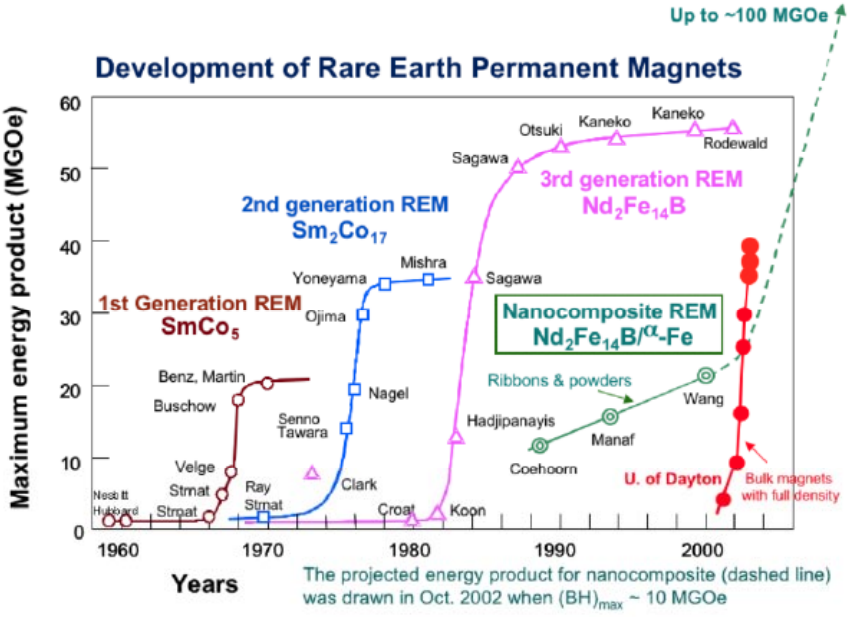
PROPULSION DIRECTORATE

Monthly Accomplishment Report
March 2003

Contents ***Page***

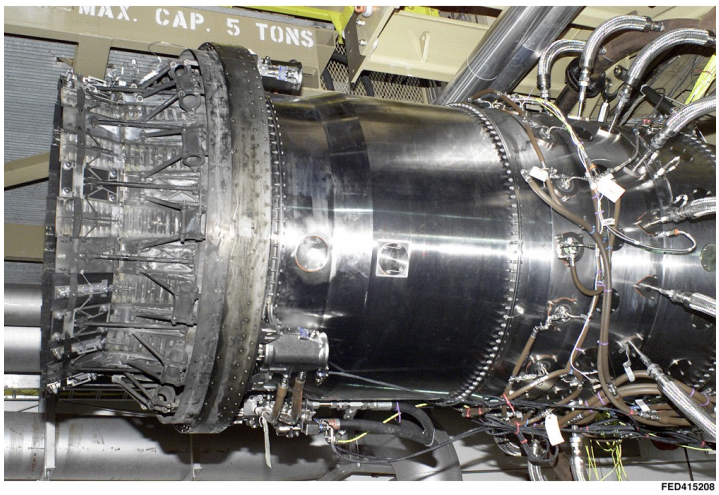
NANOCOMPOSITE RARE EARTH MAGNETS ON THE HORIZON: The University of Dayton Magnetics Laboratory recently achieved a breakthrough in the technology of synthesizing fully dense anisotropic nanocomposite bulk magnets. Much of the push for these magnets was provided by the Propulsion Directorate's Power Division (AFRL/PRP), who has a need for a new breed of very high density electrical machines for use in lightweight, high-power aircraft generators and actuator applications. The new nanocomposite magnets developed by the University of Dayton Research Institute (UDRI) are composed of a mixture of nano-scale hard and soft materials, and they offer the potential to produce permanent magnets with greatly enhanced energy products. Prior to this effort, technical problems persisted in reaching higher coercivities, producing fully dense bulk magnets, making anisotropic magnets, and fully magnetizing the magnets. However, UDRI's research efforts resulted in an enormous increase in the state of the art for this type of magnet. Recently, UDRI produced a fully dense anisotropic nanocomposite magnet with an energy product of 38.5 MGOe (MegaGauss Oersted is a magnet power measurement where the theoretical maximum energy product is approximately 100 MGOe). Other worldwide attempts to create nanocomposite magnets so far have resulted in levels reaching only about 20 MGOe. This rapid success puts the planned effort almost a year ahead of the original projections. If recent trends in this magnet type's material development are maintained, this magnet type could push past the maximum energy product of more expensive neodymium (NdFeB) magnets. Support for this technology was difficult to find initially, but demonstrating the impact these magnets could have on future power generation systems has increased overall advocacy. A number of commercial users have now expressed interest for a very high energy product magnet with a lower percentage of rare earth (RE) content. The lower RE content leads to cheaper magnets with better corrosion resistance, while the fine grain size leads to better fracture toughness than previously possible. This work was performed under the sponsorship of the Defense Advanced Research Projects Agency (DARPA)/Office of Naval Research (ONR) and DARPA/AFRL. (E. Gregory, AFRL/PRPG, (937) 255-6205)



Want more information?

- A press release from the University of Dayton on this topic is available by clicking here.

XTE67/1 AUGMENTOR DEMONSTRATES ADVANCED CAPABILITY IN RIG TEST: The Integrated High Performance Turbine Engine Technology (IHPTET) XTE67/1 augmentor demonstrated its design performance objectives during sea level static testing at a Pratt and Whitney test facility. The advanced Pratt and Whitney augmentor was mounted on a JSF119 Concept Demonstration Aircraft engine, and it demonstrated improved efficiency, pressure loss, and stability over the F119 baseline augmentor. The primary purpose of the rig test was to validate new augmentor design tools that can be used to design and develop advanced military augmentors. This test validated the predicted thermal environment and operability limits at sea level static conditions. Follow-on tests, scheduled for late this year, will validate these design tools at altitude conditions. (J. Datko, AFRL/PRT, (937) 255-4100)



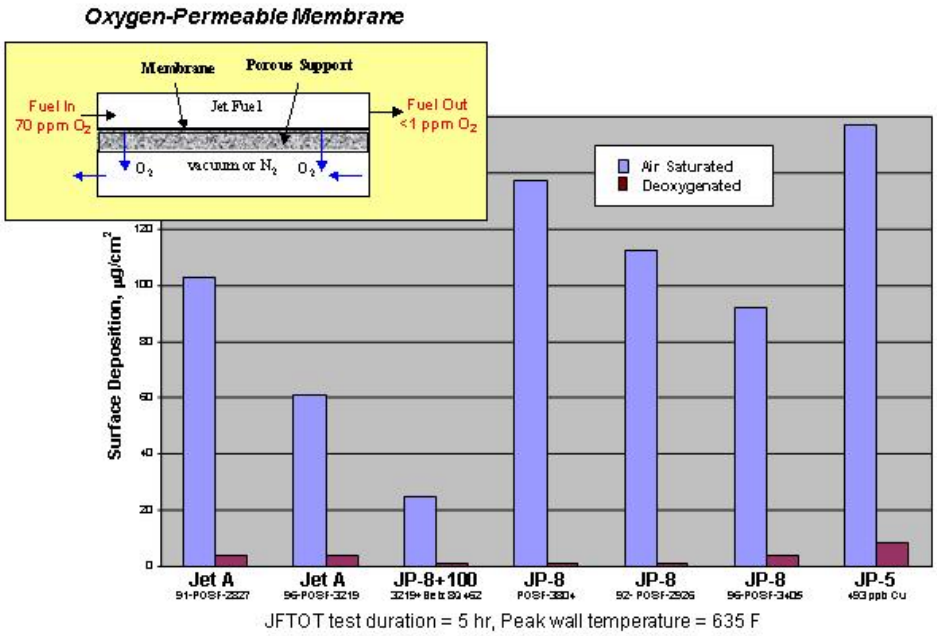
The XTE67/1 augmentor

KOOP HONORED FOR TURBINE ENGINE S&T LEADERSHIP: The Propulsion Directorate's Mr. William E. Koop was recently selected to receive the Meritorious Civilian Service Award. Mr. Koop was selected for this honor in recognition of his leadership and technical excellence as the Chief of Technology for PR's Turbine Engine Division (AFRL/PRT) and as the Integrated High Performance Turbine Engine Technology (IHPTET) Program Manager from 27 June 1993 to 31 October 2002. Mr. Koop demonstrated outstanding leadership, management skills, and technical expertise over an extended period as he directed the annual execution of approximately 150 science and technology investments focused on advancing the state of the art of aircraft gas turbine engines. He is frequently chosen for the most difficult of technical tasks, and his superior judgment and vision have been a huge influence on the direction of major turbine engine programs within PR and the military turbine engine industry at large. Upon the retirement of Mr. Richard J. Hill in January 2003, Mr. Koop was chosen as his successor as the Chief of the Turbine Engine Division. His selection for this key position serves as further evidence of his outstanding reputation and widely recognized abilities. Mr. Koop's distinctive achievements and


Mr. William E. Koop was selected to receive the Meritorious Civilian Service Award

dedication are most deserving of this special recognition. (Col A. Janiszewski, AFRL/PR, (937) 255-2520)

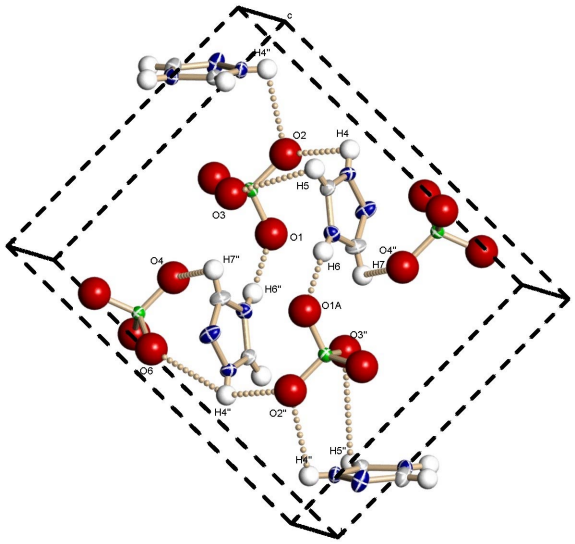
FUEL STABILIZATION UNIT SUPPRESSES COKE FORMATION: The Propulsion Directorate's Fuels Branch (AFRL/PRTG) and United Technologies Corp (UTC) have developed a Fuel Stabilization Unit (FSU) for suppressing autoxidative coke formation in aircraft fuel systems. This technology will increase the exploitable cooling capacity of the fuel and enable major increases in engine operating temperature and cycle efficiency, with reduced maintenance as an added benefit. Recently developed membrane technology has shown the potential for removing oxygen that dissolves in the fuel due to contact with air. This dissolved oxygen reacts when heated to form coke precursors. UTC has demonstrated a small, practical FSU in which fuel flows over a permeable membrane structure consisting of an ultra-thin coating that has the requisite oxygen separation properties. The oxygen molecules in the fuel dissolve into the membrane and then diffuse across it, driven by the difference in oxygen partial pressure across the surface, while the hydrocarbon fuel molecules are unaffected and pass over it. A convincing demonstration of coke suppression was performed when several air-saturated (normal) and on-line deoxygenated jet fuels were tested in a standard ASTM (American Society for Testing and Materials) heated tube apparatus at wall temperatures as high as 850ºF (454°C). With deoxygenated Jet A, JP-8, and JP-5 fuels, there were dramatic reductions (approximately a factor of 20) in coke deposition relative to air-saturated fuel. In this test, deoxygenated Jet A was shown to perform as well as JP-7, the Air Force's highest thermal stability fuel. Based on these results, this technology will allow the maximum fuel temperature to be increased by approximately 400ºF (204°C), tripling the available heat sink. These encouraging results were successfully repeated with copper contaminated fuel found in shipboard applications, which is noteworthy because copper is known to be a catalyst for autoxidative coke formation. UTC and PRTG are proceeding with a plan to perform a feasibility demonstration of a prototype FSU in a small aircraft engine later this year. (P. Pearce, AFRL/PRTG, (937) 255-6918)



Removal of dissolved oxygen dramatically decreases coke formation

PATENT ISSUED FOR NOVEL ENERGETIC SALTS: US Patent #6,509,473 was issued to Dr. Gregory W. Drake of the Propulsion Directorate's Propellants Branch (AFRL/PRSP) on 21 January 2003. This patent, titled "Energetic Triazolium Salts," describes a method for preparing a family of energetic salts that have potential application as rocket propellants. The salts described in the patent are attractive for a number of reasons. They can be readily synthesized from commercially available starting materials with high yields, they possess excellent thermal stability, and they have desirable safety properties, including mechanical insensitivity. Furthermore, these new salts hold several advantages over the state-of-the-art monopropellant hydrazine. These advantages include an approximately 50 percent greater density, higher predicted specific impulse (I_{sp}) values, and no vapor pressure at ambient temperature, which results in decreased toxicity. The lower toxicity is particularly desirable, as it offers the potential to save considerable time and resources in the handling and loading of toxic materials such as hydrazine. These inventive salts can be used to produce higher performing liquid and solid propellants for increased payloads and/or cost savings. Potential applications for this technology include reaction and attitude control propellants, booster propellants, gas generators, and emergency power units. Consequently, companies employed in satellite development and production, vehicle restraint systems, and space launch system development and production stand to benefit from the energetic salts presented in this patent. (G. Drake, AFRL/PRS, (661) 275-5355)

Dr. Gregory W. Drake



The single crystal x-ray diffraction structure of 1,2,4-triazolium perchlorate was recently determined and revealed a significantly higher density (1.96 g/cm^3) than previously expected, due mainly to hydrogen bonding (dotted lines). Unit cell shown.

Want more information?

- The full text of this patent is available by clicking here.

PR MAKES MAJOR CONTRIBUTIONS TO SUCCESS OF LOCAL SYMPOSIUM: The Propulsion Directorate played a major role in the success of the 28th Annual Dayton-Cincinnati Aerospace Science Symposium held on 4 March 2003 in Dayton, Ohio. The American Institute for Aeronautics and Astronautics (AIAA) sponsors this symposium, which for many years was known as the "AIAA Mini-Symposium." Over the years, this event has blossomed into a top-notch forum for technical exchange between the members of the sizable local technical community. This year, PR personnel again made substantial contributions to both the organization of the symposium and the technical program. The Executive Co-chairs for this year's symposium were Dr. Joe Zelina of the Propulsion Directorate and Dr. Jeffrey C. Tromp of the Air Vehicles Directorate. PR government and on-site contractor personnel chaired 6 of the 39 technical sessions held at the symposium including sessions on turbomachinery, fuels, combustion diagnostics, sensors and instrumentation, and pulse detonation engines. In addition, PR personnel co-authored more than 40 of the 165 papers presented at the symposium. By all accounts, this was yet another in a long line of successful symposia, due in large part to the enthusiastic participation of the Propulsion Directorate. (J. Zelina, AFRL/PRTS, (937) 255-7487)

A large crowd gathered for the keynote address at this year's Aerospace Science Symposium

Want more information?

- More information on this event can be found at the AIAA Dayton-Cincinnati Section's webpage located here.

METHOD FOR DETECTING FUEL ADDITIVE GARNERS INTERNATIONAL INTEREST: The Propulsion Directorate has developed a simple method for detecting the presence of the +100 fuel thermal stability additive in fuel samples, and this method has recently been embraced by the Australian military. This new method, developed by Dr. Don Phelps of the Fuels Branch (AFRL/PRTG), is attractive because of its simple, low-cost approach to the problem. Using this method, the presence of the +100 fuel additive can be detected by mixing a fuel sample with a solution consisting of water, vinegar, and a commercial food coloring. If +100 is present in the fuel, a pink layer appears indicating its presence. If the additive is not present, the fuel remains clear. In recent testing, the Australian military found that this method gives a quick go/no-go result as opposed to shipping samples to a laboratory for a much more elaborate, costly, and time consuming method. The Australians have dubbed this method the Bain Marie test, which refers to a water bath that is generally used in cooking to apply gentle heat to food. While the method does not give quantitative results, it is valuable as a screening tool to determine if a fuel sample

contains the +100 additive and could be a candidate for further, more elaborate analyses. The Australians are considering putting together kits so they can employ this method in the field. This is an excellent example of the manner in which cooperative programs, such as those that exist through the Air Standardization Coordinating Committee (ASCC), can provide benefits for the participating member nations. (P. Pearce, AFRL/PRTG, (937) 255-6918)

The pink color in the vial on the right indicates the presence of the +100 additive

HENDRICKS & MCGUINNESS CAPTURE AFMC CONTRACTING AWARDS: On the evening of 25 March 2003, the FY02 AFMC Annual Contracting Awards were presented at a banquet at the Wright-Patterson AFB Officers' Club. Contracting professionals working in support of the Propulsion Directorate fared well at this year's ceremony, capturing two of the awards presented. Ms. Jane Hendricks was named the Outstanding Civilian in Contracting (GS-12 and above) in the Science & Technology category. Ms. Hendricks works in PR's Contracting Division (AFRL/PRK) at Wright-Patterson AFB, Ohio. She is responsible for the planning, development, and implementation of acquisition strategy for many of the most complex and highest priority programs in PR, including the Integrated High Performance Turbine Engine Technology (IHPTET) Program. PR's other award winner was Ms. Suntok McGuinness, who was named the Outstanding AFMC Civilian in Contracting (GS-11 and below) in the Science & Technology category. Ms. McGuinness works in the contracting unit at the Air Force Flight Test Center (AFFTC/PKT), which supports Science and Technology contracting for the Propulsion Directorate's Rocket Site at Edwards AFB, California. Notably, Ms. McGuinness was selected to continue on to compete for the Air Force Level award in this category. (R. Mullins, AFRL/PRKB, (937) 255-4818 and A. Kuphal, AFRL/PRO, (661) 275-5343)


Ms. Jane Hendricks was named AFMC's Outstanding Civilian in Contracting (GS-12 and above) in the Science & Technology category

MCFALL HONORED FOR EFFORTS TO ADVANCE ROCKET TECHNOLOGY: The Propulsion Directorate's Dr. Keith A. McFall was recently selected to receive the Exemplary Civilian

Dr. Keith A. McFall was selected to receive the Exemplary Civilian Service Award

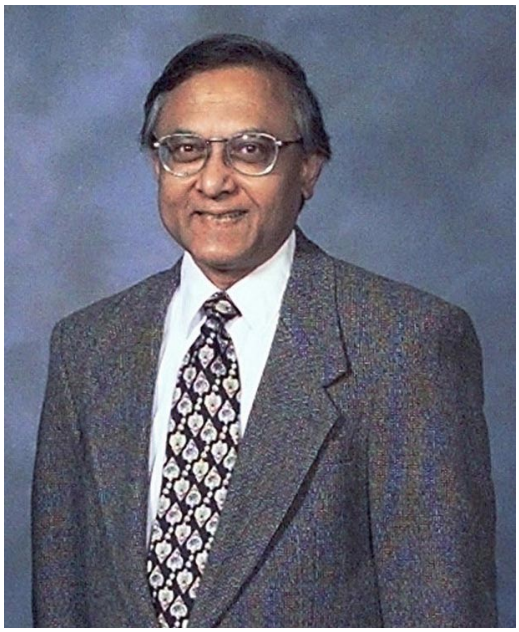
Service Award. Dr. McFall was recognized for his distinguished service as Acting Branch Chief and Branch Chief of PR's Motor Branch (AFRL/PRSB) at Edwards AFB, California, from 1 February 2001 to 31 October 2002. Dr. McFall demonstrated extraordinary commitment and performed beyond the expectations of a person in a new leadership role and a new technology area. In addition to his primary branch leadership role of conceiving and directing advanced rocket propulsion technology for strategic and tactical systems, he contributed significantly on numerous occasions to national rocket propulsion and space launch initiatives. He was the Integrated High Payoff Rocket Propulsion Technology (IHPRPT) lead in developing an IHPRPT Phase III Missile Propulsion roadmap, and he was also the Space and Missile Propulsion Division's (AFRL/PRS) lead contributor to DoD's Technology Sustainment of Strategic Systems (TSSS) initiative. In addition, Dr. McFall has greatly benefited the mission of AFRL/PRS by seeking opportunities to transfer technology and methodology to other government agencies and to aerospace companies, and he set an excellent example for sharing best practices and technologies within DoD as well. Dr. McFall's outstanding contributions make him well deserving of this honor. (M. Huggins, AFRL/PRS, (661) 275-5230)

<u>BEARING WORK EARNS DIRECTORATE HONORS FOR WAGNER</u>: Mr. Matthew J. Wagner has been selected as the Propulsion Directorate's Employee of the Month for February 2003 in the Scientist, Engineer, or Supervisor Category. Mr. Wagner was praised for recognizing an opportunity to accelerate the transition of a revolutionary technology to the field. This opportunity arose when Williams International wanted to explore new concepts for the rear bearings in the WJ24-8 turbine engine used in the Navy BQM-74 target drone. Mr. Wagner participated as the Air Force leader on a joint Air Force, Navy, and industry team to design an air foil bearing based on work done under a SBIR program he managed and insert that bearing into the hot section (high pressure turbine module) of the Williams International engine. The original plan would not have tested an air foil bearing in an engine for 3 to 4 years, but largely due to Mr. Wagner's

Mr. Matthew J. Wagner was named PR's Employee of the Month for February 2003

leadership, an engine with the air foil bearing was tested at Williams International, Walled Lake, Michigan, in December 2002. This first-ever demonstration of a foil bearing in a propulsion turbine engine provided valuable data, and it also supplied the confidence needed to insert this simple, cheap, and very high temperature rotor support technology into many types of small to mid-size turbine engines. The air foil bearing offers significant benefits, such as the total elimination of the engine oil system, much higher bearing temperature operation, an increase in performance, and a reduction in specific fuel consumption. It is a credit to Mr. Wagner's efforts that this bearing technology is moving forward, and with it, the promise of significantly improved performance and affordability for small turbine engines. (R. Wright, AFRL/PRTM, (937) 255-5568)

WORKSHOP HELD ON AIR PLASMA REFERENCE BOOK: A two-day workshop on the reference book titled *Non-Equilibrium Air Plasmas at Atmospheric Pressure* was held at the Stevens Institute of Technology in Hoboken, New Jersey, on 23-24 January 2003. This workshop was attended by 22 individuals from the US, Europe, and Japan who represented industry, university, and the government laboratories. The workshop was organized to formulate the objectives and establish the important physics issues for industrial applications of non-thermal air plasma. A select team of internationally recognized technical experts in non-equilibrium air plasmas (at or near atmospheric pressure) presented their views about the topics that should be included in this reference book. Some of these members were then selected to serve as section editors, including the Propulsion Directorate's Dr. Bish Ganguly, who was chosen as the section editor for the Diagnostics section. The primary editors for this book are Professors Karl Schoenbach[*] & Kurt Becker,[†] and Dr. Robert Barker.[‡] The research topics in the book will include electron kinetics, plasma chemistry, modeling, diagnostics, self-sustained and externally sustained plasmas, current applications, and future technical opportunities. This book will be partly sponsored by the Air Force Office of Scientific Research's Directorate of Physics and Electronics (AFOSR/NE), and some of the contributors are currently funded under the program managed by Dr. Robert Barker. (B. Ganguly, AFRL/PRPE, (937) 255-2923)


Dr. Bish Ganguly

[*] Old Dominion University, Norfolk, Virginia.
[†] Stevens Institute of Technology, Hoboken, New Jersey.
[‡] Air Force Office of Scientific Research, Arlington, Virginia.