



FUSION POWER ASSOCIATES

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HUNTER SHIFTS FUSION PRIORITIES

DOE Director of Energy Research Robert O. Hunter, Jr., has decided to shift emphasis within the magnetic fusion program to put more effort on near-term studies of tokamak physics and less emphasis on long-range technology, materials research, alternate and advanced concepts, and preparation for tritium operation in TFTR. In addition, sources indicate that lower than anticipated OMB budget allocations for FY 90 will result in additional delays for the Compact Ignition Tokamak (CIT) and no cost-of-living increases for the fusion program as a whole.

Although some shifts in program emphasis in FY 90 were expected as a result of the MFAC Summer Study (see our October newsletter), the immediate shifts ordered by Hunter for the current year caught the fusion community by surprise and triggered strong negative responses from Representatives Roe and Lloyd of the House Science, Space and Technology Committee. As a result, the planned budget shifts for FY 89 have been scaled back from an original plan of about \$23 million to about \$13 million. Immediate casualties of the Hunter action were approximately 120 industry personnel who were given one-day's notice to stop work by the Princeton Plasma Physics Laboratory.

The primary results of the proposed budget shifts are to effectively halt plans for deuterium-tritium operation of TFTR, causing at least a two year delay; to severely hamper operations of the recently completed stellarator (ATF) at Oak Ridge; to further constrain construction of the Compact Physics Research Facility (CPRF) and other operations at Los Alamos, and to make widespread cuts in materials and long-range technology projects. Programs targeted for acceleration include operations and upgrades of DIIID at General Atomics and TEXT at the University of Texas to incorporate electron

cyclotron heating tests on plasma confinement; increased effort on tokamak theory, and enhanced gyrotron development. In addition, a study of the potential of inertial fusion for civilian applications is proposed.

TRANSPORT TASK FORCE

The budget shifts proposed by DOE jumped the gun on a careful analysis of the status of understanding of tokamak energy transport physics and what could be done to improve it. This study, recommended by the MFAC Summer Study, is being carried out by the Transport Task Force, headed by Jim Callen of the University of Wisconsin (see our November newsletter). This group will hold a meeting January 11-13 at the University of Texas. The meeting is open to all interested parties from the morning of January 11 through the morning session on January 12. The open sessions will consist of review-type presentations on theory and experiments related to transport. For further information, contact Jim Callen at (608) 262-1370, Dave Baldwin at (512) 471-1322, or Carolyn Valentine at (512) 471-6145.

ELECTRON CYCLOTRON HEATING REPORT

The search for experimental techniques to improve tokamaks has centered recently on uses for electron cyclotron heating (ECH) technologies. It is believed that improved plasma confinement (reduced energy transport) might result from the control of heating and current profiles made possible by the localized nature of electron cyclotron wave-plasma interactions. ECH is also viewed favorably by fusion reactor designers as an elegant and efficient way to couple power to plasmas. Progress in this area has historically been paced by the availability of high power ECH sources

(primarily gyrotrons) at the high frequencies required by high magnetic field strength to confine the plasma.

This ECH topic was the subject of an MFAC (Panel XXI) study, commissioned by DOE on May 31, 1988. The study report is entitled "Electron Cyclotron Heating Requirements for the Fusion Program," dated December 6, 1988. The report was accepted by MFAC and sent to DOE director of energy research Robert O. Hunter, Jr. Copies can be requested from MFAC chairman Fred Ribe (206) 543-0355, or from the panel co-chairmen, Jim Leiss (301) 948-5649, or Lee Berry (615) 574-0988.

The panel noted that experiments up to 4 MW using 200-300 kW gyrotrons in the 60-100 GHz range have resulted in plasma heating in accordance with theory. They support the development of a 140 GHz, 1 MW gyrotron as a stepping stone to the development of a 280 GHz, 1 MW cw tube. They note that 100 kW cw has been produced at 140 GHz and 800 kW pulsed has been produced at 280 GHz. They also support the development of microwave sources based upon free electron lasers, with lesser efforts on other alternatives, notably the quasi-optical gyrotron and the cyclotron autoresonance maser.

FUSION PROGRESS: ALTERNATE CONCEPTS

Progress on non-tokamak magnetic fusion concepts was summarized by John Sheffield of ORNL at the IAEA fusion conference in Nice, France, in October. Sheffield organized his discussion in terms of ten different concepts: (1) stellarators, (2) reversed field pinch, (3) ultra-low q devices, (4) EXTRAPS, (5) spheromaks, (6) field-reversed configurations, (7) tandem mirrors, (8) simple mirrors, (9) plasma focus and (10) dense Z-pinch.

"The stellarator is an interesting complement in the toroidal area to tokamaks," Sheffield said, "and because you can vary the (magnetic) well and the shear, as well as control it from outside, you may shed light on the whole area of toroidal confinement." In terms of results, Sheffield praised the Heliotron-E in Japan, saying that it had operated at collisionalities of 10^{-2} to 10 and that in the central region of low collisionality "they

found that electron transport is in the region of neoclassical." However, he said, transport remained anomalous in the edge region "which gives a scaling reminiscent of tokamaks." He noted that "the bootstrap current has been seen in L-2 and ATF." A variety of new experiments have shown that "modular stellarators work the same as those with continuous coils," Sheffield said.

With respect to reversed field pinches (RFP) and ultra-low q devices, Sheffield noted that in the RFP "reversal sustainment and the dynamo action is generally believed to be due to nonlinear coupling" of various modes. The role of the conducting shell around the plasma is an important topic for the RFP, Sheffield said. "Experiments have been underway on how resistive can you make it and how much can you rely upon equilibrium toroidal field control to keep the plasma well-centered," he said. "In the future there is the hope of an intelligent shell where you use feedback on specific modes to try to control their growth," Sheffield said.

Sheffield called the initial operation of the MST reversed field pinch device at the University of Wisconsin "particularly encouraging," noting that in initial operation of this low aspect ratio device they have achieved currents of 0.5 megamaps and that there were no volt-seconds problems. "This augers very well for the RFX device which is being built at the University of Padua," in Italy. Early data from MST "suggests that the temperature is proportional to the current and not the current density," Sheffield said.

Sheffield called ultra-low q devices and EXTRAPS (Sweden) "intriguing." Although such devices are normally unstable to kink modes, it is found experimentally that "such a configuration can be set up if you ramp up the current fast enough," Sheffield said.

With respect to spheromaks, Sheffield noted that in the S-1 at Princeton, an experiment which is now terminated, researchers found that the "central electron density times temperature is proportional to the square of the magnetic field, coming mainly from the fact that the electron temperature increases with current density and therefore beta is constant at 4-6%, with the ions hotter than

the electrons." The ion temperature was raised to about 0.5 keV using compression. In the CTX device at Los Alamos, a very rapid current decay is observed that depends on density but not on temperature as would have been expected, a result Sheffield terms "an unfortunate condition." Machine modifications fixed this problem, Sheffield said but then "perversely, they got an instability but it doesn't appear to be the same one that is seen in S-1."

With respect to Field Reversed Concepts (FRC), Sheffield noted "the surprising stability to the tilt mode" of these devices: this may be due to the number of gyro-radii in a minor radius of the plasma, Sheffield said. Scale-up in this parameter, called "s," is being planned at Los Alamos and Spectra Technology. "Respectable parameters" have already been achieved at Los Alamos, Sheffield said.

Sheffield described the Gamma-10 tandem mirror experiment at Tsukuba, Japan, saying they had "very nice data." He also described the TARA device at MIT and the Phaedrus at the University of Wisconsin, which have now been terminated. Increasing the thermal barriers improves confinement, Sheffield noted. Mirror experimentalists are primarily aiming their research toward the evolution of a neutron source for materials testing.

Finally, Sheffield noted work in progress on the plasma focus and dense Z-pinch concepts aimed at achieving increases in pulsed neutrons with increasing current. Typically 10^{11} neutrons per shot are achieved. He noted the "surprising stability" of the dense Z-pinch, e.g., for about 200 times longer than predicted. New experiments are being completed at Los Alamos and the Naval Research Laboratory at the megaampere level. If the plasma remains stable and the temperature continues to increase with current, these devices could produce small plasmas with ion temperatures of many kilovolts.

In conclusion, Sheffield said "I think there has been a lot of exciting progress in all these areas, including a lot of interesting connections between theory and experiment." He said that new facilities coming on line could present us with "exciting data that could stir us up."

VARIAN GYROTRON RECORD

Varian Associates, Inc. of Palo Alto, CA, announced on December 16 setting a new world record in power generation by operating a 140 GHz gyrotron oscillator at 823 kilowatts at a one millisecond pulse length. "It's an important milestone towards our goal of a one megawatt tube at 140 GHz," said Howard Jory, manager of gyro device engineering for Varian's Microwave Tube Division.

The gyrotron was developed under contract with the Department of Energy (DOE) for the University of California's Lawrence Livermore National Laboratory. The 140-GHz gyrotron is the newest member of a family of gyrotrons built by Varian for DOE-sponsored fusion energy research. Varian's previous record-breaking developments have produced 100 kilowatts cw at 140 GHz.

Varian Associates, Inc., a corporate member of Fusion Power Associates, is a diversified, high-technology company with some 12,000 employees and 1988 sales of \$1.2 billion. Headquartered in Palo Alto, CA, it produces systems and components for communications, defense, medical, scientific and industrial markets worldwide. For further information contact Laurie Alire (415) 424-5781.



VARIAN'S NEW 140 GHz GYROTRON

FUSION MATERIALS TESTED IN FISSION REACTOR

Fabrication is now underway at Westinghouse Hanford Company on the first large irradiation test assembly devoted exclusively to fusion energy materials. Experimental specimens are being designed and fabricated by teams of researchers in the U.S. and Japan. The specimens will be inserted into a 40-foot-long test device being assembled by Westinghouse Hanford engineers and technicians, then installed in the Fast Flux Test Facility (FFTF).

"This constitutes the largest and most extensive program of collaboration ever to involve Hanford's advanced reactor capabilities," says Dr. Michael K. Korenko, manager of the Advanced Reactor Development Division at Westinghouse Hanford.

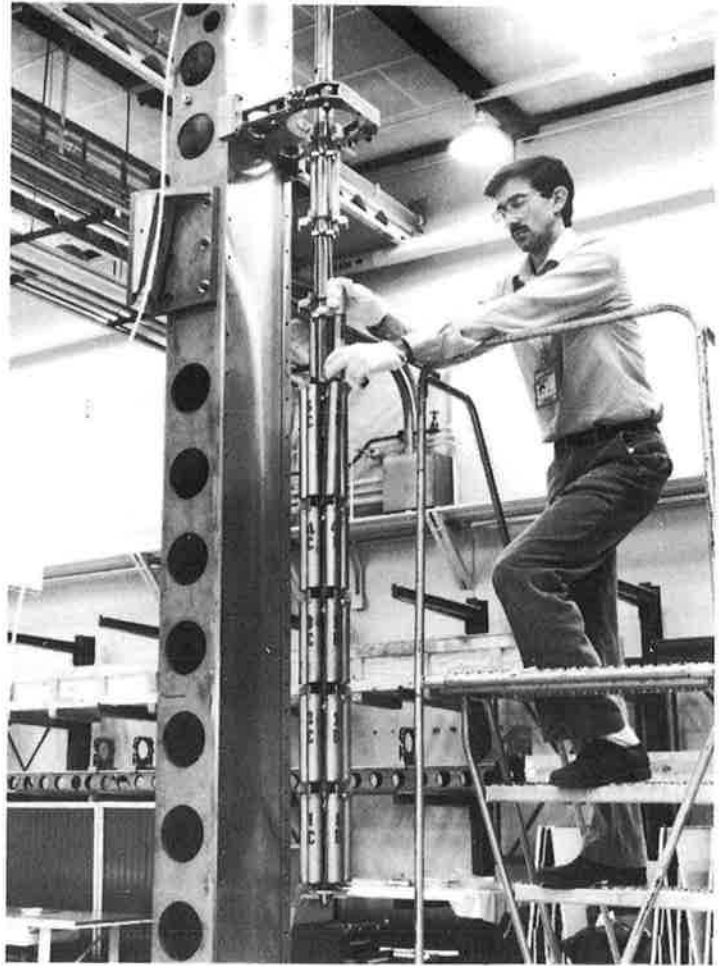
The device, called the Materials Open Test Assembly (MOTA), will be irradiated in the FFTF to determine the behavior of lithium oxide, beryllium and other materials as they undergo intense heat and irradiation. The materials are being studied for potential use in fusion reactor power plants of the future.

FFTF is the multipurpose sodium-cooled fission reactor plant which Westinghouse Hanford operates for the Department of Energy. It is the largest test reactor of its kind in the world, and features unique instrumentation and sensors that gather research data for a wide variety of test programs.

Foreign participation has been provided by international agreements developed through the Department of Energy during the past year.

NEW MFAC PANEL

A new MFAC panel study on "Confinement and Machine Physics" under the chairmanship of Kim Molvig of MIT has begun work aimed at an April 1989 reporting date. The panel will summarize "the status of our understanding of confinement in tokamaks and recommend what needs to be done to improve understanding." It is also to comment on "the capability of the MFE program's machines to produce good physics, regardless of any reactor implications."



FUSION MATERIALS TEST ASSEMBLY FOR FFTF

The study is to include tokamaks, stellarators, reversed field pinch and compact toroid devices.

APRIL MEETINGS

The Seventh International Workshop on Stellarators will be held in Oak Ridge, TN, April 10-14. The workshop will emphasize overview talks, reviews of recent work and topics of general interest. Contact Jim Rome (615) 574-1306.

The Second International Symposium on Aneutronic Power will be held April 28-29 in Washington D. C. Fusion reactions other than DD or DT are covered at the conference. The proceedings of the first symposium held Sept. 10-11, 1987 have been published in Nuclear Instruments and Methods in Physics Research, A271 (1988). Copies are available. Contact Aneutronic Symposium, P.O. Box 3037, Princeton, NJ, 08543.



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CLARKE HEADS CLIMATIC CHANGE GROUPS

DOE Associate Director for Fusion Energy John F. Clarke has accepted an assignment to head two groups at DOE set up to study the issue of global climate change. He will serve as Executive Director of the DOE Working Group on Climate change, reporting to the DOE Under Secretary. This group is charged with defining "the needs of the DOE on global warming over the next few years." He will also chair a task force, reporting to the Director of Energy Research, "to address the issue of how ER's research programs should integrate into the Intergovernmental Panel on Climate Change program." Clarke is expected to retain his chairmanship of the ITER Council (see our July 1988 newsletter), but he will be on indefinite leave of absence from his post as head of the Office of Fusion Energy. That job will be filled by Dr. N. Anne Davies, serving as Acting Associate Director for Fusion Energy.

LANL KrF LASER MEETS MILESTONE

In an experiment December 13, scientists at Los Alamos National Laboratory achieved an output of 2.5 kilojoules in 96, five-nanosecond beams from their new KrF laser called Aurora. The current setup permits 0.78 kilojoules in 48 beams to reach a target chamber. The results marked the accomplishment of a project milestone to reach the kilojoule level by the end of 1988. These initial tests are part of bringing the system up toward its nominal 10 kilojoule design level.

"Krypton-fluoride lasers like Aurora are strong candidates for inertial-confinement fusion drivers because of their short wavelength, high efficiency and potentially low cost," said David Cartwright, Los Alamos' program director for inertial-confinement fusion.

"Although the advantages of krypton-fluoride lasers are well recognized, no integrated krypton-fluoride laser system has demonstrated appreciable output energy in short, optimally multiplexed pulses until now," Cartwright said.

"For these initial tests, a downsized laser beam was used to extract energy from the final amplifier," said Joseph Figueira, Los Alamos' krypton-fluoride laser program manager.

"In January, a full-sized final amplifier mirror will be installed, resulting in expected laser energies from the final power amplifier in the range of four to seven kilojoules," Figueira said.

FPA ELECTS DIRECTORS

Fusion Power Associates announces the election of five persons from non-member organizations to its 18 member Board of Directors. The five are Charles A. Baker (Argonne National Laboratory), Ronald C. Davidson (Massachusetts Institute of Technology), Alexander J. Glass (Lawrence Livermore National Laboratory), Dale M. Meade (Princeton Plasma Physics Laboratory), and J. Pace VanDevender (Sandia National Laboratories). They will serve three year terms beginning February 1.

CIVILIAN RESEARCH DOWN IN '80'S

The American Association for the Advancement of Science (AAAS) states in the January 6, 1989 issue of the AAAS Observer that government support for non-defense research and development declined 24% during "The Reagan Years" in constant dollars. Because defense R&D grew by 83% in constant dollars and by 169% in "as spent" dollars during the same period, research and development did experience an overall growth, however.

Looking only at "basic research," the AAAS notes that there was an overall increase of 37% in constant dollars.

WEAPONS, SCIENCE UP; ENERGY DOWN AT DOE

President Reagan's FY 1990 budget, submitted to Congress on January 9, contains an overall proposed increase for DOE of \$1B to a total of \$15B. Within the totals, weapons activities increase by about \$1.1B, science programs increase by about \$300M, while energy technology programs decrease by about \$400M. Magnetic Confinement Fusion is slated for \$349.2M, a decrease of \$1.5M from FY 1989. Inertial Confinement Fusion is slated for \$168.9M, an increase of \$5.1M. The major cutbacks proposed are in fossil energy (\$81M), conservation (\$75M) and renewable energy (\$35M). In the science programs, the supercollider is slated for \$250M, an increase of \$151M and \$340M is requested for new weapons production reactors.

FUTURE MEETINGS

The 1989 Sherwood Theory Meeting will be held in San Antonio April 2-5. Abstracts are due February 10. Contact Carolee Adams, SAIC, 206 Wild Basin Rd., Suite 103, Austin, TX, 78746.

The Seventh International Workshop on Stellarators will be held in Oak Ridge, TN, April 10-14. Contact Jim Rome (615) 574-1306.

An International Conference on Emerging Nuclear Energy Systems will be held July 3-6 in Karlsruhe, FRG. New concepts in nuclear fission and all concepts in fusion will be covered. Contact Prof. G. Kessler, KfK-INR, P.O. Box 3640, 7500 Karlsruhe 1, FRG.

The Fourth International Conference on Fusion Reactor Materials will be held December 4-8, 1989 in Kyoto, Japan. Contact Prof. S. Ishino, Dept. of Nuclear Engineering, Faculty of Engineering, University of Tokyo, Bunkyo-ku, Tokyo 113, Japan.

KMS INDUSTRIES ANNOUNCES FIRST DIVIDEND PAYMENT AND PLANS FOR STOCK REPURCHASE

KMS Industries, Inc., Ann Arbor, Michigan, has announced that its Board of Directors

has declared the first cash dividend in the Company's history. The regular quarterly dividend of \$.03 per share of Common Stock will be payable on March 15, 1989, to stockholders of record on February 17, 1989. KMS intends to pay dividends on a regular quarterly basis in the future.

KMS also announced plans to purchase shares of its Common Stock in the open market or in privately negotiated transactions. The Company's Board of Directors has authorized the purchase of up to 400,000 shares of KMS Common Stock.

Patrick B. Long, Chairman and CEO, stated, "I am confident that our current performance and our future prospects will support and sustain a quarterly dividend program. We have been quite successful in expanding our strictly research-oriented enterprise into a growing and prosperous advanced-technology company. The decision to begin paying a dividend marks a new era for KMS and confirms our determination to increase shareholder wealth by building a growing and profitable company. The stock repurchase program is also an indication of confidence in the Company's future."

KMS Industries' primary area of business is the development of laser fusion as a safe and economical energy source. The Company is also involved in the development of laser and space/defense systems, diagnostic measurement instrumentation, and ruggedized digital computers.

COPPI WINS EUROPEAN PRIZES

The 1988 European Biancamano Prize for Scientific Research has been awarded to Prof. Bruno Coppi of the Massachusetts Inst. of Technology and to Prof. Renato Dulbecco (1975 Nobel Prize for Medicine) of the Salk Institute. The award ceremony took place during the celebration of the 9th Centenary of the University of Bologna.

The citation concerning Prof. Coppi included these statements..."he has given fundamental contributions to the theory of both laboratory and space plasmas. He has conceived and developed experimental machines of the Alcator type, featuring high magnetic fields, that have opened a new field of research on nuclear fusion. He is also the originator of the Ignitor concept and project for the scientific demonstration of the

feasibility of a self-sustained thermonuclear fusion reactor. He is a prominent figure, in the outstanding community of Italian physicists, who has received numerous recognitions such as the Excellence in Plasma Physics Award (1983) and the 1987 Maxwell Prize of the American Physical Society...".

Other recent recognitions to B. Coppi include the nomination as the 1988 David Saxon lecturer at the University of California, the 1987 Dante Gold Medal of the Dante Alighieri Society for his contributions to physics and education, the 1986 Gold Medal of the University of Pavia, the nomination by the President of Italy to the

Virgilian National Academy, and the S. Silvestro Gold Medal.

BUSH ADMINISTRATION BEGINS

President George Bush has named retired admiral James Watkins as Secretary of Energy. Watkins' strong technical background (he graduated from the reactor engineering school at Oak Ridge, worked at the Atomic Energy Commission and commanded a nuclear submarine) has drawn praise from the technical community. In a letter to Watkins, FPA president Steve Dean transmitted the policy statement of FPA's Board of Directors and offered to arrange technical briefings for Watkins on fusion energy development.



FPA PRESIDENT STEVE DEAN (LEFT, AT TABLE) ATTENDING WHITE HOUSE MEETING ON ENERGY POLICY WITH THEN VICE PRESIDENT GEORGE BUSH.

TOKAMAK SCALING REPORT

"The Impact of Confinement Scaling on ITER Parameters" (ORNL-FEDC-88/5) by R. L. Reid, J. D. Galambos, and Y-K. M. Peng shows the impact of assuming any of six popular tokamak scaling laws on such ITER parameters as plasma current, major radius, direct cost, etc. The report concludes that the plasma current necessary for ignition lies between 10 and 21 MA for 5 of the 6 scaling laws, when optimizing for minimum capital cost. Contact authors at ORNL FEDC, (615) 556-5500.

GLASS NAMED LIVERMORE AD

Dr. Alexander J. Glass has been named to the new post of Laboratory Associate Director for Programs. He will assist laboratory director John Nuckolls in the

high level management of the laboratory's non-weapons programs. He was at LLNL previously but left in 1981 to become president of KMS Fusion. "I'm happy to be back at the Laboratory," Glass said, "This is a very exciting place to work."

NATIONAL GEOGRAPHIC FUSION VIDEO

The National Geographic Society has completed a 25 minute educational video and film entitled "Fusion: Work in Progress." The film includes animation and interviews aimed at answering the question "Fusion technology. . .How far have we come? How far do we have to go?" For information on purchase or rental contact National Geographic Society, Educational Services Department, Dept. 89, Washington, D. C., 20036. Also, ask for their catalog of many fine films.

Summary of Magnetic Fusion Energy Program FY 1990 Congressional Budget Request

	(\$ in Millions)	
	<u>FY 1989</u>	<u>FY 1990</u>
Compact Ignition Tokamak	\$ 18.5	\$ 20.5
Tokamak Fusion Test Reactor	74.1	70.0
Princeton Beta Experiment	10.0	0
Alcator C-Mod	15.2	16.0
Doublet III-D	31.2	37.0
Microwave Tokamak Experiment	11.5	10.0
Advanced Toroidal Facility	17.7	13.7
International/Other	8.5	10.0
Mirrors	2.8	3.0
Total Confinement Systems	<u>189.5</u>	<u>180.2</u>
Plasma Technologies	16.4	16.6
Fusion Technologies	23.0	20.9
Fusion Systems Analysis	2.9	5.5
International Thermonuclear Engineering Reactor	16.0	16.0
Total Development and Technology	<u>58.3</u>	<u>59.0</u>
Reversed Field Pinch	14.6	17.9
Compact Toroids	9.6	8.4
Experimental Plasma Research	18.4	23.7
Fusion Plasma Theory	19.6	21.0
Computing Network	18.4	16.0
Total Applied Plasma Physics	<u>80.6</u>	<u>87.0</u>
General Purpose Equipment/General Plant Projects/Program Direction	<u>22.3</u>	<u>23.0</u>
Total Magnetic Fusion Energy	<u>\$ 350.7</u>	<u>\$ 349.2</u>



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NEW AFFILIATE

Universal Voltronics Corporation, 27 Radio Circle Drive, Mt. Kisco, NY, 10549) has rejoined Fusion Power Associates as a Corporate Affiliate. Barry Ressler, president of UVC, will represent the company. He can be reached at (914) 241-1300. We welcome UVC to Fusion Power Associates.

FPA FAX

Fusion Power Associates now has a FAX machine. You can send us materials on (301) 258-0547.

FORSEN NAMED TO ACADEMY

Dr. Harold Forsen, Senior Vice President, Bechtel National, Inc., has been named to the National Academy of Engineering. Harold is chairman of the Fusion Power Associates Board of Directors. He pioneered the fusion systems and engineering efforts at the University of Wisconsin and served on DOE's Magnetic Fusion Advisory Committee. Currently he is serving on an Academy panel to review fusion as a part of national energy policy.

FUSION PBS SPECIAL APRIL 9

New Jersey Network's fusion documentary "The Sun of Man" will air nationally on public television April 9, 10:00 P.M. EST. In some areas it may air Monday. Check your local listings for times in your area. The documentary includes a trip to the USSR and interviews with scientists there. It also features "a day in the life of" Princeton physicist Rob Goldston.

FPA ANNUAL MEETING

Fusion Power Associates annual meeting and

symposium will be held June 1-2 at the Westin Hotel, Washington, D. C. The theme of the symposium will be "Fusion and the Environment." For further information contact Ruth Watkins or Susan Kinkead at (301) 258-0545.

DOWLING NAMED ACTING DEPUTY

Robert J. Dowling has been named Acting Deputy Associate Director for Fusion Energy at DOE, reporting to Acting Associate Director N. Anne Davies. In addition, Michael Crisp has been named Executive Assistant to Dr. Davies. In other changes, Greg Haas has given up his position as chief of the Fusion Technologies Branch and will work for John Willis, director of the Confinement Systems Division. Bob Price has become acting chief of the Fusion Technologies Branch, reporting to Bob Dowling who retains his position as director of the Development and Technology Division. Dowling will also serve as ITER Technical Director, overseeing an ITER Coordinating Committee within the Office of Fusion Energy. Al Opdenaker will serve as ITER Program Manager. Opdenaker will report administratively to Mike Roberts, director of International Programs. Opdenaker's title is International Collaboration Manager.

DENSE Z-PINCH MEETING, APRIL 26-28

The Second International Conference on High-Density Pinches will take place April 26-28 at the Surf and Sand Hotel, Laguna Beach, CA. Topics include experiments, theory and applications. Applications include fusion, x-ray spectroscopy, x-ray laser, microscopy and lithography, and magnetic field compression. Contact Nino R. Pereira (703) 750-3434.

REPRINTS AND REPORTS

"High-Temperature Plasma Physics" by Harold P. Furth, a 30-page monograph reprinted from Physics in a Technological World. Contact the author at (609) 243-3555.

The 1988 Annual Report of the University of Rochester's Laboratory for Laser Energetics is available from Dr. Robert L. McCrory (716) 275-4973.

ITER ORGANIZATION

John Gilleland (LLNL), U.S. Managing Director for ITER (International Thermo-nuclear Experimental Reactor) has announced the following organizational appointments for the U.S. team. Carl Henning (LLNL) will continue to serve as deputy director. Jim Dogget (LLNL) will manage the U.S. ITER engineering effort. Doug Post (PPPL) and Charlie Baker (ANL) will continue as managers for the Physics Group and Nuclear Engineering Group, respectively.

LASER INTERACTION WORKSHOP SCHEDULED

The Ninth International Workshop on Laser Interaction and Related Plasma Phenomena will be held November 6-10, 1989 at the U.S. Naval Postgraduate School in Monterey, CA. A one day tour of laser facilities at LLNL is also planned. For information contact George Miley (217) 333-3772.

JACK DUGAN JOINS CORTANA CORPORATION

Jack Dugan, formerly staff director of the House Science, Space and Technology Committee, has joined Cortana Corp. (520 N. Washington St., Suite 200, Falls Church, VA, 22046) as Director, Washington Operations and Director, Advanced Submarine Programs. Jack can be reached at (703) 534-8000.

MURRAY JOINS HOUSE COMMITTEE

Frank Murray has joined the Energy Research and Production Subcommittee of the House Science, Space and Technology Committee, replacing Jack Dugan. Frank was formerly with Booz, Allen, Hamilton Corp. He can be reached at (202) 255-2884.

NEW NEWSLETTER

A new newsletter entitled "Fusion: Edge-

Edge-Circuit News" discusses the importance of currents flowing in limiters, structures and edge regions of the plasma and describes techniques for controlling these currents. The newsletter is available without charge from John G. Murray (813) 938-8263.

LANL SEEKS THEORY HEAD

The Los Alamos magnetic fusion program has an opening for Group Leader of Theory and Computational Group. The position has been filled for the past 10 years by Dr. Richard Gerwin, who intends to return to full-time research. For further information contact Dr. Harry Dreicer (505) 667-4483.

NOVA COMPLETES GLASS REPLACEMENT

Scientists at LLNL have completed an 18-month activity to replace 260 defective NOVA glass amplifier disks. The original disks were inadvertently imbedded with microscopic particles of platinum during their manufacture and this has prevented operation of the NOVA laser at full design power. Scientists expect to more than double the current laser output with the new glass disks.

MILLS NAMED ANS FELLOW

Robert G. Mills, director emeritus, Plasma Science and Fusion Technology Program, has been named a Fellow of the American Nuclear Society. Bob was cited for direction of the engineering of experimental machines at Princeton Plasma Physics Laboratory for over 20 years; for invention of the D-shaped coil; for conception of the catalyzed-D advanced fusion fuel mixture; and for his leadership as the first director of Princeton's Interdepartmental Program in Plasma Science and Fusion Technology.

MUONIC FUSION

Research on the process of using muons to catalyze fusion reactions in hydrogen molecules is summarized in AIP Conference Proceedings 181 entitled, "Muon-Catalyzed Fusion," edited by Steven E. Jones, Johann Rafelski and Henrik J. Monkhorst. The proceedings are of a 1988 conference held in Sanibel Island, FL. Muon Catalyzed Fusion is also the title of a new journal published by J. C. Baltzer, AG Scientific Publishing Company (U.S. address P.O. Box 8577, Red Bank, NJ, 07701-8577).



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FUSION TV SPECIAL

On Sunday April 9, 10:00 P.M. EST, Public Television stations throughout the country will air New Jersey network's fusion documentary "The Sun of Man." Check your local listings for possible deviations from the primary east coast time slot. According to the producers, the documentary provides "an in-depth look at the research to harness the same fusion energy that powers the sun" and "includes an exclusive interview with Soviet Nobel prize winner, Dr. Andrei Sakharov, who fathered fusion science." The documentary describes both magnetic and inertial fusion programs, including Princeton's TFTR, Livermore's Nova laser and the Kurchatov Institute's T-10 and T-15 tokamaks. A variety of fusion scientists are interviewed.

UNIVERSITY OF UTAH FUSION "BREAKTHROUGH"

Tremendous press coverage was given to the University of Utah's March 23 announcement that they had "successfully created a sustained nuclear fusion reaction at room temperature in a chemistry laboratory." The experiments were conducted by Dr. Martin Fleischmann, professor of electrochemistry from the University of Southampton, England, and Dr. B. Stanley Pons, chairman of the Department of Chemistry at the University of Utah.

The scientists used an electrolysis setup in heavy water (D_2O). The deuterium-deuterium fusion reactions are said to have occurred in the interior of a palladium electrode due to lattice force influence on the deuterons' normally repulsive force. The primary diagnostic is a temperature rise in the electrode, but the scientists said that neutrons and tritium were also



**NEW JERSEY NETWORK'S MARC LEVINSON
INTERVIEWS DR. ANDREI SAKHAROV IN HIS
MOSCOW HOME**

observed. No scientific paper or report was released by the scientists, who said that they were planning to publish in May and had applied for patents on the process. The University's press release said that industries interested in commercial aspects of the technology development should contact Dr. Norman Brown, director of the University of Utah Office of Technology Transfer at (801) 581-7792.

The experiments had been privately funded but the University had applied for, and has been approved to receive, a grant from DOE for continuation of the work. Similar work has been supported for several years by the DOE Basic Energy Sciences program at Brigham Young University. The Brigham Young group, under Steven Jones, has also pioneered work

on fusion catalysis at low temperature using muons to replace electrons in deuterium-tritium molecules. The Brigham Young group reportedly has also seen fusion reactions in their experiment, although at a far slower rate than reported by Utah. The Wall Street Journal quotes Jones as saying "We cannot verify their results." Jones is scheduled to report his results in an invited paper at the American Physical Society meeting in Baltimore, May 1-4.

According to press reports, the Utah group claimed to have produced 4 watts of heat over a period of many hours while consuming about 1 watt of electricity. Many scientists are skeptical of the magnitude of the Utah claims and are awaiting the release of a scientific paper, outside review of the experimental data and/or confirmation by other experimentalists.

GENERAL ATOMIC SETS RECORD BETA

Scientists at General Atomics in San Diego have reached record values of plasma pressure compared to magnetic field pressure (beta) in the DIIID tokamak. A value of 8% was recorded, compared to the previous high of 6.8%. Values in the range of 8-15% are believed necessary for commercial fusion power reactors. The result was obtained using 12 MW of deuterium beam power, 0.8T field and 1.27 MA of current in double null discharges. The theoretical limit for the experimental conditions is 9%. The GA scientists hope to reach still higher values in the near future.

CIT IGNITION PROBABILITY

On February 3, DOE director of energy research Robert O. Hunter, Jr., requested the Magnetic Fusion Advisory Committee to comment "with respect to the certainty of (achieving) ignition in the (proposed) Compact Ignition Tokamak (CIT)." In early March MFAC Panel 22 noted that "the present CIT proposal is a two-phased experimental attempt to explore the physics of burning plasmas near ignition and to study and optimize fully ignited plasma discharges should they be obtained." The panel states that "the overall expectation for ignition in the first phase is very low." By increasing the magnetic field from 8T to 10T and the current from 9 MA to 11 MA,

and by adding an as yet undetermined amount of auxiliary heating power, the panel felt "the CIT would have a high probability for ignition in the second phase with only modest enhancements (less than factor of two) over empirical scalings required." "However," the panel said, "without a physics basis for the empirical scaling laws, and without known scaling behavior of the enhanced regimes, there cannot be confidence at the present time in obtaining the performance required for ignition." The full MFAC essentially endorsed the panel's findings and transmitted them to DOE after their March 6-7 meeting in Austin, Texas. A copy of the report and the MFAC letter of transmittal are available from DOE Office of Fusion Energy.

MAGNETIC FUSION REPROGRAMMING

DOE Office of Fusion Energy plans to redirect \$17.8M of current year funds in order to give "high priority to the improvement of our understanding of tokamak confinement...." "In addition," DOE says in a letter to Senator Bennett Johnston, "efforts on a new heavy ion/gas laser reactor study would be initiated to provide an assessment of these technologies." "The heavy ion/gas laser reactor study will combine recent progress in laser technologies and in generic fusion technology, using the systems design expertise of the Magnetic Fusion Energy program in conducting reactor studies," the letter, signed by Robert O. Hunter, Jr., says.

A total of \$12.8M will be cut from the following programs: TFTR D-T preparations (\$6.0M), ATF (\$1.3M), CPRF (\$2.5M), Other LANL (\$0.5M), ORNL Magnets (\$0.4M), LBL Neutral Beams (\$0.6M), ORNL ICRF (\$0.4M), ORNL Materials (0.2M), Other Materials (\$0.9M).

A total of \$12.8M will be added to the following programs: General Atomics (DIIID) (\$3.0M), University of Texas TEXT (\$2.5M), Diagnostics (\$2.0M), Gyrotrons (\$1.5M), Theory (\$1.5M), New Ideas (\$1.3M), Reactor Studies (\$1.0M).

In addition, \$1.5M of people at ORNL will be redirected from ATF to work on DIIID (approximately \$1M) and TEXT (approximately \$0.5M). At PPPL, an additional \$3.5M will

be redirected from TFTR DT work to TFTR non-DT physics. This makes a total of \$17.8M of redirected effort.

CONGRESSIONAL TESTIMONY

DOE and outside witnesses presented testimony to the House Subcommittee on Energy Research and Production of the House Committee on Science, Space and Technology on February 21. Dr. Robert O. Hunter, Jr. represented DOE. Outside witnesses were Lee Berry (ORNL), Harold Furth (PPPL), Rulon Linford (LANL), Dave Overskei (GA), Ron Parker (MIT), Erik Storm (LLNL) and Steve Dean (FPA).

Hunter told the subcommittee that, in his view, "the probability of CIT achieving the ignition goal may be unacceptably low" and that over the next two years his "number one priority is to come up with a design for an affordable CIT."

Berry told the subcommittee that a budget of approximately \$19M was required to properly operate the Advanced Toroidal Facility (ATF) program. He noted that, after the FY 1989 reprogramming action (see above article) only \$14.9M was available for this year and only \$13.75M had been requested for FY 1990. Berry said that "operating time will fall by about 50%" this year and that the proposed FY 1990 budget "would stop almost all diagnostic fabrication and installation and would require further substantial reductions in staffing." Berry also described the importance of technology development to fusion progress.

Furth stated that "The TFTR experiments in deuterium plasmas have actually advanced to within a factor of two of break-even conditions." He also said that the recent DOE reprogramming action has "serious consequences...for the D-T phase of TFTR, for the CIT project, and for the institutional health of the laboratory." "About 160 (industrial) subcontractor jobs have been eliminated," he said, "and the Laboratory staff has had to be reduced from about 1000 at the outset of FY 1989 to 900 at the outset of FY 1990, including a lay-off of about 60 employees."

Linford told the hearing that, due to budgetary reductions, the proposed Confinement Physics Research Facility (CPRF) has been descoped from its original 4 MA capability to 1.7 MA, while maintaining the option for future upgrades. The schedule has slipped from its original date of October 1990 to early 1993, also due to DOE budget projections for the project. Linford said "I accept the FY 89 reprogramming action because of the importance of initiating this emphasis on transport studies. I disagree, however, with the continued shift of funding in the FY 90 budget from the Concept Improvement activities into the Mainline Tokamak program in order to carry out this transport study." "Transport is not the only issue that needs resolution in order to improve the development path toward an attractive fusion power source," he said.

Speaking to those who are disappointed that we will not achieve the (1970's) goal of "a working fusion reactor by the turn of the century," Overskei noted that those expectations "were predicated on certain assumptions about funding levels which did not come to pass." "In fact," he said, "funding levels have been less than half of what was assumed in 1976...." In spite of the funding shortfalls we have made a "thousandfold improvement in (the) critical performance criterion (of the density-temperature-confinement time product) and "we are within a factor of ten of achieving the levels required for a self-sustaining fusion reaction." Looking to the future he said "We need a national program with full participation by all the experts in the U.S. fusion community, and a new facility (CIT)." He urged that all budgeted CIT funds be spent "to carry out additional research on the CIT design, and physics modelling." "Within approximately a year," he said, "we should have a much improved CIT design...." "At that time," he said, "we should aggressively proceed with construction."

Parker told the subcommittee that the "facets of the fusion program which I currently view as the most important and deserving of strong support (are): (1) understanding and controlling toroidal transport; (2) continuing the design of a compact ignition device, and carrying out

supportive scientific and technical R&D; and (3) conducting basic R&D in technology and materials areas which have critical impact on the attractiveness of a fusion reactor."

Parker noted that the fusion budget has declined by about \$100M since FY 1985. "It should be obvious that the fusion program cannot undertake an ignition experiment within this proposed (FY 90) budget without suffering serious damage to the pursuit of other objectives," Parker said. Parker, as Overskei, recommended that all CIT monies be spent on "continuing to optimize the CIT design and for carrying out essential R&D." He further recommended that during FY 1990 the "DOE and the fusion program leadership ... identify and commit to a funding pattern...which will permit building a compact ignition device with good probability of ignition at the beginning of its operating phase" and that they "establish an ignition-project management structure which reflects a national fusion program undertaking." If these steps are undertaken, "I believe we will be in an excellent position to embark on construction of an ignition device beginning in FY 1991," Parker said. Parker also cited two examples of critical technologies that need development funds: higher field superconducting magnets, with associated high strength materials and low activation materials.

Erik Storm, appearing before the subcommittee for the first time, described progress in inertial confinement fusion (ICF). Data obtained during the past 2-3 years "support our projections about the basic feasibility of achieving ignition and high energy gain under the conditions required for electric power production with ICF," he said. "The rate of progress has motivated the Department of Energy to begin a planning activity for a Laboratory Microfusion Facility (to demonstrate the achievement of ignition and high gain...," he said. "In (the) Halite/Centurion (program), a portion of the much greater energy from a nuclear device in underground explosions at the Nevada Test Site has been used to implode inertial fusion capsules, thereby extending the range of inertial fusion research. These experiments have produced excellent

results, contributing considerably to our increased confidence in the basic feasibility of achieving high-gain ICF," Storm said.

Dean noted that TFTR, our largest tokamak, was authorized in the FY 1976 budget and that we have had no major new tokamak construction projects authorized since that time. "As long as this situation continues, and until it is corrected, fusion power will not become a reality," he said. "It will take about \$20 billion over about 20 years to develop any new energy technology for commercial central station power," he said, and "until and unless the government recognizes that this level of investment is good and necessary, the nation's energy future will remain insecure." "If you spend \$1 billion a year and you spend it all on physics...you would not have fusion," he said, "You must get into the engineering. You must get into technology development. You must get into reactor design. You must build engineering test reactors. You must build devices that make fusion power," he said. "The reprogramming action...makes some scientific sense," he said, because "the (fusion) program is ready to make a concentrated effort on understanding physics." "But," he noted, "the programs that the monies were taken out of also made sense." He urged that ATF operations and CPRF construction be fully funded and that monies be restored to the total budget for these purposes. He also expressed support for studies of the civilian applications of inertial fusion, including funding for a new heavy ion fusion accelerator project, "which has not yet survived the DOE budget making process."

ICF BUDGET

The following is a summary of the DOE's FY 1990 budget request for inertial confinement fusion (\$ millions)

	<u>FY 1989</u>	<u>FY 1990</u>
Gas Laser	\$ 32.1	\$ 34.8
Glass Laser	96.0	95.3
Pulsed Power	25.8	28.5
Support Activities	1.6	1.6
Equipment	<u>8.2</u>	<u>8.7</u>
Total	\$163.7	\$168.9



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STATEMENT OF
DR. STEPHEN O. DEAN
PRESIDENT
FUSION POWER ASSOCIATES
TO THE
SUBCOMMITTEE ON ENERGY AND WATER DEVELOPMENT
OF THE
HOUSE COMMITTEE ON APPROPRIATIONS
APRIL 11, 1989

In 1980 it was estimated that the fusion budget would have to be doubled, and a commitment to building a tokamak engineering test reactor would have to be made, in order that fusion power be demonstrated by the year 2000. Since 1980 the fusion budget has declined to about one-half of its 1980 level and no new tokamak construction projects have been initiated. As long as this situation continues, and until it is corrected, fusion power will not become a reality.

Of course, fusion is not alone among the many new and improved energy technologies that have been neglected during the 1980's. Our national energy policy has been to increase our dependence on fossil fuels and to simply not respond to the many objective studies showing an impending energy shortage. "Let the private sector worry about it," has been our de-facto public energy policy. The electric utilities have given us the private sector's response to this challenge. They have made essentially no investment in new installed base-load capacity during the past decade.

Fortunately the American public's awareness of the global environmental damage that may result from continued burning of fossil fuels is on the rise. Hopefully this public awareness will result eventually in a change in government policy towards the funding of energy technology development, including the development of a fusion energy source. It will take about \$20 billion over about 20 years to develop and qualify any new energy technology for commercial central station power. Until and unless the government recognizes that this level of investment is good and necessary, the nation's energy future will remain insecure.

In spite of the declining budgets of the 1980's, the fusion program has made steady progress on achieving the conditions required for fusion power, by using facilities that were committed in the 1970's. The TFTR at Princeton, for example, has produced plasmas with temperatures of over 300 million degrees Celcius. Such temperatures were almost incomprehensible to imagine ten years

ago. In so-doing, TFTR has met or exceeded its original minimum design objectives of producing a plasma very close to the regime we call "scientific breakeven."

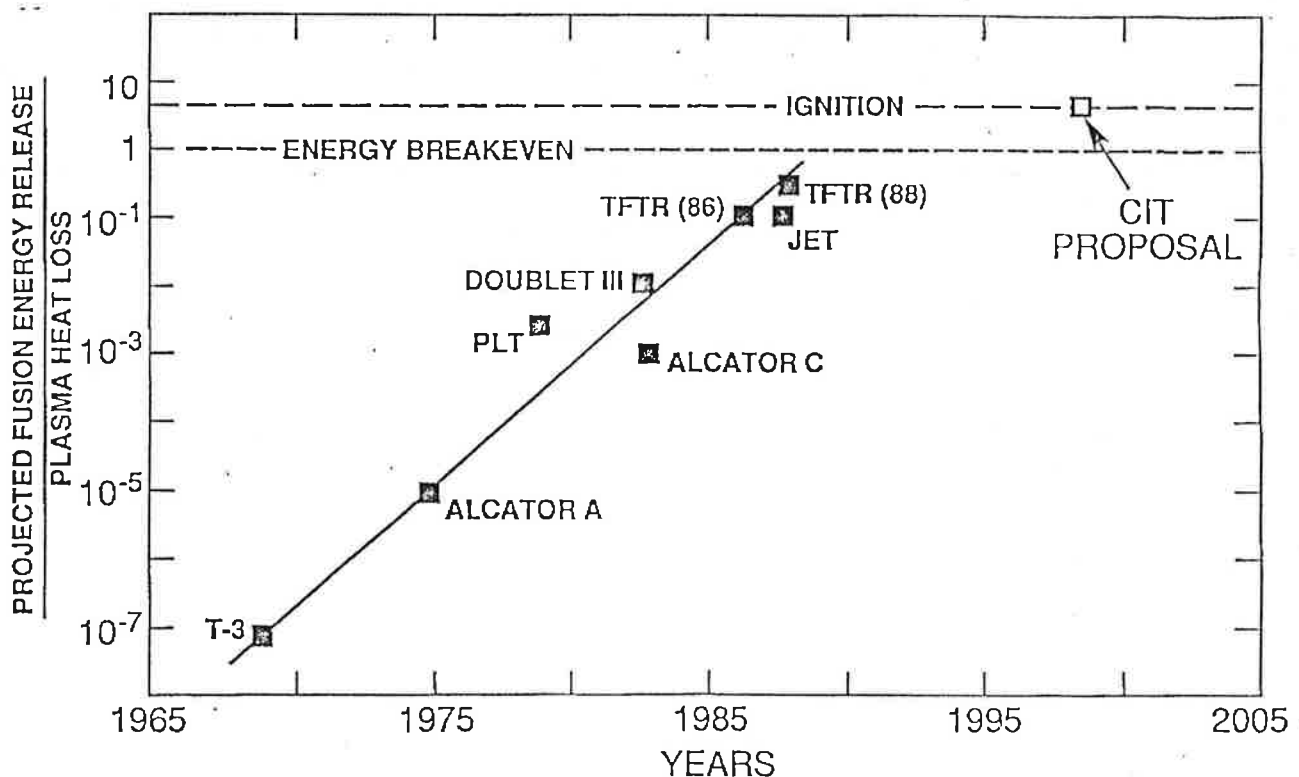
Progress toward fusion can be illustrated (see figure) by comparing the equivalent fusion power produced to the rate of heat loss from the plasma to its colder surroundings. Experiments have increased this ratio by a factor of a million over the last 20 years by raising the plasma temperature and improving the quality of heat insulation. A factor of only about 10 remains to be achieved in order to reach the "ignition" point, where the heat insulation will be good enough so that the heat deposited in the fuel by the fusion reactions themselves will be sufficient to maintain the temperature. A facility has been proposed (CIT) to produce such a plasma.

The DOE has asked for a "reprogramming action" in FY 1989 that would reduce activity on the ATF program at Oak Ridge, the CPRF program at LANL, preparation for DT operation on TFTR at Princeton and numerous smaller cuts at several sites. I would ask that these funds, totalling about \$18M be restored in FY 1990 as an add-on to the DOE's budget request.

I support the proposed program of systems studies aimed at assessing the civilian potential of inertial confinement fusion. However, I believe that these studies should include a broader evaluation of the many possible types of both inertial and magnetic fusion concepts.

Finally, I urge you to continue to provide strong support to the heavy ion fusion accelerator activity which is managed at DOE as part of its Basic Energy Sciences program.

PROGRESS IN ACHIEVING THE CONDITIONS REQUIRED FOR FUSION POWER





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NEW SMALL BUSINESS AFFILIATES

Fusion Power Associates welcomes the following companies as Small Business Affiliates.

D.I.R. Corporation, 3560 B Dunhill Street, San Diego, CA, 92121. D.I.R. provides support systems and electronic supplies for fusion research. Dean S. Irwin, president of D.I.R. will represent the company. He can be reached at (619) 587-1500.

IGC Superconductors, Inc., 1875 Thomaston Ave., Waterbury, CT, 06704. IGC provides superconducting materials and high strength metal matrix composites. Bruce A. Zeitlin, Vice President, will represent the company. He can be reached at (203) 753-5215.

FPA FINANCES

	1988	1987	1986
<u>Income</u>			
Research	\$151,408	\$155,293	\$189,938
Dues	80,983	79,021	90,955
Other	25,841	50,927	52,576
Total	\$258,232	\$285,241	\$333,469
<u>Expenses</u>			
Research	\$156,220	\$161,350	\$189,944
Education	29,610	54,615	47,204
Admin.	70,907	68,578	73,396
Total	\$256,737	\$284,543	\$310,544
<u>Assets</u>			
Net Cash	1,677	(4,784)	7,469
Equity	23,429	26,180	28,657
Engineering Prize Fund	6,658	5,496	4,270



DR. CHARLES BAKER

BAKER JOINS OAK RIDGE

Dr. Charles C. Baker, currently Fusion Power Program Director at Argonne National Laboratory, will join the Oak Ridge National Laboratory May 15 as Associate Director for Technology in the Fusion Energy Division. Charlie is a member of Fusion Power Associates Board of Directors and a Fellow of the American Nuclear Society.

COLD FUSION UPDATE

Hundreds of scientists around the world spent the past month trying to duplicate the University of Utah experiments which claimed to have produced 4 watts of fusion power using only 1 watt of input power in a heavy water electrolysis apparatus (see our April newsletter). At press time groups at Stanford University and Texas A&M had also claimed to have observed "excess heat." No major government laboratory in the U.S. had observed any heating as of the time this

FPA FAX

THE FPA FAX NUMBER HAS BEEN CHANGED.
OUR NEW NUMBER IS (301) 975-9869.

newsletter went to press. There were scattered reports from Europe, the USSR and elsewhere that small numbers of neutrons above natural background had also been observed. Thus far the neutron observations are billions of times too small to account for the heat observed in the Utah experiments.

The House Science, Space and Technology Committee convened a hearing on cold fusion April 26. Witnesses included Pons and Fleischmann from the University of Utah, Steven Jones from Brigham Young University, Robert Huggins of Stanford University, George Miley of the University of Illinois, Mike Saltmarsh of ORNL, Harold Furth of Princeton and Ron Ballinger of MIT. The hearings were televised by C-Span. Inquiries on the availability of the 5-hour videotape should be directed to Matt Moore at C-Span at (202) 737-3220.

At the hearings, George Miley stated "Regardless of the actual outcome, I feel that Congress and all concerned must be patient and not over react. Considerable time will be required to unravel the situation and great harm could be done by acting prematurely."

Mike Saltmarsh stated that "the excitement generated by the reports of cold fusion has been very stimulating. Whether these results and their interpretations will be totally or partially confirmed is still an open question which can only be resolved in the course of time by careful scientific scrutiny."

Ron Ballinger stated "As far as the results of attempts by the team at MIT are concerned, we have been thus far unable to scientifically verify any of these results. However, we and the other teams have been handicapped by a lack of enough scientific detail to guarantee that we are actually duplicating these experiments."

The Boston Globe quotes Joseph Weneser of Brookhaven National Laboratory as saying "I truly don't understand how the results could have been produced by fusion. But then, there are lots of things I don't understand. I see things my way; God sees things his way, and we don't always agree." The Globe quotes Harold Furth as saying "One good experiment is worth 100 half-baked opinions."



STATUS OF COLD FUSION, MAY 1, 1989

Dr. Steven E. Jones of Brigham Young University, who pioneered the idea of achieving fusion at low temperatures using muons, testified at the April 26 Congressional hearing on cold fusion. He listed several possible fusion reaction candidates for explaining cold fusion, including d-lithium, and d-d yielding only helium. With respect to the latter, which has become the most popular way of attempting to explain the large heat release claimed at the University of Utah, Jones said that such a process would produce high energy electrons in the lattice that would be observable by bremsstrahlung. No evidence of bremsstrahlung radiation has been detected. "It is my opinion," he said, "that the bonafide fusion component is a factor of many millions below the energy output of interest for commercial interest at this time." "Cold nuclear fusion does not offer a short cut to fusion energy," he said.

Dr. Daniel Decker, a solid state physicist and chairman of BYU Department of Physics and Astronomy said "The results that are observed at the University of Utah are interpreted by the scientists as being unexplainable by normal chemical processes. A nuclear physicist would say, in the same vein, that those results could not be explained by any known nuclear process. So now we have two unknown processes, neither of them possible." "We have to make a factor of 100 jump in chemistry or a factor of 10^{12} in physics in order to explain this energy source," he said. "I think that gives you an idea of why we feel, as physicists, that maybe the chemists should also look very seriously into possible chemical reactions and not tell us physicists that we need to change our physics to explain the process. Now it is true that any good theoretical physicist can explain anything. But I think first we've got to have some experimental data to explain," Decker said.

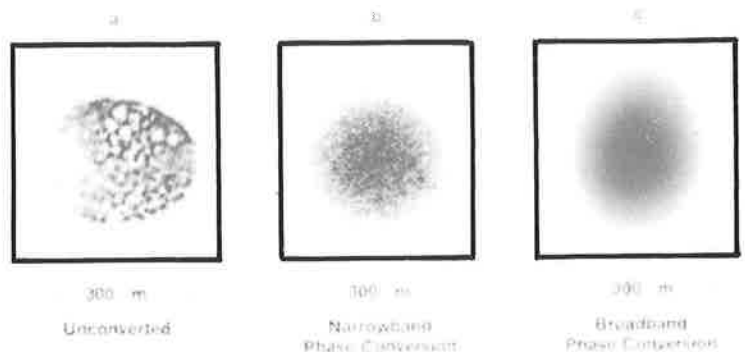
Energy Secretary Watkins has reportedly given the DOE laboratories "90 days" to clarify the Utah claims and has asked Los Alamos National Laboratory to convene an international workshop on the topic in Santa Fe May 22-25. Watkins has ordered 10 national laboratories to report weekly to Director of Energy Research Robert O. Hunter, Jr., on specific details and

results from every experiment they are doing on cold fusion, even if the results are preliminary and unconfirmed.

In a press release dated April 21, DOE issued its first public statement on cold fusion. It said: "The origin of any heat released has not been established, be it nuclear, chemical, mechanical or another process. Similarly, a mechanism for production of a fusion reaction, if any, at room temperature in solids has not been established." The press announcement also said, "Admiral Watkins will request DOE's Energy Research Advisory Board (ERAB) to establish a panel to conduct an independent review of the entire research situation." It said, "The ERAB panel will consist of experts in the fields of electrochemistry, solid state physics, nuclear physics, engineering and other fields important to the type of experiments conducted. The purpose of the review is to provide DOE with an assessment of this new area of research. ERAB provides guidance to the Secretary of Energy and advises on overall R&D conducted in the department. DOE will request that ERAB prepare an interim report by July."

ROCHESTER MAKES SMOOTHER LASER BEAM

Scientists from the University of Rochester have demonstrated a novel laser beam smoothing technique which demonstrates beam uniformity levels approaching those required for laser fusion.



TARGET PLANE PHOTOS USING (a) UNCONVERTED BEAM, (b) NARROWBAND CONVERSION AND (c) BROAD BAND CONVERSION

The technique, Smoothing by Spectral Dispersion (SSD), allows the uniform compression of a target pellet of fusion fuel. The technique allows target illumination three to four times more uniformly than previously possible. Currently, one laser beam from the OMEGA laser is divided into 24 beams that are broken up into nearly a quarter of a million beamlets on target. These beamlets hit the target within a millionth of a millionth of a second of each other.

The heart of SSD involves broadening the spectrum of laser light hitting the target. The source of the broadening is a microwave cavity containing a crystal of lithium niobate, which divides the single wavelength laser pulse into 23 slightly different wavelengths. Previously the interference pattern formed by the beams was stationary on the pellet, causing very small hot spots on the pellet and illumination non-uniformities of 10-30 percent. With the broader bandwidth used in SSD, the slightly different wavelengths cause a more uniform interference pattern, thus eliminating the hot spots. Experiments have shown that smoothing by spectral dispersion allows uniform illumination of a pellet with variations of only a few percent.

Using only 1000 Joules of frequency-tripled (blue) laser light the Rochester scientists have compressed fusion targets by about a factor of 25 in radius, achieving neutron yields in good agreement with theory.

ACADEMY INITIATES INERTIAL FUSION REVIEW

In response to a congressional mandate, the Department of Energy has asked the National Academy of Sciences/National Research Council to conduct a review of the inertial confinement fusion (ICF) program. The study will update an earlier study completed in 1986 (see our May and June 1986 newsletters). A committee is being established and it is expected that the review process will begin in June. The committee will review the accomplishments since the 1986 review, including published reports that tests of ICF capsules using the radiation from underground nuclear explosions have verified the feasibility of ICF (see our April 1988 newsletter). A new element in the current review is the requirement that the committee evaluate the

civilian energy potential of this technology. The committee is also expected to advise DOE on the timing for moving ahead with a new construction project called the Laboratory Microfusion Facility (LMF).

SANDIA MEETS BEAM FOCUSING MILESTONE

J. Pace Van Devender, director of Sandia National Laboratories Pulsed Power Program has announced that the fusion group under Don Cook has focussed protons to a power density of 5×10^{12} watts/cm² averaged over a 6 mm diameter target in the PBFA II facility. The value achieved was about 5 times better than had previously been achieved on PBFA II and 15 times better than that achieved on an earlier device, PBFA I. Eventually, values of about 100×10^{12} must be achieved using lithium ions.

NOVA LASER SETS NEW WORLD ENERGY RECORD

Having installed new, improved laser glass (see our March 1989 newsletter) the NOVA laser at LLNL set a new world record of 124,500 joules of laser energy at 1 micron wavelength. The laser delivered all this energy in 2.5 billionths of a second. After frequency conversion to shorter wavelengths, LLNL expects to be able to provide nearly 80 kJ of energy to a fusion target.

PEOPLE

Dick Briggs is taking an extended leave of absence from LLNL to become deputy director/project manager for the SSC project in Texas. He will assist SSC director Roy Schwitters by overseeing the project baseline design and by helping to build the organizational structure for the SSC laboratory. Dick has been a leader in the development of induction linacs and free electron lasers.

Alex Glass will assume Brigg's responsibilities for the Beam Research and Magnetic Fusion Energy Programs. Alex is currently LLNL Laboratory Associate Director for Programs and is a member of Fusion Power Associates' Board of Directors. He was previously president of KMS Fusion.

D. Allan Bromley, a professor of physics from Yale University, has been selected by President Bush to be White House Science Advisor. Bromley has also served as head of the American Association for the Advancement of Science. He served as a member of the White House Science Council throughout the Reagan Administration.



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ACADEMY URGES FUSION SPEEDUP

After a year-long study, the National Academy's Committee on Magnetic Fusion in Energy Policy has issued a report calling for an immediate 20% increase in funding for magnetic fusion energy research, followed by an additional 25% increase in the mid-1990's. The primary purpose of these increases, according to the study, is "to permit construction and operation of the Compact Ignition Tokamak ... and participation in the construction of an international engineering test reactor beginning in the mid- to late-1990's."

The report, entitled "Pacing the U.S. Magnetic Fusion Program" also recommends "that the Department of Energy develop a revised program plan providing for greater participation by U.S. companies, to ensure that these companies are not placed at a disadvantage relative to their foreign competitors. Such participation could, for example, follow the Japanese practice of assigning industry responsibility for both the design and construction of major systems and subsystems," the report said.

The committee was chaired by Dr. Irvin L. (Jack) White, president of the New York State Energy Research and Development Authority.

In its executive summary, the committee stated: "This study addresses the priority and pace of the nation's magnetic fusion research and development program in the context of long-term national energy policy. In particular, the committee interpreted its task as follows: To review the implications of long-term national energy policy for current research and development in magnetic fusion; to identify factors that should enter the further development of such policy to reduce risks associated with the future electricity

supply system; to propose criteria applicable to research and development in electric generation in reaching long-term energy policy goals; to apply these criteria to magnetic fusion and alternative electric generation technologies in order to develop recommendations on the priority and pace of the magnetic fusion program; and to present its results in a final report."

Among its conclusions, the committee states, "that a prudent long-term energy strategy for the United States requires that alternative electric energy supply technologies be researched, developed and demonstrated. A diversified array of alternatives is needed as insurance against the vulnerability of existing alternatives, such as coal and nuclear fission.

"Thus, the committee concludes that the United States should adopt an energy-insurance strategy, developing an array of diverse technologies as hedges against serious shortfalls in coal-derived and nuclear fission-derived power. As a part of this study, the committee surveyed broadly the prospects for a number of technologies, but within study constraints was not able to assess their relative merits as a basis for allocating federal R&D funds. Thus the committee recognizes a need--not fulfilled by this study--to conduct a comprehensive comparative evaluation of demand management and electrical supply alternatives, leading to the formulation and implementation of a balanced national energy R&D program. Pending such an evaluation, the committee believes that magnetic fusion merits continuing support as a potentially important technological alternative to resolve energy-supply uncertainties such as those noted above."

Other members of the committee were W. Howard Arnold (Westinghouse), Peter L. Auer (Cornell U.), Stanley I. Auerbach (Martin Marietta), Robert W. Conn (UCLA), Daniel A. Dreyfus (Gas Research Institute), Frederick J. Ellert (General Electric), Harold Forsen (Bechtel), L. Charles Hebel (Xerox), Robert Herzstein (Arnold and Porter) and Erle Nye (Texas Utilities Co.)

GAVIN SPEAKS TO SENATE STAFF

Joseph Gavin, retired president of Grumman Corp., spoke to a luncheon gathering of Senate staff on May 8, "to review for you what I consider some of the basics in energy research--including the promise of fusion power." He noted that, "Power generation is not a problem that can be isolated from the other factors that concern us. It affects not just our economy, but the global economy; not just our standard of living, but the global standard of living; not just domestic politics, but global politics. The world's dramatic increase in population, especially in the underdeveloped countries; the continuing growth in urbanization; the unequal distribution of fossil fuels, as well as their increased cost to extract; the more acute awareness of world-wide air and environmental pollution--all of these are factors in the power equation."

Furthermore, Gavin said, "the fundamental problem is that we do not have a national long-term energy policy that deals with a reasonable priority for first limiting and, later, eventual replacement of fossil fuels." "The missing element seems to me to be a far-sighted political view of this world we live in," Gavin said.

Gavin noted that "In 1983, the United States seemed to have a clear lead in magnetic confinement fusion research and very likely the lead in inertial confinement fusion experiments." He then traced the U.S. fusion budget decline during the last 6 years, and concluded, "In the meantime more consistently supported programs in Europe and Japan have progressed to the point of leadership."

He praised the Reagan-Gorbachev summit process that has led to joint design for an International Thermonuclear Experimental

Reactor (ITER) but asked "How does the U.S. establish a commitment to ITER in face of some 30 big ticket projects that are competing for priority in these budget-crunch times?" He proposed that the U.S. "establish a per barrel fee on imported oil and an additional tax on automotive fuel at the pump...." "Conservation would be incentivized and funds from fossil energy use would be invested in solutions for a limited fossil future," he proposed.

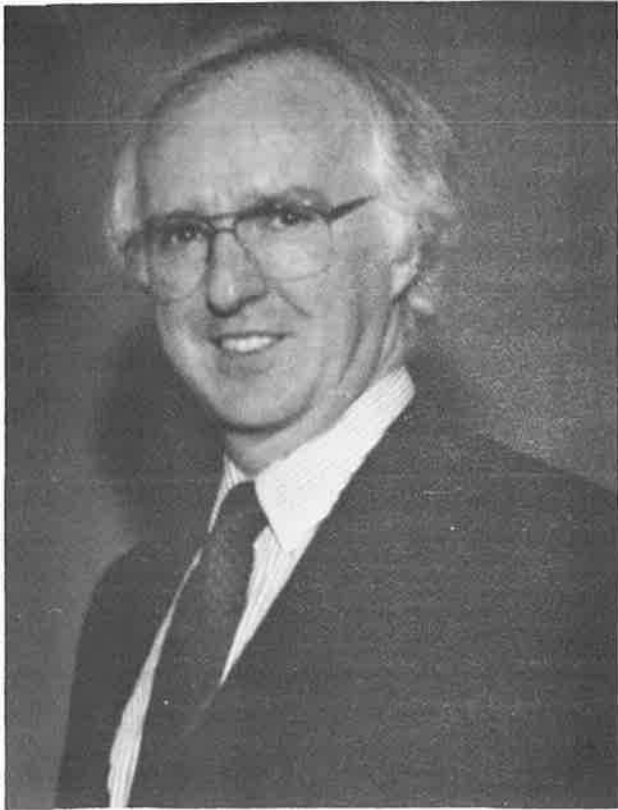
"We Americans desperately need to take a longer term view, despite Wall Street's emphasis on the next two quarterly earning statements and in spite of the great pressures exerted by the full-time political campaigning attendant to our election cycles," Gavin concluded.

Joe Gavin is a member of the National Academy of Engineering and of the DOE Energy Research Advisory Board.

The luncheon was organized by Fusion Power Associates and hosted by the following FPA members and affiliates: Burns and Roe, Inc.; CBI Services, Inc.; Enserch Corp.; General Atomics Co.; Grumman Corp.; KMS Fusion, Inc.; Martin-Marietta Corp.; McDonnell Douglas Astronautics Co.; Stone and Webster, Inc.; Varian Associates; Westinghouse Corp. Their financial assistance is greatly appreciated.

DOE RELEASES ICF NEXT STEP STUDY

The DOE Inertial Fusion Division has issued a comprehensive "Laboratory Microfusion Capability (LMC) Study Phase I Summary" (DOE/DP-0069). The 95-page report summarizes the results of a two year study of the issues associated with initiating construction of a facility to reliably ignite fusion capsules using lasers or particle beams. The study discusses the utility of such a facility; development issues; technical requirements; safety, environmental and siting criteria; staffing and management and cost factors. The study concluded that a laser or particle beam capable of 10-20 MJ for indirect drive or 6-12 MJ for direct drive would be required. Further information can be requested from Dave Bixler at DOE (301) 353-4919. The report is available from the National Technical Information Service, U.S. Dept. of Commerce, Springfield, VA, 22161.



JOHN F. CLARKE



DAVID EHST



Y-K. MARTIN PENG

EXCELLENCE IN FUSION ENGINEERING AWARD

Fusion Power Associates Excellence in Fusion Engineering Award is being presented this year to David Ehst of Argonne National Laboratory and Y-K. Martin Peng of Oak Ridge National Laboratory.

Ehst is cited for his important contributions to fusion reactor design in the areas of rf heating and steady-state current drive. Peng is cited for his innovative Spherical Torus concept and for his design contributions in the areas of plasma start-up, shaping and control.

The awards were established, in memory of Prof. David J. Rose, to recognize individuals in the early part of their careers who have shown outstanding technical accomplishment and leadership potential in the field of fusion engineering.

Previous recipients were Steven J. Piet (EG&G Idaho, Inc.) and Michael A. Ulrickson (PPPL).

APS FELLOWS

David Cartwright and Bob Jameson of Los Alamos have been named Fellows of the American Physical Society. Dave is program director for inertial confinement fusion. Bob has pioneered the development of high brightness linear accelerators for fusion and free electron lasers.

FPA LEADERSHIP AWARD PRESENTED TO CLARKE

Fusion Power Associates Board of Directors has designated Dr. John F. Clarke as recipient of FPA's 1988 Leadership Award. The awards are presented annually to those individuals who have shown outstanding leadership qualities in accelerating the development of fusion. Clarke's citation reads, "Your dedication and leadership has served the fusion program well during the difficult decade of the 1980's. Your tenure has been marked by scientific integrity. You have forged an impressive degree of international collaboration which recognizes the global importance of fusion development."

Previous recipients of the award are Solomon J. Buchsbaum, Robert L. Hirsch, Mike McCormack, Paul Tsongas, Edwin E. Kintner, Harold P. Furth, John H. Nuckolls, John L. Emmett, T. Kenneth Fowler, Tihoro Ohkawa, Gerold Yonas, Evgeni P. Velikhov, Chiyo Yamanaka, Ronald C. Davidson, and Marshall N. Rosenbluth.

MFAC REPORTS PUBLISHED

The Journal of Fusion Energy (Vol. 7, No. 4, Dec. 1988, Plenum Press) has published the reports of Panels 14-20 of the DOE Magnetic Fusion Advisory Committee (MFAC). The issue also contains the report of the 1988 MFAC Summer Study. The studies covered are "Assessment of Burning-Plasma Phenomena in a Compact Ignition Tokamak (14); Review of the Technical Planning Activity (15); Review of the Magnetic Mirror Program (16); The Scientific and Technical Merit of Deuterium-Tritium Operation in TFTR (17); Assessment of Environmental, Safety and Economic Aspects of Fusion (18); The Role of Plasma Theory in the Development of Magnetic Fusion (19); Report on Long-Range Technology Development for Fusion (20) and Fusion Program Planning for the Early to Mid-1990's (Summer Study).

MFAC reports have not been widely available to the scientific community in the past. The Journal's editor (Dan Cohn) hopes that this and other issues of the Journal will serve a useful purpose in elucidating the many policy questions involved in managing fusion research.

The Journal of Fusion Energy not only publishes research results but it also provides a forum for discussion of the broader policy and planning issues of the fusion program. Subscriptions for individuals certifying that the journal is for their personal use are \$39.50 (outside U.S., \$45.00). Write Plenum Publishing Corp. 233 Spring St., New York, NY, 10013.

RESEARCH OPPORTUNITIES

The DOE Office of Fusion Energy has indicated (Federal Register, April 20, p. 15987) its intent to provide up to \$5M in FY 1990 for research grants to "enhance the understanding of transport physics issues in fusion plasmas and/or provide new methods and operational scenarios to achieve improved energy confinement."

The announcement states "Such R&D includes new diagnostics, use of existing diagnostics on new experiments, data reduction and analysis techniques and experiment-specific models of transport and confinement. New experiments may involve,

for example, installation of auxiliary equipment on existing devices, or requests for operating time on the devices to conduct a specific program that might either reduce transport or contribute to the understanding of transport in plasmas. Applications from collaborative teams or multi-institutional research groups will be welcomed."

Further information is available from Steve Eckstrand (301) 353-2848 or Ron McKnight (301) 353-3421 at DOE.

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MAYDAY

ASH WEDNESDAY

It was Wednesday June 14, but it was Ash Wednesday and MAYDAY for magnetic fusion research. On that day, at 2:00 P.M. in Senate Hearing Room 366 Dirksen Building, Dr. Robert O. Hunter, Jr., the DOE director of energy research announced his plan to reduce the magnetic fusion FY 1990 budget request by \$50 million. The FY 90 presidential budget request before the committee was for \$349M but Hunter indicated he wished to reduce this to \$299M. It was the first time in memory that a program manager came before Congress proposing to cut his own budget. He indicated he would plan to maintain the magnetic fusion budget level at about \$300M "through the end of the (1990's) decade, in today's dollars, to get ignition." Thus the magnetic fusion base program would face further cuts in order to fund construction of the Compact Ignition Tokamak (CIT) during the 1990's.

Alerted to Hunter's Senate offer to reduce magnetic fusion by \$50M, the House Appropriations Subcommittee on Energy and Water Development jumped the gun on the same Wednesday morning and voted to cut the magnetic fusion budget by \$68M (\$50M in operating and \$18M in construction). The construction projects proposed to be cancelled were CIT at Princeton and the Confinement Physics Research Facility (CPRF) at Los Alamos.

On the next day, June 15, Energy Secretary James Watkins sent a letter to the chairmen of various congressional committees stating, "Due to lack of resolution of key scientific unknowns, the Department is no longer proposing to begin actual

construction of this device (CIT) in FY 1990. Watkins stated that, "After receiving the formal report of the (MFAC) review panel, I met with leaders of the magnetic fusion community in late April to discuss (the panel's) findings." [Actually, the formal report of the panel was not completed until June 7.] "I am now convinced of the possibility that the CIT will be unlikely to meet the key ignition goal ...," Watkins said.

MFAC POSITION

As evidenced by Adm. Watkins' letter cited above, the DOE position on CIT obviously hardened long before the Magnetic Fusion Advisory Committee completed its analysis on June 7. MFAC Panel 22 was convened to consider (1) the status of our understanding of confinement in tokamaks, (2) the capability of the fusion program's machines to do good physics, and (3) the certainty of achieving ignition in the CIT.

In their June 7 letter to Hunter, transmitting the Panel 22 report, MFAC said in part:

"While transport is an important issue and is properly being given high priority, it would be a great mistake to focus unduly on this issue at the expense of other program elements important for fusion development or to use it as a sole criterion for evaluating program activities.

"In attempting to identify resources for the transport initiative, the Panel (22) on several occasions identifies and questions continuation of facilities that it sees as

not contributing to transport. This is in spite of considerable program investments in facilities that are close to completion, and which have capabilities of doing valuable fusion physics. Examples of this include the D-T option in TFTR, CPRF/ZTH, the FRC program, and to a lesser extent MTX. These programmatic decisions must be reviewed in the context of the full fusion program.

"Fusion progress, like almost any scientific development effort, will proceed best when both empirical and theory driven means are used in conjunction. The Panel 22 report underemphasizes contributions that can be made by empirical science."

MFAC further states, "...assuming the CIT is to be built, D-T operation in TFTR would provide valuable experience of tritium handling in an operating tokamak. The Panel 22 report implicitly discounts this value by dismissing tritium operation as not important for transport studies."

They also say, "In questioning the value of the descope ZTH facility, the Panel (22) focusses on its 1.7-MA capability as a single figure of merit, rather than addressing the physics contribution that the facility would make. MFAC reaffirms the value of the RFP research program and notes the substantial resources already committed to the CPRF/ZTH construction."

They state, "MFAC likewise continues its support for the construction of CIT as expressed on a number of earlier occasions. This will require additional funds in future years."

MFAC continued, "We believe that the CIT design, R&D, and prototyping should proceed in parallel with the transport work; and that the check point should release construction funds for the project, rather than initiate them."

MFAC PANEL 22 FINDINGS

MFAC Panel 22, chaired by Kim Molvig of MIT, produced a 40-page report analyzing in detail the issues associated with transport and ignition. The report states, "the likelihood of ignition with the first phase

of the current design is assessed and found to be quite low. The second phase of the CIT would have a high probability of ignition, providing modest confinement improvements relative to L-mode scaling are achieved. However, there remains an attendant uncertainty resulting from extrapolating on an empirical knowledge base."

THE "INNOVATIVE NEW POLICY"

In his June 15 letter to members of Congress, Secretary Watkins states "I had hoped to be able to present to you the full account of an innovative new policy that embraces all the fusion research in the Department--both magnetic and inertial confinement approaches. This new policy would focus research on resolution of the key unknowns that now limit progress, and inspire strongly competitive research and development to achieve specific objectives over the mid and long terms. A draft of such a policy now exists, and meets the general tenets I have described. But because of the significance of such a decision, I am persuaded that the Department should conduct an independent, high level policy review of the draft to assure that its managerial and scientific logic are sufficiently solid to meet responsible critique by both advocates and detractors of fusion research. I hope to have the policy review completed, and the final version of the new policy validated, within the next two months."

The draft fusion policy referred to by Secretary Watkins was authored by Thomas Johnson, a professor from West Point, in collaboration with Kim Molvig and John Deutch of MIT and John Foster of TRW. Johnson recently co-authored with Hunter (while Hunter was president of Western Research Corp.), a paper entitled "Scaling of KrF Lasers for Inertial Confinement Fusion" (IEEE J. Quantum Electronics, March 1986). None of the DOE fusion line managers (either magnetic or inertial) were consulted on the preparation of the draft plan, nor were any of the responsible managers at fusion research facilities. In fact, DOE upper management appears to have taken great pains to exclude the entire fusion community from the process.

The draft policy plan notes that there are "current proposals to build very large experimental facilities--the Compact Ignition Tokamak (CIT) in magnetic fusion and the Laboratory Microfusion Facility (LMF) in inertial fusion." [In fact, CIT has already been submitted to Congress, whereas the LMF is only at an early stage of conceptual design, so that the time-scales envisaged by their respective advocates is about 5 years apart.] The draft plan states that "The locations of magnetic fusion in the Office of Energy Research and of inertial fusion in Defense Programs serves further to obscure the goal orientation of both programs."

The plan then proceeds to set up a timetable in which the CIT schedule is delayed, and it outlines a competition between magnetic and inertial fusion. The plan states, "Thus, the overall development plan is to make a decision early in the next century between magnetic and inertial fusion." "The Department does not plan to request sizeable increases to the DOE budget to construct either of the near-term ignition devices (CIT or LMF)," the plan says.

With respect to magnetic fusion, the plan says, "The Department has already proposed the CIT construction to the Congress. However, as described above, either ignition in CIT is very unlikely or the cost of the device will grow to unacceptably large levels, contrary to the original intent. Second, the lack of confinement physics understanding that has become the major problem for the CIT proposal will become even more significant in attempting to scale beyond CIT to an ETF, and thus threatens the ability of magnetic fusion to present a credible fusion alternative. Finally, there is the problem of the designated site at Princeton Plasma Physics Laboratory, a suburban New Jersey area. The potential political difficulties of this site, associated with the necessary tritium handling, could well be fatal to carrying out ignition experiments in that laboratory. Because of all these difficulties, the Department is proposing to withdraw the present CIT proposal. It is the Department's intention to resubmit this proposal in approximately two years after

physics understanding milestones are achieved, and employing a realistic funding and site selection process."

The plan generally emphasizes the physics uncertainties in tokamak physics scaling and glosses over the uncertainties in the scalings for inertial confinement. The plan states "A 10MJ driver should be capable of producing target gains above ten, and possibly as high as a few hundred. Even gains of about ten, however, will permit confident evaluation of the scaling of gain with driver energy to be made based upon fundamental understanding of the dominant processes." [In fact, a recently issued DOE report, DOE/DP-0069, indicates considerable uncertainty in the energy required to achieve gain 100, stating "The best current estimate is that indirectly driven LMF targets will require 10 to 20 MJ of laser or ion beam energy." That report further states that "The cost of the LMF will probably be greater than \$500 million and less than \$2 billion."]

With respect to magnetic fusion alternate concepts, the plan states that the "maintenance of large programs in alternate confinement schemes has become an unaffordable luxury if magnetic fusion is to move forward toward an energy production goal."

With respect to inertial fusion alternate concepts, the plan states that both direct drive and indirect drive approaches will be continued and that glass lasers, krypton fluoride lasers and light ions will compete until the driver for the LMF is chosen. In addition, "Heavy ions will be investigated separately as a possible inertial fusion reactor driver..." the report says.

INERTIAL FUSION DRIVER DEVELOPMENT

In his June 14 testimony, DOE's Robert Hunter stated that he wished to retain the \$50M cut from the magnetic fusion program and "to transfer" the \$50M "into another account, in a civilian ICF account, to put into driver development in FY '90, and in FY '91 to add an additional \$50 million that we would obtain from the rest of the programs in the Department." He stated that "those funding streams, which would be \$300 million for magnetic fusion and

roughly \$260 million for ICF [The current ICF budget is \$155 million] would continue through the end of the decade, in today's dollars, to get ignition."

The draft policy plan states, "In outline, the logic is to compete the three driver options at the time of LMF design decision. Because most of the detailed experimental evidence on indirect-drive target performance comes from lasers, the details of light-ion target performance remain to a significant extent theoretical predictions. Thus, light ions present a special case in the driver competition. Unless they are capable of demonstrating the capability to focus at high powers ($>10\text{TW}/\text{cm}^2$) by the end of FY 1990, they will be effectively eliminated as competitors for the LMF. Assuming that high-power focusing is achieved, the light-ion research team at Sandia will have about two further years to demonstrate the physics and scaling of light ion targets and higher power focusing for operation on the LMF.

"The laser competition for the LMF driver is thus between glass and KrF lasers. Both of these alternatives will be funded to perform critical technology demonstrations by the time of the LMF decision. Glass laser development will be sponsored to construct and operate, on a design-to-specification basis, a single beam line of a linearly scalable 10MJ design. Subscale demonstration of beam control and alignment adequate for precision experiments will also be performed. KrF laser development will be based upon competitive design and operation of nominal 500 kJ modules on a build-to-cost basis; minimum pulselength and pulse shaping criteria will be specified. Demonstration of pulse-compression and beam control technologies will also be performed."

MFAC RESPONDS

The Magnetic Fusion Advisory Committee, faced with a situation in which the DOE was giving the public impression that its actions were based upon MFAC review and recommendations, took the unprecedented action of writing directly to energy secretary Watkins on June 21.

In the letter, signed by its unanimous membership, MFAC took note of the fact that DOE had used the low probability of ignition in phase I of the CIT project as the justification for pulling the project from the president's budget. The letter states, "We take exception to the CIT being equaled to only its first phase; doing so conceals the sound logic and value of the CIT project." Citing a July 11, 1988 letter from DOE to Representative Lloyd, MFAC points out that "in order to achieve ignition at minimum cost, the project was laid out with two phases, only the second of which was regarded as having high probabilities for ignition."

The letter notes that tokamak transport is only one of a variety of issues which must be addressed in order to assess the potential of fusion as an energy source. "These issues are now being addressed not only in the mainline tokamak but also through work on selected alternate magnetic fusion concepts, allowing both a complementary view of the underlying physics and an examination of other potential avenues to a reactor," MFAC said.

Discussing the proposed competition between magnetic and inertial fusion, based on operation of CIT and an LMF, MFAC states, "The competition, as posed, would not serve its intended purpose and is unlikely to assure a well-defined path to commercial fusion energy." "In the attempt to create a competitive situation, the effect of the initiative would be to slow one program and accelerate the other," MFAC says. They conclude, "Out of concern for the long-term health of fusion development, we strongly urge that recommendations for major changes in the MFE program plan and for reprogramming of funds, including the magnitudes of funds involved, be delayed until their technical merits and impact on the affected programs have been thoroughly reviewed.

Editor's Note: Copies of all letters and reports referenced in this newsletter are available on request from Fusion Power Associates, with the exception of the Panel 22 report, which is available from Kim Molvig (617) 253-5825.



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NEW SMALL BUSINESS AFFILIATE

Batzer Vacuum Technology Associates (1730 Murdell Lane, Livermore, CA, 94550) has become a Small Business Affiliate of Fusion Power Associates. Company representatives are Tom Batzer (president), Dwight Lang (V.P., engineering) and Ralph Moir (treasurer). The company is designing and building large diameter (30cm to 1m) all-metal gate valves. Such valves should find use on fusion devices such as CIT and ITER for isolating pumps and RF heating units. At present large, all-metal valves do not exist and the small ones are heavy, hence costly, as they are scaled up in size. Batzer holds a patent on the seal, which is being developed by the fusion program at LLNL; the valve is being developed by the company under a Phase II SBIR contract.

FUSION BUDGETS

House and Senate have each passed FY 1990 fusion appropriations bills, but the conference bill is not expected until after Labor Day. The House passed a \$308 million magnetic fusion appropriation, while the Senate came in at \$330 million. This compares to the President's request for \$349M and this year's budget of \$351M.

The House passed a budget for inertial confinement fusion of \$184.2M compared to the President's request for \$168.9M and this year's budget of \$163.8M. The \$15.3 increase was earmarked for an upgrade to the Omega Laser at the University of Rochester. The Senate marked the inertial fusion budget at \$173.9M.

SPECIAL SESSIONS AT APS MEETING

The American Physical Society Division of Plasma Physics will meet at the Disneyland Hotel in Anaheim, CA, Nov. 13-17. On Monday

evening November 13, there will be a special evening session on the topic "Plasma Physics, Public Policy and the Future of Fusion." On Tuesday evening there will be a special session featuring a presentation by DOE director of Energy Research Robert O. Hunter, Jr.

The Monday evening session was organized by FPA president Steve Dean, based on a suggestion from Sam Hokin of the University of Wisconsin. Four panelists will make prepared remarks. They will then be questioned by a 3-person panel and then the session will be opened to comments from the audience. The four panelists (all tentatively confirmed) are Jim Slade (ABC-TV News), Paul Gilman (Staff to Sen. Dominici), Sol Buchsbaum (V.P., Bell Labs) and Jan Beyea (National Audubon Society). The questioners will be Abe Bers (MIT), Mel Gottlieb (Grumman), and John Lohr (General Atomics).

COLD FUSION UPDATE

The DOE Energy Research Advisory Board Cold Fusion Panel (see our May 1989 newsletter) issued a draft interim report in July stating "The Panel finds that the experiments reported to date do not present convincing evidence that useful sources of energy will result from the phenomena attributed to cold fusion. Indeed, evidence for the discovery of a new nuclear process termed cold fusion is not persuasive." The 20-person panel is co-chaired by John Huizenga (Univ. of Rochester) and Norman Ramsey (Williams College). A final report is due in November.

ACADEMY REVIEW OF INERTIAL FUSION BEGINS

A congressionally-mandated review of inertial confinement fusion, chaired by Steve

Koonin of Caltech, held its first meeting in Washington July 18-19. A second meeting is scheduled at LLNL for August 15-16. An interim report is due January 15, 1990; final report is due September 15, 1990.

The statement of work for the review is as follows: (1) Provide an assessment of the most promising technologies for continuation of the program; (2) Assess the potential contributions of the program under the following scenarios: a comprehensive test ban on underground nuclear testing, and prohibition of underground nuclear testing to levels of 1 kiloton, 5 kilotons, and 10 kilotons; (3) Assess the civilian energy potential of ICF; (4) Assess the adequacy of the ICF target performance data base for supporting program plans and decision milestones; (5) Identify major technical and programmatic issues facing the program; (6) Determine the status of each major candidate inertial fusion driver (including heavy ion drivers), and specify critical issues involved in the development of each; (7) Recommend program priorities, particularly with regard to the Centurion/Halite program, driver development, and laboratory experiments and theory. Recommend relative priorities of individual support laboratory activities; (8) Examine the strategies and plans of the ICF program, comment on their soundness, cohesiveness, and programmatic effectiveness, and recommend management initiatives that could improve progress of the program toward achievement of its goals.

TRANSPORT WORKSHOP

The magnetic fusion Transport Task Force (see our January 1989 newsletter) will sponsor a workshop August 21-24 at the Horton Grand Hotel, 311 Island Avenue, San Diego, CA, 92101. The meeting is open to interested scientists. The theme of the workshop is Plasma Turbulence: Theory and Experiments (theory, diagnostics, basic experiments, edge turbulence). For further information, contact Lena Walker (619) 455-3419. The Task Force has issued a summary statement of "Issues and Recommendations" dated May 1989. Copies may be requested from Jim Callen (608) 263-1370.

FPA ACTIVITIES

Fusion Power Associates has been having an active 1989. These are some of the things we have been doing:

- April and May were spent keeping the media advised on the cold fusion "breakthrough." Steve Dean appeared on several TV news programs and was interviewed for numerous radio broadcasts and helped many science reporters keep abreast of the events.
- We held our annual meeting and symposium on "Fusion Energy and the Environment."
- We held separate luncheons for House and Senate staffs, sponsored by some of our member companies. Luncheon speakers were Alexander Glass (House) and Joseph Gavin (Senate).
- Steve Dean gave presentations on fusion at Cornell University, University of Virginia's School of Mass Communications, Argonne National Laboratory's annual Science Teacher Workshop, and a teacher's conference at the University of Missouri.
- We have responded to the budget crises precipitated by DOE's plan to pull CIT from the budget and cut \$50M from the magnetic fusion budget. Activities have included writing letters to members of Congress, testifying before congressional committees, and meeting with congressional staff.
- Steve Dean and Susan Kinkead met with DOE top officials Linda Stuntz and her staff, and Robert O. Hunter, Jr. They also met with Nancy Maloley, Associate Director for Environment, Energy and Natural Resources, Office of Policy Development at the White House; and OMB budget examiners Tom Palmieri and Judy Bostock.
- Steve Dean organized fusion sessions for the 24th Intersociety Energy Conversion Engineering Conference in Washington and the national meeting of the American Institute of Chemical Engineers in Philadelphia.
- Susan Kinkead arranged a showing of the National Geographic fusion video at the Annual meeting of the American Association of Physics Teachers. We have also been advising on another PBS film which will air this fall.



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JET ADVANCES

Scientists at the Joint European Torus (JET) facility in England have taken a major step forward toward the achievement of breakeven conditions in the world's largest operating tokamak. The results equal the best results achieved on TFTR in the U.S. However, JET has used only 80 kV of the available 140 kV voltage on the neutral beam heaters. The results were made possible by using beryllium gettering as a way to reduce impurities in the plasma.

The beryllium gettering of JET is highly effective in reducing the carbon and oxygen content. Beryllium is observed to be present at the few percent level for 1-2 shots and then drops to about 0.5 percent for the next 20-40 shots, during which the Z_{eff} is reduced to as low as 1.5. In addition to the reduced Z_{eff} and the greater percentage of reacting ions, the strong pumping action of the beryllium produces much greater density control, peaked profiles and greater resistance to disruption.

With 18 MW of neutral beams they have Z_{eff} of 2.2, T_i of 20 keV, τ_e of 0.8 sec and n_D of $2.2 \times 10^{13} \text{cm}^{-3} \text{sec}$ for an $n_D T$ of $3.5 \times 10^{14} \text{cm}^{-3} \text{sec keV}$. This is nearly a factor of two better than their 1988 results and about the same as the best TFTR results in terms of Q_{equiv} . These results are still with almost all of the beams at the 80 kV setting and at 3 MA plasma current, so that even better results may be expected as the beams are raised to higher voltage and the machine run at higher current.

Of even greater import are the results with ion cyclotron resonance heating (ICRF) where they have succeeded in obtaining a

good H-mode with ICRF heating alone. Peaked profiles are obtained in these cases as well. Already they have obtained $n_D T$ of $2 \times 10^{14} \text{cm}^{-3} \text{sec keV}$ with 17 MW of ICRF. Apparently the beryllium allows them to run the plasma closer to the ICRF antennas without introducing the nickel impurities that had limited the RF experiments previously.

They are now switching the carbon limiter to beryllium and will change the Faraday shields to beryllium as well. In the meantime they will also increase beam voltages to the 140 kV range and run experiments with combined neutral beam and ICRF.

DOE FUSION POLICY IS MIA

On June 15 Energy Secretary Watkins announced (see our July "Mayday" newsletter) that he was developing an "innovative new policy" for fusion development and that "a draft of such a policy now exists." In letters to the chairmen of several congressional committees, Watkins stated that he would conduct "an independent, high level policy review of the draft to assure that its managerial and scientific logic are sufficiently solid to meet responsible critique by both advocates and detractors of fusion research." He said that he hoped "to have the policy review completed, and the final version of the new policy validated, within the next two months."

Two months have now passed and there is no sign of the promised policy review. Sources indicate that the appointment of the policy panel is bogged down somewhere in the DOE bureaucracy. Furthermore, DOE has refused to make copies of the draft policy paper available or to acknowledge the validity of those copies which have been widely

circulated in the community. The same sources indicate that the members of the policy panel are being selected by the same persons who prepared the draft policy which is to be independently reviewed.

EIGHT SENATORS WRITE WATKINS

Eight members of the U.S. Senate have written two letters to energy secretary James Watkins expressing concern regarding fusion policy. In one letter, signed by Senators Bradley (NJ), Domenici (NM), Kasten (WI), Lautenberg (NJ), McClure (ID), and Sasser (TN), the senators noted that "Since 1974, the federal government has spent more than \$5.3 billion on the magnetic fusion program, and U.S. experiments have progressed nearly all the way to the parameters needed for a fusion reactor. It is crucial that the country's significant investment in magnetic fusion research continue until it is a proven technology." The senators said the DOE's proposed new policy "constitutes a major departure from the findings and recommendations of the most recent reviews of fusion research, such as the 1986 Energy Research Advisory Board Technical Panel on Magnetic Fusion, the 1986 National Academy of Sciences review of the DOE's inertial confinement fusion program, and the 1989 report from the National Research Council Committee on Magnetic Fusion Energy Policy." "For these reasons, we believe that program changes of the magnitude proposed by Dr. Hunter should be considered only on the basis of comprehensive, thorough and independent technical reviews of both the magnetic and inertial fusion programs," the senators said.

A second letter, signed by Senators Adams and Gorton of Washington, states "There are many areas of the Department that are critically in need of reform and we commend you for the actions you have taken concerning the nuclear weapons complex. We do think, however, that where the Department's fusion research program is concerned a substantial investment in advanced nuclear research has been made over many decades and to dramatically alter the priorities of the program could result in a major loss of ongoing research and experimental facilities. We urge the Department to reconsider Dr. Hunter's recommendations and to preserve the ongoing research and experimental

capability that has been so painstakingly developed under the Department's long years of support."

The senators have not yet received a reply from Secretary Watkins. Sources indicate that Watkins reply is being prepared by Col. Tom Johnson, who was principal author of the controversial new fusion policy draft plan. Johnson was named "Special Assistant for Military Systems" to Admiral Watkins on July 10. The sources indicate that Col. Johnson will advise Watkins to assert that the new plan is actually not a change in policy but has been the DOE strategy for fusion since 1978. Johnson was a principal architect of the 1978 policy as a consultant to the then DOE Director of Energy Research John Deutch. A comparison of the 1989 DOE "innovative new policy" draft and September 18, 1978 congressional testimony of Deutch shows that whole sections of the "new" plan have been lifted from the 1978 Deutch testimony. The 1978 policy was based on a fusion review chaired by John Foster of TRW. The policy was abandoned in the early 1980's due to radical changes in energy policy in the Reagan administration. A new policy was promulgated (DOE/ER-0214) in February 1985 by then DOE Director of Energy Research Alvin Trivelpiece. Sources indicate that Foster is being considered as a possible chairman or member of the yet-to-be-formed "independent" policy review panel.

NEW FUSION INSTITUTE ESTABLISHED

The National Institute for Fusion Science was established under the Japanese Ministry of Education, Science and Culture on May 29, 1989. The majority of researchers at the former Institute of Plasma Physics, Nagoya University, have been transferred to the new institute, which has also been joined by a part of the Plasma Physics Laboratory, Kyoto University and that of the Institute for Fusion Theory, Hiroshima University. The goal of this institute is the promotion of research in fusion plasma physics and its applications both in Japan and around the world through intensive research collaboration. Atsuo Iiyoshi is Director General of the Institute. Prof. Masami Fujiwara is director of the Helical Device Project. Members of the Institute can be contacted at the National Institute for Fusion Science, Nagoya 464-01, Japan. Tel. 052-781-5111; Fax 052-782-7106.



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CRISIS BUILDING

"America's next energy crisis is building like a billowing August thunderstorm," states a June 19 article, "The Coming Power Crunch" in U.S. News and World Report. "Instead of irate motorists queued up at gasoline stations, the new crunch will be marked by dimmed lights, balky computers, stuffy office buildings and perhaps even total blackouts in some areas" by the mid-1990's. The article quotes Sen. J. Bennett Johnston as saying "Brownouts and blackouts will become a part of normal life." "While demand is soaring, the power supply is rapidly dwindling. Either unable or unwilling to build new generating facilities because of high construction costs and regulatory red tape, the nation's utilities have virtually stopped building new power plants," the article states.

NATIONAL ENERGY STRATEGY

The Department of Energy held a series of public hearings during August and September aimed at soliciting input on the development of a "National Energy Strategy." Attempts by Fusion Power Associates and others interested in fusion to testify at the hearings were rebuffed by the energy department official organizing the hearings. A later series of hearings aimed at addressing specific technologies would be a more appropriate forum, we were told.

HEARINGS SCHEDULED

In a surprise move, Rep. Robert Roe, chairman of the House Committee on Science, Space and Technology has scheduled three half-days of hearings on fusion October 3, 4, 5. According to Roe "The purpose of the hearings is to assess the progress of the Magnetic Fusion Energy Program, and to evaluate the Department of Energy's plans for carrying this Program forward."

"As a part of this review the Committee will seek to better understand the role of the Compact Ignition Tokamak in the national and international program," Roe states.

Referring to the planned hearings in a floor speech September 12, Roe states "I do not think it is the intent of Congress to give to a secretary, no matter who he is, the total right to determine the fusion program of this country after the taxpayers have spent \$6 billion on that program to date."

FUSION BUDGETS

House-Senate Conferees agreed in early September to recommend \$330 million for magnetic fusion and \$175 million for inertial fusion for the fiscal year beginning October 1. This represents a reduction of \$21 million in magnetic fusion and an increase of \$10 million in inertial fusion relative to the current year budget.

In accompanying language (relative to magnetic fusion) the conferees state "The conferees are concerned about the course and progress of the fusion research program. The date that magnetic fusion might become a commercial reality continues to be extended. The conferees are concerned about this very long-term commitment and the vast amount of funding necessary to prove the scientific feasibility of fusion." They further state, "In order to provide the Department with the flexibility to develop a meaningful program, the conferees are recommending that these funds be provided without further allocation between program components, projects and activities within the fusion program. The Secretary may reserve a modest portion of such funds which shall be available to carry out any new policy directions only after prior approval of the Subcommittee on Energy and Water Development Appropriations of the

of the House of Representatives and the U.S. Senate after review by the Committee of the result of the fusion program policy review.

"In addition, the Department is directed to provide to the Committees on Appropriations a full accounting of the policy review, a statement outlining any redirections within the fusion program, and the budgetary impacts of such redirections."

In his September 12 floor speech, Rep. Roe criticized the conferee's report. "The language suggests even though Congress has supported this program for more than a decade, there is very little to show for the investment. I believe this is totally incorrect," Roe said. "Contrary to the observation of the Appropriations Committee, progress in the last decade has been impressive and has exceeded what many careful observers thought could be achieved. Problems have been solved which could not have been anticipated by the early pioneers of magnetic fusion research. New technologies have been developed, and new methods of analyzing and understanding the phenomena that occur in the extremely high temperature gases that are required in a magnetic fusion reactor. These accomplishments are showing the way to achieve the ultimate goal--a commercial power plant based upon the fusion of atomic nuclei as the energy source. It seems to me that the language in the appropriations conference report fails to acknowledge these accomplishments," Roe said.

ROE CRITICIZES DOE FUSION ADVISORY PROCESS

In a strong letter dated September 12 to energy secretary James Watkins, Rep. Roe criticized DOE's use of Dr. Kim Molvig of MIT to chair a subpanel (22) of the DOE's Magnetic Fusion Advisory Committee (MFAC) (see our July newsletter) while at the same time Dr. Molvig was serving as a paid DOE consultant providing advice directly to DOE director of energy research Robert Hunter. Roe noted that Molvig was not a member of MFAC and said that use of Molvig in this manner was "suspect since while (MFAC) panel members may not provide direct advice to an agency...consultants may." "A direct communication under these circumstances between a non-MFAC member and an employee

of the Department on the subject in review before the panel could be a violation of the provisions of the FACA (Federal Advisory Committee Act)," Roe said.

FPA HOSTS FUSION POLICY WORKSHOPS

When energy secretary Watkins failed to deliver on his promise (see our July and September newsletters) to complete an "independent, high-level policy review" of fusion by mid-August, Fusion Power Associates asked several people to attend a Fusion Policy Workshop on August 26-27. Nine persons attended. This was followed by a second workshop September 10-11 to which 50 people were invited and 30 were able to attend.

As a result of these workshops, it was decided to try to draft a set of policy recommendations to DOE from the fusion community. A draft has been prepared and is being reviewed by the participants. Readers of this newsletter who wish to participate in this process are welcome to request copies of the latest draft.

The principles upon which this draft policy statement are being formulated are: (1) support for emphasizing the transport task force effort to improve the basic understanding of tokamak energy transport, (2) recognition of the need for a continuing broad effort in science, technology, concept improvement and materials development, (3) the importance of the timely construction of next step facilities, e.g., CIT and ITER, (4) commitment to the production of net electricity early in the twenty-first century as the appropriate program goal, and (5) justification of the next step ICF facility (i.e., LMF) as a defense program facility while recognizing the need to support ICF civilian technologies.

IAEA MEETING DATES SET

The next IAEA Conference on Plasma Physics and Controlled Nuclear Fusion will be held at the Grand Hyatt Hotel, Crystal City (near Washington, D. C.), Virginia, September 30-October 6, 1990. This conference, held every two years, is the major international gathering of fusion scientists from around the world to assess progress in world fusion development.

SANTA FE PROCEEDINGS PUBLISHED

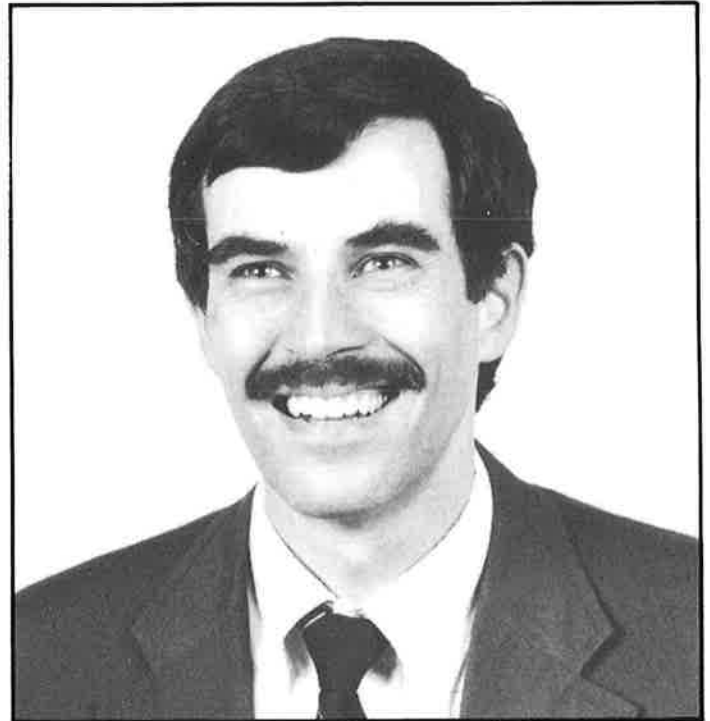
The proceedings of Fusion Power Associates 1988 annual meeting and symposium "Creating Compact, High Power Density Fusion Plasmas" have been published in the June 1989 issue of the Journal of Fusion Energy. The symposium, held September 6-8, 1988 in Santa Fe, addresses the need to reduce the size and cost of future fusion facilities while still achieving improved plasma performance. The issue describes compact tokamak ignition concepts and advanced concepts such as Reversed Field Pinches, Compact Toroids and Dense Z Pinches as well as high beta and high field tokamaks and stellarators. The issue also describes the status of inertial confinement fusion including the proposed Laboratory Microfusion Facility. This issue also includes several contributed papers, including a new look at an old concept, in a paper by FPA president Steve Dean entitled, "Impact of High Temperature Superconductors on the Possibility of Radiofrequency Confinement of Fusion Plasma."

DOE REQUESTS ICF PROPOSALS

The DOE Chicago Operations Office has issued a request for proposals (DE-RP02-90ER52162) for "unclassified design studies of credible Inertial Confinement Fusion Central Station Electric Power Plants." Two CPFF contracts will be awarded, each to separate and distinct offerors, with each contract requiring approximately 20 man-years of effort over a 12-month period. Each contractor will conduct two design studies using a different driver technology (heavy ions, light ions, gas lasers and glass lasers) for each study. Proposals are due November 13. Copies of the RFP can be requested from R. Brian Cass, U.S. DOE COO, (312) 972-2091.

GA HITS RECORD PLASMA PRESSURE

General Atomic's scientists have achieved a new record value of "beta," the ratio of plasma pressure to magnetic field pressure. A value of 9.3% has been achieved thus far and values of about 10% are expected soon. Values of 8-15% are deemed necessary for an economic tokamak fusion commercial reactor. Achievement of this long-sought tokamak goal is a real tribute to the talents and tenacity of the GA fusion scientists.



RUSH D. HOLT

HOLT JOINS PPPL

Dr. Rush D. Holt has joined the Princeton Plasma Physics Laboratory (PPPL) as Assistant Director. In this position, Dr. Holt will have a number of important internal and external administrative responsibilities, including government relations. Dr. Holt holds a Ph.D. in Physics from New York University.

He comes to PPPL from the U.S. State Department in Washington, D. C., where he served as Chief of the Nuclear and Scientific Division of the Office of Strategic Forces Analysis. During 1982-83 he was in Washington on a Congressional Fellowship awarded by the American Physical Society (APS).

ICF PLAN ISSUED

The DOE Inertial Fusion Division has issued an unclassified version of its 5-year plan entitled "Inertial Confinement Fusion Program Plan Summary for Fiscal Years 1990-1994 (DOE/DP/IFD/PP090189). In the preface, the division director, Dr. Sheldon Kahalas, states "The purpose of this FY 1990-1994 Inertial Confinement Fusion (ICF) Program Plan is twofold:

"First, it indicates that there are new (1987 and 1988) ICF experimental results that are of historical significance. These new results provide increased confidence in the technical feasibility of ICF and have motivated the Inertial Fusion Division (ICD) to begin planning for a Laboratory Microfusion Facility (LMF). Such a facility could begin to provide a significant return on the investment in ICF research and development in the form of both military and civilian applications at about the turn of the century.

"Second, it presents a strategic plan for accomplishing this LMF objective. The plan presents a range of resource options consistent with achieving the objective of an LMF on a nearer or longer term schedule, depending on the policy selected.

HEAVY ION FUSION REPORTS ISSUED

Several reports summarizing the status of heavy ion fusion have recently been issued. "Heavy Ion Fusion Accelerator Research 1988" (LBL-27002) is available from Denis Keefe (415) 486-6376. "High Energy Density in Matter Produced by Heavy Ion Beams" (GSI-89-21) and "Status and Perspectives of Heavy Ion Inertial Fusion" (GSI-89-41) are available from R. Bock, GSI, Planckstr 1, Postfach 11 05 52, D-6100 Darmstadt 11, Federal Republic of Germany.

IGNITEX NEWSLETTER STARTED

The IGNITEX project at the University of Texas at Austin has begun to issue a "Bulletin of the IGNITEX Project." The objective of the project is to design a device "to produce and control ignited plasmas for scientific study in the simplest and least expensive way possible." The design is based on a single-turn coil tokamak device with 20 Tesla field on axis, powered by homopolar generators, ohmically heated to ignition. For further information contact Rodolfo Carrera, (512) 471-6148.

NEW ADDRESS FOR KMS FUSION

KMS Fusion, Inc. new address is: 700 KMS Place, P.O. Box 1567, Ann Arbor, MI, 48108; their new FAX number is (313) 769-1775.

MEETINGS

Nov. 6-10 Ninth International Workshop on Laser Interaction and Related Plasma Phenomena, Monterey, CA. Contact Mrs. Chris Stalker, Fusion Studies Laboratory, University of Illinois (217) 333-3772.

Nov. 13-17 Annual Meeting of the APS Division of Plasma Physics, Anaheim, CA. Contact Charles Kennel (213) 825-4018.

Dec. 4-8 Fourth International Conference on Fusion Reactor Materials, Kyoto, Japan. Contact Prof. S. Ishino, Dept. of Nuclear Engineering, Univ. of Tokyo, Bunkyo-ku, Tokyo 113, Japan.

Dec. 4-7 First International Toki Conference on Plasma Physics and Controlled Nuclear Fusion, Toki City, Japan. Sponsored by National Institute for Fusion Science (see our Sept. 1989 newsletter). Contact Junji Fujita, FAX 052-782-7106.

PEOPLE

Mujid Kazimi has been named chairman of the Department of Nuclear Engineering at MIT. He succeeds Neal Todreas who has returned to full-time teaching and research.

Gerold Yonas has returned to Sandia National Laboratories, Albuquerque, as an associate director. He was previously a vice president of Titan Corp.

John Gilligan has received the 1989 Alcoa Foundation research award at the North Carolina State University College of Engineering.

Greg Haas has left the DOE Office of Fusion Energy (OFE) to join the DOE Superconducting Supercollider (SSC) office in Houston, TX. Warren Marten and Don Priester have also left OFE to join the SSC office at DOE Headquarters.

Judy Bostock, fusion budget examiner at the OMB, has joined the staff of the Office of Science and Technology Policy as assistant to presidential science advisor Alan Bromley.



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HEARINGS

The House Committee on Science, Space and Technology held hearings on the "Status and Direction of the Magnetic Fusion Energy Program" on October 3, 4, 5. Additional hearings on inertial fusion are scheduled October 26.

In his opening statement, chairman Robert A. Roe noted that "In Senate testimony this year (see our July newsletter), the Energy Department made known its desire to reduce funding for magnetic fusion, delay construction of the CIT, and direct those funds into more research on the scientific theories behind magnetic fusion. The purpose of these hearings is to learn from the magnetic fusion community itself what they view the next step in the program should be."

Robert S. Walker, Ranking Republican Member, in his opening statement, asked "Why shouldn't we spend a little time (perhaps two years or so) and money to find out more about the basic science, before we move on to the CIT?"

Twelve witnesses testified on the first two days, followed by DOE director of energy research Robert Hunter on the third day. At the end of the second day Mr. Roe polled the witnesses and found that eleven witnesses advocated proceeding with CIT and one (Kim Molvig of MIT) favored delay.

The witnesses were: Harold Furth (PPPL), John Gilleland (LLNL), Alex Glass (LLNL), Rulon Linford (LANL), Ronald Parker (MIT), David Overskei (General Atomics) on day 1; and Steve Dean (FPA), Ken Gentle (U. Texas), Robert Iotti (Ebasco), Kim Molvig (MIT), Fred Ribe (U. Washington), and John Sheffield (ORNL) on day 2. Several of the witnesses pointed out that it was universally agreed to emphasize physics studies

during the next few years and that "freezing design and cutting of metal" for CIT would not occur for several years in any event.

In his testimony on the third day, Dr. Hunter finally released his draft fusion policy paper (see our July and September newsletters). He stated that it was still the department's intention to conduct a high level policy review before implementing it. He attributed the delay in carrying out the review to a desire to ensure that the review be carried out properly and objectively.

COLD FUSION STILL WARM

The National Science Foundation and the Electric Power Research Institute hosted a workshop October 16-18 in Washington on the topic "Anomalous Effects in Deuterated Metals." Cold fusion discoverers Stanley Pons and Martin Fleishman led the list of about 50 invited participants of mostly cold fusion believers. A few key skeptics, notably Nate Lewis (Cal Tech) and Allen Bard (U. Texas) were also present, as was scion Edward Teller.

There was no narrowing of the large quantitative gap between the amount of "excess heat" claimed in some experiments and the small numbers of fusion products observed. However, evidence is mounting that some anomalous nuclear process is giving rise to small numbers of nuclear reactions of some type, possibly a reaction involving deuterium and isotopes of palladium.

Teller, as usual, was a colorful participant. Shortly after the cold fusion "breakthrough" announcement last March he underwent major surgery, he said, and his last words before going under the general anesthetic were "I wish I knew what is the truth about cold fusion."

HUNTER LEAVING DOE?

The departure from DOE of director of energy research Robert O. Hunter, Jr. is imminent according to several sources, including an article in the September 20 issue of Science. During his one-year tenure, Hunter has been the nemesis of several energy research programs including the fusion and high energy physics programs. The problems of the magnetic fusion program under Hunter's direction have been legion and have descended upon the program regularly without advance warning.

Early during Hunter's tenure word began to reach the fusion community that he was denigrating the progress of the program during visits with congressional staff. In October 1988, in a banquet speech to the American Nuclear Society fusion engineering conference, he stated that no progress had been made in ten years and that he found no support for fusion on "the Hill." About that same time, he decided to "reprogram" \$23 million of magnetic fusion funds. This action resulted in the layoff of 160 industry personnel at the Princeton Plasma Physics Laboratory on one-day's notice and caused major disruption of several programs, including ATF at Oak Ridge and CPRF at Los Alamos. He quoted the results of the MFAC 1988 summer study (see our October 1988 newsletter) as a partial justification of the reprogramming, but MFAC members felt he had inappropriately focussed on only a portion of the summer study report.

Hunter then removed the director of the U.S. magnetic fusion program, John Clarke, and during all of 1989 the program has been without a permanent director. Hunter set up a shadow management, consisting of two outside consultants (Tom Johnson from West Point and Kim Molvig from MIT), to plan, manage and oversee magnetic fusion. Johnson created a radical new fusion policy document without consulting any of the DOE staff charged with managing the program under the able leadership of Dr. N. Anne Davies. All budgets and program actions proposed by Dr. Davies and her staff were reviewed and approved by Dr. Molvig and Hunter personally. The new policy was being used to shape the fusion program since early spring but its existence was not publically known until May when a copy

leaked. Even then Hunter refused to acknowledge its authenticity.

Early in the year, Hunter asked MFAC to review the status of tokamak confinement physics, including the "probability" of ignition in CIT. He asked MFAC to appoint Dr. Molvig to chair the panel. Although the panel did not make its final report through MFAC until June, Hunter arranged for the results of the panel's interim report in March to be presented to Energy Secretary Watkins. Based on one section of the report, eventually discounted by the full MFAC, Secretary Watkins decided not to proceed with the CIT project and secretly endorsed Hunter's new policy, which he called "new" and "innovative." Watkins prepared to announce this policy (including a \$50 million cut in magnetic fusion, postponement of CIT, and established a civilian energy competition with inertial fusion) at a Senate hearing in June. At the last minute, under pressure from several senators, Watkins pulled back from endorsing the plan and instead agreed to a "high level independent review" of the "draft policy." He did, however, send letters to the Hill requesting that CIT construction be postponed.

Although Watkins originally stated the policy review would be completed by mid-August, he did not actually authorize the establishment of the review committee until mid-October. Meanwhile, the fusion program's future was placed in additional jeopardy since the DOE FY 1991 budget submission to OMB in September contains no justification for the program, only a statement that the policy is under review.

POLICY REVIEW

In a letter to several congressman dated October 16, Watkins says "Because of the decision to significantly revise the Department's fusion policy, I am establishing a Fusion Policy Advisory Committee to conduct an independent, high level review of this strategy." The final written report of the committee should "provide advice on how to structure the fusion programs--either by the proposed policy, some modifications to it, or some totally different approach," Watkins' says. The the review committee "will operate within the requirements of the Federal Advisory Committee Act and its implementing regulations, and will expire upon completion of its task."

ZWILSKY ELECTED PRESIDENT OF ASM

Dr. Klaus M. Zwilsky has become president of ASM INTERNATIONAL, the society for material technology, for the 1989-1990 term. He moves up to the presidency following a one-year term as vice president and trustee of the technical society.

From 1973 to 1981, Klaus was chief of the Materials and Radiation Effects Branch, Office of Fusion Energy at DOE. While in that position he helped establish the U.S. fusion materials program and was instrumental in establishing a number of bilateral and multilateral exchanges with Europe, Japan, the USSR, the International Energy Agency, and the International Atomic Energy Agency.

Since 1981, he has served as staff director of the National Materials Advisory Board of the National Research Council in Washington, D. C. The National Research Council is the operating arm of the National Academy of Sciences and National Academy of Engineering.

FUSION IN CANADA

The Tokamak de Varennes at Hydro Quebec conducted Phase I of operations June 1987-December 1988, underwent modification during the first half of 1989, and has begun Phase II operations. The modifications included installation of double-null closed divertors and internal fast horizontal plasma position control. Among the results from Phase I, studies of plasma turbulence and energy transport were conducted by small-angle scattering of CO₂ laser radiation and a novel technique was developed for determining electron density and temperature in the plasma edge regime. The technique depends on measurements of spontaneous radiation emitted by atoms sputtered from a surface placed in contact with the plasma. For her work on this diagnostic, Deborah Poirier was awarded the Lumonics Prize from the Canadian Nuclear Association. She can be contacted at (514) 468-7734 for more information.

The Province of Ontario has allocated additional funding of \$9.4 million to Ontario Hydro's Canadian Fusion Fuels



KLAUS M. ZWILSKY

Technology Project (CFFTP), bringing the total funding to \$33 million over 5 years. CFFTP plays a major role in design and equipment for fusion tritium systems world-wide. For example, a tritium system for filling microballoon laser fusion targets has been delivered to the University of Rochester and KfK has ordered a complete hydrogen isotope separation system. A preliminary design for the ITER isotope separation system has been completed. CFFTP is also contributing to ITER in the maintenance, assembly and breeder blanket designs and has prepared a detailed design for the NET (Next European Torus) fuel processing loop. Ontario Hydro is also doing research on laser isotope separation (LIS) and is evaluating an LIS separation method for detritiation of light water in fusion applications.

The CFFTP 1988-89 annual report, which lists all technical reports published since January 1988, is now available. CFFTP also publishes a newsletter three times a year. For copies, contact Sonja Morgan, Tel. (416) 823-0200; FAX (416) 823-8020.

Another important source of information is Fusion Canada, published four times a year in French and English. Contact Bob Macphee, Tel. (416) 925-3117; FAX (416) 925-2809.

GA BUYS VARIAN GYROTRONS

General Atomics has placed a \$2 million order to buy four 110-gigahertz, 500 kilowatt, cw gyrotrons from Varian Associates. The tubes will be used to heat the plasma in the DIII-D tokamak. The four new tubes will provide 2 megawatts of power, a feat which previously would have required 10 tubes. For information on Varian's gyrotrons, contact Bob Alper (415) 424-6984; FAX (415) 852-9517.

CLUSTER ION FUSION

Brookhaven National Laboratory scientists R. J. Beuhler, G. Friedlander and L. Friedman have published (Physical Review Letters, Sept. 18, 1989) a paper describing experiments in which they accelerated singly charged clusters of 25 to 1300 D₂O molecules to energies of 200 to 325 keV and then impinged the clusters onto TiD targets. The experimenters observed 3 MeV protons from D-D reactions at a rate of 0.05 sec⁻¹ per cluster nanoampere. This corresponds to approximately 10⁻¹⁴ events per incident deuteron. The authors state "The experiments reported here provide a novel approach to the study of fusion reactions in dense assemblies of reactant atoms. The high fusion rates and the sensitivity to projectile energy suggest the possibility of a possible new path to fusion power." The results were also described by Bill Broad in the Sept. 12 New York Times.

SMALL BUSINESS GRANTS

The DOE is inviting small business firms to submit grant applications for the Small Business Innovation Research (SBIR) program. Approximately 120 awards of up to \$50,000 will be made "to explore the feasibility of their ideas, with up to \$500,000 available in a second phase for those ideas with the highest potential to meet the SBIR program objectives." Fusion topical areas are plasma diagnostics, plasma confinement systems technology and fusion energy systems. Applications must be received by January 23. For application material, contact SBIR Program Manager, U.S. Department of Energy, Washington, D. C., 20545, (301) 353-5707.

GET WELL WISHES

We wish a speedy return to work to Bruno Coppi who suffered a heart attack in mid-September and to John Killeen who suffered a stroke in mid-August. Well wishers can send their thoughts to Bruno at 30 Pilgrim Dr., Winchester, MA, 01980; and to John at 1528 Campus Drive, Berkeley, CA, 94720.

RECENT FPA ACTIVITIES

Fusion Power Associates has had a busy summer and fall. Here are some of the things we have been doing:

- Completed the preparation of a report entitled "An Accelerated Fusion Power Development Initiative," along with a brochure entitled "The Global Warming Imperative: Bring Fusion to Earth," and a "Fusion Power Primer" for the Agency for the Advancement of Fusion Power. Copies are available from FPA.
- Organized two fusion policy workshops.
- Testified at the October 3-5 congressional fusion hearings.
- Met with several key congressional staff.
- Met for a second time with DOE personnel responsible for preparation of the National Energy Strategy.
- Organized a special evening session Nov. 13 for the APS Division of Plasma Physics.
- Attended ARIES workshop at UCLA.
- Participated on a review panel for the Defense Nuclear Agency's pulsed power program.

PEOPLE

Dan Barnes has left SAIC to become magnetic fusion theory group leader at Los Alamos.

Harry Dreicer has become laboratory fellow at Los Alamos. Rulon Linford will assume Harry's managerial duties in addition to maintaining his previous position as program leader.



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EUROPEANS SET NEW FUSION RECORDS

JET SETS FUSION RECORDS

Scientists working on the Joint European Torus (JET) have achieved record high values for the fusion breakeven parameter Q (ratio of fusion power produced to input power to the plasma). The results were announced at a press conference in England on November 7 and presented November 13 at the annual meeting of the American Physical Society Division of Plasma Physics.

Using deuterium plasma's, JET achieved equivalent Q values in the range of 0.7 to 0.8 of breakeven, which is 50% higher than the previous record value of 0.5 held by TFTR in the U.S. The values achieved in TFTR and JET are close enough to the 1:0 breakeven value that JET team leader Paul-Henri Rebut feels that, for all practical purposes, breakeven conditions have been demonstrated. In the November 7 press release, Rebut states, "I consider that the problems of heating and confining a thermonuclear plasma are now solved." The press release further states "Over the past year the JET Project has more than doubled its best fusion factor and has now basically achieved its principal objective of establishing the scientific feasibility of nuclear fusion as an energy source."

"We now have to concentrate on reducing impurities and controlling the plasma fueling for long enough for a reactor," Rebut said.

The JET also set a new record for another key measure of fusion progress: the product ($n\tau T$) of plasma density, confinement

time and temperature, achieving a value of $7 \times 10^{14} \text{cm}^{-3} \text{sec keV}$. The previous record was 4.3×10^{14} , held by TFTR in the U.S. The JET result was achieved with a density of $3 \times 10^{13} \text{cm}^{-3}$, confinement time of 1.1 sec and temperature 22 keV. The temperature and confinement time achieved are adequate for an operating fusion reactor.

A new record for plasma pressure relative to magnetic field pressure of 9.3%, achieved in the DIII-D experiment at General Atomics, was also reported at the conference. This value (reported in our October newsletter) is also sufficiently high for an operating fusion reactor. The JET, DIII-D and other data reported at the meeting resulted in an air of optimism about the prospects for fusion power.

NATIONAL ENERGY STRATEGY

A draft outline of the National Energy Strategy interim report will include a section on fusion within a chapter on "Securing Future Energy Supplies." Separate hearings are being considered for nuclear and for renewables, but as yet, no hearing is being scheduled for fusion. We are continuing to request a separate hearing for fusion.

Fusion Power Associates has met twice with DOE officials preparing the National Energy Strategy, submitted materials for their use and requested treatment of fusion on a par with nuclear and the renewables. However, speaking to the Energy Research Advisory Board November 9, DOE deputy undersecretary Linda Stuntz stated, "There's not exactly a

huge public sector out there when it comes to fusion programs and other science programs at DOE."

We suggest that our readers express their views on how to include fusion in the National Energy Strategy to Ms. Linda G. Stuntz, Deputy Under Secretary for Policy, Planning and Analysis, U.S. Department of Energy, 1000 Independence Avenue, S.W., Washington, D. C., 20585.

WATKINS CRITICIZES FUSION; BACKS SOLAR AND COAL

In an interview with reporter Keay Davidson, published in the October 29 San Francisco Chronicle, energy secretary James Watkins says the fusion "track record hasn't been all that impressive. I was at Oak Ridge (National Laboratory in Tennessee) in 1958 and I was told by all the scientists we were within seven years of fusion...for sure by 1965! Well, here we are in 1989 and people are telling me, 'we're just right there, all we need is (to generate) a little more magnetic field and we'll have a wonderful time.' That's one way to do it--but I don't believe it's the best way now, not with the (federal) budget crunch."

According to the Chronicle, Watkins expressed a desire to double the DOE's research expenses for solar energy. "It's going to get a lot more (support) from me," Watkins said. "You'll see we're going to be very serious about (energy) conservation and (energy) renewables, with photovoltaics (electricity-generating solar cells) right up there in front."

Speaking to the National Coal Council November 9, Watkins said, "I can assure you that under my watch, the influence of your expertise will continue. There are those who are ready to write off coal--to impose carbon taxes or moratoria on coal. They do not understand that neither the United States nor the world can turn its back on coal. With more than 30 percent of the world's coal reserves, the United States has enough coal to carry this country into the 24th Century at our current rate of consumption. In short, the world's developing nations--and many of the industrialized nations as well--are looking to coal to meet their growing

energy needs. And with increased use of coal will come increased concerns about the environment--all of which presents enormous opportunities for U.S. coal and clean coal technology. That's why the Bush administration has ambitious plans to bolster the country's coal and coal technology export initiatives. Rest assured that this administration will see the clean coal technology program through to the full extent of its \$5 billion, 5-year commitment," Watkins said.

However, at a half-day seminar on global warming in mid-October, sponsored by the National Energy Resources Organization (NERO) and the Global Climate Coalition, Michael DeLand, chairman of the White House Council on Environmental Quality said that the nation must rethink its energy mix and eventually turn away from fossil fuels. "We've simply got to ratchet back on those sources of energy," he said. DeLand said coal, wood and oil will play less of a role in the nation's energy future. In the long run, the energy mix must be redirected toward sources that won't make the problem worse, he said. DeLand said that the U.S. should channel its research dollars toward finding alternative forms of energy.

FUSION DOCUMENTARY PREVIEWED

A new fusion documentary "Fire from the Sun" was previewed for attendees at the APS Division of Plasma Physics meeting in Anaheim, November 13. The program, hosted by E. G. Marshall, is expected to air nationally on PBS through the South Carolina Educational TV network. Advance copies on VHS video may be purchased from the producer Michael Pack, Manifold Productions, (213) 462-1844.

ITER PROGRESS CITED

Recent worldwide conferences have heard of the encouraging progress in ITER (International Thermonuclear Experimental Reactor) activities. Speaking before the World Energy Conference in Canada, in September 1989, on the subject "World Progress Toward Fusion Energy," ITER Council Chairman John Clarke assessed the activities as "the largest fusion collaboration ever attempted." He reported that "the Definition Phase of the ITER activity has been concluded successfully, and the Design

Phase will be finished in 1990." Dr. Clarke outlined the major objectives of the activities, described the direction and management aspects and provided figures illustrating the scale of the Parties' contributions including both the core design team work and supporting R&D.

The Director General of the International Atomic Energy Agency, Dr. Hans Blix, in his statement to the 33rd General Conference of the IAEA, 25-29 September 1989, cited ITER as a project "of major importance to the international fusion community." Also, he informed the Conference that "preliminary discussions will now start about a possible second phase."

A special evening session entitled "ITER Design and R&D," chaired by Paul Rutherford was held at the APS Division of Plasma Physics meeting, November 16. Speakers included Ken Tomabechi (Japan), Boris Kadomtsev (USSR), Romano Toschi (Italy) and Doug Post (USA).

SUDAN RECEIVES MAXWELL PRIZE

The APS Division of Plasma Physics has awarded its James Clerk Maxwell Prize in Plasma Physics to Ravi Sudan of Cornell University. Sudan is IBM Professor of Engineering and also a professor of electrical engineering and applied physics. Sudan was awarded the Maxwell Prize "for wide-ranging contributions to the theory of plasma stability and turbulence and pioneering work on the generation and propagation of ion beams," according to the citation. "His penetrating analytic and computational studies, often done with his numerous students, have had considerable impact on ionospheric and magnetospheric physics, on confinement and heating in field-reversed ion rings, and on light-ion beam drivers for inertial confinement fusion."

Sudan received his Ph.D. from the Imperial College, University of London, came to Cornell in 1958 as a research associate in electrical engineering and served as director of the Laboratory of Plasma Studies for 10 years. He helped found the Cornell Theory Center as its first deputy. He is a Fellow of the American Physical Society and of the Institute of Electrical and Electronic Engineers.



PROF. RAVI SUDAN

HUNTER RESIGNS

As expected (see our November newsletter) DOE Director of Energy Research Robert O. Hunter, Jr., resigned his post and left the DOE at the close of business October 26. Dr. James F. Decker has been named Acting Director. Dr. N. Anne Davies continues as Acting Associate Director for Fusion Energy.

FPA ELECTS OFFICERS

The following have been elected by the Fusion Power Associates Board of Directors to serve two year terms commencing November 1, 1989: Robert C. Iotti (Ebasco), Chairman of the Board; Tim Henderson (KMS Fusion), Vice Chairman; Stephen O. Dean, President; Ruth A. Watkins, Vice President, Administration & Finance; Gerald L. Kulcinski, Vice President, Research.

Susan D. Kinkead continues as Director, Public Affairs.

FEF VINDICATED (BELATEDLY)

On April 24, 1987, over a hundred federal marshals and state police descended on the Leesburg, VA, offices of three organizations affiliated with Lyndon LaRouche, including those of the non-profit Fusion Energy Foundation (FEF), publishers of Fusion

Magazine. The agents were armed with automatic weapons and a court order forcing the organizations into "involuntary bankruptcy." The bankruptcy action was necessary, the government argued, in order that their assets could be liquidated, if necessary, to satisfy a \$21 million fine imposed by a federal judge in Boston for failing to cooperate with the court. The 1987 federal action effectively shut down the Fusion Energy Foundation and Fusion Magazine.

During a lengthy bankruptcy trial during 1988, the FEF argued that, as a non-profit foundation, it was not legally subject to involuntary bankruptcy proceedings. On October 5, 1989 federal judge Martin Bostetter dismissed the charges against all three organizations. Bostetter ruled that the government filed the bankruptcy petitions improperly, knowing that there were hundreds of creditors and yet noting the government as the sole creditor in the filing. "The government's decision to file the petitions despite that knowledge constituted an improper use of the involuntary bankruptcy statute," Bostetter said.

The judge also found that two of the three organizations were non-profit institutions and therefore not subject to involuntary bankruptcy actions. Furthermore, Bostetter wrote, "while the government has alleged that (the organizations') methods of fundraising were reprehensible, that alone does not change the debtors' status and provide the appropriate basis" for federal bankruptcy.

LaRouche and several associates are currently serving jail sentences for allegedly improper fundraising without intent to repay loans. LaRouche's lawyers have argued that the bankruptcy proceeding, initiated by the federal government, made it impossible to repay the loans. During LaRouche's criminal trial the jury was told that the organizations were in bankruptcy, but the judge in that case refused to allow the jury to be told that the government was the creditor that forced them into bankruptcy. The government convicted LaRouche in a 3-week trial in federal court in Alexandria, VA, after failing to obtain a conviction in a federal court in Boston, when the judge dismissed the case because its length (over 6 months) had become a hardship for the jury.

In his ruling, bankruptcy judge Bostetter said "the government's action (in closing down the organizations) could be likened to a constructive fraud on the Court, wherein the Court may infer the fraudulent nature of the government's conduct."

SPECTRA TECHNOLOGY PURCHASED

Effective September 30, Amoco Technology Company of Naperville, IL, a wholly owned subsidiary of Chicago-based Amoco Corporation, acquired Spectra Technology, Inc. (STI). Spectra Technology, Inc. is a leader in laser research and development and the delivery of custom laser systems. STI also researches magnetic fusion energy, a potential energy source for the 21st century, and is developing diagnostic hardware for the electrical utility industry. STI's staff of 120 includes more than 50 professional scientists and engineers for its development programs. Since 1982, STI has been a wholly owned subsidiary of Spectra-Physics, Inc.

Bob Center, the president of STI, stated that the Amoco acquisition will not result in any significant change in the focus or operation of STI. For further information, contact K. E. Willis, VP, F&A, Spectra Technology, Inc., 2755 Northrup Way, Bellevue, WA, 98004 (206) 827-0460.

TTF TO MEET

The (tokamak) transport task force (TTF) will hold a workshop February 19-23 at the Hilton Head (SC) Marriott. The workshop will emphasize the status of understanding of fluctuations, transient and steady-state transport. For information, contact Jim Callen (608) 262-1370.

AAAS TO MEET

The Annual Meeting of the American Association for the Advancement of Science (AAAS) will meet February 15-20 in New Orleans. For information contact Rolf Sinclair (202) 357-7996.

QUOTABLE

"The only thing worse than failure is not to try at all."

James Beggs
former NASA Administrator