car battery."] Courtesy of Dr. Cravens.

G. Christopher Anderson, "Clandestine NSF Panel Warms to Cold Fusion.", The Scientist, November 13, 1989, page 1 ff. [Article reports on the NSF-EPRI Workshop. Article quotes NSF's Werbos as responding to the complaint that the panel was loaded with cold-fusion believers. Werbos stated, "We did the best we could to get a balanced ratio, but a lot of people who were 'nonreplicators' when we invited them showed up as 'replicators'."]

R.J. Beuhler, G. Friedlander, and L. Friedman (Brookhaven National Laboratory), "Cluster-Impact Fusion.", Physical Review Letters, Sept 18, 1989, pages 1292-1295. [Article reports on the production of nuclear byproducts by accelerating heavy water globules into a deuterated titanium target.]

A.J. Leggett and G. Baym (U of Ill. Urbana), "Can solid-state Effects Enhance the Cold-Fusion Rate.", Nature, 1989, 340(6228), pages 45-46. [A study that shows that it is unlikely to be able to penetrate the coulomb barrier to support cold fusion.]

J.S. Cohen (Los Alamos) and J. D. Davies (University of Birmingham), "Is cold fusion hot?", Nature, Vol 342, Nov. 30, 1989, pages 487-488. [Authors propose the acceleration of d's in local electric fields yielding fusion. They also suggest that d + t --> ^{4}He + n is a more probable nuclear reaction.]

Amal Kumar Naj (Wall Street Journal), "California Team Develops New Battery With Up to 30% More Power Per Ounce.", WSJ, December 4, 1989. [Because of the importance of appropriate battery technology to cold fusion this article is of interest. The article states, "The key development by the Berkeley scientists is a new material for the cathode. It consists of disulfide polymers, long chains of organic molecules each containing sulfur atoms. The chains are linked to each other by chemical bonds between their sulfur atoms. When the two terminals are in contact with the electrolyte, electrons released from the lithium anode break the sulfur bonds of the cathode, unlinking the chains, or "depolymerizing" them, and creating a flow of electrons. The current will continue to flow until all the sulfur bonds are broken and the chains are unlinked. During recharge, when a current is applied from an external source, the electrons flow in the opposite direction, and the sulfur atoms rebond to each other, reforming the polymers. ... The new cathode enables a higher power output partly because the electrons can travel much faster between the terminals than they can when metal terminals and a liquid electrolyte are used. Mr. Visco said another advantage of the polymer cathode is that the battery need not operate at high temperatures to deliver peak power. ... battery needs only 176 degrees to 212 degrees [F] to deliver peak power ..." The application to a fusion power cell seems obvious.]

NUCLEAR DATA.

Dr. Samuel P. Faile (one of our correspondents) calls our attention to the following publication:

C. Maples, G.W. Goth, and J. Cerny, "Nuclear Reaction Q-Values.", Nuclear Data (A Journal Devoted to Compilations and Evaluations of Experimental and Theoretical Results in Nuclear Physics), Volume 2, Numbers 5 and 6, December 1966, pages 429 to 613. [These two hundred pages provide Q-Value Tables for the various reactions on 293 isotopes. A matrix of 11 incoming particles and nine outgoing particles for each isotope are provided. Incoming particles are gamma, n, p, d, t, He3, He4, Li6, Li7, C12, and O16. This publication should be a good reference for cold fusionists.]

COLD FUSION PATENTS.

Dr. Dennis Cravens shares the following: "I have been told that the cold fusion patents are filed within the electrochemistry division in the patent and trademark office. Therefore, the normal time for cold fusion patents to be processed is about one year.

Dr. Cravens has filed for further patents on "Propulsion and Energy Generating Method and Apparatus." based on cold fusion applications. The filing follows his work on exploding deuterated palladium wires which is reported in this issue. See Section E.

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C. NEWS FROM ABROAD.

FROM JAPAN.

Nobuhiko Wada and Kunihide Nizhizawa (Nagoya U. Japan), "Nuclear Fusion in Solid.", Japanese Journal of Applied Physics, Vol. 28, No. 11, November 1989, pages L 2017-L 2020. [Spontaneous neutron emission were intermittently detected from activated palladium rods well soaked with deuterium gas in a closed glass bulb. By the stimulation of the palladium rods with a high voltage discharge between the rods, a burst of neutron flux 2 x 10^4 ??? time larger than background was detected. Atoms or molecules of mass number 1, 2, 3, 4, 5, and 6 were found in the residual gas. Nuclear fusion is solid is interpreted in terms of the supersaturation of the solid solution of deuterium.] Courtesy of Dr. Michael Gordon. Isao Shimamura (Inst. Phys. Chem Research, Hirosawa), "Intramolecular Nuclear Fusion in Hydrogen-Isotope Molecules." <u>Prog. Theor. Physics</u>, 1989, Vol 82, No. 2, pages 304-314. [Under certain conditions it is shown that the d-d fusion rate reaches 10^-23 per second, a value akin to recent measurements made with a Ti electrode in heavy water after electrolytic infusion of d.]

FROM INDIA

The following courtesy of Ramtanu Maitra, New Delhi, India.

Ramtanu Maitra, "The 'Utah Experiment: " What it Might Mean". <u>Fusion Asia</u>, Vol. 6, No. 1, 1989 pages 10 - 15. [Article reviews P-F Effect and lists the following successes: Jones BYU; Texas A&M; Santhanam, Tata Institute of Fundamental Research, Bombay; Kuzmen, U. of Moscow; several groups lead by Mathews, Balasubramaniam, and Raman, Indira Gandhi Centre for Atomic Research, Madras, India; Kossuth Univ, Hungary; Chidambaram, Bhabha Atomic Research Centre, Trombay, India; Morato of Brazil (who stated, "I would tear up my Ph.D. if it is not nuclear reaction".); Arriola & Soberon, National Autonomous U., Mexico; Scaramazzi, ENEA, Italy; Coey, Dublin, Ireland; and Schoessow, U. of Florida. BARC scientists are working on annular cathode with heat-removing water flowing through the center.]

Ramtanu Maitra, "A New Problem for Cold Fusion Non-Believers." <u>Fusion Asia</u>, Vol. 6 No. 2, 1989 pages 12-13. [Reports on the Texas A&M experiments finding copious amounts of tritium and similar findings of nuclear byproducts at BARC using both palladium and titanium cathodes. All this tritium and no neutrons is a challenge to orthodox plasma physics. The issue also included a short article about Fusion Information Center at the University of Utah Research Park.]

Kiyoshi Yazawa (Japan), "Cold Fusion in Japan: Excitement and Success.", <u>Fusion Asia</u>, Vol. 6. No. 2, 1989 pages 14-15. [Article cites the excitement in Japan following the July 31, 1989 symposium in Tokyo in which ten research teams announced their success in a variety of cold fusion experiments. Among successful teams were those at U. of Tohoku, U. of Hokkaido, Aoymaa-Gakuin U., and jointly Tokyo U of Ag and Tech and the Japan Atomic Energy Research Institute. On

August 1, 1989 it was announced that 80 scientists from 25 institutes, colleges, and universities would proceed on cold fusion research.]

Editor's Note: Word just received: Copies of several recently published papers are in the mail from India. See our January issue.

N. Kumar (Dept of Physics, Indian Institute of Science, Banglador), "Cold Fusion: Is There a Solid State Effect?", Current Science, 1989, Vol. 58, NO. 15, pages 833-835. [Since He is known to spontaneously desorb from a Pd/Ti host, it is expected that a d-d pair would also desorb and simply not be available in the lattice.]

S.K. Ghosh, H.K. Sadhukhan, A.K. Dhara (Heavy Water Div, Bhabha, Trombay), "A theory of cold nuclear fusion in deuterium-loaded palladium.", Pramana, 1989, Vol. 33, No. 2, pages L339-L342. [Deuterium gas compressed in a Pd lattice forms a quantum plasma of bosons leading to significant screening of the Coulomb potential between D ions. The resulting quantum mechanical tunnelling probability adequately explains the recently observed cold fusion rates.]

S.N. Vaidya, Y.S. Mayya (Chem. Div., Bhabha, Trombay), "The role of combined electron-deuteron screening in deuteron-deuteron fusion in metals.", Pramana 1989, Vol 33, No. 2, pages L343-L346. [The d-d fusion rate in Pd possible can be enhanced by the combined screening of the electrostatic interactions by the itinerant d and the condition e-. The model assumes that, under certain conditions, d exists as D+ in Pd. The combined screening by e- and D+ (ds) is more effective than that due to e alone. The calculate values of the d-d fusion rates, considering screening, for comparison PdD at 300 K are 10^-16 per second and 10^-14 per second for d2+ and D_2 respectively. These values lie in the range suggested by the recent electrochemical experiments.]

NEWS FROM EUROPE

Norman D. Cook (Oxford University, England), "Computing Nuclear Properties in the fcc Model.", Computers in Physics, Mar/Apr 1989, pages 73-77. [Article describes both a model and a computer program for calculating three nuclear properties for any specified nucleus: the rms radial value, the total Coulomb repulsion, and the total binding energy.]

Editor's note: Dr. Cook writes, "I have been engaged in theoretical work in nuclear structure theory for many years, and am convinced that there are enough unsolved problems at the level of nuclear structure (quite aside from lower level problems) that, on theoretical grounds alone, it would be quite premature to dismiss cold fusion as theoretically unlikely."

C. Petrillo, F. Sacchetti (CNR, Frascati, Italy), " A possible mechanism for bulk cold fusion in transition metals hydrides." Europhys. Lett. 1989, Vol 10 No. 1, pages 15-18. [A simple phenomenological model for the high fusion rate recently observed in transition metal deuterides is presented. The existence of localized vibrational modes of D atoms, like those actually found in NbD and TaD, can account for the experimental fusion rates.]

P. Tomas, S. Blagus, M. Bogovac, D. Hodko, M. Krcmar, D. Miljanic, V. Pravdic, D. Rendic, M. Vajioc, M. Vukovic (Ruder Boskovic Inst. Zagreb, Yugoslavia), "Deuterium Nuclear Fusion in Metals at Room Temperature.", Fizika (Zagred), 1989, Vol. 21 No. 2, pages 209-214. [A negative report on attempts to achieve cold fusion. Specialized in measuring neutrons.]

G. Benedek, P.F. Bortignon (Milano, Italia), "Cold Nuclear Fusion: Viewpoints of Solid-State Physics.", Il Nuovo Cimento, Note Brevi, Vol 11 D, No. 8, August 1989. [Paper discusses the results on fusion probability of deuterons attracted into a negative hole in the metal lattice and other contributions to electron screening to reduce the Coulomb barrier.]

MORRISON'S STUDY OF PATHOLOGICAL SCIENCE

Douglas R.O. Morrison (Zurich), "Cold Fusion Note No. 20.", privately circulated letter from Dr. Morrison, November 1989. [Morrison is the seeker of pathological science and thinks that he has found an example in cold fusion. To quote, "... in terms of Pathological Science where the history of an erroneous result is in three Phases which are; Phase 1. After the original claim the first results are almost al confirmations. Phase 2. About equal numbers of positive and negative results. Phase 3. An avalanche of negative results." Morrison's letter involves segregating the world's cold fusion results into geographic areas which can be shown to be in Phase 1, 2, or 3. Morrison's persistence is remarkable. He reports on a tour at Texas A&M where he viewed the work by Packham, Bockris, and Appleby. He also reports on visits to other places, including the University of Utah where he gave a lecture on his view of cold fusion as bordering on pathology. Morrison's letter appear to emphasize the negative aspects of cold fusion and, of course, Fusion Facts can be criticized for emphasizing the positive findings. We both will admit that the experiments in cold fusion are difficult to replicate, not thoroughly understood, and not easily repeatable. Which statements could have been made about the early days of the semi-conductor technology. The tendency to select or emphasize those reports which substantiate one's view in real. May we suggest that Dr. Morrison consider the summary article under Section E of this issue. Editor.]

NEWS FROM USSR

M.A. Yaroslavskii (Inst. Fiz. Zemli im. Shmidta, Moscow), "Possible Mechanism of Nuclear Reaction Initiation due to Temperature Variations and Phase Transitions in Condensed Matter.", Dokl. Akad. Nauk SSSR, 1989, Vol 308 No. 1, pages 95-97 (in Russian). [Describes a proposed mechanism for neutron emissions during cooling and heating of heavy water solutions from liquid nitrogen temperatures to melting. Paper reports on the possible existence of controlled nuclear reactions in living organisms. 5 references.] Courtesy of S.P.Faile.

NOT SO NEW FROM CANADA

M.W.C. Dharma-wardana and G.C. Aers (National Res Council of Canada, Ottawa), "A Model for the Cold Fusion of Deuterium in Deuterated Palladium Systems.", Submitted to Chem. Phys. Letters, Apr 24 revised June 15, 1989. [Prelude states: "We have estimated the enhancement of the nuclear fusion rate of Pd-D type systems and the Deuterium-muonium molecule in comparison with the fusion rate of a D_2 molecule at room temperature. Electronic screening present in the Pd leads to an insufficient enhancement of the fusion rate to account for the claimed results. The enhancement factor decreases as the Deuteron concentration increases. However, we argue that observable fusion could occur if ionic-screening from non-equilibrium deuteron concentration could come into play. The screening dependence of the deuteron-diffusion under a driving potential could generate bursts of non-equilibrium deuteron densities, presenting some condition when cold fusion might happen.] Courtesy of Dr. Samuel P. Faile.

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D. 'TWAS THE NIGHT BEFORE CRISIS

MERRY CHRISTMAS AND A FUSION NEW YEAR

'Twas the night before CRISIS -- the energy crunch.
The fixers had taken an extended lunch.

When what in our wondering ears did we hear,
The answer to our problems from UTAH so clear.

Jones - FATHER OF COLD FUSION from old B.Y.BLUE
Said, "**Pons and Fleischmann**, we've found it. Why then did U?" [1]

"Just a simple fusion cell.", **F-P** told the world.
Then thousands of white coats to ENERGY labs swirled. [2]

From yellow-rosed TAM and the smart **Appleby**,
"We've measured excess heat from our own recipe." [3]

Bockris said, "Don't know if FUSION is what we've got,
But I surely can tell you CHEMICAL it's not!" [4]

Well - the next thing we heard was a **Wolf** at the door.
He said, "I've found TRITIUM and I will find more." [5,6]

Now **lo and behold** by yon Indian Ocean
Ten tribes in twenty days stirred up a commotion.

The **Indians** said, "We've probed our own cranium.
Palladium's not cheap, so we used **titanium.**" [7]

Uncle Sam when wakened by all the commotion
Sent his **Fusion Panel** from ocean to ocean.

Doe bucks wearing a hot-fusion bonnet,
Said, "Found curious things. Don't spend money on it." [8]

But **Wolf** still insisted - "I've got tritium and heat."
And silenced **Peter** said, "My theory is neat." [9]

And **Huggins** at Stanford, within its perimeter,
Still measures excess heat on his calorimeter. [10]

Dr. Bush in Pomona at Cal Polytech
Has a new theory that's a good one, by heck. [11]

And just before Christmas the truth was unveiled.
Oak Ridge invited **Peter** and FUSION prevailed. [12]
By Hal Fox (Editor, Fusion Facts) with apologies to Clement Moore.

REFERENCES

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[2] 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).

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

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[7] P. K. Iyengar (BARC - Trombay, India) in "Cold Fusion Results in BARC Experiments", Fifth International Conference on EmergingNuclear Energy Systems, Karlsruhe, July 3-6, 1989. See more extensive discussion in Fusion Facts, Vol. 1, No. 3, Sept. 1989).

[8] "DOE Panel Meeting and Report.", Fusion Facts, Vol. 1, No. 5 November, 1989.

[9] P.L. Hagelstein, (MIT), "Coherent Fusion Theory.", Paper given at Cold Fusion: A Status Report, A session of the ASME Annual Meeting, San Francisco, December 12, 1989.

[10] Robert A. Huggisn, (Stanford), "Recent Work of Excess Heat Generation During Electrochemical Insertion of Deuterium into Palladium." Presented at Cold Fusion: A Status Report, A session of the ASME Annual Meeting, San Francisco, December 12, 1989.

[11] R.T. Bush (Calif Polytechnic, Pomona), "A Transmission Resonance Model for Cold Fusion", Paper presented at Cold Fusion: A Status Report, A session of the ASME Annual Meeting, San Francisco, December 12, 1989.

[12] Oakridge scientists A.R. Sadlowe, and G.E. Michaels chaired ASME Meeting Session: Cold Fusion: A Status Report. See also, C.D. Scott, J.E. Mrochek, E. Newman, T.C. Scott, G.E. Michaels, M. Petek, ORNL/TM 11322, A Preliminary Investigation of Cold Fusion by Electrolysis of Heavy Water. November 1989. Report details Oak Ridge's replication of the F-P cold fusion work. Order from National Technical Information Service, U.S. Dept. of Commerce, 5285 Port Royal Rd, Springfield, VA 22161.

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E. SHORT ARTICLES FROM AUTHORS

OTHER ROUTES TO FUSION

CLEAN UP OF RADIOACTIVE MATERIALS BY COLD FUSION?

ION IMPLANTATION AND CHANNELING IN PD

UNDERSTANDING COLD FUSION

OTHER ROUTES TO FUSION

By Dr. Dennis Cravens,
Vernon Regional College, Vernon, Texas.

The electrochemical approach of Fleischmann and Pons is the most often reported method of achieving fusion under normal laboratory conditions. There are two other methods that one may wish to consider. Beuhler, Friedlander, and Friedman at Brookhaven National Laboratory have reported fusion in targets of titanium deuteride when water molecule ions are accelerated under high voltages by corona discharge [1]. This experimental approach is apparently similar to the method first discussed here in Fusion Facts (July 1989, page 9) where a fluid (gas, plasma, liquid particles) is electrostatically accelerated to a metal host lattice containing deuterium.

The importance of the approach is the target can sustain temperatures greater than the boiling point of water. Since the thermal efficiency of a power-generating device is related to the temperature differentials, this process could produce a more efficient power unit than an electrochemical cell. The Brookhaven group uses energies of up to 325 KeV supplied by a simple Cockroft-Walton accelerator to accelerate "water clusters".

The effect is dependent on the size of the water clusters and is maximum at sizes of 100 to 500 ??? D2O molecules per cluster. The proof of the fusion came in the form of detection of the 3 Mev protons from the following nuclear reaction:

D + D --> T + H (proton)

It is extremely interesting to note that they found no evidence for the ??? 3He ion from the expected nuclear reaction:

D + D --> ??? 3He + n (neutron)

This point should be of interest to those working with electrochemical cells who also fail to detect ??? 3He and neutrons.

Another important feature of the work is that the logarithms of the proton counts were found to be proportional to the energy. The rate was about ??? 10^-1 protons/sec. for clusters of 150 D2O molecules at 300 Kev. This measurement may mean that there could be substantial energy released at higher potentials.
Still another approach has been tried by the author. The approach uses an exploding wire to rapidly disrupt the metal host lattice holding the deuterium. Small Pd wires (0.127 mm dia) were first loaded with D (electrochemically in LiOD with 30 mA/cm^2 ???). The wires are then vaporized by a large electrical discharge of about 30 kv from a condenser and spark gap. This current rapidly disrupts the metal host and the contained D. After the discharge there is a small change in the background radiation as detected by fogging of photographic emulsions. The fogging is through to be due to the production of tritium.

The point here is that a dynamic (not static) force within the metal host lattice may be required to cause nuclear transmutations. This effect has also been implicated in the work involving temperature changes of Ti containing D when warmed from liquid nitrogen to about -30 degrees C. In the exploding wire approach, the temperature changes can reach over 10^7 ??? degrees Kelvin per sec. It is interesting to note that Wendt and Irion claimed in 1922 to have produced He from exploding wires of W [2].

[1] R.J. Beuhler, G. Friedlander, and L. Friedman (Brookhaven National Laboratory), "Cluster-Impact Fusion.", Physical Review Letters, Sept 18, 1989, pages 1292-1295.

[2] Gerald L. Wendt and Clarence E. Irion (U. of Chicago), "Experimental Attempts to Decompose Tungsten at High Temperatures.", JACS, Vol. 44, No. 9, Sept 1922, pages 1887-1894.

CLEAN UP OF RADIOACTIVE MATERIALS BY COLD FUSION?

By Dr. Samuel P. Faile

The cold fusion process, where alloys containing radioactive materials are used for the cathode, may be able to transfer neutrons to produce more stable isotopes. Even for palladium with stable isotopes there may be a shift towards isotopes with the greatest binding energy. If the report of a shift of Pd-105 to Pd-106 is verified, there could be evidence of such a process.
The weight of Pd-105 is 104.905079 atoms masses while the weight of Pd-106 is 105.903478 atomic masses. Such a shift is energetically more favorable than Pd-104 to Pd-105 since Pd-104 weighs 103.904029 atomic masses. More than one atomic mass is needed to go from Pd-104 to Pd-105 while less than one atomic mass is needed to go from Pf-105 to Pd-106.

Radioactivity could be considered to be a metastable condition which with the aid of a cold fusion environment could be transformed to a more stable isotopes plus an energy release that is channeled into heat or phonon effects. A big question is whether the neutron-rich fission products could be de-activated by a neutron transfer which would involve a neutron removal. Would radioactive cobalt-60 in a cold fusion environment by neutron transfer change into stable cobalt-59?

Even in the up-neutroning process there are questions. Is the process powerful enough to change U-235 to U-238 in an alloy of palladium and uranium loaded with deuterium? For this process to work it seems there would be a nearly simultaneous transfer of three neutrons or the creation of a sequence of U-236 and U-237 by single neutron transfer.

ION IMPLANTATION AND CHANNELING IN PD.

By Dr. Samuel P. Faile
Reporting about Dr. William E. Wells, Miami University at Oxford, Ohio.

In a discussion with Dr. William E. Wells (December 5, 1989), there was mentioned various approaches to cold fusion. In one study, Dr. Wells predicted the deuterium-loaded palladium lattice with it regular array of channels would tend to trap neutrons and other radiation products. This trapping would lead to enhanced fusion under specific crystallographic orientations during ion-beam bombardment. Professor Wells sent a proposal to DOE. Sandia Laboratory tried his suggestion and obtained an enhancement of fusion by a factor of three (as contrasted to the enhancement of 100 that had been predicted).

The theory that appears to be partially verified is that in a regular, as contrasted with an amorphous array, a chain reaction would be more probable in the regular crystal due to the lining up of atoms that would intercept neutrons. A deuteron fired down a crystal channel can fuse with another releasing a neutron whose flight path would take it directly into another atom. The channeling effects could increase the change of a chain reaction with a greater output of heat.

UNDERSTANDING COLD FUSION

By Hal Fox

Nine months of full-time study of and reporting on cold fusion have resulted in my acceptance of cold fusion as a new physical principle. On June 7, 1989 our first press release stated "Cold fusion is real, more than one nuclear reaction is involved, the reactions are controllable, and the process can lead to early commercialization." Not all scientists agree with that statement.

The understanding of the reality of cold fusion is hampered by the following:

1. The experiment can be replicated with relatively simple laboratory equipment but the experiment is not simple. Replication requires great care and considerable attention to a variety of chemical and physical principles that are not as yet fully understood.

2. Many experimenters and theoreticians make the assumption that the observed results of plasma physics must be replicated in a metal crystalline lattice. Such is not the case. Specifically, the three nuclear reactions involving d + d are not remotely similar in frequency of occurrence in metal lattices as compared to high energy physics. The following three nuclear reactions could be expected:

$d + d \rightarrow {}^3He$ + neutron + energy (1)

$d + d \rightarrow T$ + proton + energy (2)

$d + d \rightarrow {}^4He$ + energy (3)

Classical high energy physics demonstrates that (1) and (2) occur with almost equal regularity and that (3) is a rare event. In the deuterated palladium lattice (3) appears to be the favored reaction (either virtual or real), (2) occurs more frequently than (1). Not finding ${}^4He$ as a byproduct is not crucial. It is probable that any ${}^4He$ is being scavenged by other nuclear reactions.

3. Many experimenters and theoreticians make the assumption that the above nuclear reactions must be accompanied by discrete gamma rays or energetic particles that carry off the appropriate amount of energy (computed from the mass fraction difference between the mass sums of each equation). The palladium lattice does not know this. Experimental observations strongly demonstrate that the fusion reactions (whatever they are) appear to be using, producing, or exchanging nucleons at very low energies or velocities and that the mass fraction, being converted to energy, appears as a series or shower of phonons or photons that are easily absorbed by the palladium lattice.

4. Many experimenters and theoreticians are extrapolating the known plasma physics Coulomb barrier between two deuterons to show that fusion cannot occur with sufficient probability to produce useful results. The deuterated metal lattice does not react to extrapolated plasma physics or high energy particle physics.

5. Current theory has not kept pace with experimental observations. Too much time has been spent showing that the observed phenomena cannot occur. The earlier suggestion by David Mitchell [1] and the current paper by Dr. Bush [2] appear to have relevance to observed phenomena. It appears that in a palladium lattice that is fully occupied by deuterons, conditions are favorable to support laser-like actions. The fusion of two deuterons does not occur because two deuterons occupy adjacent potential wells. The fusion seems to occur because the deuteron loaded lattice can support some type of resonating phenomena in which the probability of a traveling or "hopping" wave-like deuteron fusing with a target deuteron is greatly increased.

Professor Bush's approach in treating the traveling deuteron as a wave and the imbedded deuterons as a series of impedances (akin to a comb filter) appears to be a fruitful method of viewing the observed phenomenon of d + d fusion.

6. The role of surface phenomena on the metal cathode (usually palladium) and what must occur to allow deuterons to penetrate the cathode is not understood and has received little attention in the literature. It is not certain, but it appears that the palladium cathode must have a d/Pd ratio of about 1 before nuclear reactions begin. Ordinary electrolysis of the heavy water is not sufficient. It appears that the surface of the rod must be changed to provide a "diode action" that lets deuterons enter the palladium lattice but reduces the ease by which deuterons leave the lattice. Older literature treating this subject uses the term "poisoning" of the surface. It is believed that the lack of this surface conditioning is the principal reason for experimental failure. The understanding

of how best to treat the palladium surface is one of the key experimental findings to be determined and the information shared.

7. Experimenters having equipment and skills in measuring neutrons have wasted considerable effort in searching for the least likely cold fusion event. The deuterated palladium lattice does not know that it is supposed to follow the observations of plasma physics and produce neutrons. In fact, the deuterated palladium lattice does not even know that it should be producing tritium. Setting up experiments to produce neutrons is far more difficult than producing tritium or excess heat. Even to produce tritium requires "tuning" the experiment to favor the production of tritium. For example, using a nickel anode rather than a platinum anode favors tritium production.

8. Experimenters are not using the experience of others. Dr. Huggins (Stanford) [3] in his continuing and eminently successful studies of anomalous heat in a palladium, heavy water environment does not even try to measure neutrons. None were found so he prudently ceased looking for them. Instead he has focussed his attention on consistency in palladium preparation, improvements in calorimetry, and now is moving to experiments at increased temperatures.

It is time to focus our collective attention on the acceptance of the reality of cold fusion, that copious amounts of tritium cannot be produced by chemistry, and that the measured excess heat is the result of fusion reactions and not world-wide incompetence in heat measurements.

It is also time for all researchers, after appropriate protection of new discoveries, to share their experience immediately with the rest of the scientific world. The discovery of cold fusion is the most importance scientific discovery since Adam's rib. It is too important not to be shared immediately and unselfishly with other workers in the field. The abundant use of energy has polluted our planet. We cannot waste unnecessary time in concerns over "publish or perish", or waiting for a prestigious journal to print our findings. This is a time for cooperation and the early commercialization of cold fusion to help solve world problems of pollution, hunger, ignorance, and disease.

Scientific prizes and recognition should not go to the secretive nor the silent. Prizes for the advancement of mankind should go to the talented and sharing among us. Because it is unlikely that the U.S. government can react quickly to reality. The role of government funding should emphasize the development of new technology. Our capitalistic system, in the absence of government restraint, has all of the resources and inducements to fund and manage the commercialization of the new cold fusion technology. The best role that government can play is to stop denying reality and encourage the stupendous potential of our American corporations by removing legal barriers to cooperation.
Additional six-month studies by panels of scientists are not needed. The proceedings of the NSF/EPRI conference (held in semi-secrecy) should be immediately published and widely disseminated. Coordinating committees should be sponsored by the corporations who will soon be making profits from cold fusion.

This coordination should emphasize the dissemination of the newly discovered principles of cold fusion and the assignment of research tasks to explore the problems of replication and reproducibility. The coordinating committees should include the most successful fusionists who are willing to help. My nominations would include Appleby, Bass, Bockris, Bush, Cravens, Faile, Fleischmann, Guruswamy, Hagelstein, Hansen, Huggins, Jones, Jorne, Miley, Oriani, Packham, Palmer, Pons, Schoessow, Wadsworth, Wolf, and many others whom I have not as yet met. In addition, the list must include the many corporate scientists who have had dramatic successes but have not as yet made their work public. I will volunteer to document and disseminate the results.

My apologies to our many non-American friends, especially those in India, Japan, Bulgaria, Italy, Spain and elsewhere for not including you in the above list. However, in most cases you already have the benefit of a favorable government-business cooperation and are already ahead of us (especially in India and Japan). We will share with you but first we want to catch up.

[1] D. Mitchell, "Fusion Amplification by Stimulated Emission of Radiation.", Fusion Facts, Vol 1, No 4, pages 6-10.

[2] R.T. Bush (Cal. State Polytechnic, Pomona), "A Transmission Resonance Model for Cold Fusion", Paper 89-WA/TS-3 presented at the ASME Winter Meeting, San Francisco Dec. 12, 1989. Available from ASME, 345 E. 47 Street, New York, N.Y. 10017.

[3] Personal communication, December 12, 1989.

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F. FUSION IMPACT ON FINANCIAL COMMUNITY

BACKGROUND

The discovery of cold fusion (also known as solid-state fusion) is the greatest scientific/technological discovery of the century if not of all time. Professor Steven Jones (BYU) was one of the first to publish information about cold fusion [1]. Professor Paul Palmer (BYU) suggested in 1986 that electrolysis be tried [2].

However, the announcement that shook the world was the press release by the University of Utah proclaiming the discovery by Professors Fleischmann and Pons that practical atomic fusion could be carried out with relatively simple laboratory equipment at near room temperature [3]. Of course, the great news was that the experiment, properly done, could produce more energy output than was used as energy input.

Although the equipment may be simple, the experiment is difficult to perform. Replicability and reproducibility are current problems that are being carefully studied in many parts of the world. This lack of predictability is reminiscent of the early days of transistors (solid-state semiconductors) and will be solved in the same way -- by clever scientists.

Now that cold fusion has been definitely proven to exist and now that the excess energy output has been replicated by many university, corporation, and government laboratories commercialization will begin [4]. The traditional sources of information, especially in the nations of the west, are being assailed with fusion information from prejudiced sources. The prejudice stems from government-funded groups who appear to be concerned that they will lose federal funds for hot fusion research. This factor is complicated by high-level government concern for the ease with which tritium (a component of H-bombs) can be produced. The result is that Japan and India have strong national support for cold fusion research while the U.S., England, France, Germany, Switzerland are more supportive of hot fusion development.

As of the end of November 1989, few important scientific papers have come from England, France, Germany, Switzerland (the CERN countries), nor from the U.S. DOE-funded national laboratories. One of the most important technical papers on fusion theory has been withheld from publication until recently [5].

Another important paper [6] released just before publication is the report of the work that Oak Ridge National Laboratory has done on the replication of cold fusion. Now that a DOE laboratory has replicated the fusion byproducts reported by Pons and Fleischmann (excess heat, tritium, and neutrons above background), there should be a greatly reduced number of scientists proclaiming that cold fusion is non-existent.

INDUSTRIES THAT WILL BE AFFECTED

Nearly all industries will be affected by the commercialization of solid-state fusion. Some industrial groups, such as energy industries, may be negatively affected. Other industries, such as the heating and air-conditioning industry, may be positively affected. In general, there will be an immediate need for all managers to assess the impact of fusion energy on their industry.

The financial industry will be seriously impacted. Plant and equipment that are used for loan collateral may suffer serious devaluation such as heating/cooling equipment. Businesses that are strongly dependent on fossil fuels may lose customers to the extent that some businesses will become unprofitable. Businesses that have been established around some distortions in the energy market may find rapid loss of revenues (for example, the co-generation of electrical power where the price paid is based on the latest cost for producing electricity). Those financial agencies carrying debt or investment interests in companies at strong risk can be financially damaged. This risk can be minimized by an early restructuring of investment portfolios based on accurate technical information and technological forecasting.

The financial industry will have enormous opportunities. There are now corporations and affiliations being formed for the purpose of commercializing fusion energy systems. Some of these new companies will grow to be future IBMs, XEROXs, and 3Ms of the future. Most financial organizations will miss the investment opportunities because they will not have staff who are qualified to evaluate the fusion-related investments. These organizations will want to employ the consulting services of groups who have specialized in the solid-state fusion developments (such as the correspondents and consultants of Fusion Facts).

APPLICATIONS OF COLD FUSION

There are so many applications for low-cost energy that it is apparent that most industries will be strongly impacted either by loss of market share or by opportunities to expand into new markets. Fusion energy system will create more distortions in the industrial markets than any other technological development. Here again, the financial industry should be strongly willing to invest modest amounts to ensure that they are kept aware of the rapid developments that are occurring and will occur in solid-state fusion technology.

THE TYPE OF ENERGY PRODUCED

An electrochemical fusion cell produces low-level heat. The heat from any working fusion cell is sufficient to boil water. If the fusion cell is pressurized, higher temperatures can be obtained. Because the metal lattice tends to give us deuterium at higher temperatures, there is an upper limit (yet to be firmly established) to the temperatures that are practical. The heat output is characterized as low-level heat as contrasted with the super-heated steam produced in a modern power plant.

NATURAL APPLICATIONS FOR HEATING

The most fundamental application for solid-state fusion, at the present stage of development, will be for heat-generation. One of the great uses of oil, natural gas, and electricity is to provide heat energy. As soon as fusion energy systems can provide heat at lower costs than currently being paid for oil, gas, or electricity, there will be strong economic demands for both new and replacement heating systems. Here are some of the more obvious applications that will impact many industries and their need for financial assistance:

1. Water heating.

2. Steam generation for sterilization.

3. Water distillation. Especially needed for ships at sea.

4. Air conditioning.

5. Cooking especially for food preparation.

6. Heat source for refineries. (Especially where fusion-generated heat is cheaper than crude oil).

7. Heating for greenhouses, orchards, and food storage.

8. Heaters for chemical processing plants.

9. Heaters for various transportation vehicles (trains, planes, buses, trucks).

10. Heaters for snow and ice removal, swimming pool water heating, and heating hot tubs.

HEED THE FOLLOWING:

Here are a few of the warnings that should be heeded by the financial community:

Do not underestimate the rapidity with which fusion power will be commercialized. Currently in Japan MITI (the Japanese Ministry for new technology and trade) has organized over 85 scientists from over 15 universities and institutions into a coordinated fusion research activity. The workers are divided into working groups for experiments, theory, and applications.

The first impacts will occur in applications where heat is the desired by-product. Examples are water heating, distillation, food preparation, furnaces, steam production, and air conditioning.

Timely and accurate INFORMATION will be a valuable product and segment of the fusion industry. Information here is used in the broadest sense and includes publications, electronic published information, and education.

Education, as an industry, will be strongly impacted. Currently a person entering the work force can expect to have five career changes, largely due to technological changes. Career changes in the fusion world may be six to eight changes in the 45 years of employment. The impact on educational institutions, especially for the "corporate classroom" will be very large.

Environmental businesses will be strongly impacted. The reduction in the burning of fossil fuels will negatively impact companies who supply equipment to remove pollutants. The availability of clean fusion power will be of immense importance in cleaning up the environment.

Do not pay great heed to those who will proclaim that cold fusion cannot occur without the production of radio-active contaminants. For the first time in nuclear physics, previously unknown nuclear reactions are being found and controlled. There is a high probability that deuterium fusion will be able to create energy without any radioactive or other harmful byproducts. Huggins [7] reports that he has quit measuring neutrons in his work at Stanford.

The science of materials will be strongly affected. There will be many new discoveries that will lead to the production of and/or improvement in new materials. Some transmutation of elements (and isotopes of elements) are already being reported. For example, tritium (used in H-bombs) can now be produced at a small fraction of the current costs [8].

Heavy water production facilities will be needed. One gallon out of every 7,000 gallons of ordinary water (hydrogen oxide or H_2O) is heavy water (deuterium oxide or D_2O). The energy equivalent of a gallon of heavy water is about equal to 300,000 gallons of fuel oil. The costs of production of one gallon of heavy water is estimated at less than $1,000 or less than one cent per gallon of oil (energy equivalent). This fact is the primary driving element behind the enormous world-wide interest in solid-state fusion.

Palladium or titanium appear to be the predominant metals that can be used to support fusion reactions within a metal lattice. The optimum metal will probably be an alloy. Palladium is scarce but titanium is the ninth most abundant element in the earth's surface. Be careful with metals speculation in both palladium and titanium.

The greatest salesperson for solid-state fusion may be governments. As soon as it is definitely understood that a metal lattice can be used to support clean (no radiation) fusion, laws may be passed that strongly support the change from using fossil fuels to cold fusion.

It should be illegal to burn fossil fuels. Unborn generations will need the fossil fuels as chemical feedstocks. Previously, we have had no choices. With the advent of clean fusion energy there will be strong efforts to curtail the burning of fossil fuels, particularly of oil. Therefore, the existing fossil fuels should be retained for use as chemical feedstocks and the prices of oil reserves will be adjusted accordingly. Financial organizations with heavy investments in fossil fuels should closely follow the technological developments in solid-state fusion.

INTERNATIONAL IMPLICATIONS

Heretofore developing countries have had to export billions of dollars of their native products to import the oil that fuels the structure of westernization. Cars, trucks, factories, airplanes, bulldozers, etc. are currently fueled by oil. This practice has caused an outflow of financial resources from developing countries who have no fossil fuels and an inflow to oil-exporting nations. The development of solid-state fusion energy systems will greatly impact this current flow of funds.

Nations who are exporters of palladium and/or titanium will have a long-term advantage in the flow of international funds. Currently the primary palladium producing countries are USSR and South Africa. If palladium remains as the primary cold fusion metal, there will be a strong geological search for additional palladium resources.

However, the metal (palladium or titanium) is not consumed in the process of solid-state fusion (the fuel is the deuterium in heavy water). Therefore, after the initial demand for fusion metals, the imports by fusion metal short countries will reduce to metals need for expansion. The use of cold fusion systems will be greatly encouraged by developing countries because of the lesser costs as compared to oil imports.

The entry costs for some industries is large. The fusion power industry entry costs are relatively small. Therefore, there will be a universal demand for information and education, especially for products written in native languages. The results will be a strong increase in the need for language translations, especially for computer-assisted translation.

The relatively low cost for fuel (deuterium energy at the equivalent of one cent per gallon of fuel oil) will strongly impact the entire technological design and fabrication of industrial equipment. However, the initial costs of fusion energy systems will be relatively high. Therefore, to achieve the advantage of low fuel costs, there will be required relatively high initial costs. These factors will cause some distortions in the timing of design change-over for a variety of industries.

Electrical power will be generated by cold fusion energy systems. Because the cold fusion system lends itself to small-size plants there will be a tradeoff between investments in transmission lines and smaller plants placed at points of power consumption. In addition, there will be a trade-off in the production of electricity and its use for heating purposes and the installation of plants to provide heat. For example, in many places in the

USSR, all housing heat is centrally provided. The advent of fusion energy systems is expected to favor this arrangement. It is estimated that the cost of solid-state fusion electrical power 2will be about one-fourth of the cost of coal-fired electrical power.

IMPACT ON VENTURE CAPITAL

The demand for venture capital will be large and has already begun. The major difficulty for the venture capital managers will be to find consultants who are sufficiently skilled in the technology of cold fusion and related technologies to provide accurate evaluation of candidate projects.

Early placement of venture capital funds can be highly rewarding if done with a combination of project selection and patience. There will be opportunities for large returns on investment in the long run and less opportunities for quick high returns.

One of the first venture capital projects is the funding of a group who plan to produce early fusion cell heaters ranging from experimental units to units that produce up to 2500 watts of continuous power. Because there will be an early demand for such fusion systems, this project has an excellent chance for strong returns on investment.

To properly evaluate venture capital investments in fusion energy projects, the following points need to be considered:

1. Is the product expected to have an early demand in the growing fusion technology?

2. Does the project depend on scheduled inventions or it is based on well-understood scientific principles?

3. Because it will be very difficult to assess competition, the product should have a potential demand that far exceeds the planned production.

4. Products should be designed around existing technology so that product sales are not dependent on hard-to-schedule developments by other companies.

5. Sources of supply for components needed for the product should be carefully considered in the business plan. For example, if palladium and heavy water are to be used, are the sources of supply secured by contractual or other arrangements?

6. Projects can be developed for later acquisition by larger companies. However, beware of entering a market that is traditionally controlled by large corporations. For example, it would be wise to avoid funding the development of a fusion automobile unless prior arrangements were made with an appropriate automotive giant.

Venture capital companies, and other financial institutions are advised to immediately assign a technically-qualified person to follow the developments solid-state fusion. You will be soon called on to evaluate the impact of fusion energy systems on your own projects or for your customers. A wait-and-see attitude has little merit because in the rapid developments that are being made, it is a zero-win choice. Proper decisions can only be made based on relevant information.

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[3] 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).

[4] Gary M. Sandquist (U of Utah) and Vern C. Rogers (Rogers and Assoc. Engr'g Corp. SLC, Utah), "Evaluation and Verification of 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 session on cold fusion is probably the most important public presentation of papers that has been given. The session was organized and chaired by two scientists from Oak Ridge National Laboratories, A. R. Sadlowe and Gordon E. Michaels.]

[5] Dr. Peter L. Hagelstein, M.I.T., "Coherent Fusion Theory.", 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 mathematical model for cold fusion developed from basic physical principles. This work plus further experimental work will probably be the foremost theoretical work on cold fusion.]

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

[7] Dr. Robert A. Huggins (Stanford University), "Recent Stanford Work on Excess Heat Generation During Electrochemical Insertion of Deuterium into Palladium.", presented at COLD FUSION - A STATUS REPORT session in conjunction with the ASME Winter Annual Meeting held in San Francisco, CA December 12, 1989. [Huggins reports on many continuous hours running time with fusion cells producing excess heat. Planned for the immediate future are experiments at higher output temperatures. This work is close to commercialization.]

[8] J. O'M. Bockris in a presentation to attendees at the 13th Annual Utah Conference on Energy, Mining, and New Technology, U/U Sept 8, 1989 discussed the following: It is suggested that in the electrical field environment of a palladium deuteride lattice the nuclei of two adjacent deuterons will line up as follows: p - n : n - p. As a result of statistical tunneling the end result will be p - n - n : p. Where the p-n-n becomes the tritium nucleus and the p escapes. He also estimated that fusion cells could be used to produce tritium at about 2% of the current government costs.

* * * * * *

G. CALL FOR PAPERS AND CONFERENCES

CONFERENCE ON COLD FUSION SCHEDULED AT UNIVERSITY OF UTAH RESEARCH PARK, UNIVERSITY PARK HOTEL, SALT LAKE CITY, UTAH.
MARCH 29-31, 1989.
We will publish more information about this conference as soon as available.

CALL FOR PAPERS

1990 Tesla Symposium, "Towards a New Dawn..." to be held at Colorado Springs, CO, July 26-29, 1989. Abstracts must be submitted by January 31, 1990 to the International Tesla Society, Inc., 330-A West Uintah, Suite 215, Colorado Springs, CO 80905-1095, Phone (719)392-6404.

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COLD FUSION BIBLIOGRAPHY

The Fusion Information Center, Inc., publisher of FUSION FACTS has agreed with Dr. Samuel P. Faile to publish his FUSION ANNOTATED BIBLIOGRAPHY on computer media.

Dr. Faile began reading and annotating all available articles on cold fusion immediately after the March 23, 1989 announcement by Fleischman and Pons. Three volumes (sized for publication on 5 1/4 inch diskettes) are now available.

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