Cold Facts

The Magazine of the Cryogenic Society of America, Inc.

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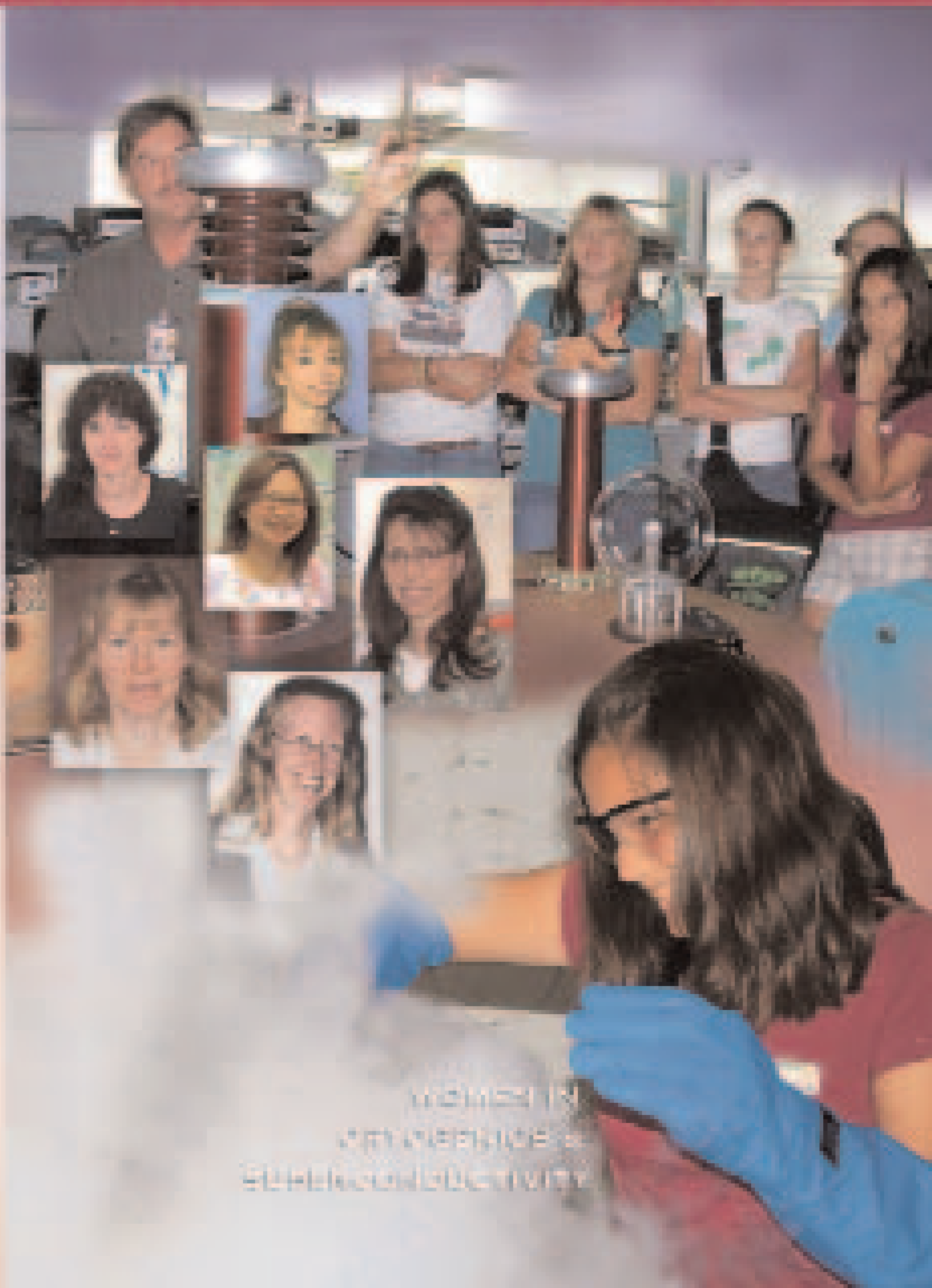

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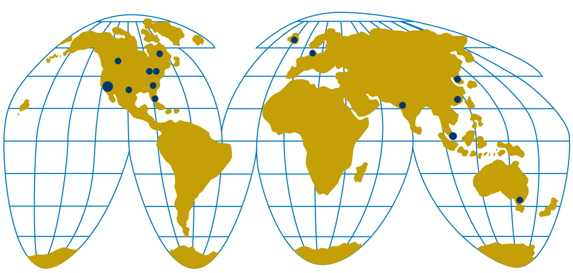

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Cold Facts

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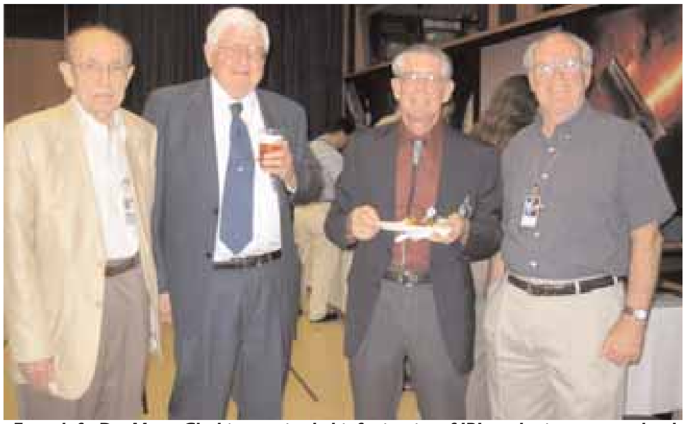
Ron Ross Retires from JPL

Ronald Ross retired as Supervisor of the Advanced Thermal Group at the Jet Propulsion Laboratory (JPL) on November 16. Ross had served as Cryocooler Manager for JPL's Atmospheric Infrared Sounder (AIRS) instrument during the 1990s, and starting in 2002 managed NASA's Advanced Cryocooler Technology Development Program, which successfully developed 6K cryocoolers for cryogenic observatories such as the James Webb Space Telescope (JWST). For the past 18 years, Ross has managed JPL's Advanced Thermal Technology Group with a primary focus on cryocoolers and cryogenic instrument design. He has authored or coauthored more than 170 formal reports and journal articles covering his technical experience, more than 65 of which are in the field of cryocoolers and cryogenic instruments. He is the past Chair of the International Cryocooler Conference and has been its Publications Chair and Proceedings Editor for the past 12 years.

Starting in 2007, Ross hopes to do consulting work in the field of space cryocoolers for JPL and possibly others. He is currently completing supervision of the production and distribution of the proceedings of the 14th ICC Conference which will be published in early 2007.



From left: Dr. Mous Chahine, retired chief scientist of JPL and science team leader of the Atmospheric Infrared Sounder (AIRS) instrument, Fred O'Callaghan, past production manager of the AIRS instrument and current manager of JPL's Astronomy and Fundamental Physics Program Office, Ron Ross, Larry Sumas, retired Deputy Director of JPL. Photo taken at Ross' retirement party on Nov. 8.

Absolute Zero TV Show to Debut in '07

The TV program *Absolute Zero and the Conquest of Cold* is now in post-production and on schedule to air in 2007. Executive Producer, Meredith Burch said they have a "whale of a tale, remarkable visuals and impressive experts. Three interviewees (among others) will launch viewers on a magical mystery tour of the strange quantum world that exists a few billionths of a degree above zero. They are Eric Cornell, Carl Wieman and Wolfgang Ketterle, who shared the 2001 Nobel Prize for physics for their discovery of Bose Einstein Condensates, a new form of matter never before seen in the universe."

The program will air on the BBC before summer, and possibly in early summer or fall in the US, according to Absolute Zero Project Manager Allan Childers. The program will feature a combination of science, cultural history and adventure that explores concepts, events and individuals in the field of low-temperature physics and their impact on society. Recently, several partners of the project previewed 40 minutes of the 2-hour series, and reported positive feedback. New partner organizations are joining the Absolute Zero campaign, including the National High Magnetic Field Laboratory (NHMFL) and the National Society of Hispanic Physicists. At the national AAAS meeting in February, Russ Donnelly, the principal investigator for the project, and Tom Shachtman, author of the book, "Absolute Zero and the Conquest of Cold," are set to present at a session for low-temperature physics.

Many physicists, educators and engineers have volunteered to act as AZ Experts, using their knowledge to help inspire young people, participating in after-school educational events, or making presentations before professional organizations. AZ Experts include David Haase, director of The Science House, John Pfotenhauer of the University of Wisconsin and Eric Palm, chief of the Millikelvin Facility at NHFML. Visit the Absolute Zero Web site, www.absolutezero.org, which now features educational games, such as Absolute Zero Sudoku and downloadable versions of the ***Community Educational Outreach Guide*** and the ***Science Educator's Guide***, both created to provide educators with hands-on demonstrations for explaining such topics as states of matter, thermometers, cryogenics and technology, and refrigeration and superconductivity.

Elie Track Predicts Superconductivity Breakthroughs

Dr. Elie Track, senior partner at HYPRES Inc, a leading developer of superconducting microelectronics technology, has developed a top 10 list of likely breakthroughs in the field of superconductivity in 2007.

Track began compiling the list in the latter half of 2006 through his work at HYPRES, as vice president of the IEEE Council on Superconductivity and vice president of the Yale Science and Engineering Association. Much of his research took place through conversations with scientific experts around the world, especially at conferences such as the Applied Superconductivity Conference (ASC) in Seattle and the International Symposium on Superconductivity (ISS) in Nagoya, Japan. Track reviewed the talks given at both conferences and began dialogs and email exchanges with people in the scientific community, often speaking with top level managers with a good overview of the breakthrough in question, and other times going directly to the source working on the project.

In compiling the list, Track spoke with a range of experts, including but certainly not limited to, Dr. John Rowell, currently a distinguished visiting professor at Arizona State University and a member of the National Academy of Engineering, member of the National Academy of Science, and a fellow of the Royal Society; Professor Nate Newman of Arizona State University, Dr. Don Gubser of Naval Research Laboratory, Dr. Richard Harris of NIST, Dr. Mutsuo Hidaka, Manager of Low Temperature Superconducting Device Laboratory, SRL-ISTEC, and Professor Hans Hilgenkamp of the University of Twente (The Netherlands). In the end, Track relied on his own judgment and subjectivity as he narrowed the list down to 10 upcoming breakthroughs.

Track said there have always been lists of this nature in magazines, but the publications didn't have a wide circulation and catered predominately to engineers, and he didn't recall seeing a top 10. He created a top 10 rather than a longer list, thinking it might attract more press attention.

"My motivation is that superconductivity has a lot to contribute. If it can get [recognition] and support from congressmen and the public then it will help bring in resources," Track said. He added, "As a community [those of us working] in superconductivity, are not doing a good enough job of communicating in a simple way…we need to be better communicators with the public."

Track said the list is also a way to hold the superconductivity community accountable. "[The list] creates a dialog. At the end of the year we can look back [and see what progress we have made]." Since the list debuted at the end of 2006, various Web sites, newspapers and magazines are picking up the news.

"I've seen publications that don't usually talk about superconductivity talk about superconductivity," Track said. Track will even be appearing in an interview on the upcoming PBS TV show *Absolute Zero and the Conquest of Cold*. He said he hopes the list continues to generate news, increasing support for superconductivity and making breakthroughs happen faster or, in some cases, actually happen. Already, new dialogs are beginning between colleagues, with people calling Track with questions and comments.

He said the list is most useful to people who report about science and act as a liaison to the public, as well as to people in the field of superconductivity working on the breakthroughs, by forcing them to think about getting the word out.

"One main goal was to raise the consciousness of the general public and make the people doing the research aware of the public...taking [the breakthroughs] out of the lab and engaging the public, and making things practical." Practicality was something Track looked for as he considered breakthroughs for his list. "What is practical and what will make it in the marketplace so people's lives are made better…those were important criteria for me."

Topping the list is a low-cost MRI machine, which will make it easier and less expensive to screen for serious medical conditions. Track placed it in the number one spot because he said it holds the most promise for widespread use and is more affordable than other pending breakthroughs. In creating the list, Track placed the advancements set to happen sooner toward the top of the list, noting that large-scale applications can be marketed more quickly.

Track said it is still too soon to see many of the breakthroughs become everyday reality, but many are on their way and right on schedule. "Within 2007 we will see breakthroughs in the realm of impressive demonstrations." Consumers, he added, can expect to find the breakthroughs as a part of everyday life in five to 10 years, based on the fact that this is new technology and there are barriers, some of them regulatory or legal, to move them from concept to mainstream reality. For example, low-field MRI needs FDA approval before it can be used in hospitals around the world.

Track said the wireless digital receiver, number four on the list, will probably be used by the military before it enters the commercial market. In fact, several of the breakthroughs on the list might first be used by the military, and then after five to 10 years, when they can be generated in large quantities and priced to compete in the market, they will be available to consumers.

Track said number five on the list, the advanced magnetic cardio-imaging machine, is the closest advancement to realization, and its use should be mainstream within 2007. While the FDA has granted the approval to use the

Track's SC Predictions for 2007

machine, the FDA still needs to approve the use of the machine to correlate its data with that of a specific medical condition and apply it to make a diagnosis. Once this process is approved, doctors can more effectively screen for coronary artery disease and diagnose more accurately, Track said.

Track doesn't know if he will create a new list in 2008, but he plans to monitor what happens in 2007, including the amount of interest the list generates and the progress of the breakthroughs. He said a 2008 list created by the community as a whole might be a possibility if there is enough interest. Until then, Track will continue to get the word out about superconductivity. HYPRES has rejoined the Coalition for the Commercial Application of Superconductors (CCAS), hoping to work with them to promote superconductivity with lawmakers and the public.

Elie Track's predictions of expected breakthroughs in superconductivity in 2007

1) Announcement of laboratory demonstrations that can lead to an advanced, low-cost MRI machine that leverages superconducting technology. This will make it easier and cheaper to screen for many serious medical conditions, such as breast cancer and brain tumors. By using tiny magnetic fields, these advanced MRI machines will also work in a more open environment, easing concerns for claustrophobic patients.

2) Ultra-high-speed Internet switches that will carry Internet traffic to a much higher level, leading to a much faster information highway. The specific advancement would involve the use of superconducting technology to process optical signals in interconnecting circuits, leading to 100 Tbps routers.

3) High-capacity power lines that use cables made out of superconductors to efficiently carry electricity to areas that are without power infrastructure. These innovative cables carry 3-5 times more current than traditional power lines of the same size. Such a system was demonstrated in New York state in 2006, and Track expects further, more comprehensive demonstrations and implementations in 2007.

4) The demonstration of a wireless digital receiver, using superconducting electronics, outside of the laboratory, leading to improved wireless communication systems—in speed, accuracy, and data capacity—for military and commercial applications.

5) The FDA granting approval for the use of superconducting sensors in advanced magnetic cardio-imaging machines that will be used to more effectively screen for coronary artery disease.

6) The proven design of a 10 TFLOPS workstation computer, to replace room-sized systems. This superconductor-charged system would have many applications, including increasing the accuracy of weather forecasting.

7) Demonstration of a superconductor-based ship propulsion motor for the US Navy, leading to savings in size, weight and power needs for future transportation systems.

8) Progress in the development of an analog quantum computer, which is expected to improve the speed for processing complex mathematical computations from years to minutes.

9) The successful demonstration of the SCUBA-2 infrared camera on the James Clerk Maxwell telescope in Hawaii, the most complex demonstration of superconducting electronics, will provide an unprecedented view of the universe.

10) Addition of an AC Josephson voltage standard device, leading to improvements in the basic accuracy of measurements of electrical signals. This would be an enormous breakthrough in the metrology community.

CEC Scholarship Applicants Sought

The Cryogenic Engineering Conference Scholarship Fund is now accepting applications for the CEC Timmerhaus Scholarship Award. Qualified graduate students involved in cryogenic studies are encouraged to apply.

The scholarship winner will be announced at the awards luncheon during the upcoming CEC meeting, which will be held in Chattanooga during the week of July, 16. Additional information, such as eligibility requirements for candidates, and application forms for the CEC Timmerhaus Scholarship may be obtained on the CECSF Web site, www.cecsf.org. The application deadline is April 30.

The 2005 CECSF Scholarship recipients were Jeesung Jeff Cha of Georgia Institute of Technology and CSA Member Jinglei Shi of the University of Wisconsin. Both received $10,000 toward their continuing education in cryogenics studies.

"I feel honored for having been chosen as one of the first recipients of the CEC Scholarship," said Cha, who added that he plans to "continue research in the area of modeling cryocooler components, focusing on steady, pulsating and periodic anisotropic hydrodynamic parameters in the regenerators."

Shi, whose interests focus on "the numerical modeling and experimental study of the mini/large scale cryocoolers," said she aims to do something meaningful in the cryogenic community and make her work valuable.

The CEC Board of Directors sponsors the award. Corporate sponsorship assistance is also provided by various companies, including CSA Corporate Sustaining Members Cryomech, Cryofab, Lake Shore Cryotronics and Scientific Instruments.

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CSA/ASC sponsored courses at Seattle Applied Superconductivity Conference, 2006

Introduction to Superconducting RF $106
Dr. Isidoro E. Campisi and Dr. J.G. Weisend II
These two-disk notes break down the high-tech and complicated world of superconducting materials and cavity fabrication technologies.

Application of Cryocoolers to Superconducting Systems
Dr. Ray Radebaugh, NIST $106
His acclaimed cryocoolers course tailored to SC Systems

CSA sponsored course at the International Cryocooler Conference, Baltimore, 2006

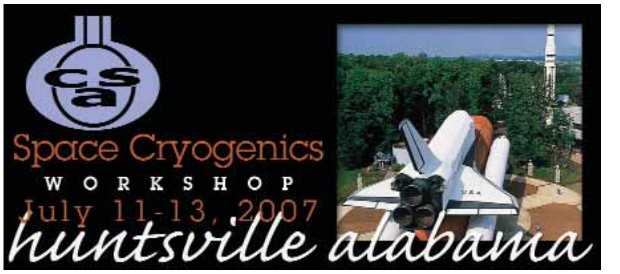
Foundations of Cryocoolers $106
Drs. Ray Radebaugh, NIST, and Willy Gully, Ball Aerospace, team-teach a very popular, comprehensive course with detailed graphs and figures, including the latest developments in this important field.

CSA sponsored courses at Keystone CO Cryogenic Engineering Conference, 2005

Design of Optimal Helium Refrigeration & Liquefaction Systems
Dr. Vankata "Rao" Ganni $90
Rao's notes have been edited and expanded since his last course session.

2005 Safety Short Course
Dr. John Weisend II, Robert Bell,
Dr. Friederich Haug, Dr. Robert Fagaly $90
Extensive notes from the Flynn/Cryoco course, plus new materials from Haug and Fagaly. Hard-to-find material.

Cryogenics Safety Manual, 4th Editon
The British Cryoengineering Society $70
This text covers general and specific safety considerations when working with various cryogens. Contains charts, photos and bibliography.



Save the date • July 11-13, 2007

The 22nd Space Cryogenics Workshop (a division of CSA) will be held in Huntsville AL, July 11-13, 2007, in conjunction with NASA Marshall Space Flight Center. The workshop venue is the luxurious Embassy Suites Hotel, just 12 miles from Huntsville International Airport. The brand new all-suite hotel, connects by sky bridge to the Von Braun Center, a convention center overlooking the picturesque Big Spring Park. Huntsville features mountainous views and a plethora of dining venues, nature preserves and recreational and cultural activities, including the US Space and Rocket Center. Registration is now available at www.spacecryogenicsworkshop.org.

Registration fees: early $295 (by April 6, 2007), $320 (after April 6, 2007); students and retirees, $210; guest tickets for the Welcome Reception and for lunches are $25 (each). Guest banquet tickets are $75. Please see the Web site for more details.

Co-chairs are Sally Little, sally.little@nasa.gov, and Leon J. Hastings, leon.j.hastings@nasa.gov, both of NASA Marshall SFC. Awards committee chair is Peter Shirron, NASA Goddard SFC.

Haruyama Honored for P-T Cryocooler

The December 2006 issue of the *CERN Courier* reported, "Tom Haruyama of KEK has won the Commendation of the Research and Education Promotion Fund from the Alumni Association of Keio University Faculty of Science and Technology. It recognizes his development of a pulse-tube cryocooler for liquid-xenon particle detectors. This technology is used at CERN and is being studied for further applications in detectors. " Dr. Haruyama is a long-time member of CSA and active in the Cryogenic Society of Japan.

CryoCrete Used at Hoover Dam

Air Liquide's CryoCrete technology has helped reconstruct the Hoover Dam. One of the largest hydroelectric dams in the world, Hoover features one of the most magnificent sites in the western United States. So much so, traffic on US Highway 93, which runs across the dam in the Colorado River and is the main road connecting Las Vegas to Phoenix, often comes to a standstill as travelers slow to see the view. With the help of Air Liquide's CryoCrete technology, a bypass bridge is being constructed to open the route to smooth travel again.

The massive undertaking required many cubic yards of concrete with special placing and curing requirements. Using liquid nitrogen to cool concrete mixtures to exacting specifications, CryoCrete injection technology was used to reduce the temperature of the concrete used in the bridge's footings before it was pumped down to molds resting 300 feet into the canyon. CryoCrete technology cooled the concrete to 20 to 30 degrees F and was integral in delivering the quality pour and precise curing necessary to ensure the structural integrity of the bridge.

"This has been a spectacular opportunity for Air Liquide to contribute to a project at this historic site. It is a world-scale example of the capabilities of the CryoCrete process, a technology with a wide range of industrial applications," said Etienne Lepoutre, president of Air Liquide Industrial US LP.

Air Liquide's CryoCrete being prepared at the Hoover Dam.

CryoCrete has been used in a variety of mass pour applications including the San Francisco-Oakland Bay Bridge. The Hoover Dam was originally constructed in the 1930s, to harness the power of the Colorado River as a major source of hydroelectric energy and flood control for the region.

US Computer Center To Crunch LHC Data

A new Chicago-Indiana computer system is set to join an international network of computer centers and receive mass quantities of data from the Large Hadron Collider (LHC) at CERN.

When the LHC begins operating later this year, beams of protons will collide 40 million times per second. When the beams reach full intensity, each collision will yield 23 proton interactions that will create various subatomic particles, but it could take time for scientists to know what they've discovered.

"Even once the data is recorded, it will take years of careful sifting and sorting, which will require massive amounts of computing power to extract the final scientific results," said Frederick Luehring, a senior research scientist at Indiana University.

Physicists at 158 institutions in 35 nations will participate in the ATLAS (A Toroidal Large Hadron Collider Apparatus) experiment at CERN. The Chicago-Indiana system, which is operated jointly by the University of Chicago and Indiana University, is one of five Tier 2 regional centers in the US particpating.

The Chicago-Indiana Tier 2 system is connected to a national computing infrastructure called the Open Science Grid, a national network that works with large-scale computing-intensive research projects. This January, the site expanded to achieve the computing power equivalent of 300 personal computers to the national infrastructure, through wide-area connections that can transfer data at 10 gigabits per second. HighBeam.com compared this speed to downloading the music library of an iPOD in less than two seconds.

The Chicago-Indiana system is funded by annual $600,000 grants from the National Science Foundation, and by previous investments from the states of Illinois and Indiana in I-WIRE and I-Light. One goal of the experiment is to find the Higgs Boson, a theoretical particle that endows all objects in the universe with mass. The energy required to create the Higgs Boson is speculated to be within the capabilities of the LHC. Another goal is to find evidence of supersymmetric particles, which it hopedcould lead scientists to the discovery of alternate dimensions.

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Spotlight on New Sustaining Member

Austrian Aerospace

Austrian Aerospace GmbH (AAE) recently joined as a Corporate Sustaining Member of CSA. AAE is the largest supplier of space products and related ground support equipment in Austria, focusing on electronics, mechanisms and thermal insulation.

The company is made up of 120 employees and is owned by the Swedish Saab Space Group. The business mission of AAE is to market, develop and manufacture satellite equipment for the global space industry and cryogenic insulation for terrestrial applications that strengthen and support the competitiveness of its customers. AAE has produced high quality Multi Layer Insulation (MLI), since 1991 and is the leading supplier of MLI for spacecraft of the European Space Agency and a number of other European programs. AAE designs, manufactures and integrates thermal hardware products in-house or at the customer's site. In addition, AAE offers procurement and the assembly of heaters, thermistors, thermostats, Optical Surface Reflectors (OSR) and Second Surface Mirror Tapes.

As a product diversification, AAE has adopted space MLI for cryogenic applications, covered by the "Coolcat" line of insulation products. "Coolcat" is used for the insulation of superconducting magnets (MRI, NMR and others), cryostats, transfer lines and automotive liquid hydrogen tanks. AAE offers engineering consultancy and thermal analysis for customer systems. Its state-of-the-art manufacturing facility for insulation is equipped with automated cutting machines and all processes for production on an industrial scale. Austrian Aerospace is certified according to both ISO 9001:2000 and ISO 14001:2004. Contact Johannes Stipsitz, phone: 43-1-80199-3070, fax: 43-1-80199-3060. cryo@space.at, www.space.at.

New! For Members Only

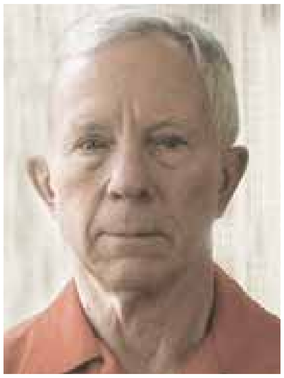
Exciting news! The CSA Web site now offers a Members-Only section with special features:

- View free back issues of *Cold Facts* magazine in downloadable pdf files. A list of highlights under each issue will help readers locate the desired issue with ease.
- CSA Board contact information.
- Coming in 2007: a special edition of Ask the Experts, exclusively for our members, which features answers to the toughest technical questions by top-notch cryogenic authorities.

www.cryogenicsociety.org

Cryogenic Concepts

by Dr. Glen McIntosh, President, Cryogenic Technical Services, Inc., 2005 CEC Collins Awardee, gmc@cryo.com



We frequently encounter people who need to use cryogenics but don't know how to do it. In one recent case a large aluminum surface in a space chamber was to be maintained at approximately 77K. In another application, an adsorbent bed was to be held near 80K during flight operations. People working on each project were initially thinking of a pump and sump arrangement but were not happy with the complexity and power requirements.

In both cases, personnel were astounded to learn that their needs could be met with a no-moving-parts thermal siphon system like the simple one illustrated in Figure 1. Three principal elements are required: An elevated reservoir with a liquid level controller; an insulated, low heat leak down-flowing liquid supply line, and the heat exchange system which converts some of the liquid to vapor and directs the lower density mix up to the vapor space of the reservoir.

Specifically, this is how it works:

1. The reservoir and liquid line form one leg of a U-tube which is filled with high density liquid. Heat leak and boiling in this line is to be minimized.

2. As liquid is boiled in the upward flowing leg its average density decreases. This produces a differential pressure causing flow. This is the thermal siphon effect.

3. Flow is self-regulating. Delta P generated by head density differences is offset primarily by two-phase pressure drop in the heat exchanger side. Low pressure drop in this leg is desirable to enhance flow and improve heat transfer.

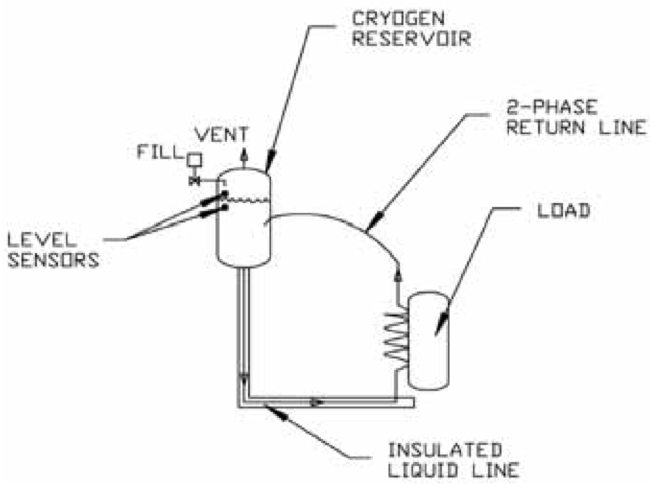
Design Guidelines:

1. Raise the reservoir as high as convenient to increase liquid head.

2. Minimize heat leak to the downward flowing liquid line to preserve fluid density.

3. Cause flow to rise (without traps) in the heat transfer leg and direct return flow downward as it reaches the reservoir vapor space to achieve vapor/liquid separation.

Figure 1 Thermal Siphon System



Some rudimentary vapor pressure drop calculations are usually adequate for design of a functional system. However, for inquiring minds, this is an elegant two-phase flow problem.

Mendelssohn Biography, Part III: Early Years, 1906-1933

Excerpts from his biography of Mendelssohn by Dr. J.G Weisend II, Stanford Linear Accelerator Center, weisend@slac.stanford.edu

Kurt Alfred Georg Mendelssohn was born on 7th January, 1906, as the only child of Ernst and Elizabeth Mendelssohn, in the Schoeneberg suburb of Berlin.

The first Mendelssohns were the brothers Saul and Moses, who were born the sons of Mendel of Dessau, Prussia, in the early 18th Century. Kurt was a direct descendent of Saul, and the composer Felix Mendelssohn was a grandson of Moses. Kurt's father was a businessman who represented a foreign wholesaler of men's clothing and the family had a comfortable existence at the time Kurt was born. Berlin in 1906 was at its peak as the capital of the newly reunited Germany. Kaiser Wilhelm II wanted to make Berlin into another Paris or London, and a German research society, the Kaiser-Wilhelm-Gesellschaft (renamed Max-Planck-Gesellschaft after WW2), was founded in 1909.

As a child, Kurt Mendelssohn attended the Goethe Schule where he shone in physics, earth science, drawing and gymnastics but was weaker in art and mathematics. His differing performance between drawing and mathematics is reflected in his later life, in which his hobbies, such as photography and collecting oriental ceramics, were visual by nature.

In 1925, Mendelssohn entered the University of Berlin (renamed Humboldt-University of Berlin after WW2) where he studied physics, mathematics, chemistry and psychology. He took great pride in having studied under Einstein, Planck, Schroedinger and other leaders of the new "Modern Physics." He started research at the University's Physikalisch-Chemisches Institut in 1927, studying under his cousin Franz Simon. Simon had produced his dissertation at Berlin under Walther Nernst who formulated the third law of thermodynamics. An older research assistant in Simon's research group was Martin Ruhemann, later founder of Petrocarbons Developments Ltd, Manchester, UK, who was Mendelssohn's brother-in-law as a result of his marriage to Barbara Zarniko, the elder sister of Kurt Mendelssohn's wife Jutta.

Nernst's development of the Third Law was motivated by the problem of predicting chemical reactions via the measurement of the free energy of the reactants and products. He postulated that at a temperature of absolute zero, the difference between the free energy and total energy of a substance must be zero and that the difference must approach zero as absolute zero temperature is approached. To prove his theory, Nernst and his research group had to reach very low temperatures and make precision measurements of specific heat and thermal expansivity. Over a number of years, Nernst, aided by Frederick Lindemann, his brother Charles Lindemann, Franz Simon and others, made measurements that supported his hypothesis. As a result, the Third Law of Thermodynamics is accepted as one of the fundamental laws of nature today

Simon, having completed his doctorate in 1921, remained at the Physikalisch-Chemisches Institut where he organized a cryogenic group and built a hydrogen liquefier and then a helium liquefier. Mendelssohn's work in Simon's group was centered in two areas, specific heat measurements at cryogenic temperatures and the construction of small helium liquefiers. The first of these led to his doctorate, the second led to Oxford.

Mendelssohn's thesis project was the measurement of the specific heat of solid hydrogen. It was known by then that hydrogen existed in two molecular states, parahydrogen in which the nuclear spins are oriented antiparallel to each other, and orthohydrogen in which the nuclear spins are oriented parallel to each other. The Pauli exclusion principle, part of the radical new theory of quantum mechanics in the 1920s, predicted that the energy of orthohydrogen close to absolute zero should be higher than that of parahydrogen. Consequently, the specific heat of orthohydrogen should rise with decreasing temperature as the temperature approaches absolute zero, above that of parahydrogen. This was a very difficult

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CSA's Expanded Short Courses at CEC/ICMC

Register now for The Cryogenic Society of America's 2007 Short Course Symposium, scheduled for Monday, July 16, 2007, in Chattanooga TN, just before the CEC/ICMC conference. Registration is at www.cryogenicsociety.org.

CEC-related full-day courses are **Cryocoolers and Microcryocoolers** with Dr. Ray Radebaugh and Dr. Marcel ter Brake, and **Design of Optimal Helium Refrigeration and Liquefaction Systems** with Dr. Rao Ganni. Prices: Early registration (on or before June 1, 2007) is $285.00. Regular registration (after June 1, 2007) is $295.00. Full-time students with ID get a discount rate of $100.00.

Cryocoolers and Microcryocoolers: Radebaugh, a world-renowned expert on cryocoolers, is Group Leader, Physical and Chemical Properties Division, Chemical Science and Technology Laboratory, NIST Boulder. A recipient of the CSA Vance Award and a ***Cold Facts*** columnist, he has taught extensively on this subject. He has invited ter Brake, Associate Professor at University of Twente/Technological University, Eindhoven, the Netherlands, to cover the challenges associated with the design and development of microcryocoolers for refrigeration powers of only a few milliwatts and fabricated with MEMS technologies. He is presently conducting research on microcooling, a 4K SQUID-based cryocooler-cooled fetal heart monitor, and a 4K sorption cooler for an ESA-Darwin mission.

Cryogenic temperatures provide benefits in a wide variety of applications. However, various problems usually occur in achieving such temperatures that often hinder the development of applications. Developments in cryocoolers in the past twenty years or so have alleviated many of these problems, which has ushered in many more practical applications, especially many space applications. This course will review many of the advances that have been made to overcome some of these problems. The course begins with a study of the fundamentals of refrigeration and then shows how these principles are used in the various types of gas-cycle cryocoolers to achieve temperatures from about 2K to 120K. Cryocoolers covered include Joule-Thomson, Brayton, Claude, Stirling, Gifford McMahon, and pulse tube systems. The advantages and disadvantages of each type will be discussed and examples of applications of each will be shown. Alternative cooling methods to reach the millikelvin temperature range are briefly mentioned.

A new area to be covered in this course is the advances that have been made very recently in reducing the size of cryocoolers to better match the requirements of recent microelectronic devices and detectors. The course will examine new directions in higher frequency operation of regenerative cryocoolers that allow for significant size reductions in both the compressor and the cold finger. Faster cooldown is an added benefit.

Design of Optimal Helium Refrigeration and Liquefaction Systems: Dr. Venkata "Rao" Ganni and his colleagues at Jlab will present this course. They have extensive experience and background in both the design concepts and practical operation of the helium cryogenic systems. Course materials include a compilation of Rao's personal notes.

This course is an attempt to provide the fundamentals for the design of an optimal system using "Simplified Concepts and Practical Viewpoints" and operation of the existing systems at the optimal conditions. The course has been developed primarily for encouraging inquisitive minds to think about "What is an optimum system and how can it be provided?" for both new and existing systems. Does it result in a system of (a) Minimum operating cost, (b) Minimum capital cost, (c) Minimum maintenance cost, (d) Maximum system capacity, and/or (e) Maximum availability?

Presentation topics include (1) Introduction (2) Carnot Helium Refrigeration and Liquefaction Systems, (3) Idealized Helium Systems and the Carnot Step, (4) The Theory Behind Cycle Design, (5) System Optimization, (6) LN_2 Pre-cooling, (7) Sub-atmospheric Helium Refrigeration Systems, (8) Typical Helium Cryogenic System and its Basic Components, (9) Instrumentation and Controls, (10) Optimal Operation of the Existing Helium Refrigeration Systems, (11) System Design Overview (12) Design Verification and Acceptance Testing and other. Although some of these concepts have never been formally published, a number of these ideas have been shared with many colleagues over the years to help them understand the concepts for the Design and Operation of Optimal Helium Refrigeration and Liquefaction Systems.

Dr. Ganni is a Fellow of CSA and began his cryogenic process engineering career more than twenty five years ago at CTI/Helix Process Systems which became Koch Process Systems. He was later employed at the SSCL as head of the Cryogenic Systems Engineering Group and is presently working at Jefferson Lab (Jlab) as senior staff in the Cryogenics Systems Group. He has designed new processes, modified existing processes, and supervised the fabrication and commissioning of many helium refrigeration/liquefaction systems presently operating in many laboratories. These include the four cryogenic plants at JLab, plants for SNS, MSU, BNL, and Fermilab as well as the standard product line of the commercial Model 1400, 1600 and the 2800 cryogenic systems presently sold by Linde.

For ICMC-related courses, attendees can choose any or all classes. Early registration: $75 per class ($85 after June 1, 2007). Discounts are available: two courses for $145 (early) $165 (late); or take all four for $295 (early) $335 (late). Students: $50 per class.

Morning classes include **Low Temperature Superconductors** with Peter J. Lee, which will discuss the latest advances and prospects for future LTC development, and **High Temperature Superconductors** with Eric E. Hellstrom, which will focus on the methods used to process HTC superconductors from raw materials to final wires as well as their associated properties.

Afternoon classes include **Metals and Alloys** with Richard P. Reed, which focuses on the low temperature properties and testing of structural metals and alloys, and **Composites and Resins** with Dave Evans, which discusses the main processing techniques for composites and the influence of fiber/filler/resin types on the mechanical and thermal properties at low temperatures.

Spotlight on Sustaining Member

Eden Cryogenics LLC New Name for Brehon

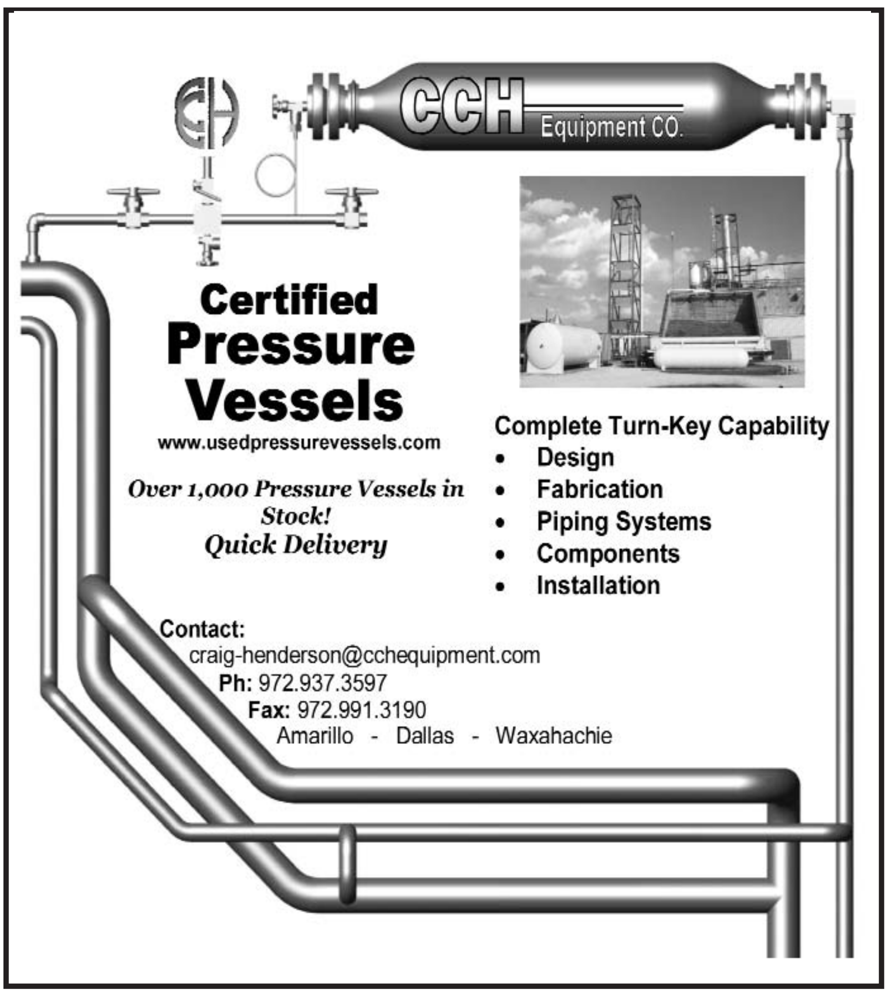
Eden Energy, Ltd has announced a global re-alignment of its worldwide organization, including corporate name changes, facility moves and the advancement of key personnel, in order to focus on key customer segments and capture future global-growth opportunities. This includes a name change for Brehon Cryogenics, LLC, to Eden Cryogenics, LLC, moving the organization into a new, modern engineering and manufacturing facility as of January 2, and the promotion of Steve L. Hensley from general manager to company president.

Steve L. Hensley

Eden Cryogenics, LLC, was founded to support the alternative fuel, energy, aerospace, and commercial cryogenic and vacuum markets with a new line of next-generation cryogenic products and equipment. Although the name is new, the company is entering the market with a prestigious list of seasoned veterans in cryogenic and vacuum technology. These personnel have dedicated their careers to increasing the cryogenic and vacuum technology base while promoting sound engineering and manufacturing practices. In addition, a wealth of technical and manufacturing support is provided through a sister division, Hythane Company, LLC, and the parent company, Eden Energy Ltd, and its international and US divisions. Eden Energy has domestic facilities on the east and west coasts, and an international presence in the UK, China, Italy and Australia. Visit www.edenenergy.com.au.

New Eden Cryogenics, LLC, facility, in Plain City OH, combines office and manufacturing, with room for expansion, and is just five minutes from the former plant.

Contact Steve L. Hensley, Eden Cryogenics LLC, 8445 Rausch Drive, Plain City OH 43064-8064, 614/873-3949, shensley@edencryogenics.com. www.edencryogenics.com.



Spotlight on New Sustaining Member

Austin Scientific

Austin Scientific, an Oxford Instruments Company and a leader in the development, manufacture and service of cryopumps, coldheads, helium compressors and accessories, has joined as a new Corporate Sustaining Member of CSA.

Their extensive portfolio of new Cryo-Plex cryopumps and helium compressors offers a wide variety of solutions to the Semi-Conductor, Vacuum Coating, Research Labs and University markets. Product maintenance is a fundamental core competency of Austin Scientific. They offer repair and exchange service for their own products as well as all major cryopumps suppliers from their repair and distribution center in Austin TX. Oxford Instruments, a global leader in advanced instrumentation, acquired Austin Scientific in 2000 after eight years as a customer of the company. Oxford Instruments, employing 1,200 worldwide, specializes in the development, manufacture and application of tools, processes and solutions needed for research and development, industry, healthcare and education. Contact Donna Dent, 512/441-6893, fax: 512/443-6665, info@austinscientific.com, www.austinscientific.com.

New Book Now Available from CSA!

Low-Loss Storage and Handling of Cryogenic Liquids: The Application of Cryogenic Fluid Dynamics

by Dr. Ralph Scurlock, MA, DPhil Oxon,
CEC Collins Awardee

Combines Scurlock's more than 50 years' experience and research, providing readers with the latest information on improving design, construction and operation of low-loss cryogenic liquid storage systems. This hardcover book expands on the previously-published *Low Loss Dewars and Tanks*, also available from CSA.

Highlights:
- Innovative ways to minimize costs and maximize operational safety
- The complex surface evaporation process
- The complex behavior of multi-component liquid mixtures
- Trouble-fee transfer of cryogenic liquids via adequate sub-cooling
- Ground-breaking research on the convective and evaporative behavior

Available for $136.00 US per copy from www.cryogenicsociety.org

Price includes shipping and handling

Cryo Frontiers

by Dr. Ray Radebaugh, NIST Boulder (radebaugh@boulder.nist.gov)

Halt, or I'll Zap You!

Today (January 24) the US Department of Defense hosted a media day at Moody Air Force Base in Valdosta, Georgia, to give the media an opportunity to get an up-close and personal view of the DoD's first non-lethal counter-personnel, directed energy weapon.

This new weapon is called the Active Denial System (ADS), but is often referred to as the "pain ray." It works by transmitting a powerful beam of millimeter waves with a frequency of 95 GHz (= 3 mm wavelength) at an adversary. A standard microwave oven operates at 2.45 GHz (= 12 cm wavelength). Millimeter waves will penetrate through thick clothing but will penetrate only about 0.4 mm under the skin, which is sufficient to reach the nerve endings and cause an intolerable heating sensation on the skin that results in an instantaneous repel effect without causing injury. The sensation is like touching a hot stove but without any burning of the skin. It could be useful in stopping, deterring and turning back an advancing adversary, providing an option to lethal force.

The ADS can be used effectively with targets up to 500 m away, much beyond the range of rubber bullets or tear gas. The reaction of any adversary carrying weapons would be to drop the weapons and flee the beam immediately. The system underwent several years of safety studies to ensure that no injuries to any parts of the body would occur, including the eyes. The shallow penetration depth prevents any injuries to internal organs. The studies were followed with many tests using voluntary military personnel as subjects. Often tough Marines would volunteer, thinking they were tough enough to handle many tests, but after a few tests they had enough. Even some of the scientists volunteered. On the January 24 media day a few reporters volunteered to be zapped by the beam to experience the effect first hand. A Reuters reporter was one such volunteer and his reaction to the beam was to immediately dive for cover and try to escape from the beam. The pain stops immediately after escaping the beam or when the beam is turned off.

An official DoD photo of the System 1 demonstration unit is shown in Fig. 1 with all components mounted in a Humvee and the antenna to direct the focused beam mounted on top. Hand-held and aircraft mounted versions are on the drawing boards. Such applications require the components be reduced significantly in size and weight. The millimeter waves are generated by a gyrotron source tube requiring at least 100 kW of power. Airborne units may require a megawatt or more of power, which could be provided by a compact superconducting generator while maintaining light weight. The gyrotrons operate with a magnetic field of 3 T, which can only be provided by a superconducting magnet.

The demonstration unit shown in Fig. 1 used a superconducting magnet of NbTi cooled to 4K with a Gifford-McMahon cryocooler. The large mass of the cryocooler and the gyrotron systems required modifications to the Humvee to accommodate the ADS. Long-range plans of the Air Force are to replace the low temperature superconducting magnet in the gyrotron with a magnet made from second generation high temperature superconductor and cool it to about 50 to 60K. The overall system would be much more compact and lightweight. It could easily be deployed in the field in places like Iraq, although 2010 is given by DoD as a probable first date for deployment.

Figure 1. Official DoD photo of the System 1 demonstration unit of the Active Denial System that uses high-power millimeter waves as a non-lethal weapon.

The gyrotron magnet has a mass of about 20 kg, which requires several hours to be cooled to operating temperature. The Air Force is currently investigating methods to speed up the cooldown process to make the system more acceptable to military personnel in the field who need to be ready for a mission on short notice.

The use of cryogenics in military operations is certainly not new. Cryocooled infrared detectors have been used by the military for many years and many space-borne systems have been flown in the last few years. Superconducting ship motors for the Navy are being developed to significantly reduce their size compared with conventional electric motors. The Active Denial System represents another case where cryogenics may aid the military. In this case, where the weapon is a non-lethal one, innocent civilians in the wrong place at the wrong time would not be injured or killed accidentally. It is nice to know that cryogenics can contribute to a more humane wartime scenario.

Women in Cryogenics and Superconductivity

A December 19, 2006, *New York Times* article entitled "Women in Science: The Battle Moves to the Trenches," by Cornelia Dean, detailed the challenges women face as they compete for careers in the field of science. *Cold Facts* surveyed several women working in various aspects of cryogenics and superconductivity to ask their reactions to the article and learn more about their experiences and their advice for how to surmount the obstacles women in science commonly encounter.

The women we polled listed a lack of female mentors, balancing the responsibility of caring for a family with the demands of their career and trying to inspire more young women to enter the field of science as the major challenges women in science face today.

"Girls (like boys) need to be motivated in their early age to be attracted by the sciences…For women, as well as girls, I think motivation is a key issue to stay in these male-driven disciplines. It is not always motivating to fight in a male arena, on male principles, to do what you love. It is sometimes problematic to be the one who has to learn, who has to change her behavior, in order to fit in or be more competitive, with the current environment perceived as a constant. The ideal working environment would be a world where women could be women, and men men, not equal but complementary, with equal possibilities," said Christine Darve.

Kathleen Amm said she has seen great progress in overcoming the challenges women in sciences face. To get more women involved she recommends "…getting out into the community and mentoring female students in high school and college to encourage them to go on to graduate education."

Katherine Develos-Bagarinao, Research Scientist at AIST, Japan, said she would like to see steps taken to involve female scientists in Asia and balance the under-representation of female scientists on that side of the world. "...There are just so few women working in my field—superconductivity—that it is difficult to create networks or find role models to pattern my career after. In all my years here [in Japan] I have yet to join any organization or attend any conference where the focus is on women scientists and their impact on society...there is almost no interaction, no venue where these issues can be discussed openly."

Amm, who leads a group of 18 engineers and scientists in developing next generation superconducting technology, said one of her biggest challenges was establishing credibility in the superconducting community. "My 8 years at GE have given me the opportunity to build my technical reputation with the superconducting community…having a supportive environment that encourages development and excellence in research has been critical to my success as a scientist."

Anna Kidiyarova-Shevchenko, a professor in Microtechnology and Nanoscience, said she has a full load of responsibilities including research, supervision, administration of projects and teaching. She said her main problem is overload. "I work from 9 a.m. till 5 p.m. and then from 9 p.m. till 12 p.m. when the kids are in bed."

"The main issue is the workload and, most importantly, time wasted on administration, etc. Time purely used for research is less than 20%. Another problem is that science is a highly competitive field that requires complete involvement…This is practically impossible to combine with family and kids," one woman said.

Susan Breon, head of the Cryogenics and Fluids Branch, NASA Goddard Space Flight Center, mother of one daughter, says, "It is still very challenging to set and maintain boundaries between work life and personal life. Although senior management talk about life balance, the example they set includes emails sent late at night and expectations for completing of tasks over weekends. This can be grueling even when you have the freedom to commit your "off" hours to these tasks. If your "off" hours are already committed to your family and outside interests, it makes you question whether or not you want to be part of the senior level."

Breon had been working for about 13 years when she adopted her daughter, "so my career was well-established at that point. Some of the career roles I have filled in the past would be very difficult today, particularly those involving irregular hours or lots of travel with relatively short notice. Being a parent means more challenging logistics for anything that is outside the normal routine. If my daughter is sick or schools are closed for snow, then I scramble to make sure things are covered at the office. Fortunately, I have a flexible work schedule and can telework from home when necessary. I have chosen a career path that doesn't make as many time-critical demands on me to be physically present: email and phone calls can fill in when need be. There are also times when my daughter accompanies me to the office."

Another woman said a challenge for her is not knowing how groups of men consider her and her work. "This is obviously very important when things like job interviews and promotion committees get together because they are predominately men. The token female on the committee is normally chosen because she is quiet and demure and ticks a box. (I never want to be the token female). Of course, women are excluded from the male bonding thing."

Sylvie Fuzier cites a lack of understanding as one of the challenges. "While some sexist comments may not seem that offensive by themselves, the accumulation of them is."

"In singles settings, saying you're a scientist turns men off fast," said one woman, "They can't stand the threat of competition."

Another added, "As a single woman…challenges I had to face [included] unwanted attention by superiors and colleagues."

One challenge *The New York Times* article focused on was the issue of assertiveness. One source told *The New York Times* that women who assert themselves may be derogated. The women we talked to weighed in on the issue of assertiveness.

"I am by nature quite assertive and this often gives me problems in my daily work. In general women have more compassion, which leads them to have more difficulties to dare what men would do with little hesitation. Women often think too much on the repercussions of a strong attitude," one woman said. Another woman said while she does not have problems asserting herself, she is labeled as aggressive, something she takes as a compliment.

Other women said they have not noticed a negative reaction to being assertive.

"I have not seen noticeable differences in how my colleagues interact with me or a male colleague. So, I do not worry about being assertive," said Melora Larson.

Amm said it "is a very delicate balance. I have been successful in sharing my thoughts and opinions while always being respectful of my counterparts. It is important to stand your ground in negotiations and not be run over by your counterparts."

The need for finding a balance was echoed by other women as well, who said

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Women in Cryogenics and Superconductivity

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there are varying degrees and styles of assertiveness. "In general, my impression is that assertiveness in a woman can be appreciated by male colleagues when it is accompanied by a warm and genuine interest in others and in their work," said Barzi.

Another issue focused on in *The New York Times* article was a double standard for dress code, where women need to dress to impress at all times, while men can arrive in more relaxed attire. Feedback was mixed with some women saying this definitely exists and others writing to say they have never seen or experienced such a double standard.

"Initially there was a difference. When I first started in this field, the females (all office personnel) far out-dressed the men in business attire. Over time, the dress code has relaxed for us," said Eileen Cunningham, who noted that today the dress code for both men and women is business casual.

Darve said she would like to wear nicer clothes, such as dresses, on occasion, but feels she has to dress down like her male colleagues and downplay the fact that she is a woman to be accepted in the workplace.

"I definitely think this [double standard] exists. Most of the younger women who I see who are clearly viewed as upwardly mobile are of the slight build and fancy dressing sort. Most have limp handshakes and I perceive them as weak physically…In grad school my woman's group discussed dressing down to the point where gender wasn't being noticed in order to guarantee that response to gender wasn't behind response to actions/words/deeds. That uncertainty of origin of response is one reason I have never wanted to emphasize being a woman. For most men, they don't respond first to other men's sexuality/handsomeness," one woman said.

Some women added that it is never advisable for a woman to wear revealing clothing.

Breon said that her attire on days when she does not have major meetings with persons from outside Goddard is fairly casual, though not jeans, similar to that of her male counterparts. In more formal settings, she wears a dress or suit and heels. The men may be wearing ties and a sport jacket, although not always, "so perhaps there is a double standard as the formality of the meeting increases." She added that she has learned to wear the right clothing when presenting with a microphone, which is designed to clip to man's tie or shirt! This does not work with lightweight blouses or many dresses. She can depend on a suit jacket working well, with the mic clipped to the lapel and the transmitter in her pocket.

Another point covered in *The New York Times* article was the subject of mentoring. The article said that women do not always receive support and mentoring to the same degree as their male counterparts. Most of the women we spoke with credited lists of male mentors who helped them navigate the field.

"All my mentors have been male. These have been fair people who, I believe don't consider whether I am a man or a woman," said Judith Driscoll.

"Yes, they are all males. I have never been under the guidance of a woman scientist or professor," said Develos-Bagarinao.

Breon had two mentors when she started her career: Dr. Edward Klevans, one of her professors at the Pennsylvania State University, who encouraged her to continue on to graduate school, and her thesis advisor at the University of Wisconsin-Madison, Dr. Steven Van Sciver, now at Florida State University. "My supervisor at Goddard for many years, Dr. Stephen Castles, really was key in helping shape my career," she said. "In addition to identifying work assignments that were challenging, he introduced me to a broad array of technical professionals who did work that related to aerospace cryogenics, but were not necessarily in the field. Another mentor, and friend, is Ms. Lynne Slater, Associate Chief of Goddard's Equal Opportunity Office. She provided invaluable insight into the working of Goddard and the effect that various aspects of the Goddard culture have on my work. Lynne has also been working to make connections among Goddard's women supervisors, many of whom are somewhat isolated amongst their male counterparts."

"I could list many people whom I consider my mentors. Many of them are my scientific supervisors. In the area of research they helped a lot…they acted as 'door openers.' In my personal life, their advice was extremely important. I believe a significant part of my current social skills was developed under their influence," said Kidiyarova-Shevchenko.

"My first mentor was my father who is a scientist. He started me on the path to being a scientist. This continued in my academic career with my advisor, Dr. Justin Schwartz, who encouraged me to excel as a researcher in superconductivity by teaching me the skills that are critical to success as a scientist...After starting my career at GE, I have been fortunate to have many mentors…Dr. Xianrui Huang, Dr. Evangelos T. Laskaris, Dr. Jim Bray and Dr. Peter Jarvis have shared with me their years of experience…I have also had some great female mentors, Dr. Cynthia Landberg and Donna Fairbanks, who gave me great advice on how to manage people and programs," said Amm.

"By far, my biggest mentor was my father. Though quite a chauvinist himself, (he did not allow his daughters to train on the shop floor when growing up as he required his son to do), he was my biggest supporter. It was his idea that I join the family business and he believed that, even without a shop background, my other skills would allow for success in this field. He pushed me to achieve advanced certification beyond a four-year degree, knowing that this would go a long way toward my gaining personal credibility in the workplace. And he was right! While a four-year engineering degree or fabrication skill with no formal education was enough to establish credibility for the male workforce, a bachelor degree in accounting did not carry enough weight for others to consider me any more than just another paper shuffling 'girl' in the office. After achieving my Certified Public Accountant certification, I was definitely treated with more professional respect. It gave me a voice, allowing me the opportunity to really contribute toward building the company, something I could not do if my co-workers did not view me as accomplished," said Cunningham.

"During my fellowship at CERN, Alain Poncet permitted me to access the cryogenic world and pushed me to work hard, letting me do everything from A to Z, with support of course, which helped me develop…I never noticed that his group treated me any different because of my sex and have the highest respect for them…While at Fermilab, another great mentor (Tom Nicol) emphasized that no project can be 100% perfect, but one needs to reduce our entropy and focus on action," Darve said. She added, "More than mentors it

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Women in Cryogenics and Superconductivity

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is important to have our own image of success like a guiding star, an unattainable goal, a direction to work towards. There are several women in the sciences and in engineering whom I consider my role models."

Fuzier listed a female undergraduate adviser as one of her key mentors. "Her abilities to show her success as well as at least some of her insecurities helped me at that time and later on to have more acceptance of my own doubts."

The New York Times article talked about women negotiating jobs for their spouses after they themselves were hired with a company, and women attending job interviews while visibly pregnant. We asked several women if they had either experience.

"I did not exactly negotiate a job for my spouse, but I did bring him to the attention of my bosses when they were looking to fill a new post-doctoral position a few months after I was hired. Because of my effort, he and I have been working for the same laboratory for over a decade," said Larson.

"I had my daughter before I obtained tenure. Fortunately, in spite of the obvious effect of child-rearing on my productivity at work, I was still able to qualify for tenure," said Develos-Bagarinao.

Perhaps the largest challenge of all is juggling family and managing a full-time career.

"Although I don't have kids, issues related to juggling with child-care and career seem the most difficult challenge and I do admire my colleagues who handle this perfectly. Women need a lot of energy to organize both their family life and ensure an ambitious career," said Darve.

"I have a 5-year-old boy, whose birth I planned in between a couple of conferences. If I can manage the juggling act, it is thanks to my partner who provides huge support," said Barzi.

"Issues of children's needs are relevant to both men and women; I find employers to be flexible and understanding," said Margareta Rehak. She added, "Childcare is a very big worry. I manage my children with my husband's support. I would recommend taking on both. It is better for the children, too to have a mother who has varied interests and can eventually also mentor them."

Amm, who has two children, credits her employer, which helps employees find primary and backup childcare. "The support I have received from GE in terms of finding excellent childcare and flexible scheduling has been critical to my success."

Cunningham, who has four children, also credits suitable childcare for allowing her to focus on her career. She was able to find a caregiver who remained with the family for 10 years, which meant she could avoid sending her kids to daycare. "There will always be feelings that you are shortchanging both ends. However, when you are working, you must be able to put your 'mom guilt' aside. Conversely, when you are focused on home, you must put your 'work guilt' aside. That doesn't mean you can never work at home…It just means when you do, you try to remain focused on work for the duration so you can get back to your 'mom job' as soon as possible."

"No kids. Never felt safe enough in job/career to face conflict…People who want kids and a career had better not want much sleep or relaxation time. I work 60 hours a week just to not feel always behind…the coworker I most resent is a woman who gets by making work calls while commuting or at kids' events and can never be counted on to do the good work she is capable of because she puts her five kids first," one woman said.

Kidiyarova-Shevchenko said that managing family is the most critical issue. "…Publications, funding and respect cannot replace family, love and kids. I had three female graduate students and was very sorry for them. At the prime age of 25, instead of building families, they were sitting in the office for the whole day. They are quite successful in their research careers, but I have a feeling that I have destroyed their lives."

Develos-Bagarinao credits daycare and help from relatives in being able to juggle both motherhood and her career. At one time her husband was working in another city, an example of the two-body problem mentioned in the *New York Times* article. "Literally and figuratively, I had to go it alone during those critical years. If there had been no relatives or daycare, I would have quit my job."

Despite the challenges, many women weighed in on the advantages of being female in a male-dominated career.

"[Play] on people's prejudices against a woman's worth by taking them by surprise, i.e., we are supposed to be understanding and sweet, but not so strong in science? Elegantly walk out there smiling, but confident enough of your own worth and the quality of your work so that it shows so clearly in your presentation that there will be only a very small number of skeptics left in the room," said Barzi.

"Women have maybe more abilities to understand the psychological character of the opponent and they work hard to achieve their goal. Therefore, in industry they can be more persuasive. Women are sometimes perceived as more honest, which could be an example of a positive prejudice. Some women have a lot of determination and organization based on the daily experiences required by motherhood…" said Darve.

"Are there [advantages]? I can see that women are a minority [in Japan]; it doesn't seem to be an advantage when one is in the minority. It's easier to be ignored,...isn't it?" said Develos-Bagarinao. Rehak said being a woman "definitely helps in getting a job, all other qualifications being equal, when government affirmative action programs [are a factor]." When she was beginning her career, it gave her a strong start.

"[One] perk of being female is a general understanding when we put the family first. It may not be the best for our careers, but the decision is better understood than when fathers do it. Fathers are still fighting for their right to be as involved as mothers in the family unit," said Cunningham

Many women listed visibility as one advantage to being female in a male dominated career. "Being a female in the superconductivity field gives you a great advantage of visibility. With the small number of females in the field, it is easy for people to recognize and remember you. I feel that I can have a broad, positive impact on the community by being successful," said Amm. "In our field there are fewer than 10% women, so it is quite natural to be visible and recognizable," said Kidiyarova-Shevchenko.

As the numbers of women entering the field of science appear to be reaching another plateau, several women offered advice on how to the rise above the challenges women face and overcome this plateau.

"I often hear the comment that it is hard to find good women but I would like the men who choose between resumes to think about the extra obstacles that most women have to face to reach the same level and give more women a chance instead of going the conservative way. Also, being the only female in a

(Continued on page 24)

Women in Cryogenics and Superconductivity

Several women contributed to our article by answering the survey. Some of them, pictured here, are: A. Dr. Emanuela Barzi, Superconductor R&D Group Leader, Magnet Systems Department, Fermilab's Technical Division; B. Dr. Christine Darve, Cryogenic Engineer, Fermilab; C. Dr. Judith Driscoll, Department of Materials Science and Metallurgy, University of Cambridge; D. Dr. Melora Larson, Manager for a space instrument sub-system, Jet Propulsion Laboratory; E. Dr. Susan Breon, Head of the Cryogenics and Fluids Branch at the NASA Goddard Space Flight Center; F. Dr. Katherine Develos-Bagarinao, Research Scientist, Superconductor Technology Group, AIST; G. Dr. Kathleen Amm, Lab Manager, Electromagnetics and Superconductivity Lab, GE Global Research; H. Dr. Sylvie Fuzier, Assistant Scholar/Scientist, National High Magnetic Field Laboratory; I. Eileen Cunningham, President, Meyer Tool & Mfg., Inc.; and J. Docent Anna Kidiyarova-Shevchenko, Research Fellow of the Royal Swedish Academy of Sciences, Chalmers University of Technology. Not pictured, Margareta Rehak, Senior Research Engineer, Brookhaven National Laboratory.

Women in Cryogenics and Superconductivity

(Continued from page 22)

large cryogenic group and having done my PhD in a Mechanical Engineering department with only one female professor, I do not understand why many men feel satisfied with the diversity issue when there is one woman. Having two or more women would help people go beyond our gender and see our work independently from it (good or bad)," said Fuzier.

"I think it takes a lot of self-confidence for women to succeed in science and the culture does not reinforce that very well and indeed often denigrates. TV shows like *NUMB3RS* help make being a scientist [or being] competent at logic seem more OK," one woman said.

"I believe that there are not many women in the world who would prefer to tear themselves between research and the family. It is emotionally a very difficult life and I would not recommend it as a first choice to anybody. In my case I simply cannot do anything else," said Kidiyarova-Shevchenko. "Work hard, communicate clearly, and learn to network and connect with the leaders who can help you to meet your goals. It is not enough to produce excellent scientific results—you need to have your impact recognized by leaders in the field who can advocate for you. To move beyond the plateau we need more female leaders," said Amm.

"My advice to everyone, both male and female, is to believe in yourself and understand that where you go is really up to you...when you allow yourself to feel like a victim of circumstance you lose the ability to control your own destiny...Those who believe they can, make decisions accordingly and probably will! It truly is all up to you, so don't worry about where the rest of the world is. Just choose to do what you love. That's the only way both genders will continue to evolve beyond the current plateau," said Cunningham.

"I advise [women] to be good at what they are doing. Recognition will follow. I have seen merit prevail. Women are just as good as men in science. What little lack of natural predisposition to science there may be can easily be compensated for by effort and training."

"In my opinion it is fundamental that women be the first not to fall in the prejudice trap, that we develop a mentality of greatest appreciation of one another, of union and loyalty," said Barzi.

"As women, we have to set realistic goals for our personal lives and scientific careers. I don't think any mother would ever say on her deathbed, 'I wish I had been a better scientist.' Children and our families fulfill our lives as much as, if not more than our careers do," said Develos-Bagarinao.

"To stay motivated and open-minded and to discuss potential issues freely. The role of women in science will continue to evolve if education becomes more adequate and if industries/labs support the problems related to motherhood. I believe that it should be every parent's aspiration and every teacher's goal to motivate girls to access the understanding of what the wonders of science and engineering are," said Darve, "I disagree with the idea of a plateau; one can always improve the situation."

Mendelssohn Bio: His Early Years (Continued from page 13)

experiment, due to the low temperatures, the low thermal conductivities and the small effect involved.

However, Mendelssohn was finally able to measure a rise in the specific heat of orthohydrogen at 5K, while the specific heat of parahydrogen continued to fall with decreasing temperature down to 3K. While consistent with the predictions of the new quantum mechanics, his results also supported the new Third Law of Thermodynamics. The excitement and stimulating intellectual atmosphere in Berlin in the 1920s is very well described in his 1973 book, "The World of Walther Nernst."

Mendelssohn was awarded his doctorate in 1930 and decided to stay on at Berlin University to work as Simon's assistant. In 1931, Simon accepted the position of Professor of Physical Chemistry at the Technische Hochschule in Breslau, Germany (now Wroclaw, Poland). He invited Mendelssohn and Nicholas Kurti to come with him as his assistants.

During the Spring semester of 1932, Simon was invited to the University of California at Berkeley, as a visiting professor in the Chemistry Department. Meanwhile, back in Breslau, Mendelssohn was left in charge. Simon had already recognized the danger of the rise of Nazism and as a precaution had left his wife and two daughters in Switzerland while he went to California. The Simon house in Breslau was therefore let to his assistants, Mendelssohn, Kurti, London and Kaichev, to live there during his absence. The four young physicists got on quite well and worked hard together to set up the new research facility.

However, the need to build up a laboratory from scratch, the absence of Simon and increasing political turmoil, prevented much research work being done during Mendelssohn's stay in Breslau. The group continued to develop Simon's expansion liquefier and conduct early experiments in superconductivity.

In 1919, Frederick Lindemann, who had studied under Nernst in Berlin, was appointed Dr. Lees Professor of Experimental Philosophy at the University of Oxford.

This position made him head of the Clarendon Laboratory and responsible for the physics program at Oxford. At this time, however, there was effectively no physics research program. As a result of his experience with Nernst in Berlin, one of the first research areas that Lindemann started was cryogenics. He purchased a hydrogen liquefier from Simon's laboratory in Berlin and started work on a small scale. The first hydrogen liquefier never worked properly. After Simon's group moved to Breslau, Lindemann bought an improved hydrogen liquefier, which became a mainstay of the Clarendon Laboratory.

In 1932 Lindemann invited Mendelssohn to spend a year at the Clarendon Laboratory to assist them in their low temperature research. He was now quite interested in moving on to work at liquid helium temperatures. Mendelssohn proposed to work in two areas: first, the physical properties of superconductors, and second, the gas desorption from copper surfaces at very low temperatures. Lindemann approved of these research topics and applied for a Rockefeller Foundation grant to support him. However, setting up this grant took time and by the end of 1932 there was still no funding.

In the meantime, Lindemann wished to purchase a small helium liquefier as soon as possible from Simon's group, and asked Mendelssohn to come over to Oxford to set it up. The timing of this was not solely to enable Lindemann to conduct experiments but, additionally, to compete with Cambridge University, Oxford's traditional rival! Cambridge had received a large sum of money from the Mond family to build a cryogenics laboratory to be run by the Russian physicist Peter Kapitza. This Royal Society

(Continued on page 31)

Book Review

"Experimental Techniques for Low-Temperature Measurements," by Jack W. Ekin, NIST Boulder, Oxford University Press. Reviewed by Dr. Zuyu Zhao, Janis Research Company, Inc., zzhao@janis.com.

This book is a valuable addition to the literature of cryogenic engineering and techniques, presenting technical details about the design and handling of cryogenic facilities, and information about electrical transportation and critical current measurements at cryogenic temperatures above 1K. The book can be divided into three distinct but related sections: Design (Part-I), Measurements (Part-II and Part-III), and Data Handbook (Appendix).

Part-I includes six chapters which combine to form an overview of cryostat design and material selection. After a brief review of cryogenic liquids, the first (introductory) chapter presents examples of types of cryostats commonly used for transport measurements, including the pulse tube cryocoolers developed during the past decade. Detailed cryogenic techniques and material properties at cryogenic temperatures are discussed in the remainder of the chapter.

Chapter one presents several topics of particular interest:

Design guidelines and a check list are presented in section 1.3.1 (helpful for readers of all experience levels).

Sketches of sample mounting details are shown in section 1.4.2, and the story of magnetic snowballs is told in section 1.4.2.

The author presents most of the topics in this book with vivid and interesting language, rather than by flooding the contents with formulas. With the exception of several separate examples, I did not observe a single formula in the first chapter.

Chapter two discusses heat transfer at cryogenic temperatures in an introductory but fairly complete manner. While few books have offered useful information concerning heat conduction through gases (and liquid), section 2.3 presents an interesting discussion of this topic. Heat conduction across interfaces is presented in sections 2.5, 2.6, and 2.7, and is another useful but somewhat difficult topic for cryostat designing (in particular for solid-to-solid interfaces). I have personally encountered this aspect of cryogenic design quite frequently over the years, and found it presented in a reasonably thorough manner.

The reader would have benefited if additional practical information had been included, such as the discussion of the thermal conduction of gold plated metallic contacts at liquid helium temperatures by P. Kittel et. al. An excellent review article on this subject by E. Gmelin and et. al. [J. Phys. D: Appl. Phys. 32 (1999), R19-R43] might be worth referencing.

Several useful examples of heat transfer calculations are given at the end of the chapter, with one mistake in section 2.9.1 in an example presented to estimate the heat flux from radiation "in the best case" (on page 75). The radius of the top plate should be 0.15 meter instead of 10.5 meter, although the final result of 0.15 watt is correct.

Information on cryostat construction is presented in chapter three, including the subjects of material selection, joining techniques, etc. Construction examples of simple cryostats are provided. Discussion of the sizing of parts for mechanical strength in section 3.5 covers the most frequently encountered mechanical issues for cryostat design, such as Euler buckling criterion, deflection of beams and circular plates, and the forces due to vacuum loading.

Vacuum and some UHV techniques are also discussed in this chapter, including the subjects of pumping speed and ultimate pressure in section 3.8. The author demonstrates a practical approach for calculating the ultimate pressure that can be obtained in a cryostat using vacuum pumps (see equations 3.15 to 3.18), which should prove very useful for many cryostat designers.

If you don't have time to read the entire book, make it a priority to read chapter four. It includes an excellent discussion of wiring and connections and provides the reader with valuable information, needed in day-to-day engineering work. It is nearly impossible to find these useful skills and techniques anywhere else. Such techniques are generally acquired either from a senior "trainer" or from personal experience (with the price of mistakes along the way). For example, how to design and fabricate a reliable and cost-effective cold wire feedthrough remains a commonly asked question, and is detailed here. The information provided should shorten a new engineer's learning curve.

A modification to the discussion of vapor cooled current lead design on page 178 is suggested. The vented cold helium vapor should be balanced between the high current leads and the dewar neck, instead of "all the

Book Review

escaping gas…vented through the vapor-cooled leads" as described in the discussion. This is particularly true when the magnet is operated in the persistent mode. New and efficient designs for vapor cooled current leads which do not utilize active helium vapor venting may be worth introducing in the next edition.

Discussion of thermometry is a necessary subject for any article about cryogenics, and it is not an easy task since many excellent review articles have been published in past years. Chapter five succeeds in giving the reader an organized and fairly complete discussion of cryogenic thermometry, including the selection of thermometers for different applications. Special skills and techniques required for the correct installation of thermometers at low temperatures are presented in detail. Temperature controlling is also discussed, including a succinct discussion of PID control. A check list to help users select the right temperature controller for experiments is provided in section 5.4.3.

One suggestion: while the author strongly praises Cernox thermometers, readers should be reminded that the magneto-resistance of Cernox sensors becomes quite high at very low temperatures (~300mK).

Chapter six presents a wide range of material properties of solids at cryogenic temperatures without delving deeply into the underlying physics, and is supported by an excellent data handbook. This chapter also provides guidance for readers who are interested in related topics and want to find additional dedicated literature. Before getting deeply involved with Part-II and Part-III, I should mention that I have had limited experience making transportation measurements on solid samples as a student, as the sample subject of my PhD thesis experiments was superfluid He-3 liquid. My major tasks as a post-doc at Harvard University and as a cryogenic scientist at Janis Research Company have been equipping ultra-low temperature labs and developing ultra-low temperature instruments and facilities. I am by no means a professional magnet designer, and am not overly familiar with critical current measurements. Nevertheless, I read these two parts with interest and was fascinated by the details presented by the author.

Part-I presents information for a wide audience range, while Part-II and Part-III are focused on specific topics. Part-II includes two chapters and addresses techniques related to electrical transportation measurements. The two key issues for successful measurements are proper design of the sample holder and making good electrical contact between the sample and the measurement wires. These topics include many intricate details that are widely scattered throughout cryogenic technical literature, rather than presented systematically in one book. The author has combined these details nicely, incorporating theoretical background and practical design details.

Chapter seven focuses on sample installation, including sample holder design, and sample wiring for both bulk samples and thin film samples. Effects from aspects, such as strain, thermal contraction, magnetic fields, are considered.

Chapter eight discusses sample contact in great detail for bulk samples as well as thin film samples. Interesting examples with quantitative calculations are presented giving readers a better understanding of the subject: the topics covered in Part-II are much more specific than those in Part-I.

Part-III includes two chapters and addresses critical current measurements. Chapter nine focuses on how to measure critical currents, while chapter 10 focuses on the data analysis of critical current measurements. The protocol checklist for high-current Ic measurement listed in table 9.1 was of great interest, providing a good foundation for other experiments and for design and operation procedures. The author describes in detail the scaling law, which he developed in 1980 (and confirmed in later years). The discussion of the mathematical framework of the unified scaling law was most interesting, and includes the equation for the unified scaling law in separable form and the summaries of the strain scaling law presented in sections 10.5.6 and 10.5.7. Useful examples with quantitative calculations are presented in chapters nine and 10. These examples make it almost inevitable for the reader to better understand the discussion, since the topics covered in Part-III are more sophisticated than other topics in this book. These chapters are especially useful to those who design magnets, or who perform modeling on the critical current data of type-II superconductors. However, the user must clearly understand the conditions of all equations before trying to use the data in the appendix.

One can never overestimate the importance of having a complete and accurate data source on hand for cryostat design work. Nearly every experienced person working in this field has created a personal data base. However, the data handbook presented in the Appendix of this book includes the most comprehensive data collection I have seen in a single book; I highly recommend adding it to your data base library. (The term-abbreviations-acronym decoder in Appendix A1.1 was found to be particularly useful.)

In summary, the greatest contribution of this book may be its clear presentation of information to a broad range of individuals working in the field of cryogenics. In the US, there are no cryogenic technical schools for training professional cryogenic technicians, nor are there college cryogenic engineering departments. Few schools offer a single theoretical or experimental cryogenics course for training expert cryogenic engineers. Nearly all of the detailed technical skills required for cryogenic engineering are passed from generation to generation during daily practice in university low temperature labs. What has been lacking is an encyclopedic type of professional textbook, summarizing commonly needed cryogenic engineering and technical details in a systematic manner: this is the first book I have found that successfully fills the void.

I consider this an excellent resource for the cryogenic community. The author has provided a great addition to the literature of our field, and fulfilled his mantra for this literature: USEFUL.

Spotlight on Sustaining Member

Scientists Inch Closer to Elusive Higgs Boson

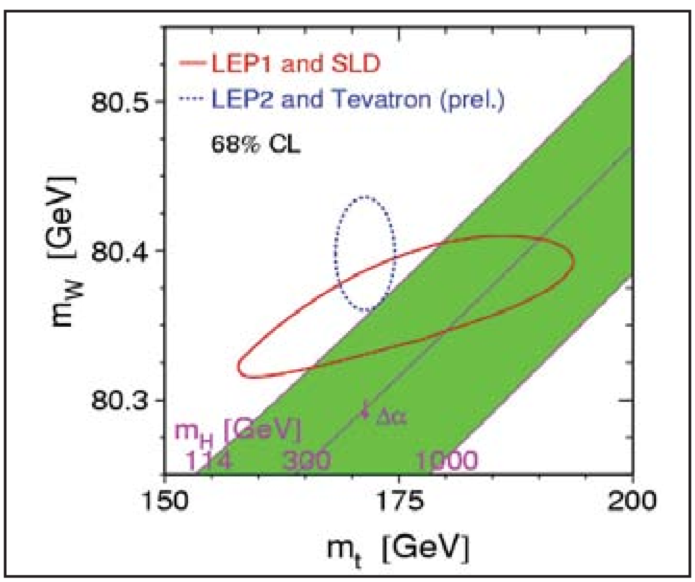
Fermilab

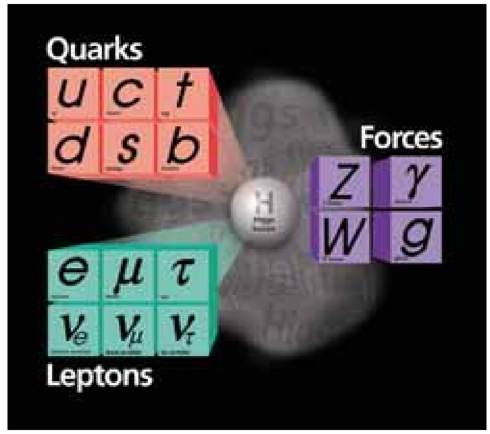
The discovery of a single top quark and the new W-mass value at the DZero collaboration at Fermilab's Tevatron and at the Lab's CSF collaboartion are helping scientists inch closer to finding the elusive particle, the Higgs boson.

Scientists of the DZero collaboration, an international experiment conducted by physicists from 90 institutions and 20 countries at the Department of Energy's Fermi National Accelerator Laboratory, have discovered the first evidence of single top quarks produced in a subatomic process, involving the weak nuclear force. The physicists said the result was an important test of predictions of particle theory and the techniques used in the analysis will allow scientists to search for the elusive particle known as the Higgs boson. The finding was announced in a seminar at Fermilab on December 8, 2006.

Ten years ago, the top quark was discovered at Fermilab's Tevatron, but each top quark that scientists observed was accompanied by its anti-matter partner, produced by a strong nuclear force, ***Fermilab Today*** reported. The relationship has since been studied, with scientists searching for a single top quark that could appear solo, as opposed to with its mate, an occurrence expected to transpire only once in every twenty billion proton-antiproton collisions. Another obstacle is the fact that this occurrence is easily mimicked by other "background" processes that happen at higher rates.

Beginning with a million billion proton-antiproton collisions produced by Tevatron, the world's most powerful particle collider, the DZero collaboration used modern sophisticated analysis techniques to search for 60 collisions, each containing a single top quark. DZero scientists relied on three different techniques to combine 50 discriminating variables to represent their results, allowing scientists to recognize the true single-top events, much like a mother's ability to tell the difference between identical twins.





"This analysis is an important milestone in our continuing search for the Higgs boson, the missing keystone in the Standard Model," said DZero co-spokesperson Terry Wyatt, of the University of Manchester, UK.

"The discovery of the Higgs boson would help explain why particles have mass. Observing the Higgs requires us to see very low rate singles in the presence of substantial backgrounds. The sophisticated analysis techniques we are honing in our current analyses will be directly applicable to our Higgs searches."

What's more, scientists of the CSF collaboration, (an international experiment of 700 physicists from 61 institutions and 13 countries at Fermilab, which is supported by the US Department of Energy, the US National Science Foundation and a number of international funding agencies), announced on January 8, 2007, that the world's most precise measurement by a single experiment of the mass of the W boson, the carrier of the weak nuclear force and a key parameter of the Standard Model of particles and forces. The new W-mass value leads to an estimate for the mass of the Higgs boson that is lighter than previously predicted, in principle making observation of this elusive particle more likely by experiments at the Tevatron particle collider at Fermilab.

Scientists working at the Collider Detector at Fermilab measured the mass of the W boson to be 80,413 ± 48 MeV/c^2, determining the particle's mass with a precision of 0.06 percent. Calculations based on the Standard Model intricately link the masses of the W boson and the top quark. By measuring the W-boson and top-quark masses with ever greater precision, physicists can restrict the allowable mass range of the Higgs boson, the missing keystone of the Standard Model.

"This new precision determination of the W boson mass by CDF is one of the most challenging and most important measurements from the Tevatron," said Associate Director for High Energy Physics at DOE's Office of Science, Robin Staffin. "Together, the W-boson and top-quark masses allow us to triangulate the location of the elusive Higgs boson."

Mendelssohn Bio: His Early Years (Continued from page 26)

Mond Laboratory would include a helium liquefier and would then be able to qualify as the first place in the United Kingdom where helium had been liquefied.

By bringing Mendelssohn over with a working liquefier, Lindemann hoped to beat Cambridge to the title. The academic year had already begun in Breslau and so Mendelssohn agreed to visit Oxford during the 1932 Christmas break, to set up and operate the liquefier. In preparation for this, Mendelssohn corresponded in some detail with Lindemann's assistant, T.C. Keeley, to ensure that the appropriate equipment and facilities were available. Items such as vacuum insulated flasks and valves that were not available in Oxford were acquired by Mendelssohn in Germany and brought to England. This degree of thoroughness and preparation was typical of Mendelssohn's approach to both work and hobbies. He didn't tend to do things by half! During what must have been a fairly hectic month, Mendelssohn and Jutta Zarniko were married, in December, 1932, and went to Prague for their honeymoon.

Mendelssohn then travelled to Oxford with the liquefier, set it up and on 5th January 1933, the first liquid helium in England was produced. As Lindemann and Keeley reported in ***Nature*** 131, 191–2, (1933) (11th February issue), "Dr. Mendelssohn brought the liquefier over from Breslau and produced liquid helium within one week of the arrival of the apparatus."

It is interesting to note that in the same issue of ***Nature*** was a report of the formal opening of the Royal Society Mond Laboratory, in Cambridge, "…with the hope of constructing a helium liquefier within a few months."

Mendelssohn afterwards returned to Breslau with the intention of going back to Oxford in October, 1933, but events in Germany made everything move more speedily than that.

Hitler came to power in February of 1933 and the Nazi terror started rather quickly in Breslau with the Nazi Police Chief Heines being effective in rounding up so called "undesirables." Mendelssohn had three strikes against him. He had a very famous Jewish background, although he had been baptized a Lutheran. Secondly, he was an intellectual and, worse, a physicist (Hitler believed that Einstein's Theory of Relativity was an example of degenerate "Jewish Physics"). Thirdly, and most seriously, Mendelssohn had been a member of an anti-Nazi Social Democrat group.

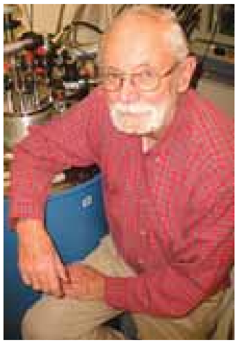
One particular incident made Mendelssohn realize the precariousness of his situation. He and Jutta went to Berlin for the Easter holiday. He was leaving a U-Bahn underground station when a group of Nazi SA men cordoned off a crowd and started taking people away. Mendelssohn was fortunately pushed outside the cordon and escaped attention. This incident was the last straw and convinced him that he had to leave Germany right away without returning to Breslau, so he left for England immediately. Jutta, who came from an old Prussian family that could trace its ancestry back to the Teutonic Knights, was not in serious danger from the Nazis, so she returned to Breslau to settle their affairs and followed on to England separately. Mendelssohn arrived in England in early April and immediately went to Oxford to seek a position with Lindemann.

Like Mendelssohn, Lindemann had quickly recognized the danger of the Nazis. He realized that there would be a flood of refugee scientists and saw this as an opportunity to bolster the research program at the Clarendon Laboratory. The problem was funding, since the University did not have sufficient resources to create a lot of new permanent or temporary positions. The Rockefeller Foundation, whose

(Continued on page 35)

Space Cryogenics

by Dr. Peter Mason, retired, Jet Propulsion Laboratory, and Visiting Associate, California Institute of Technology, pmason@alumni.caltech.edu



In the 1980s and 1990s, space astronomy came into its own. The Infrared Astronomical Satellite provided the first all-sky survey in the infrared, the Cosmic Background Explorer first showed the milliKelvin variations in the cosmic microwave background, and the Hubble Space Telescope showed the value of a long-duration, general-purpose telescope in space. These outstandingly successful missions provided strong motivation for a general-purpose long-duration space infrared telescope. The Space Infrared Telescope Facility (after launch the name was changed to Spitzer Infrared Telescope Facility to honor the great infrared pioneer) was conceived to provide astronomers with just such a capability.

SIRTF was first conceived in 1969 as a shuttle-borne telescope, but early measurements with a small shuttle-based telescope showed a high infrared background, leading to the choice of a free flyer. This was first planned to be an IRAS-like telescope in low earth orbit, but as the mission developed, cost and weight considerations led to a radically new design. Dr. Johnny Kwok of JPL conceived the idea of an earth-trailing orbit. The telescope would be launched with just enough velocity to achieve solar orbit, but falling slowly behind the earth. Thus it would avoid earth radiation, a major source of heat input to the IRAS and COBE cryogenics, but would remain close enough to Earth to allow communications. Because it needed to reach only escape velocity rather than orbital velocity, it could be launched with a Delta vehicle, rather than the much larger and more expensive Titan.

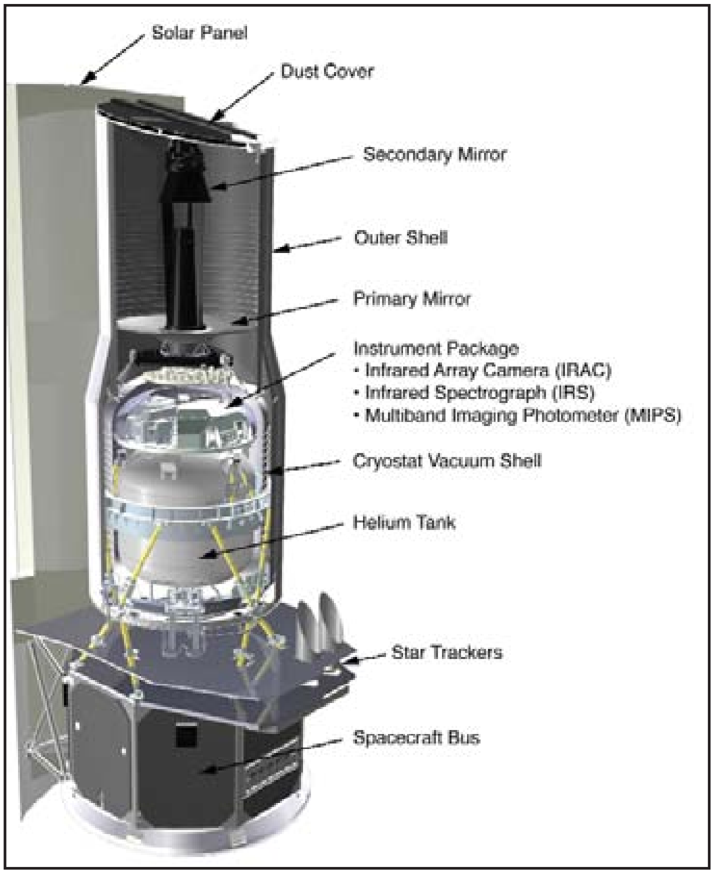


Fig. 1 Cutaway View of SIRTF Telescope. Courtesy of Ball Aerospace

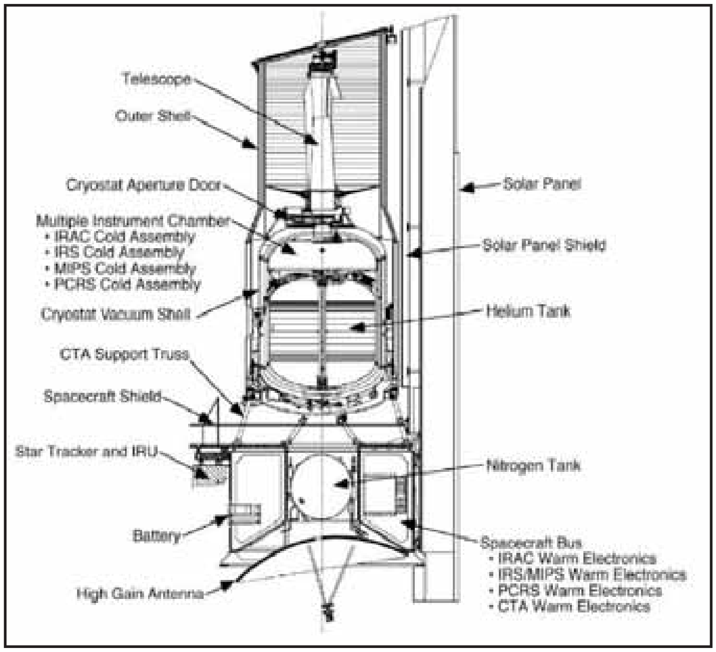


Fig. 2 Cross Section of SIRTF Telescope and Spacecraft Bus. Courtesy of M. Werner, Jet Propulsion Laboratory

Several technical advances have made SIRTF a vastly more capable mission than IRAS. Certainly the most important is the increase in the number of cryogenic sensors from 62 to about 350,000, wavelength coverage from 5.2 to 160 microns, and an increase in sensitivity by several orders of magnitude. A second was an increase in the duration of the mission. By going to the earth-trailing orbit, by an ingenious design that minimized the helium-cold mass and volume, and by taking advantage of radiation cooling, lifetime was increased from 10 months to six years, while reducing the LHe volume from 540 liters to 360l.

A cutaway view of the SIRTF telescope is shown in Fig. 1, and a cross section in Fig. 2. From the outside in, the thermal and cryogenic elements are: sun shield, extended outer shell, outer vacuum-cooled shell, (VCS) cryostat vacuum shell, inner VCS and multilayer insulation, and the helium tank. The principal change from IRAS is the placement of the telescope outside of the cryostat, (suggested by Prof. Frank Low, U. of Arizona) allowing a much smaller cold volume. To keep it as cold as possible, it is surrounded by an additional vapor-cooled shield. This arrangement allows the reduction of parasitic heat flow to the helium bath to about 1 mW, small compared with the instrument heat loads of about 4 mW. This compares to the IRAS parasitic heat load of about 30 mW. A substantial disadvantage is that cooling of the telescope can take place only in

Space Cryogenics

space or in a vacuum chamber, a substantial impediment to functional testing before launch. However, a careful test and modeling program overcame these difficulties.

SIRTF carries three instruments. The Infrared Array Camera (PI, Giovanni Fazio) covers 3.6 to 8.0 micron wavelength. The Infrared Spectrometer (PI, James Houck), covers 5.2 to 38 microns, and the Multiband Imaging Photometer for SIRTF (PI, George Rieke), covers 24 to 70 microns. All are contained in an instrument housing inside the cryostat, and the cold assemblies operate very near the LHe temperature of 1.24K.

The telescope assembly is 85 cm in diameter and is made of beryllium. It operates at 10 to 12 K during IRAC and IRS operations. The MIPS long-wavelength (70 micron) observations require the telescope to be at about 5.5K, to avoid interference with the observations. A heater is used to boil more liquid helium and thus provide cooling from the enthalpy of the gas via a heat exchanger on the telescope. This is done for a limited time to conserve helium.

A heat flow diagram is shown in Fig. 3. Several kilowatts of solar radiation strike the solar panel. A combination of reflection and insulation and solar panel and spacecraft thermal shields reduce this to about 300 mW on the outer shield. Vapor cooling of the outer shell, outer and inner VCSs and the vacuum shield reduce this to less than 1 mW to the helium. Extremely efficient heat exchangers were developed to make maximum use of the cooling.

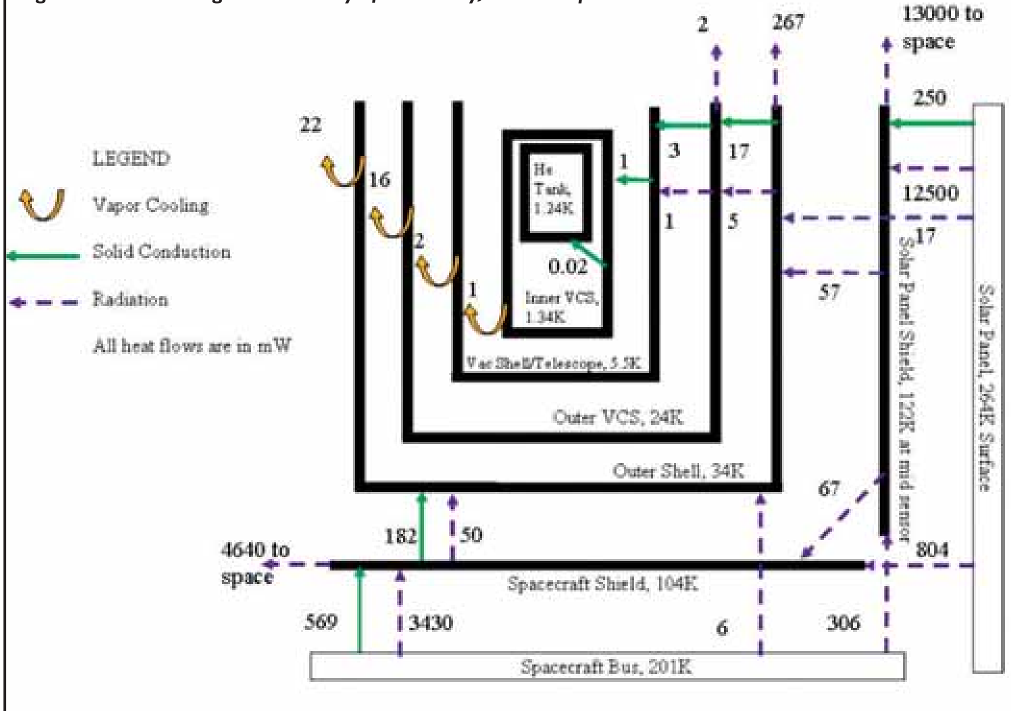
To maximize science return, a long operating lifetime is crucial, as is the ability to predict it accurately. The NASA requirement is 2.5 years, but the entire design was based on a 5 year lifetime. At present, 3.5 years after launch, the prediction is a lifetime of 5 years, 10 months. This prediction is determined by the temperature rise of the bath when a known amount of heat is introduced. Since the specific heat is known accurately, the calculation is quite precise, after corrections are made for the amount of liquid evaporated. A dedicated heat-pulse mass gauge is incorporated, but has been used only twice, to avoid depletion of the liquid helium. An alternative that does not require additional helium uses the heat needed to generate helium cooling for the telescope for the MIPS 70 micron observations.

SIRTF has produced thousands of beautiful and often spectacular pictures. I have included (Fig, 4) a false color image of the Crab Nebula, which is the remnants of a supernova first seen by Chinese and American Indian observers, but, oddly, is not reported in European literature.

A comprehensive paper "The NASA Spitzer Space Telescope", by R. D. Gehrz, et al, is to be published in the *Review of Scientific Instruments*. I have drawn several of the details of the history, design, performance and operation of SIRTF from this paper. I highly recommend it for a complete account of the mission, the instruments and the results to date, including many stunning pictures. The figures are taken from this paper and are attributed to the originators in the captions. My thanks to them. I encourage the reader should also to visit the SIRTF Web site at http://ssc.spitzer.caltech.edu for a wealth of information on the technology, the mission and the scientific results.

***Fig. 4** The Crab Nebula, as seen in a composite of the IRAC and MIPS images. It is the remnant of a supernova first seen in 1054 by Chinese astronomers. Courtesy of T. Termin, R. D. Gehrz and C. E. Woodward, et. al, U. of Minnesota.*

***Fig. 3** Heat Flow Diagram. Courtesy of Paul Finley, Ball Aerospace*



Sci-Girls Summer Camp Promotes Science Careers for Young Women

In an age when more girls look to Britney Spears as a role model than to Astronaut Sally Ride, there is a great need to offer young women additional career options, and to inspire them to choose a career in science and feel comfortable with their choice. Tallahassee is home to two major research universities and is surrounded by extensive natural resources, such as the Gulf of Mexico, the Apalachicola River and estuaries, as well as the Apalachicola National Forest. In 2006, through a grant from Dragonfly TV, the Tallahassee Museum of History and Natural Science, the Florida State University High Magnetic Field Laboratory (a CSA Corporate Sustaining Member) and WFSU-TV sponsored a two-week science camp for middle school aged girls, called SciGirls. The unique partnership allowed the sponsors to develop a program utilizing their resources, as well as those of the surrounding science community. The end result far exceeded initial expectations and has provided insight into how the program could be developed into a sustainable and highly effective science program to inspire young women to pursue careers in science.

During Summer 2007, there will be two two-week SciGirls camps—one for 15 rising eighth and ninth graders, and the second for 15 returning girls. This year's program will be expanded. It will welcome back the girls who attended the first year, providing them with opportunities to pursue more in-depth experiences, while introducing the camp to new middle-school aged girls. The camps will run concurrently, to allow for interaction and mentoring among the girls.

Sci-Girls Summer Camps afford a variety of experiences for young girls, to encourage them to pursue science as a career. From laboratory demonstrations to group activities, the camp is a positive step in support of the advancement of women in science.

Mendelssohn, Pt. III: His Early Years

(Continued from page 31)

grant was originally envisaged to support Mendelssohn's visit for one year only, was not the solution.

Lindemann solved the problem by going to Sir Harry McGowan, who was an old friend and the Chairman of Imperial Chemical Industries, and convinced him of the benefits to England, ICI and Oxford if some funding could be found to support the refugee scientists. Lindemann was quite persuasive and the first of these ICI grants, for £400 per year, was awarded to Mendelssohn, starting on 1st May, 1933.

Now that the funding had been obtained, Lindemann started work on bringing other people to Oxford. At Lindemann's request, Mendelssohn corresponded with the rest of the Breslau group. The letters between Oxford and Breslau took the form of inquiries regarding a series of air compressors that the Clarendon Laboratory was interested in buying. The high pressure compressor referred to Franz Simon, while the low pressure compressor referred to Nicholas Kurti. The working pressure of the compressors in atmospheres stood for the annual salary in English pounds. Simon was also seeking to place Heinz London at Oxford—and London asked if he could be known as the "vacuum pump," in letters.

In the fall of 1933, Simon, Kurti and London all emigrated to England and took positions in Oxford. Later, in 1936, London moved to the University of Bristol. The last member of the Breslau group, Kaichev, returned to Bulgaria and had a successful career as a physicist there.

Mendelssohn's father was Jewish and also under threat from the Nazis. Fairly soon after arriving in England, Mendelssohn brought his parents over as well and they remained in England for the rest of their lives.

With his family safe and a position, however tenuous, at Oxford, Mendelssohn could start to put the events of 1933 behind him. It was time to get to work.

People, Companies in Cryogenics

In a corporate reorganization, **Gladstone Investment Corp**., the **ACME Cryogenics** Senior Management Team and **Brant Point Partners** have purchased controlling interest in **ACME Cryogenics, Inc.** from founder **Roderic Fink**. **Frank Hartzell** has been promoted to President and CEO and **Michael Brown** has joined ACME as Director of Sales and Marketing.

The environmental group **reEarth** hosted the first Environmental Awareness concert in the Bahamas on December 2, to gain protest signatures against the LNG plant planned for Ocean Cay. The concert was free, open to all and featured top Bahamian artists protesting **AES Corporation's** plans to put an LNG terminal at Ocean Cay, and lay 100 miles of pipeline, 43 miles of which would run through Bahamas' waters, to bring LNG to Southern Florida. The project has seen delays because of protests in the Bahamas and governmental bureaucratic issues. Protesters want a ban on LNG because of environmental dangers, the terrorist threat it could pose, and the issue of regulating an industry that is not connected with the Bahamas.

Dave McConathy has been appointed **Cyl-Tec's** new cryogenic product manager. McConathy currently oversees the cryogenic repair facility and product line at Cyl-Tec and also provides technical support of customers and sales personnel. "He has the expertise we need to move to the next level," Said Cyl-Tec President **Jim Bennett**.

Donald Levy, the Albert A. Michelson Distinguished Service Professor in Chemistry at the **University of Chicago**, was recently appointed the University's Vice President for research and for national laboratories.

American Superconductor Corporation has completed its previously announced acquisition of **Windte**.

Praxair Distribution Inc. has introduced Remote Cylinder Monitoring Service, a new wireless pressure monitoring service for the remote management of cylinder gases. It includes wireless communication pressure gauges and Praxair's proprietary prediction software, which provides continual pressure readings of gas products at a customer's site. Subscribers can view their individual cylinder pressures and actual product usage online at www.praxair.com/cylindermonitoring.

The International Linear Collider (ILC) is designed to collide high-energy electrons with high-energy positrons (electrons' antimatter counterparts). Recently, the American contingent of the ILC Global Design Effort sent two prefabricated niobium ILC accelerator cavities—the components that will accelerate the electrons and positrons for experiments—to **Jefferson Lab** for initial screening and performance tests. Members of the **Accelerator Division's Institute for Superconducting Radiofrequency Science and Technology** processed, completed the final assembly of, and tested the first cavity. They found its accelerating gradient, its ability to stuff energy into particles, was 30 Megavolts per meter. "It's the first nine-cell ILC cavity tested at JLab and the first in the US to reach this gradient level," **Robert Rimer**, Director of the Institute, said. "Significantly for us, it is by far the highest gradient multi-cell cavity ever produced at JLab and shows the fruit of our program to systematically improve quality and eliminate field emission in accelerating cavities."

AMCS Corporation has commissioned its ULTRA-N-25 nitrogen plant stateside for installation at the port of Umm Qasr, Iraq. The nitrogen plant project is part of the Iraq reconstruction effort. The nitrogen plant produces 25 tons per day (755 Nm^3/hr) of high-purity nitrogen gas and liquid. The overall project also included liquid storage and vaporization equipment, engineering, and field services. AMCS also had overall engineering and project management responsibility.

National Stem Cell Laboratory Services, Inc., a new subsidiary of National Stem Cell Holdings, Inc., is set to manage the cord blood and tissue banking operations of its parent company. The development of the Baltimore-based laboratory will be directed by **Jacob Cohen**, National Stem Cell COO, a PhD in Molecular Biology. www.nationalstemcell.com.

Air Products reached an agreement with **The Linde Group** this January to acquire the Polish industrial gas business, **BOC Gazy Sp z o.o,** for 370 million euros ($481 million). For regulatory purposes, Linde was required to sell BOC Gazy, as a result of its purchase of the BOC Group plc in September 2006.

L. Derek Lindsay has joined **CryoCath Technologies Inc.** as Chief Financial Officer. CryoCath recently announced its 12-month follow-up data from 15 patients treated during the feasibility stage of its STOP AF trial. This trial, now in its pivotal stage, is assessing the company's proprietary Arctic Front™ catheter to treat Atrial Fibrillation (AF), the most prevalent cardiac arrhythmia affecting more than 2.2 million Americans. A total of 33 patients were treated during the feasibility stage. At the six-month mark, 11 of the original 15 patients (73%) were AF-free. Of the 11, nine are AF free at 12 months and off antiarrhythmic drugs (AADs) and two did not show up for their one-year visits. Of the four that were not AF-free at six months, all are off AADs at 12 months, suggesting their AF condition improved to the level that AAD treatment is no longer necessary.

CryoCath has also announced that the first patients have been treated with SurgiFrost XL, a new minimally invasive surgical probe for treating cardiac arrhythmias, for which the FDA provided 510(k) clearance in late 2006. The first two patients were treated before the end of December 2006. Both patients left the operating room in sinus rhythm and are doing well. "Up until now, treating cardiac arrhythmias without invasive surgery has proven to be a technical challenge for the surgical community; SurgiFrost XL addresses that challenge," said **Allan Zingeler**, CryoCath's Vice-President, Global Marketing.

Flowserve opened new administrative headquarters this December, for its Flow Solutions Europe, Middle East and

Africa operations. Located in Essen, Germany, the facility contains a quick response center and a learning resource center. www.flowserve.com.

People, Companies in Cryogenics

Los Alamos National Laboratory announced that after 10 years of work, the world's most powerful pulsed, non-destructive magnet is ready for use at 85 Tesla, Associated Press reported. A Tesla is a measuring unit for magnetic fields. Researchers can join low temperatures with a strong magnetic field to inspect materials at a nanometer scale, a billionth of a meter. The magnet is expected to be used to study large organic molecules, such as drugs. **Alex Lacerda**, leader of the National High Magnetic Field-Los Alamos Center said that the magnet has already achieved 87.8 Telsa and is expected to reach 100 Tesla during its lifetime.

The ATLAS Barrel Toroid, the largest magnet ever built, has successfully been powered up to its nominal operating conditions at the first attempt. Named for its shape, this magnet provides a powerful magnetic field for ATLAS, one of the major particle detectors being prepared to take data at **CERN's Large Hadron Collider** (LHC), the new particle accelerator scheduled to turn on in November 2007. The ATLAS Barrel Toroid consists of eight superconducting coils, each in the shape of a round-cornered rectangle, 5m wide, 25m long and weighing 100 tonnes, all aligned to millimeter precision. It will work with other magnets in ATLAS to bend the paths of charged particles produced in collisions at the LHC, enabling important properties to be measured. Unlike most particle detectors, the ATLAS detector does not need large quantities of metal to contain the field because the field is contained within a doughnut shape defined by the coils. This increases the precision of the measurements it can make. At 46m long, 25m wide and 25m high, ATLAS is the largest volume detector ever constructed for particle physics. Among the questions ATLAS will focus on are why particles have mass, what the unknown 96% of the Universe is made of, and why Nature prefers matter to antimatter. Some 1800 scientists from 165 universities and laboratories representing 35 countries are building the ATLAS detector and preparing to take data next year.

Air Products is forming a joint venture company with **Nanjing Chemical Industries Co. Ltd**, a subsidiary of Sinopec Assets Management Corporation, a wholly-owned subsidiary of **China Petrochemical Corporation**, to produce hydrogen, oxygen, nitrogen and liquid products. Air Products and Nanjing Chemical will jointly build and operate an air separation unit and a hydrogen facility in Nanjing. Slated to come on-stream in 2009, this facility will have the capacity to produce more than 100-million standard cubic feet per day of hydrogen for Nanjing Chemical and other customers in the Nanjing area to meet their industrial gas needs.

Upcoming Meetings & Events

MARCH 18-20
CGA 94TH ANNUAL MEETING
St. Petersburg FL, Renaissance Vinoy Golf Resort. www.cganet.com.

MARCH 22-23
2007 CGA HYDROGEN SEMINAR
San Antonio TX, Hilton Palacio del Rio. www.cga.net; registration at http://www.hydrogen-conference.org/cgaseminar.asp.

APRIL 4-5
MAGNETICS 2007
Chicago, Lincolnshire Marriott Resort. www.magneticsmagazine.com/mag_conf_index.htm.

APRIL 11-13
2ND INTERNATIONAL CONFERENCES OF THE IIR ON MAGNETIC REFRIGERATION AT ROOM TEMPERATURE
Portorosz, Slovenia. www.thermag2007.si.

APRIL 16-20
HANNOVER MESSE 2007
SUPERCONDUCTING CITY 2007
Hannover, Germany. superconductingcity@runkom.de.

MAY 16-18, 2007
SHORT COURSE ON PRESERVATION OF CELLS, TISSUES AND GAMETES
Minneapolis, University of Minnesota, Contact Dr. Allison Hubel, preservecourse@me.umn.edu; www.me.umn.edu/education/shortcourses/preservation.

JUNE 10-14
2007 ISEC
Washington DC, Omni Shoreham Hotel. www.isec07.org.

JUNE 21- 23
INTERNATIONAL WORKSHOP ON LOW TEMPERATURE ELECTRONICS
Noordwijk, The Netherlands. www.congrex.nl/06c01.

JUNE 24-27
ITCC29/ITES17
Birmingham AL. www.thermalconductivity.org/index.html.

JUNE 25-29
PARTICLE ACCELERATION CONFERENCE
Sponsored by American Physical Society. Albuquerque NM, Albuquerque Convention Center http://pac07.org.

JULY 8-12
INTERPACK AND ASME-JSME THERMAL ENGINEERING AND SUMMER HEAT TRANSFER CONFERENCES 2007
Vancouver, British Columbia. www.interpackconference.org, www.heattransferconference.org, epd@engr.arizona.edu.

JULY 11-13
SPACE CRYOGENICS WORKSHOP, Div. of CSA
Huntsville AL, Embassy Suites Hotel www.spacecryogenicsworkshop.org. Abstracts due March 1 to leon.j.hastings@nasa.gov.

JULY 16
CSA SHORT COURSE SYMPOSIA--EXPANDED!
Chattanooga TN, Chattanooga Marriott at the Convention Center. John Weisend II, weisend@slac.stanford.edu, www.cryogenicsociety.org.

JULY 16-20
THE CRYOGENIC ENGINEERING CONFERENCE/INTERNATIONAL CRYOGENIC MATERIALS CONFERENCE (CEC/ICMC)
Chattanooga TN, Chattanooga Convention Center. Centennial Conferences, cec-icmc07@centennialconferences.com, www.cec-icmc.org.

AUGUST 6-9
CRYOGENIC ENGINEERING SHORT COURSE
Boulder CO. Dr. Thomas Flynn, www.cryoco.com, thomasmflynn@comcast.net.

AUGUST 21-26
22ND IIR INTERNATIONAL CONGRESS OF REFRIGERATION
Beijing, China. Sponsored by the Chinese Association of Refrigeration, www.icr2007.org.

AUGUST 27-31
20th INTERNATIONAL CONFERENCE ON MAGNET TECHNOLOGY (MT-20)
Philadelphia. www.mt-conference.org. Chair: Bruce Strauss, mt20@centennialconferences.com.

SEPTEMBER 16-20
8th EUROPEAN CONFERENCE ON APPLIED SUPERCONDUCTIVITY (EUCAS)
Brussels, Belgium, www.eucas2007.be.

On Our Cover

Our cover celebrates women in cryogenics and superconductivity, as well as girls starting on the road to science careers. Top: girls attending the Sci-Girls Summer Camp in Tallahassee FL (page 34). Individual photos: Women in Cryogenics and Superconductivity (page 18; all photos with job titles, page 23): clockwise from top, Dr. Emanuela Barzi, Fermilab; Eileen Cunningham, Meyer Tool & Mfg., Inc.; Dr. Susan Breon, NASA Goddard Space Flight Center; Dr. Judith Driscoll, University of Cambridge; Dr. Christine Darve, Fermilab, and center, Dr. Katherine Develos-Bagarinao, AIST. Bottom right: A Sci-Girl camper experiments with LN_2 (note the Tempshield gloves and big smile).

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