The Fourth International

Report from Maui

By the sea at Maui—cold fusion conferences as far as the eye could see. The International Conferences on Cold Fusion have become milestones in a rapidly expanding field. The Fourth International Conference on Cold Fusion (ICCF4), held on Maui, December 6-9, 1993, did not disappoint. At the very beautiful Hyatt Regency in Lahaina, dozens of researchers announced landmark and breakthrough results. How fitting this time to have a cold fusion conference on a beautiful island surrounded by the fuel of the future.

In the background of Maui were sweet and bitter memories of earlier cold fusion conferences. One year after the March 23, 1989, cold fusion announcement, the First Annual Conference on Cold Fusion convened in Salt Lake City amid loud controversy. *Nature* magazine sent no reporter, but still felt free to attack the conference in its editorials. Robert Park of the American Physical Society on national television called that meeting a "seance of true believers."

The more serene Second International Conference on Cold Fusion (ICCF2) was held in Como, Italy, June—July, 1991. Nagoya, Japan, was the venue of ICCF3 in late October 1992, which had the full support of the Japanese scientific establishment. The Maui conference was sponsored by the U.S. Electric Power Research Institute (EPRI) of Palo Alto, California, the research arm of the American electric utility industry, which continues to fund cold fusion research at SRI International and elsewhere.

Future cold fusion conferences will continue the custom of following a rotation: U.S., Europe, and Asia. At the conclusion of the Maui conference, the Organizing Committee announced that ICCF5 will be held in the spring of 1995 in Nice, France, and ICCF6 in Beijing, China, thus fulfilling the strong wishes of the Chinese researchers and government to host a cold fusion conference.

The four-day conference consisted of morning plenary sessions— each with five or six speakers. The afternoons featured for the first time *parallel* sessions, e.g. one session devoted to calorimetry, one to theory, one to nuclear effects, and one to materials, in various combinations for the different days. A measure of how mature the cold fusion field has become is that it required parallel specialist sessions. Thus, it became impossible, for the first time, for one person to take in everything. The scope of the conference encompassed almost 300 participants, and more than 150 technical paper presentations. A technical poster room was open throughout the conference. On the afternoon of the closing day, a panel session of participants summed up ICCF4.

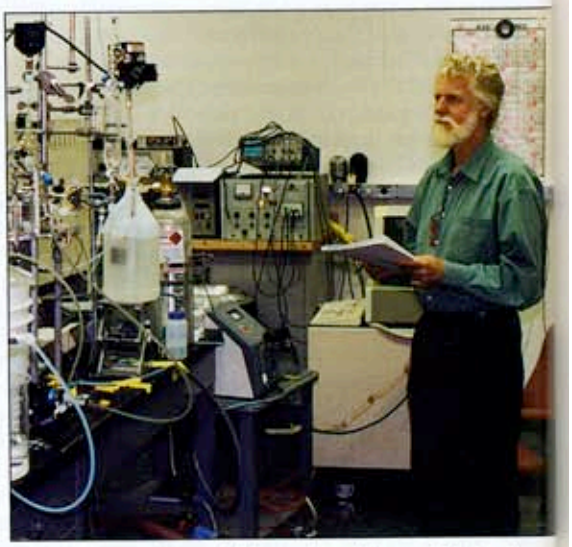
Since it is obviously impossible in a very short space to relate all that took place at the conference, this is a modest attempt to recall some of the most significant findings and events. To illustrate the depth and breadth of activities, we have appended the pre-conference listing of papers, which was necessarily incomplete. Also, Professor Robert A. Huggins of the Department of Materials Science at Stanford University, an early pioneer in the cold fusion field, has graciously provided *"Cold Fusion"* Magazine with his impressions of ICCF4, which we reprint after this overview of ICCF4 highlights. Professor Huggins writes of the conference from the special viewpoint of a materials scientist.

Japan's New Hydrogen Energy (NHE) Research Program

During the first morning session, Dr. K. Matsui, director of the R&D Center for New Hydrogen Energy in the Institute of Applied Energy in Tokyo, announced that the NHE program would be launched to "clarify the feasibility of NHE as one of the future energy sources." The period of the project: November 1993—March 1997. The budget: $30 million dollars for four years. [This is a budget request, for which confidence exists that it will be granted.] Leading industries are involved: Ten (10) electric utilities, plus Tokyo Gas, Mitsubishi Heavy industries, Hitachi, Toshiba, Nippon Steel, Aishin Group (Toyota), Tanaka Kikinzoku, NTT, IHI, and NFI. The organizational chart shows that MITI will provide the research funding to the New Energy Development Organization (NEDO), which will have under it the Institute of Applied Energy—the R&D center for the NHE project based in Tokyo and the NHE Laboratory in Sapporo. Cooperation with EPRI and SRI International in the U.S. is explicitly provided for.

Cold fusion with solid state devices

One of the most startling developments at ICCF4, one which has already captured the attention of the Japanese press, was that the cold fusion effect can be produced at a high level in a solid ceramic material, such as a strontium-cerium-oxide "proton conductor." These materials are similar to high-temperature superconductors. Professor T. Mizuno and his group at Hokkaido University have tested these "solid electrolyte" plates maintained at 300 to 400°C. Excess heat on the order of 100 watts per square centimeter emerged during absorption-desorption cycles of deuterium-containing hydrogen gas under the application of an alternating elec-



Roger Stringham, visiting at Los Alamos National Laboratory in 1993, conducts a "microfusion" experiment with the E-Quest device.

Conference on Cold Fusion

BY EUGENE F. MALLOVE

tric field. Excess heat amounting to 50 watts for some 20 hours was achieved. The input electric power was tiny—about 7.2 x 10^{-4} watts. The power ratio was thus a huge 70,000. This device was only 0.8 cm in diameter and 0.1 cm thick.

True, the Mizuno solid-state device requires elevated temperatures of a few hundred degrees C for the excess power to emerge, provided in this experiment by a separate electrical resistance heater. In a practical implementation, the reaction chamber would be well-insulated so that the energy of the reaction would self-heat the ceramic, unlike in Mizuno's experimental apparatus where heat transfer to the environment was large.

Independently of Mizuno et al, Jean-Paul Bibérian of R&D International, Orinda, California, had a poster display on his "Solid State Cold Fusion" device made of $AlLaO_3$, aluminum lanthanum oxide. He, too, has observed what appears to be copious excess heat evolution in a deuterium atmosphere. It appears that he is able to achieve 500 watts/cm^3 from his small wafer crystals, with a total output power of tens to a few hundred watts. The excess heat is highly reproducible. The originator of this work, according to Bibérian, was F. Forrat in France, who took out French patents in 1989 and 1990.

Confirmation of excess heat in ordinary water

The Indian group at the Bhabha Atomic Research Center (BARC) brilliantly confirmed its earlier series of tests with ordinary water. They continue to get excess heat and, in many cases, tritium above background level. They have even made a serendipitous discovery: that stainless steel poisons the process and prevents excess heat evolution. The group studied different types of nickel. Out of a series of 28 cells, 14 showed excess heat. Excess power in these cells was in the range 0.2 to 0.7 watt.

The BARC group has used off-the-shelf consumer "thermos bottles" to conduct its experiments. The thermal characteristics of the standard internally aluminized thermos bottles is typically 20-35°C temperature differential (between inside and ambient) per watt of input power (i.e., 20-35°C/watt). The group now reports a simple technique of de-aluminizing the thermos bottles with nitric acid. This allows the cells to reach steady state temperature within 10 hours instead of the 24 hours required earlier; the calibration constant now is 7-10°C/watt.

Dr. Srinivasan told this author that almost everyone at BARC now accepts the reality of cold fusion. He is planning eventually to put together a "kit" that will allow any experimenter to observe the cold fusion excess heat effect in light water—with >90% confidence. Dr. Srinivasan currently is on leave from BARC and is working at SRI International to help that group perform ordinary water-nickel experiments.

Electrochemist Dr. Reiko Notoya of Hokkaido University also has achieved excess heat in ordinary water, and like the BARC researchers, finds tritium above background level.

The team of Professors Robert Bush and Robert Eagleton of California Polytechnic University continues to report excess heat results in electrolysis with light water and potassium carbonate, as well as sodium carbonate electrolyte. The excess heat found in sodium-carbonate cells—a finding also of the BARC group—runs contrary to the claim of Dr. Randell Mills of HydroCatalysis Power Corporation in Lancaster, Pennsylvania, that no such excess is found in sodium carbonate solution, one of the requirements of Dr. Mills' electrocatalytic ("shrunken" hydrogen atom) theory for explaining excess heat.

Bush and Eagleton performed experiments in special "de-deuterated" light water having only 1% of the normal trace heavy water content. These tests, they say, prove there is a "genuine light water excess heat effect," because the de-deuterated light water cells gave the same order of excess heat as the ordinary light water cells.

The most remarkable claim of Bush and Eagleton is a seemingly definitive experiment demonstrating that rubidium (from rubidium carbonate electrolyte) transmutes into strontium during excess heat experiments. Examination of the strontium isotopes in the solution showed "statistically-significant enhancements in the ratio of $^{86}S_r$ to $^{88}S_r$ relative to the natural abundance ratio," i.e., by 325 standard deviations. The claim is that this rules out contamination from possible natural sources of strontium.

Heat After death

This follows work reported in Pons' and Fleischmann's May 3, 1993 *Physics Letters A* paper on heavy water cells that go to boiling, boil away virtually all of the heavy water, and then remain at 100°C for three hours without electric current input. This high temperature in the open dewar cell—caused by an electrode obviously hotter than the 100°C of the vapor in the cell—has been found to occur for much longer periods, for 40 hours or more. Other work reported at the conference (or hinted at as "work in progress") suggests that various materials, including special types of ceramics in deuterium atmospheres, can remain hot for long periods with minimal or absolutely no current input. This remarkable phenomenon of "heat after death," i.e., infinite power ratio, may well become a primary direction in a variety of cold fusion systems.

Triggering cold fusion by radio frequency stimulation and magnetic fields

Drs. John Bockris, Dennis Letts, and Dennis Cravens separately discussed the astonishing new finding, discovered by Dennis Letts, that radiofrequency stimulation (RF) in the MHz range (around 82, 365, and 533 MHz) produces excess heat in electrochemical cold fusion experiments. In particular, RF stimulation must be applied at precise frequencies to bring about the effect, and the effect typically occurs within 30 minutes of imposition of the RF. The power levels of RF imposed on various cells were low, in the range 10— 300 milliwatts. Magnetic fields, either from permanent magnets or electromagnets, also seem to enhance heat production.

Heat production with multi-layer thin-film electrodes

Professor George H. Miley, et al, Fusion Studies Laboratory, University of Illinois, have developed a unique process to coat a stainless steel plate electrode (25 mm x 25 mm x 3 mm) with alternating layers of titanium and palladium, which are deposited by a special electron-beam evaporation method. The layers have a total thickness of only 100 Angstrom units, topped off by a 60 Angstrom thick layer of chromium to "act as a barrier to retain a high loading of deuterium or hydrogen." In the reported experiments they work with light water and LiOH electrolyte. They have achieved about 2 kilowatts/cc power production in these thin films. They have actually gone as high as 10 kW/cc, but the layers have a nasty habit of peeling off at these power levels.

Preliminary confirmations of the Kucherov et al glow discharge experiment

Professor Peter Hagelstein of MIT's Department of Electrical Engineering and Computer Sciences showed one gamma ray emission line that this group attempting to replicate the Kucherov et al experiment thinks it has found—a 129 KeV feature that may represent the ^{105}Pd to ^{105}Rh transmutation found by Kucherov et al in Russia. This is only a very preliminary finding.

A group known as "Space Exploration Associates" of Cedarville, Ohio, has obtained preliminary confirmation of gamma radiation in a Kucherov replication attempt. The group was successful in seeing the gammas six times, with no failures. The MIT group is collaborating with them.

A lovely quote from the team's preprint: "It is perhaps worthy to note that Fermi won the Nobel prize for mistakenly believing that he had transmuted uranium by bombarding it with neutrons. So strong was the prevailing belief in the integrity of all atoms that the splitting of uranium was inconceivable. Hence Fermi's experiment was not interpreted correctly at first. Thus, the finding that palladium may be transmuted under the influence of electromagnetic fields in the presence of deuterium may likewise be inconceivable, but may nevertheless be the truth."

(L to R):Dr. Talbot Chubb (Research Systems, Inc.), Dr. Yan Kucherov (ENECO), and Prof. Robert Huggins (Stanford University)

Dr. Martin Fleischmann, in his concluding remarks at the end of the conference, praised Kucherov and said that in France they had reproduced "parts" of the Kucherov experiment.

Dr. Yan Kucherov spoke and reviewed both the thermal excess energy and nuclear effects data that his Moscow group has obtained over the past four years in more than 500 glow discharge experiments in deuterium atmospheres.

Helium-4 results

Evidence continued to build that at least in some varieties of cold fusion experiments, helium-4 (^{4}He) is produced as "nuclear ash." Dr. Melvin H. Miles of the Naval Air Warfare Center at China Lake presented convincing evidence of a correlation between the measured excess power in Pd-heavy water cells and the production of helium-4. His group claims helium production in the range 10^{11} to 10^{12} helium atoms per second per watt of excess power. Dr. Miles said that this is "the correct magnitude for typical deuteron fusion reactions that yield ^{4}He as a product." By this he meant that helium yield would be about right if the powerful 23.8 MeV gamma ray normally associated with the D + D to ^{4}He reaction emerged instead as thermal energy.

The group used metal flasks this time to collect gas samples, instead of the glass vessels used in earlier runs. Critics had complained that the glassware could be a source of contamination by atmospheric ^{4}He diffusion through the glass. Dr. Miles suggested that at the low excess power levels of his recent experiments (~0.1 watt), the possible measurement errors were large, but still he had confidence that the ^{4}He produced exceeded the levels in control experiments (runs with no excess heat).

The group of Professor Daniele Gozzi et al at the University of Rome examined ^{4}He from Pd-heavy water cells by continuous mass-spectrographic analysis—in six cells for over 1,000 hours. They found a correlation in the emergence of helium-4 peaks and rises in excess heat. However, the group is still trying to rule out contamination from atmospheric helium-4 by using the neon-20 (^{20}Ne) measurement simultaneously.

Cold fusion by hydrogen sparking

Dr. Jaques Dufour of Shell Research (France) reported on excess energy produced by sparking onto various metal electrodes in hydrogen gas atmospheres, both light and heavy hydrogen. He reported stable excess energy production of a few watts for periods of several weeks.

Ultrasonic activation—"microfusion"

Roger Stringham and Russ George presented their work. It is clear that they and others who have checked these experiments find substantial levels of ^{4}He after ultrasonic (20 kHz sound frequency) beaming against palladium immersed in heavy water. The ^{4}He is roughly proportional to the excess power evolved, and is said to account for about 20% of that excess. ^{4}He levels are higher than atmospheric concentration, up to 65 ppm, which is on the order of 10 times higher, so atmospheric contamination is unlikely. The excess heat level claimed by this group is at a level of up to 90 watts (input power, 350 watts). The local heating of palladium foils is so great that these occasionally melt through under even continuously circulated heavy water. No observable excess heat or melting was found in ordinary water control experiments. The reaction chamber is normally pressurized to several atmospheres by D_2 and argon gas.

Stringham et al suggest that the collapse of cavitation bubbles created by the ultrasonic transducer at the surface of the palladium injects deuterons into the Pd lattice. The metal lattice, thus locally and rapidly loaded to a high level, gives rise to D + D "microfusion" reactions. On microscopic examination, they have observed evidence for localized ejection of molten metal.

They also claim to have found after testing that isotopes of cadmium are present "skewed in relationship to natural abundance ratios." In particular, they suggest that ^{114}Cd has been formed from the reaction of an alpha particle (^{4}He nucleus) and ^{110}Pd. Measurements made at various laboratories found no tritium, gamma ray, or neutron evolution from the operating apparatus.

Stringham et al, who have a company based in Palo Alto, California, E-Quest Sciences, are offering to sell their "microfusion" apparatus to serious groups as a research tool. E-Quest will guarantee the ability of the device to produce excess power and ^{4}He.

IMRA Japan's work on material properties and triggering parameters

The IMRA Japan laboratory group of Dr. Keiji Kunimatsu continues to pioneer the investigation of alloys, current densities, and loading in Pd-heavy water cells. The group's work in closed cell calorimetry is viewed as among the finest in the world. IMRA Japan uses deuterium gas to pressurize its cells so that the anode becomes a gas-diffusion electrode.

The team has found alloys of Pd using 5% rhodium to be of particular value. IMRA Japan found that Pd materials from different vendors produced excess heat, with one exception. It found excess heat to be "almost proportional" to current density. The critical current required to turn on the excess heat is about 200 mA/Cm^2 of cathode surface area, and the critical loading ratio for turn on was found to be D/Pd=0.84. The addition of thiourea was effective in pushing the loading ratio over 0.9. No excess heat emerged in light water experiments with Pd cathodes.

SRI International's McKubre gears up for nuclear measurements

The EPRI-funded SRI International group, led by Dr. Michael C.H. McKubre, has continued to verify its earlier excess heat work, but is now rapidly mounting a search for nuclear products, including ^{4}He. It wishes "to attempt to quantify the appearance, and set limits on the non-appearance, of po-

tential products of nuclear reactions: neutrons, gamma and x-rays, ^{3}He and ^{4}He, and isotopic shifts of Pd lattice and electrolyte-derived species." The group made a serendipitous discovery of the beneficial effect on excess power of going to higher temperatures. This temperature effect is now being found almost universally in the cold fusion field.

Dr. Reiko Notoya (Catalysis Research Center, Hokkaido University)

McKubre said that his group has "reproduced, wholly, our previous observations of excess power, and are beginning to study the controlling parameters for the purpose of attempting scale-up."

Tritium production confirmation

Dr. Fritz Will, formerly director of the National Cold Fusion Institute in Utah, and now temporarily with EPRI, reported the reproducible and incontrovertible production of tritium in Pd-heavy water cells that were closed. This work has recently been published in the *Journal of Electroanalytical Chemistry*. It appears to show that tritium can be produced at low energy. Absolutely no tell-tale 14 MeV neutrons were detected that would have been evidence of collisions by T with D in the lattice. Dr. Will meticulously outlined all the reasons to believe that the tritium was generated and could not possibly have been pre-existing contamination. On chance alone, he said in conclusion, it would have required a probability of 1/130,000 to obtain the result of picking the four active electrodes out of the total of 17.

Drs. Tuggle and Claytor of Los Alamos National Laboratory reported continued success in producing tritium continuously and reliably in various "novel morphologies of palladium." They use small solid wires combined with pressed metal powders, and observed tritium production in the range over 5 nano-Curies per hour (>5 nCi/h), which they said "far exceed" their previous results.

The Case of the Missing Scientist

Dr. Kevin Wolf of Texas A&M University was supposed to have been the lead speaker for the December 7 session, but he didn't show up and no explanation was offered. Three high-level sources have seen the data report that Dr. Wolf has discovered astonishing transmutations in three of the palladium rods that he tested in Pons-Fleischmann-type protocols. He has observed many different gamma ray spectral lines from short-lived isotopes. He has no doubt that these transmutations are real. This makes his work similar to the results found by Kucherov in Russia, which was reported in *Physics Letters A*, November 9, 1992.

Unfortunately for Dr. Wolf, he has had an ambivalent position in the cold fusion field after accusations in 1990 by Gary Taubes of fraud in the Bockris lab at Texas A&M. This led Wolf to recant inappropriately his tritium results. Now he can barely imagine associating these extremely intriguing results—in which he allegedly fully believes—with the "discredited" field of cold fusion and transmutation. We know that Wolf wanted to attend the meeting, even though he was going to suggest that these transmutations were really due to cosmic rays from space, which "just happened" to be detected during a cold fusion experiment. It has been learned that he was under great pressure by an opponent of cold fusion,who funds him, *not* to attend the ICCF4 conference.

Hydrosonic Pump continues to evidence excess energy

One of the most unusual presentations at Maui, a last-minute addition to one of the special afternoon sessions, was prompted by a journalist's article. An unusual apparatus came to light as a result of Jerry Bishop's cover story on cold fusion in the August 1993 *Popular Science*. That story prompted Georgia inventor James L. Griggs to contact people in the cold fusion field. He wanted help to explain the baffling excess energy that he and his colleagues had regularly observed with their Hydrosonic Pump.

This device, which has been developed and patented by Mr. Griggs of Hydro Dynamics, Inc. of Cartersville, Georgia as an efficient heating unit for buildings, has regularly demonstrated (it is claimed) significant levels of excess energy. It consists of a specially-designed cylindrical aluminum rotor that spins at close tolerances inside a steel case. Ordinary water is forced through the gap between rotor and case, thus producing hot water and/or steam via turbulent action. The measured energy content of the steam and hot water apparently exceeds the electrical input power of the device by a large margin—10-100% and beyond.

If this effect is real, perhaps this device is related in some way to the cavitation-induced "microfusion" apparatus of Roger Stringham.

Griggs and his colleagues gave a brief presentation at the Maui conference. *"Cold Fusion"* Magazine will continue to investigate the Hydrosonic Pump's performance, and will bring you more news as further testing develops.

Theories abound

At ICCF4, as at previous cold fusion conferences, dozens of papers were devoted to theories that might explain the seemingly bewildering host of experimental findings. *"Cold Fusion"* Magazine will delve into these arcane theoretical matters in a subsequent issue, making a valiant effort to disentangle some of the most difficult issues theorists face. Apologies for this postponement to our theorist colleagues, who perhaps view their efforts as equally important with experimental findings.

We will make one bow toward discussing theory, because ^{4}He nuclear ash has been such a hot topic in the cold fusion field, and because Nobel laureate Julian Schwinger's paper (read in his absence by this author) suggested how a metal lattice reaction generating ^{4}He would not have to be commensurate with excess energy. This is the part of Schwinger's talk ("Cold Fusion: A Brief History of Mine") pertinent to that reaction:

"I note here the interesting possibility that ^{3}He produced in the pd [proton-deuteron] fusion reaction may undergo a secondary reaction with another deuteron of the lattice, yielding ^{5}Li (an excited state of ^{5}Li lies close by). The latter is unstable against disintegration into a proton and ^{4}He. Thus, protons are not consumed in the overall reaction, which generates ^{4}He."

"To this I add, as of some time in 1992, that observations of ^{4}He, with insufficient numbers to account for total heat generated, are consistent with the preceding suggestion. The initial pd reaction produces heat, but no ^{4}He. The secondary reaction generates heat and ^{4}He. There is more total heat than can be accounted for by ^{4}He production. The smaller the ratio of secondary to primary rates, the more the ^{4}He production will be incapable of accounting for the heat generation."

Concluding remarks

Rounding out ICCF4 were summations of the meeting by various senior participants. Dr. Edmund K. Storms, Los Alamos National Laboratory (retired) made one of the most comprehensive and eloquent statements, which *"Cold Fusion"* Magazine has reprinted *(see page 48)*. To summarize, ICCF4 showed that the cold fusion field is becoming ever more vital and expansive—clear evidence of a scientific and technological revolution in the making. Not all papers reported success in finding excess heat and nuclear products, but inexorably scientists are learning the conditions for repeatability of positive experiments, and discovering new methods for generating the phenomena. With small steps and large leaps, the pieces of the puzzle are falling together.