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CONTENTS FOR MAY 1991

JUNE 1991 SPECIAL ISSUE

The June 1991 issue will mark the end of two years of publishing *Fusion Facts*. This special issue will include a survey list by country, by institution, of cold fusion successes. All articles in which positive results were achieved will be listed and referenced.

The June 1991 issue will be provided, at no additional cost, to all attendees at the Como, Italy Second Annual Conference on Cold Fusion. We hope you will be there to receive your copy.

A. A LETTER FROM INDIA.

From Dr. M. Srinivasan
Bhabha Atomic Research Centre
Trombay, Bombay, India

Subject: Whither "Cold Fusion?"

It is now two years since the phenomenon of "cold fusion" burst out into the open. Many of you are aware of the intense activity this had triggered at BARC and how the initial BARC work won international acclaim and recognition. As one who was deeply involved in this effort, I had hoped that by now, two years after it all began, the intense controversy that was generated by the initial announcement of Fleischmann and Pons would have died down and things settled to a phase of quiet and unruffled scientific activity. Indeed, things have settled down but for a very different reason - most people have simply written off cold fusion as a dead horse and have tried to forget it! However a small band (estimated to be about 600 scientists at present) of dedicated researchers the world over have continued to study the subject passionately and have indeed obtained, at least in my judgement, very convincing evidence for the authenticity of the phenomenon and its nuclear origins. Unfortunately, much of the new results have not yet received the publicity they deserve. As most of you know, it takes several months to over a year between submission of a paper and its appearing in print in a journal or conference proceedings. The enclosed review article which is to appear in the April 25th, 1991 issue of *Current Science* is an attempt to draw the attention of the Indian scientific community to the very interesting results that have come out over the last one year alone.

I must admit that I am amazed to see the intense anti-cold fusion propaganda launched by a handful of influential people at an international level. Most of the highly critical articles on cold fusion can be traced to a few writers such as Maddox, the Editor of *Nature*, Robert Pool of *Science*, Douglas Morrison of CERN, Gary Taubes, the investigative science journalist, and most recently Frank Close, a physicist of Rutherford Appleton Laboratory, U.K. who has authored a new and highly critical book on cold fusion. But most of these writers do

not refer very conveniently to the large number of confirmatory results which have poured in from different parts of the world in recent months as can be seen from my review article. Frank Close's book, for example, deals entirely with the events immediately following Fleischmann and Pons' original paper, how the gamma ray spectrum presented therein was wrong, etc. (See *Nature* of 7th March 1991 for a review of his book). It is perhaps more than a coincidence that Close's book is being published in the USA by the Princeton University which hosts TFTR, the biggest hot fusion Tokamak in the USA! The other sources of virulent attack on cold fusion are MIT and LLNL, also recipients of massive Magnetic Confinement Fusion (MCF) funding.

Many of you must be aware of my efforts, particularly during the last one year, to try and communicate the excitement of the cold fusion phenomenon to audiences both at BARC and elsewhere in India. I have also had occasion to discuss the subject with several distinguished scientists both Indian and foreign. I have noted during these dialogues that the reaction of scientists, particularly physicists, to the phenomenon of cold fusion can be classified under one of five categories or "levels of response" as one may label it, as follows:

Level 0: Those who "believe" or have "become convinced" that cold fusion does not exist, that it is a myth and an illusion, that all the "claimed" experimental results (heat, neutrons, tritium, etc.) are all explainable in terms of experimental artifacts.

Level 1: Those who "believe" in the neutron measurements such as that of Jones, Menlove, etc. but are "convinced" that these can readily be explained and understood in terms of the phenomenon of "fracto-fusion", namely (d-d) reactions caused by deuterons accelerated in the high electric fields generated across cracks and fissures in palladium or titanium deuteride (See Sec. 18 of the review paper). But this they say is good old nuclear physics and there is nothing new in it! This category of people also dismisses away the excess heat of Fleischmann and Pons as of no "nuclear relevance."

Level 2: This group of people believes in the low steady rates of neutron production such as that of Jones. They are willing to concede that electron or other screening effects in a solid environment may contribute to a lowering of the Coulomb barrier resulting in occurrence of (d-d) fusion reactions at a low rate of "academic interest" only. But apart from this "concession" they are not willing to concede that any other new physics is involved. For example, they insist that the neutron-to-tritium yield ratio cannot be anything other than unity. "Any good physicist knows this"; if experiments indicate that tritium yield is high and the (t/n) ratio is 10^8, then either the measurement is wrong (must be "chemiluminescence") or it must be due to prior contamination of Pd with tritium (Sec. 4 of my paper discusses the Wolf episode!). This group also dismisses the excess heat observations as being due to some manifestation of stored chemical energy; nothing nuclear about it, they would say.

Level 3: This group goes one step further and is willing to accept the branching ratio anomaly, i.e. the tritium yield, as being several orders of magnitude higher than that of neutrons. They explain the preferential "neutron transfer mode" of the (d-d) reaction on the basis of a manifestation of the Philips-Oppenheimer process, or as resulting from polarization effects of the loosely bound deuteron etc. But this group, too, does not believe in "this excess heat business."

Level 4: This group swears by Fleischmann and Pons and fully "believes" that the excess heat phenomenon is of nuclear origin (especially now that ^{4}He has been detected both in the gas stream as well as in Pd; See Sec. 2 of my paper). They proclaim that it is the excess heat that is the "essence of cold fusion." The other virtue of excess heat acclaimed by them is that it is virtually "clean."

Although the differences between Levels 1, 2, and 3 would appear to be minor on the face of it, from the physics point of view each level invokes some new physics principle. However, the jump from Level 3 to Level 4 is a big one since the physicist has to swallow quite a few "bitter pills" to accept Level 4. Many hard core physicists find crossing this bridge to be the most difficult.

Note that in the above discussions I have used words such as "believe" and "have become convinced," etc. How can different people come to different conclusions looking at the same set of experimental data? This is the root of the controversy surrounding cold fusion.

What does the presently available experimental evidence really "prove"? For this you are the best judge! I offer the enclosed review article merely as a guide to the literature. I urge you and entreat you to go to the bottom of it for yourself. Nothing like reading the original papers and references. But for heaven's sake, don't "accept" the opinions, pronouncements, interpretations, and declarations of any intermediary as final, not even this reviewer. To me, it has been a very painful experience to see responsible people pass judgements and opinions without reading any of the original new experimental papers. It is with a view to help you in this effort that I offer this review paper containing 173 references. My review is bound to be somewhat "biased," but you are welcome to go to the original sources of information, and indeed you should. However, irrespective of your present level of response, I

feel confident that you will move at least one rung up the ladder after reading my review article and possibly one more if only you would take the trouble of reading at least 10 good experimental papers giving positive results!

Mercifully, to settle the question as to whether the cold fusion phenomenon is authentic, whether the accumulated experimental evidence is adequate to give a clear cut digital answer to the question: "Do nuclear reactions occur in a deuterated solid such as Pd or Ti?", it requires only one week's time and patient effort, with an open mind of course!

I have meanwhile tried to pin point for myself what could be the causes for the widely prevalent skepticism towards cold fusion. I have indeed dealt with some of these issues in the paper, but there are some things that one can't quite include in a scientific paper.

1. The most important reason for the skepticism is the non-reproducibility. Admittedly anything that is not reproducible or repeatable is against the spirit of science. But is it right to settle the question by putting it to vote? Invariably whenever I discuss cold fusion with my skeptic friends the response to my statement that "I can show you 10 papers where they have seen neutrons," they would quip "I can show you 100 who have seen nothing!" In my assessment even if one good carefully conducted experiment shows that neutrons are being emitted, that is enough to clinch the issue. If there are 10 good reliable papers it is even better! But to say 100 people tried and failed and only 10 succeeded and therefore the phenomenon does not exist is complete nonsense. As I have said in the review article it is obvious that there are some as yet unknown parameters/factors which seem to be determining whether or not an experiment is successful. Bush, for example (Ref 137 of my article), has brought out succinctly some of these factors. The success rate, however, has been steadily improving in the recent experiments.

2. A second possible reason for the skepticism is the poor quality of the early experiments. The sloppy early work has no doubt given a bad name to cold fusion. This is understandable because in the flush of enthusiasm many groups simply used whatever equipment was readily available/accessible to them. (This is true of some of the early BARC work also). But one can't go harping on the poor quality of the 1990 work! I urge the critics to study the newer experiments; the more recent results. As I have said repeatedly many people are simply not aware of the new good work and results. The purpose of the enclosed review article is precisely to help you in this.

3. Lastly, much of the criticism can be attributed to the number of "miracles" involved. There are many preconceived notions and concepts that one has to give up before accepting the cold fusion phenomenon as part of physics. I have summarized these in Section 22 of my article under the heading "Puzzles of the Cold Fusion Phenomenon." It is the new physics that the phenomenon has unlocked that makes it really exciting.

I sincerely hope that this will initiate a fresh debate in India so that we can all put our heads together and get to the bottom of it all. If you do get converted into agreeing that the phenomena is as fantastic as the Level 4 believers proclaim, then it is obvious that it is too important to the future of nuclear energy technology to be ignored and worse still ridiculed!

Happy reading!

Yours sincerely, /s/ M. Srinivasan

[This letter from an eminent scientist is the most lucid description we have read of the current situation of the developing technology cold fusion. His paper is reviewed under News From Abroad. Ed.]

B. MALLOVE'S BOOK REVIEWED

The best book yet on the scientific history of cold fusion.

Eugene F. Mallove (Chief Science Writer for the MIT News Office and Lecturer in Science Journalism at MIT), **Fire from Ice - Searching for the Truth Behind the Cold Fusion Furor,** John Wiley & Sons, Inc., New York, c1991, 326 pages, illustrated, resource list, index.

Dr. Mallove's book is the latest and the best book about cold fusion and is highly recommended for those who would like to read an objective treatment of the most important scientific discovery of the century. Dr. Mallove called *Fusion Facts* in June 1989 with the statement, "I am a seeker of truth. What is going on in Utah with cold fusion?" The book is appropriately dedicated "**To all who have struggled to bring the fire of stars down to Earth. To seekers of Truth, everywhere.**"

The Table of Contents reads better than blind verse:

Prologue: Desperately Seeking Fusion
A Brief History of Hot Fusion
Claiming the "Impossible"
A Frenzy of Replicators
Dallas and Beyond
The Prehistory of Cold Fusion
The Beginning of Wisdom
Yes, We have no Neutrons
New Mexico Sunrise
Evidence Builds and Skeptics Dig In
Denial and Acceptance

Approach to an Answer
The Turning Point
Still Under Fire
Whither Cold Fusion?
Fusion Confusion and Scientifico-Media Madness
Hard Lessons in Science
Whither Hot Fusion?
Epilogue

Within these chapters Gene Mallove leads the reader through the maze of information and disinformation to reach the following conclusion:

"After reviewing mounting evidence from cold fusion experiments, I am persuaded that it provides a **compelling** indication that a new kind of nuclear process is at work. I would say that the evidence is **overwhelmingly** compelling that cold fusion is a real, new nuclear process capable of significant excess power generation. The evidence for significant power generation, however, cannot be said to be **conclusive**. The word conclusive in science denotes an intimate melding of experimental observation and theoretical explanation. In the case of cold fusion, this cannot be said to have occurred. There is yet no **proved** nuclear explanation for the excess heat. That excess heat **exists** is amply proved."

Dr. Mallove's book is remarkable in that he is not the intellectual captive of any professional society nor of any political group of scientists (such as those who are spending the $500 million per year provided by DoE for the study of hot fusion). The author indeed demonstrates that he is a "seeker of Truth" in his objective reporting of the developing science of cold fusion from the University of Utah's press conference in March 1989 to the events near the close of 1990. The only place where Gene Mallove may be accused of losing objectivity is in his treatment of Professor Peter Hagelstein's (MIT) developing theory of cold fusion. Because his close friend Peter is such a brilliant and charming scientist, Gene can be forgiven for given Peter top billing among the cold fusion theorists.

The book is best described as a highly readable history of science revolving about the discoveries and debates of cold fusion. The major events along the way that are reported are the following:

1. The Santa Fe conference (the first conference on cold fusion), where the lines of controversy began to be delineated (May 1989).

2. The DoE report, "The present evidence for a new nuclear fusion process is just not persuasive." (July to November 1989).

3. The hush-hush meeting of 50 scientists sponsored by the National Science Foundation and the Electric Power Research Institute (October 1989) in which positive reports far outnumbered negative reports.

4. A brief mention of the ASME conference in San Francisco at which Peter Hagelstein first presented his developing theory for cold fusion (December 1989).

5. The "seance of true believers" better known as the First Annual Conference on Cold Fusion (March 1990) -"the turning point."

6. An exposure of the self-appointed "fraud buster" Taubes on his infamous report concerning cold fusion work at Texas A&M (published in June 1990).

7. The World Hydrogen Energy Conference #8 held in Hawaii where Liebert and Liaw reported on their molten-salt cold fusion cell which produced over 1500 percent excess energy (July 1990).

8. The "Anomalous Nuclear Effects in Deuterium/Solid Systems" workshop held at Brigham Young University, Provo, Utah (October 1990). The reports from this conference drove a final spike into the imaginary coffin conjured up by some hot fusionists and cold fusion arose anew.

Dr. Mallove's book is not a "proof" of cold fusion. However, it is an objective report on the happenings in a developing science and a revealing insight into the human frailties of scientists when faced with threats to their "visualization of the cosmic all."

Another book being released in May 1991 is Too Hot to Handle by Frank Close, a written attack on Pons and Fleischmann's work. When the two books are compared for objectivity, the latter book doesn't come close.

C. NEWS FROM THE U.S.

BRADLEY U (IL) - ELECTROPIONICS

John P. Kenny, "Electropionics and Fusion," *Fusion Technology* **19(3)**, May 1991, pp 547-551.

ABSTRACT

The electropionic mass formula does not differentiate between nuclei and elementary particles, but it gives the deuteron a unique bifurcated space-time description. This hints at fusion products produced by anomalous intermediate mass states of 3026, 3194, and 3515 MeV/c^2 that then decay to produce energy. Another unique possibility in electropionics is that no fusion of deuterons

occurs, but the deuteron is changed by electron capture into a D-meson that then decays to produce observed cold fusion energies. All these cold fusion electropionic reactions violate baryon conservation but do produce energy yields consistent with reported cold fusion decay products and energy levels.

EDITOR'S COMMENTS

This theory is highly non-conventional in proposing the possibility that cold fusion is the first example in which "baryon conservation" is violated.

CAL POLY - EXPERIMENTAL PAPER
Courtesy of Dr. Bush

Robert D. Eagleton and Robert T. Bush, "Calorimetric Measurements Supporting the Transmission Resonance Model for Cold Fusion," accepted for publication in *Fusion Technology*, September 1991.

ABSTRACT

This paper presents the experimental details of calorimetric measurements that provide support for the transmission resonance model (TRM) of one of us, Bush, to explain cold fusion. In a companion paper in the March issue of *Fusion Technology*, Bush shows that the TRM provides a good fit to the data of the experiments described here in more detail. Thus, for the first time a theoretical model provides a good fit to calorimetric data and permits an understanding of the data. This is emphasized by the fact that, after the first experiment in which excess power was achieved, the model was employed to guide further experiments. Thus, not only does the TRM suggest how to proceed with regard to what experimental parameters to hold fixed and which to vary, the TRM also predicted significant nonlinear structure and guided the search for that structure. Here, the following are described: Calorimeter and cell designs, electrode preparation, electrode charging, and excess power measurements. Tables are presented of raw data that were the basis for the figures of the companion paper comparing the fit of the model (TRM) to the experimental results.

EDITOR'S COMMENTS

The data shown by Dr. Bush at the Anomalous Nuclear Effects conference in October 1990 and published in *Fusion Technology* **19**, March 1991, p 313, have been interesting in that they support unique predictions of Dr. Bush's TRM model, such as, the general upward trend in excess heat with current density will periodically be interrupted by narrow dips. In addition, the nature of the experimental data implied relatively stable cell operation.

The paper indicates that the D_2O electrolysis cells used 0.1 M LiOD in 99.9% D_2O, 0.25 X 1 X 2 cm Pd cathode (Engelhard, 99.9% Pd, with 99.9% Ag lead), and a spiral Pt anode. The cell also had a Pt recombiner ("closed" cell) to reform D_2O from the D_2 and O_2 gases, and was continuously stirred. All metal surfaces other than the electrodes were sealed with Teflon to prevent contamination of the electrolyte.

The paper reports that excess heat (on the order of 1-3 W) was measured in two of three recent cells. The cumulative excess heat generation of the first was 0.35 MJ greater than the electrical input of 2.0 MJ over 48 hours; that of the second was 0.2 MJ above the input of 2.3 MJ over 34 hours.

It is noted that the cathode in one of the successful cells was cleaned in aqua regia for 5 minutes, rinsed, and heated in air at 200 C for 24 hours, then preloaded at 30 mA/cm^2 for 6 days. The cathode in the other successful cell was cold worked by compression in a vise, annealed in air at 600 C for 8 hours and 350 C for 16 hours, further annealed in N_2 at 650 C for 1 hour, then preloaded at 60 mA/cm^2 for 19 days.

It is indicated that heat production was measured using a forced flow calorimeter, in which cooling water was passed through a copper coil surrounding the cell. The cell and surrounding water bath were insulated with Styrofoam to minimize heat losses through routes other than the cooling water, and the steady-state temperature difference between the electrolyte and bath was monitored. Calibration was performed using a resistance heater.

When the excess heat was monitored as a function of changing current density, with the cell temperature held constant, two experiments showed indications of the expected cusp-like structure, and one also showed the excess heat to disappear at sufficiently high current density (approximately 500 mA/cm^2 in the example shown). In another experiment in which the temperature was varied, the excess power likewise dropped to zero as the temperature reached 330 K.

In addition, the paper notes that subsequent experiments using an improved calorimeter of different design (not described) were performed. Although two cells were negative, at least one other again showed cusplike structure in plots of excess heat versus current density. (Furthermore, in conversations with Dr. Bush, it was also noted that the locations of the cusps remained constant, over reasonably short periods of time, as the current density was cycled up and down. Such a demonstration, in our opinion, should be particularly helpful in ruling out experimental error.)

CALIFORNIA STATE U - CLUSTER IMPACT

M.H. Shapiro (California State U) and T.A. Tombrello (CalTech), "Simulation of Energetic Cluster Impacts on Metallic Targets," *Mod. Phys. Lett. B* **5(5)**, 1991, pp 341-349.

EDITOR'S COMMENTS

This paper uses molecular dynamics simulations to attempt to explain the Brookhaven cluster impact experiments [e.g. Beuhler et al., *J. Phys. Chem.* **94** p 7665]. The authors conclude that although highly nonlinear effects should result in increased thermonuclear fusion rates, such efforts can still not account for the rates measured.

UCLA - SCHWINGER THEORY

Julian Schwinger, "Phonon Dynamics," *Proc. National Academy of Science USA* **87**, November 1990, pp 8370-8372.

ABSTRACT

An atomic lattice in its ground state is excited by the rapid displacement and release of an atomic constituent. The time dependence of the energy transfer to other constituents is studied by using a phonon dispersion relation that is linear in frequency and propagation vector components.

EDITOR'S COMMENTS

This paper presents a mathematical treatment of processes in which the energy from a high-energy event in a lattice excites lattice vibrations (phonons).

The paper updates the theoretical work by Dr. Schwinger in *Z. Naturforsch.* **45a** p 756, *Z. Phys. D* **15** p 221, *Proc. Natl. Acad. Sci. USA* **87** p 6983, and the First Annual Conference on Cold Fusion. *Fusion Facts* apologizes for the delay in reporting on this paper.

U OF CALIFORNIA RIVERSIDE - THEORY

Shu-Yuan Chu and Benjamin C Shen, "Can the Color Force Be Used to Achieve Fusion?," *Mod. Phys. Lett. A* **6(3)**, 1991, pp 237-244.

ABSTRACT

We explore the possibility that the color force can be used to overcome the Coulomb barrier in fusion. If there are small deviations from exact color neutrality, large separations of color may occur when two elements of opposite color defects are mixed non-uniformly. In order to restore color neutrality locally, the strong color force polarizes the nuclei and brings them close enough to fuse. If palladium and deuterium are such elements, it is possible that *all* the recent cold fusion results are but different manifestations of the above process.

EDITOR'S COMMENTS

This theory proposes a novel way of surmounting the electrical repulsion between deuterons through a different physical force, associated with the "color" quantum number of quarks. Although particles with non-zero net color quantum numbers have not been experimentally observed to date (and may not be possible), it is pointed out that measurable fusion rates could occur even at concentrations of colored D and Pd at present experimental limits of roughly 1 part in 10^{20}. Such features as poor reproducibility, lack of effect with ordinary hydrogen, and suppression of energetic particle emission can also be explained.

Although not noted in the paper, this theory may have significance even aside from present experimental evidence for cold fusion, since it also implies that future techniques to create or isolate appropriate free quarks could also be used for controlled energy generation by cold fusion.

U OF COLORADO - THEORY

A.O. Barut, "Prediction of New Tightly-Bound States of H_2^+ (D_2^+) and 'Cold Fusion' Experiments," *Int. J. Hydrogen Energy* **15 (12)**, 1990, pp 907-909.

ABSTRACT

It is suggested that in the "cold fusion" experiments of Fleischmann and Pons and other new tightly-bound molecular states of D_2^+ are formed with binding energies predicted to be on the order of 50 KeV accounting for the heat released without appreciable fusion. Other tests of the suggested mechanism are proposed and the derivation of the new energy levels is given.

EDITOR'S SUMMARY

This paper discusses the possibility of hitherto unknown quantum states of H_2 and D_2 ions arising from the anti-Born-Oppenheimer approximation of the three-body problem. In these states, the two nuclei rotate rapidly about the electron, rather than vice versa. The energy released is more than 4 orders of magnitude higher than in conventional chemical reactions, and would be 4 times greater for D than H. Pd may provide the environment

necessary for the formation of these states, which may ordinarily be unstable. The closer D-D spacing would also lead to increased fusion.

GEORGIA - THEORY

(Courtesy of Dr. Russell)

J.L. Russell Jr., "Virtual Electron Capture in Deuterium," *Ann. Nucl. Energy* **18(2)**, 1991, pp 75-79.

ABSTRACT

An unconventional quantum mechanical description is used to describe the process of a deuterium nucleus capturing its orbital electron to temporarily become a di-neutron plus a bound neutrino. The resulting rates so estimated are found to be consistent with the phenomena of cold fusion provided the rest mass of the neutrino is very approximately 0.1 eV.

EDITOR'S COMMENTS

In this theory (as in that of F. Mayer noted elsewhere in this issue), it is proposed that deuterium can undergo nuclear reactions with a variety of other nuclei through a process in which its electrical charge is momentarily neutralized through capture of an electron. A mechanism is proposed that would result in far greater probability that the deuteron can momentarily capture an electron (extremely small in conventional treatments due to the involvement of the weak nuclear force). Based on experimental measurements of cold fusion rates, it is proposed that the lifetime of the neutral state (i.e. the time available for fusion with another deuteron, Li nucleus, etc.) is on the order of 10^{-14} seconds.

An earlier paper [J.L. Russell Jr, "Plausibility Argument for a Suggested Mechanism for Cold Fusion," *Ann. Nucl. Energy* **17(10)**, 1990, pp 545-548] was also noted in *Fusion Facts*, February 1991. Further information is also available in an unpublished paper [John L. Russell Jr., "Proposed Heat Producing Nuclear Reaction for Cold Fusion"].

The latter paper also presents more speculative arguments that suppression of the normal d-d fusion branches would result in the favoring of alternate reactions, accounting for heat generation far in excess of tritium and neutron production. In addition, it is suggested that the production of secondary products can also be suppressed if the reaction energy is transferred to the lattice by the neutrino. It is noted that secondary gamma radiation would be expected only if charged particles produced have energies over 500 KeV, and secondary X-rays if particle energies exceed 100 KeV.

LOS ALAMOS - COLD FUSION REVIEW

Edmund Storms (Nuclear Materials Tech. Div.), "Review of Experimental Observations About the Cold Fusion Effect", *Fusion Technology,* to be published in August, 1991, 82 manuscript pages, 363 refs.

ABSTRACT

The experimental literature describing the Cold Fusion phenomenon has been reviewed. The number and variety of careful experimental measurements of heat, tritium, neutron, and helium production strongly support the occurrence of nuclear reactions in a metal lattice near room temperature as proposed by Pons, Fleischmann, and Jones.

EDITOR'S COMMENTS

In the introduction, Dr. Storms cites 118 references from those reporting negative results and 112 references reporting positive results for one or more of excess heat, tritium, helium, neutrons, or other nuclear signatures. Storms states, "This work [negative results] can give valuable information about conditions that prohibit the Cold Fusion effect and an understanding that can help bound the conditions in which the effect operates, but it [evidence] does not demonstrate that the effect is not real."

After the introduction, Storms sections the paper into the following: Excess Heat Production; Tritium, Neutron, and Radiation Production; Discussion; and Conclusion.

In the section on excess heat production, Storms reports on the following issues:

1. Is the excess heat caused by errors in the measurements?

2. What is the reaction that produces excess heat?

3. What nuclear reaction produces the excess energy?

4. What is the new phenomenon, how can it be initiated in the lattice, and what nuclear reactions are influenced by the phenomenon?

In discussing answers to these questions, Storms cites specific references, describes experimental conditions, and comments on results. In Figure 1, the author plots reports from 12 successful scientists in terms of excess power in Watts per cu cm versus input electrical current. This figure illustrates that excess heat is strongly dependent on cell current up to about 200 mA/cu cm.

In the Tritium and Neutron section, Storms summarizes large numbers of experiments for an easy comparison of the positive results achieved. In his summary of neutron measurements, Storms compares results under columns labeled Metal [cathode], Method, Detector, Efficiency [of neutron counting], Background, and Excess [as compared with background]. This neutron table lists both negative and positive results. This table should be useful in determining the choice of experimental approaches to achieve cold fusion.

Dr. Storms asks the question, "Do Nuclear Reactions Take Place on the Surface or in the Bulk?" He then discusses the experimental evidence on both sides to lead to an appropriate answer to this question.

In the Conclusion section, Storms states the following, "At the present time, heat production equal to at least 10 times the input energy has been achieved. This magnification is well above the break-even on a laboratory scale. The effect appears to involve mainly the surface rather than the bulk materials and it has a limited lifetime in present cells. Consequently, a possibility exists for considerable magnification of the effect should ways be found to involve a greater fraction of the metal for a longer time. This potential provides an important incentive for possible commercial application."

In his final paragraph Storms summarizes as follows, "A large fraction of the limited resource has been devoted to proving that Cold Fusion is real in contrast to understanding how it works. Except during the early euphoria, support has been minimal in many countries. As a result, many people have continued to do excellent work in spite of very little support from the scientific institutions or their peers, with a few exceptions. Although there are still many uncertainties, I suggest that the possible applications are so important and the present evidence for the reality of the effect is so strong that a more optimistic attitude and more support are warranted."

LOS ALAMOS - DEFECT THEORY

John K. Dienes (Los Alamos National Laboratory), "On Nuclear Reactions in Defects," *Fusion Technology*, **19(3)**, May 1991, pp 543-546.

ABSTRACT

The variability of results concerning cold fusion, together with the difficulty of explaining the observations, suggests that some nonstandard process may be occurring. One such possibility is that nuclear reactions occur in defects of a deuterated lattice as a result of transient motions that momentarily bring deuterium atoms into close proximity. A mechanism involving shear of a one-dimensional lattice is described that illustrates this possibility. Order-of-magnitude estimates indicate that the expected fusion rate is not inconsistent with some experiments.

EDITOR'S COMMENTS

This model investigates the possibility that the localized high stresses and intense shear at crack tips, or during other defect movement, can momentarily result in very short D-D spacings. Previous "fractofusion" models have invoked electrical fields in cracks of metal deuterides to accelerate deuterons, a totally different process. Initial calculations using a simplified model estimate that conventional d-d fusion can occur at measurable rates, with a maximum fusion rate comparable to that reported by Jones et al. This rate results from over 100-fold reductions in interatomic spacings due to slippage at rapidly growing crack tips combined with lattice vibrations. The fusion rate was found to be extremely sensitive to parameters such as the strain rate at the crack tip, possibly resulting in erratic burstlike behavior.

MICHIGAN - NEUTRON TRANSFER

Frederick J. Mayer and John R. Reitz (Mayer Applied Research, 1417 Dicken Dr., Ann Arbor MI 48103), "Nuclear Energy Release in Metals," *Fusion Technology* **19(3)**, May 1991, pp 552-557.

ABSTRACT

A scenario for nuclear energy release in metals produced through resonant direct nuclear reactions of low-energy "virtual" dineutrons and trineutrons is proposed. These reactions produce heat, tritium, and only low levels of penetrating radiations. The proposed scenario is shown to be consistent with some detailed data from "cold fusion" experiments. Furthermore, the possible connection of the proposed scenario with some other previously recognized, but anomalous, nuclear observations of geophysical interest is suggested.

EDITOR'S COMMENTS

Fusion reactions between two nuclei (e.g. d+d fusion) in a plasma typically require extremely high temperatures because of the electrical repulsion between charged particles (Coulomb barrier). In contrast, capture of a neutron by a nucleus can take place readily at thermal energies (eV rather than MeV) because the neutron is a neutral particle [1].

Accordingly, some theorists have considered the possibility that cold fusion does not represent fusion at all, but

rather the transfer of a neutron from one nucleus to another. Indeed, a paper prior to the Pons-Fleischmann announcement had speculated on the question of whether any such reactions could theoretically be used as an energy source, based solely on conventional physics [2].

A principal difficulty in neutron transfer theories has been the requirement that the process occur between nuclei separated by a large fraction of an angstrom, a distance far larger than the "cross-sections" of nuclei in typical neutron capture reactions. While classical nuclear physics indicates that transfers of "virtual" as well as real particles can occur in nuclear reactions, the maximum time for which such virtual particles can exist is limited by the amount of energy which would be required to create them. The greater the energy involved, the shorter the lifetime, and hence the shorter the distance which the particle can travel during its existence.

The present theory is thus very challenging in that the mechanism invoked would allow the energy required to form the particle to be sufficiently low that exchange between nuclei much further apart can occur. The basis for this mechanism is a pair of very recent papers by other researchers [3,4].

According to these references, the virtual particles can have radii of nuclear rather than atomic dimensions (i.e. comparable to real neutrons), and virtual particle lifetimes of up to 60 microseconds are proposed (immensely longer than in typical previous theories). The required electron energies of a few tenths of an eV to 5 eV, Mayer notes, are in the range found in certain metal lattices.

The authors state that one of the nuclei involved in the reaction must be a hydrogen isotope (since higher-atomic-number elements would retain a positive charge). Thus, the possible virtual particles mentioned represent combinations of electrons with protons, deuterons and tritons. The remaining nucleus, on the other hand, can come from among a wide variety of possibilities, although it is argued that higher-atomic-number elements are favored.

The theory is also very interesting in that it is claimed to be able to account for a number of the unusual experimental observations commonly made in cold fusion:

First, heat production even in the near-absence of neutron, tritium, or helium production can be readily explained, as the predominant result is isotopic changes in the elements acting as the reactant and product, with production of minor amounts of neutrons and other products due to secondary reactions. However, unless the reactant or product is present in small amounts, such isotopic changes would be much more difficult to detect. For instance, conversion of small quantities of deuterium to hydrogen would not be noticeable in the same way as the production or consumption of tritium.

Second, production of products at very low kinetic energies is also possible, thus accounting for the formation of tritium without significant numbers of 14-MeV neutrons from secondary d-t fusions, and heat without high energy gamma radiation (or, presumably, without copious secondary X- and gamma-rays).

For example, 23 possible reactions are listed which are only slightly exothermic (small positive energy yield), and it is suggested that the resulting resonance effects should favor such reactions. Of the reactions, 8 involve deuterons stripping neutrons from other nuclei to form tritons, and 15 in which other nuclei strip neutrons from already-existing tritons. Thus, either tritium production or consumption can occur. Or, if protons and deuterons are involved, rather than deuterons and tritons, only the H/D ratio will change, and the T/D ratio will remain constant.

Third, the authors indicate the possible involvement of other elements besides hydrogen and palladium (i.e. participation of impurities in the reaction) may account for the irreproducibility of the effect. Also, the existence of multiple reactions may account for variability in the nature of the results from different groups; for example, one reaction may generate heat and tritium while another generates only heat.

Nevertheless, we would suggest three possible areas for further discussion:

1. Should the theory be modified to require hydrogen absorption by a metal lattice to occur? If not, excess heat generation in control experiments (Pt cathodes, etc.) could be equally conceivable if other circumstances are favorable.

2. What conditions favor reactions involving deuterium rather than hydrogen (such that excess heat, etc. are seen in D_2O but not H_2O).

3. By what other mechanisms can the theory account for burstlike behavior? The paper argues that this may be due to the reactants being brought together at an erratic rate, but this mechanism may not be sufficient.

4. Can the theory account for the verification of the high helium levels in the Miles et al. experiment? For example, secondary helium production could presumably occur, **even in the electrolyte**, if the product happens to decay by alpha emission with a sufficiently short half-life, such as certain isotopes of the heavier elements or a few light isotopes such as ^{8}Li.

Possible experimental avenues suggested or implied by the paper include testing the effects of impurities such as Pt, U and tritium which could participate in the reactions, monitoring of isotopic changes in all elements present (impurities as well as hydrogen, lithium and palladium), and testing for radioactive products.

References Cited in Comments:
[1] An extremely limited analogue of this process also exists for deuterons; it has long been known that neutron transfer from deuterium nuclei to other nuclei can take place even when the energy of the collision is less than that required for the two nuclei to come into contact (the Oppenheimer-Phillips process).

[2] J.R. McNally Jr., "Cold Fusion and Graser Prospects," *Fusion Technology* **7** (1985) p 331.

[3] J.R. Spence and J.P. Vary, "Electron-Positron Scattering Resonances from Relativistic Two-Body Wave Equations," *Bull. Am. Phys. Soc.* **35** (1990) p 1673.

[4] C.J. Benesh, J.P. Vary and J.R. Spence, "Cluster Fusion by Formation of Compact Electron-Deuteron Resonances," *Bull. Am. Phys. Soc.* **35** (1990) p 1677.

[Note: Dr. Mayer has long been active in controlled thermonuclear fusion research (previously with KMS Fusion, Ann Arbor MI). Dr. Reitz was previously manager of the Physics Department at Ford Motor Company. Because of this background, Dr. Mayer was invited to address his colleagues at MIT on the day that his article was printed. It was expected by some of us that Dr. Mayer's theory would be acceptable to the "hot fusionists". Much to our surprise (and disappointment), it was reported that Dr. Mayer's presentation was poorly attended by those who should be most interested in the topic. Our prediction that Dr. Mayer's new theory would be acceptable to "hot fusionists" is seriously flawed. Dr. Srinivasan's comments (lead article in this issue) are pertinent.]

NAVAL OCEAN SYSTEMS CENTER - PdD DEPOSITION EXPERIMENT

Courtesy of Drs. Samuel Faile and Jeff Jones

S. Szpak, P.A. Mosier-Boss (Naval Ocean Systems Center, San Diego CA) and J.J. Smith (Dept. of Energy), "On the Behavior of Pd Deposited in the Presence of Evolving Deuterium," *J. Electroanal. Chem.* **302**, 1991, pp 225-60.

EDITOR'S COMMENTS

This paper discusses a radically new variation on traditional cold fusion electrolysis experiments, in which Pd deuteride is electrodeposited on a cathode of a different metal such as Cu foil. Codeposition of Pd (from 0.05 M $PdCl_2$) and D (from D_2O) over the course of the experiment was indicated to eliminate the need for lengthy charging times. Many hours may be required to reach high D/Pd ratios during conventional electrolysis experiments if thick Pd cathodes are used. In addition, the new method was suggested to assure nonequilibrium conditions and eliminate the need for uniform current distribution.

In the experiments, excess heat, radiation emission by the cathode, and tritium production were measured after unusually short times. (Partial replication of the Szpak results were also presented by Dr. Haven Bergeson of the National Cold Fusion Institute at the October 22-24, 1990 Anomalous Nuclear Effects conference at BYU, as reported in *Fusion Facts*, November 1990.)

Excess heat was roughly estimated at between 10 and 40%, beginning after 20 minutes, with negative results in an H_2O control experiments. The temperature of the cathode was also significantly higher than that of the electrode. Two further potential anomalies were noted: the cathode was hotter than the electrolyte only in the D_2O experiment (although this could perhaps be explained by overvoltage differences), and only in the D_2O experiment was a cathode temperature increase measured when the electrolysis was halted (although this could possible be explained by outgassing of D_2). It was noted that a more detailed discussion of the calorimetric results would be published in a later paper.

In addition, radiation emanation from the cathode, possibly low-energy X-rays, was detected by fogging of photographic film placed close to it. The film was sealed in a light-tight, impermeable container to prevent fogging due to other sources. In one case, a clear image (in fact a double exposure) of the metal mesh between the electrode and film demonstrates that the cathode is the source. An H_2O control experiment was negative.

Finally, increases in tritium levels in the electrolyte from 30 to 230-270 dpm/ml were measured after 10-16 hours of electrolysis in each of 8 runs. Again, an H_2O control experiment was negative. The possibility of electrolytic tritium enrichment was eliminated because the length of the experiment was too short to cause a large change in the electrolyte volume.

OAK RIDGE - Pd ISOTOPES

D.L. Donohue and Milica Petek (Oak Ridge National Laboratory), "Isotopic Measurements of Palladium Metal Containing Protium and Deuterium by Glow Discharge Mass Spectrometry," *Analytical Chemistry* **63**, 1991, pp 740-744.

EDITOR'S COMMENTS

This experiment was designed to look for isotopic changes in Pd cathodes electrolytically loaded with D, using a type of mass spectrometer capable of making precise measurements of isotopic ratios (0.1-0.01% relative). However, inaccurate analyses were caused by interference from molecular ion species containing Pd bound to H and D atoms, unless the H and D were removed beforehand (e.g. by heating at 800 C for 1 minute). It was also noted that the extent of the interference differed considerably for H and D samples (such that care would need to be taken in interpreting even experiments in which apparent isotopic changes appear only with D and not with H). Finally, the analyses also confirmed that H was taken up preferentially from an H_2O/D_2O mixture.

PENNSYLVANIA - EXCESS HEAT

Randell L. Mills & Steven P. Kneizys, "Excess Heat Production by the Electrolysis of an Aqueous Potassium Carbonate Electrolyte and the Implications for Cold Fusion", Accepted for publication in *Fusion Technology*, August 1991, 45 manuscript pages, 15 refs.

ABSTRACT

According to a novel atomic model, the predominant source of heat of the phenomenon denoted Cold Fusion is the electrocatalytically induced reaction whereby hydrogen atoms undergo transitions to quantized energy levels of lower energy than the conventional "ground state". These lower energy states correspond to fractional quantum numbers. The hydrogen electronic transition requires the presence of an energy hole of approximately 27.21 eV provided by electrocatalytic reactant(s) (such as Pd^{2+}/Li^{+}, Ti^{2+}, or K^{+}/K^{+}), and results in "shrunken atoms" analogous to muonic atoms. In the case of deuterium, fusion reactions of shrunken atoms yielding predominantly tritium are possible. Calorimetry of pulsed current and continuous electrolysis of aqueous potassium carbonate (K^{+}/K^{+} electrocatalytic couple) at a nickel cathode was performed in single cell dewar calorimetry cells. Excess power out exceeded input power by a factor greater than 37.

EDITOR'S COMMENTS

Dr. Mills graduated in chemistry, received his M.D. from Harvard Medical School in 1986, and also took electrical engineering classes at MIT. Dr. Mills and Professor John J. Farrell (Franklin and Marshall College, Pennsylvania) have written a book, The Grand Unified Theory. This book describes, in detail, a self-consistent theory that links electromagnetic, gravitation, and strong & weak forces into one unified presentation. Some of the theoretical material presented in Mills and Kneizys paper is taken from the book. The reader should withhold his immediate criticism of, for example, "fractional quantum numbers", until he/she has studied Mills and Farrell's theory.

It is not necessary to be an expert in a grand unified theory to be able to read and understand the present paper. However, when you come to equation (3.11) and find that the speed of light is exactly 3×10^8 meters per second, you may be disturbed. However, a careful reading of the series of equations, boundary conditions, and assumptions will show that Dr. Mills is suggesting that **if the speed of light were 3×10^8 ms^{-1}, (by redefining the length of the meter), then one can have a relatively simple set of fundamental constants.** Or alternatively, the equations can be taken as a definition of the length of a **new meter.**

In words, the theory states that the electron around a nucleus is in the form of a sphere having a certain energy at ground state; can absorb a photon (of a specific energy) and move to a higher orbit. The unusual part of the theory is the concept that, in the presence of a suitable **energy sink**, the electron can emit energy and drop to a permitted orbit of 1/2 of the previous orbit. The magnitude of this energy emission (21eV) is about ten times as large as compared to ordinary chemical energy. The collapsed hydrogen atom, after undergoing such a collapse, is obviously smaller. Two such hydrogen atoms could be expected to get closer together and thereby strongly increase the probability of fusion. The article proposes that such an effect, the collapsing of deuterium atoms is primarily responsible for the heat measured in some cold fusion experiments. In addition, the theory provides for an increase in fusion events.

Another major point of the theory is the prediction that only certain types of materials can provide the "energy sink" that can catalyze the collapsing of the hydrogen atom. Using a computer program to calculate the type of materials, the authors found that titanium, palladium with lithium, rubidium, and potassium carbonate would provide the "energy holes". Because the potassium carbonate is relatively inexpensive, the experiments were carried out with this chemical and by using sodium carbonate as a control.

The paper describes in considerable detail the experimental method, including the part numbers for the components, to make the 500 Hertz square-wave generator that appears to improve the performance of the electrochemical cell. Note that this device can use ordinary water because the electrochemical cell is designed to cause the collapse of the hydrogen atoms and is not concerned with deuterium fusion. The experimental data

shows that this new chemical reaction provides up to 3700 percent of input electrical energy. Data from 33 experiments (of the several hundred made) are given in the paper. The table of data includes 17 columns of cell parameters; includes series of experiments in which controls are used; and shows sequences where similar experiments are sandwiched around a parameter change. For example, experiment 9 achieved 395% excess heat, experiment 9A (changed only excess heat added - high operating temperature) achieved 3766% excess heat, and followed by experiment 10 (returning to the same conditions as experiment 9) which achieved 408% excess heat. This type of care in running experiments; the completeness of the data and the experimental apparatus; and the use of controls make the experimental data impressive.

The challenge now is to have independent experimenters replicate this set of experiments. As of press time, several teams had begun to replicate Dr. Mills new chemical approach to excess heat production. In a discussion with Dr. Mills, he stated that one corporation had replicated his process; is in the process of writing a report; and that the results would be made public later this month (May 1991).

One might ask if Mills approach to excess heat production disprove cold fusion and the answer would be, "Not at all." Mills approach, if it can be independently verified, is an order of magnitude improvement in chemical heat-producing processes. It also provides a possible theoretical explanation that could lead to a better understanding of deuterium fusion in an electrochemical cell. Mills process uses light water and produces ten times the usual chemical energy. Cold fusion uses heavy water (deuterium) which could possibly produce one million times as much energy (per unit mass of fuel).

We have carefully read the paper and have read Mills and Farrell's book. We are cautiously enthusiastic about both. If replication can be independently verified, this work will be a major advance in both chemistry and cold fusion.

For those who cannot wait to read Mill's article, you may want to communicate with Dr. Randell Mills, Mills Technology, The Griest Building, Suite 700 I, N Queen Street, Lancaster, PA 17603.

PURDUE - CLAYTOR DESIGN THEORY

Yeong E. Kim, "Surface Reaction Mechanism for Deuterium-Deuterium Fusion with a Gas/Solid-State Fusion Device," *Fusion Technology* **19(3)**, May 1991, pp 558-566.

ABSTRACT

Recent highly reproducible results of tritium production by deuterium-deuterium (D-D) fusion from gas/solid-state fusion experiments are discussed in terms of a surface fusion mechanism. Theoretical criteria and experimental conditions for improving and optimizing D-D fusion rates in a gas/solid state fusion device are described. It is shown that the surface fusion mechanism also provides a plausible explanation for the nonreproducibility of the results of electrolysis fusion experiments.

EDITOR'S COMMENTS

This paper proposes a theoretical explanation for experiments conducted by Dr. T.N. Claytor of Los Alamos, in which tritium production is measured when high voltages are passed across a palladium-containing disk (formed when alternating layers of palladium and silicon powder are pressed together) in the presence of D_2 gas.

Conventional d-d fusion at the surface of the Pd grains is proposed to result from acceleration of D_2^+ and D^+ ions across gas pockets between the grains of the powder, aided by electron screening. More erratic behavior in cold fusion electrolysis experiments is attributed to the fashion in which similar D_2 gas layers form on the cathode surface (possibly enhanced by periods of outgassing resulting from temperature fluctuations).

Theoretical calculations are given indicating that fusion rates sufficient to explain the measured tritium production are attainable. Possible explanations of extremely low neutron/tritium branching ratios are indicated to include unknown low-energy resonances, 3-body collisions and the Efimov effect.

It is suggested that the fusion rate in Claytor-type experiments can be greatly enhanced by higher voltage pulses; by increasing asperities (pointed projections) on the Pd surface, and by the use of a magnetic field to deflect electrons out of the path of the deuteron flux.

A talk on this hypothesis and related hypotheses was also given by Dr. Kim at the October 22-24, 1990 Anomalous Nuclear Effects conference at BYU (*Fusion Facts*, November 1990), and published in the conference proceedings. (The latter is also contained in Y.E. Kim, Purdue University physics dept. paper PNTG-90-17, "Surface-Reaction Theory of Cold and Warm Fusion," November 1990.)

PURDUE - HYSTERESIS THEORY

Courtesy of Dr. Kim

Y.E. Kim, "Time-Delayed Apparent Excess Heat Generation in Electrolysis Fusion Experiments," Purdue University physics dept. paper PNTG-90-16, October 1990, to be published in *Mod. Phys. Lett. A*.

ABSTRACT

In many recent electrolysis fusion experiments, excess heat, tritium, and neutron production have been reported as intermittent bursts. These burst phenomena are described in terms of a surface reaction mechanism involving hysteresis of deuterium solubility in palladium as a function of the metal temperature. Excess heat generation is shown to be attributable to a hitherto neglected time-delayed chemical process due to the solubility hysteresis of deuterium in palladium. Negative results of no apparent heat generation from light-water electrolysis experiments is attributed to the fact that the solubility hysteresis of hydrogen occurs at a higher temperature range than that for deuterium. Apparent excess heat generation is expected to be also observable in blank electrolysis experiments with light water at higher pressures.

EDITOR'S COMMENTS

This paper notes the solubility hysteresis curves for D and H in Pd [e.g. A. Sieverts and W. Danz, *Z. Phys. Chem. (B)* **34**, 1936, pp 158-159, and **38**, 1937, pp 46-60]. As also noted by Arata and Zhang [*Fusion Technology* **18** pp 95-102], the D/Pd ratio resulting from exposure of Pd to 1 atmosphere of D_2 increases from approximately 0.06 at 86 C to 0.56 at 73 C; once absorbed, however, the equivalent drop in D/Pd ratio does not occur until the temperature is raised from approximately 103 to 113 C.

Since deuterium absorption by Pd is exothermic, heating the Pd (decreasing the D solubility), while desorption is endothermic, cooling the Pd (increasing the D solubility), a pronounced oscillation in the D/Pd ratio may be established if the Pd temperature is high enough. Associated with this would be a corresponding oscillation in the heat generated by the cell, on which any excess power production due to cold fusion would be superimposed. It is noted that rapid desorption followed by slow absorption may give a pattern of heat bursts above a baseline corresponding to an only slightly negative heat balance which could be mistaken for excess heat generation. Also, the nonequilibrium behavior would depend on cell parameters such as temperature and presumably surface conditions, thus possibly accounting for experimental irreproducibility.

In the experiments by Arata and Zhang, for a 2 cm x 5 cm cathode, such a cycle occurred with a periodicity of approximately 10 minutes, with the desorption stage lasting approximately 80 seconds, as indicated by monitoring of by the Pd temperature. It is suggested that future experiments also monitor the cathode temperature.

During the desorption stage, D_2 gas bubbles may cover virtually the entire cathode, leading to the formation of a high-intensity double-layer electrical field. If enhanced further by asperities (features with sharp tips), electrical fields on the order of 10^9 V/meter and high D_2^+ currents due to dielectric breakdown of the gas bubbles may occur, accelerating large numbers of D's towards the surface and resulting in bursts of nuclear fusion.

Since the hysteresis behavior of H solubility in Pd occurs at a higher temperature of 120-150 C at atmospheric pressure, the triggering of an equivalent phenomenon in H_2O cells would require operation at higher pressures.

This paper was very briefly discussed at the Anomalous Nuclear Effects conference in October 1990, and more extensive portions appear in the conference proceedings.

SANDIA LABORATORY - DIFFUSION IN $PdD_{1.6}$

Courtesy of Dr. Samuel Faile

S.M. Myers, P.M. Richards, D.M. Follstaedt and J.E. Schirber, "Superstoichiometry, Accelerated Diffusion, and Nuclear Reactions in Deuterium-Implanted Palladium," *Phys.Rev. B* **43(12)**, April 15, 1991, pp 9503-9510.

EDITOR'S COMMENTS

In this experiment, annealed and cold-rolled Pd foils were bombarded with 10 KeV deuterons, and the resulting D/Pd ratio inferred from the intensity of charged particle emission due to thermonuclear d-d fusion. After the beam was turned off, an unsuccessful attempt was then made to look for continuing production of energetic particles (up to 12 MeV) from cold d-d fusion in the foil, using a Si surface barrier detector. An upper limit of 10^{-21} fusions/second per D was calculated.

The paper indicates that when implantation was carried out at 41-81 K, such that D diffusion is negligible, the D/Pd ratio is inferred to have stabilized at a very high value of 1.6 ± 0.2 in the upper 100 nm of the foil surface. On warming to approximately 120 K, the D/Pd ratio dropped to 1.0 in an unusually rapid fashion, then remained at 1.0 until 210 K.

Using molecular dynamics simulations, it was calculated that this accelerated diffusion at low temperature could reasonably be attributed to correlated D hopping among

octahedral and tetrahedral sites, if D/Pd ratios greater than 1 result in partial occupation of octahedral sites rather than multiple occupation of the normal tetrahedral sites. Thus, this analysis also supports the inference that the superstoichiometric deuterium occurred in the Pd lattice, rather than in defects and bubbles.

U/TEXAS AUSTIN & NAVAL WEAPONS CENTER

B.F. Bush, J.J. Lagowski, M.H. Miles and G.S. Ostrum, "Helium Production During the Electrolysis of D_2O in Cold Fusion Experiments," *J. Electroanal. Chem.* **304**, April 1991, p 271.

EDITOR'S COMMENTS

A preprint of this paper was reviewed in the March 1991 issue of *Fusion Facts*. The paper has also been reviewed in *Science News* [E. Pennisi, "Helium Find Thaws the Cold Fusion Trail," *Science News* **139**, March 23, 1991, p 180] and *Chemical & Engineering News* [Ron Dagani, "New Evidence Claimed for Nuclear Process in 'Cold Fusion'," April 1, 1991, pp 31-33].

U OF TEXAS EL PASO - METALLURGY

Courtesy of Dr. Samuel Faile

L.E. Murr, "Dislocations in Palladium," *Scripta Metall. et Mat.* **25**, 1991, pp 575-578.

EDITOR'S COMMENTS

This paper represents an extension of the work in a previous paper by Dr. Murr [*Scripta Metall. et Mat.* **24**, 1990, p 783], noted in *Fusion Facts* in February 1991, which discussed the potentially important role of metallurgy in replicability of cold fusion experiments. The present paper notes that solubilities and diffusion rates of hydrogen isotopes in metals such as Pd may be significantly affected by dislocation densities. Furthermore, it is suggested that in some cases grain boundaries may increase diffusion rates. However, although not noted in the article, other studies have suggested that defects, by acting as traps for hydrogen, could reduce rather than increase diffusion rates.

UTAH - NCFI REVIEW

The following comments were made by Dr. Wilford N. Hansen (Utah State U) on April 16, 1991 at a meeting of the Governor's Advisory Committee on Energy and Cold Fusion regarding his independent review of research by Drs. Pons and Fleischmann:

"I. Based on unpublished raw data given to me by Drs. Stanley Pons and Martin Fleischmann, my independent analysis shows that they do have cells which generate significant excess heat. The total excess heat amounts to hundreds of electron volts per palladium atom in some cases. This seems to rule out ordinary chemistry as a source of the excess energy.

"Drs. Pons and Fleischmann supplied raw data and answered hundreds of questions during this difficult and tedious investigation. I wish to thank them for their cooperation. They did not counsel me on the analysis, however. The data are theirs. The analysis is mine.

"II. This is a preliminary release and tentative in the sense that I will not present my review in detail in public nor put my signature on it until I have discussed it with respected colleagues and answered the challenges they might have to my methods and reasoning.

D. NEWS FROM ABROAD

CHINA - REDUCED DIMENSIONALITY THEORY

J.H. You, F.H. Cheng, F.Z. Cheng and F.H. Huang (U of Science and Technology of China), "Interior Adsorption, Channel Collimation, and Nuclear Fusion in Solids," *Phys. Rev. B* **43(9)**, 15 March 1991, pp 7293-7296.

ABSTRACT

The physical mechanism of strong body adsorption of solid palladium to hydrogen ^1H and/or deuterium ^2D atoms is discussed semiquantitatively. The feasibility of nuclear fusion between adsorbed ^2D atoms in solids and incident fast deuterons $^2D^+$ is discussed in light of the strong adsorption to ^2D together with the "channel-collimation effect" of single-crystal palladium.

EDITOR'S COMMENTS

This note suggests that in Pd oriented with the crystallographic <110> channels perpendicular to the surface, fusions involving high-energy ions of hydrogen isotopes will be favored. Although not noted by the authors, such an enhancement due to reduced dimensionality in crystal lattices has previously been suggested by other researchers such as M. Rabinowitz.

ENGLAND - INDUCED RADIOACTIVITY

I.M. Chapnik (U of London), "Possibility of Induced Beta Radioactivity in PdD," *J. Radioanal. Chem. Lett.* **146(4)**, 1990, pp 273-282.

ABSTRACT

Evidence is presented of the possibility that the observation of gamma-rays and charged particles emission from PdD could be caused by beta-type radioactivity induced in deuterons by outer atomic electrons in palladium.

EDITOR'S COMMENTS

This very speculative note suggests that a novel nuclear process involving $beta^+$ or $beta^-$ decay of deuterons, followed by neutron transfer reactions, may be the mechanism for cold fusion. This suggestion is based on the hypothesis that the instability of all but the lightest nuclei with odd numbers of both neutrons and protons may be due to the electron density in the region of the nucleus. References are cited in which the effect of chemical state on beta-decay half-lives may be greatest in such odd-Z, odd-N isotopes.

INDIA - THEORETICAL CONSTRAINTS

Lali Chatterjee and Goutam Das (Jadavpur U), "Sub-barrier Nuclear Fusion of Amuonic and Muonic Flavor," *Phys. Lett. A* **154(1-2)**, 25 March 1991, pp 5-8.

ABSTRACT

Sub-barrier d-d fusion has been investigated for low energies, using the Allis-Morse cut-off type screening potential. It is found that cut-off parameters smaller than 0.1 Å are required to explain the new experimental results for cold fusion in condensed matter. Possible theoretical bases for realizing such anomalous screening conditions are explored. The study is extended to collisional muon catalyzed fusion as well.

EDITOR'S COMMENTS

This note considers conditions necessary to account for Jones-type fusion rates through increases in electron screening (allowing unusually close approach of deuterons). An avenue suggested for exploration is local increases in electron density and mobile deuterons resulting from nonequilibrium conditions during loading.

INDIA - REVIEW

Courtesy of Drs. Srinivasan and J.O'M. Bockris

M. Srinivasan (Bhabha Atomic Research Centre), "Nuclear Fusion in an Atomic Lattice: An Update on the International Status of Cold Fusion Research," *Current Science* (India), April 25, 1991, 174 refs.

ABSTRACT

It is now two years since the first reports of the occurrence of nuclear reactions at ambient temperatures in deuterated metals such as Pd or Ti were published. "Cold Fusion" as this phenomenon has now come to be known has, however, become embroiled in intense controversy, with the scientific community becoming sharply polarized into "believers" and "non-believers" of this novel phenomenon. This ambivalence is primarily because of the non-reproducibility of the claimed results by many reputed research groups often using sophisticated experimental equipment. However, as the present review clearly shows, a large number of laboratories in many different countries have now obtained very reliable experimental evidence confirming the generation of 2.45 MeV neutrons, tritium, charged particles, X-rays, etc. both in electrolysis experiments and in a variety of other D_2/plasma/ion beam-loading experiments thereby confirming the nuclear origin of the phenomenon. These experimental results are such that they cannot be dismissed away as being "experimental artifacts" any more. It is understandable that the scientific community finds it difficult to accept a phenomenon that is not repeatable at will as "science". It would seem that the sporadicity of the results is due to some as yet unknown parameters which seem to be controlling the onset of nuclear phenomena in solid deuterated matrices. It has now become apparent that the phenomenon of cold fusion is highly complex. Although simple (d-d) reactions leading to the production of 2.45 MeV neutrons do seem to take place, that appears to be only one form of manifestation of the phenomenon. The excess heat measurements of Fleischmann, et al. have also been confirmed by now. The main indication at hand that it is of nuclear origin is the detection of He^4 in the off gases issuing from an electrolytic cell producing "excess power" as well as in some "spent" Pd rods which had produced "excess heat". Besides, the enormous magnitude of the energy released, up to a GJ/mole of Pd, is very difficult to be explained by any chemical mechanism. Theoreticians have come up with models which are beginning to explain many of the "puzzles" raised by the experimental observations. The fascinating new field of cold fusion has thus opened up new vistas in physics and technology.

EDITOR'S COMMENTS

This timely paper presents a lengthy review of the extensive progress that has been made over the past two years in the field of cold fusion. In addition to attempting an in-depth treatment, the paper also includes experimental data as recent as the helium measurements of Bush and Miles.

Unusual data such as the > 3 MeV charged particles detected in some experiments are pointed out, as are

unusual types of experiments such as those of Szpak, Claytor, Yamaguchi and Nishioka, Liaw and Liebert, Wada and Nishizawa, Arzhannikov (Novosibirsk), and Beuhler et al.

Puzzling aspects of the experimental data are noted to include not only the occurrence of measurable fusion rates, poor reproducibility, and ratios between heat, tritium, and neutrons which are inconsistent with thermonuclear d-d fusion, but also the measurement of particles with unusually high energies and the lack of secondary X-rays and 14-MeV d-t fusion neutrons. A number of current theories dealing with these questions are discussed.

Note: See also the lead article, a letter from Dr. Srinivasan, on page 1.

JAPAN - METALLURGY

Takaaki Matsumoto (Hokkaido U.), "Microscopic Observations of Palladium Used for Cold Fusion," *Fusion Technology* **19(3)**, May 1991, pp 567-575.

ABSTRACT

The microscopic structures of palladium metals used for cold fusion experiments are examined. Tiny spot defects suggesting cold fusion have been observed in grain boundaries as the Nattoh model predicts. The relationship between these defects and a series of neutron bursts and an indirect loop of hydrogen chain reactions are discussed.

EDITOR'S COMMENTS

Cracking and spot defects at grain boundaries are well shown in SEM photographs. The author cites his previous papers in which the experiments using these palladium rods were reported. Cold fusion had been successfully observed for all of the rods. The 29 photographs show considerable evidence for the expected development, growth, and even merging of crystal defects due to cold fusion events. The author notes that the careful examination of the grain defects (presumable as compared to Pd not used in cold fusion) shows that changes have occurred: "This suggests that inside the defect the temperature and the pressure have increased to some extent because the materials of the grains have burned out."

Dr. Matsumoto's series of papers in support of his "Nattoh" model for cold fusion are of considerable interest. He has been trapping nuclear by-product evidence in special gels and reporting his results. We hope that he will be able to report to us a direct comparison between two Pd rods having the same treatment right up to the stage of electrolysis. It would also be of interest to be able to position a gel so that a Pd fracture could be correlated with the tracks for nuclear particles. The paper provides an excellent set of photographs and should be considered by those who are seeking to understand the underlying causes of fusion events in deuterated Pd.

MEXICO - TRITIUM

Courtesy of Dr. Samuel Faile

Jose Maria Malo Tamayo, Jesus Morales Rivas, Blanca Zamora Celis, Francisco Pablo Ramirez Garcia and Octavio Novaro Penaloza, "Cold Fusion Experiments at IMP," *Rev. Inst. Mex. Pet.* **22(1)**, 1990, pp 42-47 (Spanish).

EDITOR'S COMMENTS

This paper summarizes the results of cold fusion electrolysis experiments conducted at the Mexican Petroleum Institute, in which tritium generation was measured during an 8-day run. (As reported in *Fusion Facts*, October 1990, tritium increased from 85 to 2200 dpm/ml in 1 of 3 cells.)

TURKEY - HEAT & GAMMA RAYS

Courtesy of Dr. Samuel Faile

Ozgen Birgul, Serdar Celebi, Ahmet Ozdural, Kadir Pekmet, Attila Yildiz and Yuda Yurum (Hacettepe U, Ankara), "Electrochemically Induced Fusion of Deuterium Using Surface Modified Palladium Electrodes," *Doga: Turk Muhendislik Cevre Bilimleri Derg.* **14(3)**, 1990, pp 373-380.

ABSTRACT

Bursts of gamma-ray emission accompanying sudden temperature rises were observed during the constant current electrolysis of D_2O containing LiOD electrolyte using the surface modified Pd cathodes following the charge-up of the cathode material with the electrolytically produced D. The macroscopic and microscopic deformations of the cathode material were noticed at the end of the electrolysis that could only be caused by extreme positive thermal changes. The results were compared with blank experiments using H_2O in which no such changes occurred.

EDITOR'S COMMENTS

This paper is not yet available to us. However, we welcome the country of Turkey to the cold fusion club! This is the 17th country (by our count) which has reported success in cold fusion experiments.

USSR - NEUTRON & SOUND EMISSIONS

P.I. Golubnichii, V.V. Kuz'minov, G.I. Merzon, B.V. Pritychenko, A.D. Filonenko, V.A. Tsarev and A.A. Tsarik (Lugansk Mechanical Engineering Institute, Institute of Nuclear Research, and Lebedev Physics Institute, Academy of Sciences of the USSR), "Correlated Neutron and Acoustic Emission from a Deuterium-Saturated Palladium Target," *JETP Lett.* **53(2)**, 25 Jan. 1991.

ABSTRACT

In experiments carried out in a low-background underground laboratory, 42 events of neutron and acoustic emission correlated within 100 microseconds were observed as a palladium sample becomes saturated with deuterium. The number of random events expected was six. These results correspond to the predictions of the acceleration model of cold fusion, according to which neutrons are produced in the collision of deuterons accelerated in microfissures formed during the cracking of a deuterium-saturated palladium sample.

EDITOR'S COMMENTS

This note is a translation from *Pis'ma Zh. Eksp. Teor. Fiz*. (USSR) **53(2)**, 25 January 1991, pp 115-118 (in Russian). Preliminary data was also presented by Dr. Tsarev at the Anomalous Nuclear Effects conference (Provo, Utah, October 22-24, 1990). The study represents an interesting approach for testing the noted "fractofusion" theories by using acoustic emissions to attempt to monitor cracking during electrolysis experiments.

USSR - SUPERCONDUCTOR FRACTOEMISSION

A.G. Lipson, D.M. Sakov, V.A. Kuznetsov and V.V. Gromov (Inst. of Phys. Chem., Academy of Sciences of the USSR), "Mechanoemission from High-Temperature $YBa_2Cu_3O_{7-x}$ Superconductors," *Sov. Phys. Solid State* **32(8)**, pp 1455-1456.

EDITOR'S COMMENTS

This paper is a translation from *Fiz. Tverd. Tela* (USSR) **32**, August 1990, pp 2503-2505. Although only emission of accelerated particles following fracture of "1-2-3" high-temperature superconductor was measured, previous experiments of this type by this group were followed by measurements of apparent induced d-d fusion.

USSR - ION IMPLANTATION

Courtesy of Dr. Samuel Faile

V.F. Zelenskii, V.F. Rybalko, A.N. Morozov, G.D. Tolstolutskaya, V.G. Kulish, S.V. Pistryak and I.S. Martynov, "Experiments on Cold Nuclear Fusion in Palladium and Titanium Saturated with Deuterium by Ion Implantation," *Vopr. At. Nauki Tekh, Ser. Fiz.* **1990 (1)** pp 65-77 (in Russian).

EDITOR'S COMMENTS

Neutron and charged particle emissions indicating cold dd fusion were measured.

V.F. Zelenskii, V.P. Bozhko, V. Ya. Golovnya and S.N. Oleinik, "Experiments on Cold Deuteron-Deuteron Fusion During Ion Implantation," *Vopr. At. Nauki Tekh, Ser. Fiz.* **1990 (1)** pp 91-93 (in Russian).

EDITOR'S COMMENTS

In this second experiment, negative results were obtained in implanted Ti and Pd. For Pd implanted with $10^{18\text{-}19}$ D/cm^2 and treated by cyclic annealing at 80-150 C, an upper limit of approximately 10^{-22} fusions/second per d-d pair was obtained.

USSR - THEORY

Courtesy of Dr. Samuel Faile

V.V. Gann and V.I. Pokhodyashchii, "Metastable Bound States of Deuterium in Palladium and Their Role in Cold Nuclear Fusion," *Vopr. At. Nauki Tekh, Ser. Fiz.* **1990 (1)** pp 89-90 (in Russian).

EDITOR'S COMMENTS

This paper suggests the possibility of heavy-electron effects in Pd deuteride allowing the development of metastable bound pairs of D atoms, leading to cold fusion.

E. COLD FUSION IN THE MEDIA

An editorial summary of comments and views about cold fusion from the technical media:

Although considerable negative sentiment is still expressed, coverage of cold fusion in both the scientific and nonscientific media has included some interesting statements and opinions.

In the US, an editorial by editor Dr. George Miley in the May 1991 issue of *Fusion Technology* notes that since the field of cold fusion has progressed, and the evidence for anomalous nuclear effects has mounted, the journal's standard review process for Technical Notes on Cold

Fusion is being strengthened to reflect the greater sophistication of current research efforts.

In a *Chemical & Engineering News* article [R.Dagani, "New evidence claimed for nuclear process in 'cold fusion'", April 1, 1991 p 31] on the Miles et al. helium results (noted previously), Dr. Nate Hoffman of the DoE's ETEC center also notes that as investigations around the world continue, more and more evidence is being found that "some anomalous nuclear processes" can occur in metal-deuterium systems.

Editor Roger Parsons of the *J. of Electroanalytical Chemistry*, in which the Miles paper appeared, also made the observation that *JEC* had now published between 20 and 25 papers on cold fusion, of which approximately half were positive.

Another recent article in the *Executive Intelligence Review* [Marjorie Mazel Hecht, "Cold Fusion Still Providing Exciting Scientific Results," *EIR* **18(5)**, April 19, 1991, pp 20-29] includes an interview with Dr. Martin Fleischmann (U. of Utah) and a prior interview with Dr. Fritz Will (National Cold Fusion Institute). Dr. Fleischmann indicates that while there are many factors which can cause electrolysis experiments to fail, he has had success in his efforts to increase reproducibility. Fleischmann also cites a previous estimate that Japanese government funding of cold fusion totals about $25 million per year. [Reportedly 5% of the Japanese hot fusion budget. Ed.]

In a prior interview with Dr. Srinivasan of the Bhabha Atomic Research Centre in India (reported in the same EIR article) successful follow-up experiments to the early work by numerous groups at BARC were noted, and it was indicated that increasing emphasis was being placed on the use of titanium (in both electrolytic and plasma focus experiments).

In addition, Dr. Srinivasan made two interesting observations: First, in the early experiments [*Fusion Technology*, August 1990], neutron emission apparently **began earlier in cells using NaOD** [5 M] than in cells using LiOD, even though other groups using NaOD [in lower concentrations] have gotten negative results. Second, Dr. Srinivasan suggested that even though real-time measurements have continued to show that various phenomena such as neutron and tritium production occur simultaneously, the **optimal conditions need not be the same for heat as for specific nuclear products** such as tritium or neutrons.

A recent review article from the editor of the *Indian Journal of Technology* [Subbiah Arunachalam, "Chronicling Cold Fusion Developments," *J. of Scientific & Industrial Research* (India) *50*, January 1991, pp 49-51], notes that the replacement of media hoopla with international conferences and publications in refereed journals suggests that "at last cold fusion is coming of age." Dr. Arunachalam also notes that the Indian government has continued to actively fund cold fusion research.

More recently, a review article by Dr. M. Srinivasan in the Indian journal *Current Science* (noted previously) also voices the opinion that cold fusion is "rapidly acquiring the status of a respectable new branch of science." Dr. Srinivasan also pointed out the over 50 Japanese groups, involving over 250 scientists, are believed to be engaged in cold fusion research. Srinivasan's role is to update the Indian scientific community on the increasing body of positive experimental results.

In Japan, Dr. T. Matsumoto notes an article in the March 1991 issue of *Bungei-Syunju*, which is widely read by business executives, which reviewed the status of cold fusion and recommended a further increase in the intensity of research on cold fusion energy production.

Incidentally, *Fusion Facts* has recently been cited as a source of information in most of the above articles [*Fusion Technology*, *EIR*, *Current Science* and *J Sci & Ind Res*].

F. SHORT ARTICLE

TRITIUM PRODUCTION FROM SPARE PARTS
By: Dr. Dennis Cravens

Much of the efforts of cold fusion researchers has been concentrated on heat production. Tritium is also an important product of the fusion reactions and has commercial potential. This is especially important since nuclear reactors (e.g. Savannah River) which normally are used for its production are now the center of concern within the U.S. [1]. The method described here is solely for the production of tritium. It is a variation of the gas/plasma approach used in a system originally designed for propulsion [2]. The approach is also similar to the work by M. Srinivasan at BARC [3] using a plasma focus device. The main different is that the palladium cathode is pre-loaded by electrochemical methods to include lithium and deuterium within the electrode.

It is still unclear as to the exact physical process involved during the cold fusion event. My personnel view is that heat producing events proceed via D+D to He-4 (although D+Li cannot yet be ruled out). This is not normally considered possible in high temperature fusion reactions due to momentum conservation rules. One possible explanation is that the momentum is absorbed by the crystal lattice in an inverse Mossbauer effect [4] as described by Chubb et al. This theory assumes that at

least one of the deuterium nuclei be rigidly held by the crystal lattice. The idea of R.T. Bush's TRM (Transmission Resonance Model) theory [5] seems to show how mobile deuterium moving within a structure array of other static deuterium atoms can enter nuclear events due to quantum overlap effects. The recent work of B. Bush and Miles [6] seem to indicate that the heat can be accounted for by helium-4 production. The tritium and neutron production can then be seen as being produced when the static deuterium is not rigidly held by the lattice. Tritium can also be produced by interactions between hydrogen and lithium isotopes. For example, the reaction of hydrogen with lithium has been known for some time [7]. It is likely that neutron bursts could be occurring at times of crystal fractures when the crystal lattice cannot support an inverse Mossbauer type coupling.
One part of the theoretical puzzle has not yet been addressed. That is the question of nuclear spin. Hydrogen and deuterium ions which are adsorbed on paramagnetic metals are known to align their nuclear spin. In conventional high temperature plasma fusion events the nuclei do not have time to spin interact (i.e. spin effects are assumed separable and small). Neutrons are expected from the plasma discharge events. However, if quantum overlaps of deuterium held for extended times within a lattice are at play, then spin effects can become important. The availability of proper parity and spin alignment of the reactants should be taken into account.

The plasma work at BARC seems to have used titanium cathodes in a plasma focus device [3]. Due to budgetary restraint, the work here used some palladium wires/rods that were previously used in electrochemical cells. The amount of tritium produced was inferred from the degree of fogging of photographic film [8]. The preliminary results show that pre-loaded palladium generates more tritium than virgin material. This is still not unequivocal since fogging by outgassing and lithium content can not yet be ruled out. The palladium was pre-loaded by electrochemical methods. The method used here was described in an earlier article [9]. Since some people are still having difficulties, there are some practical points on the electrochemical methods used to pre-load the palladium cathode.

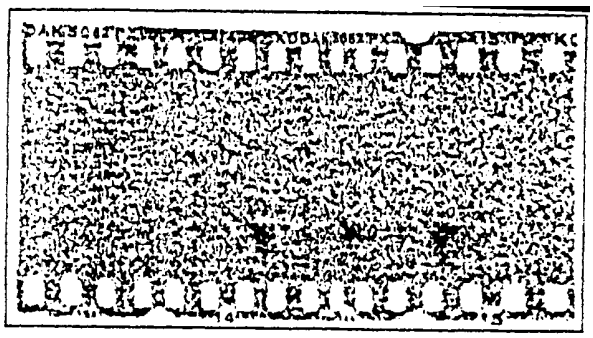
The palladium (Johnson Matthey) is annealed [10] overnight at about 600 C. Palladium/silver alloys can also be used. It is then lightly sand papered with aluminum oxide sand paper, wiped with filter paper and stored in heavy water to avoid atmospheric absorption of normal hydrogen. The electrochemical loading is done at about 60 milliamps for 2 weeks in 0.1 molar LiOD. The extended time is to assure the lithium absorption, which proceeds much slower than the loading of the deuterium. For some reason, not all palladium loads the same. The better samples seem to demonstrate larger volume expansion. The expansion is most pronounced near the extreme edges of the anode. For plasma work the expanded region is placed at the tip of the cathode. This is done by either its fortuitous production at the end of the rod or by cutting the palladium in that region. It should be noted that when the palladium is highly loaded it out gasses profusely when the current is removed. The expansion and profuse outgassing are indications that a good cathode has been produced. Lack of these indications usually signal poor cathodes.

The anode for both the electrochemical loading and the plasma work is a nickel-plated [11] 1 inch copper tube obtained from the hardware store. Care was taken to smooth all edges before plating. Both electrodes were electrically connected by silver solder to copper wire. The standoff between the electrodes was made from Teflon. The cathode was quickly moved from the electrolyte to the plasma device to limit hydrogen outgassing. The electrodes were placed in a plastic jar to contain the deuterium gas. The deuterium gas used was gathered from deuterium gases released from electrolytic cells and was used as generated at about atmospheric pressure. Needless to say, it likely contained heavy water vapor and may have even contained some generated tritium from other cells. Future experiments will use purified and characterized gas.

The power source for the gas discharge device was constructed from a high voltage transformer used in copier machines and generated about 20 KV of DC. This voltage was stored in high voltage capacitors constructed from tin foil and window pane glass. The voltage was discharged between the anode and cathode as the voltage built and jumped across a spark gap. The spark gap was constructed from separated stainless steel screws and the gap was adjusted by turning screws within a wooden block. The gap allowed for greater energy dumping at the cathode. It should be remembered that the loading of cathode incorporates lithium within the outer surface of the electrode [12]. This is quickly volatilized during the gas discharge and changes the resistance over what is expected from pure deuterium gas. The outer anode was grounded.

To keep cost down, the tritium can be monitored by autoradiography using dental X-ray film or simple photographic film. The figure presented here was produced from Kodak black and white film and was commercially developed. The pre-loaded palladium wire produces fogging at about 4 times the non-loaded wire. The ratio was obtained by comparing the fogging produced by the loaded wire to that of the non-loaded wire for different exposure times on the same film roll. Four times the exposure time was need to achieve the

about the same fogging for the non-loaded wire (1 hr.) as compared to the pre-loaded wire (15 min.). Loaded wires used in heat studies but which where not used in the discharge apparatus failed to produce a spot on the film.



A B C D

AUTORADIOGRAPH OF WIRE USED IN PLASMA DISCHARGE- A & B are 15 min exposures of unloaded and preloaded wires, respectively. C is a 1 hr. exposure of an unloaded wire and D is a 15 min. exposure of a preloaded wire.

It is obvious that better controls and experimental protocol are needed before definite results can be claimed. However, the goal here is to show that the gas discharge methods can be done on a relatively tight budget. The production of tritium by a gas discharge process seems to be much more reproducible than the heat studies. Studies of tritium production as a function of loading levels, voltages, energy of spark, lithium content of the electrode, gas pressures, electrode materials, etc. are needed. There are some indications that neutrons may be released during the discharge process. Although better tritium analysis can be used, the autoradiographic method is good for rapid screening of variations in methods.

REFERENCES

[1] "Tritium Dangers", by Dennis Cravens, *Fusion Facts*, Vol. 1, No. 8, p 18, Feb. 1990.

[2] "Patent Applied for a solid state fusion rocket propulsion", *Fusion Facts*, vol. 1, No.1, July 1989. also U.S. Patent application # 347,473 ,#594,750, The applications point out the use of molten salts and gas/plasmas to obtain higher working temperatures. The gas discharge method includes the use of pulsed high voltages involving deuterium and metal hosts. In #445,350 the use of electrical explosions (similar to a fuse blowing at high voltage) of deuterium loaded palladium wires was described. These were early and sketchy disclosures and improvements such as uses of sodium tetraethyl aluminate (U.S. # 591626) are now being studied.

[3] "Tritium Production in Gas/Plasma Phase Loading Experiments at BARC" by M. Srinivasan et al. presented at BYU Anomalous Nuclear Effects in Deuterium/Solid Systems, Oct 22-24, 1990. A brief report is available in *Fusion Facts*, Vol. 2. No. 5, Nov. 1990. "Detection of High Tritium Activity on Central Titanium Electrode of a Plasma Focus Device", by Rout, Srinivasan, Shyam and Chitra, in *Fusion Technology*, Mar. 19, 1991, p 391 ff.

[4] "Nuclear Fusion in a Solid via a "Bose Bloch Condensate", T.A. Chubb and S.R. Chubb, NRL Memorandum Report 6617, Naval Research Laboratory , 1990. Also see "Band State Deuterium Fusion", by T.A. Chubb, in *Fusion Facts*, vol. 2, No. 1, July 1990 and see "Lattice Induced Nuclear Chemistry", by S.R. and T.A. Chubb, presented at BYU Anomalous Nuclear Effects in Deuterium/Solid Systems, Oct 22-24,1990. A brief report is to be found in *Fusion Facts*, Vol. 2. No. 5, p 30, Nov. 1990. The concept allows for momentum to be exchanged between the products and the entire crystal lattice. This idea was also implicit in the development by J. Schwinger. This involved the excess energy to be transferred to the lattice because of the coherent wave-function of the lattice being coupled to the nuclear states (presented at the First Annual Conference on Cold Fusion, Mar. 28, 1990.)

[5] "Production of Tritium, Neutrons, and Heat Based Upon the Transmission Resonance Model (TRM) For Cold Fusion", By Robert T. Bush, presented at BYU's Anomalous Nuclear Effects in Deuterium/Solid Systems, Oct. 22-24, 1990. Briefly described in *Fusion Facts*, Vol. 2. No. 5, p 28, Nov. 1990. This theory allows for D-wave forms to accumulate within properly sized and spaced potential wells.

[6] Published in *J. Electoan. Chem.*, April, 1991, B.F. Bush, Lagowski, Miles, and Ostrom, a brief review is available in "Helium Find Thaws the Cold Fusion Trail", *Science News*, Vol. 139, p 181, March 23, 1991. and in *Fusion Facts*, Vol. 2, No. 8, 1991. Preliminary reports indicate it was a blind experiment where the gases were sampled from active D_2O and H_2O cells at China Lake. The gases where analyzed for He-4 at U. Tex. Only cells producing heat were found to give a He-4 mass spectrum signal.

[7] J.D. Cockcroft and E.T.S. Walton in *Proc. Roy. Soc.* (London), A139:477, 1930 and A137, 229, 1932. This was perhaps the first artificially induced nuclear transformation and involved bombarding Li + p. The reaction proceeds via excited Be-8. A Li-6 +d reaction is also expected to proceed via excited Be-8 (2+) state and would likely give only alphas since it is a even parity state. (See a standard text such as Nuclei and Particles by E. Segre, W. A.

Benjamin, Inc. N.Y., page 444-447, 1965. The energy level diagram of Be-8 is especially enlightening.)

[8] "Thermal Efficiency and Autoradiography", by Dennis Cravens, in *Fusion Facts*, Vol. No. 8, page 18-19, Feb. 1990.

[9] "A Solid-State Fusion Review" by Dennis Cravens, in *Fusion Facts*, Vol. 1, No. 9, p 14, Mar. 1990. This describes the major practical points used to prepare electrodes for the electrochemical loading.

[10] "Evidence for Excess Heat Generation Rates During Electrolysis of D_20 in LiOD Using a Palladium Cathode - A microcalorimetric Study" by A.J. Appleby, S Srinivasan, Y.J. Kim, O.J. Murphy and C.R. Martin, in *Proceedings of Workshop on Cold Fusion Phenomena*, Santa Fe, NM, May 23-25, 1989. This seems to be one of the earlier announcements indicating annealing the cathode. Some people do not anneal but my experience shows better results by annealing and then storing under D_2O or spent LiOD solutions to prevent contamination via atmospheric H_20.

[11] Wolf et. al. presented at the Santa Fe Workshop on Cold Fusion Phenomena, Santa Fe, NM, May 23-25, 1989. This is one of the early papers in support of tritium production. The use of nickel was for anodes was suggested. The use of nickel or ferromagnetic materials may be linked to tritium production. This signals some magnetic spin polarization effects could be at work.

[12] During Question and Answer section of The first Annual Conference on Cold Fusion, by J.O'M. Bockris, Texas A&M had indication that the lithium is absorbed during the charging to a distance of about 6 microns. Early reports by Texas A&M showed that replacement of LiOD with NaOD quenched the heat production. I have never got any indications that NaOD produced any excess heat. Drexler has claimed cold fusion proceeds via D + Li6. However, gas loading events bring this into question. It is interesting that some early results (i.e. Huggins) were conducted with palladium which had been previously in contact with lithium containing materials.

G. LETTERS FROM READERS

IONIC BAND STATES AND COLD FUSION

From Scott R. Chubb and Talbot A. Chubb

The observation of large quantities of "untrapped", low-energy ^{4}He in regions outside heat-producing electrodes during cold fusion experiments by Bush, Lagowski, Miles, and Ostrom, is a remarkable finding. What is perhaps equally astonishing is that prior to these experiments, we had independently predicted this effect based on two assumptions: 1) that periodic order plays a key role in electrolytically induced cold fusion heat, and 2) that ordinary quantum mechanics, when applied correctly, including the effects of periodic order, can be used to explain cold fusion heat without significant generation of high energy particles.

A second result of potentially greater significance also follows directly from these two assumptions: the rate at which cold fusion reactions occur in some cases will increase in direct proportion to the amount of ^{4}He that is present. This has important implications because it means not only should it be true that ^{4}He promotes cold fusion heating, it also means that by properly controlling the amount of ^{4}He that escapes from the electrode, it may be possible to increase the reaction rate.

A detailed description of these and other implications of our ionic band state theory of cold fusion is given in our most recent article, entitled "Cold Fusion as an Interaction Between Ion Band States", which will be published in the August 1991 issue of *Fusion Technology*. The theory provides explanations for such apparently unrelated cold fusion phenomena as the generation of low frequency sound, rearrangement of host atom isotopes at the surfaces of the electrodes, the generation of low-energy, untrapped ^{4}He, and, at higher temperatures, the generation of low-energy X-rays.

LOS ALAMOS - NOTE & ARTICLE

Edmund Storms, Nuclear Materials Technology Div.

Enclosed is my recently finished review of cold fusion work. While I have tried to find and include all papers in the field, I'm sure I have missed some. Please let me know if you find any additions or changes that should be made . . .

I'm hoping that this effort [Storm's extensive report on both positive and negative experiments] will allow us to resume our work here. There is now sufficient experience to suggest approaches that would have a high likelihood for success. Some of these approaches are not being taken at the present time. . . .

I appreciate your efforts in publishing *Fusion Facts*. As you will notice, I used some information from *Fusion Facts* [in the report] . . .

[Dr. Storm's extensive (363 references) report is reviewed in this issue under News From the U.S. Ed.]

H. ITALY CONFERENCE

II ANNUAL CONF. ON COLD FUSION
June 29 through July 4, 1991
Villa Olmo, Como, Italy

From BULLETIN No. 1 I. PURPOSE

After two years, the puzzle of **NUCLEAR PHENOMENA IN METAL LATTICES (COLD FUSION) is still with us.** The aim of the conference is to promote the broadest discussion and confrontation on all scientific aspects of this phenomenon. Participation is open to all interested scientists.

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Abstracts must be received by May 1, 1991.

JOURNAL CALLS FOR PAPERS
Courtesy of Subbiah Arunachalam, Editor, IJT

The Indian Journal of Technology invites papers on cold fusion. Both original research papers and critical review articles in all areas of cold fusion are solicited.

Manuscripts may be sent, in duplicate, to Editor, Indian Journal of Technology, PID, Hillside Road, New Delhi 7110012, India.

TECHNICAL NOTES IN *FUSION TECHNOLOGY*

Fusion Technology has initiated and is continuing a very successful section for "Technical Notes" on cold fusion. This section in intended for fast publication of important papers on new directions, innovative ideas, and new results. Over the past year over 48 papers on cold fusion have been published, making *Fusion Technology* one of the premier professional journals covering this area.

Technical Notes do not have a page limit but they typically run 2-4 journal pages (1 journal page approx. = 3 double-spaced typed pages). A brief abstract is required. ASCII format computer media can be accepted.

Technical Notes will be reviewed but the process stresses rapid response. **Reviewers are instructed to consider Technical Notes as speculative, sometimes incomplete work that should be judged on the basis of innovation, originality, and importance to fusion power development. Appropriate citations to prior work are also essential.**

Deadlines for future issues are as follows:
November 1991 issue: June 3, 1991
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