FUSION facts

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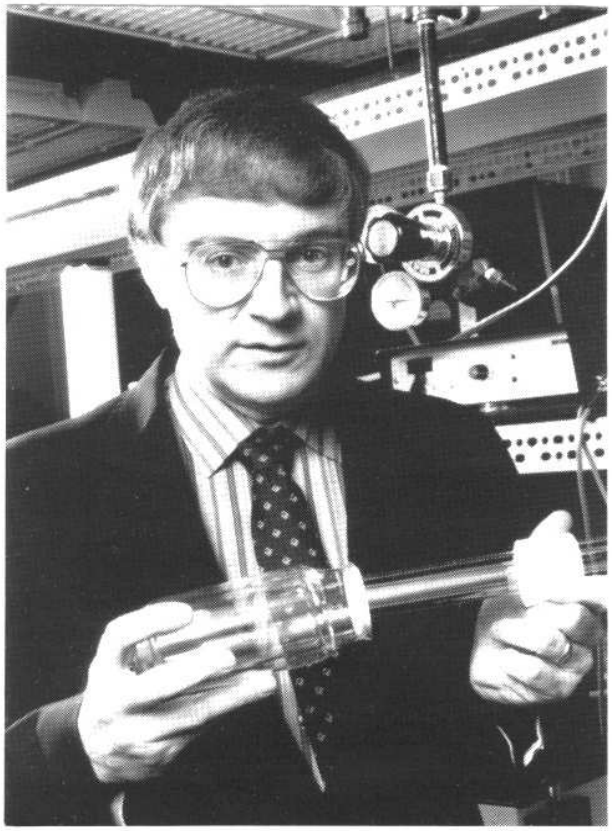
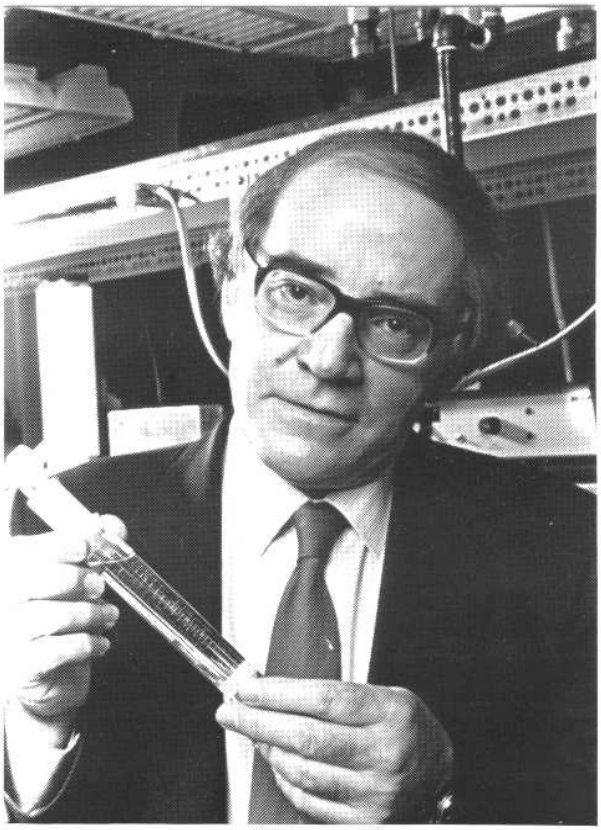
SALT LAKE CITY, UTAH

FUSION FACTS NAMES PONS AND FLEISCHMANN AS FUSION SCIENTISTS OF THE YEAR 1989.



Professor B. Stanley Pons
1989 Fusion Scientist of the Year



Professor Martin Fleischmann
1989 Fusion Scientist of the Year

CONTENTS JANUARY ISSUE

A. FUSION SCIENTISTS OF THE YEAR

Fusion Facts awards its "1989 Fusion Scientist of the Year" award to be shared by Professors B. Stanley Pons and Martin Fleischmann. From the announcement date of March 23, 1989 of the discovery of "fusion in a bottle" to the year-end verifications by both Oak Ridge National Laboratory and Los Alamos National Laboratory, 1989 was a tumultuous year for fusion. Finding that nuclear reactions can take place in a metal lattice at near room temperatures and produce excess heat will probably be recorded as the world's greatest scientific discovery.

DR. B. STANLEY PONS

Dr. Pons skiing season came to an abrupt halt when his work on cold fusion was announced to the world on March 24, 1989. Born in Valdese, North Carolina in 1943, Pons quickly grew into a science enthusiast but with the usual time out to play football, run the mile on the track team, and play the saxophone. Starting with "the usual chemistry set and a cheap microscope in my room" Pons grew to pursue a major in Chemistry at Wake Forest University where he obtained his B.S. degree.

Pons continued his education at the University of Michigan and later obtained his Ph.D. from The University, Southampton, Hampshire, England. His admittance to the graduate program at Southampton was at the recommendation of Professor Martin Fleischmann. During the process of obtaining his Ph.D. Pons established a relationship with Dr. Fleischmann based on mutual respect for each other's talents.

Dr. Pons began his career at the Department of Chemistry at Oakland University until 1980 when he move to the University of Alberta. In 1983 he joined the staff of the Department of Chemistry at the University of Utah where he later became chairman of the department. During his chairmanship the Department of Chemistry led the nation in the amount of research dollars per faculty member - a little known fact about the caliber of the both Pons and his department.

Dr. Pons is a member of the American Chemical Society, the International Society of Electrochemistry, and The Electrochemical Society. He has published over 145 scientific articles many of which were co-authored with Martin Fleischmann.

DR. MARTIN FLEISCHMANN

Martin Fleischmann was born in 1927 in Carlsbad, Czechoslovakia and later became a naturalized British citizen. He graduated from high school in Worthing, Sussex, England before entering the Imperial College in London. Later he received his Ph.D. (1951) from London University.

From 1950 to 1967 Dr. Fleischmann was successively a Research Fellow and Imperial Chemical Industries Research Fellow at Kings College (University of Newcastle-upon-Tyne) and then Lecturer and Reader in Physical Chemistry at the same university.

From 1967 until his mandatory retirement in 1983 he was Professor of Electrochemistry at University of Southampton where he held the prestigious chair originally endowed by the Electricity Council. It was during this time that he recommended Pons to be admitted to the university and where that mutual admiration was developed.

Since 1983 Dr. Fleischmann has been a Research Professor at the University of Utah. During one of their canyon strolls, Pons and Fleischmann discussed some outlandish "one-in-a-billion" ideas that led to using their own funds in cold fusion experiments. They have since stated that no one would believe what they were trying to do, so they had better sense than to ask for funds for such a long-shot project. As it turned out, many in the world didn't believe cold fusion after they had achieved success.

Dr. Fleischmann has received the Medal for Electrochemistry and Thermodynamics (1979) from

the Royal Society of Chemistry; the Olin-Palladium Medal of the Electrochemical Society (1985); and the Bruno Breyer Medal from the Royal Australian Chemical Society (1988). In addition, in 1986 he was appointed to be a Fellow of the Royal Society - a prestigious honor. Fleischmann has published 242 scientific articles, many of which were co-authored with Dr. Pons.

MODERN PIONEERS

Pons and Fleischmann are truly modern pioneers. However, instead of being shot at by Indians and outlaws, they have had to ward off the darts of outrageous fortune from fellow scientists. Many scientists have accepted the reported scientific findings of Pons and Fleischmann, have recognized their leadership into a new and fascinating new field of knowledge, and have replicated some or all of their early work. A few misguided scientists have hurled verbal and published abuse.

With ears closed to the din of controversy, Pons and Fleischmann have continued their quest and have outlasted their critics. Fusion Facts is pleased to welcome these two famous scientists to be the first recipients of the FUSION FACTS FUSION SCIENTIST OF THE YEAR award. Thank you Pons and Fleischmann for your leadership, your ideas, and your courage of righteous convictions.

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B. NEW DIRECTOR FOR NATIONAL COLD FUSION INSTITUTE

GENERAL ELECTRIC SCIENTIST TO HEAD NCFI

Dr. Fritz G. Will, a scientist who gained international recognition for developing an electrochemical technique to study electrode surfaces, has been named director of the University of Utah National Cold Fusion Institute (NCFI). The appointment is effective February 1, 1990.

Dr. Will's appointment was announced December 19, 1989 by Dr. James J. Brophy, vice president for research at the University of Utah and the current interim director of NCFI. Will is a leading scientist at General Electric Co.'s Development Center in Schenectady, N.Y., where he has worked since 1960.

The ultimate goal of NCFI is to discover the range of practical applications for solid-state fusion energy systems. Dr. Will's experience in directing industrial research programs was a strong factor in being offered the position of director.

The NCFI has been started and operated using funds allocated by the Utah State Legislature. Utah has been far sighted in allocating $5 million for the further development of cold fusion and for the processing of appropriate patents. Dr. Will can build on the work that has already been accomplished to set up NCFI and to pursue future support for NCFI research and development.

As part of an agreement signed June 28, 1989, General Electric is cooperating in the verification of the Pons-Fleischmann breakthrough in solid-state fusion. Dr. Will has been a principal figure in GE's fusion-related research in Schenectady.

Dr. Will is a native of Breslau, Germany and was educated at the Technical University in Munich, were he earned a Ph.D. in physical chemistry in 1959. He is a former president of the Electrochemical Society and has been active in various positions with the society for the past thirty years.

Since 1973, Dr. Will has directed General Electric's research programs in the areas of zinc-bromide batteries, aluminum-air batteries and hydrogen sensors. In recent years he has directed research on conducting polymers and the insulators for space power systems.

A technique developed by Will for studying the chemisorption layers on metal electrodes has been widely used in a broad range of electrode surface

investigations. Will's publication describing his potential sweep, or potentiodynamic technique [1] received a "Citation Classic" designation in 1984 from the Institute for Scientific Information. The paper has been cited more than 300 times in scientific literature.

Dr. Will is the author of more than 50 publications, and has been issued two dozen U.S. patents. Industrial Research magazine presented GE with its "IR-100" Award in 1975 for Will's work in solid electrolytes that led to development of the ambient temperature sodium-halogen solid electrolyte battery.

In 1964 Will received the Research Award from the Electrochemical Society's Battery Division for a paper that provided the basis for understanding the operating mechanism of fuel cell gas electrodes [2].

After receiving his doctorate, Will joined the research staff at the U.S. Army's Engineering Research and Development Laboratories in Ft. Belvoir, Va. He initiated an in-house fuel cell program and served as program manager for external contract work in the area of fuel cells.

From 1969 to 1973, Dr. Will served as a technical coordinator of the physical chemistry laboratory and manager of the electrochemical materials and reactions unit. In 1973 he spent a sabbatical at the University of Bonn in West Germany. He was a consultant on battery research at Murdoch University in Australia in 1981.

Dr. Will has given invited lectures at the Gordon Research Conference for Electrochemistry in Santa Barbara, Calif.; the International Society for Electrochemistry meeting in Eindhoven, Holland; the NATO Conference on Materials for Advanced Batteries in Aussois, France; the American Chemical Society's annual meeting in Miami Beach, Fla.; and the First Australian Electric Vehicle Conference in Adelaide.

Dr. Will is currently the Electrochemical Society's representative to the American Association for the Advancement of Science. He is coorganizer of the First International Symposium on High Temperature Insulators scheduled for Seattle, Wash. in October 1990.

Other activities for Dr. Will include coeditor of Symposia Proceedings Volumes on Electrode Materials and Processes for Energy Conversion and Storage and Electrocatalysis. He has also served on the National Materials Advisory Board`s Committee on Battery Materials Technology and the Selection Committee of the National Inventors Hall of Fame.

Fusion Facts welcomes Dr. Fritz Will to his new position as Director of NCFI. His skills will help build NCFI as a premier research facility in non-conventional energy systems.

PENDING PATENT PROBLEMS

Dr. Will may have some patent problems to contend with as part of his new job as director of NCFI. According to a recent report in a Salt Lake City newspaper [3], the requirements for a patentable process or device is that you set forth a reproducible scheme.

The lack of a repeatable recipe by which a working fusion cell can be made by "one skilled in the art" can place a patent in a gray area. The article reports, however, that the University of Utah is sufficiently convinced of the future validity of the patent that they have not been willing to make financial contracts with companies who want to buy a percentage of future royalties.

There is some speculation that the patent "...examiner assigned to cold fusion is just beginning to assess the 50 or so applications the office has received." could treat a cold fusion device as a perpetual motion machine. If this were the case, then a working model would have to be provided. However, the University of Utah has several working models that could be used.

In any event, reproducibility of the cold fusion electrochemical cells will continue to be one of the major problems to be resolved at the NCFI (or at

other research facilities). Either under Dr. Will's direction or by some other ingenious scientist, it is predicted that the problem of reproducibility will soon be resolved.

REFERENCES:

[1] F.G. Will and C.A. Knorr, "Investigation of Hydrogen and Oxygen Adsorption Layers on Platinum Electrodes.", Elektrochem., (1960) Vol 64, pages 258-169.

[2] Fritz Will, "Electrochemical oxidation of hydrogen on partially immersed platinum electrode. I-Experiments and Interpretation. II-Theoretic Treatment", Jrnl. Electrochem. Soc. (1963), Vol, 110 pages 145-160.

[3] Tim Fitzpatrick, "U. May Have to Share Fusion Wealth, Say Lawyers", Salt Lake Tribune, B-1.

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C. MORE NEWS FROM U.S.

NEW FROM LOS ALAMOS

Edmund Storms and Carol Talcott, "Electrolytic Tritium Production", Draft Paper #2, LAUR:89-4138 (Information provided at the NSF/EPRI Workshop on Anomalous Effects in Deuterated Metals, Washington, D.C. October 16-18, 1989. (To be published in the Proceedings).

The paper describes the experimental work using the F-P cells in attempts to produce tritium. The conclusion states: "Tritium has been produced in 11 cells at levels between 1.5 and 80 times the starting concentration. Over 1500 tritium measurements have been made on 53 cells of various designs. ... Based on this background, we believe that tritium is real, it is not caused by contamination and it is not a product of normal electrolysis. It is evident that tritium production in these cells is still very inefficient and probably isolated to a few special locations on the cathode. However, we cannot yet say what special conditions are required for its production."

"Experiments prove cold fusion is for real, experts say.", El Paso Times, Sunday December 24, 1989 page 2B.

The article reports that scientists at Los Alamos National Laboratory have confirmed the production of tritium in experiments with a cold fusion process. Tritium production up to 80 100 times the starting concentration has been recorded by scientist Edmund Storms and Carol Talcott.

"It's the end of the game - the beginning of a new tomorrow. The battle is finished," stated Prof. John O'M. Bockris (Texas A&M), "I don't think there is any more that anyone else could say. If they know the facts, there is not any doubt about cold fusion now [being a reality] because of the findings at Oak Ridge and Los Alamos." Edmund Storms and Carol Talcott believe that the tritium production is real; it is not caused by contamination; and it is not a product of normal electrolysis.

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NAVAL RESEARCH LABORATORY

Dr. Scott R. Chubb provided the following information:

The first NRL publication on cold fusion is now at the printers. The publication is "Memorandum Report 6600" and is available from Department of the Navy
Naval Research Laboratory
Documents Code 2627
Washington, D.C. 20375-5000
Telephone 202-767-3367

This first NRL fusion publication is a theory paper discussing bulk theory of cold fusion. The paper discusses helium production and also discusses the lithium reaction in a fusion cell. Two other NRL

publications on cold fusion are expected in the near future.

The following paper from NRL Scientists will appear in the May 1990 issue of Fusion Technology: Talbot A. Chubb and Scott R. Chubb, "Block Symmetric Fusion in PdD_x", Fusion Technology, May 1990.

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PURDUE UNIVERSITY

Fusion Facts is indebted to Dr. Yeong E. Kim for briefing us on his latest important theoretical work on cold fusion.

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. (To be published in the proceedings.)

Abstract: Based on nuclear theory hypotheses, a consistent and plausible explanation is described for tritium production and excess heat generation above that due to the electrode reaction recently reported by Fleischmann, Pons, and Hawkins and others in their electrolysis experiments. A surface reaction mechanism is proposed for electrolysis experiments in which deuterium-deuterium fusion takes place in the surface zone of Pd cathode where whiskers of metal deuterides are formed in the electrolysis experiments. Conventional theoretical estimates of the D-D fusion rate at room temperature are critically re-examined and are shown to be inadequate. Other nuclear theory hypotheses involving neutron-induced reaction processes, which may occur subsequent to and concurrent with the D-D fusion, are also discussed. Experimental tests of the proposed mechanism and new improved devices for the cold fusion are suggested.

Yeong E. Kim (Purdue), "Comment on 'Cluster-Impact Fusion'", Department of Physics, Purdue, West Lafayette, IN 47907, paper PNTG-89-11, October 1989.

Dr. Kim's paper has the following interesting observation: "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 to lower energies where no direct experimental tests and measurements exist, except the indirect measurements of Fleischmann, Pons and Hawkins (FPH) and others [cites Jones, Wolf, Iyengar [1,2,&3].

Recent experimental results of Beuhler, Friedlander and Friedman at deuteron laboratory energy of (about) 0.3 KeV show that both the D-D fusion rate and the branching ratio for (^{3}H - p) channel are extremely large as in the case of the FPH effect compared to the conventional estimates, thus indicating that the extrapolation method is not valid at low energies.

[1] S. E. Jones, E. P. Palmer, J. B. Czirr, D. L. Decker, G. L. Jensen, J. M. Thorne, S. F. Taylor, and J. Rafelski, "Observation of cold nuclear fusion in condensed matter.", Nature, 338, pages 737-740 (1989).

[2] 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.

[3] 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).

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TEXAS A&M
SURFACE COMPOSITION OF PD ELECTRODES

T. Mebrahtu, J.F. Rodriquez, M.E. Bothwell, I.F. Cheng, D.R. Lawson, J.R. McBride, C.R. Martin, and M.P. Soriaga (Texas A&M), "Observations on the surface composition of palladium cathodes after D2O electrolysis in LiOD solutions", J. Electroanal. Chem. 267 (1989) pages 351-357.

This article is an excellent treatment of the possible problems with surface contaminations using Pd. Those newly involved in the attempt to replicate the FPE should be aware of the variety of contaminations that may be important in properly preparing a Pd cathode.

Note: My apologies for not getting this information to our readers sooner. Ed.

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AT&T BELL LABS
(Courtesy Jim Burlew)

NEW MEASUREMENT TECHNIQUE

J. Bokor, "Ultrafast Dynamics at Semiconductor and Metal Surfaces", Science, Vol. 246, 1 December 1989, pages 1130-1134.

The author heads up the Laser Science Research Dept. at AT&T Bell Labs in Holmdel, NJ. The summary of the paper states, "A variety of important dynamic phenomena at metal and semiconductor surfaces are now being investigated with the use of new ultrafast measurement techniques involving lasers and nonlinear optics. Understanding of the rates and mechanisms for relaxation of optical excitations of the surface itself as well as those of adsorbates on the surface is providing new insight into surface chemistry, surface phase transitions, and surface recombination of charge carriers in semiconductors."

The ultrafast laser spectroscopy described in this paper can be used for studying surface diffusion, catalysis, and chemical reactions, among other uses. This new equipment and techniques may be very useful in learning more about fusion reactions that have taken place in a Pd cathode. The possibility exists for some creative experimenter to discover how to use this technique for real-time measurements on a working fusion cell.

Note: Jim Burlew of Topeka, Kansas has been doing experimental work in nuclear fusion. He predicts that the progress being made in cold fusion will be accelerated as we wed the knowledge of "solid-state physics with micro-plasmas". He may be right. Ed.

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BRIEF NOTES ON ASME SESSION

"Cold Fusion -- or something", Science News, Vol. 136 Dec 23 & 30, 1989.

Short report on the cold fusion session at the San Francisco meeting of the American Society of Mechanical Engineers (See Dec 89 Fusion Facts). Quotes Dr. Charles D. Scott of ORNL, "Anomalous effects have been seen often enough that the phenomena can't be explained away as artifacts."

Robert Pool, "In Hot Water Over Cold Fusion", Science Vol 246, December 15, 1989 page 1384.

Note: I attended the same conference and found substantial positive contributions to the science of cold fusion (headline report in Fusion Facts, Dec. 1989). It is amazing to me that Science News and Science fail to report the significance of this meeting. Ed.

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LETTERS FROM READERS

"ELECTROMAGNETIC RESEARCH TO WIN", states Andrew Huber of San Diego, CA. Huber writes, "The researchers who are using (magnetic)

nickel grids are approaching cold fusion from an electromagnetic point of view. I believe they are going to win out. Harwell Labs took the chemical approach and showed that if the circuit is "demagnetized", such as by using the IHF and isothermal calorimeters, the excess heat of the (magnetic) F-P calorimeter goes away. The implication of their research is that even greater excess heat is to be found by making the (magnetic) F-P circuit even more magnetic." Huber has been professionally involved in the analysis of spacecraft subassemblies to ensure extended life in rigorous environments.

"WALL STREET JOURNAL WAITING FOR LOS ALAMOS", says Steve Roen of
New York City. Roen says, "As of this date (1/3/90) the Wall Street Journal hasn't included this [info from scientist Edmund Storms and Carol Talcott of Los Alamos] (science writer says he's waiting for Los Alamos confirmation) and nothing in the New York Times nor Financial News of London."

Note: We'll suggest they subscribe to FF. Ed.

"INVENTORS MAY OBTAIN PROJECT FUNDS", says Dr. Dennis Cravens of Vernon, Texas. Dr. Cravens suggests that inventors who have inventions to be evaluated for possible funding, write to: Office of Energy-Related Inventions
National Bureau of Standards
Gaithersburg, MD 20899
Ask for information about the inventor's program.

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D. NEWS FROM ABROAD

SOFIA, BULGARIA
DR. NONINSKI - NEW FF CORRESPONDENT

Dr. V. C. Noninski has written the following: "I would like to inform you that it will be a pleasure for me to act as a correspondent for you to provide any information concerning cold fusion experiments professionally and ethically made available to me."

We welcome Dr. Noninski to our growing list of professional fusion scientists who are helping to provide our subscribers with the latest information on cold fusion. In addition, we extend our most sincere best wishes to all the people of Bulgaria in their quest for improved living standards.

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INDIA
(Courtesy Dr. Faile)

K.S. Jayaraman (New Delhi), "Singh shifts India towards nationalism", Nature, Vol 342, 14 December 1989, page 723.

The article states the strong research and development emphasis that Prime Minister Vishwanath Pratap Singh is bringing to India following the November elections. The author writes, "...This is consistent with the decision to divert half of the country's financial resources to the development of rural India. **Harnessing non-conventional and renewable sources of energy has been declared as the government's major objective."** It is estimated that India now has over 100 scientific and technical persons working on cold fusion.

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CANADA

FIRST BOOK ON COLD FUSION

F. David Peat, COLD FUSION, The Making of a Scientific Controversy, Contemporary Books (Chicago) and Beaverbooks (Ontario, Canada), c 1989.

The Canadian author, F. David Peat, has written other science books such as Superstrings and the Search for the Theory of Everything. His cold fusion book explains to the intelligent non-professional (or to the interested professional) the background of the development of cold fusion,

the controversy that has arisen, and some extrapolated scenarios for the future.

The latest dated events in the book end about June 1989, soon after the Workshop on Cold Fusion Phenomena that was held in Santa Fe, New Mexico, May 23, 1989. In the 188 pages of the book a considerable amount of high school science background material is presented to aid in the understanding of cold fusion. The book is reasonably well indexed but has almost no citations to the professional literature. Reading the book requires no mathematical skills and is a good choice for the lay person or for the high school and college libraries. The jacket price is $16.95.

David Lindley, "Setting on the fence", Nature Vol 342, 21/28 December 1989. [This review of Peat's book calls it "stubbornly uninformative."]

Note: Nature has been stubbornly uninformative about cold fusion even though many papers reporting positive results have been submitted. Ed.

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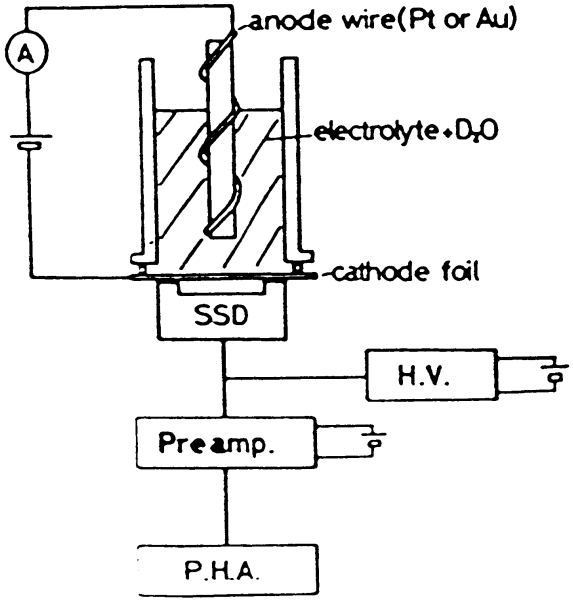
JAPAN

DETECTING FPE EVENTS

Ryoichi Taniguchi, Takao Yamamoto, and Setsuko Irie, "Detection of Charged Particles Emitted by Electrolytically Induced Cold Nuclear Fusion", Japanese Journal of Applied Physics, Vol 28, No. 11, pages L2021-L2023.

The summary states, "We have tried to obtain evidence for electrolytically induced cold nuclear fusion by detecting charged particles associated with the nuclear reaction. Charged particles were detected by a conventional silicon surface barrier detector attached close to the thin foil cathode which formed the bottom of an electrolysis cell. The efficiency and signal-to-noise ratio of this system are higher than those of neutron detection systems, which made it easy to determine whether the fusion occurred or not. The energy spectrum measured with the electrolysis of D_2O suggested that the nuclear reaction took place in palladium cathode."

The following diagram shows the arrangement of the experimental apparatus:



The paper cites the difficulty of making neutron measurements of cold fusion due to the low detection efficiency and that the large volume of neutron detectors cause degradation of the signal-to-noise ratio. The use of a bottom cathode foil in the electrolytic cell was designed to strongly improve the measurements of the neutron emission.

Note: For those who wish to explore the emission of neutrons from a fusion cell, we suggest that this method has considerable merit. However, other authors (Iyengar [1] and Packham et al [2]) have shown that the neutron events are relatively rare in most cold fusion working cells.

[1] 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 byOppenheimer over half a century ago and elaborated on more

recently by Rand McNally..." [See Oppenheimer and Phillips, Note on the Transmutation Function for Deuterons. Phys Rev 48, 500 (1935).]

[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 D_2O Electrolysis at a Palladium Cathode.", J. Electroanal. Chem. vol 270 (1989), pages 451-458.

COLD FUSION SOY SAUCE MODEL
(Courtesy of Dr. Faile)

Takaaki Matsumoto (Hokkaido U), "'NATTOH' Model for Cold Fusion", Fusion Technology, Dec. 1989 Vol 16 No 4, pages 532-534.

Abstract: "A hypothetical model, the "Nattoh" model, is proposed to answer the questions that result from cold fusion experiments. This model proposes the formation of a small cluster of deuterons and examines the feasibility of many-body fusion reactions. The gamma-ray spectrum, heat production, neutron emissions, and fusion products are discussed." Note: "Nattoh" means fermented soybeans.

The model suggests ten possible nuclear reactions that may be taking place with the Pd cathode, including the following:

$2D + D \rightarrow {}^4He + d$

The author states that this reaction occurs with the largest probability and predominantly contributes to heat production. The recoil energy from the fusion is transferred to the third deuteron and/or to the deuteron cluster. This energetic deuteron may then be involved in additional fusion reactions.

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REVIEW OF FUSION

Takahaski (Eng. College, Tokyo U), "Room Temperature Nuclear Fusion", Gendai Kagaku (1989), Vol. 223, pgs 48-54 (In Japanese). [A review with no references is given on the cold fusion studies of FP, Jones, and the Italian work without electrolysis.]

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GREAT BRITAIN
(Reported by Dr. Faile)

R.D. Armstrong, E.A.Charles, I Fells, L. Molyneux, and M. Todd, (U. of Newcastle upon Tyne), "A long-term calorimetric study of the electrolysis of D_2O using palladium cube cathodes", J. Electroanal Chem, Vol 272 (1989) pages 293-297.

The preliminary note finds that "...there is no excess thermal energy generated during the electrolysis of D_2O using palladium cathodes. In our view the small excess enthalpy production reported by Fleischmann and Pons could easily be due to a calibration error..."

No discussion was made of the loading time for a one cm. Pd cube. The preparation of the Pd as discussed did not include treatments that would be expected to work in a FPE cell. The experimental procedure included, "...long-term calibration tests which involved switching off the current supply for 2 h every day for 14 days..." The issue of D/Pd ratio is reported: "The test times used in this work are clearly long enough to allow saturation of the cube electrodes with deuterium, and this comment is supported by the observation of distortion of the electrodes, due to formation of palladium deuteride..."

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NORWAY
(Courtesy of Dr. Faile)

Signe Kjelstrup Ratkje and Bjorn Hafskjold (U. of Trondheim), "Local heat effects by electrolysis of heavy water", J. Electroanal. Chem., vol. 273 (1989), pages 269-273.

An analytical paper showing that, "During electrolysis there is always a reversible heat production or consumption at the electrodes caused by the electric current. This is due to the Peltier effect and a thermodynamic effect. In the present case, we shall see that these effects represent a cooling of both electrodes..."

The analysis may be of some importance to those performing precise calorimetric measurements on fusion cells.

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WEST GERMANY
(Courtesy A.F.Fairbanks)

SOLAR POWER PLANT

David Scott, "Night and day solar", Popular Science, February 1990, pages 70-73.

David Scott summarizes, "This unusual German power plant can supply the energy needs of a family around the clock, its developers claim. A windproof panel of solar collectors tracks the sun, concentrating sunlight at a fixed focus. Special metal powders store heat and release hydrogen gas that provides energy for cooking, electricity, heating, and cooling."

The system uses magnesium hydride for a hot cell and a titanium hydride for a cold cell (during part of the cycle). Two Max Planck Institutes have helped in the development of the hydride technology. The system uses an advanced Stirling engine connected to an electrical generator.

Note: The future heat source may well be solid-state fusion. Ed.

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ROMANIA & WEST GERMANY
(Courtesy Dr. Faile)

COLD FISSION ALSO

A. Snadulescu, A. Florescu (Bucharest), W. Greiner (J.W. Goethe-U.), "Cold fission as emission of fragments", J. Phys. G; Nucl. Part. Phys. 15 (1989) pages 1815-1831.

Abstract: "Cold fission, defined as a process where virtually all the available energy goes into the total kinetic energies of the fragments such as ^{14}C, ^{24}Ne, ^{28}Mg and ^{32}Si, already observed experimentally (exotic decays). Both processes lead to fragments in their ground states. It is shown that the criterion of maximum barrier penetrability around the charge equilibrated values in cold fission could explain the recent experiments on the cold fission of thermal-neutron induced fission of U and Pu isotopes and of the spontaneous fission of ^{252}Cf with fragment masses and charges being resolved one-by-one.

It is also shown that, contrary to exotic decays where the deformations of the emitted fragments are not very important, the deformations of both fragments are essential for the explanation of the present data. The deduced quadrupole deformations are in total agreement with the theoretical ones based on macroscopic-microscopic models. We conclude that cold fragmentation of heavy nuclei with fragments in their ground states is a quite general phenomenon."

This paper ends with the following statement: "Finally, considering together the recent discoveries of exotic decays, of bimodal symmetric fission, of cold fission and of cold fusion, we consider that cold rearrangements of a large number of nucleons from one ground state to two ground state and vice-versa is a quite general phenomenon."

Note: As the authors discuss both the liquid drop model and the macroscopic-microscopic model of nuclei, we hope that they are communicating with Drs. Norman D. Cook and Valerio Dallacasa in their work on the FCC model of the nucleus. See "NUCLEAR MODEL" under "ENGLAND AND ITALY" below.

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ENGLAND AND ITALY
(Courtesy Dr. Norman D. Cook)

NUCLEAR MODEL
Norman D. Cook (Oxford) and Valerio Dallacasa (Parma U.), "Face-centered-cubic solid-phase theory of the nucleus", Physical Review C, Vol 35, No. 5, pages 1883-1889.

Abstract: "The symmetries of an antiferromagnetic face-centered-cubic (FCC) lattice with alternating isospin layers reproduce simultaneously several one- and two-dimensional spin- and isospin-ordered states which have previously been shown to be low energy configurations for a condensed nuclear phase. The face-centered-cubic lattice also shows a precise correspondence with the j-j model and, consequently, the entire nucleon buildup procedure of the independent-particle model. It is concluded that the study of nuclear condensates at normal nuclear densities should begin with the face-centered-cubic configuration."

The article contains the following, "...Nevertheless, the striking isomorphism between the FCC lattice and the known eigenvalue symmetries of normal nuclei indicates that, if a condensed nuclear phase is energetically stable, then investigations of the solid phase should begin with the FCC model. Other solid-phase nuclear models, briefly discussed below, show few advantages and many disadvantages -- primarily in their inability to account for the independent-particle nature of nuclei."

Dr. Cook is affiliated with Transtech (Rehalpstrasse 94, Zurich CH-8008, Switzerland). Transtech produces a structural kit for building your own nuclei out of nucleons. In addition, Transtech markets a computer program that will allow the user to develop colored models of the nuclei using EGA colored monitors on desk-top computers. It is suggested that the use of the computer programs and/or the model should provide an improved understanding of the nature of the Pd and other nuclei. The computer programs also compute important parameters for each nuclei, such as the Coulomb barrier. Ed.

* * *

ITALY

NEUTRON PRODUCTION IN NIOBIUM

F. Demanins, M. Graziani, J. Kaspar, S. Modesti, F. Raicich, R. Rosei, F. Tommasini, and A. Trovarelli (U. Trieste), "Search for the neutron production in niobium deuteride", Solid State Communications (1989) Vol 71 (7), pages 559-561. [Possible cold fusion reaction in Nb deuterides was investigated using p-recoil scintillation detector to count neutrons. Rates measured were less than 10^{-24} d/sec].

* * * * * * *

E. SHORT ARTICLES FROM AUTHORS

DOE EXPENDITURES
By Hal Fox

The U. S. Department of Energy has a substantial budget over and above what is spent on fusion. The following table shows the annual expenditures for the DOE:

YEAR	BUDGET *	FUSION #
1988	$11.2 bil	$ 500 mil
1989	11.9	525
1990	14.1	500
1991	15.2	
1992	16.5	

*Source: Senator Garn's office.
Bob Davis, "Hot Fusion Produces Cold Results.", WSJ 12/18/89.

The amount spent on hot fusion research from 1970 ($50 mil) to 1987 ($500 mil) peaked in 1983 and

1984 at about $600 million. Since that time there has been a cutback in hot fusion expenditures and a sharing of hot fusion funding between magnetic confinement and fusion using lasers and related technologies.

According to correspondence with the office of the Secretary of Energy, DOE has been spending about one million dollars a month in its investigations into cold fusion. Additional funds are expected to be allocated to cold fusion research from DOE's budget. According to the Deseret News [3],: "...Bockris said Storms has told him that he and Talcott have been given $331,000 to continue their cold-fusion research at Los Alamos. According to Bockris, the lab, run by the University of California and funded by the federal government, is in some sense 'the most authoritative in the country because it is the national tritium center. What this (the funding) means is that as far as the Los Alamos National Laboratory is concerned, the bosses there -- the people who control the funding -- have decided that the thing is real. And they are going in for it', Bockris said."

In addition to DOE, the Naval Research Laboratory in Washington and in China Lake have been doing research on cold fusion. The Navy's findings that palladium is being modified in the solid-state fusion processes is an important discovery [1]. It is probable that the NRL work will receive further funding. The first NRL publication on cold fusion is a theory paper [2].

It is of great importance to the fusion researchers that both Oak Ridge [3] and Los Alamos [4] scientists have been permitted to release their research findings. It is this type of official recognition of the reality of cold fusion that will help corporate America increase their interest in and their funding of further research and development of solid-state fusion energy systems.

The release of information from Oak Ridge and Los Alamos is a refreshing change from comments made in the Report of the Cold Fusion Panel [5]. For example, "Consequently, with the many contradictory existing claims it is not possible at this time to state categorically that all the claims for cold fusion have been convincingly either proved or disproved." Change 'cold fusion' to 'gravity' and the statement would be just as informative.

The latest anti-cold fusion action within DOE is that the modest funds available to support non-traditional energy studies was drastically cut (by two million dollars). Other projects received cuts but this particular fund appears to have been treated to more than its fair share of fund reductions [6].

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[1] Personal communication. The information that the ratio of Pd105 to Pd106 is being changed in an electrochemical fusion cell is widely rumored among fusion scientists.

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[5] "Report of the Cold Fusion Panel", A Report of the Energy Advisory Board to the Department of Energy, November 1989.

[6] Personal communication with DOE.

* * *

FUSION: AN HISTORICAL PERSPECTIVE
By Dr. Richard A. Forman, President
Optimum Technology, Inc. Potomac, MD

The history of science is replete with examples of unusual results that are later proved or disproved. The proper requirement for publication of a piece of work is that sufficient information is given so that others can duplicate the research and test the conclusions. The reception of the work of Pons and Fleischmann is an example of what should properly be called **pathological editing**. It is clear by their treatment of positive results from cold fusion research that the editors of some journals have not truly examined historical precedents. If they had, they might have left to the reader the task of judging the difficult-to-reproduce experiments in cold fusion.

Some prestigious scientific journals seemingly are happy to publish negative articles on cold fusion but treat positive articles that report irregularly reproducible facts with great scrutiny.

I was widely quoted in the media at the time of the Baltimore APS chemist bashing. I believe Pons and Fleischmann to be pioneer experimentalist in a field in which it is difficult to obtain meaningful results. Most of the successful experiments with cold fusion have shown phenomena that occur in bursts. An explanation for this behavior is that the exact conditions for the reaction are difficult to attain and are perturbed by the release of energy as soon as the reaction begins.

The most analogous historical precedent is the discovery of nuclear transmutations. A good summary is found in "The Making of the Atomic Bomb" by Richard Rhodes. In that experience, the chemical analyses (almost the only methods available at that time) misled the experimenters in their evaluation of their own experiments.

A similar situation exists today with cold fusion. It is nearly impossible to understand cold fusion unless the nuclear products are known by both chemical and physical measurements.

It is inappropriate to assume that the participating nuclear species are fully known. The magnitude of the reaction energies available in nuclear processes are so large that impurities could be responsible for some of the observed results. The "rule of thumb" of nuclear physics is that nuclei below iron (on the periodic table) fuse; and that nuclei above iron fission. Clearly the problem is to understand how to modify the **rate** at which nuclei participate in nuclear reactions.

Since it now well demonstrated that there are **nuclear reaction** products from operating fusion cells, an effort to measure **ALL** of the products of a given reaction should lead to the identification of all of the reacting species. This procedure will lead to understanding so that experiments can be optimized to learn more about the reactions. Too much theoretical effort has been expended in the absence of sufficient, appropriate experimental data.

A quotation from the anonymous author of a jacket note to P. Wl. Bridgman's book "The Logic of Modern Physics" (1927) sums up the situation perfectly, "...The physicist does right to use mathematics as a tool wherever that tool can be employed; but physics is science of experimental fact; and however far the mathematicizing process may go, the student of physics must never lose sight of fact and experimental manipulation of fact. The concepts of physics are not logical or mathematical abstractions, but simply names for unique groups of experimental operations. The historical concepts have been built up on what one may call the level of every-day experience....So the question naturally arises whether traditional concepts can repeat their old work in the novel environments." Many scientists today do not appreciate these comments about the methods used by one of America's great experimentalist.

The closed nature of the recent "Workshop on Anomalous Effects in Deuterated Materials" has provoked considerable criticism by non-attendees. Yet the circumstances which led the members of the

NSF/EPRI meeting to communicate only among themselves and a few select friendly individuals are obvious. Friendly discussions among those individuals who had positive results were certainly needed. Protection was also needed for invited researchers who were awaiting approval from publishers.

I did not attend the NSF/EPRI meeting but, fortunately, one of the grand men of physics, Dr. Edward Teller, did. He was kind enough to abstract from a preprint of my paper on cold fusion theory (which I sent to him) and suggest possible experimental directions to both the attendees and the press.

There is a major caution to be noted with respect to the use of uranium (as suggested by Dr. Teller). The report in "Science" magazine of 2 December 1977 of airborne radionuclides detected in Sweden can be interpreted as the result of a violent nuclear reaction between uranium and deuterium. Considering the distance between the suspected source at the Soviet nuclear facility at Semipalatinsk and the monitoring stations in Sweden, the size of the non-bomb explosion must have been large.

Editor's Note: Wanted - A high speed information exchange among professionals. Would a computer database for **preprints** suffice if peers could add their comments via telecommunications? We need to save scarce experimental dollars by not re-researching the same experiments. Ideas anyone?

* * *

FUSION - FISSION?
By Dr. Samuel P. Faile

With recently published articles on cluster fusion (Matsumoto) and on cold fission (A. Sandulescu) [see above under New from Abroad - Japan, and Romania & West Germany] it would be appropriate to consider some fusion-fission concepts.

One possible reaction is 10D --> ^{20}Ne --> 2 ^{10}B.

Another reaction involves the formation of ^{6}Li which can emit 2185 KeV radiation. A peak corresponding to this value was found by Fleischmann, Pons, and Hawkins [1]. The suggested reaction is 6D --> ^{12}C --> 2 ^{6}Li where most of the released energy could be kinetic.

However for a few of the ^{6}Li fragmentation nuclei, some of the
excess energy would reside in excited nuclei where 2185 KeV gamma radiation would be emitted. In nearly all the other nuclei, the excess energy could be carried off by the emission of photons or phonons during a laser-like interaction with the metal matrix. Thus a tiny fraction of the atoms involved in the fusion-fission could produce a tiny amount of 2185 KeV radiation.

[1] M. Fleischmann, S. Pons, and M. Hawkins, "Electrochemically
induced nuclear fusion of deuterium." J. Electroanal. Chem., 261, pages 301-308, and erratum, 263, page 187 (1989).

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F. FUSION RESEARCH DIRECTION

A REVIEW BY FF STAFF

BACKGROUND
Two factors in solid-state fusion research promote secrecy and interfere with fast exchange of information. These factors are:

1. The patent laws that preclude protection after publication.

2. The professional abuse directed against new ideas in nuclear processes.

Japan organizes its R&D (e.g. through MITI) and India has established solid-state fusion as a national priority. In contrast many U.S. academicians and national laboratory leaders have been slow to respond to the cold-fusion potential.

Improvements in the exchange of information among professional researchers in universities,

government, and industry will help benefit the world with clean energy.

SOURCES OF INFORMATION

The delay in disseminating solid-state fusion information has generated a telecommunication rumor mill. Some of the research suggestions given here are a result of information received that cannot be attributed to a published paper, however, the information can be important in the direction of research. Therefore, the following undocumented suggestions must be treated as our staff's best efforts to promote efficient use of research funds by directing attention to the most important problems and some of the measurements that should be considered. These suggestions are based on nine months of intensive information-seeking efforts but are presented without documentation. we hope that the summary will save our readers time and money.

FACTUAL BASIS FOR RESEARCH

The following are treated as experimental facts:

1. The Fleischmann-Pons Effect (FPE) produces excess energy.

2. Tritium can be produced and consumed by the FPE.

3. Lithium appears to be necessary for FPE success.

4. Many contaminants can prevent FPE success.

5. There are several nuclear reactions occurring in FPE.

6. The traditional branching ratios of d+d nuclear reactions are not observed in FPE.

7. The ease with which expected nuclear byproducts are produced in FPE are in the order of heat, tritium, and neutrons and the later is most difficult to produce and measure.

8. Loading time of Pd rods is a strong function of rod diameter.

SOME PROMISING "NEAR-FACTS"

1. The ratio of palladium isotopes are being changed in long-running FPE cells.

2. Lithium promotes the d+d nuclear reaction(s) but is not a nuclear fuel. (?)

3. The D/Pd ratio must exceed 0.8 for FPE success.

4. Palladium rods raised to high temperatures (near melting point) is a suitable pre-treatment for use in FPE cells.

5. Palladium rods should be loaded at low current levels and operated at higher current levels.

6. The coulomb-barrier is strongly modified within a palladium lattice to permit a variety of nuclear reactions that have previously been observed only in high-energy physics.

MAJOR PROBLEM AREAS

1. Repeatability.

Using replicate cells, the onset and the degree of excess heat are not predictable.

2. Controllability.

When excess heat is being produced at a low level, bursts of heat (minutes to many hours) occur.

3. Loading Palladium.

The limits on D/Pd ratio before fusion reactions begin and the optimum rod conditions for achieving the optimum ratio are not fully determined.

4. Nuclear Reactions.

That certain nuclear reactions can occur is well documented. The mechanism for nuclear reactions within a metal lattice is not understood.

NOTE: One scientist claims to have resovled the above problems but has elected to retain his patent-pending results for until commercial arrangements are completed.

SPECULATIONS WORTHY OF EXPERIMENTS

1. The natural ratio of palladium isotopes are being modified by nuclear reactions in extended FPE experiments. Some possible reactions are endothermic stripping reactions. (For example, Pd106 + p --> Pd105 + d). Some possible reactions are exothermic. (Pd105 + n --> Pd106 + gamma).

Possible experiment: Long runs of FPE cells producing excess heat
followed by precise measurements of Pd ratios at various levels (surface to interior of rod).

2. The onset of excess heat is a function of surface chemical changes on the Pd cathode. The changes provide a surface condition (like a solid-state diode) that helps prevent the escape of d from the rod and thereby increases the D/Pd ratio to the level at which nuclear reactions begin to occur.

Possible experimental approach: Using a large array of FPE cells,
measure the D/Pd ratio immediately that excess heat is detected. Also make highly accurate determinations of surface and near-surface chemistry of the Pd cathode.

3. Helium is being both produced and consumed by nuclear reactions within the Pd cathode. (Warning: Rumor has it that some palladium refinery processes result in miniature helium gas bubbles being present in as-received palladium). Ensure that prior and post measurements of helium are made. The suggested experiments could support experimental evaluation of the following statement: Many nuclear reactions are occurring in the palladium cathode and range from reactions involving hydrogen up to nuclear reactions involving carbon.

Possible Experiments: Begin with complete chemical analysis of the palladium including presence of all atoms ranging from Hydrogen to Carbon. Run FPE cells, producing excess heat, for many hours. Make a post-experimental isotopic analysis.

Note: It would be reasonable to compute a measure of nuclear activity based on the integrated amount of excess heat. This measure could be plotted against the isotopic analysis to correlate the production of isotopes with excess heat (as contrasted with hours of operation).

4. Lithium is a catalyst in promoting nuclear reactions near the surface of a Pd rod and the isotopic ratio is not changed. You will be able to find proponents of the statement that the isotopic ratio is changed and that Li is a fuel.

Suggested experiments: See the experiment suggested under 3 above. Modify to make measurements only for the lithium isotopes. However, remember that the complexity of the nuclear reactions that "could possibly exist" in a metal lattice may consume lithium after an isotopic modification has occurred.

LITERATURE

The past six issues of Fusion Facts has documented nearly all of the above observations. Back issues are available at nominal cost and can be used as sources of reference for most of the topics discussed. Those who are fully acquainted with the literature on cold-fusion will find nothing new in these experimental suggestions. Some of our readers will find the information useful in planning some research efforts. Fusion Facts will be reporting on new research findings in every issue.

STARTING RESEARCH IN COLD FUSION

The most important instrumentation for early work is to plan for experimental excellence in measuring excess heat. Huggins at Stanford and Appleby and

others at Texas A&M are considered to be some of the best communicating experts in this area.

The first step is to ensure replication of a successful FPE cell. Therefore, closely follow the advice of others -- with no changes. Work from the known to the unknown. When you have several successful cells running, then plan for changing experimental conditions. Use small diameter Pd wires or rods to cut down on Pd loading time.

Don't be concerned about the traditional nuclear physics
literature especially in terms of what can and can't be done. It is reported that one scientist said that when Dr. Teller says it can't be done, he is often wrong, but when Dr. Teller says it can be done he is always right.

* * * * * * *

G. FUSION IMPACT ON GOVERNMENTS

INTRODUCTION

The discovery that nuclear fusion could occur in a palladium lattice and that excess heat could be generated (more energy developed than being consumed) is probably the greatest scientific discovery ever made. Drs. Fleischmann and Pons submitted their first paper on cold fusion in March 1989 [1]. By the end of 1989 dozens of research laboratories had successfully replicated some or all of the results obtained by Fleischmann and Pons, including Oak Ridge National Laboratory, Tennessee and Los Alamos National Laboratory, New Mexico.

Now we can foresee further rapid developments and the early commercialization of solid-state fusion (cold fusion). When solid-state fusion becomes commercialized, the results will strongly impact every level of government and every industry. The purpose of this article is to specify how government agencies may be impacted at all levels: municipal, county, state, and federal.

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 by the loss of market share. Other industries, such as the heating and air-conditioning industry, may be positively affected by new product development and sales. Agriculture and the food manufacturing industry will be impacted by fusion developments. Some industries will plan for and achieve dramatic growth by developing new products based on cold-fusion energy systems.

COLD FUSION ENERGY ADVANTAGES

There is a pervasive world-wide interest in cold fusion and the reason is the promise of clean, low-cost energy. Excess heat in a electrochemical fusion cell is produced by the fusion of deuterium atoms from heavy water in the cell. There is about one gallon of heavy water in every 7,000 gallons of ordinary water (including fresh water, sea water, and underground water). The heavy water can be extracted from normal water at a cost of about $1,000 per gallon of heavy water.

The deuterium in heavy water is a source of fuel for fusion energy. If all of the deuterium atoms in one gallon of heavy water are turned into energy in a fusion cell the energy produced would be equivalent to the energy produced by 300,000 gallons of fuel oil or gasoline! The fuel costs would be less than one cent per gallon of fuel oil (energy equivalent). In addition, there is enough heavy water on this planet to provide all of the energy needs of an expanded population for several million years.

It is assumed that with proper design and operation of a solid-state fusion energy system, the energy can be produced with
little or no harmful radiation. Nuclear power plants produce radioactive byproducts. The shielding in "hot-fusion" experimental plants (which currently do not produce excess energy) becomes radioactive. **[Cold-fusion energy systems are currently the only technology**

that has the potential of providing clean, low-cost energy]. This is the reason for strong world-wide interest in cold fusion.

IMPACT FROM INDUSTRY CHANGES

Governments at all levels can be strongly impacted because much of the tax base for government operation comes from industry. The impact of fusion energy systems will cause a greater dislocation of plants, services, and workers than any other scientific discovery. For example, the current energy industry that is based on the extraction, processing, and burning of fossil fuels can be severely impacted by loss of markets [2]. Fossil-fuel industries will ultimately be impacted at all levels from mine to market. Oil will be used mainly for chemical feedstocks. A new coal-chemical industry will emerge but with a much less demand for coal as compared with the current use of coal as a fuel. Many coal operations will close.

Every installation of a solid-state fusion energy system will either take the place of or be a substitute for some energy consumption now being supplied by coal, oil, gas, or fission power. The resulting dislocations of cash flow, tax payments, workers hired or released, and property values will be enormous. There will be a resulting impact on government agencies at the local, state, and federal levels.

On the positive side, fusion energy systems are expected to lower the costs of energy to about one-fourth of the present energy costs. (Fuel costs are much lower but the fusion energy systems are expected to have relatively high initial costs). Many new companies will be formed around new products and new services.

Energy intensive industries, such as refineries (of both metals and chemicals), food processing, and transportation will have lower costs but will have to become restructured to utilize new equipment. These new industries will create new jobs, new taxes, and demands for new or expanded governmental services.

EDUCATION AND RETRAINING

Every old company that loses market share will release workers who will need to be retrained in new skills. Every company that gains market share from fusion energy products or services will require an educated workforce. The demands for education will be large [3]. Human welfare agencies at all levels of government will be forced to divide available resources between welfare and retraining.

Retraining of older workers will require the use of effective means (such as computer terminals and programs) to assess the specific concepts that the worker has mastered and the concepts that need to be taught. To be cost-effective, education should be student-interactive, concept-based, and computer-centered. To make the shift from the out-moded "chalk-and-talk" classrooms to computer-assisted instruction will require enlightened and courageous allocation of scarce government funds.

PROPERTY VALUATION

Every new development in fusion energy systems will make some
existing energy system obsolete. The dramatic difference in energy costs (estimated to be one-fourth of current energy costs) will force rapid changeover from existing energy systems to new solid-state fusion energy systems. The result will be the rapid decrease in value of plant and equipment involved with current energy systems. Many plants will be abandoned when companies that are slow to adapt to new energy changes become bankrupt. Tax payments in many built-up communities will decline while new industrial parks may add markedly to the tax income base of communities who have planned for new developments.

TRANSPORTATION

Governmental agencies that depend on gasoline tax dollars will be strongly impacted. As the oil and gasoline consuming automobiles, trucks, planes, and ships are replaced with vehicles based on fusion

energy systems, the taxes collected for roads, highways, waterways, and airports may decline rapidly [4].

While vehicles will still need servicing, many gasoline service stations may become obsolete. The distribution systems for gasoline and fuel oil are expected to be greatly curtailed as fusion-energy powered vehicles increase in numbers.

The entire vehicle-licensing and taxing regulations will need to be modified. New categories of vehicle license fees will need to be established. Careful evaluation will need to be given to the wear and tear on the highways, freeways, and bridges of the new vehicles and equitable adjustments made in vehicle taxes.

FINANCIAL

The financial industry will have enormous opportunities [5]. There are now corporations and affiliations being formed for the purpose of commercializing fusion energy systems. Some of these new companies may grow to be future IBMs, XEROXs, and 3Ms of the 1990's and beyond.

There can be a strong impact on regulatory agencies. Many companies will be formed that are technological unsound. Investors will gain or lose depending on the management skills provided for these new organizations. Government agencies will be faced with a rapid proliferation of companies based on some factor associated with new fusion energy systems.

Government agencies, especially on the state level will be faced with decisions that will promote or inhibit the location of new industries into a state or region. Decisions on municipal bonds, securities regulations, banking regulations, limited partnerships, income tax rates, and property taxes are typical of financial-type decisions that will have to be considered.

AGRICULTURAL

Many dislocations and opportunities will occur because of the use of fusion energy systems for heating greenhouses, pumping irrigation water, and improving the local processing of food and fiber [6]. There will be an associated impact on governmental inspection and regulatory agencies. New legal issues may emerge in terms of water rights and access rights.

Because the new energy systems are nuclear, there will be strong (and often incorrect) opinions about the dangers from using fusion energy systems for growing or processing food and fiber. Education will be required about the dangers (if any) and the advantages of using new energy systems. Some inspection procedures will need to be considered to ensure that fusion energy systems are properly installed and maintained when used near food production.

It is likely that there will be less danger from fusion energy systems than from leaded-gasoline systems. Because of the newness of the technology, there should be studies and decisions made concerning the safety of the food supply where fusion energy systems are used.

ENVIRONMENTAL

It currently appears that fusion energy systems will be able to provide energy with no adverse environmental impact [7]. If this capability proves correct, there will be strong pressures for legislation to curtail the use of any equipment that causes pollution in our air, rivers, lakes, and oceans. The burning of oil and gasoline may become illegal in many areas of the country that are now troubled with transportation and industrial pollution.

The most immediate concerns will be the air and water pollution. With lower-cost energy, new methods of treating water and sewage will be designed. Strong steps will be taken to improve air quality as soon as it is demonstrated that fusion power systems are effective and non-polluting.

Some metropolitan areas that have re-built their central city areas to inhibit the operation of automobiles (to adapt to national clean-air requirements) may change. Central cities may want to redesign their downtown areas to promote the use of and provide parking for the new non-polluting fusion-powered automobiles.

SOCIAL SERVICES

The distortions made by industrial changes will have strong impacts on job security. Layoffs, bankruptcies, business closures, and the changes in many jobs will have an effect on government social services. Unemployment benefits, job service challenges, mental health, welfare services, and other social services will all be impacted by changes in the industrial labor force. These changes may best be met by re-training, therefore, there may be strong demands for additional funds for social services including both welfare and re-training.

FOREIGN COMPETITION

Currently both India and Japan have given high priority to the development of solid-state fusion. It is apparent that the country which invents, designs, patents, manufacture, and markets the early fusion energy systems (or components) will have a competitive advantage in world trade. In most countries there are government agencies that are strongly involved in promoting exports. Both the United States and individual states will need to increase their role in increasing exports.

Perhaps the greatest change that should be made is to modify the U.S. laws pertaining to competition so that it is legal and more simple for corporations to work together in the research and development of new products. This type of legislative change is needed not only for solid-state fusion but also for such new technology as high-density television.

State governments will find it highly desirable to become involved in the promotion of exports. If state governments are to benefit from increased employment, then the states may best help by ensuring that new businesses are helped in their desires to increase the markets for their products.

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