FUSIONfacts

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A. NEWS FROM THE UNITED STATES

LATEST INFORMATION FROM UNIVERSITY OF UTAH

Except to provide information as to travels of our local fusion scientists, the University has elected to curtail inquiries from media representatives until further work is done on the preparation of technical papers. However, the following information has been received: Members of the Physics department have set up instruments to measure both neutrons and the presence of tritium. The measurements have all been negative. This is an important finding. Excess heat is still being produced in many of the experiments going on at the University of Utah. While Texas A & M has been "tuning" their experiments to produce tritium, many of the University of Utah experiments have been emphasizing the excess heat production.

The implication is that the D + D fusion reaction is producing heat but not through the two better known reactions:

1. D + D --> ^{3}He + neutron.
2. D + D --> T + proton.

Therefore, it is expected that the following reaction (or a reaction that consumes tritium as fast as it is produced) is responsible for the excess heat:

3. D + D --> ^{4}He + energy. (This is a highly desirable reaction, if indeed it can be proved to be real and controllable).

One researcher has reported, in at least one experiment, that a level of tritium was achieved in the electrolyte and then the tritium decreased. The explanation could be that the tritium was being consumed (probably on the surface of the cathode) in a fusion reaction involving deuterium or possibly helium.

As Dr. Hugo Rossi, Director of the National Cold Fusion Institute, emphasizes the most immediate priority is to solve some of the problems of reproducibility and repeatability. The National Cold Fusion Institute has moved into their new quarters at the University of Utah Research Park and have several experiments running.

WORKSHOP ON ANOMALOUS EFFECTS IN DEUTERATED MATERIALS

Sponsored by National Science Foundation (NSF), and Electrical Power Research Institute (EPRI), October 16-18, 1989, Washington, D.C.

From MARSHA FREEMAN, Washington Correspondent.

The workshop, sponsored by NSF and EPRI was closed to the press. Attendance was by invitation. Dr. Paul Werbos of NSF introduced the press to Dr. Thomas Schneider (EPRI), Dr. John Appleby (Texas A&M), Dr. Edward Teller (father of the H-bomb), Dr. George Miley (U. of Ill. Urbana and Editor of Fusion Technology), and Dr. Paul Chu (Houston and of super-conductivity fame). This report is based on the meeting with the press.

NSF/EPRI PLANS.

Dr. Werbos stated that the workshop was originated in discussions with EPRI and NSF and resulted in invitations to some highly credible people to chair the workshop. Drs. John Appleby and Paul Chu, who are internationally known and respected agreed to be co-chairpersons. Dr. Werbos continued, "Our goal was to have a small, little research planning session -- the kind of thing NSF does every day of the week -- the goal was to try to assess the general state of the field. Even more importantly, to figure out what kinds of new research might or might not be justified in this area." Dr. Werbos stated that NSF does not have an official position on cold fusion. The goal was to determine if the scientific findings were important and to determine what NSF and/or EPRI could or should do about it.

Dr. Thomas Schneider of EPRI stated, "We do not have enough information ... In fact, the phenomena reflect a lack of understanding about aspects of both electrochemistry and physics which are in themselves important questions.

The focus of the meeting is to address these phenomena and seek and understand what is happening and provide some suggestions for directions for future work."

STATEMENTS BY CO-CHAIRMEN.

Dr. Paul Chu read the following statement, "The anomalous effects reported in the metal-deuterium system are interesting. NSF and EPRI decided to hold this workshop ... to invite scientists who have direct and related experience in the research to assess the experimental status, to identify the experimental issues, and to determine possible future research needed to clarify these issues. In this respect, the meeting has been very successful.

"New, positive results in excess heat production and nuclear product generation have been presented and reviewed in a logical, frank, open, and orderly manner. Based on the information that we have, these effects cannot be explained as a result of artifacts, equipment, or human errors. However, the predictability and reproducibility of the occurrence of these effects and possible correlations among the various effects, which are common for the accepted established scientific facts, are still lacking. Given the potential significance of the problem, further research is definitively desirable to improve the reproducibility of the effects and to unravel the mystery of the observations."

Dr. Chu also stated that a large volume of experimental data has been presented and various models proposed.

Dr. George Miley was appointed as a subcommittee chairman. The co-chairmen and the subcommittee chairmen would be working closely with scientists in the field to produce a formal report of the Workshop. The report will be completed within a few weeks.

Dr. John Appleby stated that Texas A & M had presented some of the data at the Santa Fe

workshop and that now much of the results have been widely accepted. Dr. Appleby was careful to characterize the experiments as "on palladium and D in the presence of lithium." He also stated that there were participants in the workshop who are definitely still sitting on the fence.

Dr. Appleby made the following statement, "We are happy our results are showing there is something strange going on and we have found that other people have confirmed those results, and those of F&P. Carefully performed new experiments show that anomalous heating at palladium cathodes in deuterium oxide with lithium ions present appear to be real in many cases. More ... experiments are needed by different groups under controlled conditions. This is so that confirmation by other groups of results obtained elsewhere can be obtained. When detected, low-level heat is sporadic and high-level events, such as those described by F&P and those that were discussed at the meeting by other workers at the University of Utah, seem to be even more sporadic. There is evidence that the appearance of high levels of tritium, which has been noted definitely by two groups, may not be an artifact. I would like to point out that if tritium turns out not to be an artifact in this system that means that nuclear phenomenon are involved. There is no other explanation. Notice, I did not say fusion phenomenon".

Dr. Appleby emphasizes that we need to learn more about the palladium surface conditions and of the role of lithium and deuterium. Further, if the events observed are confirmed they are of great scientific interest. It is difficult, Appleby observes, to account for the data by application of the present knowledge of physics and chemistry. There is a reluctance to have to rebuild the whole system of knowledge of physics and chemistry but he implied that some such structural changes may be necessary based on the phenomenon observed.

TELLER SAYS TRY URANIUM

At the NSF/EPRI press conference meeting, Dr. Teller (father of the H-bomb) suggested that uranium be tested for its ability to host fusion reactions in a metal lattice. (This suggestion taken together with the idea of the structure of the atomic nuclei [1] makes excellent sense. According to Moon's theory of the structure of the nuclei there is a basic series of 46 nuclear configurations followed by a second series of 46. Palladium is the end element in the first series of 46 and uranium is the end element in the second series of 46. Editor).

Dr. Teller stated the following: "Numerous interesting and partially contradictory results on cold fusion are in disagreement with the solidly established nuclear theory of fusion. There is a possibility to reconcile the results with the theory, assuming that the deuterons act as neutron donors with various materials (other than deuterons or lithium or palladium) acting as neutron acceptors. The neutron transfer by direct exchange is prohibited by the Gamow penetration factor, but a catalytic transfer of neutrons might be possible. It is conceivable that the catalyst could be an as yet undiscovered neutral particle.

"It is proposed that U-235 be tried as a neutron acceptor because of its great energy release and of its characteristic response to neutron absorption. One may also try to replace deuteron in its role as neutron donor by beryllium nuclei.

"It is recommended in recognition of the high class work that yielded surprising results that the effort be supported in order to obtain clarification, whether the results are due to sophisticated difficulties in the experiments, or whether a new phenomenon is involved. An example of such a new phenomenon has been proposed above without claiming that this indeed is the explanation of the results."

Appleby stated that the whole story of the meeting is not being revealed. There were some very interesting new results that need to be carefully checked by the scientific community, he stated. It is expected the information will be published in the near future in appropriate scientific journals. (As George Miley is the Editor of FUSION TECHNOLOGY, some of the papers will likely be published in that journal. Ed.)

COMMENTS FROM GEORGE MILEY

Dr. George Miley, who was appointed as a sub-committee chairman, stated that his role was to stress reaction products. He told the press that the reports of tritium production is promising in the effort to unlock the mysteries still present in cold fusion experiments. Miley also said there was considerable time spent in discussion of new experiments including the search for helium.

Miley said, "Almost all fusion reactions that can be thought of as taking place would have the tell-tale signal of helium ash. There have been attempts to measure this but it's a difficult measurement. We discussed at length the need to stress additional measurements that might look for helium in both the solid electrode materials and in gas evolving from the cells."

Dr. Miley also mentioned that the measurement of neutrons is difficult especially when being observed in bursts. He states, "We have to remember that observations of any of these products leave open a number of issues. One of the most obvious being, instead of what we're calling cold fusion or cold reactions, might be micro hot fusions due to perhaps certain surface effects."

The group Dr. Miley was chairing recognized that there are a lot of particles and reactions that were discussed. Experiments that can get more data from a correlated experiment so that more of the expected nuclear by-products can be measured were also discussed. Further he observed that it would be a big help if the experiments could be tied to theory. Some of the theoreticians observed that there is some hope that conventional physics might be corrected to provide suitable theory to guide the ensuing work.

Dr. Miley concluded with, "For example, low-energy cross-sections are not that well known. They haven't been measured. Perhaps the conventional wisdom of the extrapolation of lower energies is not correct, and if that were straightened out, some of the need for new physics would be solved. This meeting made some progress in helping the experimenters and theoreticians understand better what the problems were, what each are looking at, where some of the agreements are, where some of the disagreements are in the experiments, and as the area matures -- as in all scientific areas, maturity is often measured by the agreement between experiment and theories -- we would hope these two will begin to come together and lead to better understanding."

QUESTIONS AND ANSWERS:

In response to a question about participants being less skeptical, Dr. Appleby stated, "I would say that the meeting was certainly up-beat rather than down-beat." Miley stated, "We assumed that something's happening, what do we do to find out what it is. There was great enthusiasm to try to unravel that issue." Dr. Chu said, "Everyone who participated agreed more work should be done."

In answer to the question about the lack of doubting Thomases in the workshop, Dr. Schneider made the following comment, "The meeting included people who uphold individually speculative opinion ranging from one extreme to the other. However, the ground rules for the meeting were a conventional scientific exchange of opinions and views. It was very successful in

achieving that objective. There were people who I'm sure were skeptical when they came here. There were people with positive results who were here. There were people who were skeptical when they came here and may have been skeptical when they left. ... We saw a good scientific exchange. We still have gaps in our information and the effort today was to identify research areas to go back home and work on to answer those questions." In the same vein, Dr. Chu said, "We proposed, and all agreed, that the skeptics and the strong believers should work on the same experiments."

When questioned about the interim DOE report (July 1989) which was negative, Dr. Appleby answered that it was only an interim report, and this workshop will give its findings and recommendations to the DOE advisory group. He also stated, "The evidence now is more persuasive that it was in July."

[1] Lawrence Hecht, "The Geometric Basis for the Periodicity of the Elements.", 21st Century Science and Technology, pg 18, (May-June 1988). Note: Hecht describes in detail the theory developed by Robert J. Moon, professor emeritus at the University of Chicago. Moon attributes his theory to an idea advanced by Nobel Prize winner Klaus von Klitzing. The theory indicates a structure for the nuclei of elements that is based, in part, on observations made of the fragment products of atomic fission.

Editor's note: One of the FUSION FACTS subscribers talked to an invited attendee at the workshop. He stated that 35 papers were presented that were positive and two papers that were negative. The presenters of the negative papers left early.

In a telephone conversation with Dr. Thomas Schneider (EPRI) he mentioned that a proceeding of the workshop would be published. FUSION FACTS will publish time and place of availability as soon as that information becomes available.

EPRI ALLOCATES THREE MILLION.

Subsequent to the NSF - EPRI meeting, the Electrical Power Research Institute announced the allocation of three million dollars to further the progress of research into solid-state fusion.

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ELECTROCHEMICAL SOCIETY MEETING

The Wall Street Journal [1] reported on the meeting of the Electrochemical Society held in Hollywood, Florida October 16-20, 1989. Of the 1300 attendees registered for the meetings fewer than 200 attended the cold fusion presentations. Last May 1500 scientists attended a special session on cold fusion in Los Angeles when Pons and Fleischmann made one of their presentations. Neither Pons nor Fleischmann attended the Florida meeting but some members of the DOE ad hoc expert committee did attend.

Twenty-four scientists delivered papers at the meeting and reported results with new, more sophisticated equipment. One of the seven reports reporting excess heat from replication of the Fleischmann-Pons experiment was given by Professor Richard A. Oriani, Chemical Engineering Department of the University of Minnesota. Oriani number among the skeptics after his early failure to replicate the FP experiment. However, after obtaining a palladium rod from chemists at Texas A&M he soon was observing excess heat. Dr. Oriani reported the results were fascinating but erratic. The rod would be involved with the evolution of gases from the heavy water and then at totally unpredictable times, it would begin producing excess heat for as long as 10 or 11 hours before becoming less active. "There is a reality to the excess energy," Dr. Oriani reported.

Turgut M. Gur, an associate of Prof. Huggins at Stanford, reported that two cells were being run -- one with ordinary water and one with heavy water. The cell with heavy water was producing excess heat at the rate of 1 to 1.5 watts more than the adjacent cell.

Dr. John Bockris of Texas A&M reported that they have found a weak correlation between the bursts of excess heat and the production of tritium (a byproduct of nuclear reactions). However, as the tritium is being produced and enters the electrolyte, it is difficult to measure the sudden addition of tritium that may be associated with the bursts of energy.

Efforts to measure the production of neutrons, another byproduct of some nuclear reactions, was not so successful. Several papers reported on efforts to measure neutrons. The data, generally, was not conclusive.

REFERENCES:

[1] Jerry E. Bishop, "Cold Comfort on Cold Fusion Front.", The Wall Street Journal, Monday, October 23, 1989 pg B1.

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DEUTERONS AND TRITIUM PRODUCTION.

One of the better papers to discuss the branching ratio of deuterium fusion is the following:

Magdi Ragheb and George H. Miley, "On the Possibility of Deuteron Disintegration in Electrochemically Compressed D^+ in a Palladium Cathode", FUSION TECHNOLOGY, Vol. 16, Sept. 1989 pages 243-247.

The summary of the article is: "The possibility of deuteron disintegration due to polarization in the coulomb field of a target nucleus according to an Oppenheimer-Phillips process is discussed within the context of electrochemically compressed D^+ in a palladium cathode. This reaction is possible between deuterons and palladium isotopes, as well as between the deuterons themselves. In the last case, the equivalent of the proton branch of the deuterium-deuterium fusion reaction occurs in preference to the neutron branch. The process provides a possible explanation for the observed energy release, tritium production, and neutron suppression in the Fleischmann and Pons experiment. If such a process can be experimentally verified, analogous processes leading to the disintegration of the ^9Be nucleus may be achievable."

Now that the reality of tritium production has been demonstrated by the excellent research performed by scientists at Texas A&M [1], the suggestion of the use of ^9Be should be explored. Note that Ragheb and Miley are nuclear scientists. Their papers also include methods to calculate the energy of various nuclear reactions and show that internal conversion of energy in a palladium lattice could be achieved.

[1] Packham, Wold, Wass, Kainthla, and Bockris (Texas A & M) in "Production of Tritium From D_2O Electrolysis at a Palladium Cathode" (publication pending).

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FUSION AMPLIFICATION BY STIMULATED EMISSION OF RADIATION

By David H. Mitchell. (Printed by permission of the author).

INTRODUCTION

The recent high level of interest in fusion [1,2] has generated more questions regarding the basic nature of the phenomenon than have been answered. Indeed, there appears to be no present theory to explain it. Recent breakthroughs in high temperature superconductors have again outstripped available theories. Could there be a relation between the wave/particle nature of matter that, when

explored from the point of view of standing waves and electromagnetic theories, could explain aspects of fusion and superconductive experiments? It is the author's contention that the evolution of knowledge from standing waves that led to the MASER, and later LASER, theories may point the way to an understanding of recent breakthroughs and also indicate new areas of research.

BACKGROUND

There are several different areas that should be covered in order to fully explore the potential for finding a common explanation of newly discovered phenomenon. First, let us explore some of the recent history in Amplification by Stimulated Emission of Radiation.

The concept of standing waves and resonance in solid, liquid and gaseous matter has been explored for centuries. Resonant effects of tuning forks on various materials are used in beginning science experiments for children. In the field of electronics, basic formulas for transmission lines, wave guides, communications systems and analog systems in general are well known. (The recent conversion to digital forms has greatly reduced the general knowledge of this information - except to designers of high frequency hardware which requires designing around limitations imposed by wave properties).

The 1964 Nobel Prize for physics was shared by Townes, Basov, and Prochorov for maser (Microwave Amplification by Stimulated Emission of Radiation) theory. Initially, masers operated intermittently and had to be pumped in order to raise the energy level of the electrons to provide a microwave emission. Bloembergen was able to use a three-level system which provided the first continuous maser. Note that this is a method of achieving a resonance and standing wave phenomenon with microwaves.

Next, T. Maiman constructed the classic ruby Laser, which has higher energy levels of emission. Higher energy levels mean that emission is in the visible portion of the spectrum. A. Javan proceeded to develop the Helium/Neon Laser. Notice that the effect can occur in either solids rich in electrons or in gases which also allow for richness of electrons.

Chemical lasers followed and breakthroughs in Free-Electron Lasers [3] that use magnetic fields to allow electrons to directly impart energy to light waves. Again note that in all these devices, the basic electromagnetic concept that a moving electron creates an electromagnetic field that propagates through space which can then move an electron is exploited. Also, note that a moving electromagnetic wave can also be expressed as a photon.

In short, it is beneficial to be aware that the present understanding of the universe makes it necessary for the reader to keep in mind that at any time we may refer to particles as waves and vice versa. So, light may be units of photons or electromagnetic waves. Likewise, an electron, proton or neutron may be considered as a particle or a wave. By recognizing that a particle or wave is only an approximation of reality, we may open up new areas of thinking.

Second, fusion phenomenon appears to have been more abundant than previously thought [2]. Aside from stellar processes and hydrogen bombs, new areas being explored include the work of Fleischmann, Pons, and Hawkins [1], and of Jones [2]. In addition, the author has evidence that "ball lightning" may indeed be fusion phenomenon [4]. Research by Tesla at his laboratory in Colorado shows he observed ball lightning on several occasions [5] but he attributed it to hot air expansion which created a short-lived plasma ball. The author has analyzed the apparent energy output and behavior and sees evidence that a standing wave or resonance may be occurring which enhances the fusion rate in the "ball".

Lack of positive feedback and/or fusing material prevents long-term stability and the ball lightning event even collapses. Reported sightings where the ball has gone through solid barriers without collapsing indicate a fusion effect on an atomic scale. A plasma would either burn a hole or self-extinguish.

Reported sightings of ball lightning where burn holes are present could support either fusion or plasma. A likely explanation is that the speed of travel through a barrier would determine the amount of heat transfer from the fusing material. Hence, fusion could account for both reported sighting while a plasma ball could not. Indeed, it is clear that sightings would at first appear to a trained scientific observer as illusions, fabrications, or outright mystical aberrations. However, the explanation of ball lightning as a naturally occurring form of fusion explains the phenomenon in a manner consistent with the apparently incredible observations. Also, the decrease in sightings of unusual phenomenon, in general, is usually attributed to better ability to rule out false claims. Hence, any item that appears to be reported less in recent years is assumed to be folklore and/or false claims.

In the case of ball lightning the reduction in the number of sightings may be due to other causes. The migration of populations away from rural areas and the widespread use of nitrogen-based fertilizers may have reduced the number of sightings possible. It is likely that methane is the fusing material in ball lightning or methane in which one or more hydrogen atoms are replaced with deuterium. Current farming practices would prevent accumulation of methane pockets where observations would be likely to take place.

It is interesting to note that experiments at Sandia Laboratories did produce what appears to be a ball lightning event. A single experiment that involved destruction of the test apparatus did produce a visible ball which left the field of vision at high speed. The author does not know the details of the experiment but did see a video tape of the resulting ball.

In naturally occurring ball lightning, sightings are almost always before, during, or immediately after a lighting storm. In Tesla and Sandia experiments, large electrostatic fields were created. It is important for the reader to know the large electrostatic fields naturally occur in the atmosphere and during electrical storms. These fields intensify and then collapse with lightning as the result. All of these man-made and natural events may create conditions where the electrical potential is strong enough to propel ions together with enough force to fuse. However, the number of ions fusing is too small for any practical use.

Third, as demonstrated by Free-Electrons Lasers and present fusion reactor design, powerful magnetic fields do exert very large and meaningful forces on the medium of interaction. The fact that Free-Electron Lasers exist and work shows that standing waves of high energy content can be achieved and controlled. The fact that high temperature containment structures where near breakeven fusion energy is occurring indicates that controlled fusion is possible.

STATEMENT OF THEORY

Fusion Amplification by Stimulated Emission of Radiation is a resonant or standing wave effect that may be created by electron injection into solids or magnetic or electromagnetic injection into gases. As the name implies, the purpose of a FASER device is to produce output energy greater than the input energy by creating a resonant area at the proper wavelength to allow for fusion of the desired material.

The concept involves energy injection to create a condition where electric field potential is sufficient to create a fusion reaction. A properly tuned medium will then resonate, producing more fusion. In a metallic medium, low energy photons should be produced, in either the

microwave or infra-red (heat) range; experimental evidence for this is the Fleischmann/Pons experiment (FPE). Visible light would occur in an intermittent medium temperature plasma; evidence for this is the orange/yellow color of ball lightning. Very high energy would occur in a high temperature fusion explosion (gamma rays). In simple terms, the resonant effect known in lasers is the key to high energy output in fusion.

FASER theory is therefore the theory that meaningful fusion occurs when energy is pumped into a resonant medium for the materials to be fused. If the wavelengths of the resonant medium and the material to be fused are properly balanced, then energy injection will create a resonant state that results in amplification of the fusion effect. This means that energy of any reasonable wavelength can be achieved using the proper resonant cavity, fusion material, and method of pumping.

A possible corollary to this theory is that superconductivity occurs when a resonant state exists due to a proper balance between resonant cavity, material, and energy pumped in. This approach would explain why there are various limits to how much energy can be pumped into a high temperature superconductor before it loses its properties. Since superconductors can lose their properties in the presence of strong magnetic fields, this would indicate a loss of resonance due to pumping imbalance.

By doing calculations of an entire system using wave properties for all materials involved, it may be possible to predict optimum combinations for various fusion results. The basic concept in calculation and design is to treat all particles as waves of a specific wavelength of correct magnitude based on the particle's mass and energy components, then proceed to determine the resonant frequency of the entire system. A simple way to state the theory is that an entire system should be viewed as one massive particle having one wavelength. Proper pumping of energy into the system enhances resonance at the characteristic frequency of the system.

AREAS OF EXPLORATION

Several areas of exploration present themselves. One is the construction of high intensity electrostatic fields, modulated by microwaves, into which CD_4 or CH_4 gas may be injected to test for fusion effects. Also, injection of gases into properly tuned Free-Electron lasers may yield positive results. Since there may be a relation between superconductor behavior and resonance, metallic fusion may be optimized by analysis of the system with the intent of optimizing resonance. Also, large solar flares are a major electromagnetic effect. If FASER processes account for some fusion in the stellar environment, then observable effects should manifest themselves in the form of areas of lesser and greater fusion due to resonant disruption during a flare. Is this a possible cause of sun spots?

CONCLUSION

Fusion Amplification by Stimulated Emission of Radiation may be a unifying concept to help in the development of detailed theories of various aspects of fusion and possibly super-conductivity. Many observed phenomenon can be accounted for by analysis of entire systems not as groups of particles but as standing sets of waves. Optimization of fusion systems should be achieved by resonant analysis of the entire system: fusion cavity, fusion material, and pumping method.

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

[2] S. E. Jones, E. P. Palmer, J. B. Czirr, D. L. Decker, G. L. Jensen, J. M. Thorne, S. F.

Taylor, and J. Rafelski, Observation of cold nuclear fusion in condensed matter., Nature, 338, 737 (1989).

[3] Freund and Parker, Free-Electron Lasers, Scientific American, April 1989.

[4] David H. Mitchell, Global Impact of Small Scale Thermonuclear Fusion Furnaces., (unpublished), June 8, 1986.

[5] Tesla, Colorado Springs Notes 1899-1900. (pages 368-370), Nolit. (Beograd, Yugoslavia). 1978.

FORMULAS TO COMPUTE WAVELENGTH OF A SYSTEM

Ws = h / E, where Ws is wavelength of system, h is Planck's constant, and E is energy.

Ep = Eo + Ek + Ee, where Ep is total energy of a particle, Eo is rest energy of a particle, Ek is kinetic energy of a particle, and Ee is electropotential energy applied to a particle by pumping using electric, magnetic, or electromagnetic fields. Note that Ek+Ee is constant. Since Ek is essentially zero, we can use the value Ee which energy applied by pumping.

Es = summation of Ep (for all particles in chosen system. Or E_s = summation of rest energies of all particles plus total pumping energy. This allows Es to be computed in bulk.

Knowing Es allows the computation of Ws. The current formulas for standing waves, resonant cavities, and laser design may be used for optimal system design. It should be possible to generate FASER output throughout much of the electromagnetic spectrum using Free-Electron Laser techniques and at microwave/infra-red frequencies in metallic lattices.

Editor's Comments: Science has often been advanced by the insight from persons working outside the field. Certainly Fleischmann and Pons are not considered to be nuclear specialists and yet have made an unique contribution to nuclear physics. Mitchell's article has been printed here in the hopes that his suggested way of viewing fusion reactions may trigger the thinking of our readers and lead to some further creative thought experiments that may advance solid-state fusion.

Please consider the following excerpts from other scientists:

J. Rand McNally, Jr. in "On the Possibility for a Nuclear Mass-Energy Resonance in D + D Reactions at Low Energy" Fusion Technology, Vol 16, Sept 1989 p. 237ff states: "Thus nuclear mass-energy resonance together with other physics might account for the reactions observed by Pons, Fleischmann, Jones, and others. Experimental and theoretical confirmation of this hypothesis is needed. Should the results be favorable, the scientific study of other nuclear resonances at `low temperature' and high density might be quite promising, possibly ensuring `cold fusion' a valid place in science."

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

P. K. Iyengar as quoted in The Hindu August 7, 1989. "The fact that we see more tritium than neutrons in our experiments is important for this

explanation... Deuterium fusion proceeds through two nodes: one giving rise to tritium as a byproduct and the other to neutrons. Under normal conditions these proceed with roughly equal probability. If one sees more tritium, then it implies that the neutron mode is for some reason suppressed... Within solids deuterium nuclei have very low energy and therefore their wave spread, as implied by quantum theory, is much larger, of the order of an angstrom. This is nearly a million times more than the spread in free space and, therefore, its charge distribution cannot be treated as that of a point particle. The increased wave spread reduces the strength of the barrier and increases the overlap of two deuterium nuclei. This enhances the probability for neutron in one nucleus to tunnel and fuse with the other deuterium nucleus, while the proton remains as a spectator, resulting in tritium production."

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

Packham, Wold, Wass, Kainthla, and Bockris (Texas A & M) in "Production of Tritium From D_2O Electrolysis at a Palladium Cathode" (publication pending) make the following statement after their report of experiments proving that the observed tritium cannot be explained by contamination: "We are aware that, according to the classical theory of nuclear physics, when D-D fusion occurs, the rate of neutron production should be approximately equal to that of tritium. This is not observed in the present experimental program. We believe that it is important firstly to establish the **facts** about tritium production on electrodes. The theory of electrochemical confinement will be discussed elsewhere."

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NUCLEAR SPIN CURTAILS NEUTRON PRODUCTION

Dr. Dennis Cravens, our Texas correspondent, has sent FUSION FACTS a report in which it is shown that the probability of deuterium fusion reactions can be modified even in hot fusion. There has been a lack of acceptance of cold fusion in an electrolytic cell because of the expected equal branching of the deuterium - deuterium nuclear reaction. Traditional nuclear physics has reported many d-d events but with an almost equal occurrence of tritium (with a proton) and neutrons (with helium three). In addition, the probability of occurrence of a nuclear fusion reaction in a cold metal lattice has been viewed as being highly unlikely. The importance of this report is to show that we are still learning about the enhancement of fusion reaction under various conditions.

The technical report [1] states the following in the introduction: "One of the major benefits to be gained by polarizing the plasma nuclei is that the fusion cross-sections, e.g. for D-T and D-^{3}He, can be **increased** by almost exactly 50% for D-T and by slightly less than 50% for D-^{3}He when all spins of both reacting nuclei are completely polarized to be parallel to the confining magnetic field. This enhancement factor has been widely established both theoretically and experimentally."

The author reports the conjecture that it may be possible to entirely suppress the D-D reactions by polarizing the spins of the interacting deuterons parallel to each other. Experiments have been carried out to confirm that laser-polarization has confirmed a large change in the D-D cross sections as compared to unpolarized systems.

The conclusion of the report raises the question as to whether spin polarization partially or greatly suppresses the D-D reaction. The statement is made that: "Probably the DD reaction is partially suppressed, through it is not completely understood at present.

The conclusion also reports the findings of increased power output of the D-^{3}He reaction due to spin polarization. Dr. Cravens questions whether the spin alignment may exclude the D+D --> ^{3}He + n as a nuclear reaction and thereby favor the D+D --> T + p as the favored reaction in the cold fusion environment.

Editor's note: The production of ^{3}He and possibly ^{4}He through relatively simple electrochemical fusion should be carefully considered. It may be that the ^{3}He and ^{4}He atoms are quickly consumed by other fusion reactions. In addition, it is possible that just as spin polarization changes the fusion reaction cross-section for the D-T and the D-^{3}He reactions, it may be possible to affect the fusion reactions in an electrochemical cell by similar means. Joe Champion of Columbia, Tennessee and Abe Linton of Salt Lake City, Utah have both filed patent applications on the use of NMR-type electromagnetic radiation as a means of improving fusion reactions.

REFERENCE:

[1] Chan K. Chol, "Nuclear Spin Polarization of Advanced Fusion Fuels.", A Final Report prepared for Astronautics Laboratory (AFSC) under contract F04611-88-C-0014. Obtainable through NTIS.

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DOE CURTAILS ASPECTS OF FUSION DEVELOPMENT

Marcia Freeman, FUSION FACTS correspondent in Washington, D. C. has sent us information about the DOE's change of policy in funding hot fusion.

Robert O. Hunter, Jr., Director, Office of Energy Research, DOE testified before the Senate Subcommittee on Energy Research and Development of the Committee on Energy and Natural Resources, June 14, 1989.

Hunter's testimony included the following:

1. There is considerable controversy in the department over the future design and scope of the fusion energy program.

2. The Compact Ignition Tokamak (CIT), the main unit to prove hot fusion, has a low probability of achieving its ignition objectives. ("Ignition" is a fusion buzz word used to imply that the energy out of a fusion machine reaches the amount of energy input into the machine. Ed).

3. The department is convinced that the fundamental physics of tokamak confinement is not understood.

4. Secretary Watkins, (Sect. of DOE) has a strong personal interest in the future of fusion R&D that will embrace both magnetic and inertial confinement fusion.

In a letter to Rep. Robert Roe, chairman, House Committee on Science, Space, and Technology, June 14, 1989 Secretary James D. Watkins makes the following points:

1. The construction of the CIT will be postponed due to lack of resolution of key scientific unknowns.

2. After a policy review by an independent, high-level committee, a final version of the new energy policy will be presented.

3. The same amount of funding will be needed, however, the funding for construction of CIT will be deferred.

This testimony and letter from high-level DOE officials is best understood by reading a more complete background summary which appeared in the September 8, 1989 issue of EIR. This summary does not do justice to the lengthy interview with Stephen O. Dean, president of Fusion Power Associates (Gaithersburg, MD) who was formerly the head of the magnetic confinement systems division at the DOE Office of Fusion Energy. In summary the message is:

The present administration and the Reagan administration have been moving away from following the Magnetic Fusion Energy Engineering Act of 1980 which was passed by Congress during the Carter administration. There has been a concerted effort to reasonably reduce spending. The current funding decisions are concerned with the splitting of funds between inertial and magnetic fusion projects. The administration is not asking to expand funding to cover both approaches to the study of hot fusion. Regardless of the decisions of the administration, a committee will be assembled to make recommendations. There is strong lobbying for both inertial and magnetic fusion projects, however, it appears that the projects of most interest to the military will be favored in the expected rearrangement of funds to both inertial and magnetic. There is little likelihood that any significant funding of cold fusion will result from the current competition for funds.

Note: The editorial position of FUSION FACTS is the following:

1. The lack of an organized national policy for the development of both "hot" and cold fusion provides the Japanese with an advantage by default.

2. Federal funds to support the health of American industry is just as important as the expenditure of funds to support the health of American citizens.

3. Current fusion development efforts funded by the government should not be curtailed but funds should emphasize early commercialization of whichever fusion designs show the most promise.

4. There exists an organization vacuum in the United States for the effective and efficient development of fusion energy systems. FUSION FACTS welcomes any for-profit or not-for-profit corporate activity that will lead a consortium of American business and scientific leaders to develop cold fusion energy systems.

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B. NEWS FROM ASIA

COLD FUSION USING TITANIUM

Dr. P. K. Iyengar, Director of the Bhabha Atomic Research Centre (BARC), Trombay, near Bombay, India has written about the use of titanium in cold fusion experiments [1]. The Frascati group in Italy led the way with their experiment of loading titanium shavings with deuterium gas under pressure. Their results were the measurement of the emission of neutrons [2].

A Chemistry Group at BARC treated titanium cut pieces with deuterium gas at 50 atmospheres. The end result was the release of neutrons at a peak value of 3900 counts in 40 seconds compared with a background count of 60 for 40 seconds. Neutrons were emitted for about 30 minutes. Further experiments measured about 6,500,000 counts over a 7-hour period which is well above any background count.

In a separate set of experiments, a deuterated titanium disk was placed overnight between sheets of standard medical X-Ray film. A typical result was that the developed film showed about a dozen spots of activity randomly distributed on the disk. Repeated exposure of the same target disk showed activity in the same regions. Further measurements showed that the titanium disk was emitted beta particles of the same energy level to be expected by the radio-active breakdown of tritium.

The following conclusion is copied from reference [1]:

"Autoradiography of gas-loaded Ti targets demonstrates in a simple and elegant manner not only the occurrence of cold fusion, but also the production of tritium. The estimated tritium to deuterium isotopic ratio in these targets is several orders of magnitude higher than in the initial stock D_2O and as such cannot be explained away on the basis of preferential absorption of tritium by the titanium as may be suspected. The existence of highly localized regions (hot spots) on the target surface wherein tritium is concentrated as well as the occurrence of spots all along the periphery of the disc, points to the important role of lattice-defect-sites in the absorption process or in the accumulation of tritium following migration after its formation, at least in titanium."

"The very high probability for the tritium branch in cold (d-d) fusion reactions would indicate processes of neutron transfer across the potential barrier as postulated by Oppenheimer over half a century ago."

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

FUSION FACTS urges its experimental readers to duplicate the work that has been done in Italy and India using titanium to produce cold fusion. There is no question that the lower cost of titanium, as compared to palladium, would be a large benefit for commercializing cold fusion. First, however, it is important to ensure that the cold fusion findings of these scientists can be replicated.

An entirely different use of titanium to promote fusion is reported in [3]. Scientists at Brookhaven National Laboratory accelerate clusters of heavy water molecules in a vacuum chamber and bombard a titanium target. The result is pressures up to 80 million atmospheres and temperatures estimated to be in the hundreds of thousands of degrees. In the short impact time some deuterium atoms fuse. Both neutrons and tritium by-products are observed. This work is expected to be continued at higher impact velocities. The chemists, Robert J. Beuhler and Lewis Friedman, and the nuclear chemist Gerhart Friedlander reported their findings in the Sept. 18, 1989 Physical Review Letters.

REFERENCES:

[1] P. K. Iyengar, "Cold Fusion Results in BARC Experiments.", Fifth International Conference on Emerging Nuclear Energy Systems (ICENES V), Karlsruhe, July 3-6, 1989.

[2] A. De Nino, et.al., "Evidence of Emission of Neutrons From a Titanium - Deuterium System.",

Submitted for Publication to Europhysics Letters (1989).

[3] I. Amato, "Colliding Clusters Hint at New Fusion Route.", Science News, Vol 136, page 196.

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C. LATEST ON FUSION CELL PREPARATION

When Fleischmann and Pons announced that the fusion cell could be replicated using equipment found in a typical high school chemical laboratory, they neglected to add that a highly-skilled electrochemist was necessary. Although Fleischmann and Pons explicitly stated on a later television interview (at the 175th Meeting of the Electrochemical Society, Los Angeles, CA, May 1989) there were concepts that they were restrained from talking about (due to patent considerations), many scientists misunderstood. It has been widely believed that all of the information necessary to replicate the Fleischmann-Pons Effect (FPE) was published in their first paper [1].

Proper preparation of a fusion cell requires certain treatment of the palladium cathode both in terms of physics and chemistry. In addition, the electrode arrangement must be symmetric. Sticking two electrodes into a solution of heavy water and lithium deuteroxide is not sufficient.

The combination of treatment of the palladium cathode (physical and chemical) must prepare the cathode for receiving and maintaining deuterium atoms so that the ratio of D/Pd is about 0.9 to 1.0. In the literature, the preparation of the palladium cathode is sometimes referred to as "poisoning the electrode." "Poisoning" can be viewed as a treatment that prevents an ion from entering an electrode (or escaping from an electrode when inside). Drs. Storms and Talcott at the Santa Fe Workshop on Cold Fusion Phenomena, stated that the D/Pd ratio cannot exceed about 0.67 unless the surface of the palladium cathode is poisoned. In a personal communication Dr. Carol Talcott stated that Mo, Arsenic, and Co are typical poisons used with Pt and would probably work with Pd.

The skilled electrochemists, who have replicated the FPE, have not as yet reported in the published literature the precise details of their successes. Ten teams in India, ten teams in Japan, and at least ten teams of scientists in the United States have all been successful in replicating all or part of the FPE. Other scientific teams such as MIT [3] have reported their lack of success. None of the discussion and none of the 32 references cited in reference [3] appear to bear on the key factor of the treatment of the palladium cathode to enable the loading of sufficient deuterium to support fusion reactions. Reference [3] reports only negative findings.

Here is the latest summary of the experimental conditions that should be observed (as learned by FUSION FACTS staff):

1. The palladium must be annealed [2]. Prof. Huggins used cast Pd [4].

2. The heavy water must be pure.

3. The electrolyte must be free from C and carbon-containing compounds.

4. The spacing of the anode with respect to the cathode must be symmetric.

5. Quartz rods are suggested for use in spacing the two electrodes.

6. Chemicals added to the electrolyte to "poison" the cathode must be in the milli-mole levels.

7. The "charging" of the palladium should be done at low current levels so that the metal lattice expansion has time to adjust to the

buildup of the deuteride. Appleby, et al [2] used 60 mA/sq cm during charging and 600 mA/sq cm after a suitable charging time for the fusion cell current.

8. After charging, the palladium cathode will have changed dimensions. One investigator states that the measure of expansion is a good indicator as to whether the cathode will function properly (support fusion reactions).

9. Even those experimenters who have been working successfully for several weeks on fusion cells do not have 100 percent successes. Particularly where the emphasis is on the finding of neutrons, the success rates are low. Where the experimental emphasis is on measuring tritium, the success rates have been higher. Also, the success of replicating palladium cathode preparation to achieve excess heat has been 90 percent or more with some of the more experienced scientists.

10. It is suggested that an experienced electrochemist be consulted to help with any fusion cell experiments. It is also suggested that the experimental group carefully review all the success papers that have been published, especially [1] and observe the cautions.

REFERENCES

[1] M. Fleischmann, S. Pons, and M. Hawkins, J. Electroanal. Chem., 261, 301ff, and erratum, 263, 187 (1989).

[2] A.J. Appleby, S. Srinivasan, Y.J. Kim, O.J. Murphy, and C.R. Martin, Evidence for Excess Heat Generation Rates During Electrolysis of D2O in LiOD Using a Palladium Cathode - A Microcalorimetric Study, Workshop on Cold Fusion Phenomena, Santa Fe, NM, May 23-25, 1989.

[3] D. Albagli, R. Ballinger, V. Cammarata, X. Chen, R.M. Crooks, C. Fiore, M.J.P. Gaudreau, I. Hwang, C.K. Li, P. Lindsay, S.C. Luckhardt, R.R. Parker, R.D. Petrasso, M.O. Schloh, K.W. Wenzel, and M.S. Wrighton, Measurement and Analysis of Neutron and Gamma Ray Emission Rates, Other Fusion Products, and Power in Electrochemical Cells Having Pd Cathodes, prepared for publication in the Journal of Fusion Energy.

[4] A. Belzner, U. Bischler,n S. Crouch-Baker, R.M Gur, E. Lucier, M. Schreiber, and R.A. Huggins, untitled invited paper presented by Huggins at the Workshop on Cold Fusion Phenomena, Santa Fe, NM, May 23-25, 1989.

Editors note: Previous issues of FUSION FACTS have stressed the treatment of the palladium cathode. Such treatment is such a critical factor to success that we will continue to seek for more detailed information and share it with our readers.

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D. FUSION IMPACT ON ENVIRONMENT

SOLID-STATE FUSION CAN PRESERVE THE ENVIRONMENT.

Atmospheric pollution, acid rain, holes in the ionosphere, polluted beaches, polluted seas that support little marine life, vanishing forests, ravaged mountains, flooded plains, and spreading deserts are all environmental problems. Many of these problems can be solved or alleviated by the wide-spread use of solid-state fusion energy.

BURNING OF FOSSIL FUELS.

Much, but not all, of the atmospheric pollution stems from the burning of fossil fuels (oil, gas, coal) in large power plants to produce electricity. Millions of tons of coal and its equivalent in oil and natural gas are used to fuel the boilers of the large power plants that turn steam into electrical energy. The by-products of combustion: carbon dioxide, carbon monoxide, various sulfur compounds, and particulates are

either removed at the power plant or enter the atmosphere. The resulting pollution of the atmosphere results in compounds that produce acid rain.

Acid rain slowly destroys forests, destroys aquatic life (unless there is plenty of natural limestone to counter the acid in the rainwater) and even destroys the stone statutes in our cities. Even tombstones and buildings made of limestone or dolomitic building blocks are slowly eaten away by the acid rain and the atmospheric pollution.

Power plants are not the only burners of fossil fuels. The millions of automobiles and trucks that burn gasoline and diesel fuel also add to the atmospheric pollution. In addition to the carbon compounds, these transportation vehicles also vent nitrogen compounds into the air. Some of these chemicals, in the presence of sunlight, turn into a variety of chemicals that create the eye-burning smog in some of our large cities.

Other atmospheric pollution comes from ships at sea burning fuel oil and from thousands of railroad locomotives burning diesel fuel. In addition, the aircraft that ply our skies consume thousands of tons of high-grade aircraft fuel. Many parts of the world depend on wood-burning stoves, heaters, and fireplaces for cooking food and warming homes. In some countries, like Nepal, the wood-gathering has denuded the forests and created conditions for periodic flooding as the watersheds are destroyed.

THE ROLE OF ENERGY IN MANUFACTURING

There is scarcely a product that is made or consumed that is not created by energy. For example, the energy cost of a head of lettuce delivered to a New York grocery store is estimated to be about seven times the energy value of the lettuce (or other food). If the rest of the world used as much energy to grow and transport food as we do in the United States, our current consumption of the polluting fossil fuels would greatly increase with a strong increase in atmospheric pollution.

Building materials for our home, offices, and factories are produced by energy intensive manufacturing processes. Gone are the days when hand-work cut the trees, sawed the wood, and quarried the rock for our buildings. Today's structures are made of steel, concrete, wood, aluminum, plastic, glass, and plaster boards -- all of which require copious amounts of energy to manufacture.

Some of the energy that is now used in manufacturing comes from electricity generated in nuclear power plants. To the extent that we increase the use of nuclear power, we decrease the use of power derived from the burning of fossil fuels. However, today's nuclear power plants produce pollution of a different kind -- radioactive pollution. Even though the safety record of the nuclear power industry far surpasses the safety record of almost any other industry, the production, transportation, and storage of long-lived nuclear waste is a problem for today and for hundreds of years to come.

AGRICULTURAL IMPACT ON ENVIRONMENTAL POLLUTION

Currently two main sources of pollution that stem from the increases in the growing of food and fiber are the burning of forests to create more agricultural land, and the pollution caused by the washing of agricultural chemicals into our streams, rivers, lakes, and oceans.

Satellite pictures taken at night over Brazil (and other developing nations) show enormous areas of burning forests. The growing populations of the world's nations must be fed and people do not eat tree leaves. Therefore, just as we in America destroyed a continent of forests to produce the vast farmlands of our midlands, so

too do other nations destroy their forests to provide more land to grow crops.

A century ago, we began to learn to rotate crops so that nitrogen-replenishing crops were rotated with nitrogen-depleting crops. After the discovery that the major plant macro-nutrients, nitrogen, phosphorous, and potassium (NPK) could be manufactured and spread on our lands, an agricultural revolution took place. Crop yields increased dramatically. A new chemical industry was born and a new source of pollution was found. Billions of tons of phosphates, potash, and nitrogen-bearing chemicals are now being poured out on the land and, to some extent, washed into our water ways.

Another source of less toxic pollution is the gradual eroding of our agricultural lands by wind and water. The Colorado River after leaving the high Rockies enters land formations where water erosion cuts through sedimentary rocks that are easily eroded. The result is a river that has been characterized as being "too thin to plow and too thick to drink." However dams have helped to contain and settle out this residue with the result that the great canals flowing from the Colorado to the fields of Southern California are, by comparison, pure water.

However, other waterways have seen the reversal of the process. The mighty Mississippi carries millions of tons of top soil from the heartland of America to build deltas in the Gulf of Mexico. The Amazon is carrying scarce soil from agricultural lands that were once Brazilian rain forests. All around the world the water and the wind is removing soils and the deserts, in many places, are encroaching on arable lands.

THE ROLE OF SOLID-STATE FUSION ENERGY

There is no longer a question among the informed that solid-state fusion is a reality. The question now is, "Can solid-state fusion become a commercial source of energy?" The answer is, "Yes."

Within 20 days after Pons and Fleischmann announced their incredible discovery, ten teams of scientists in various nuclear energy laboratories and universities in India had replicated the discovery. In America, our nuclear laboratories are still writing articles about their negative results. This dramatic difference in achievement requires some explanation.

India is a land of 800 million people. The growth in energy production is a critical national priority. Therefore, several scientists had been, for several years, experimenting with various forms of nuclear fission to help solve the national energy problem. Some Indian scientists were working in the area of cold fusion and in the electrolysis of heavy water seeking the means by which the vast energy of water (actually of the deuterium in water) could be unleashed.

When Pons and Fleischmann announced their incredible discovery, scientists in India had only to modify some of the experiments they were already performing. In America, the fusion research teams were all working on hot fusion and lacked the experimental knowledge of working with electrochemical fusion. The result is history. Ten Indian teams from nuclear energy laboratories replicated the Fleischmann-Pons Effect (FPE) within 20 days. In the United States where little or no electrochemical work was being performed in our ten tax-supported nuclear laboratories, the results were negative.

However, at Texas A & M a group of scientists, including some internationally renown electrochemists, replicated the FPE within less than three weeks.

In India some 18 teams are now working on solid-state fusion. The results hold great promise for the commercial production of energy. One

group has demonstrated and calculated that the energy available from solid-state fusion compares favorably with the energy density in a modern coal-fired power plant. Their preliminary design calculations show that a plant can be built and produce electricity at about one-fourth the cost of an equivalent coal-fired power plant.

SOME PROBLEMS IN POWER PLANT DESIGN

This power plant design by Indian scientists is probably based on some reasonable technological forecasting in which it is predicted that the life of the fusion reactor parts will be extended and that some current known cold-fusion reactor problems are handled. However, work is proceeding on the construction and testing of a five-foot long palladium mesh cathode. (As far as the author knows, the Indian report is the first mention of the use of a palladium mesh for a cathode. The removal of heat from the small wires of a mesh is obviously an improvement over a rod configuration).

Some of the problems that must be resolved before a commercial power plant can be designed, built, and work successfully are:

* Heat exchange designs must be improved to work effectively with the relatively lower level of heat from solid-state fusion (as compared with the level of heat from a coal-fired boiler.)

* The metal lattice (palladium or titanium) must remain stable and productive over long periods of time before removal and refurbishing is required.

* The observed bursts of energy (and sometimes neutrons) must be controlled.

* The reproducibility of the effect must be improved.

* The production of tritium must either be avoided or the tritium carefully contained. (Tritium is almost as hazardous as leaded gasoline).

THE IMPACT OF LOW-COST ENERGY ON THE ENVIRONMENT

Although it takes several years to design and build a power plant, the cumulative impact of the widespread use of solid-state fusion energy is expected to have a beneficial impact on the environment. First, the amount of fuel that is available is enormous. All fresh and salt water contains about one gallon of heavy water for each 7000 gallons of normal water. Calculations show that the available deuterium can provide the energy needs of the world for several million years.

In the early days of nuclear fission power plants, the happy talk was that energy would become so cheap that it could replace all other energy sources. This over optimism must be, and is being, replaced by careful and practical projections. There is no question but that the deuterium fuel costs will be low (about one cent per gallon of fuel oil energy equivalent.) However, plants must be built, maintained, and periodically refurbished. The cost of capital plus the cost of all maintenance will be responsible for an estimated one-fourth of the equivalent costs of fossil-fuel fired power plants.

The best estimate for the cost of energy from solid-state fusion is that it will cost from one-fourth to one-half the cost of current electrical power. However, some further cost reductions might be achieved by siting small plants near the areas of power consumption.

PROJECTED IMPROVEMENTS

Assuming that the electrical power from solid-state fusion is practical and lower in cost than power from fossil-fuel power plants, then the impact on the environment will be beneficial.

The following trends toward improving the environment are forecast:

1. Fusion energy will replace fossil-fueled energy with a reduction in atmospheric contamination. Acid rain will decrease.

2. The transportation of oil will decrease and therefore the potential for oil spills will decrease.

3. The transportation of fossil-fuels by train and truck will decrease with a decrease in air pollution.

4. Energy costs will decrease, power plants will be sited in appropriate regions of the world so that the removal of wood for energy will decrease. The result will be the preservation and, perhaps, the regeneration of some of the world`s watersheds.

5. The decrease in sulfur in the atmosphere will result in an increase in the need for the production and application of agricultural sulfur.

6. Low-cost energy will be used to process human-produced wastes and garbage. Metals, glass, paper, and plastics will be recycled. The rivers and oceans will not be used as much for dumping garbage and sewage.

7. Low-cost energy will make it practical to dredge the rivers and reclaim the soils and restore it to agricultural lands.

8. Low-cost energy will be used to store, distribute, and process water so that the agricultural lands are retained or protected from the periodic damage by wind and water.

9. Low-cost energy will be used to process brackish or salt water for agricultural use in reclaiming lands lost to the desert.

10. Remotely sited solid-state fusion power plants will be sources of waste heat that will be used for the promotion of food production, probably under greenhouse conditions.

11. Agricultural products will be grown in less temperate regions of the world with a reduction in food transportation costs and a reduction in the associated transportation pollution.

12. Companies involved in power production, including alternative energy sources, will be impacted by the lower cost of solid-state fusion energy.

13. Low-energy costs will increase the building of plants for recycling home and industrial wastes. The municipalities of the world will consider legislation for the control of waste processing that would be prohibitive in today's world. The result will be the gradual cleaning of waterways and even the mining and processing of some landfills for the glass and metals they contain.

14. Home and industrial greenhouses will become practical. The increase in local gardening will decrease transportation pollution and moderate the demands for more agricultural developments.

15. The processing of home sewage at high temperatures (to destroy disease-causing micro-organisms) will increase and the residue be used for agriculture purposes.

16. Stringent laws will be passed to prevent the pollution of rivers, lakes, and oceans. National waterways will be restored to more pristine conditions and natural aquatic life will again inhabit dead rivers, lakes, and seas. Commercial fishing will be restored in vast areas such as some coastal regions of the U. S. and Europe.

17. Improved agricultural practices involving the principles of organic gardening and farming will become widespread. The use of chemical fertilizers will decrease with the resulting

decrease in the pollution of some of the world's rivers and lakes.

18. Large sources of underground brackish water will be processed for agricultural purposes. Some desert lands will be restored to production.

19. Planting and watering of new woods and forests will be encouraged. The result will be the trapping and containment in growing trees of some of the atmospheric pollutants and the production of oxygen.

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E. LATEST NEWS AND DEVELOPMENTS

Dr. Faile (Ohio correspondent to FF) has sent us the following papers:

K. Murukesapilliai, "Ignition of Thermonuclear Fuels Utilising the Energy Liberated in $^{6}Li(n, T)^{4}He$ Reactions.", Japanese Journal of Applied Physics, Vol. 28, No. 8, pp 1462-1467, (August 1989). Note: Murukesapilliai is with the Dept. of Physics, University of Jaffna, Sri Lanka. The paper is of interest for its discussion of the lithium helium reactions which "occur readily at room temperature and liberate 4.8 MeV per reaction."

K.H. Johnson and D.P. Clougherty,"Hydrogen-Hydrogen / Deuterium-Deuterium Bonding in Palladium and the Superconducting/Electrochemical Properties of PdHx/PdDx.", Modern Physics Letters B, Vol. 3 No. 10 pg 795-803 (1989). Note: The paper discusses strong similarities between superconductivity and fusion potential. A formula is developed for calculating the upper limit to the fusion rate of about 5 x 10^{-24} fusions per deuteron pair per second in Pd. This value is considerably larger than the figure of 10^{-70} fusions per deuteron pair per second for an isolated D-D molecule. The authors note that this figure is still too small to explain excess heat.

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Marcia Freeman (Washington, D.C. correspondent to FF) has sent us copies of the following:

M.M. Hecht, "Cold Fusion is Alive and Well.";
R. Maitra, "India joins the Race to Prove Cold Fusion."; and
K. Yazawa, "Cold Fusion in Japan: Excitement and Success."; all appearing in 21st Century Science and Technology, September-October 1989.

Ramtanu Maitra, "Cold Fusion: New Findings Overpower Stale Lies.", a series of interviews with various U. S. scientists working in cold fusion. 21st Century Science and Technology, November-December 1989.

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G. CALL FOR PAPERS

1990 INTERNATIONAL CONFERENCE ON COLD FUSION
*Vienna...May 17-18, 1990
*Toronto..June 7-8, 1990
*Bombay...November 15-16, 1990

Send 2 copies of abstract of paper and biographic data to:

Dr. V.M. Bhatnagar
Alena Enterprises of Canada, Chemicals Division
P. O. Box, Cornwall, Ontario, K6H 5V7

Abstract Deadline: November 30, 1989.

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COMING IN THE NOVEMBER ISSUE:

The November issue of **FUSION FACTS** will contain more information about the NSF/EPRI Workshop and on the papers presented at the October meeting of the Electrochemical Society. The impact article will be on the agricultural industry. Further information on a FUSION BIBILIOGRAPY with a search and retrieval program will be provided. This computer-based diskette is expected to save our readers many horus in tracking fusion references.

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