August 1999

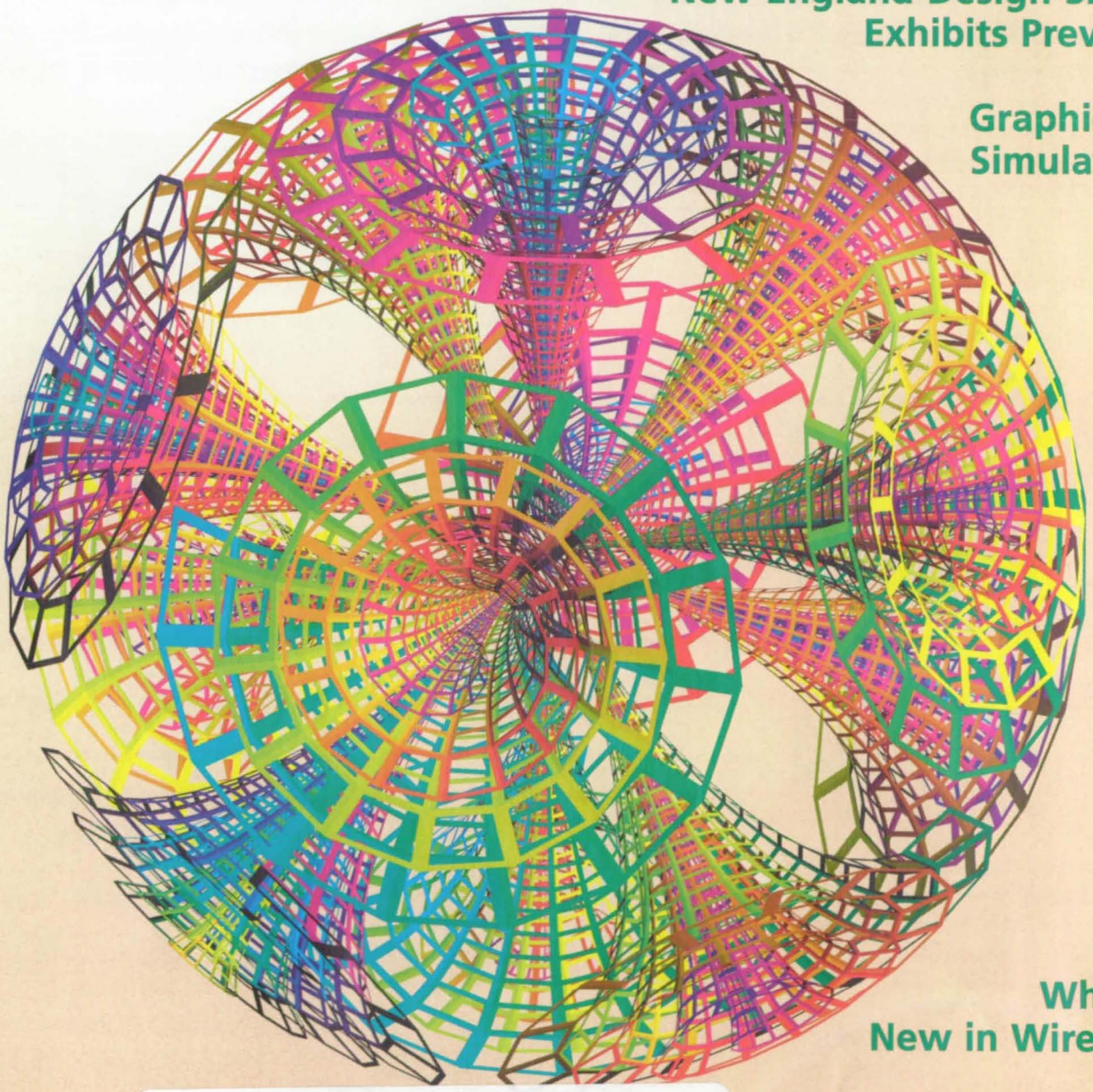
Vol. 23 No. 8

TECH BRIEFS

ENGINEERING SOLUTIONS FOR DESIGN & MANUFACTURING

New England Design Show Exhibits Preview

Graphics & Simulation



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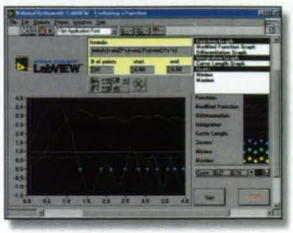

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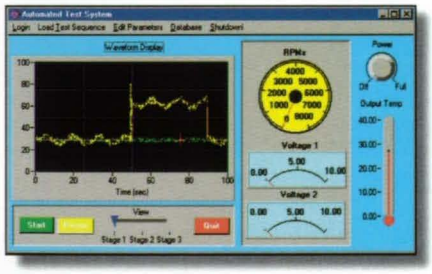

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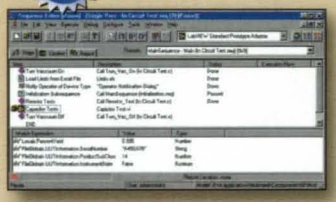

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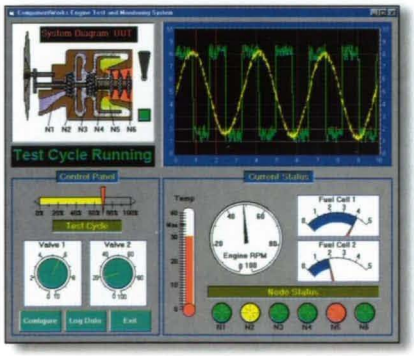

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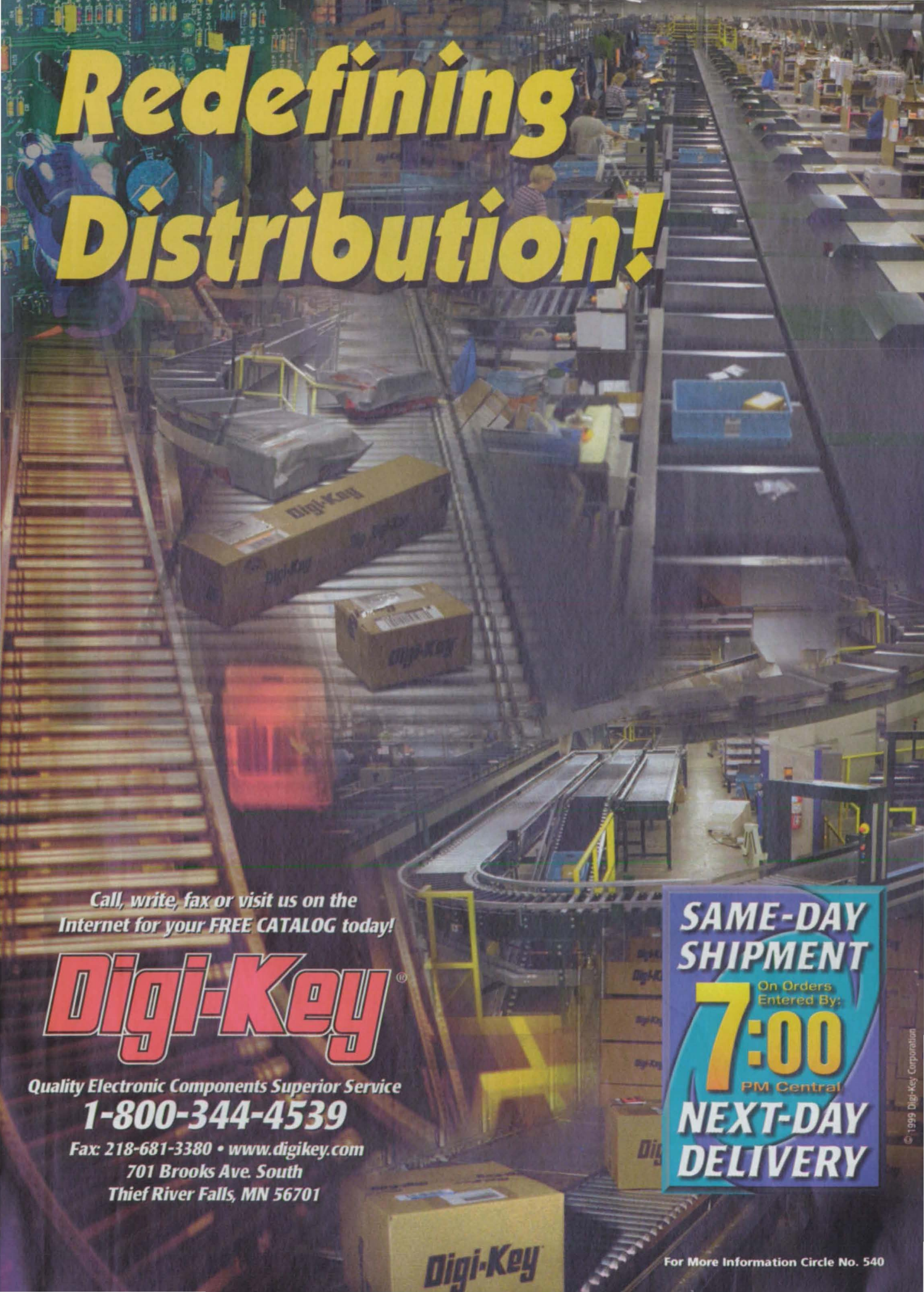
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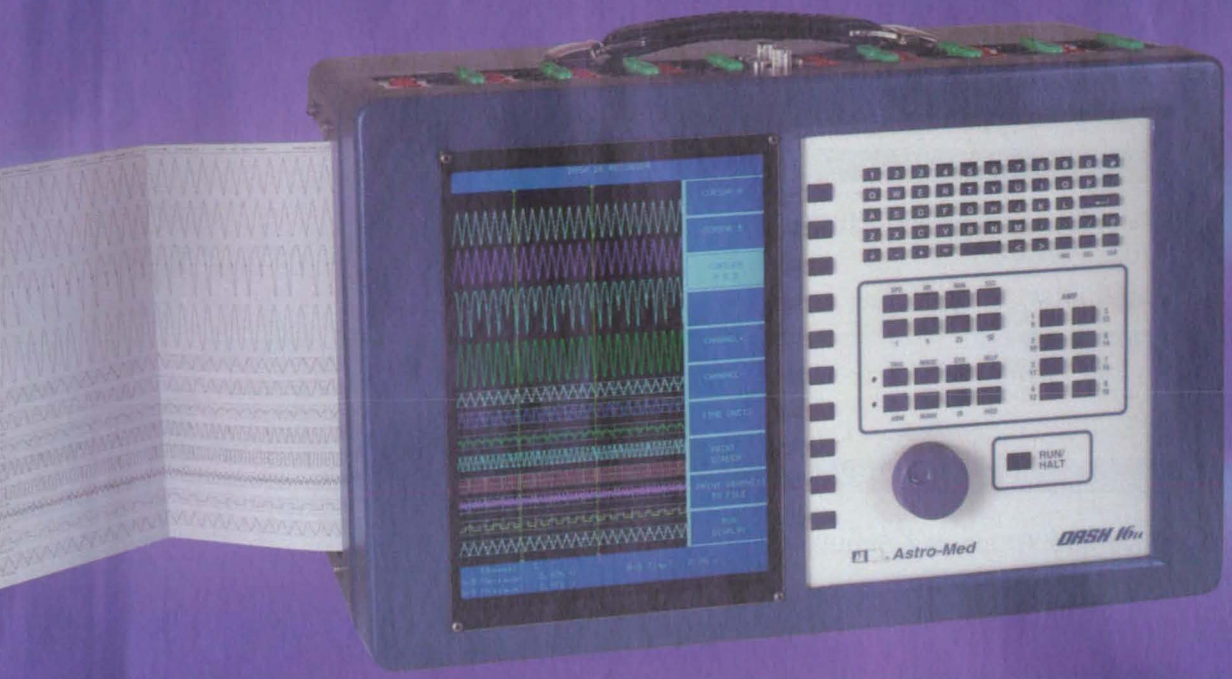

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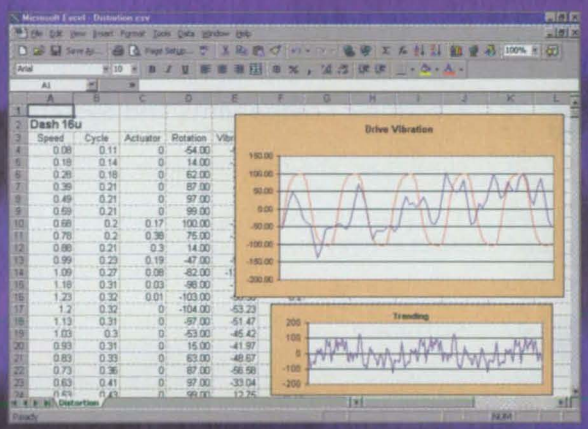

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ENGINEERING SOLUTIONS FOR DESIGN & MANUFACTURING

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FEATURES

BRIEFS

DEPARTMENTS

SPECIAL SUPPLEMENTS

1a - 14a
Electronics Tech Briefs

Follows page 48 in selected editions only.

1b - 14b
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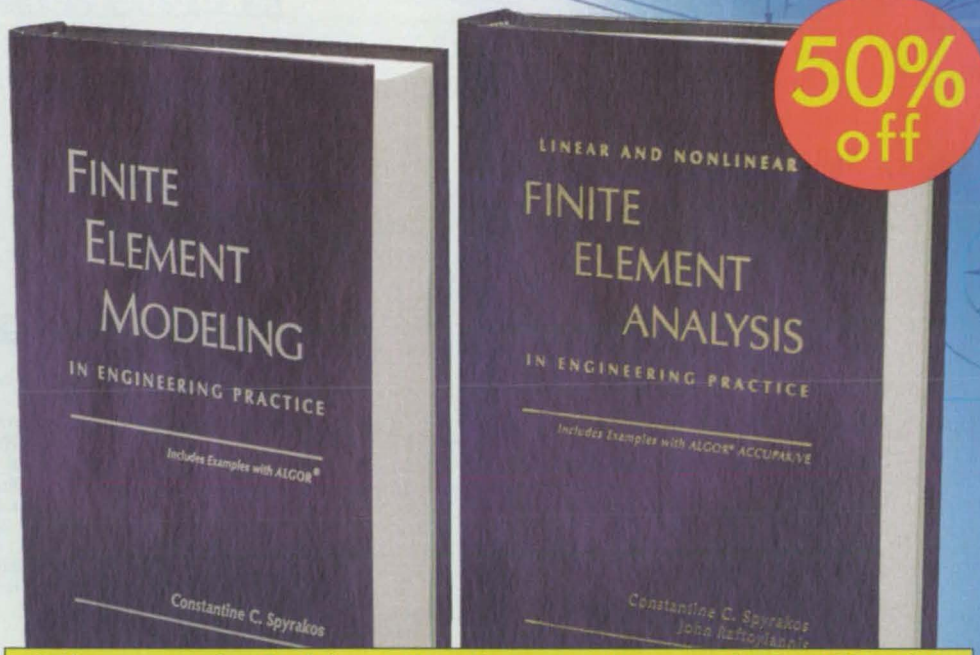

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About the Authors

Professor Constantine Spyrakos is a faculty member at the National Technical University of Athens (NTUA) and the College of Engineering at West Virginia University. He holds B.S. and M.S. degrees in Civil Engineering from NTUA, Greece. He also holds an M.S. in Engineering Mechanics and a Ph.D., with an emphasis on the utilization of FEA methods to solve dynamics problems, from the University of Minnesota. **Dr. John Raftoyiannis** holds B.S. and M.S. degrees in Civil Engineering from NTUA. He also holds an M.S. in Civil Engineering and a Ph.D. in Mechanical Engineering from West Virginia University with an emphasis in stability, composite materials and computational mechanics. He was recently invited to join the Civil and Geological Engineering Department at the University of Manitoba in Canada.

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Contents *continued*

PRODUCT OF THE MONTH

Wolfram Research unveils the newest version of *Mathematica*.

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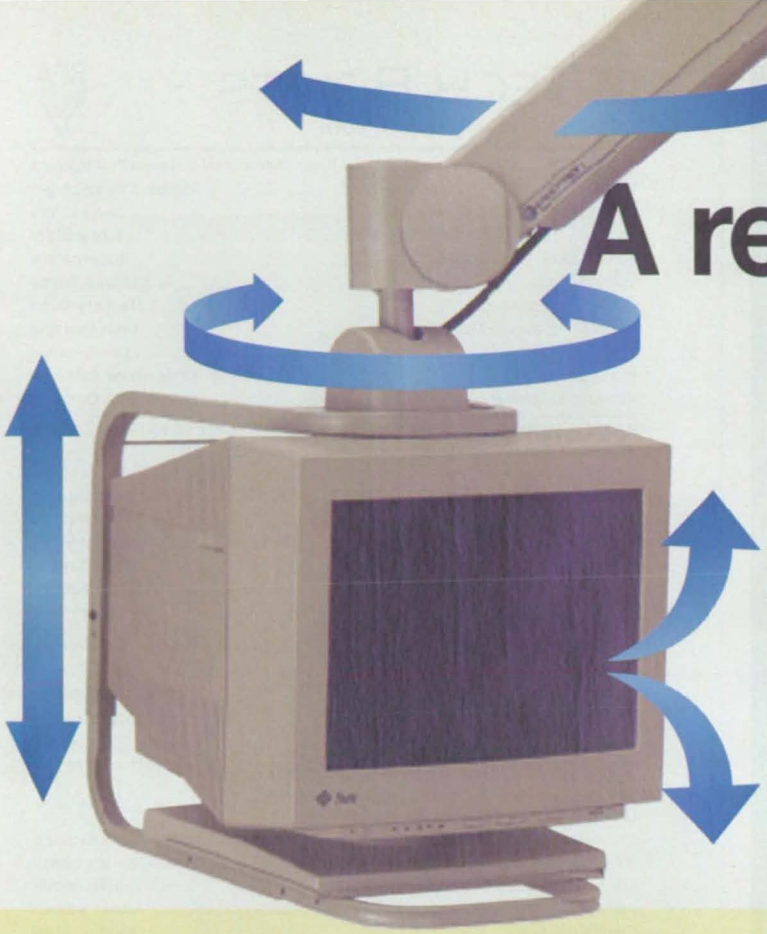
ON THE COVER

Horn-shaped spirals open along the directions of the faces of a dodecahedron in this image created with *Mathematica*® technical computing software from Wolfram Research, Champaign, IL. The latest version of the software, *Mathematica* 4, is this month's Product of the Month. For more information on the new version's enhancements and features, see UpFront on page 16.

(Image created by Michael Trott, courtesy of Wolfram Research)



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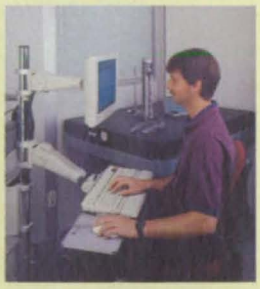

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Method for Surface Texturing Titanium Products

(U.S. Patent No. 5,853,561)

Inventor: Bruce A. Banks, John H. Glenn Research Center

This patent discloses a method by which the surface of titanium and/or titanium alloy objects, having both simple and/or complex configurations, may be electrolytically textured with a pattern of uniformly configured "pock mark" pores or pits. Such a surface is particularly suitable for the bonding of graphite epoxy structures to titanium components such as may be required for metal termination of polymer matrix composite beams and/or other structures commonly used in aerospace applications. The process employs an electrolytic cell in which the object or objects to be textured are immersed in a sodium chloride and water solution in a metal container. The objects to be textured (anode) are electrically connected to the positive terminal of a DC power source and the metal container (cathode) is similarly connected to the negative terminal of the power source. During the electrochemical process the electrolyte is agitated by an ultrasonic transducer.

Two-Phase Quality/Flow Meter

(U.S. Patent No. 5,861,755)

Inventors: J. Steven Moerk, Robert C. Youngquist, and Rudy J. Werlink, Kennedy Space Center

The present invention deals with a two-phase quality/flow meter that can measure the ratio (or "quality") of liquid to gas in, and the flow velocity of, a two-phase flow stream by using capacitance measurements. It seeks to overcome the drawbacks of currently employed capacitance-based meters by providing a device that eliminates the need for a high-frequency oscillator circuit to measure capacitance changes. This type of device's oscillator is typically very sensitive to electrical noise-induced errors. Furthermore, temperature and pressure changes affect the device's capacitance and are thus a source of error. Instead of the oscillator, this invention uses circuitry that accurately measures the time required to charge a probe capacitor to a threshold voltage. Timer and counter circuits are employed to measure the elapsed time between the start of charging and the attainment of the threshold value, resulting in a digital value that is fed directly into a microprocessor and is linearly proportional to the capacitance value. Another advantage is that the device generates a high-resolution digital value based upon analog measurements without use of an expensive high-resolution A-to-D converter. In addition, this arrangement is extremely noise-tolerant, since it does not rely upon frequency changes to convert a capacitance measurement to a digital value.

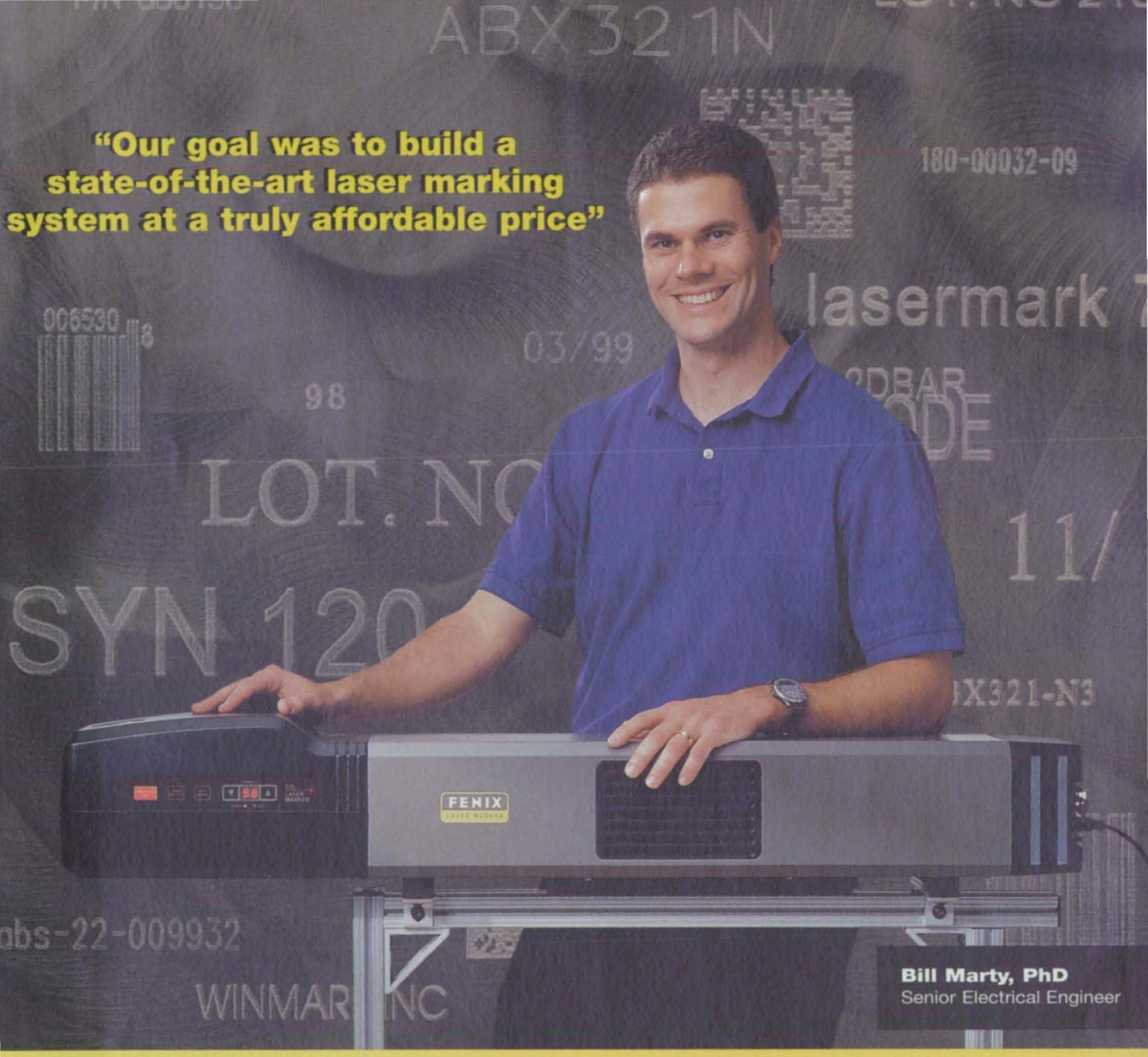
Ferroelectric Stirling-Cycle Refrigerator

(U.S. Patent No. 5,867,991)

Inventors: Anthony Jalink, Jr., Richard F. Hellbaum, and Wayne W. Rohrbach, Langley Research Center

Stirling-cycle cryogenic refrigerators have problems, among them the deleterious effects of dead space, lack of controllability of flow rate, contamination of the working fluid, and vibration that is communicated to the delicate components being refrigerated. The invention addresses these factors, providing a cryogenic device that is suitable for cooling sensitive infrared detectors to very low temperatures. It has a three-pump configuration and pumping sequence, in which one pump serves as a compressor, one as an expander, and one as a displacer. The pumps are ferroelectrically actuated diaphragm pumps that are coordinated by synchronizing the ferroelectric-actuator voltages in such a way that the net effect of the displacer is to reduce dead space — that is, to circulate a greater fraction of the working fluid through the heat exchangers than would be possible using the compressor and expander alone. In addition, the displacer can be controlled separately to make the fluid flow in the exchangers turbulent, to increase the rate of transfer of heat at the cost of greater resistance to flow, or laminar, to decrease the resistance to flow at the cost of a lower heat-transfer rate.

For more information on the inventions described here, contact the appropriate NASA Field Center's Commercial Technology Office. See page 14 for a list of office contacts.



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The core of this compact, self-contained system is a 25 watt Synrad sealed CO_2 laser. Designed for rugged environments, a Synrad laser can be expected to operate for tens of thousands of hours with no maintenance requirements. Fenix operates from a standard, user-supplied PC. It couldn't be more simple to set up - just connect it to the computer, plug it into the wall, and start marking!

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The first truly affordable laser solution to industrial marking, Fenix brings all the benefits of a state-of-the-art laser system at a lower cost than you ever imagined. For more information on Fenix, call us at **1-800-SYNRAD1**, or look us up on the world wide web at **www.synrad.com/fenix**

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www.synrad.com/fenix

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For More Information Circle No. 552

NASA Commercial Technology Team

NASA's R&D efforts produce a robust supply of promising technologies with applications in many industries. A key mechanism in identifying commercial applications for this technology is NASA's national network of commercial technology organizations. The network includes ten NASA field centers, six Regional Technology Transfer Centers (RTTCs), the National Technology Transfer Center (NTTC), business support organizations, and a full tie-in with the Federal Laboratory Consortium (FLC) for Technology Transfer. Call (609) 667-7737 for the FLC coordinator in your area.

NASA's Technology Sources

If you need further information about new technologies presented in *NASA Tech Briefs*, request the Technical Support Package (TSP) indicated at the end of the brief. If a TSP is not available, the Commercial Technology Office at the NASA field center that sponsored the research can provide you with additional information and, if applicable, refer you to the innovator(s). These centers are the source of all NASA-developed technology.

Ames Research Center
Selected technological strengths: Fluid Dynamics; Life Sciences; Earth and Atmospheric Sciences; Information, Communications, and Intelligent Systems; Human Factors.
Carolina Blake
(650) 604-0893
cblake@mail.arc.nasa.gov

Dryden Flight Research Center
Selected technological strengths: Aerodynamics; Aeronautics Flight Testing; Aeropropulsion; Flight Systems; Thermal Testing; Integrated Systems Test and Validation.
Lee Duke
(805) 258-3802
lee.duke@dfrc.nasa.gov

Goddard Space Flight Center
Selected technological strengths: Earth and Planetary Science Missions; LIDAR; Cryogenic Systems; Tracking; Telemetry; Command.
George Alcorn
(301) 286-5810
galcorn@gsfc.nasa.gov

Jet Propulsion Laboratory
Selected technological strengths: Near/Deep-Space Mission Engineering; Microspacecraft; Space Communications; Information Systems; Remote Sensing; Robotics.
Merle McKenzie
(818) 354-2577
merle.mckenzie@ccmail.jpl.nasa.gov

Johnson Space Center
Selected technological strengths: Artificial Intelligence and Human Computer Interface; Life Sciences; Human Space Flight Operations; Avionics; Sensors; Communications.
Hank Davis
(281) 483-0474
hdavis@gp101.jsc.nasa.gov

Kennedy Space Center
Selected technological strengths: Environmental Monitoring; Sensors; Corrosion Protection; Bio-Sciences; Process Modeling; Work Planning/Control; Meteorology.
Gale Allen
(407) 867-6226
gale.allen-1@ksc.nasa.gov

Langley Research Center
Selected technological strengths: Aerodynamics; Flight Systems; Materials; Structures; Sensors; Measurements; Information Sciences.
Dr. Joseph S. Heyman
(757) 864-6006
j.s.heyman@larc.nasa.gov

John H. Glenn Research Center at Lewis Field
Selected technological strengths: Aeropropulsion; Communications; Energy Technology; High Temperature Materials Research.
Larry Viterna
(216) 433-3484
cto@grc.nasa.gov

Marshall Space Flight Center
Selected technological strengths: Materials; Manufacturing; Nondestructive Evaluation; Biotechnology; Space Propulsion; Controls and Dynamics; Structures; Microgravity Processing.
Sally Little
(256) 544-4266
sally.little@msfc.nasa.gov

Stennis Space Center
Selected technological strengths: Propulsion Systems; Test/Monitoring; Remote Sensing; Nonintrusive Instrumentation.
Kirk Sharp
(228) 688-1929
ksharp@ssc.nasa.gov

NASA-Sponsored Commercial Technology Organizations

These organizations were established to provide rapid access to NASA and other federal R&D and foster collaboration between public and private sector organizations. They also can direct you to the appropriate point of contact within the Federal Laboratory Consortium. To reach the Regional Technology Transfer Center nearest you, call (800) 472-6785.

Joseph Allen
National Technology Transfer Center
(800) 678-6882

Ken Dozier
Far-West Technology Transfer Center
University of Southern California
(213) 743-2353

Dr. William Gasko
Center for Technology Commercialization
Massachusetts Technology Park
(508) 870-0042

J. Ronald Thornton
Southern Technology Applications Center
University of Florida
(352) 294-7822

Gary Sera
Mid-Continent Technology Transfer Center
Texas A&M University
(409) 845-8762

Lani S. Hummel
Mid-Atlantic Technology Applications Center
University of Pittsburgh
(412) 383-2500

Chris Coburn
Great Lakes Industrial Technology Transfer Center
Battelle Memorial Institute
(440) 734-0094

NASA ON-LINE: Go to NASA's Commercial Technology Network (CTN) on the World Wide Web at **http://nctn.hq.nasa.gov** to search NASA technology resources, find commercialization opportunities, and learn about NASA's national network of programs, organizations, and services dedicated to technology transfer and commercialization.

NASA Program Offices

At NASA Headquarters there are seven major program offices that develop and oversee technology projects of potential interest to industry. The street address for these strategic business units is: NASA Headquarters, 300 E St. SW, Washington, DC 20546.

Carl Ray
Small Business Innovation Research Program (SBIR) & Small Business Technology Transfer Program (STTR)
(202) 358-4652
cray@mail.hq.nasa.gov

Dr. Robert Norwood
Office of Aeronautics and Space Transportation Technology (Code R)
(202) 358-2320
rnorwood@mail.hq.nasa.gov

John Mulcahy
Office of Space Flight (Code MP)
(202) 358-1401
jmulcahy@mail.hq.nasa.gov

Gerald Johnson
Office of Aeronautics (Code R)
(202) 358-4711
g_johnson@aeromail.hq.nasa.gov

Bill Smith
Office of Space Sciences (Code S)
(202) 358-2473
wsmith@sm.ms.ossa.hq.nasa.gov

Roger Crouch
Office of Microgravity Science Applications (Code U)
(202) 358-0689
rcrouch@hq.nasa.gov

Granville Paules
Office of Mission to Planet Earth (Code Y)
(202) 358-0706
gpaules@mtpe.hq.nasa.gov

NASA's Business Facilitators

NASA has established several organizations whose objectives are to establish joint sponsored research agreements and incubate small start-up companies with significant business promise.

Wayne P. Zeman
Lewis Incubator for Technology
Cleveland, OH
(216) 586-3888

B. Greg Hinkebein
Mississippi Enterprise for Technology
Stennis Space Center, MS
(800) 746-4699

Joe Boeddeker
Ames Technology Commercialization Center
San Jose, CA
(408) 557-6700

Marty Kaszubowski
Hampton Roads Technology Incubator (Langley Research Center)
Hampton, VA
(757) 865-2140

If you are interested in information, applications, and services relating to satellite and aerial data for Earth resources, contact: Dr. Stan Morain, **Earth Analysis Center,** (505) 277-3622.

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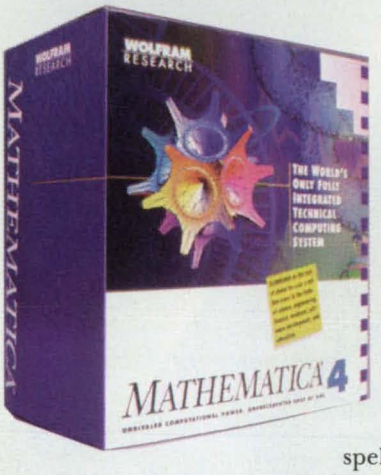
GE Plastics

We bring good things to life.

For More Information Circle No. 547

PRODUCT OF THE MONTH



Mathematica 4 technical computing software from Wolfram Research, Champaign, IL, combines calculating capabilities with a collection of visualization and technical publishing tools. New features include speed enhancements; direct import and export from over 20 standard data, graphics, and sound file formats; spell-checking and hyphenation in the notebook interface; and extended HTML and TeX output capabilities. The software offers support for handling computations in specified algebraic domains, and features extended range and improved functions for data analysis. New document-processing features make *Mathematica* 4 suitable for final simulations as well as prototyping. The software allows users with ordinary PCs or Macintosh systems to handle operations on large numerical matrices with a million or more elements, and perform calculations with million-digit accuracy.

For More Information Circle No. 737

Spaceports of the Future

NASA's Kennedy Space Center in Florida is leading a major initiative to identify the technologies that will enable revolutionary "spaceports" of the future. The goal is to develop the infrastructure needed to support the next generation of manned space planes, which would take off and land much like a commercial aircraft, and eventually, carry passengers.

Kennedy has initiated a joint-sponsored research program called "Vision Spaceport." Current partners include NASA's Ames Research Center, Boeing, Command & Control Technologies, Lockheed Martin, Quantum Technology Services, SAIC, and the University of Florida. NASA and the "Spaceport Synergy Team" will be looking for design ideas, partners, and investors.

To find out how your organization can participate, be sure to attend a special workshop on November 1-2 at the Miami Fontainebleau Hilton, held concurrently with the NASA-sponsored "Technology 2009" national technology transfer conference. The initiative will be one of the main tracks of the workshop, which will focus on emerging business opportunities in aerospace, aviation, space-based manufacturing, and related technologies.

To receive a brochure, e-mail joe@abptuf.org or visit the web site at www.techeast.net. You can visit the Vision Spaceport web site at **www.visionspaceport.org**

Fact or Fiction?

Futuristic propulsion drives that send spacecraft streaking across the screen in the mega-blockbuster "Star Wars" sequel may jump from science fiction to science fact in the not-so-distant future. Scientists at NASA's Marshall Space Flight Center in Huntsville, AL, are developing propulsion technologies that are very close to the "hyperdrives" used in the "Star Wars" movies.

The "Star Wars" hyperdrive gets its boost from fusion — an exotic propulsion technology being developed at Marshall. Fusion combines two or more atoms to form one heavier atom, releasing a tremendous amount of energy that can be used to drive a spacecraft. The energy efficiency of fusion compares to a car traveling 7,000 miles on one gallon of gas.

"Achieving the level of technology portrayed in 'Star Wars' is quite a challenge," said George Schmidt, deputy manager of Marshall's Propulsion Research Center. It will require overcoming the physical limitations of space itself in order to travel faster than the speed of light. "We're examining a variety of propulsion technologies, which will help us conquer the incredible challenges of interplanetary and even interstellar travel," explained Schmidt. "We're convinced that several of these technologies will likely transform the space travel seen in sci-fi movies into real-life experience."

NASA Marshall engineer Bill Emrich examines one of the magnetic coils that will power the gas dynamic mirror fusion propulsion experiment. (Photo by Doug Stoffer)

According to Garry Lyles, manager of NASA's Advanced Space Transportation Program at Marshall, laser propulsion and antimatter have long been the stuff of science fiction. "And now we're experimenting with them as viable options for space travel."

As far as when these real-life technologies will be in use, Lyles said no one really knows which of the technologies will open the space frontier. "What we do know is that we must push technology to achieve breakthroughs that are necessary to travel beyond our solar system."

For more information, visit NASA Marshall's web site at: www.msfc.nasa.gov; for information on the Advanced Space Transportation Program, visit: www.highway2space.com

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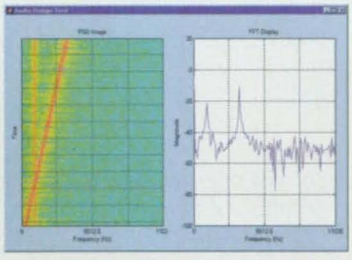

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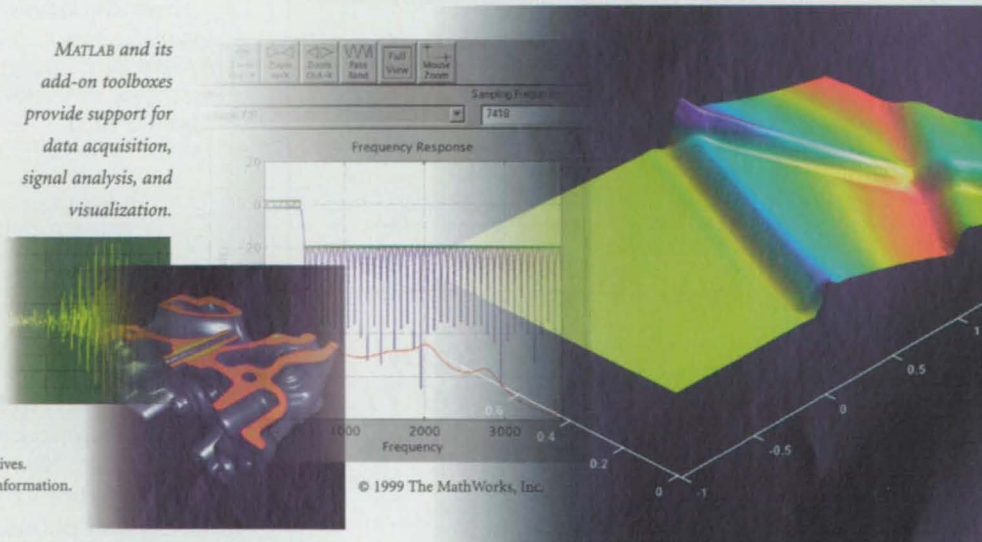

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For More Information Circle No. 521

Reader Forum

Reader Forum is devoted to the thoughts, concerns, questions, and comments of our readers. If you have a comment, a question regarding a specific technical problem, or an answer to a question that appeared in a recent issue, send your letter to the address below.

I read the feature "NASA Selects Top Inventions of the Year" in the May issue of NASA Tech Briefs *(page 30), describing PETI-5 (Phenylethynyl Terminated Imide Oligomers). I am looking for a strong sheet adhesive and wanted to know more about PETI-5. Can you provide a contact for more information? Thank you.*

Martin S. Kramer
General Motors Powertrain
Detroit, MI
martinkramer@prodigy.net

*(**Editor's Note:** PETI-5 was developed at NASA's Langley Research Center in Hampton, VA, by Paul Hergenrother, Joseph Smith, and Brian Jensen. You can reach the inventors, respectively, at the following e-mail addresses: p.m.hergenrother@larc.nasa.gov;joseph.g.smith@larc.nasa.gov; b.j.jensen@larc.nasa.gov)*

Your May issue featured a tech brief entitled "Biotelemetry Using Implanted Unit to Monitor Preterm Labor" (page 45) by John W. Hines at NASA's Ames Research Center. I'd like to thank Mr. Hines and his team for this development. My wife and I lost twin girls at 25 weeks, just one week after an ultrasound technician asked my wife if she was having contractions. Since this was her first pregnancy, she wasn't sure. This device could have saved our girls. The only problem would have been determining a conclusive reason for implantation of the device the first time around. Hopefully, the inventors will find a manufacturer and get through approvals in a timely manner!

Tim Wolf
trw90@usa.net

I read with interest a tech brief in the May issue, "Compact Magnetic-Sensor Units for Detecting Mines" (page 38) from NASA's Jet Propulsion Laboratory. If these devices work as described, they could save years' worth of time in the elimination of land mines in places such as Bosnia and Vietnam. Thanks for the information.

Richard Teichgraeber
Tactical Aircraft Systems
Lockheed Martin
Fort Worth, TX

Post your letters to **Reader Forum** on-line at: **www.nasatech.com** or send to: Editor, *NASA Tech Briefs*, 317 Madison Ave., New York, NY 10017; Fax: 212-986-7864. Please include your name, company (if applicable), address, and phone number or e-mail address.

Sealing and Bearing Solutions

Turcon® Varilip® the High-performance Rotary Shaft Seal

Combinations of high speed, high temperature and/or high pressure, cause conventional rubber-lip seals to wear out prematurely or fail suddenly. While a single requirement such as low friction may restrict the use of rubber lip seals, applications that combine several extreme operating conditions virtually eliminate the successful use of elastomeric seals.

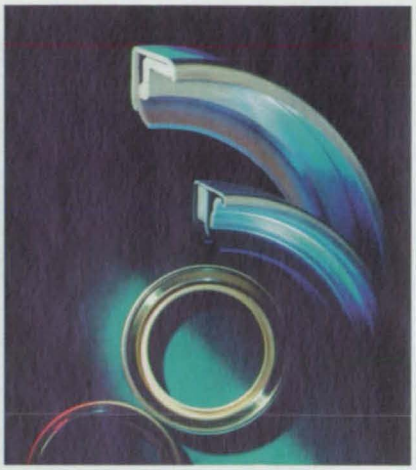
Turcon® Varilip® rotary shaft seals, made from high-performance polymers, offer an alternative to rubber lip seals for these difficult applications. In addition, higher performance and increased efficiency are now possible due to the Turcon® Varilip®.

The Turcon® Varilip® offers universal chemical compatibility, exhibits very low friction, operates above 12,000 sfpm and produces leak-tight sealing. These seals are available in standard inch nominal and metric sizes in addition to a vast range of custom sizes and configurations.

For an extra measure of performance and reliability in difficult operating conditions, without the problems of degradation, embrittlement and premature wear, the Turcon® Varilip® is a very effective alternative to rubber lip seals.

Busak+Shamban, 800-767-3257.

For More Information Circle No. 531



Three spring-energizer designs make the Turcon® Variseal™ more versatile.

With a choice of three spring-energizer designs, engineers can now specify seals optimized for virtually any application.

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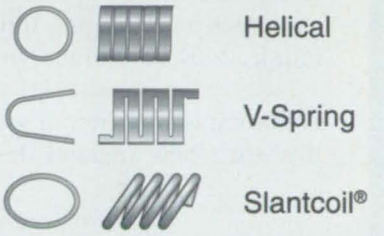

Choosing the right spring is a critical step in the design process. The Helical Spring applies the highest unit load, making it an excellent choice for static and slow-speed reciprocating applications. For high-speed reciprocating, or moderately fast rotary applications, the V-Spring is a better choice. This spring is also used for applications with abrasive environments where superior scraping is critical.

The Slantcoil® Spring, which is designed for both rotary and reciprocating service, is unique in that its spring force is virtually constant over a wide deflection range. Because it compensates for tolerances in the gland and for wear, it helps to ensure an exceptionally long operating life.

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For More Information Circle No. 532

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For More Information Circle No. 533

New England

Design & Manufacturing Expo

Exhibits Preview

Sponsored by *NASA Tech Briefs* and *Rapid Product Development* magazine, the second annual New England Design & Manufacturing Expo will take place September 20-22 at Boston's Hynes Convention Center. Exhibitors will showcase the latest products and services for design, prototyping, testing, and manufacturing applications. Special attractions will include the popular CAD and Rapid Prototyping Pavilion, highlighting an array of products and services to help engineers develop better products faster. More than 7,000 design and development engineers and managers attended the first New England Design & Manufacturing Expo and the concurrent events of Tech East '98 — Technology 2008, Photonics East and Electronic Imaging International — representing a wide range of industries, including computers, communications, electronics, medical, and manufacturing.

Following is a preview of some of the innovative products and services that will be displayed by exhibitors at this year's New England Design & Manufacturing Expo. For registration information, visit www.techeast.net.

Booth 201

The HBN series of anti-backlash nuts from **Haydon Switch & Instrument**, Waterbury, CT, eliminates backlash between the leadscrew and nut interface. It is designed for the company's external linear actuators. The nuts incorporate a three-piece design and are self-compensating. They are made from self-lubricating plastic or glass-reinforced resin, depending upon the application. A range of preloads from 0.75 pound to 9.5 pounds is available. Nuts are available for 0.140" and 0.218" screw diameters; available leads are 0.024, 0.048, and 0.096. Applications include laboratory instruments, metrology equipment, and other equipment requiring repeatable linear motion.

Circle No. 778

Booth 412

HardZap™ beryllium scanning mirrors from **Hardric Laboratories**, North Chelmsford, MA, are designed for high-power YAG and CO_2 laser systems and diamond-turned mirrors. Hardric will introduce a new HardZap mirror that is one-third lighter than standard beryllium mirrors. The company provides ultra-precision machining of all standard and many exotic materials for optics, aerospace, military, and other applications. Also featured will be demonstrations of RMS/surface finish and dielectric coatings on beryllium.

Circle No. 781

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Windows NT is a U.S. registered trademark of Microsoft Corporation.

Booth 404

Madison Polymeric Engineering, Branford, CT, offers packaging products and medical foams, including foam plastics. Products include sterilizable pressure-sensitive adhesives, foam and non-woven filter media, and foam positioners in the forms of wedges, head supports, and donuts. Packaging products include corrugated and chipboard boxes and inserts; urethane, polyethylene, and EPS foam inserts and die-cuts; plastic and metal shipping and storage cases; foam and plastic corrugated materials handling trays; and Kraft paper honeycomb inserts, die-cuts, and pallets.

Circle No. 779

Booth 205

Adhesive Prepregs For Composite Manufacturers (APCM), LLC of Plainfield, CT, is a leading epoxy adhesive prepreg (pre-impregnated) manufacturer that began in 1992, and grew out of a company called McCann Manufacturing. Their products include two-part, low-viscosity epoxy adhesive systems; unidirectional E-Glass epoxy prepregs; woven epoxy prepregs; and film adhesive.

Circle No. 786

Booth 300

ARRK Product Development Group, San Diego, CA, offers a wide range of capabilities, including rapid prototyping, CAD/CAM machining, fabrication, vacuum pressure molding, rapid casing, pre-production injection molding, and complete model-making services.

Circle No. 788

Booth 211

ARTIS Corp., Worcester, MA, specializes in real-time industrial information systems. Production, inventory, and labor tracking can be customized rapidly using the company's Real-Time Production Tracking Framework (RT-PTF) and Microsoft Access components.

Circle No. 798

Booth 202

The Center for Technology Commercialization (CTC), a non-profit company based in Westborough, MA, is NASA's Northeast Regional Technology Transfer Center (RTTC) covering the six New England States plus New York and New Jersey. Acting as a gateway for the transfer of NASA and other federal technology to private industry, CTC is one of six RTTCs providing a nationwide network devoted to the common mission of assisting American industry to improve its worldwide competitiveness.

Circle No. 799

Booth 406

Ceramco, Center Conway, NH, is an OEM for ceramic components for welding, instrumentation, and high-temperature furnace applications. Low-pressure injection molding and CNC grinding enable production of components in Al203, PSZ mullite, and other oxides. Stock alumina bolts and nuts are available in 1/4-20 to 2-56 up to 1", and in metric from 2 mm to 6 mm. Lengths to 3" are custom.

Circle No. 776

Booth 718

Algram America of Nanuet, NY, is a manufacturing company with 30 years experience in mold tool making, injection molding, vacuum forming, and assembly. Their focus is manufacturing tools for prototype or low- to medium-volume production for the aerospace, automotive, telecommunications, and medical/laboratory equipment sectors.

Circle No. 785

Booth 203

NU-CAST of Londonderry, NH, produces high-strength castings derived from computer-generated prototype patterns. Working with NASA engineering and technology, the company utilizes stereolithography (STL), selective laser sintering (SLS), laminated object manufacturing (LOM), computer-generated wood, and fused deposition modeling (FDM) technologies. NU-CAST received the Small Business Commitment to Excellence Award from the NASA/New England Business Outreach Center in Westborough, MA, for manufacturing the castings for NASA's Spartan 207 Inflatable Antenna Experiment (IAE) spacecraft, and the Passive Aerodynamically Stabilized Magnetically Damped Satellite (PAMS).

Circle No. 794

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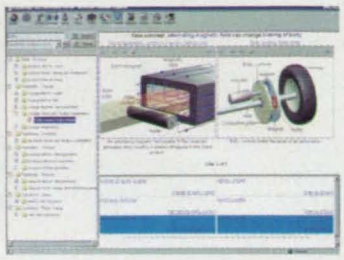


Booth 200

Invention Machine Corp., Boston, MA, offers a complete knowledge-based innovation product line for research and development teams. Semantic Knowledge Processor is the first commercially available knowledge processing system that semantically structures knowledge for use by professionals in engineering, scientific, and intellectual property fields. The software increases productivity in knowledge capturing and technical problem-solving. It enables engineering and manufacturing companies to capture technical knowledge from a range of sources to create a relevant knowledge base. The Knowledge and Innovation Server provides Intranet access to more than 6,000 animated scientific effects, as well as one's own documents. A patent analyzer works via the Internet to the U.S. and Japanese patent offices. TechOptimizer is a suite of tools designed for the senior researcher. It systematically generates concepts to solve tough engineering problems, and creates new, innovative products. It also provides powerful modules for product and process analysis, functional modeling, problem-solving, principles, and prediction analysis.

Circle No. 790

Booth 303

Coherent Laser Group of Santa Clara, CA, designs and manufactures lasers and laser systems for imaging, holography, inspection, material processing, metrology, data storage, and printing. Products include high-power laser diodes and bars, continuous wave lasers, and pulsed, solid-state lasers.

Circle No. 789

Booth 308

Founded in 1968, **Armstrong Mold**, East Syracuse, NY, provides leading manufacturers with traditional, hands-on pattern-making. Through more than 25 years of service, they've married those classic craft skills to today's most advanced technologies. They use both to serve pace-setting companies in industries such as aerospace, computer, automotive, medical equipment, and telecommunications. Today, complete in-house resources and 160 employees provide prototyping and short-run production services; short- to medium-run production in aluminum, zinc, and RIM polyurethane; and cast tooling for injection molding.

Circle No. 787

Booth 408

Microway, Kingston, MA, manufactures Pentium- and Alpha-based workstations and clusters for high-speed numeric processing, graphics engines, and servers. Microway's Linux-, UNIX-, and NT-based clusters employ MPI and PVM for efficient, parallel processing. Since 1982, Microway (www.microway.com) has provided technical support to the NASA community.

Circle No. 792

Booth 720

NERAC, Inc. of Tolland, CT, provides customized information to thousands of companies throughout the United States and Canada. Utilizing a staff of industry-trained scientists and engineers, NERAC's services include competitive intelligence; patent and trademark tracking; problem-solving updates; Table of Contents service; free full-image patents and applications from the U.S., Europe and Japan; document retrieval; and a variety of Web-based services.

Circle No. 793

Booth 402

Olympus America, Melville, NY, will display the SZX12 extended-zoom research stereo microscope; the BX30 reflected-light focusing mount; the OLY750 high-resolution color video camera; and the DP10 digital microscope photography system that provides high-resolution, 1280 x 1024 images in 24-bit color. Also featured will be the Encore high-speed video that lets users record and analyze extremely fast-moving events associated with high-speed industrial equipment. Encore captures the images, digitally stores them, and plays them back in slow motion, allowing users to study events and quickly identify problems.

Circle No. 782

Booth 410

Deltron Designs of Bethel, CT, specializes in industrial promotions. The company began as a merge between a manufacturer of linear motion components and an advertising agency. The company designs technical data sheets, brochures, and publication ads. They can provide Internet service with all the necessary data properly displayed on the web sites. They also offer CAD design and interactive CD-ROMs.

Circle No. 777

Booth 716

Oxford Polymers, New Britain, CT, has introduced PEKK (Polyetherketoneketone) Thermoplastic Resin, a melt-processible resin for applications requiring chemical, mechanical, and electrical performance at elevated temperatures. It is supplied in semi-crystalline or amorphous grades, and can be extruded, molded, and thermoformed in conventional equipment. Pellets and powder are available, as well as custom compounded products such as those containing glass or fiber. Properties include stiffness of 500,000 psi, electrical insulation, chemical resistance, a continuous service temperature rating of 250°C, and a glass transition temperature range from 155 to 165°C. It can be extruded over aluminum or copper wire plated with tin, nickel, or silver.

Circle No. 780

Booth 400

Project Schedulers, Cambridge, MA, is the authorized dealer and certified training organization for Primavera Systems, a manufacturer of Web-enabled, client/server, and desktop solutions for project management applications. Project Schedulers was established in 1983, and is one of the original Primavera marketing partners. In addition, Project Schedulers offers a full range of training and consulting services, including needs analysis and full-service implementation support.

Circle No. 795

Booth 213

High-performance electronic shielding gaskets are available from **Omega Shielding Products**, Randolph, NJ. Manufactured from a variety of engineered materials, the products offer low compression forces, high endurance, and high electrical conductivity. A variety of configurations, surface finishes, and attachment methods are available. The company is introducing an edge-mount, perpendicular contact series of products.

Circle No. 775

Booth 207

Located in Ashburnham, MA, **Woodland Energy** was established in 1985 to market the products that evolved to satisfy the transportable electrical needs of a family. Products include HUBERT, the Home Utilities and Boating Electrical Rechargeable Transporter with attached solar array; PowerBox, a pick-up-truck-mounted tool box that incorporates a solar-powered 120VAC/12VDC electric source; the Solar-Powered Electric Company - Portable (SPEC-P); and SideWinder, a portable electrified desk that is a two-part device resting on the seat between the driver and passenger.

Circle No. 797

Booth 309

SolidWorks Corp., Concord, MA, offers SolidWorks 99, the seventh major release of the 3D mechanical design software. The new release contains more than 150 major customer-driven enhancements and innovations in the areas of modeling, assembly design, detailing, visual communication, data sharing, piping, and sheet metal. It provides engineers with a comprehensive migration path from 2D to 3D modeling. The software, originally released in 1995, was designed as the first Windows-native 3D mechanical design system for mainstream engineers.

Circle No. 783

Booth 209

The US Army Soldier & Biological Chemical Command, Natick, MA, will be showing testing services capabilities, including waterjet capability, materials testing, equipment climatic chambers, and 3D anthropometric data acquisition and analysis capability.

Circle No. 796

Booth 301

The Z402 three-dimensional printer from **Z Corp.**, Somerville, MA, builds parts in an office environment, providing engineers and manufacturers a means of communicating and improving designs in three dimensions. It produces 3D models layer-by-layer from powder that is bound by a proprietary liquid. The process starts with data in CAD files that defines the part to be modeled. The system software slices the CAD model into cross-sections that can be between 0.005 and 0.010" thick. The system then prints the cross-sections, one after another, from the bottom of the model to the top. The 3D part can be infiltrated with various materials to improve strength and surface finish. Maximum part size is 8 x 10 x 8", and powder composition is non-toxic starch- and cellulose-based.

Circle No. 784

Booth 302

Matra Datavision, Andover, MA, provides engineering solutions and services for the automotive, tooling design/manufacturing and reverse engineering, and consumer products markets. The company offers consulting, deployment and implementation, education, and engineering services to more than 6,000 customers worldwide.

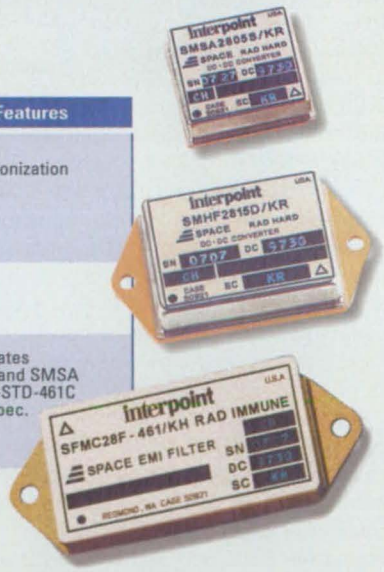
Circle No. 791

In addition to the exhibits, **NASA Tech Briefs** *will be sponsoring short courses and workshops in Boston on such topics as Small Business Innovation Research (SBIR), Rapid Prototyping & Tooling, and Technology Marketing and Licensing. For more information, visit www.techeast.net.*

DC/DC Converters for Space Applications

Model	Output	Output (volts)	Size - inches (mm)	Screening Options	Features
Converter SMHF	Power 15 Watts	3.3, 5, 12 or 15 single 12 or 15 dual	1.460 x 1.130 x 0.330 (37.08 x 28.70 x 8.38) Flanged (shown) 2.005 x 1.130 x 0.330 (50.93 x 28.70 x 8.38)	Class H* or K* Rad hard - 3 levels	Inhibit Synchronization
Converter SMSA	Power 5 Watts	5, 12 or 15 single 12 or 15 dual	1.075 x 10.75 x 0.270 (27.31 x 27.31 x 6.86)	Class H* or K* Rad hard - 3 levels	Inhibit
Filter SFMC	Throughput Current 2.7 Amps		2.110 x 1.115 x 0.400 (53.59 x 28.32 x 10.16) Flanged (shown) 2.910 x 1.115 x 0.400 (73.91 x 28.32 x 10.16)	Class H* or K* Rad hard - 2 levels	Attenuates SMHF and SMSA to MIL-STD-461C CE03 spec.

* Per MIL-PRF-38534



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NASA Kennedy Keeps Track of Parts With Wireless Data Control Network

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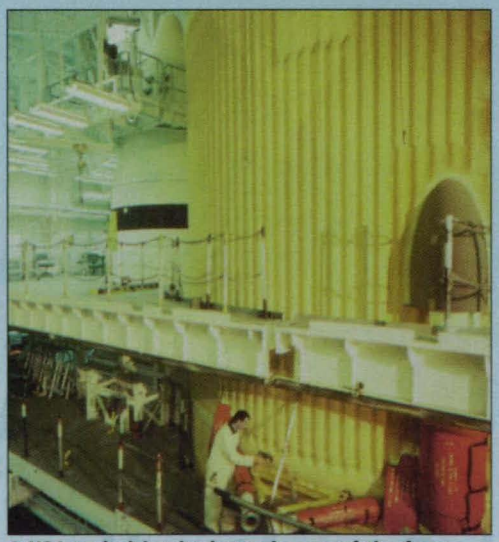
Thanks to a massive wireless local area network (LAN) — the result of a six-year effort by Intermec Technologies — NASA easily can locate any piece of its Ground Support Equipment (GSE) in seconds anywhere within the 47-square-mile Kennedy Space Center (KSC) facility in Florida.

United Space Alliance (USA), NASA's prime contractor for the Space Shuttle, needed immediate, real-time information for each piece of NASA's 300,000-item GSE inventory stored in 100 buildings at KSC. This equipment includes everything from torque wrenches, to the orbiter support braces used to hold the shuttles in place while machinists repair and refit the crafts. NASA's old batch collection system had about 40 percent accuracy in locating equipment. Now, with the radio frequency data collection (RFDC) installation, USA staff can pinpoint the location of 98 percent of the Ground Support Equipment in a few seconds. That means nearly $1 million in annual savings as a result of reduced downtime due to delays in locating equipment.

The shuttle launch structure sits on a cement base that rises 80 feet off the ground and spans about 200 feet across. The structure contains five Intermec repeaters that listen, receive radio transmissions, and repeat the information to be picked up by the next repeater. (Photo by Lonal V. Harding)

Prior to the RFDC installation, the maintenance crew relied on memory to locate the equipment. Now, each time a piece of equipment is moved, a USA worker uses a handheld Intermec computer with built-in scanner to read a bar code and input the current location of the item. This enables USA staff to locate a piece of equipment by typing in the model number. They also can type in a specific room number and the handheld will list all the equipment found at that location. Information is transferred via radio signal from the handheld computer to a repeater or radio that typically is attached to a wall or structure high above the ground. The repeater listens, hears the message, and repeats it so that the next repeater can do the same and pass along the information.



A USA technician is shown in one of the four High Bay areas in the Vehicle Assembly Building at Kennedy. He's using a handheld computer to read the bar code on the Forward Bipod Strut Fixture, the contact point where the yellow external fuel tank connects to the shuttle. (Photo by Lonal V. Harding)

To relay the RF signals, the 47 square miles of KSC were covered with yagi (directional) antennas configured in a star pattern. For building interiors, a combination of yagi and omni antennas was used. The result is a unique network providing real-time online inventory auditing and tracking. The system relies on Intermec handheld computers with integrated laser scanners to collect data and send it to an IBM ES9000 mainframe computer over a token ring network. This will change over to ethernet in the near future.

One of the challenges faced in constructing such a network was how to provide a radio frequency signal over the large area that was strong enough to provide a three- to five-second response time. The solution included nine Intermec Model 9180 controllers, 65 Model 9183 repeaters, and nine Model 9181 base radios, all operating at 900 MHz. The repeaters were set to repeat the RF signal four times, rather than the typical maximum of three times, providing the breadth of coverage needed to achieve the desired response time.

Another challenge was the diversity of construction materials used in the nearly 100 buildings at KSC.The Vehicle Assembly Building (VAB) alone, which covers eight acres and 129,428,000 cubic feet, has no "dead" spots where radio transmission is lost. "The accomplishment of this installation is extraordinary," said Pat Carlton of USA, a first-line operations manager for the VAB. "If you've never been to Kennedy Space Center, then it's hard to explain what a big place this is. Knowing that we have the capability to find the equipment we need within seconds is truly impressive."

The launch pads also presented a hurdle, with 80-foot-thick concrete from top to bottom, and 200 feet across. Another challenge came with the Orbiter Processing Facility, a pressurized building that was not suitable for drilling holes. A team scouted to locate an existing hole on the outside of the building where cable already was being routed into the facility, which would allow them to feed antenna into the building through an existing opening.

The initial site survey took over two weeks. The first phase of installation included over 30 buildings and took four months to complete. Phase two included the buildings of NASA's major contractors, as well as the shuttle landing facility, Central Instrumentation Facility, the Orbiter Processing Facility labs, and the inside of Launch Complex Pads A and B. The next stage of installation is expected to take four to six weeks. This phase will include, among other contractors, those supplying equipment for the International Space Station.

For More Information Circle No. 741

Commercialization Opportunities

Three-Phase Sine-Wave Generator

This is an inexpensive digital/analog circuit assembled from CMOS integrated circuits and other components. It is designed for use as a source of polyphase excitation in studies of the propagation of traveling waves in plasmas.
(See page 38.)

Microwave Heating of Fibers for Chemical Vapor Deposition

A microwave-cavity applicator has been developed for coating multiple fibers by chemical vapor deposition. Multiple fibers, either electrically conductive or nonconductive, can be coated simultaneously.
(See page 40.)

Polycrystalline Tb/Dy for Magnetostrictive Actuators

Studies have shown that with suitable processing one can produce polycrystalline Tb/Dy alloy for use in magnetostrictive actuators. The advantages over the single-crystal version are lower cost and, in most cases, elimination of the preload springs.
(See page 44.)

Push/Pull Magnetostrictive Linear Actuator

A proposed "kinematic inchworm" type linear actuator would move a mass as large as 2 kg along rails, with positions controllable in increments as small as 50 nm. Applications can be in interferometers, scanning tunneling microscopes, and as translation stages for inspecting integrated circuits.
(See page 47.)

Experiment on Reducing Drag on an Aerospace Launch Vehicle

Roughening of the forebody reduces base drag but not overall drag. The benefits of using surface roughness are nonintrusiveness (minimal heating), small weight penalty, mechanical simplicity, and low cost.
(See page 50.)

Miniature Turbomolecular Pump for High Vacuum

This pump would be a prototype of high-vacuum sources for a new generation of miniature, portable mass spectrometers and other scientific instruments. The pump would evacuate at a rate of about 3 L/s and would weigh about 11 oz (312 g).
(See page 52.)

Small Hybrid Rocket Engines Fabricated via X-Ray Lithography

The proposed rocket engines would burn specially shaped hollow cylinders of solid fuel. These engines would exploit a vortex flow phenomenon. The vortex-combustion-engine concept may prove useful in improving fossil-fuel power stations, boilers, retorts, gas-fired home furnaces, and turbojet engines.
(See page 53.)

Robust and Efficient Generation of Cartesian Meshes for CFD

This algorithm is suitable for component-based flow geometries.

Ames Research Center, Moffett Field, California

An algorithm for the robust and efficient generation of Cartesian meshes for computational fluid dynamics (CFD) has been developed. The algorithm generates a mesh for computing the flow in a region bounded by solid components that have prescribed sizes, shapes, positions, and orientations, and that may be moving with respect to each other.

Some background information is prerequisite to a summary of the algorithm. Unlike some other computational grids, Cartesian meshes are not body-fitted. The cells of Cartesian mesh are hexahedral (more specifically, right parallelepipeds) and some cells can extend through surfaces of solid components in the computational domain. Therefore, part of any Cartesian-mesh-generation algorithm must include identification of cells that intersect solid surfaces and the flagging or removal of cells that are completely internal to the solid objects and thus not in the flow field. The remaining cells are then considered general volume mesh elements.

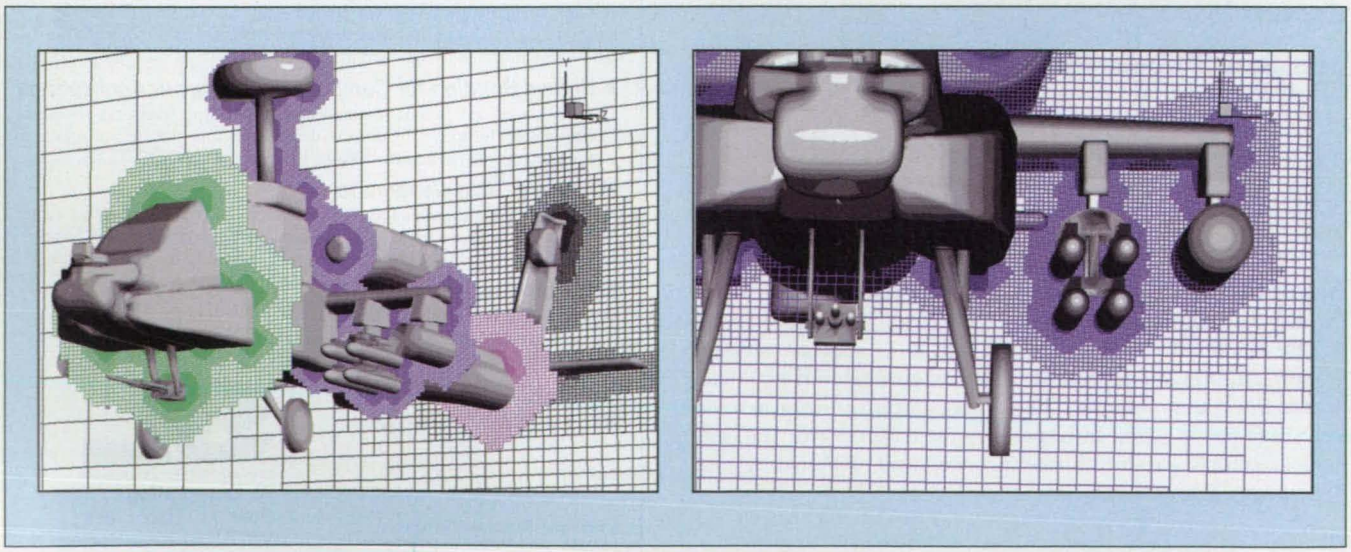
Fundamentally, in Cartesian approaches, one trades the case-specific problem of generating a body-fitted surface mesh for the more general problem of computing and characterizing intersections between hexahedral mesh cells and body surfaces. Thus, all difficulties associated with meshing a given geometry are restricted to a lower-order manifold that constitutes the wetted surface of the geometry.

Unlike the surface cells of a body-fitted mesh, the cells of a Cartesian mesh that intersect the surface are describable without describing the surface itself. In other words, the description of the surface is no longer needed to resolve both the flow and the local geometry. Therefore, efforts to describe the surface can be focused uniquely on the task of resolving the geometry, while computations that involve mesh cells are devoted to a description of the flow. Of course, accurate representations of boundary conditions in cells that intersect surfaces are essential to successful Cartesian schemes. This concludes the background information.

The present algorithm implements a two-phase strategy: In the first phase, intersections among all components are found and used to complete the description of the wetted surface, so that all surface-intersecting Cartesian cells found subsequently are guaranteed to be exposed to the flow field. The remaining mesh-generation problem can then be treated as if it were a single-component problem. In the second phase, the volume mesh is generated.

The component-intersection part of the algorithm is a robust geometry-oriented subalgorithm that, among other things, accommodates the surface triangulations commonly used to describe the surfaces of solid components. This subalgorithm utilizes adaptive precision arithmetic, and it includes a tie-braking routine that automatically and consistently resolves geometric degeneracies. The worst-case computational complexity of the intersection subalgorithm is of the order of $N \log N$, where N is the number of triangles describing the geometry.

The volume-mesh-generation part of the algorithm takes the intersected surface triangulation as input and generates the mesh through division of hexahedral cells of an initially uniform coarse grid. This approach preserves the ability to refine the mesh to different degrees in different directions, consistently with the local geometry, thereby making it possible to avoid generating excessive numbers of Cartesian cells in three dimensions. The mesh-generation subalgorithm has linear asymptotic computational complexity,



A **Cartesian Mesh Around an Attack Helicopter**, containing 5.81×10^6 cells, was generated by the algorithm in a computation time of 320 seconds on a moderately powerful engineering computer workstation with a central processing unit running at a speed of 195 MHz.

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LAMBDA Advanced Analog

For More Information Circle No. 538

with memory requirements that total approximately 14 words per cell. The figure depicts part of a mesh generated by the algorithm.

This work was done by M. J. Aftosmis and J. E. Melton of **Ames Research Center** *and M. J. Berger of the Courant Institute. For further information, access the Technical Support Package (TSP)* ***free online at www.nasatech.com*** *under the Information Sciences category.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Ames Research Center; (650) 604-5104. Refer to ARC-14275.

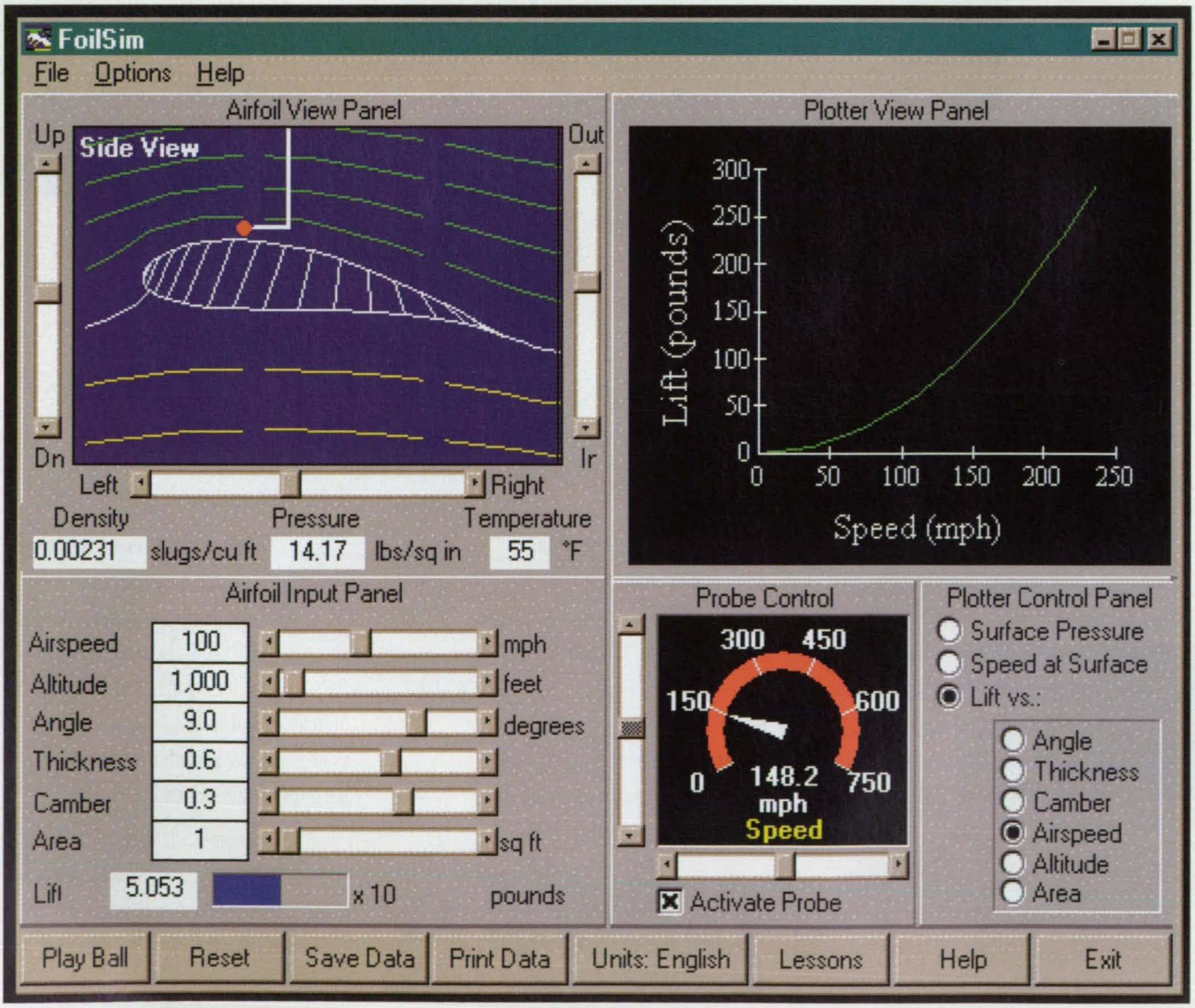
FoilSim: Software for Teaching About Airfoils

Interactive graphical displays help students perform simulated flow experiments.

John H. Glenn Research Center, Cleveland, Ohio

FoilSim is a computer program that calculates and graphically depicts information on flows of air around airfoils of various shapes. Although it is useful primarily as a teaching tool to enhance mathematical and scientific curricula, it was derived from "real-life" flow-computing software of engineering quality. To make the underlying flow-computing software useful in education, it was augmented with a graphical user interface that enables students to manipulate the features of the program easily and that guides the students through the learning process. The team that designed FoilSim combined the highly technical knowledge of scientists with the understanding of experienced educators to generate a product that is not too complex to be understood by students, yet it provides an entertaining and interactive way for students to explore substantial mathematical and scientific concepts.

FoilSim generates an interactive display, called the Airfoil View Panel (see figure), which contains a simulated view of a wing being tested in a wind tunnel with air moving past it from left to right. Students can change the position, ori-



FoilSim Generates an Interactive Display that shows aspects of the flow around an airfoil. Through the controls in the display, the user can explore the effects of design parameters like thickness, curvature, and angle of attack.

AST news
AEROSPACE SEALING TECHNOLOGY Volume 12 No. 3

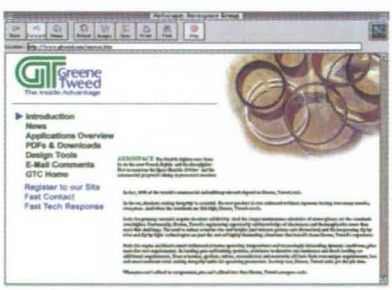
VISIT

GREENE, TWEED ONLINE AT: WWW.GTWEED.COM

"www.gtweed.com will be the premium site for information on seal and thermoplastic component technology," says Marketing Manager, Nick Hartle. *"It has already been recognized as informative, easy to use and worth going back to by a number of key industry groups."*

How Is The Site Structured?

Gtweed.com covers all the industry sectors that Greene, Tweed excels in. It includes corporate information, site map, registration area, human resources and search function.



To get an overview, check out the site map.

Applications

This section provides an in-depth look at each system in Aerospace and Defense in detail explaining Greene, Tweed's capabilities and recommendations for:

- PFCUs – Primary Flying Controls
- Engines – Engine systems including fuel system
- Landing Gear
- Secondary/Utility
- Brakes
- Defense systems

Benefits

- The **latest**, most up-to-date information
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  - MIL-G-5514 and AS4716
  - Failure analysis
- Installation procedure
- Material datasheets/capabilities
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- On-line Engineering Application Form (EAF) for rapid response
- Print off the latest literature, part number, and technical details. No more waiting for catalogs in the mail.
- A complete view of Greene, Tweed's capabilities in terms of design, service, quality and technology.
- Recommended design configurations for systems such as PFCU, Engines, Brakes, and Landing Gear will ensure designing based on the latest knowledge of material and configurations.

Design Tools

Specific section dealing with design related information. This area covers:

- Installation recommendations
- Material properties
- Failure analysis
- MIL-G-5514 and AS4716 standard tables
- Gland design recommendations
- Surface finish recommendations
- Conversion factors
- Compatibility of elastomers and thermoplastics

This is the hub of the site and will provide aerospace specific design information to allow aerospace design engineers rapid access to highly relevant information.

ASTN Backcopies

ASTNs are available here. These hold archive data related to Aerospace design issues.

Microsoft Internet Explorer

This site is best viewed using Microsoft Internet Explorer with a screen setting of 800 x 600 and a color choice of 16-bit.

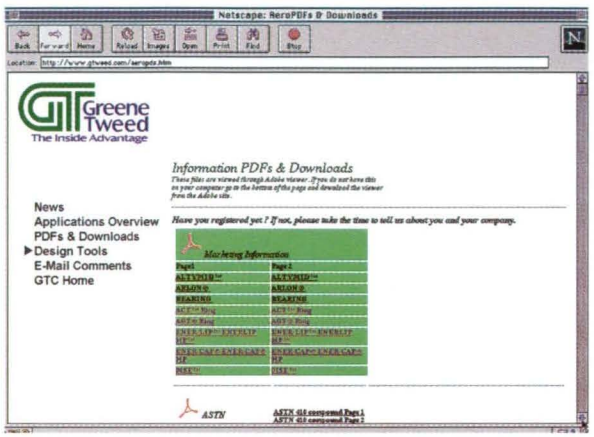
Download DXFs

DXFs are available to allow insertion of our configuration into your design drawing, thus eliminating the need to recreate and chance of mistakes.

PDFs & Downloads

All Aerospace configurations are covered in this section. To view requires Get Acrobat® Reader

Links are provided to Adobe's site to enable download of the viewer. These can be printed in color or black and white. New releases will be posted immediately.



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Latest press release information, new product releases, personnel information, job postings, announcements of internal shifts/promotions and relevant news will be added to this section.

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1b. If yes, do you plan to increase your purchase of CAD software in the next 12 months? ❑ Yes ❑ No

2. Which of the following types of CAD software do you now use? (check one) ❑ 2D ❑ 3D ❑ Both

3. Please list the names of CAD packages you (or your department) currently use.

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entation and shape of the wing by moving slider controls in the display to vary the parameters of altitude, angle of attack, thickness, and curvature. Other parameters that can be varied are the wing area and the airspeed. The software displays plots of pressure or airspeed above and below the airfoil surface. A simulated probe monitors airspeed and pressure at a particular point on or close to the surface of the airfoil. The software calculates the lift of the airfoil, enabling students to learn factors that influence lift.

Interactive lessons that accompany the program prompt students to engage in problem solving and discovery. These lessons include:

- Factors That Affect Lift
- How Lift Changes
- Flow Field Details
- The Lift Coefficient
- Baseball Lessons

In Baseball Lessons, students learn more about aerodynamics by controlling conditions of a baseball pitch, including altitude (location), speed, and spin.

The overall reaction from FoilSim users has been overwhelmingly positive. A high-school teacher reported that all of his students were using FoilSim and were beginning to "appreciate the process of experimenting." A student obtained a superior rating for a science-fair project that incorporated FoilSim. Parents, flight instructors, and engineers, each having a different reason to use FoilSim, have all expressed their delight with the program.

This work was done by Tom Benson, Bruce Bream, and Beth Lewandowski of **Glenn Research Center**; *John Eigenauer and Ruth Petersen of RMS Information Systems; Roger Storm of Fairview Park City Schools; Darryl Palmer, Jr., of Cleveland State University; and Carol Galica of Thigpen and Associates. For further information, visit the FoilSim web site at http://www.grc.nasa.gov/Other_Groups/K-12/aerosim/.*

LEW-16711

Program Generates Graphics To Help in Planning Space Flights

Data can be presented as overlays on world maps for quick analysis.

Goddard Space Flight Center, Greenbelt, Maryland

The Mission Planning Graphical Tool (MPGT) computer program provides a mouse-driven graphical representation of data on a spacecraft and its environment, for use in planning a space flight. MPGT is designed to be a generic software tool that can be configured to analyze any specified Earth-orbiting spacecraft mission.

The data are presented as a series of overlays on top of a two- or three-dimensional projection of the Earth. As many as six spacecraft orbital tracks can be drawn at one time. Position data can be obtained by either an analytical process or by use of ephemeris files. If the user chooses to propagate a spacecraft orbit by use of an ephemeris file, then files in Goddard Trajectory Determination System (GTDS) format must be supplied. The MPGT user's guide provides a complete description of the GTDS format so that the user can create the files. Other overlays include ground-station antenna masks, solar and lunar ephemerides, coverage by the Tracking Data and Relay Satellite System (TDRSS), a field-of-view swath, and orbit number. From these graphical representations, an analyst can determine such spacecraft-related constraints as communication coverage, infringement of interference zones, availability of sunlight, and visibility of targets to instruments.

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The presentation of time and geographical data as graphical overlays on a world map makes possible quick analyses of trends and of parameters related to time. For instance, MPGT can display the propagation of the positions of the Sun and Moon over time, shadowing of sunrise and sunset terminators to indicate day and night for spacecraft and the Earth, and color coding of spacecraft-orbit tracks to indicate day and night for spacecraft. In the case of the three-dimensional display, the user specifies a vector that represents a position in the universe from which the Earth is to be viewed. From the "viewpoint," the user can zoom in on, or revolve about, the Earth. The zoom feature is also available with the two-dimensional display.

MPGT also provides alphanumeric data on spacecraft orbit tracks, celestial bodies, and TDRS positions. The user can scroll through the spacecraft and celestial data; that is, can propagate data into the future or past. The program contains data files of world-map continent coordinates, contour information, antenna-mask coordinates, and a sample star catalogue.

Since the overlays are designed to be mission-independent, it is not necessary to modify the software in order to satisfy requirements for various spacecraft. All overlays are generic, with communication-zone contours and spacecraft terminators generated analytically on the basis of spacecraft-altitude data. Interference-zone contours are specified by the user through text-edited data files. Spacecraft-orbit tracks are specified via Keplerian, Cartesian, or Definitive Orbit Determination System (DODS) orbit vectors. Finally, all overlays related to time are based on an epoch supplied by the user.

A user-interface subsystem enables the user to alter any system parameter through a series of pull-down menus and pop-up data-entry panels. The user can specify, load, and save profile data files; control graphical presentation formats; enter a DOS shell; and terminate the operation of the system. MPGT includes a menu option for printing all graphical images by use of any printer compatible with the HALO Professional software. The user-interface subsystem automatically checks for errors in, and validates, all input data from either a file or keyboard entry. A help facility is also provided.

MPGT includes a utility subprogram, called "ShowMPGT," which displays screen images that were generated and saved by previous use of MPGT. Specific sequences of images can be recalled without having to reset profile-related parameters.

MPGT is written in FORTRAN, C, and Macro Assembler for use on IBM-PC-compatible computers running MS-DOS version 3.3 or higher. Necessary hardware includes 620KB of core (random-access) memory; Enhanced Graphics Adapter or Video Graphics Array; 1.5MB of either floppy- or fixed-disk storage capacity; a 1.44MB, 3.5-in. (8.89-cm) floppy-disk drive, and an 8087, 80287, 80387, or compatible processor. The software supports the use of a mouse, which is optional.

This program was written by Lisa Mazzuca, James Jeletic, and Stan Watson of **Goddard Space Flight Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Information Sciences category.*
GSC-13669

Software for Viewing Results of Computational Simulations

This program aids visualization of data from large-scale parallel processing.

John H. Glenn Research Center, Cleveland, Ohio

Parallel Visual 3 (pV3) is an interactive computer program that provides selected displays of data generated in numerical simulations — especially simulations that involve parallel processing. pV3 was originally designed to aid in the visualization of numerical results from computational fluid dynamics (CFD) calculations on unstructured as well as structured computational meshes, but can also be used to display data from other calculations and to display intermediate computational results for diagnosis of simulation software.

Parallel processing is used to reduce significantly (relative to serial processing) the time needed to perform complex numerical simulations of engines for purposes of design or analysis. Parallel processing is becoming common in industries (aerospace, automotive, financial, and oil-exploration) that rely heavily on computational simulations. As a result, there is a need for new software tools that designers and analysts can use to interact with computational simulations while the computations are in progress. pV3 is an innovative visualization-aiding software tool that satisfies part of that need. pV3 enables the viewing, steering, and understanding of results of a simulation while the results are being generated in a distributed parallel computing environment.

pV3 was developed to support work in the emerging field of parallel application programs, as part of the participation of Glenn Research Center in the High Performance Computing and Communication (HPCC) project. HPCC began to develop large-scale simulations that exceeded the computing capacity of any current single shared-memory computer. The ability of pV3 to make visible all the data generated by distributed computers made it possible for HPCC and derivative projects at Glenn Research Center and in industry to perform simulations that they were unable to perform before.

The figure presents an example of an image of the interior of a turbofan engine that contains 5,000 airfoils, generated by pV3. Optionally, a display containing images like this one could comprise still or moving pictures. Such a display could not be generated by any other currently available software running on any currently available distributed computing hardware.

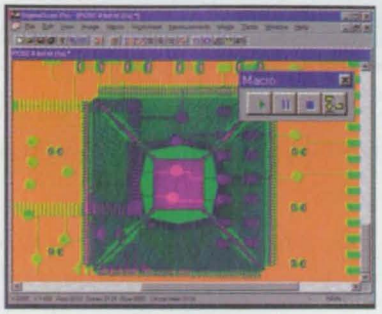
This **Image of the Interior of a Turbofan Engine** was generated by pV3. Images like this one are used to display results of Navier-Stokes computations of flow in the engine.

This work was done by R. Haimes of Massachusetts Institute of Technology and Gregory J. Follen of the Computing and Interdisciplinary Systems Office at **Glenn Research Center.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Information Sciences category.*
LEW-16712

Intergraph Corp., Huntsville, AL, has released SmartSketch® 3.0 2D **design, drafting, and diagramming software**. Formerly called Imagineer™ Technical and Imagination Engineer™, SmartSketch features an intuitive user interface, WorkSmart Technology, 46 industry solution templates, and more than 7,500 industry-standard symbols.

The software can be used alone or in a complementary role with MicroStation and AutoCAD, and fits within existing schematic, diagramming, conceptual, production, and business drawing workflows. The symbol library includes 1,000 process symbols such as valves, tanks, and heat exchangers; computer network symbols; and 300 mechanical symbols.

For More Information Circle No. 731



SigmaScan Pro® 5.0 **image analysis and data manipulation software** from SPSS, Chicago, IL, allows users to study the structure and size of visual information by transforming images into statistics, understandable graphs, and scientific conclusions. The software features a Visual Basic-based macro language that automates image enhancement, measurement, and analysis routines.

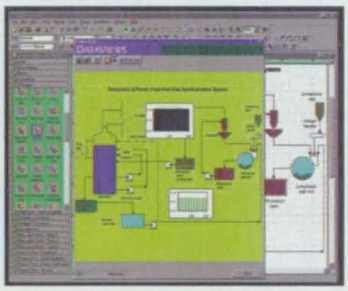
Users can apply 140 in-cell computations directly within an MS™ Excel formatted worksheet. Information from color images can be gained by altering the hue and saturation, changing the gamma correction value, or inverting the color values of images with the click of a button. Image analysis can be improved by saving or converting images to different types, or pasting and splicing images from one type to another.

For More Information Circle No. 735

FacePlate 4.0 **simulation graphics software** and component libraries from Altia, Colorado Springs, CO, enables embedded systems engineers to create graphic front panels for their simulation models. The software seamlessly connects to all leading system simulation tools, and assists with debugging, optimizing, and regression testing. Users need not have programming or graphic design experience.

The design process begins by assembling drag-and-drop graphics components from libraries. A finished design can be connected to all major system simulation software programs by clicking on signal names. The front panel exhibits the final product's proposed behavior and provides a working representation of how it will look when finished. The software's libraries include components such as buttons, knobs, meters, LEDs, and strip charts.

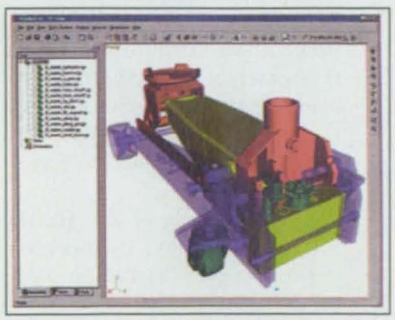
For More Information Circle No. 734



DataViews Corp., Northampton, MA, has introduced HMI-GO for Visio Technical, an add-on **graphics tool** that turns static Visio drawings into dynamic graphics. It allows engineers using Visio Technical drawing software to add a Human-Machine Interface (HMI) to existing process control diagrams such as piping and instrumentation diagrams, and process flow diagrams.

The software provides seamless integration with Visio Technical, and allows users to incorporate more than 20 predefined dynamic effects, including foreground and background color, blinking, fill, and rotation. Users also can connect to custom data sources such as PLCs and network elements. Once a Visio drawing is turned into an HMI interface with HMI-GO, it can be deployed as a standalone or client/server application using Web browsers.

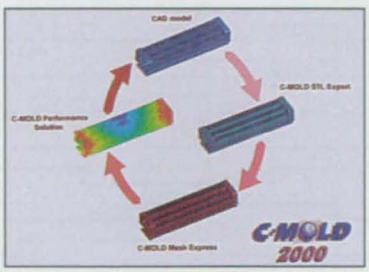
For More Information Circle No. 730



3D View™ **CAD/CAM model visualization software** from Actify, San Francisco, CA, is a Windows 95/98/NT tool for viewing CAD models without requiring a full-featured CAD system. It enables visualization, markup, and real-time cross-sectioning and dimensioning of CATIA™, SolidWorks™, Mechanical Desktop®, and other IGES, VDA, STL, DXF, VRML, and ISO G-Code files.

Other features include multiple real-time rendering options, web publishing capabilities, user activity tracking, and office document publishing. Users can share prototype models via e-mail using the software's compressed file format. Three-dimensional models also can be inserted into technical reports and presentations.

For More Information Circle No. 732



C-MOLD, Louisville, KY, offers C-MOLD 2000 Windows **molding simulation software** that enables users of any CAD/CAM system to simulate ten major molding processes. Solid, surface, or wireframe models can be used to simulate conventional injection molding, gas-assist injection molding, injection/compression molding, co-injection molding, reactive injection molding, rubber molding, resin transfer molding, microchip encapsulation, blow molding, and thermoforming.

The software features Mesh Express™ v99.7, which translates conventional plastic designs from an STL file to midplane FEM. Also included is STL Expert™ v99.7, which allows users to view, measure, refine, and correct solid surface models in STL file format. It also converts models from IGES or other finite-element mesh formats into STL models.

For More Information Circle No. 733

Three-Phase Sine-Wave Generator

A circuit generates three-phase sine waves with excellent amplitude and phase symmetry.

John H. Glenn Research Center, Cleveland, Ohio

A variable-frequency, three-phase, sine-wave generator circuit has been designed for use as a source of polyphase excitation in studies of the propagation of traveling waves in plasmas. This circuit, combined with three power-amplifier channels and three high-voltage transformers, is used to power the plasma apparatus that is used in the studies.

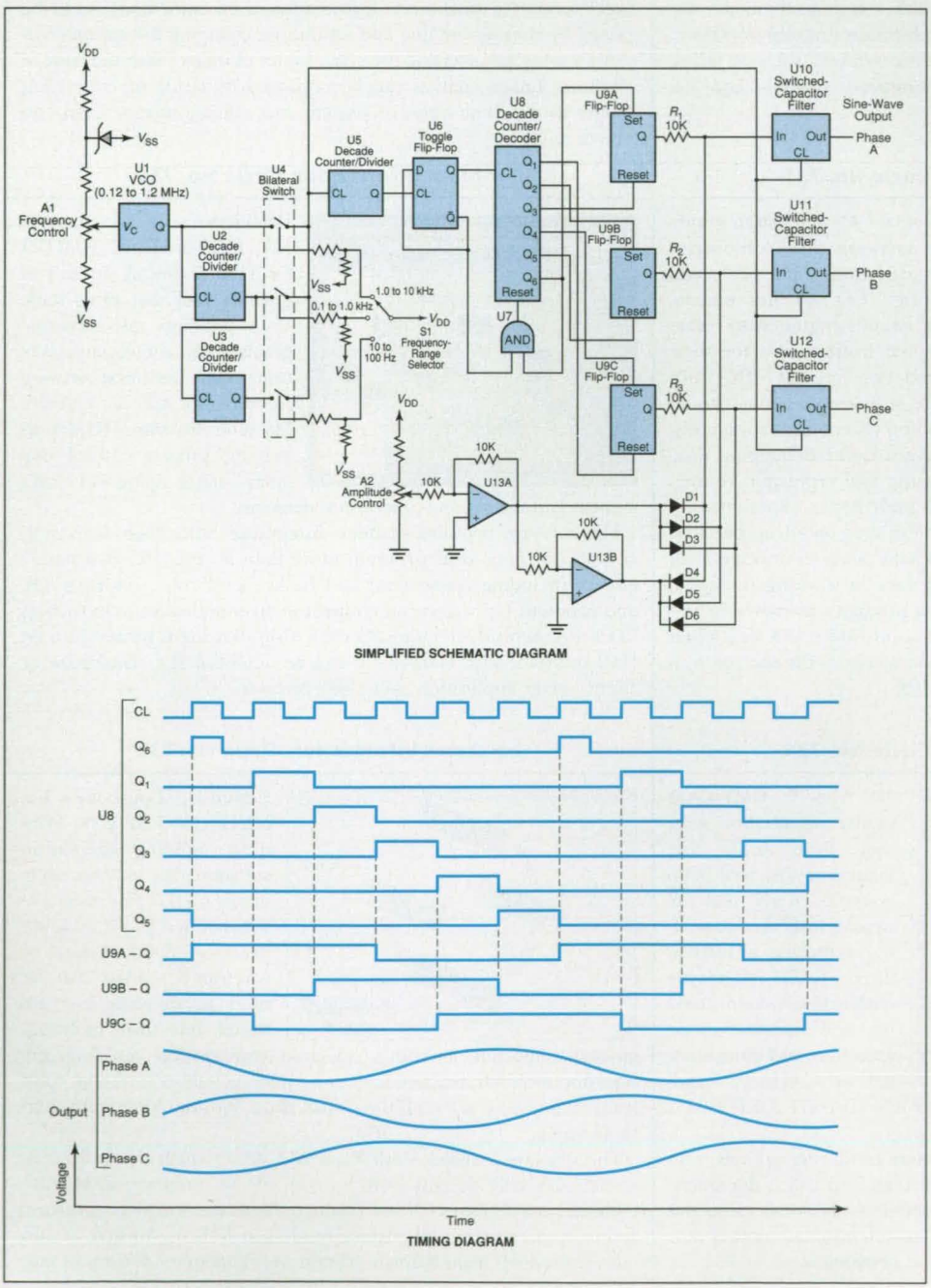
The circuit (see figure) internally generates three symmetrical square-wave voltages with precisely 120° phase difference, each square wave containing only odd harmonics. Three switched-capacitor, six-pole Butterworth low-pass filters (U10, U11, and U12) remove the harmonics but pass the fundamental sine-wave component.

The operating-frequency range of the circuit, 10 Hz to 10 kHz, is covered in three decade ranges. A Zener-stabilized voltage-controlled oscillator (VCO) functions as a variable-frequency oscillator and covers just over one decade, while a switch-selectable frequency-divider chain (U2, U3, and U4) provides frequency-range selection by decades.

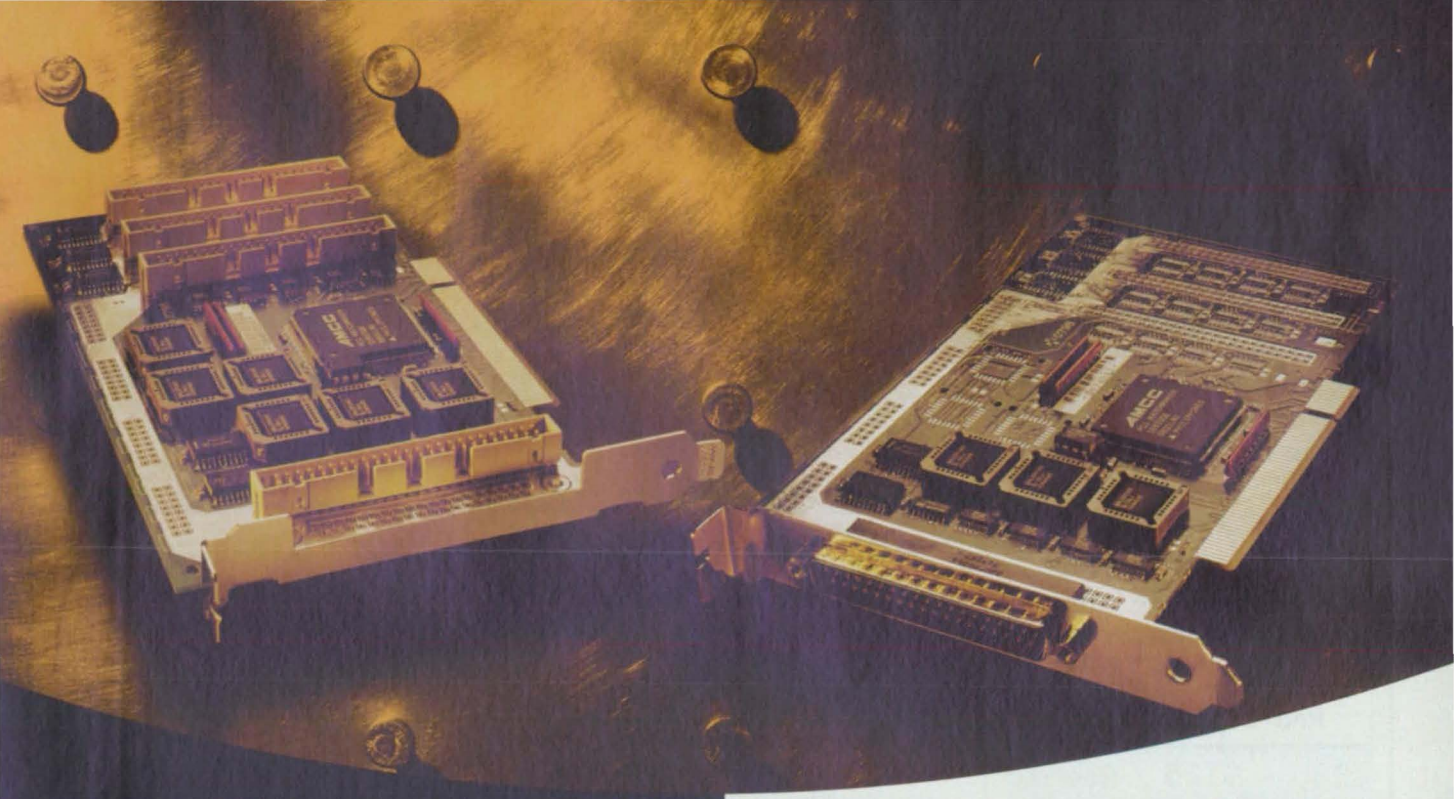
The operating frequency is 1/120th of the switched-capacitor filter clocking frequency. This frequency-division ratio is set by a fixed frequency-divider chain (U5, U6, U7, and U8). Inasmuch as this ratio is constant, the low-pass-filter cutoff frequency automatically tracks the operating frequency.

Decade counter/decoder U8 generates set and reset pulses in the proper sequence for flip-flops U9A, U9B, and U9C. In turn, these flip-flops generate symmetrical square-wave voltages. Once each cycle, AND gate U7 resets counter/decoder U8 to count zero after U8 reaches a count of six.

The amplitude of the sine-wave voltages generated by this circuit is proportional to the amplitude of the square wave at the filter input. The square-wave voltages are symmetrically clamped by diodes D1 through D6. The peak-to-peak voltage swing is limited by the total dc voltage developed at the outputs of operational amplifiers U13A and U13B. Amplitude control A2 sets the bias on the operational amplifiers, thereby set-



This **Three-Phase Sine-Wave Generator** is an inexpensive digital/analog circuit assembled from complementary metal oxide/semiconductor (CMOS) integrated circuits and other components.



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MODEL	KPCI-1801HC	KPCI-1802HC
• PCI Bus Architecture	32 Bit PCI	32 Bit PCI
• Number of Channels	64 Singled-ended/ 32 Differential	64 Singled-ended/ 32 Differential
• Resolution	12 Bit	12 Bit
• Sampling Rate	333kS/sec (Max)	333kS/sec (Max)
• Analog Outputs	2 (12 Bit)	2 (12 Bit)
• Software Platforms	Windows® 95/98/NT	Windows® 95/98/NT
• Bundled Software	DriverLINX® and TestPoint™ Drivers	DriverLINX® and TestPoint™ Drivers

For More Information Circle No. 523

ting the square-wave amplitude and ultimately the sine-wave amplitude. Controlling the amplitude in this way ensures that the amplitudes of the three sine waves track each other accurately over a wide range of amplitude settings.

Because dc control of amplitude and frequency is used in this design, the frequency- and amplitude-control components (A1, S1, and A2) can be located remotely without affecting the quality of the three-phase sine-wave signals.

This work was done by R. Ziemke of **Glenn Research Center.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Systems category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16696.

Microwave Heating of Fibers for Chemical Vapor Deposition

Multiple fibers, either electrically conductive or nonconductive, can be coated simultaneously.

NASA's Jet Propulsion Laboratory, Pasadena, California

A microwave-cavity applicator has been developed for coating multiple fibers by chemical vapor deposition (CVD). A prototype of the applicator was used to deposit silicon carbide onto carbon fibers; the design of the applicator can just as well be optimized for coating fibers made of other materials, and for depositing coating materials other than SiC.

There are two conventional techniques for CVD on fibers. In one technique, a fiber is pulled through a chamber that contains CVD reagent gases. The fiber enters and leaves the chamber through mercury electrodes that also serve as gas seals. The fiber is heated to the reaction temperature by an electrical current applied through the mercury electrode/seals. The disadvantages of this technique are that it is limited to electrically conductive fibers, each reaction chamber can accommodate only one fiber at a time, and the toxicity of mercury poses a hazard. In the other conventional technique, a fiber is heated in a waveguide-type microwave applicator. Although this technique is not limited to electrically conductive fibers and does not involve mercury, it, too, is limited to one fiber per applicator, and the waveguide applicator is intrinsically energy-inefficient because its proper operation depends upon absorption of a substantial portion of the incident microwave power in a dummy load.

The present microwave-cavity applicator overcomes the disadvantages of the applicators used in both conventional techniques: It can be used to coat multiple fibers, the fibers can be electrically conductive or nonconductive, there is no need for mercury, and microwave energy is utilized more efficiently than in the older waveguide/dummy-load microwave-applicator.

The enhancement in energy efficiency is achieved by use of a resonant microwave cavity and by positioning the fibers in the cavity so as to cause only a small deviation of the electromagnetic field from the empty-cavity normal mode while causing the fibers to absorb a large fraction of the microwave power that enters the cavity. The positioning is especially critical for coating fibers of carbon and other lossy materials; typically, such fibers should be placed near an electric-field node.

The figure is a simplified drawing of the applicator. The major structural component is a circular cylindrical microwave cavity. Microwave power is supplied through a coaxial transmission line and coupled into the cavity by a coaxial rod antenna.

The electromagnetic field in the chamber is excited in a close approximation of a TM_{0N0} mode, where N is a positive integer. (The mode would be purely TM_{0N0}, were it not for the small perturbations introduced by the objects described below.) The TM_{0N0} mode is axisymmetric; therefore, to expose multiple fibers to identical microwave conditions, one need only take care to position the fibers and other objects symmetrically about the axis of the cavity.

The cavity contains multiple (four in the example of the figure) reaction chambers in the form of tubes made of quartz or other low-loss dielectric material. The reaction chambers are placed at equal angular intervals and nominally at the same radius. In operation, reagent gases are made to flow through the reaction chambers while the fibers are pulled through the reaction chambers and heated to the CVD reaction temperature by the microwave field.

Efficient utilization of the incident microwave power depends critically on good impedance matches from the transmission line through the antenna to the partially filled cavity, then to the fibers. The length of the rod antenna can be adjusted for an impedance match from the transmission line to the chamber. The fibers must be positioned at an optimum radius, which is nearer or farther from an electric-field node, depending on whether the fibers are more or less lossy. Slots in the end plates of the cavity accommodate adjustments in the radial positions of the reaction chambers and thus of the fibers.

This work was done by Henry W. Jackson of Acro Service Corp. and Martin Barmatz and Gordon Hoover of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP) free on-line at www.nasatech.com under the Electronic Components and Systems category.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

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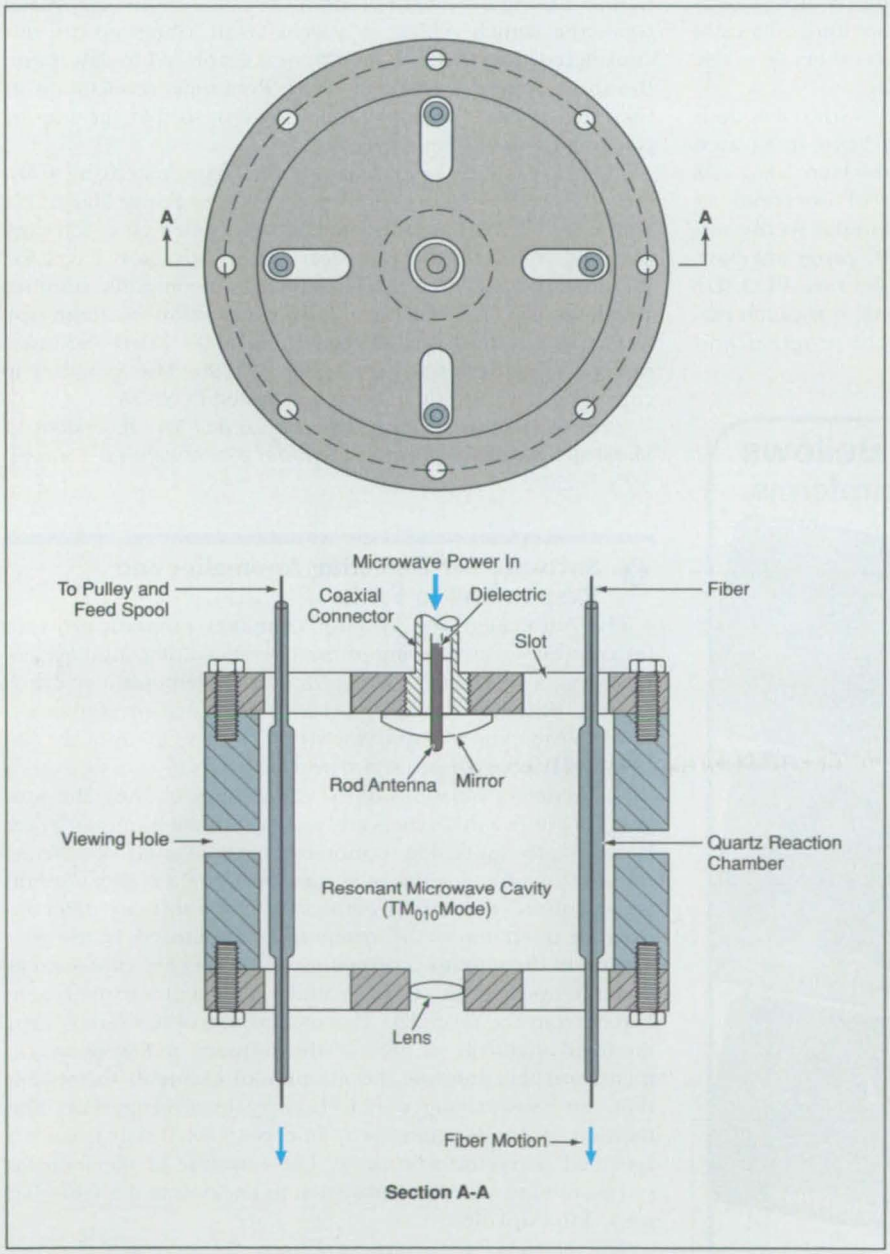


Fibers Are Pulled Through Reaction Chambers filled with CVD reagent gases in a resonant microwave cavity. The microwave field heats the fibers to the CVD reaction temperature. Although four reaction chambers are shown here, more or fewer could be included. The curved mirror and lens can be used for optical monitoring of the process.

Program Estimates Loads in Launch Vehicles

Version 1.4 of the Launch Vehicle Loads Analysis for Preliminary Design (VLOADS 1.4) computer program calculates in-flight launch-vehicle structural loads (that is, spacecraft-launching rockets) for preliminary design. The program can also be used to calculate structural loads in upper stages and planetary-transfer spacecraft.

VLOADS compiles and analyzes launch-vehicle information such as aerodynamic coefficients, mass properties, data on propellants, and engine thrusts, to calculate distributed shear loads, bending moments, axial forces, and vehicle line loads as functions of X station (position along the longitudinal axis of the vehicle). If the launch vehicle includes boosters or wings, then VLOADS also computes interface loads.

An attractive feature of VLOADS is that its source code is in Visual Basic for Applications and has been integrated into an easy-to-use Microsoft Excel user interface. VLOADS uses the individual worksheets in its Excel workbook as input and output data files, in a manner similar to the way in which traditional FORTRAN and BASIC programs have used text files as input and output files. Because VLOADS has been integrated into an Excel workbook, it is much easier for the user to edit the input data, run the program, and view the results.

The major strength of VLOADS is that it enables rapid analysis of structural loads in launch vehicles during the preliminary-design phase of development. Thus, VLOADS offers an alternative to the time-consuming and expensive chore of developing finite-element models for detailed analysis of loads. In preliminary design, much remains unknown about the details of the configuration to which the launch vehicle will mature.

It becomes necessary to make some simplifying assumptions to initiate the process by which loads can be calculated for preliminary design and analysis of structures. VLOADS implements a two-degree-of-freedom mathematical model for calculating the distribution of axial force, shear force, and bending moment along the length of the vehicle. The model essentially treats the launch vehicle as a rigid beam; vibrations are not considered. The method of sections is employed to determine the shear, moment, and axial load. Rotational acceleration in the pitch plane is assumed equal to zero, so that the sum of pitching moments equals zero.

VLOADS was developed as a Visual Basic macro in a Microsoft Excel 5.0/95 workbook program on a Power Macintosh computer. VLOADS has also been implemented on a '486-class personal computer using version 7.0a of Microsoft Excel for Windows 95, and on a '586-class personal computer running Windows NT 4.0. The standard distribution medium for VLOADS is one 3.5-in. (8.89-cm), 1.44MB, MS-DOS-format diskette. VLOADS was developed in 1996. The program is copyrighted work with all copyright vested in NASA.

This program was written by Paul L. Luz and Jerry B. Graham of **Marshall Space Flight Center**. *No further documentation is available. MFS-27332*

Software for Detecting Anomalies and Responding to Faults

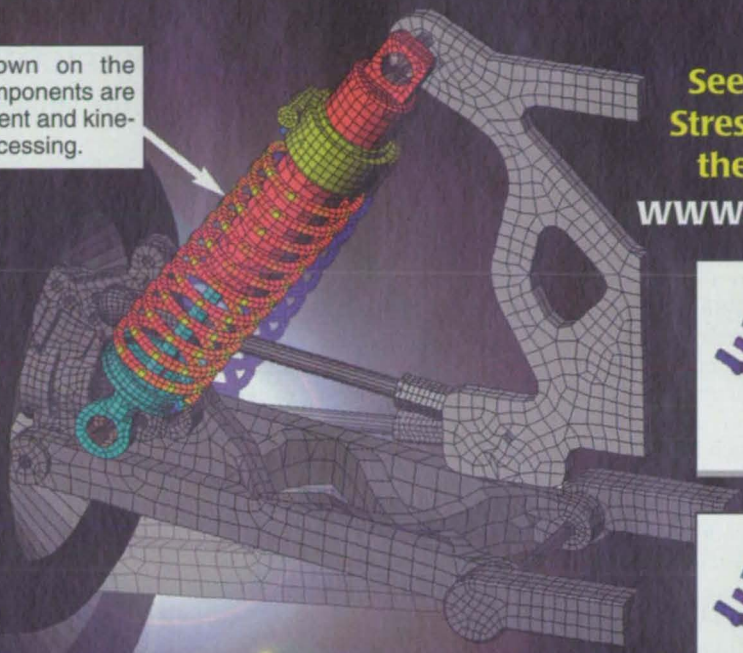
The Automated Test Monitor computer program provides for continuous monitoring of the operations of a complex system (e.g., a spacecraft). This program implements a rigorous analytic (instead of an ad hoc) technique that prescribes exactly how to express requirements for the operation of the system, and how to construct and implement a software subsystem that can detect violations of the requirements. Thus, the program provides a theoretical and computational framework that is potentially applicable to monitoring of a variety of systems. Run-time monitor software is constructed (hereafter, "monitor" for short) that can be embedded in the software that controls the operation of the system to be monitored. In the generation of the monitor, correctness properties are expressed as linear temporal logic (LTL) formulas, then a procedure is generated from the formulas. The system-control software is then modified manually to provide the software analog of instrumentation that informs the monitor of events in the system that can cause changes in LTL correctness properties. The monitor responds whenever it detects an event that violates a specified correctness property. The response of the monitor can be used to activate a subsystem to respond to the fault that caused the violation.

This program was written by Francis Schneider of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Software category. NPO-20585*

NEW Mechanical Event Simulation with Kinematic Elements

Dynamic stresses are shown on the spring. Other suspension components are modeled with a damper element and kinematic elements for faster processing.

Original CAD Solid Model from SolidWorks.



See Dynamic Stresses During the Event at www.algor.com

CAD Solid Model Assemblies to Mechanical Event Simulations and Faster Stress Analyses with Algor's New Kinematic Elements

Algor's Release 12 introduces 2- and 3-D kinematic elements, which produce massive speed gains in processing for a Mechanical Event Simulation or static stress analysis. Kinematic elements can be used in place of regular (flexible) elements when an area of the model is relatively rigid when compared with regions of stress interest. Kinematic elements can be constrained or loaded with force, traction, pressure or gravity. Because these elements have mass and can transmit forces, they can produce motion and stress in flexible elements. Engineers, therefore, can import CAD solid models or assemblies and specify which parts are to be modeled as kinematic or flexible elements, as appropriate. This means that for the first time engineers can run a virtual experiment on complete CAD solid models or assemblies using Mechanical Event Simulation on desktop computers.

Kinematic elements can interact with impact walls and other parts of an assembly made of kinematic or other element types. Engineers can set up test runs of Mechanical Event Simulations by modeling the entire assembly with kinematic elements and processing for motion only. This means the engineer can study the motion of the event to see if it works prior to adding regular (flexible) elements for the detailed stress analysis.

Kinematic elements can dramatically speed up processing runs for regular linear static stress analysis when significant parts of the model are relatively rigid.

Download and try a **FREE** Limited-time Trial Version of Algor's Release 12 Software Featuring Mechanical Event Simulation at:

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Fax: +1 (412) 967-2781
California: +1 (714) 564-0844
Europe (UK): +44 (1784) 442 246
E-mail: info@algor.com
Web: www.algor.com

For More Information Circle No. 514

Polycrystalline Tb/Dy Alloy for Magnetostrictive Actuators

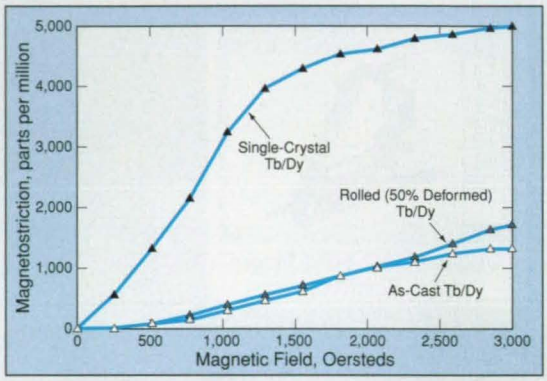
The cheaper polycrystalline version gives about 60 percent of the single-crystal magnetostriction.

NASA's Jet Propulsion Laboratory, Pasadena, California

Research has shown that with suitable processing, one can produce a polycrystalline version of a terbium/dysprosium alloy suitable for use in a magnetostrictive actuator for generating small motions. Prior to this research, only the single-crystal version had been used, and that in only a limited number of applications. One advantage of polycrystalline Tb/Dy is that it costs much less than does the single-crystal version. A second advantage of the polycrystalline material is that the preload springs, which are necessary in most single-crystal applications, can be eliminated in many cases.

Magnetostrictive actuators are attractive for generating motion at cryogenic temperatures, where piezoelectric actuators lose much of their effectiveness. The Tb/Dy alloy exhibits a large magnetostriction at low temperatures, with the ratio of Tb to Dy chosen so that the anisotropy is minimized for the temperature range of operation.

The raw polycrystalline material is produced by casting. To obtain sufficient actuation performance (see figure) that results in saturation magnetostriction, which is 60 percent of the saturation magnetostriction of single-crystal Tb/Dy, it is necessary to orient a substantial fraction of the crystal grains by a suitable mechanical treatment. Experiments have shown that by rolling the cast material and subjecting the rolled material to multiple heat treatments, one can achieve a degree of crystalline orientation that results in 60 percent of the magnetostriction of single-crystal Tb/Dy; even at this reduced level, the low-temperature actuation performance of polycrystalline Tb/Dy is still about 50 times that of a piezoelectric material.



Magnetostriction Was Measured in specimens of Tb/Dy at a temperature of 77 K. Rolled Tb/Dy performed somewhat better than did as-cast Tb/Dy. Experiments have shown that optimized thermomechanical treatment can produce an even bigger increase in magnetostriction, up to a major fraction of the magnetostriction of single-crystal Tb/Dy.

This work was done by Robert Chave, Christian Lindensmith, Jennifer Dooley, Brent Fultz, and Marius Birsan of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Materials category.*

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Refer to NPO-20273, volume and number of this NASA Tech Briefs *issue, and the page number.*

Extruding Tb/Dy for Magnetostrictive Actuators

Extrusion would yield the required crystal orientation and would be suited to mass production.

NASA's Jet Propulsion Laboratory, Pasadena, California

A process that is undergoing development would be used to mass-produce textured polycrystalline rods of a terbium/dysprosium alloy for cryogenic magnetostrictive actuators. The rolling-and-heat-treatment process described in the preceding article yields a high degree of crystal orientation, but is suitable for small batches only. The developmental process is expected to be inexpensive to provide greater uniformity in larger batches in a mass-production setting.

The process exploits an established coextrusion technique in which a tube is filled with a material, then the tube and its contents are redrawn to a smaller diameter. The uniform stretch of the tube and its contents yields a high degree of orientation of crystals along the axis of the tube.

First, the unoriented polycrystalline Tb/Dy is encased in a tube of 316L stainless steel. Then the filled tube is drawn through a die sized to increase the length of the tube by a factor of 4. Finally, the tube is split to remove the polycrystalline Tb/Dy rod. The degree of parallel alignment and long-axis orientation of the crystals in the drawn rod is sufficient for an effective magnetostrictive actuator.

This work was done by Robert Chave, Jennifer Dooley, Brent Fultz, and Marius Birsan of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Materials category.*

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Magnetostrictive Micropositioner for Cryogenic Applications

This nonbackdriveable mechanism generates small increments of motion with long overall travel.

NASA's Jet Propulsion Laboratory, Pasadena, California

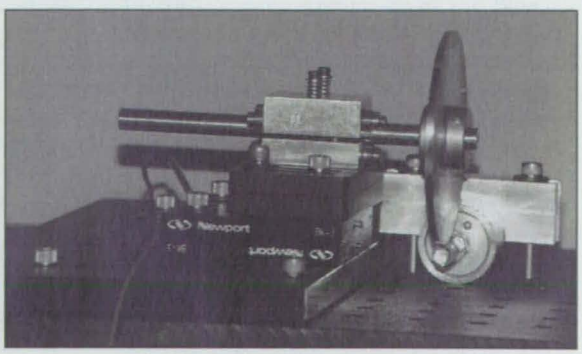
A magnetostrictive linear-translation mechanism has been designed to function as a micropositioning device at any temperature from ambient down to the temperature of liquid helium (about 4 K). Still undergoing development at the time of reporting the information for this article, this magnetostrictive micropositioner is a prototype of micropositioners for a variety of room-temperature and low-temperature applications in which there are requirements for high stiffness, increments of motion < 1 μm, and long travel (through concatenated multiple small increments). Such micropositioners could be used to make fine position adjustments in diverse scientific and industrial instruments; for example, they could be used to drive translation stages in scanning tunneling microscopes or to move optical elements that must be located at long but precise distances from each other (as in telescopes and interferometers).

Magnetostrictive micropositioners that act in "inchworm" fashion were reported in "Magnetostrictive Actuators for Cryogenic Applications" (NPO-19218), *NASA Tech Briefs*, Vol. 20, No. 3 (March 1996), page 84. Magnetostrictive micropositioners that exploit a combination of stick/slip and inertial effects were reported in "Magnetostrictive Inertial-Reaction Linear Motors" (NPO-20153), *NASA Tech Briefs*, Vol. 22, No. 6 (June 1998), page 6b. The present magnetostrictive micropositioner shares some characteristics with the inchworm and inertial-reaction types; like an inchworm actuator, it is nonbackdriveable and self-braking (it retains its position when power is not applied), and like an inertial-reaction actuator, it exploits a combination of stick/slip and inertial effects. However, the present magnetostrictive micropositioner features a distinct design that addresses major issues of lubrication and energy efficiency that arise in a cryogenic environment.

The prime mover in this micropositioner is a linear actuator that comprises (a) a single crystal of the magnetostrictive rare-earth alloy $Tb_{0.74}Dy_{0.26}$ surrounded by (b) high-temperature-superconductor solenoid. The superconductivity of the solenoid minimizes electric power dissipation, thereby contributing to energy efficiency and to reduction of waste heat (which must be removed to maintain a cryogenic environment).

The reason for choosing a magnetostrictive (instead of, say, a piezoelectric) actuator to obtain small increments of motion is that magnetostrictive actuators function throughout the desired temperature range and even work better as temperature decreases, whereas piezoelectric actuators tend to become inoperable in cryogenic environments. $Tb_{0.74}Dy_{0.26}$ was chosen because it exhibits a large magnetostrictive effect in the intended operating-temperature range; for example, application of a magnetic flux density of 1,000 G to a 20-mm-long $Tb_{0.74}Dy_{0.26}$ crystal produces a stroke as large as 0.1 mm. The use of a single crystal of magnetostrictive material contributes further to energy efficiency and reduction of waste heat, in that relative to polycrystalline mass, a single crystal undergoes much less heating when magnetostrictively flexed.

The magnetostrictive crystal is connected to a linear-to-rotary clutch: The solenoid is driven with a sawtooth signal, causing the crystal to repeatedly extend slowly and snap back rapidly. The motion of the crystal drives a pendulum that is lightly spring-loaded against a drive shaft. The slow extension of the crystal causes the shaft to rotate through a small increment of angle in one direction. However, the force of the snap-back acceleration is greater than the force of friction between the pendulum and the drive shaft, so that the shaft does not rotate in the opposite direction. The cycle then repeats, pro-



A Magnetostrictive Inertial-Reaction-Motor Rotary Drive is combined with a threadless rotary-to-linear clutch to obtain axial motion of the shaft, with very small steps, self-braking, and capability of operation in a cryogenic system.

ducing another increment of shaft rotation. Of course, the shaft can be made to rotate in repeated increments in the opposite direction by reversing the polarity of the drive waveform.

By use of a little known but highly reliable rotary-to-linear clutch, the rotary motion of the drive shaft is used to obtain lengthwise motion of the shaft. The rotary-to-linear clutch includes six small bearings that are spring-loaded against the drive shaft in two groups of three bearings each. The axes of the bearings are skewed slightly from the axis of the shaft, so that each incremental rotation of the shaft causes the shaft to advance lengthwise by an amount that depends on the skew angle and the diameter of the shaft (2 μm of advance per degree of rotation in the present design). The rotary-to-linear clutch provides the desired self-braking and nonbackdriveability, and the spring loading affords compliance needed to tolerate changes in temperature.

At the time of reporting the information for this article, there were no lubricants suitable for long-term cryogenic sliding mechanical contacts like those of lead screws in conventional linear actuators. The use of rolling-contact bearings in the present magnetostrictive micropositioner obviates the issue of lubrication of sliding contacts. The rolling contacts are lubricated with molybdenum disulfide, which is a proven low-temperature solid lubricant for ball bearings.

In a test at room temperature, this magnetostrictive micropositioner was found to be capable of producing linear position increments of about 1 μm. With further refinement, it should be possible to achieve increments as small as 0.1 μm. The overall travel is limited only by the length of the drive shaft; a typical overall travel of 10 cm is easily achieved.

This work was done by Robert Chave of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Materials category.*

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Magnetostrictive Filter-Wheel Drive

This drive could be operated at any temperature from ambient down to near absolute zero.

NASA's Jet Propulsion Laboratory, Pasadena, California

The figure shows a prototype of a magnetostrictively actuated mechanism that would rotate an optical filter wheel for a high-performance infrared camera or telescope. Typically, a high-performance infrared instrument and its filter wheel are operated inside a cryogenic system. In conventional practice, the filter wheel is turned by use of a stepping motor in a warmer location. The mechanical connection between the stepping motor and the filter wheel is designed to be as thermally isolating as possible, but it still leaks appreciable heat into the cryogenic system. In contrast, the magnetostrictive drive can be operated with minimal heat leakage because it can be mounted inside the cryogenic system along with the filter wheel and infrared instrument. Moreover, in comparison with a stepping-motor drive, the magnetostrictive drive is simpler, less expensive, and more reliable.

The magnetostrictive drive is an inertial-reaction motor; that is, a motor that exploits a combination of stick/slip and inertial effects. A linear actuator in frictional contact with an armature (in this case, the wheel) is excited by a sawtooth signal, causing one end of the actuator to repeatedly accelerate slowly in one direction, then rapidly in the reverse direction back to the starting point. Because of the frictional contact, the armature moves with the end of the actuator during the initial slow acceleration. However, the force of the reverse acceleration is greater than the frictional force between the actuator and the armature, so that the armature does not snap back along with the actuator. The cycle then repeats, producing another increment of armature motion (in this case, an increment of rotation of the wheel). By reversing the polarity of the sawtooth waveform, one can reverse the direction of motion.

In this case, the linear actuator is a magnetostrictive rod connected to a friction pawl that makes contact with the wheel. When no power is applied to the actuator, friction holds the wheel in position. The magnetostrictive material is a terbium/dysprosium alloy, which exhibits a large magnetostriction at cryogenic temperatures. To minimize the heat load of the cryogenic system, the magnetostrictive rod can be driven by use of a superconducting solenoid. For an operating temperature of about 77 K (liquid-nitrogen temperature), one would have to use a solenoid made of a high-temperature superconductor.

In a test at a temperature of 77 K, the magnetostrictive drive was found to produce rotation with angular increments as small as an arc second and with a slew rate as high as 1.5 r/min. Inasmuch as the magnetostrictive rod generates a longer stroke at lower temperature, it should be possible to achieve a greater slew rate at the typical liquid-helium temperature of 4 K.

This work was done by Robert Chave and Christian Lindensmith of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Materials category.*

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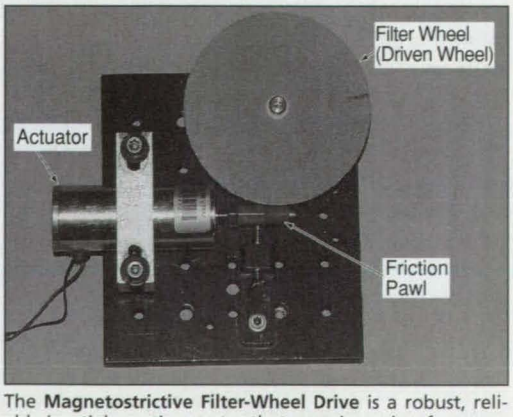

The **Magnetostrictive Filter-Wheel Drive** is a robust, reliable inertial-reaction motor that contains only a few moving parts. When operated in a cryogenic system, it contributes minimally to the heat load.

Push/Pull Magnetostrictive Linear Actuator

"Inchworm" motion would be achieved by a combination of magnetostriction and magnetic clamping.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed "kinematic inchworm"-type linear actuator would move a mass as large as 2 kg along rails, with lengthwise position controllable in increments as small as 50 nm. The actuator could be operated in microgravity or in normal Earth gravitation and at any temperature from ambient down to cryogenic. The actuator could be used, for example, to position an optical assembly precisely on a long interferometer arm, as a translation stage for a scanning tunneling microscope, or as a translation stage for inspecting integrated-circuit chips.

The figure schematically illustrates the proposed actuator as it would be used to move a stage along two parallel outer rails. The stage would include two chassis connected lengthwise by a magnetostrictive device, which would comprise a Tb/Dy-alloy rod surrounded by a drive coil. The kinematic relationship between the outer rails and the stage would be established by free legs and alignment legs on the two chassis. A noncontact inner rail made of a magnetic material would lie between the two outer rails. Each chassis would contain an electromagnet coil above the magnetic rail; this coil could be energized to provide a clamping force and an associated frictional force that would prevent the chassis from sliding along the outer rails.

Referring to the figure, a cycle of operation to move the stage one increment of distance to the right would comprise the following steps:

1. Coil 1 would be energized to clamp the left chassis in place.
2. The drive coil would be energized, causing the magnetostrictive rod to lengthen slightly, thereby pushing the right chassis a short distance to the right. The power would have to be applied to the drive coil gradually enough not to generate sufficient inertial force to overcome the friction holding the left chassis in place.
3. Coil 2 would be energized to clamp the right chassis in place.
4. Coil 1 would be deenergized, leaving the left chassis free to slide along the rails.
5. The drive coil would be deenergized, causing the magnetostrictive rod to shorten slightly, thereby pulling the left chassis to the right. At this point, both chassis would have moved one increment to the right.

The cycle could be repeated as many times as needed to move the stage a required distance to the right. By simply interchanging coils 1 and 2 in the sequence, one could obtain motion from right to left.

The size of the increment could be controlled by varying the current applied to the drive coil. Position feedback could be used for precise control of motion. For operation in a cryogenic system, it would be best if the drive and electromagnet coils were made of superconductive material to minimize waste heat. It would be especially desirable to use superconductive coils with persistent-current switches if electromagnetic clamping were to be used to hold the stage once it reached the desired final position.

This work was done by Robert Chave, Christian Lindensmith, Jennifer Dooley, Brent Fultz, and Marius Birsan of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Materials category.*

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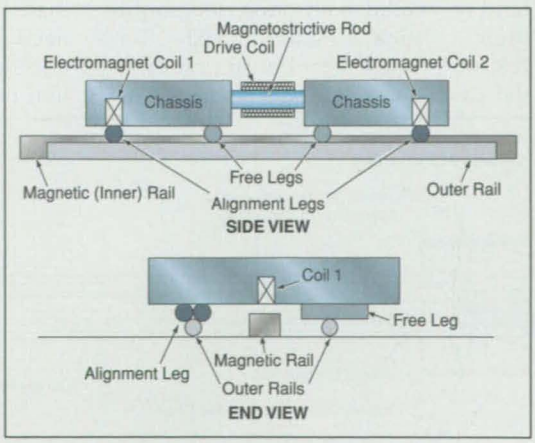


The **Push/Pull Magnetostrictive Linear Actuator** would move in a sequence of magnetic clamping and unclamping of the two chassis coordinated with energizing and deenergizing the drive coil on the magnetostrictive rod.

Improved Magnetostrictive Valve for Use at Low Temperature

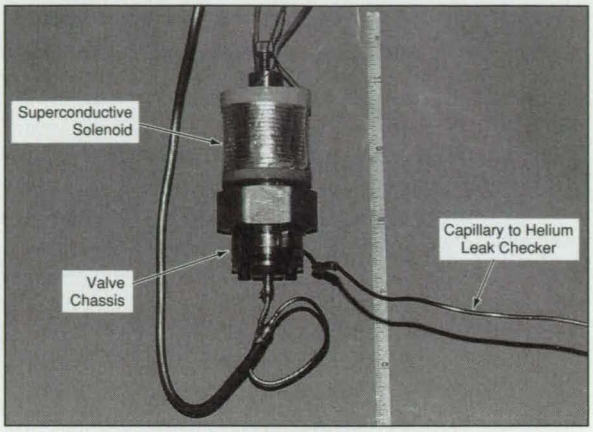
Careful design provides for low heat leakage and low dead volume.

NASA's Jet Propulsion Laboratory, Pasadena, California

An improved magnetostrictive valve for remotely controlling a flow of liquid helium has been developed. Heretofore, flows of liquid helium have been controlled by use of valves with mechanical or gas connections to actuators in warmer locations. The connections act as heat-leak paths. In contrast, the design of the present valve is optimized for operation at liquid-helium temperature (below 4.2 K), so that the entire valve can be maintained at or slightly above liquid-helium temperature to minimize leakage of heat into the liquid helium.

A valve with some similarities to the present one was described in "Magnetostrictive Valve for Use at Low Temperature" (NPO-19480), *NASA Tech Briefs*, Vol. 21, No. 2 (February 1997), page 14b. The poppet in this valve, as in the previous one, is a ball contained in a passage between an inlet and an outlet. In this case, the ball is made of 440C and is of high sphericity [root-mean-square deviation < 5 μin. (0.127 μm)]. The valve seat is made of superclean, fine-grained 316L steel and is initially lapped to optical flatness. In a later stage of fabrication, the ball is used to "coin" the seat.

As in the previous valve, the actuator in this valve is a magnetostrictive device comprising a rod of terbium/dysprosium alloy surrounded by a solenoidal drive coil that generates the magnetic field needed for actuation. The Tb/Dy alloy was chosen because it exhibits a large magnetostriction in the intended cryogenic operational temperature range. The Tb/Dy rod is mounted in such a way as to provide for removal and installation of different drive coils. To minimize generation of heat in the cryogenic environment, a superconductive drive coil can be used. For temperatures up to 77 K, one can use high-temperature superconductor; for liquid-helium temperature, one can use a superconductive Nb/Ti alloy.



This **Laboratory Setup** was used in the first successful operation of a liquid-helium valve with a magnetostrictive actuator driven by a high-temperature-superconductor solenoid.

Stainless filters containing submicron pores are inserted in the inlet and outlet ports of the valve to prevent particulate contamination and thereby prolong the operational life of the valve. The "dead" volume in this valve is only 6 μL on the outlet side. In tests at a temperature of 77 K, the valve withstood 300 actuations, with no sign of helium leakage. The valve was also tested at 4.2 K for several actuations with no sign of helium leakage.

This work was done by Robert Chave, Christian Lindensmith, Jennifer Dooley, Brent Fultz, and Marius Birsan of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Materials category.*

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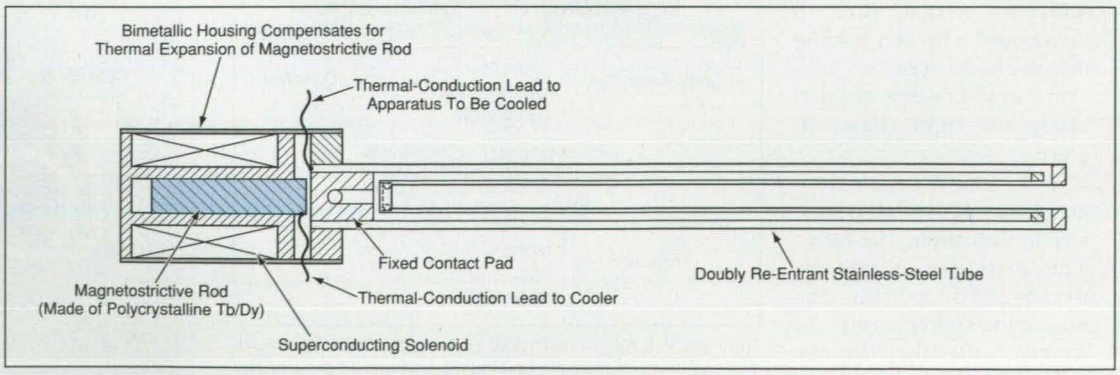
Magnetostrictive Heat Switch for Cryogenic Use

This switch would be superior to both gas-gap and externally mechanically actuated switches.

NASA's Jet Propulsion Laboratory, Pasadena, California

A magnetostrictively actuated heat switch has been proposed for use in a variety of cryogenic equipment, including adiabatic-demagnetization refrigerators, calorimeters, and coolers for high-performance infrared cameras. Heretofore, the heat switches in such equipment have generally been of two types: gas-gap and externally mechanically actuated. The gas-gap switches are limited to long cycle times and tend to exhibit both poor isolation in their "open" states and low "closed"/"open" heat-transfer ratios. In the case of externally mechanically actuated switches, the mechanical connections between the switches and the outside environment are heat-conduction paths, along which heat leaks into



The **Heat Switch Would Be Closed or Opened** by exploiting the magnetostrictive effect to make or break a mechanical contact along the main heat-conduction path.

August 1999

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ELECTRONICS TECH BRIEFS

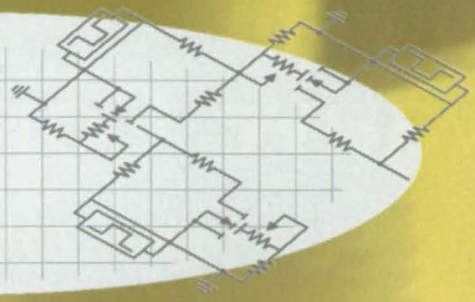

Photo courtesy of Nordson Corp.

Making an Innovative Connection

A customer-friendly terminal block addresses automation physical-layer needs.

The trend to more flexible and feature-packed electronic end products affects virtually every segment of the electronics industry. In particular, this trend is having an impact on the industrial automation and process control industries, where customers worldwide demand, and reward those suppliers that provide, flexibility in control and automation products and the resulting system installation.

While product features and adaptations often result from software engineering, new mechanical packaging and hardware engineering approaches can address the inevitable and often conflicting physical-layer issues that confront the varied users of automation and control products.

In automation systems there are many methods of system interconnect. Whether they are directly attached to a given device, or at a sublevel wiring interface, discrete wires provide the most flexibility for system installation and expansion. The traditional barrier strip has given way to the compact rising-cage clamp or European-type terminal block, especially for PC-board-based products (Figure 1). These PC-board-mount terminal blocks permit many variations of wire-to-board connection to suit specific mechanical packaging and electrical signal and power needs. The densification trend in field-wired products, and the trend toward packing more and more components into smaller and smaller spaces, began in Europe and spread to North America, making these blocks the world standard for compact wire-to-board field-terminable connections.

Pluggables Preferred

To maximize system uptime, newer automation products frequently incorporate pluggable terminal blocks (Figure 2). System installers and customers prefer pluggable terminal blocks because they provide an easier way to install, repair, and expand an installation.

For installation, the pluggable terminal block can be prewired, free of the intended device, easing the installer's effort in often difficult and cramped work environments. The installer can then mount the various automation devices and plug in far fewer individual connections, each containing multiple discrete wires. When a system error requires physical-layer work, checking or replacing an I/O, PLC, motor drive, or other automation device can be a relatively lengthy task. Pluggable terminal blocks can shorten system downtime.

The dilemma facing users of PC-board-mounted terminal blocks, pluggable or fixed, is that they sometimes conflict with the wiring requirements and practices in the customer's local area. In Europe, a discrete wire may be stripped of insulation and directly inserted into the terminal-block wire entry for the circuit. Sometimes wire ferrules are used over the conductor to provide a robust connection prior to installation in the terminal block. As long as the installed wire and wire-fixing mechanism of the installation are protected from a direct touch of the customer's finger—by using recessed wire-entry and screw tunnels—the installation is generally acceptable.

The practice and codes in the U.S. and Japan, however, often require the attachment of spade or ring-lug terminals to the discrete wire before its installation in a device. This wire-lug combination is physically incompatible with the generally accepted rising cage-clamp PC-board terminal block: the wire and its lug just won't fit. In addition, the U.S. installer, often an electrician by trade, is

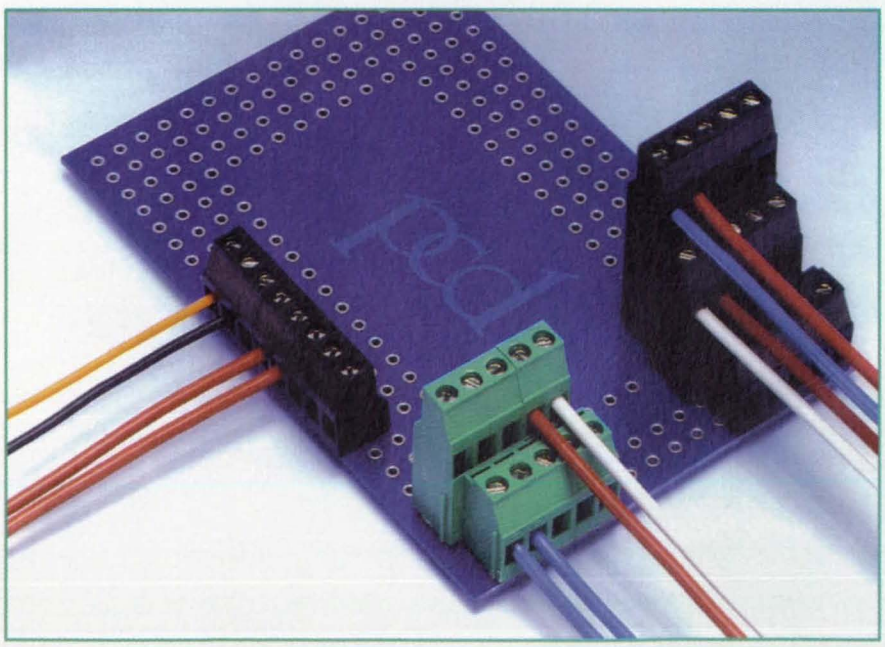

Figure 1. Rising-cage clamp terminal blocks.

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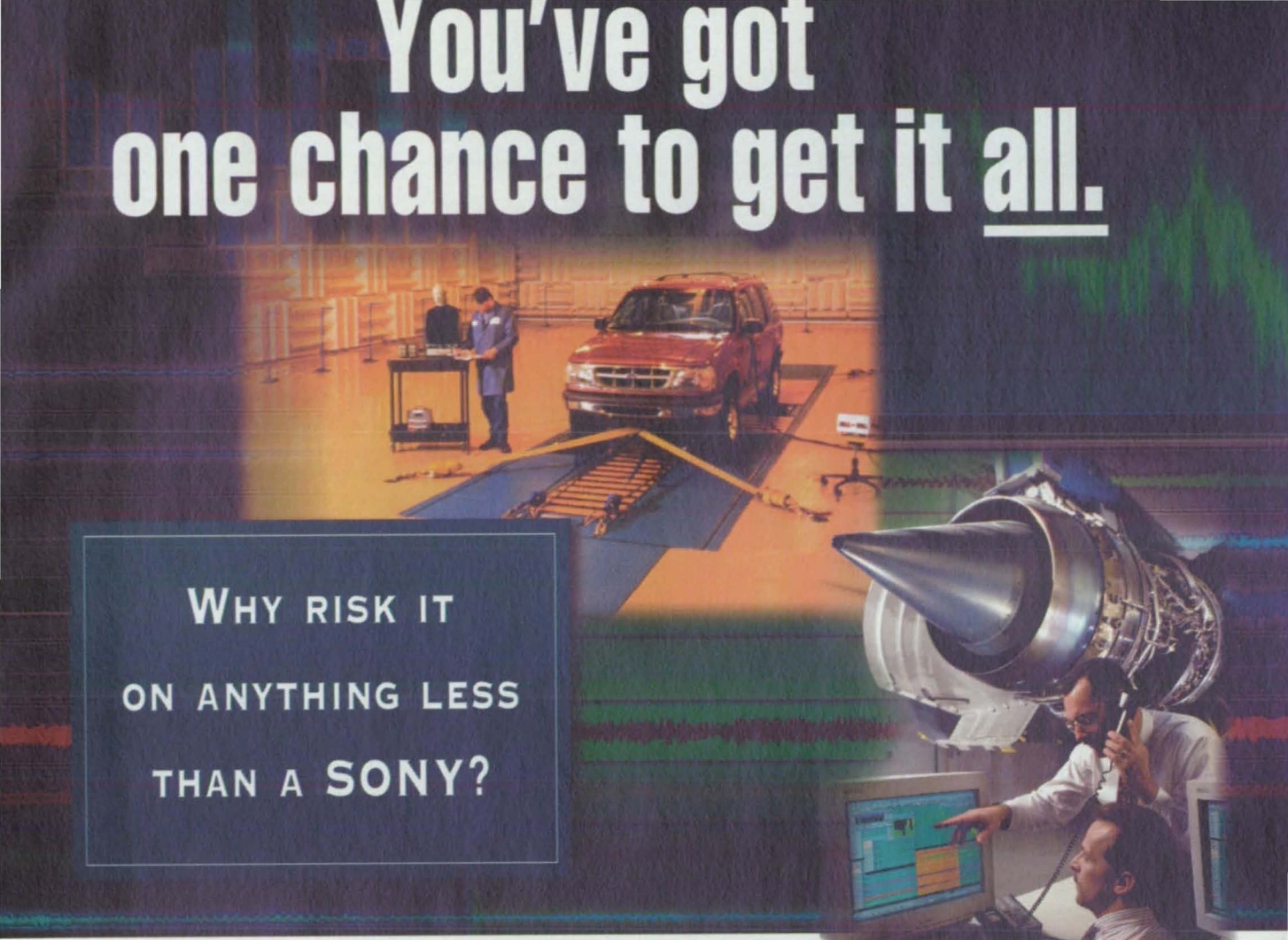

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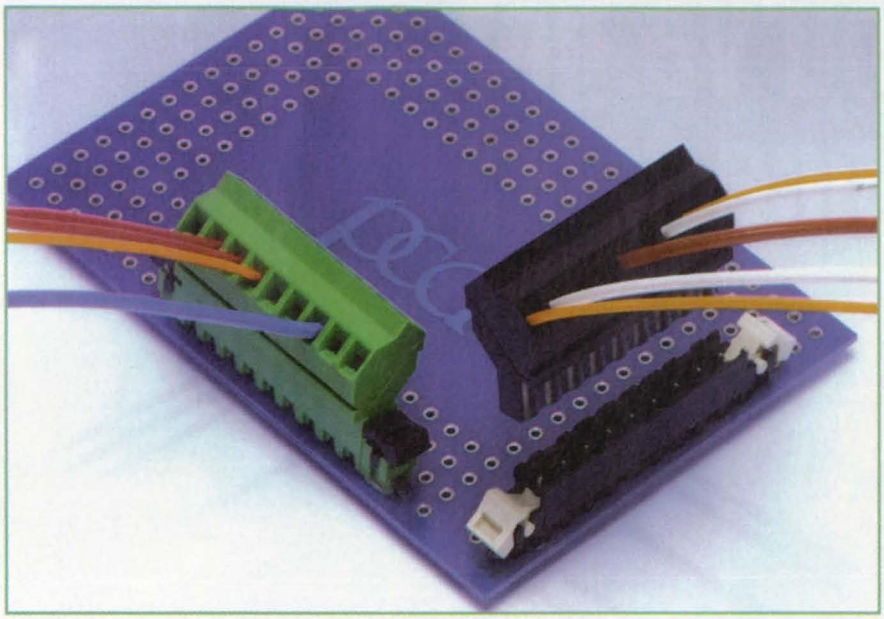

Figure 2. Pluggable terminal blocks.

more comfortable with this larger-sized discrete wire and lug combination found in traditional barrier strips, which present a large wire-fixing screw to the installer. A more standard-sized screwdriver, and so one that is more readily available, is usable as standard procedure or in a pinch with wiring systems using large screws that accommodate the lug-on-wire wiring practice.

Furthermore, the technician in Europe is often an electrician elsewhere, meaning that pocket-size miniature screwdrivers are not the norm in many local customer areas. Thus a terminal block that is acceptable for European use is often not practical in North America. This has led to somewhat unique automation products for major markets, as well as to special sublevel wiring-adaptation arrangements for specific applications. This is often an expensive situation for the electronic automation designer and manufacturer, as well as the installer or customer utilizing the flexibility of discrete-wire systems.

An Innovative Solution

An innovative and patented terminal block from PCD (Figure 3) provides a solution to this problems. This terminal block, called the FlexiPlug™, incorporates both the industry-standard pluggable terminal-block PC-board header geometry and the familiarity of the traditional barrier strip in one package. Because the FlexiPlug incorporates larger SEM-type screws than the rising-cage clamp terminal block, wires can be terminated with lugs prior to installation. The installer/electrician can easily access each circuit with a larger 1/4" flat-blade or #2 Philips screwdriver, and the wire or lug is trapped with an individual pressure plate for a robust connection.

This solution allows automation (or similar field-wired) electronic products to now be designed and produced with the standard 0.200" pitch PC-board header, ones that can simply plug in the terminal block most suited for the installation. While some customers may still prefer the rising-cage clamp terminal-block plug, an increasing number are welcoming the FlexiPlug large-screw tri-barrier plug for their electrician-friendly installations.

At present up to #12 AWG stranded or solid wire can be used with the FlexiPlug terminal block, which is UL-recognized at 15 A/300 V. As few as two or as many as 24 circuits are available in an offset two-tier configuration that offers ease of pluggability. The plug design incorporates latching tabs to engage the PC-board header shroud and provides locking screws for specific installations that require removal with tools, or that are likely to experience high vibration or unusual mechanical wire loads. This innovative terminal-block design offers both the electrician and the technician a choice of how best to connect to a device containing a common PC board.

Now any new discrete-wired product can be produced with a single PC-board layout and then configured either at the shipment stage or by those in the field-systems integrator and distribution-sales channels. For existing discrete-wired products, this plug choice permits a user-friendly product enhancement without incurring tooling costs.

Ease of installation and maintenance are often significant considerations for the automation and process control specifier, installer, and customer. Product designers and manufacturers that address these installation details, from the very visible software interface through to the sometimes overlooked wiring interface, differentiate their products and company by creating a more practical and easy-to-use product.

For more information, contact Doug Ritchie, director of sales and marketing and the author of this article, at PCD Inc., 2 Technology Dr., Peabody, MA 01960; (978) 532-8800. ext. 245; fax: (978) 532-6800; www.pcdinc.com; e-mail: dritchie@pcdinc.com.

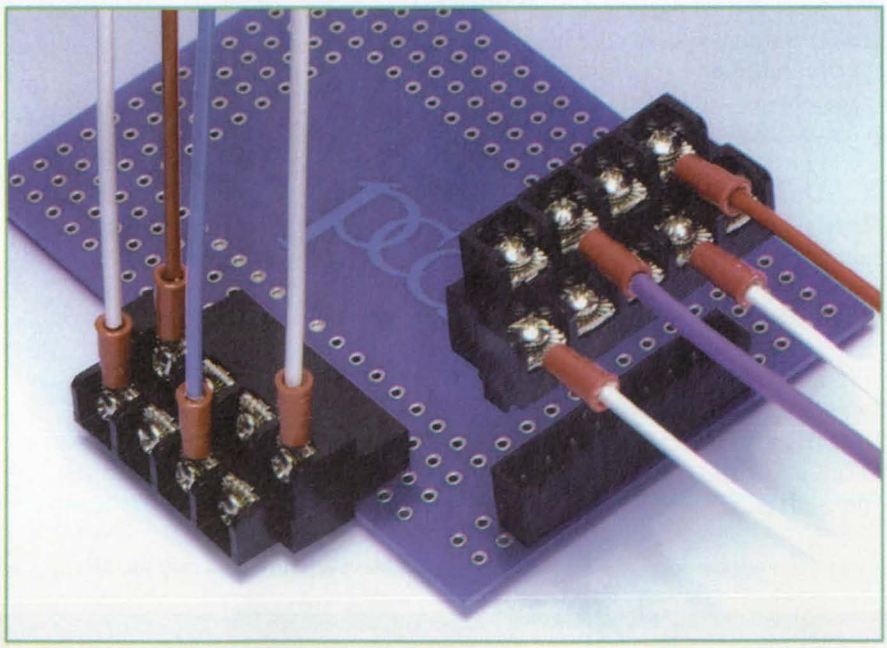

Figure 3. The FlexiPlug incorporates the pluggable terminal-block PC-board header geometry and the traditional barrier strip.

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Measuring Success in Billionths of a Second

A designer confronts a timing problem in the design of a parallel processing module.

In the world of digital signal processing (DSP), timing is everything and success is measured in nanoseconds. This was the experience of Rick Pray, founder of RPA Electronics Design LLC in Binghamton, NY. RPA's consulting business is focused principally on DSP, video, and graphics systems, as well as some embedded control and field-programmable gate array (FPGA) design. Almost every design that the firm is hired to do requires maximum performance from the hardware, but in DSP, practically everything is geared toward speed. Critical timing parameters must be met throughout in order to maximize performance, and this means an absence of wait states.

Last year one of RPA's clients presented the company with a timing problem in the processing modules that plug into motherboards to build bigger, faster parallel processors. The challenge was to put a lot of static random access memory onto the bus of a digital signal processor, within a very limited amount of space, while maintaining zero wait-state access. That meant that the processor could not waste any bus cycles doing reads or writes to memory. It all had to happen in a single clock cycle.

The difficulty lay in the fact that every SRAM has a certain amount of capacitance associated with its I/O pins, and in this customer's case it was 6 to 7 picofarads. Though not much by itself, once 36 or more of these chips are placed on the same bus, one must multiply that capacitance by 36, and the result is in the 200-picofarad range. That is enough to delay high-speed signals by several nanoseconds.

Rick Pray of RPAA Electronics Design found an innovative answer to a timing problem for a module for a fast parallel processor.

The design's dilemma was that the situation created too long a duration in the processor access time to the memory chips. All address lines had to be fully stable before the leading edge of the processor's write enable strobe comes along. But because of the cumulative capacitive loading of all the chips on the design, the stabilization of the address was delayed from when it would normally occur. In essence, the write strobe's leading edge was coming too soon.

What was needed was a part that could delay the leading edge of the write strobe until after the addresses had settled without extending the end of the write strobe. In order to stay at the zero wait state, no time could be added to the entire cycle. The end of the write cycle had to be maintained exactly where the processor had put it before.

In search of a solution, Pray E-mailed his requirements to several pulse generator manufacturers. Most of them said they could give him any pulse width he wanted, but with a delay of no less than 6 or 7 nanoseconds. But the design could not tolerate that: it had to be 3 to 5. But one company, Engineered Components Co. (EC^2) of San Luis Obispo, CA, said it could help.

Pray had first heard of this supplier when he worked for a company that designed real-time graphics systems for flight simulators that required high-speed emitter-coupled logic designs. Every piece of an algorithm was performed in a single clock cycle, in order to produce very fast processing. EC^2 parts were utilized throughout.

Pray called an engineer at EC^2, who agreed to take one of their existing modules and adapt it to RPA's design requirements. After two days of experi-

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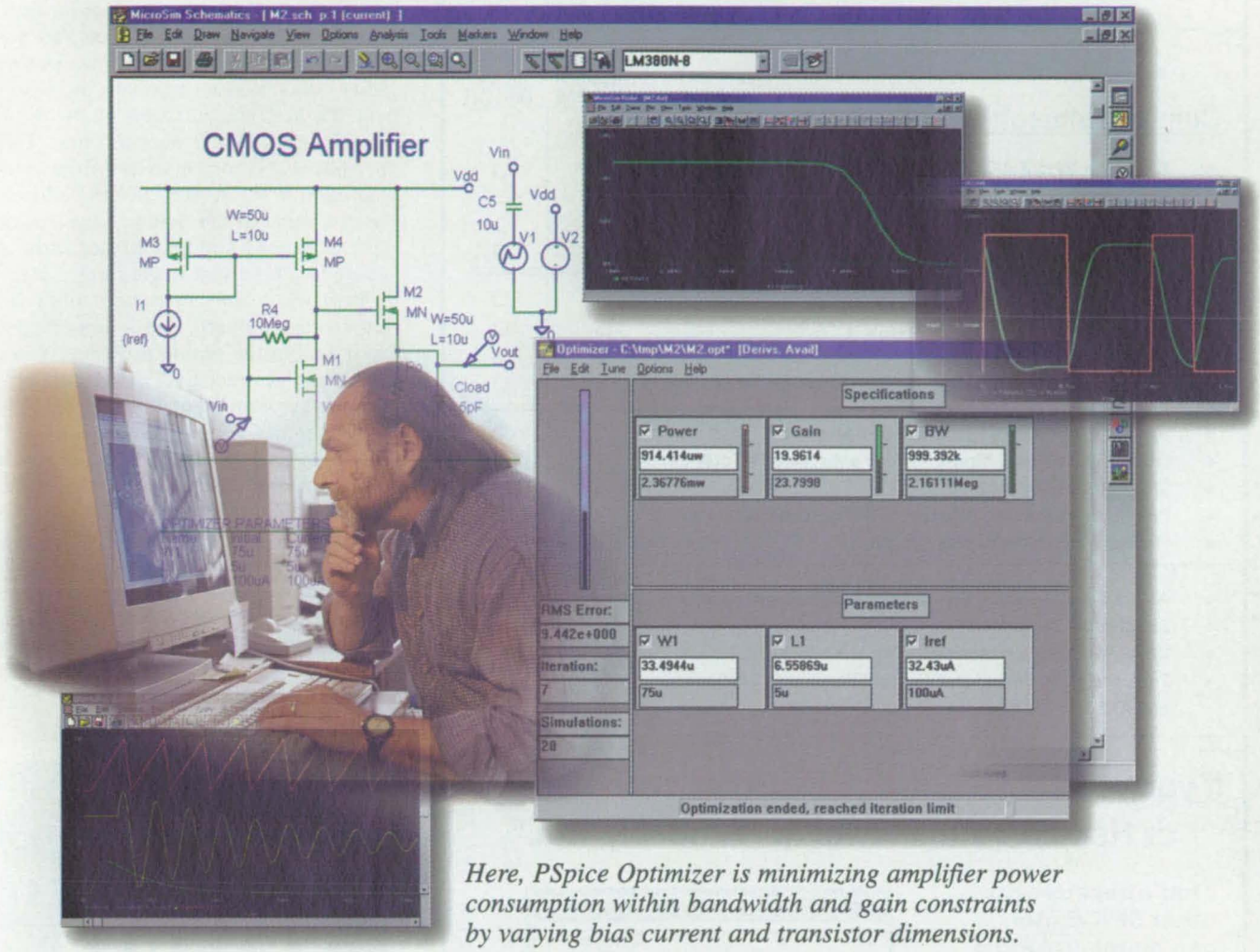

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menting, rewiring, and testing EC² delivered a prototype.

The module that EC² built now allowed RPA to meet the timing specification on delaying the leading edge of the write strobe by 3 to 5 nanoseconds. The pulse width of the device also put the trailing edge of the strobe exactly where the processor normally put it anyway. Overall, the duration of the write strobe was about 9 nanoseconds. This permitted the correct delay of the leading edge of the strobe until the address settled, and put the trailing edge exactly where it was supposed to be, without extending beyond a single clock cycle.

Pray wired the component onto his experimental board, and it immediately solved all of the timing problems. Since then, the product has passed qualification and environmental testing, and the customer has gone to production with the design, which gave the customer a zero-wait-state memory solution that none of their competitors have.

For more information, contact Engineered Components Co. (EC²) at 800-235-4144; www.engineeredcomponents.com or www.ec².com; or RPA Electronics Design LLC at 607-771-0393; rick@rpaeng.com or www.rpaeng.com.

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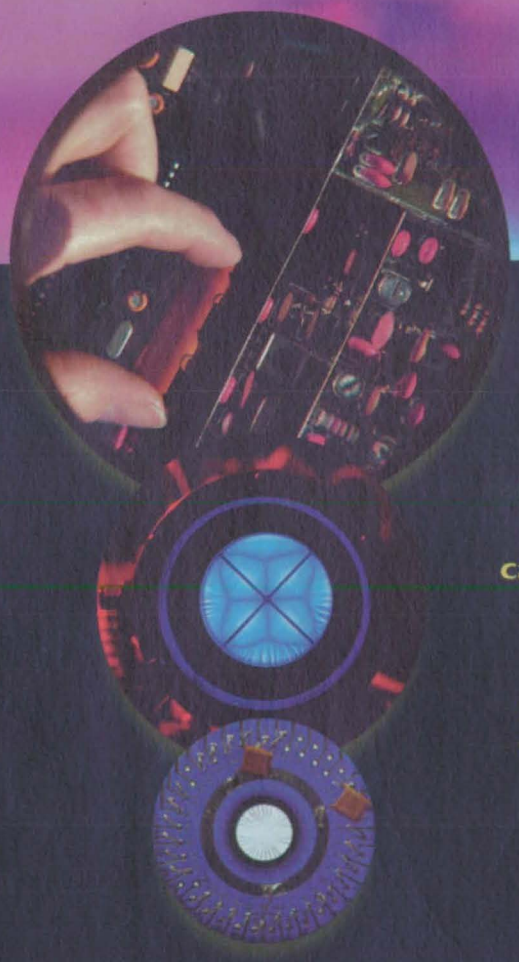

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Managing Wire Harness Design Information

New automated data-centric systems are replacing manual methods of wiring harness design.

Linius Technologies, Westborough, Massachusetts

Wiring is a major deliverable in just about all electromechanical equipment. From airplanes to semiconductor capital equipment, the key component tying together all of the technological innovations in these machines is the wiring. Until recently wiring system design has merely been an afterthought, the last task accomplished after everything else has been completed. But as the level of complexity of these machines increases, so does the complexity of the wiring. Shrinking market windows and increased competition are causing a re-evaluation of all product development processes, and as a result, old manual methods for wire harness design are being replaced by new automated data-centric systems such as Linius Technologies' EMbassy software.

A complex wiring system can contain hundreds to thousands of connections, miles of wire, and thousands of related parts such as splices, terminals, seals, plugs, tie wraps, shielding, and overbraid. Coordinating such large amounts of manually entered data is a daunting task. Incorrectly terminated wires, poorly estimated lengths, or misrouted wire bundles can cause weeks of production delays, or worse, a field failure.

Software packages that automate the design of wiring systems need to provide a mechanism to pull together electrical, mechanical, and manufacturing data and display it in a wiring-centric manner. The maturity of today's mechanical and electrical CAD tools has created an opportunity to combine their data and complement their existing automation capabilities with new tools focused on wire harness design.

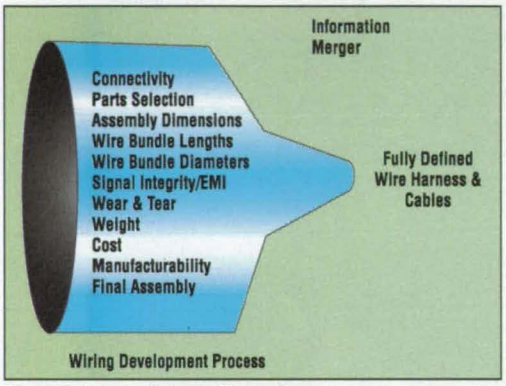


Figure 1. Fully defining a **Wiring System** requires reconciliation of a variety of electrical, mechanical, and manufacturing inputs.

A thorough review of the outputs generated to manufacture a wiring system yields a list of the input requirements. Typical harness and cable documentation includes a parts list, a wire-by-wire connectivity list, wire lengths, and wire bundle descriptions. This output data represents a merger of electrical, mechanical, and manufacturing inputs as shown in Figure 1.

The most basic electrical input is the wire-by-wire connectivity list. It is typically generated from a schematic or wiring diagram, or can be created in a tabular format. This represents only a fraction of the electrical input, however, as there are many other fac-

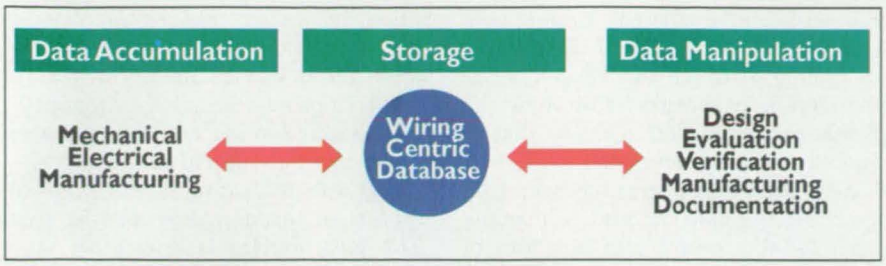


Figure 2. A **Wiring-Centric Database** facilitates the accumulation and manipulation of all the necessary data.

tors to consider. For example, connectors and associated wire terminating hardware must be chosen, current and voltage requirements must be considered as wire size is selected, and signal compatibility and maximum length constraints are evaluated to ensure proper insulation and shielding are added when needed.

The key mechanical input is the assembly geometry, and this must be merged with the electrical input. Since connectors must be properly located within the housing, connector selection will have an impact on the mechanical space. Sufficient space must be allocated in the assembly for the wire bundles, as the diameter of all the wires and cables must also be accounted for. Wire and bundle lengths are created by considering the point-to-point wire connections in conjunction with the available space for the wire paths.

Finally, manufacturing constraints must be considered in order to minimize cost, maximize quality, and create an easy-to-manufacture harness. Component availability and tooling requirements must be considered. The ease with which the wiring can be manufactured and assembled into the housing also affects the final delivery schedule.

Without software to correlate all these dependencies and centralize the harness data, the process is extremely tedious and error-prone. As a result, the only way to check consistency is through manual methods, and any design changes must be made in multiple locations. The entire process can be automated by using the EMbassy database, which was created specifically to store wiring-system data coupled with focused applications to enter and manipulate this data.

A wiring design system must provide both accumulation and storage methods for the multidisciplined data as well as access or manipulation of it through applications targeted at specific tasks in the process (see Figure 2). During the accumulation step, the designer loads all relevant inputs into the database, using specially designed interfaces and applications that facilitate gathering the data that is important to the wiring system design. This includes the 3D mechanical structure, the electrical connectivity, ini-

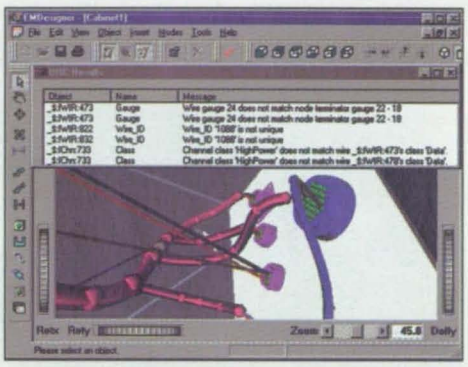


Figure 3. A **Virtual Prototype** of the wiring system is created and verified in the context of the 3D model.

tial parts data, and any design constraints that have been identified thus far.

Once the initial inputs have been gathered, the data can be used to design and specify the entire wiring system. Specific applications can be developed for each task: design, evaluation, verification, manufacturing, and documentation. Wiring designers use the applications to create a virtual prototype of the wiring system by drawing the wire bundles in the context of the 3D structure (Figure 3). This virtual prototype eliminates the need to manually measure a hardware prototype. Since all the data is centrally located, options can easily be evaluated. Design constraints such as maximum wire length or bundle diameter can be defined as the design progresses, and then the design can be verified to ensure that all guidelines have been met.

After the wiring system has been fully specified, the data can also be manipulated for the downstream functions of manufacturing and documentation (Figure 4). A 2D representation of the harness is used for incoming inspection, field service, and the creation of harness manufacturing fixtures. Because all of the data is stored centrally, these output documents will update automatically when the design changes. All views of the completed system will remain in sync when the design changes. The same is true for reports such as bills of materials, wire lists, and weight and cost estimates.

The centralization of all the data associated with the wiring system keeps all aspects of the design process in sync. The environment is associative, so a design change only needs to made in one location and it will propagate to all appropriate areas. Furthermore, it also enables enhanced automation of the development process and additional automated verification capabilities using data from multiple disciplines.

Centralized data storage also promotes design reuse and enhanced automation. An intelligent reusable library can be built that stores relationships between objects. When a component is added, all of the associated components are automatically assigned. For example, when a connector is chosen, a list of appropriate wire-terminating hardware is provided, and wires can be automatically terminated.

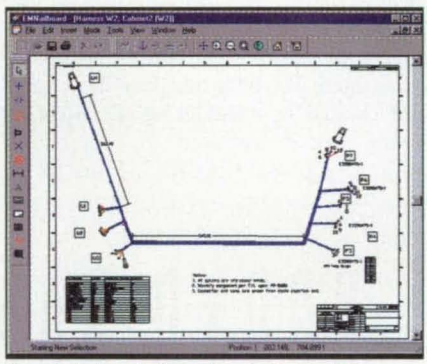
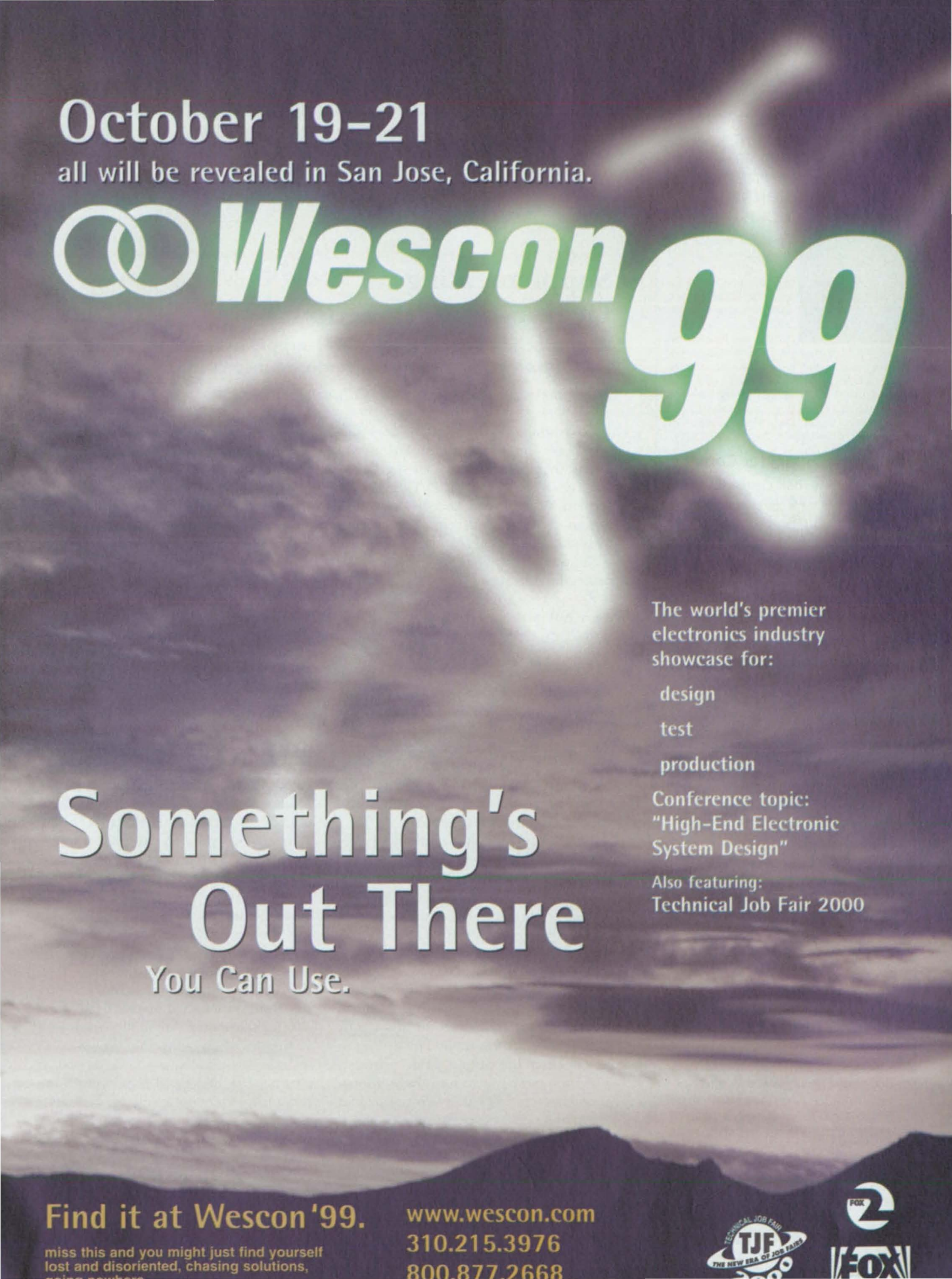


Figure 4. **Associative Manufacturing Documentation** is created automatically.

Calculations requiring input from multiple disciplines are also easily enabled. Resistance or impedance calculations can use material-specification and wire-length data to determine if the initial specifications for the electrical signal the wire is carrying have been met. All the data required to calculate total weight and cost is now centrally located, making the calculation a simple byproduct of the design process.

By automating the wire harness process through EMbassy's centralized data storage and specialized applications, the design cycle is shortened, quality is improved, and engineering and product costs are reduced. More specifically, to summarize, the benefits are these:

- The reliance on a hardware prototype is eliminated by the combination of the mechanical assembly with the electrical connectivity;
- Detailed electromechanical calculations that require the combination of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For more information, contact Amy Bunszel, the author of this brief and manager of technical applications at Linius Technologies, 276 Turnpike Road, Westborough, MA 01581; (508) 616-9360; fax (508) 616-9362; e-mail : abunszel@linius.com; www.linius.com.

Supplementing Overvoltage Protection

etb POWER SOURCES

A new technique prevents power-supply overvoltage resulting from improperly connected remote sense contacts on loads.

Elgar/Sorensen Co., San Diego, California

Low-voltage high-current loads requiring precision voltage regulation are served by power systems that sense voltage remotely at the load. This creates the risk of an overvoltage (OV) condition at the load if the remote sense contacts are incorrectly connected. A new technique to supplement standard OV protection addresses this risk.

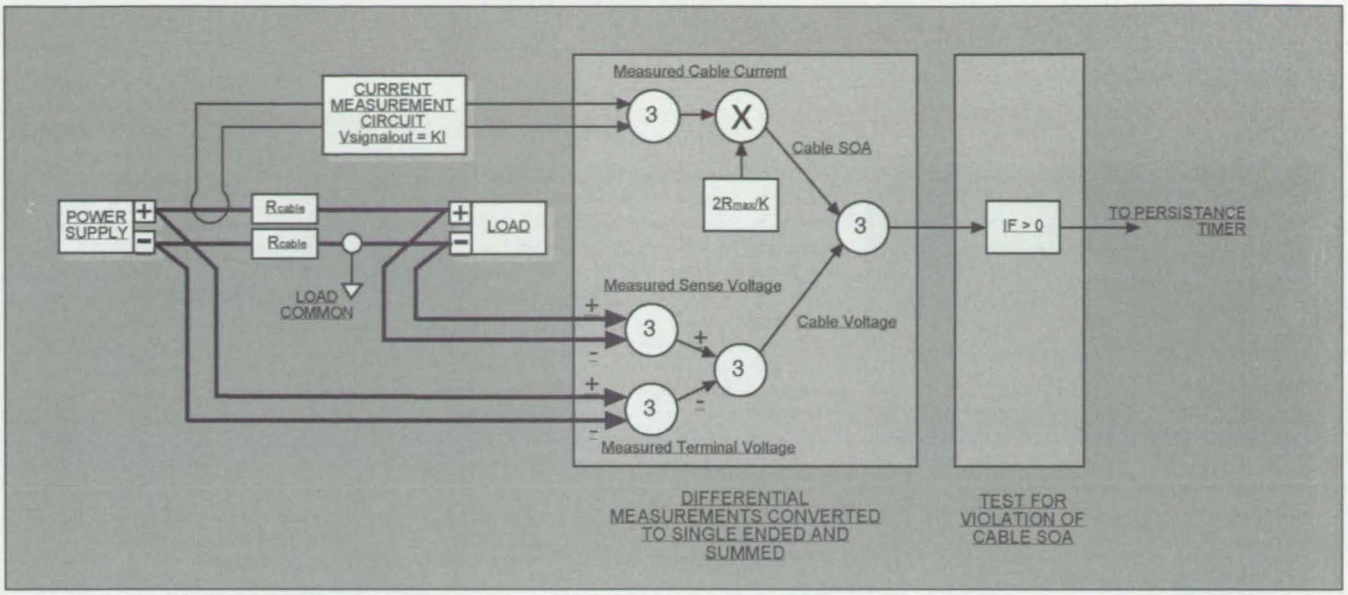
Previous supplemental protection does not protect low-voltage high-current loads. One must program a supplemental OV threshold high enough at the output terminals to accommodate the expected Ohms-law (IR) voltage drop in the cable, which results in a threshold value that exceeds the maximum voltage the load can safely tolerate. Load voltage can rise to damaging levels before protection acts. As one example, a load is not protected if remote sense contacts are shorted together.

A new supplemental method to protect the load acts by monitoring voltage drop in the output cable. A measurement circuit subtracts the remote sense voltage from the power system's output to determine a value for cable voltage drop. The power system is shut down if the measured drop violates a safe-operating area (SOA). The SOA is determined adaptively by measuring output current, and scaling it to represent the allowed IR voltage drop in the cable. For scaling to be effective, the output cable provided with the power system must have impedance characteristics that are defined in the manufacturer's specification.

When shorting the sense contacts together to produce a fault, the supplemental circuit sees a remote sense voltage measurement of zero volts. The circuit's measurement value for cable voltage drop now equals the output terminal voltage. The power supply shuts down when this value exceeds the cable SOA by more than the allowed design margin, which is well within a safe limit for the low-voltage load. When open-circuiting either one or both sense leads, the condition presents itself to the circuit in the same way as shorting the sense leads together. This is because a

large-value resistor shunts these leads at the circuit interface. Protection is identical to the case with shorted sense contacts. Within the specified common-mode voltage range, this protection is effective against conditions of open, shorted, or polarity-reversed remote sense leads. The protection threshold is always below levels that would damage the load, since the maximum allowed cable IR drop is below the load-damaging level by design.

To avoid generating fault signals due to inductive voltage drops on the cable, the supplemental circuit activates an output shutdown only if an SOA fault persists for more than one millisecond. This is simpler than adjusting the SOA to include an inductance characteristic. It also has the benefit of improving noise immunity. One disadvantage is that it creates a dependency on the performance of the output's slew rate. System performance must limit the voltage increase that can occur within the one-millisecond delay. Fortunately, for loads that typify the system's output filter capacitance in parallel with load resistance, the power system slews in current mode as it powers up, and the slew rate



Block diagram of a sense circuit.

decreases as load voltage increases. Slewing near SOA limits is slow enough not to present a problem during the delay time.

Early testing was done on several variations of the supplemental protection circuit to study the effectiveness in two system configurations. The configuration employed short cables with low impedance, terminated using load resistance in parallel with large filter capacitance. The second configuration substituted long cables, in conformance with system design specifications. Resistors were sized to accept full-rated supply current at program voltage. The power supply was programmed to regulate program voltage at the load; then output was enabled. Testing was repeated for all nine anticipated cases of misconnected sense lead termination, and maximum transient voltages seen at the load were recorded. In-regulation testing was performed only on the second configuration by removing either sense lead from the energized load. The second configuration was also tested using higher-value load resistances.

Results showed that the supplemental protection circuit worked within its expected parameters in every case tested. Voltage at the load during any startup test never exceeded 110 percent of the cable SOA maximum limit with improperly terminated sense contacts, and the power system shut down as expected. During the second test, when either sense contact was opened, load voltage overshot only minimally, then decreased to zero. All tests with improperly terminated or opened sense leads resulted in protection of the load from damaging transient voltages, and a prompt shutdown of the power supply output with the appropriate fault flag being indicated.

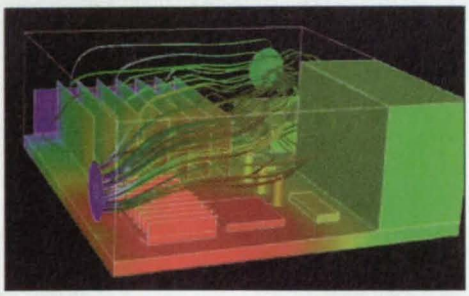
This solution is a good fit for low-voltage high-current load applications. It is also a good candidate to use in place of the earlier protection method for applications where maximum cable impedance can be controlled. Since the new method does not depend on programmed overvoltage thresholds, there is less opportunity for user error to defeat the supplemental protection. Effective OV load protection is delivered against what is perceived as an important fault condition: misconnection of the remote sense leads.

This supplemental overvoltage protection scheme is used on selected Sorensen programmable DC power supplies.

For more information, contact Don Novotny, marketing manager for Elgar/Sorensen Co., 9250 Brown Deer Road, San Diego, CA 92121; (619) 450-0085; (800) 525-2024; fax: (619) 458-0237. The author of this brief is Ray Maroon of Elgar/Sorensen.

NEW PRODUCTS

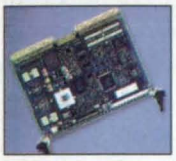
PRODUCT OF THE MONTH



Electronics Cooling Design Software

Fluent Inc., Lebanon, NH, announces the release of its Icepak™ 3.0 computational fluid dynamics (CFD) software for thermal analysis and electronics design. Fluent says that with Icepak 3.0's design, modeling, and simulation capabilities, the engineer can build a computer model of a product or system design, and then virtually prototype it, testing it under real-world conditions so that he can verify designs or make changes. The new version has parametric capabilities, so the user can automate the software to consider several design options quickly. Fluent says Icepak 3.0's object-oriented interface supports easy access to the latest CFD technology.

For More Information Circle No. 750



Single-Board Computer

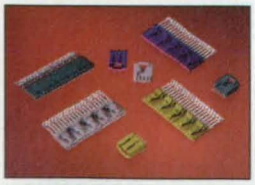
Cetia Inc., Burlington, MA, introduces the PowerEngine6, calling it a new generation of single-board computers. Currently featuring on-board PowerPC 750C, it is available in single- or dual-processor configurations. Cetia says the unit will also fully support Motorola's next-generation PowerPC processor, the G4 with the Altivec vector unit, scheduled for shipment later this year. The PowerEngine6 is available in three configurations: commercial (standard temperature range), extended temperature, and a fully ruggedized version. The extended version supports applications from -20 through +65 °C. The fully ruggedized conduction-cooled version extends temperature ranges from -40 through +85 °C.

For More Information Circle No. 752

Woven Glass PTFE Laminates

Rogers Corp., Rogers, CT, introduces the ULTRALAM™ 1000 series of woven glass reinforced PTFE laminates intended for use with high-frequency and high-performance printed circuit boards. The new series' materials match the dielectric constant and loss tangent characteristics of other woven glass PTFE laminates. They are available in up to 4-ft.-x-10-ft. sheets, and in 12-in.-x-18-in., 24-in.-x-18-in., and 24-in.-x-36-in. sizes. Standard thicknesses include 0.200 in., 0.031 in., and 0.062 in. for dielectric constants of 2.171, 2.50, and 3.0. These configurations are targeted to common antenna and amplifier applications.

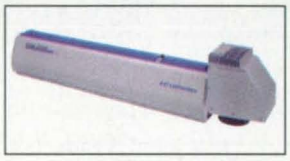
For More Information Circle No. 755



MTE Headers and Receptacles

AMP Inc., Harrisburg, PA, has broadened its mass termination economy (MTE) product line by adding headers and receptacles in color for desktop Pentium® personal computers. Both are available in black, green, natural, blue, and yellow, and come in a vertical four position at 0.100 centerline. The receptacles utilize latches with polarization and can accommodate #26-30AWG. The headers utilize latches with retentive posts and use special PCB orientation. The connectors can serve as designation for auxiliary, CD, and telephony, as well as other applications.

For More Information Circle No. 758



Diode-Pumped Laser Marker

GSI Lumonics, Wilmington, MA, makes available the DM888 diode-pumped laser marker, which it says offers high-throughput product identification and process traceability marking for semiconductor manufacturing. Because the DM888's 20-W Nd:YAG laser is fully Q-switched, the company says, it can mark the most challenging materials, including plastics and ceramics. Its precision-calibrated field measures 108 mm square. The high-capacity internal water cooling eliminates the need for external cooling or chilled water systems.

For More Information Circle No. 753

High-Voltage Flyback Transformer

Datatronics Inc., Romoland, CA, says that its Model 4253 series high-voltage transformers provide a cost-effective means of driving high-impedance loads requiring up to 7500 V rms. The company says the high-voltage signal is virtually corona-free, an achievement it attributes to state-of-the-art encapsulation techniques and other leading-edge manufacturing processes. The Model 4253 provides primary-to-secondary isolation of up to 18 kV DC. The company suggests applications for defibrillators, medical and industrial lasers, ion generators, cathode-ray tube transformers, traveling-wave tube transformers, and more.

For More Information Circle No. 756

Quad DSP Board

Blue Wave Systems, Carrollton, TX, designed its new VME/C6420 digital signal processing (DSP) board for defense applications such as radar, sonar, FLIR, and other processor-intensive areas such as digital radio research, next-generation mobile telephony base stations, and test equipment. The board is available with a choice of four integrated C6201 fixed-point or four C6701 floating-point DSPs. A high-speed multiport crossbar enables up to four 200-Mbyte/s simultaneous on-board point-to-point links to be set up dynamically, connecting the DSPs, MPC860 "PowerQUICC" control processor, PMC I/O, VME interface, and expansion ports.

For More Information Circle No. 759

Low-Cost CMOS Op Amps

Burr-Brown Corp., Tucson, AZ, offers a new OPA353 series of low-cost CMOS operational amplifiers that it says has high-speed operation, rail-to-rail input and output, excellent AC characteristics, and low noise. The series comes in single, dual, and quad versions, all in micropackages. Burr-Brown recommends the OPA353 op amps for driving sampling A-to-D converters, cellphone power amplifier control loops, and video processing. The series is unity-gain stable and operates on a single supply as low as 2.5 V. Bandwidth is 44 MHz, slew rate is 22V/µs, and noise is 5 nV/sq.rt.-Hz.

For More Information Circle No. 751

Undershoot Hardened Bus Switches

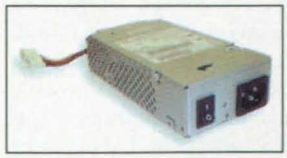
Fairchild Semiconductor, South Portland, ME, has added an undershoot hardened bus switch family to its product line. The FSTU switches are designed with integrated circuitry that senses undershoot levels in excess of -2 V on any I/O data port and provides a bias-voltage override to maintain the switch in the isolation state. Their purpose is to isolate peripheral and network interface cards from their PCI or CompactPCI bus during live insertion. Currently there are three such switches: the FSTU6800, a 10-bit switch that offers precharged outputs; the FSTU6800A with high-speed enable; and the 10-bit FSTU3384.

For More Information Circle No. 754

Logarithmic Amplifier

The Model 384 logarithmic amplifier from Analog Modules, Longwood, FL, provides high-speed signal compression of input signals from microvolts to volts with what the company calls exceptional linearity. The Model 384 has a 12-ns pulse response rise time and a 90-dB dynamic range, offering high-bandwidth logarithmic compression for both positive and negative input signals from DC to 30 MHz. The company says the surface-mount construction (2.65 in. L x 1.60 in.W x 0.55 in. H), ±12-V input power, and PCB-mount connectors make the Model 384 suited to such applications as nondestructive testing equipment that requires high dynamic range, fast response, and a compact form factor.

For More Information Circle No. 757



Low-Profile Enclosed Switcher

Astec America Inc., Carlsbad, CA, makes available a low-power switcher, Model LCT43-E, designed to address the needs of networking product manufacturers. Its low-profile design enables it to fit in 1U rack configurations. It accepts universal AC input (85 to 264 V AC and 120 to 370 V DC) and has triple DC outputs of 5, +12 V, and -12 V. The unit supplies 47 W of output power with 12 CFM forced air. The switcher's footprint is 3.2 in. x 6.2 in. x 1.5 in. high. Designed for quick assembly, it includes an on/off switch, an IEC-320 inlet, and a Molex output connector on 5-in. flying leads.

For More Information Circle No. 760

the affected cryogenic chambers. In contrast, the proposed magnetostrictively actuated switch would feature short cycle times, low heat leakage, high isolation in the "open" state, and a high "closed"/"open" ratio.

As shown in the figure, the main thermal contact in the switch would be made or broken by making or breaking, respectively, the mechanical contact between (1) the moving end of a rod of magnetostrictive material and (2) a fixed contact pad. The magnetostrictive material would be a terbium/dysprosium alloy, which exhibits a large magnetostrictive effect at low temperature. The use of a polycrystalline form of this alloy would eliminate the need for a return spring that must be used with the single-crystal form of the alloy, enabling a reduction in the weight and complexity of the switch. The magnetic field needed for actuation would be generated by use of a superconducting solenoid made of Nb/Ti alloy.

In operation, the superconducting solenoid would generate no waste heat. The entire switch, including the magnetostrictive actuator and superconducting solenoid, would be mounted at the cold stage used for temperature control. By using superconducting leads to the cold stage, the heat leak to the cold stage would be minimized. The switch would be mounted on a stainless-steel tube with a doubly re-entrant design that provides good thermal isolation in a small space; the estimated open-state thermal conductance of the assembly is 15 μW/K.

This work was done by Robert Chave, Christian Lindensmith, Brent Fultz, and Marius Birsan of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Materials category.*

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For More Information Circle No. 414

Experiment on Reducing Drag on an Aerospace Launch Vehicle

Roughening of the forebody reduces base drag but not overall drag.

Dryden Flight Research Center, Edwards, California

Current proposed shapes for single-stage-to-orbit vehicles like the Lockheed-Martin X-33 and VentureStar reusable launch vehicle have extremely large base areas when compared with previous hypersonic-vehicle designs. As a result, base drag — especially in the transonic flight regime — is expected be very large. The unique configuration of the X-33, with its very large base area and relatively low forebody drag, offers the potential for a very high payoff in overall performance if the base drag can be reduced significantly. This article presents results of a base-drag-reduction experiment that was performed in the X-33 Linear Aerospike SR-71 (LASRE) flight program.

The experiment was a flight test of a roughly 20-percent half-span model of an X-33 forebody with a single aerospike rocket engine at the rear. As shown in Figure 1, the test model was mounted on top of an SR-71 airplane. It was intended that the LASRE flight-test data would be used to define the aerospike-engine performance under realistic flight conditions and to determine interactions of the engine plume with the base and engine cowl areas.

In order to measure performance of the linear aerospike engine under a variety of flight conditions, the model was mounted on the SR-71 with a pylon that was instrumented with 8 load cells oriented to measure total forces and moments in six degrees of freedom. The model was also instrumented with surface pressure ports on the forebody, boat tail, base, engine ramps, and lower engine fence. By numerically integrating the surface pressure distributions obtained from measurements at these surface pressure ports, it was possible to calculate the model profile drag.

Figure 1. For the **LASRE Experiment**, a half-span model of an X-33 forebody with a single aerospike rocket engine at the rear was mounted on top of an SR-71 airplane.

Baseline drag measurements on the LASRE configuration demonstrated a large transonic-drag rise that is significantly larger than the wind-tunnel value predicted for the X-33. It is likely that the observed transonic-drag difference is an effect of the sting mount used to support the X-33 wind-tunnel model. With increasing mach number in the subsonic flight regime, base drag (referenced to the LASRE base area) was found to be relatively constant at a base-drag coefficient of approximately 0.38 until the divergence-drag-rise mach number of approximately 0.90 is reached.

It was found that after the divergence mach number is reached, compressibility effects dominate and the base-drag coefficient rises rapidly. Above mach 1, the base-drag coefficient decreases steadily with increasing mach number. In the subsonic flight regime, base drag constitutes approximately 125 percent of the overall model drag. (In the subsonic flight regime, there was considerable suction present on the model forebody. The forebody suction induced a negative forebody pressure drag coefficient of approximately –0.075. The forebody suction results in a drag coefficient for the entire body of approximately 0.30. Thus, in the subsonic flight regime, the base drag was nearly 25 percent larger than the total drag of the vehicle.) Approximately 80 percent of the transonic-drag rise can be attributed to effects of compressibility on base drag. Baseline LASRE drag data clearly support the assertion that base drag dominates the overall drag. If one is to reduce the overall drag of the vehicle, then the base area is clearly the place to start.

In the case of blunt-based objects that feature heavily separated base areas, a clear relationship between base drag and "viscous" forebody drag has been demonstrated. Generally, as the forebody drag on such an object is increased, base drag tends to decrease. This reduction of base drag is a result of boundary-layer effects at the base. The shear layer generated by rubbing of the free-stream flow against the dead, separated air in the base region acts as a jet pump and serves to reduce the pressure coefficient in the base areas. The surface boundary layer acts as an "insulator" between the external flow and the dead air at the base. As the forebody

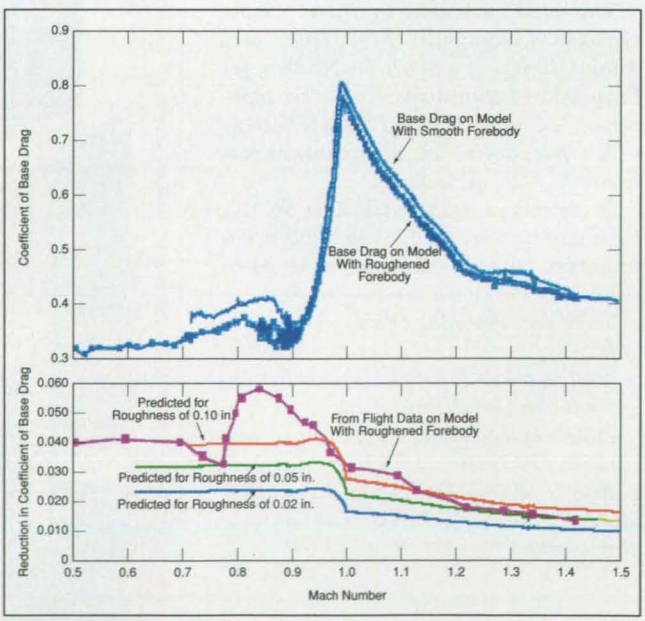


Figure 2. **Base Drag Was Reduced** by roughening the forebody with grit. The measured reduction exceeded the reduction predicted for three different roughnesses of the order of magnitude of the actual roughness. All of the coefficient values plotted here are referenced to the LASRE base area.

drag is increased, the thickness of boundary layer at the aft end of the forebody increases, with a consequent reduction in the effectiveness of the pumping and a reduction in the base drag. For subsonic flight conditions, it has been demonstrated that for objects with base drag coefficients greater than 0.30, the forebody/base drag relationship is extremely sensitive. For these flow conditions, a small increment in the forebody friction drag will result in a relatively large decrease in the base drag of the object. Since the subsonic LASRE base drag coefficient is 0.38, it is expected that the LASRE base drag/forebody drag relationship should exhibit a similar high sensitivity. Conceptually, if the increment in forebody skin drag is optimized with respect to the reduction in base drag, then it may be possible to reduce the overall drag of the configuration.

In the LASRE drag-reduction experiment, researchers sought to increase the forebody skin friction and modify the boundary layer at the back end of the LASRE model. One of the most convenient methods of increasing the forebody skin drag is to add roughness to the surface. Such other methods as the use of vortex generators to energize the boundary layer would probably work more effectively, but the intrusion of vortex generators into the airflow precludes the use of them on hypersonic reentry vehicles. The benefits of using surface roughness are nonintrusiveness (minimal heating), small weight penalty, mechanical simplicity, and low cost.

For the LASRE drag-reduction experiment, # 24 silicon carbide [0.035 in. (0.9 mm)] grit was glued to the skin by use of spray-on adhesive, and the surface was sealed by use of a high-tensile-strength, heat-resistant, white enamel paint. The resulting surface had an equivalent sand-grain roughness that varied between approximately 0.02 in. (0.5 mm) and 0.05 in. (1.3 mm). In an attempt to avoid inducing additional flow separation at the boat tail or along the forebody, only the flat sides of the LASRE model were gritted. The gritted area covered approximately one-third of the forebody wetted area.

Results of the experiment verified that surface roughness can be effective in reducing base drag. Figure 2 shows the measured reduction in base drag, in comparison with the reductions in base drag predicted for surface roughnesses of 0.02 in. (0.5 mm), 0.05 in. (1.3 mm), and 0.10 in. (2.5 mm). The predicted reductions in base drag ranged from 8 to 14 percent. The base-drag reduction calculated from flight data peaked at 15 percent. The base-drag reduction also persisted well out into the supersonic flight regime. Since base drags of supersonic projectiles had never before been correlated with viscous forebody drags, the sizable reduction in supersonic base drag in this experiment was a significant positive result.

Unfortunately, flight-test results for the rough-surface configuration did not demonstrate an overall net reduction of drag. The surface grit caused a rise in forebody pressures. Coupled with increased forebody skin drag, the forebody pressure rise offset benefits gained by reducing base drag. Clearly the techniques used to apply the surface grit must be refined. In addition, the existence of an optimal coefficient of viscous forebody drag must still be proven.

This work was done by Stephen A. Whitmore and Timothy R. Moes of **Dryden Flight Research Center.** *For further information, access the Technical Support Package (TSP) free on-line at* ***www.nasatech.com*** *under the Mechanics category.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Dryden Flight Research Center; (805) 258-3720. Refer to DRC-99-01.

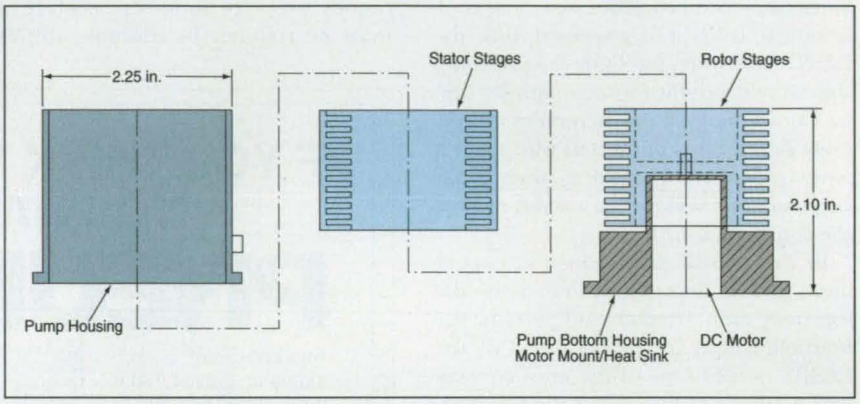
Miniature Turbomolecular Pump for High Vacuum

Pumping speed would be greater than that of a similarly sized ion pump.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed miniature turbomolecular pump would be a prototype of high-vacuum sources for a forthcoming generation of miniature, portable mass spectrometers and other scientific instruments. The miniature turbomolecular pump would be an attractive alternative to currently available high-vacuum sources (including most commercial off-the-shelf turbomolecular pumps), which are too bulky and power-hungry to be practical for use in portable instruments.

The smallest currently available high-vacuum pumps are miniature ion pumps that operate at pumping speeds of <1 liter/second. Prior to the conception of the miniature turbomolecular pump, there were plans to use two miniature ion pumps to provide high vacuum to a developmental portable miniature quadrupole mass spectrometer. The miniature turbomolecular pump would be installed in place of the two ion pumps; its overall size would be similar to that of the combination of two ion pumps but with higher pumping speed.



This **Miniature Turbomolecular Pump** would operate at a pumping rate of 3 liters/second. The rotor and stator blades would be fabricated by electrical-discharge machining.

Like other turbomolecular pumps, the miniature turbomolecular pump would contain rows of rotor blades stacked in alternation with rows of stator blades, the spaces between the blades constituting passageways through which gas molecules would be pumped. The stator blades would be mirror images of the rotor blades. The rotor would be connected by a shaft to an off-the-shelf dc brushless motor, which would drive the rotor at a blade-tip speed as close as possible to the thermal speeds of the gas molecules to be pumped.

The pump design must be synthesized in an iterative procedure that involves consideration of blade angles, number of blades per row, hub diameter, and of gaps among rotor blades, stator blades, the hub, and the inner wall of the pump housing. The maximum pumping speed and compression ratio at smaller number of stages (pump size), predicted for a given combination of design parameters are evaluated with respect to the gas load or throughput. The resulting optimum parameters are then implemented towards the construction of the pump.

As in other vacuum systems, the miniature turbomolecular pump would be connected in series with a fore pump that would exhaust to the atmosphere. This will not be necessary for the case of EVA (extra-vehicular-activity) applications and hence a much smaller pump would result. The lowest pressure achievable inside a vacuum chamber depends on the compression ratios of the turbomolecular pump and fore pump.

The figure is a simplified representation of major components of the miniature turbomolecular pump according to the design under consideration at the time of reporting the information for this article. This design is optimized for operation in conjunction with a miniature diaphragm fore pump that provides an inlet pressure of about 1.5 torr (0.2 kPa). The rotor would spin at a speed of 157 krpm. The total compression ratio for air would be 10^5, and the pumping speed would be 6 liters/second. The peak power consumption is estimated at 8 W, decreasing to approximately 0.1 to 0.2 W at maximum

rotor speed. Its weight excluding the backing pump is estimated to be about 11 oz (312 g).

This work was done by Vachik Garkanian of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free online at www.nasatech.com*** *under the Machinery/Automation category. NPO-20530*

Small Hybrid Rocket Engines Fabricated via X-Ray Lithography

X-ray lithography would extend the lower limit on practical sizes.

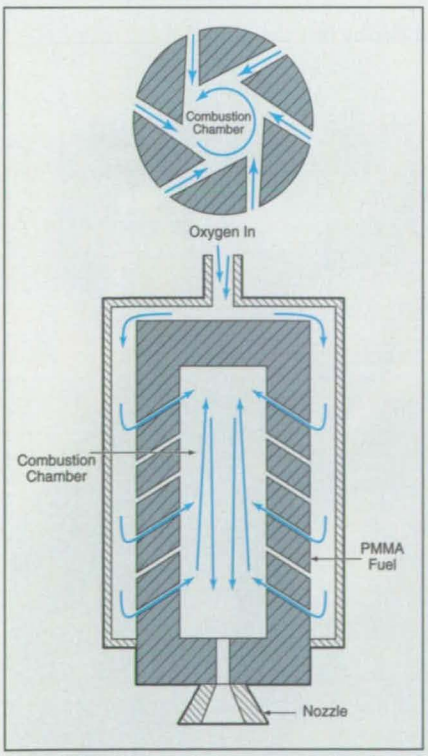
NASA's Jet Propulsion Laboratory, Pasadena, California

Small hybrid rocket engines of a proposed type would burn specially shaped hollow cylinders of solid fuel containing slanted oxygen-injection channels, as shown in the figure. These engines would exploit a vortex flow phenomenon associated with the radial inflow of the oxygen in the channels. The fuel/flow-channeler cylinders could be supplied in or as cartridges that could fit into reusable receptacles.

The basic vortex-combustion engine concept, using poly(methyl methacrylate) (PMMA) as the solid fuel, has been investigated previously. The novel aspect of the present proposal pertains to the size range and the means of fabrication. The proposed engines would be too small for conventional machining, making it necessary to fabricate the engines (including the fuel/flow-channeler cylinders) by use of x-ray lithography.

Small engines of the proposed type could be used in their own right as thrusters for small spacecraft or as experimental small-scale prototypes of larger thrusters. After further research to gain better understanding of the vortex flow in question, it might become feasible to apply the vortex-combustion engine concept to develop improved combustion chambers in fossil-fuel power stations, boilers, retorts, gas-fired home furnaces, and turbojet engines.

This work was done by Victor White of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free online at www.nasatech.com*** *under the Machinery/Automation category. NPO-20594*



In a **PMMA Vortex Engine**, oxygen is injected through holes in the PMMA fuel cylinder

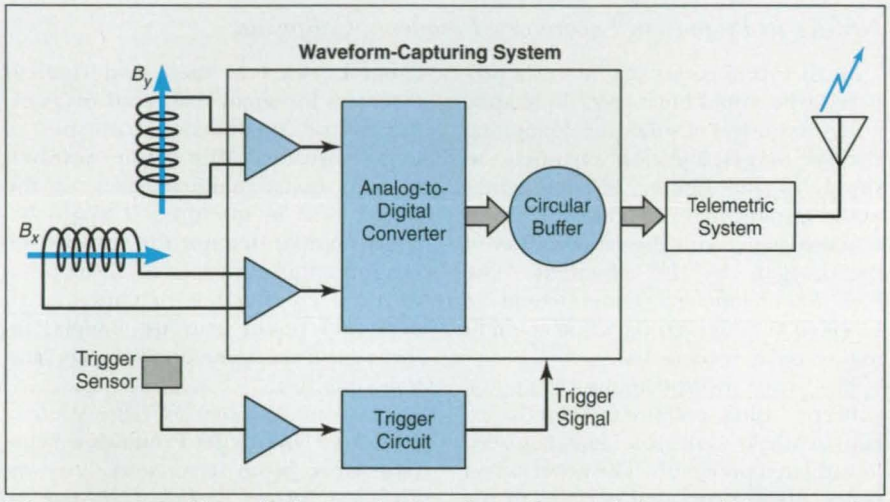
Exploiting Crossed Magnetic Antennas in a Natural Waveguide

An electrical discharge could be located through observation from a single site.

Goddard Space Flight Center, Greenbelt, Maryland

A technique that involves the use of crossed magnetic antennas in a natural waveguide has been proposed for tracking Martian dust storms from a single observing station; that is, without having to triangulate from multiple observing stations. The technique is applicable to tracking thunderstorms on Earth.

An electromagnetic wave propagating in a waveguide exhibits dispersion; that is, the components of the wave at different frequencies propagate at different speeds and arrive at a receiving site at different times. Because the degree of dispersion is cumulative with distance, a measurement of dispersion can be used to estimate the distance a wave has traveled.



This **Instrument Would Sample the B_x and B_y Waveforms.** The sample data would be processed to determine the range and azimuth of an electrical discharge.

A highly electrically conductive ionosphere and the ground below it constitute a natural waveguide. Within this waveguide, powerful low-frequency electromagnetic signals, like those generated by intense electrical discharges (e.g., lightning strokes) can travel great distances. Provided that a sufficiently sensitive radio spectrometer is used to measure the dispersion of a wave, the distance from a receiver to a lightning stroke or other source of the wave can be estimated fairly precisely from the measured dispersion, even if the distance is thousands of kilometers. Furthermore, by using two crossed magnetic antennas (search coils) to measure mutually perpendicular horizontal components of the magnetic field of the wave, one obtains the information needed to calculate the azimuth of the source. Thus, the location of source, projected onto the ground surface, can be fully determined.

Electrical discharges are expected to occur on Mars. These discharges are expected to arise from dust storms, instead of from thunderstorms as on Earth and elsewhere in the Solar system. Electrically charged dust storms may act to transfer electrical currents across long filamentary paths and may thereby radiate at frequencies <10 kHz. By exploiting the propagation of such waves within the natural waveguide between the Martian ionosphere and ground surface, one would determine the locations of the discharges according to the principle described above and would thus be able to track the dust storms from one site on the surface. The range of detectability for the instrument is determined, in part, by the ground conductivity (i.e., conductivity of lower boundary of the waveguide) with reduced attenuation associated with higher conductivities. Thus, an estimate of Martian subsurface conductivity can also be derived by the variation of discharge signal strength with distance.

An incoming electromagnetic wave would have magnetic vector components B_x and B_y where x and y denote mutually perpendicular coordinate axes aligned approximately with corresponding mutually perpendicular axes of sensitivity of two search coils. Measurements of the waveforms and analyses of the spectra of both B_x and B_y would be needed to determine the degree of dispersion and the azimuth. The results of the dispersion and azimuth calculations would be used, in turn, to estimate the distance and direction to the source of the wave. Waveform analysis would require sampling of B_x and B_y at a rate of approximately 20 kS/s.

The figure is a system-level block diagram of an instrument that would perform the necessary measurements and would not impose excessive demands on telemetric resources. The instrument would include two search coils mounted with their axes of sensitivity orthogonal to each other in a horizontal plane. The outputs of the coils would be fed to a waveform-capturing system (WCS).

WCS would accumulate data continually in a circular buffer which would pass the data to a telemetry buffer on command. The command would be issued in response to a trigger signal generated by an external sensor whenever the sensor detected a discharge event. (The external sensor could be a photometer, vertical electric-field sensor, or other device that is particularly sensitive to broadband signals from lightninglike discharges.) Thus, the only data returned by the instrument would be those obtained around the time of a discharge, and the telemetric data rate averaged over long observing time would thereby be kept low. Each set of data thus returned would be used to compute the distance and direction to a source.

This work was done by W. Farrell, M. Desch, M. Kaiser, and J. Houser of **Goddard Space Flight Center.** *No further documentation is available. GSC-13976*

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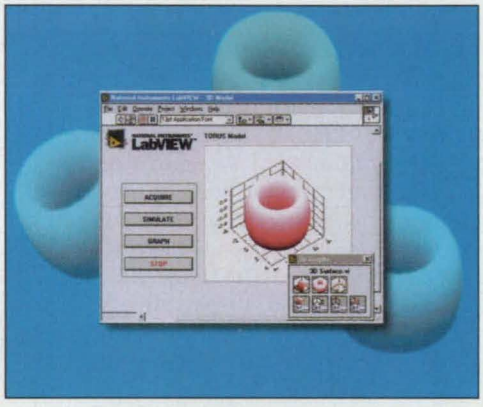

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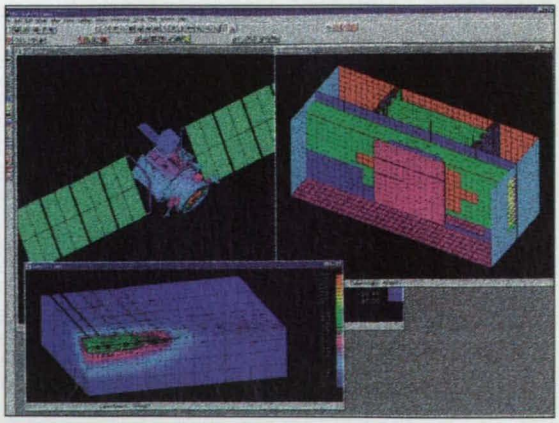
HARVARD THERMAL INC.

TAS - Thermal Analysis System general-purpose thermal modeling

TAS is a powerful and complete general-purpose thermal modeling tool. TAS is used to model electronic components, PCBs, satellites, extrusion processes, cold plates, heat sinks, and much more. Models are generated interactively with screen graphics, eliminating the need to keep track of node and element numbering. The finite element style of model generation allows you to generate complex three-dimensional models using plate, brick, and tetrahedron elements to represent geometry. TAS provides many methods for generating elements including automeshing. Convection, radiation, fluid flow, heat loads, and temperature boundaries are easily added to complete the model. The finite difference solution allows typically difficult tasks such as temperature and time dependent properties and boundary conditions, fluid flow, convection, and radiation to be easily handled. TAS includes interfaces to other thermal tools like SINDA/G, SINDA/FLUINT, TRASYS, TSS, and RadCAD, as well as other FEA tools like NASTRAN, FEMAP, and ANSYS. This is all included in a single graphical user environment at an affordable price.



For more information, contact Harvard Thermal Inc., 249 Ayer Road, Suite 201, Harvard, MA 01451-1133; Tel: 978-772-3800; Fax: 978-772-9765; www.HarvardThermal.com

Circle No. 444

KINGSTON TECHNOLOGY

Flexibility may be one of the last things you think about when purchasing storage, but the first thing you need when

your storage requirements grow or change. Kingston's line of versatile storage products provides solutions specifically designed to support increased storage capacity and system flexibility. Our Data Silo family of external expansion chassis, available in up to nine bays, will accommodate your fixed storage needs. Use our Data Express removable drive carriers for system internal removable storage, or combine it with the Data Silo to create your own custom enclosure.

New: Data Silo DS350 Rack Mount Expansion Chassis

- 4-bay external rack mount enclosure with horizontal bays;
- Rugged steel unit that supports four half-height or two full-height SCSI devices;
- Includes two 65-watt power supplies, three high-speed cooling fans, and all necessary mounting hardware;
- Supports Narrow, Wide, Wide Ultra, or Wide Ultra2 (LVD) SCSI applications.

Data Silo DS400 JBOD and DS500 RAID Enclosures

- 9-bay external enclosures in rack mount or tower designs;
- Durable housing for any combination of up to nine half-height or four full-height SCSI devices;
- Units come unwired — we offer the flexibility of choosing among our wide selection of internal daisy-chain cables, supporting 50-pin SCSI2, 68-pin SCSI3, 68-pin Ultra, and NOW 68-pin Ultra2 (LVD) interfaces.

Data Express Removable Subsystems

- Family of steel constructed removable drive carriers and receiving frames;
- Accommodates all 3.5" SCSI devices;
- Equipped with ID select indicator, device carrier key lock, device activity indicator light, and anti-static insertion guide rails;
- Ideal for any application requiring hot swapping of devices, data transfer/transportation, data security, archiving large files, JBOD, and RAID applications.

For more information, contact Kingston Technology; Tel: 800-435-0642; e-mail: storage@kinsgton.com; www.kingston.com/storage

Circle No. 445

DIGI-KEY CORPORATION

From its beginnings in 1972, Digi-Key has earned a reputation of leadership in the electronics distribution industry resulting from a unified commitment to product availability, service, and performance. Digi-Key bridges the gap between suppliers and customers, delivering product and information with efficiency and reliability.

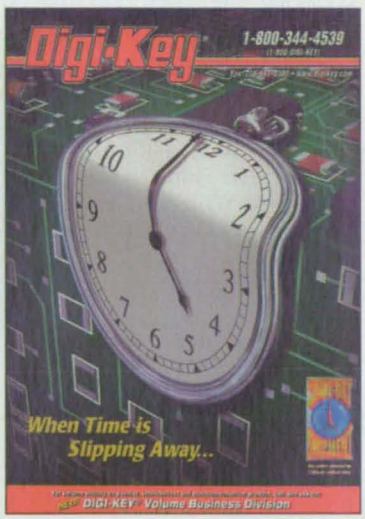
At the cornerstone of their marketing program is a 550-plus-page full-line catalog containing over 80,000 products from 195-plus vendors. Approximately 4.5 million customers and subscribers receive this catalog yearly with updates made every 90 days to accommodate constant product-line expansion and accurate pricing information.

Digi-Key also offers a comprehensive electronic media presence on the World Wide Web. Recognized as one of the industry's best sites, the link is open 24 hours a day, seven days a week (www.digikey.com). Beyond the obvious convenience, you will notice great content, access speed, ease of navigation, online parts search capabilities, online ordering, and communication options. In-depth information can be accessed through many industry links or an exact electronic copy of the latest catalog.

Find out for yourself why Digi-Key is the source for design engineers, managers, and purchasers. ISO 9002-certified, committed to product availability, a 90-plus-% fill rate, on-time delivery — from prototype to production — quality products, superior service, and performance.

For more information, contact Digi-Key Corp., 701 Brooks Avenue South, Thief River Falls, MN 56701; Tel: 800-344-4539; Fax: 218-681-3380; www.digikey.com

Circle No. 446



KEITHLEY INSTRUMENTS, INC.

A World of Measurement Solutions

Keithley Instruments, Inc. develops highly accurate instruments and data acquisition products that measure low levels of voltage, resistance, current, capacitance, and charge, along with complete system solutions for high-volume production and assembly testing.

As a world leader for over 50 years in precision electrical measurement solutions, Keithley specializes in equipment for research, design engineering, and production test applications in a wide range of electronics industries.

Communications

Keithley offers a broad line of fully integrated products for testing portable telecommunications devices such as cellular phones, pagers, mobile radio base stations, and digital switch systems used in product design, production, and QA/QC labs.

Semiconductors

Keithley's products include instruments and systems widely used in design and development, as well as systems for parametric testing.

Electronic Components

Keithley's growing line of high-throughput solutions for component testing encompasses the entire spectrum of control, connect, and source-measure instrumentation.

Recently, Keithley test and measurement innovations have included an expanded selection of PCI-based data acquisition and digital input/output boards, high-speed power supplies optimized for testing battery-operated wireless devices, and several additions to its already broad line of switch cards.

With more than 550 employees, subsidiaries in ten countries, and sales representatives in more than 40 countries, Keithley truly offers "A World of Measurement Solutions."

For more information, contact Keithley Instruments, Inc., 28775 Aurora Road, Cleveland, OH 44139; Tel: 888-534-8453; Fax: 440-248-6168; www.keithley.com

Circle No. 447

STEREOGRAPHICS CORPORATION

Visualize a Whole New World with Stereo3D™

StereoGraphics Corporation is the world's leading supplier of Stereo3D™ visualization products. CrystalEyes and Monitor ZScreen allow engineers, scientists, medical professionals, architects, and graphics professionals to visualize large, complex data sets naturally and interactively. Today, over 70,000 users utilize StereoGraphics products to reduce errors, enhance design reviews, and accelerate time-to-market.

CrystalEyes and the Monitor ZScreen deliver high-definition, Stereo3D images on all major UNIX and NT platforms, and are supported by many professional software applications used in mechanical CAD, product visualization and simulation, molecular modeling, GIS/mapping, and medical imaging.

CrystalEyes is a lightweight, wireless set of liquid crystal shutter eyewear for Stereo3D imaging. Scientists, surgeons, and engineers have used CrystalEyes to design next-generation automobiles and airplanes, perform gene-splicing, interpret images gathered from deep space, perform endoscopic surgery, and even guide the Pathfinder mission on Mars. CrystalEyes is activated by an infrared emitter that connects to the user's workstation.

Monitor ZScreen is a flat-panel overlay for workstation display monitors that provides true Stereo3D visualization capabilities using a simple pair of polarized glasses. An ideal tool for collaborative viewing and interpreting multi-dimensional images, the Monitor ZScreen significantly enhances the technical proficiency of scientific and industrial design professionals working with large 3D-object databases.

For more information, contact StereoGraphics Corporation, 2171 E. Francisco Blvd., San Rafael, CA 94901; Tel: 800-783-2660; Fax: 415-459-3020; e-mail: sales@stereographics.com; www. stereographics.com

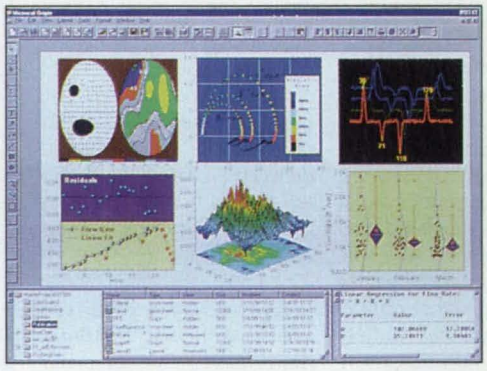
Circle No. 805

MICROCAL SOFTWARE, INC.

Origin 6.0: The Fastest Path From Data to Presentation

Origin's extensive analytical features and superior graphing capabilities have made it the software of choice for tens of thousands of scientists and engineers worldwide. With this exciting new version, Origin is better than ever.

Origin 6.0 provides ease of use, power, and speed for technical graphics and data analysis software. This 32-bit Windows application features powerful analysis and an intuitive graphical interface. Import data or directly open Excel workbooks. Quickly



create 2D and 3D graphs with a single click. Origin provides numerous built-in graph templates. Double-click to customize any graph element. Analysis features provide descriptive statistics, differentiation, integration, filtering, FFT, curve-fitting, and peak finding.

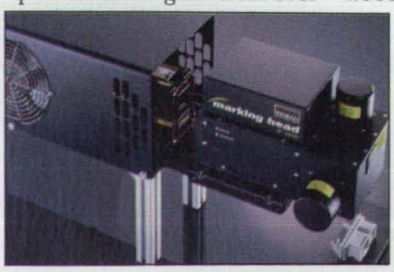
Some of the new 6.0 features include the ability to mask out data points, positive and negative peak finding, an expanded symbol library, and the ability to create custom color palettes.

For more information, contact Microcal Software, Inc., One Roundhouse Plaza, Northampton, MA 01060-4400; Tel: 800-969-7720; Fax: 413-586-0126; e-mail: info@microcal.com; www. microcal.com

Circle No. 800

SYNRAD

Headquartered just north of Seattle in Mukilteo, WA, Synrad was founded in 1984 by Peter Laakmann, a pioneer of the RF-excited CO2 laser. Synrad quickly attained a reputation as a design leader in the development and manufacture of innovative electro-optics technologies. With over 15,000 lasers delivered worldwide, it remains the recognized world leader in RF-excited CO2 lasers.



Available in power ranges from 10 to 600 W, Synrad lasers are ideal in applications involving cutting, marking, and drilling on steel, plastic, wood, paper, and fabrics, as well as many other organic materials. The durable, compact lasers easily integrate into gantry systems, XY tables, and robotic arms. Since they're sealed, there are no consumables required — the lasers operate maintenance-free for up to four continuous years. Synrad's patented "all-metal" technology allows for mass production, enabling the company to offer superior quality sealed CO2 lasers at very affordable prices.

Synrad also is a major supplier of laser marking systems. The rugged and compact DH Series Marking Head contains the latest fiber-optic and digital technology, which delivers high resolution and accuracy in tough manufacturing environments. Compatible with Synrad's 10 to 125 W lasers, the DMH delivers crisp and permanent marks. Synrad has recently introduced WinMark Pro, the first Windows-based laser marking software, which is ideal for marking alphanumerics, bar codes, and logos. WinMark Pro is ActiveX-compliant, allowing the user to create high-performance stand-alone laser marking applications using the most powerful and up-to-date programs such as Microsoft Access, Office for Windows, Visual Basic, and others.

For more information, contact Synrad, 6500 Harbour Heights Parkway, Mukilteo, WA 98275; Tel: 425-349-3500; Fax: 425-485-4882.

Circle No. 803

FLUORAMICS, INC.

Fluoramics is the company everyone calls when their machinery is using too much down time and not running smoothly the rest of the time.

They are the inventors, manufacturers, and distributors of the "Tufoil®" product line, which includes industrial lubricants, greases, oxygen-safe sealants, and even custom lubricants when necessary.

In their 25-year history, Fluoramics has been no stranger to awards. Several years ago, *The Guinness Book of World Records* chose Tufoil as "The World's Most Efficient Lubricant" because of its outstanding ability to reduce friction and wear. Frank Reick, the inventor of Tufoil and President of Fluoramics, was chosen "Inventor of the Year" in New Jersey in 1990.

It's worth the trip to the www.tufoil.com web site. You'll find the full data sheet and MSDS on each award-winning product that you can print out and use at your convenience.

For more information, contact Fluoramics; Tel: 800-922-0075 or 201-825-8110; Fax: 201-825-7035; e-mail: jgreick@ix.netcom.com; www.tufoil.com

Circle No. 801

ERGOTRON

Ergotron provides innovative computer management solutions for automating your facility. When your facility automation plans require the installation of computers for "point of use" human interface, call Ergotron.

To increase productivity, reduce costs, and improve profitability, companies are investing millions of dollars to automate their factories, plants, and facilities. However, planning an automation project involves more than just installing the latest software systems, hardware, and automation technologies. To be effective, automation must be brought to the "point of use." That's where Ergotron completes the equation.

Utilizing patented suspension technology, Ergotron has been supplying innovative ergonomic computer mounting solutions to companies for nearly 20 years. These products have been designed specifically to withstand the operational demands of the industrial environment, overcome space constraints, provide ergonomic adjustability, and maximize your industrial automation investment.

Our customer list reads like a who's who in companies leading the way in industrial automation. Wherever there is a requirement for a computer on the factory floor or in the warehouse, Ergotron is there with a solution for optimizing "point of use" computer interfaces.

For more information, contact Ergotron, 1181 Trapp Road, St. Paul, MN 55121; Tel: 800-888-8458 or 651-681-7634; www.ergotron.com

Circle No. 804

PRESRAY CORPORATION

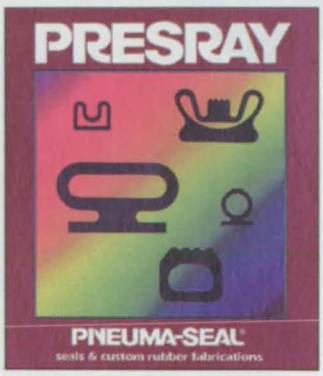
Pneuma-Seal® Solutions

Presray specializes in the custom design and manufacture of inflatable rubber products, seals, special mechanical rubber products, and standard as well as custom-designed products for new and retrofit construction.

Doors and other closures can be positively sealed by using Pneuma-Seal. The seal is inflated with air or fluid by a pressure-regulated supply system. Then, when pressurized, the seal conforms to uneven surfaces and provides an effective, reliable barrier to dust, moisture, contaminants, noise, and pressure differentials.

Typical applications include:

- Horizontal or vertical sliding doors
- Hinged doors with flush thresholds for easy personnel or equipment access
- Large fabricated doors or other closures where it is impractical to machine the sealing surfaces to accommodate conventional seals and gaskets
- Processing equipment where rapid sealing and unsealing is required
- Uneven fabrications where traditional compression gaskets and latches are ineffective.



Pneuma-Seal applications are ideal in the powder and bulk processing equipment, electronic/wafers and semiconductor processing, paper machinery, conveyor, food processing equipment, marine, medical, transportation, aerospace, converting equipment, robotic, fluid sealing, flood protection, and nuclear industries.

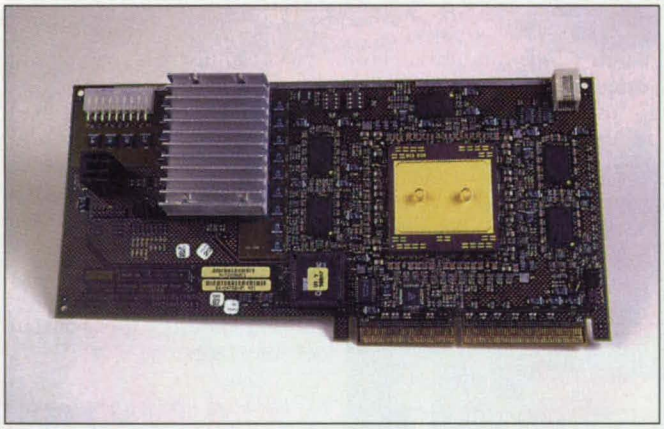
For further information, contact Presray Corporation; Tel: 914-855-1220; Fax: 914-855-1139; e-mail: info@presray.com; www.presray.com

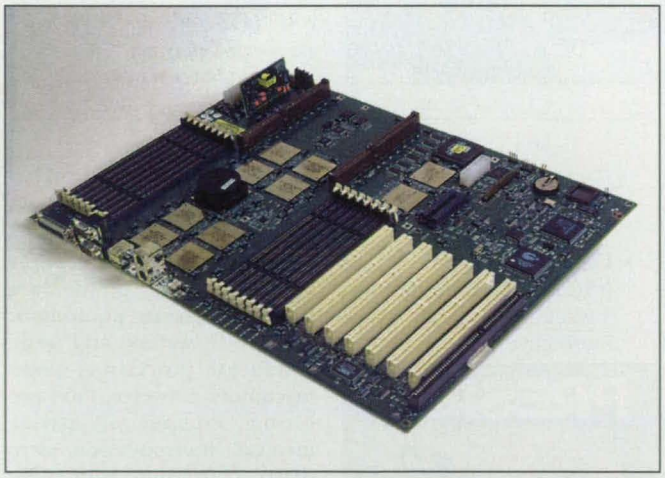
Circle No. 448

MICROWAY, INC.

Since 1982, Microway's products and technical support have helped users get more done for less money. Starting with the concept that PCs could use more numeric power, we built a product line and customer base that is now worldwide. The motherboards and workstations we design today use Pentium- and Alpha-based processors that deliver 20,000 times the throughput of the 8087s we started with in 1982.

Microway has been building Linux Beowulf clusters since 1997. Our users employ either PVM or MPI to manage communications between processors in clusters from 8 to 200 Pentium or Alpha CPUs. We design systems





using 21264 dual Alpha motherboards, UP2000 dual motherboards, 21164-LX single Alpha motherboards, or Pentium processors for all price points.

Our expertise in parallel processing dates back to the mid-80s when we were Inmos's largest customer for transputers. Following this, Microway built small supercomputers that featured up to 20 Intel i860 RISC processors. The 750-MHz dual Alpha motherboard, which we currently feature in our high-end workstations, delivers 2.6 gigaflops of throughput. If you have an application that is a big-time number-cruncher or a DSP application that needs 64 bits of precision, you should consider our solutions.

Microway is known for giving excellent service. When you call us, you talk to a competent person. Because we appreciate the critical nature of your work, every one of our products comes with free tech support for two years. Our legendary tech support makes it possible for us to quote your favorite True 64, UNIX, and OpenVMS systems, yet also deliver NT and Linux. And we know how to take care of special situations, including rack-mounted industrial-grade systems and RAID-controlled hard disk farms.

Microway's current software product line is anchored by NDP Fortran, which is available for Pentiums and generates Alpha code for Linux. Compaq and Intel's ten-year agreement insures that the Alpha 21264 and 21364 will continue to be performance leaders in the high-speed numerics market for years to come. Intel will manufacture the Alpha, which Compaq engineers will design and market. This means that you can count on Microway to continue our tradition of designing state-of-the-art clusters, motherboards, and workstations.

Microway hardware products have always been popular with government, industry, and university researchers. Our i860 powered cards were used to search for oil, improve MRI resolution, do air flow studies on jet engines, and help the NASA SETI project search for extraterrestrial life. Microway high-end Alpha and Pentium workstations are currently in use throughout the US in major universities and research organizations like NASA, NIST, NIH, Lincoln Laboratory, Smithsonian, and CDC.

Company History

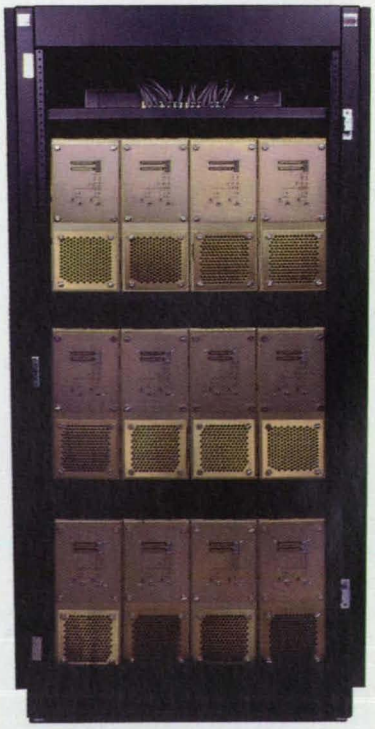
Microway was founded in 1982 to help scientists and engineers take advantage of the IBM PC. Our first product was a library, which made it possible to use an 8087 in a PC. We bundled our libraries with 8087s and became one of Intel's largest customers.

Our hardware products included PC accelerators, coprocessor cards, and motherboards. In 1986, we introduced the first 32-bit Fortran to run on an Intel PC. The first PC to hit a megaflop used a Microway/Weitek coprocessor driven by NDP Fortran. Over the years, NDP Fortran has been used to port hundreds of popular mainframe applications, including MATLAB and ASPEN, to Intel-based PCs.

Microway's workstations have been purchased by university and NASA laboratories since 1989. *PC Computing Magazine* named our Alpha system "the fastest Windows NT workstation on the planet ... the performance leader."

For more information, contact Microway, Inc., Research Park, Box 79, Kingston, MA 02364; Tel: 508-746-7341; Fax: 508-746-4678; e-mail: info@microway.com; www.microway.com

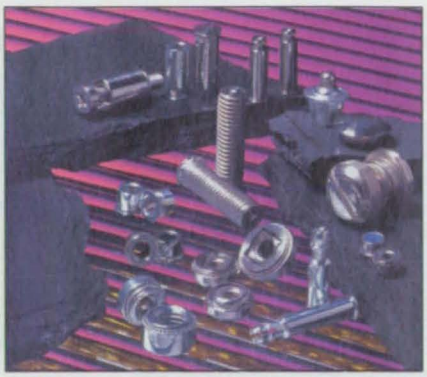
Circle No. 449



PENN ENGINEERING & MANUFACTURING CORPORATION

Founded in 1942, Penn Engineering & Manufacturing Corp. develops, manufactures, and markets PEM® self-clinching fasteners, SI® brand inserts for plastics, PEMSERTER® fastener installation equipment, and the STICKSCREW™ automatic screw insertion system. The company's Pittman Division designs and manufactures dc motor solutions for a wide range of commercial and industrial applications.

Self-Clinching Fasteners. PEM fasteners provide strong, quality threads in metal and PC boards too thin to be tapped.



SI Inserts for Plastics. SI inserts are specified where strong, durable metal threads are required in plastic materials.

PEMSERTER Presses. PEMSERTER presses are designed and built to easily and accurately install PEM self-clinching fasteners.

STICKSCREW System. The STICKSCREW system is a unique small screw installation system that eliminates expensive screw handling equipment and loose hardware. The screws are tightened to an exact torque as determined by the stick/screw design.

Pittman Motors. The company's Pittman Division products include a variety of dc motor solutions. These include brush and brushless motors and gearmotors.

For more information, contact Penn Engineering & Manufacturing Corp., 5190 Old Easton Rd., Danboro, PA 18916-1000; Tel: 215-766-8853; Fax: 215-766-0143; e-mail: pem@pemnet.com; www.pemnet.com

Circle No. 450

HARDIGG INDUSTRIES

As Hardigg Industries approaches its 50th year in business, the company continues to provide engineered packaging products to commercial and military equipment manufacturers.

The company's earliest products were proprietary cushioning devices, and custom molded foam cushions. Jim Hardigg, founder and president of the company, pioneered many of the package cushioning formulas used in the industry today.

In the 1970s, Hardigg designed the first airtight, watertight, rotationally molded shipping and storage container. The rotational molding process allows for durable corners and edges, and permits the gasketed perimeter of the case to be molded into the container — a major improvement over aluminum parting lines, which are prone to denting and burring. Hardigg is now the world's leading supplier of rotationally molded containers.

Hardigg offers several hundred sizes of standard COTS containers, including cushioned transit style, and 19" EIA rackmount shipping enclosures. The company also

manufactures highly custom containers, including elastomeric shock-mounted deck-style containers, which are used to protect fragile U.S. Navy gyroscopes.

With a fleet of modern molding machines, including one of the largest multi-stage rotational molding machines in the industry, Hardigg can quickly manufacture containers in sizes ranging from less than 12" to over 17' in length.

For more information, contact Hardigg Cases, 147 North Main Street, South Deerfield, MA 01373; Tel: 800-542-7344 or 413-665-8061; e-mail: cases@hardigg.com; www.hardigg.com

Circle No. 806

NYLOK FASTENER CORPORATION

Value-Added Fastener Products

Nylok TRUE BLUE® self-locking nylon patches, pellets, and strips provide a strong, vibration-resistant hold in a wide range of manufacturing applications in all industries.

The self-locking process developed by Nylok sprays a nylon patch, or embeds a strip or pellet, onto the threads of a fastener or nut. When the mating threads are engaged, the nylon material is compressed and establishes a counterforce. As the nylon tries to regain its original shape, a strong metal-to-metal contact and positive locking force is established.

The nylon material retains its locking properties at high temperatures and is unaffected by gasoline, oil, or many other natural elements. It also provides excellent sealing properties because the locking device acts as a dam by preventing fluid leakage around the threads. Nylok TRUE BLUE self-locking fasteners can be reused a number of times without losing effectiveness.

NYLOK® TRUE BLUE® self-locking nylon patches, strips, and pellets.

Nylok also offers an extensive variety of coatings and chemical adhesives, including NYTEMP®, a locking element that resists temperatures up to 450°F; PRECOTE® chemical adhesives; NYCOTE®, a coating that masks threads against weld spatter and buildup from electrodeposited primer and paint; and NYSEAL®, a self-sealing coating that creates a gasket-type seal.

Coatings, locking, and sealing products.

For more information, contact Nylok Fastener Corporation, 15260 Hallmark Drive, Macomb, MI 48042-4007; Tel: 800-791-7101 or 810-786-0100; Fax: 810-786-0598; www.nylok.com

Circle No. 451

ALGOR®

Drop Test Analysis Performed with MES Software Determines Limits of ELF Oil Rig Protection Net

This artist's rendering shows the main oil platform and two satellite drilling rigs currently under development in the North Sea. (Inset shows construction site in Scotland.) Pipelines on the ocean floor will transport oil to the main platform via oil-carrying risers within the platform legs. The oil will be processed and then carried ashore via separate export lines. ALGOR's Mechanical Event Simulation software was used to determine the limits of protection nets, which will be positioned at the top of two legs to prevent objects from falling into the leg trusses and damaging oil-carrying risers.

Advances in computer-aided engineering technology are enabling engineers of all disciplines to create more complex, detailed finite element models that realistically simulate the behavior of interacting systems. Recently, engineers at Selantic Industrier A.S. in Agotnes, Norway used Accupak/VE Mechanical Event Simulation (MES) software from Pittsburgh-based ALGOR, Inc. to simulate a steel container impacting a dropped object protection net—a virtual prototype test that previously could only be performed physically in a laboratory.

Selantic engineers were asked by Technip-Geoproduction of France (Technip) and McDermott of the UK in partnership with ELF Exploration UK PLC to develop a new protection net for a "jack-up" oilrig. This type of platform is constructed onshore as one complete unit and then towed into position at sea where its legs are lowered. On contact with the seabed, its deck is jacked-up above sea level.

The ELF platform is currently under development in the North Sea off of the East Coast of the UK. A protection net will be situated within the trusses of two of the platform's three triangular-shaped legs. Each net will be attached to a circular steel ring positioned just above the leg.

Loading cranes located directly above the legs will transport shipping containers carrying supplies between the platform and ships daily. The protection net will prevent falling containers from damaging oil-carrying risers, which are mounted inside the legs and transport oil from the ocean floor. The engineers needed to restrict the net's maximum deflections to protect the risers while ensuring the net will withstand stresses created upon impact by a container.

The MES Approach

Lars Bjoland, technical manager of Selantic Industrier and an ALGOR customer for over seven years, is no stranger to ALGOR's finite element analysis (FEA) software; however, the protection net project was his first attempt at using ALGOR's Accupak/ VE MES capabilities.

"In the beginning of the project, my colleague performed some rough hand calculations to determine the best approach for the net design," Bjoland said. "We could not make any solid conclusions from his work because it was too vague. Performing the calculation manually would be impossible."

The next logical step was to turn to FEA. Bjoland originally modeled the net using Superdraw III, ALGOR's precision finite element modeling tool, and replaced the falling object with nodal forces acting directly on the net. Bjoland was unsatisfied with this for two reasons: calculating the correct loading was complicated and time consuming and replicating the real-world behavior of the net impacted by a container was impossible.

Modeling the container and applying known physical properties such as its dimensions, mass and the height from which the container falls enabled Bjoland to realistically simulate the interaction of the container and the net within a short time frame.

To set up the MES, Bjoland added a container model to the existing protection net model. The net model was made of truss elements with three degrees of freedom. A rope would exhibit resistance only when pulled outward like a cable when the object strikes the net; thus, Bjoland did not consider bending moments.

Bjoland positioned the 5,000-kg steel container model, measuring 2 by 2 m, approximately 12.6 m above the net. The net had three sides, each 16-m long, and was terminated in each of the three corners with fully constrained boundary conditions. He specified gravity for the container. Bjoland designated contact elements between the container surfaces and the net to enable complete interaction, including the transfer of inertia from one object to the other.

Then Bjoland specified the duration of the MES because he wanted to simulate the system's behavior over time. After specifying material properties of steel for the

container and of aramid, a synthetic fiber, for the ropes, Bjoland processed the nonlinear elastic material model with Accupak/VE.

Analysis Results and Modifications

According to Bjoland, the initial deflections exceeded Technip's failure criteria of 2.6 m, the distance to oil-carrying risers beneath the net. Bjoland performed several variations of the analysis, dropping the container at the center, at one corner and along the edge of the net, to confirm the results.

"After the first set of analyses, we were able to determine that the current net design would fail under the extreme loading from the impact," Bjoland said. "Without Accupak/ VE, we would have been required to make a prototype to get the same conclusion."

Technip revised the requirements and asked Bjoland to perform a modified set of analyses. The new net design included ropes made of a high-performance fiber HMPE (High Molecular Polyethylene), a lightweight fiber material that is stronger and exhibits the best elasticity and breaking strength. In addition, the new design called for nine termination points at the corners and along the edges compared to the previous design's three points. Three of the points will be adjustable in order to pre-tension the net.

The modified set of analyses revealed much more reasonable deflections throughout the net and satisfactory material dimensions. Stresses at the termination points were higher, but within acceptable limits, according to Bjoland. In addition, the MES showed that the net would stretch permanently under maximum loading. This was not a concern because a net will be replaced after each drop incident. To present the results to his client, Bjoland created *.avi* files from the MES using ALGOR and converted them to VHS video format.

Physical Prototype Testing

Bjoland anticipates conducting small-scale physical prototype tests to confirm the MES. This testing will replace full-scale testing that would have been necessary if he had not used Accupak/VE. This translates into less time and material costs for prototype testing as well as decreased time-to-market.

"Had we not used Accupak/VE, we would have needed to do full-scale testing to find deflection and termination forces," Bjoland said. "We also would have been required to perform additional physical testing to determine the design modifications that we made after the initial Mechanical Event Simulation."

This small-scale physical prototype testing is planned for 1999 with the platform becoming operational in the year 2000. Bjoland expects to use Accupak/VE for future projects. "Engineers always need to be open to new ways of solving problems to get the best results," Bjoland said. "If we hadn't been open to a new method of modeling in this case, we would not have been able to show the behavior of the net as quickly or inexpensively."

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ALGOR's FEA-based Accupak/VE Mechanical Event Simulation (MES) software analyzes motion and flexing in mechanical events, replacing physical prototyping with virtual prototyping. New kinematic element technology makes MES with CAD solid models and assemblies more practical by reducing run times.

ALGOR offers a range of FEA capabilities including linear and nonlinear stress, vibration and natural frequencies, heat transfer, electrostatics, fluid flow, piping design and composite materials. Algor's entire range of modeling and analysis tools works within and alongside CAD systems. Algor has strategic relationships with major CAD companies and offers InCAD™ plug-ins for Pro/Engineer, SolidWorks, Solid Edge, Autodesk and others.

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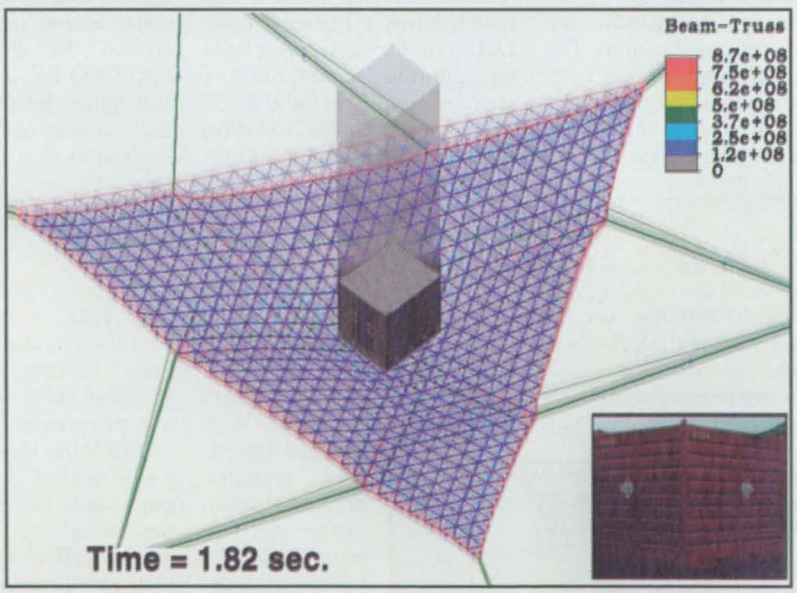

The Mechanical Event Simulation predicted the deflections and stresses caused when a container, such as the one shown in the inset, falls from a height of 12.6 m. The analysis verified that maximum deflections would be under 2.6 m, the distance to critical oil-carrying risers beneath the net. Because virtual prototypes of the net were created using Mechanical Event Simulation, Selantic will not need to conduct full-scale laboratory tests, decreasing the time and cost of physical prototype testing.

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Stahl Specialty Company is a leader in the aluminum foundry industry and has been making casting from the tilt-pour permanent mold process since 1946. Applications such as automotive, agricultural, heavy truck, marine, and food service are some of the markets served. Stahl has been making parts for the automotive industry since 1978. One area of application for automobiles that Stahl has expertise in is suspension parts such as control arms. Stahl has supplied control arms to the automobile industry since 1993.

The main reason for converting suspension parts to aluminum from other materials such as iron castings and steel stampings is weight savings. This translates into lower vehicle weight and better fuel economy. One important side benefit discovered after the implementation of aluminum control arms was an improvement in unsprung weight of each wheel, which refers to the amount of mass of each wheel that is available to be "thrown around" as the vehicle encounters road imperfections such as bumps and potholes. Additionally, aluminum control arms dampen the impact better than steel stamped control arms, resulting in less vibration transmitted through the car.

Aluminum control arms are fairly new to the automotive industry, but they are becoming more widespread each model year as the confidence level increases in their ability to perform in many different vehicle applications. Superior mechanical properties and casting soundness are a must for the aluminum control arm to be successful. A sound casting, combined with a custom tailored heat treat, will yield a casting with exceptional mechanical properties.

For more information, contact Stahl Specialty Company, 111 East Pacific, PO Box 6, Kingsville, MO 64061-0006; Tel: 800-821-7852; Fax: 816-597-3485; www.stahlspecialty.com

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Examples of Astro-Med products include the MT95K2, which has become the world standard in chart recorders, especially in telemetry applications. Other data acquisition recorders from Astro-Med include the "Dash" line of portable units, which range from 2 to 30 channels. The recently introduced Dash 16u is a 16-channel data acquisition recorder with universal inputs that features a 10.4-inch color LCD monitor, high-speed RAM for capturing data, 200 KHz per channel sample rate, and a 100-Megabyte removable Zip drive for data transfer and archiving.

Other Astro-Med products include portable paperless data acquisition systems. The AstroDAQ is a complete, ready-to-use system that can record up to 30 channels. The AstroDAQ 2 is a very compact and lightweight version, especially suitable for portable field applications.

Astro-Med is a growth-oriented company that believes in vigorous new product development, in high-quality products, and in total customer satisfaction. Astro-Med's executive offices, R&D, and manufacturing facilities are located in West Warwick, RI and Braintree, MA.

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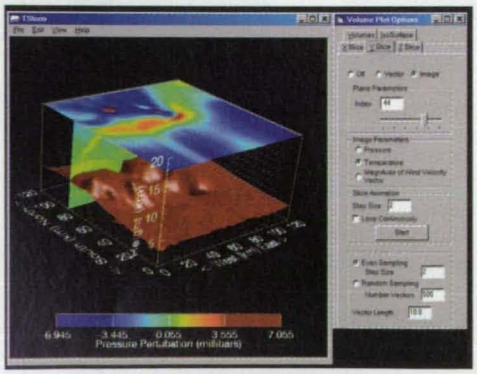

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Circle No. 455

August 1999

Motion CONTROL Tech Briefs

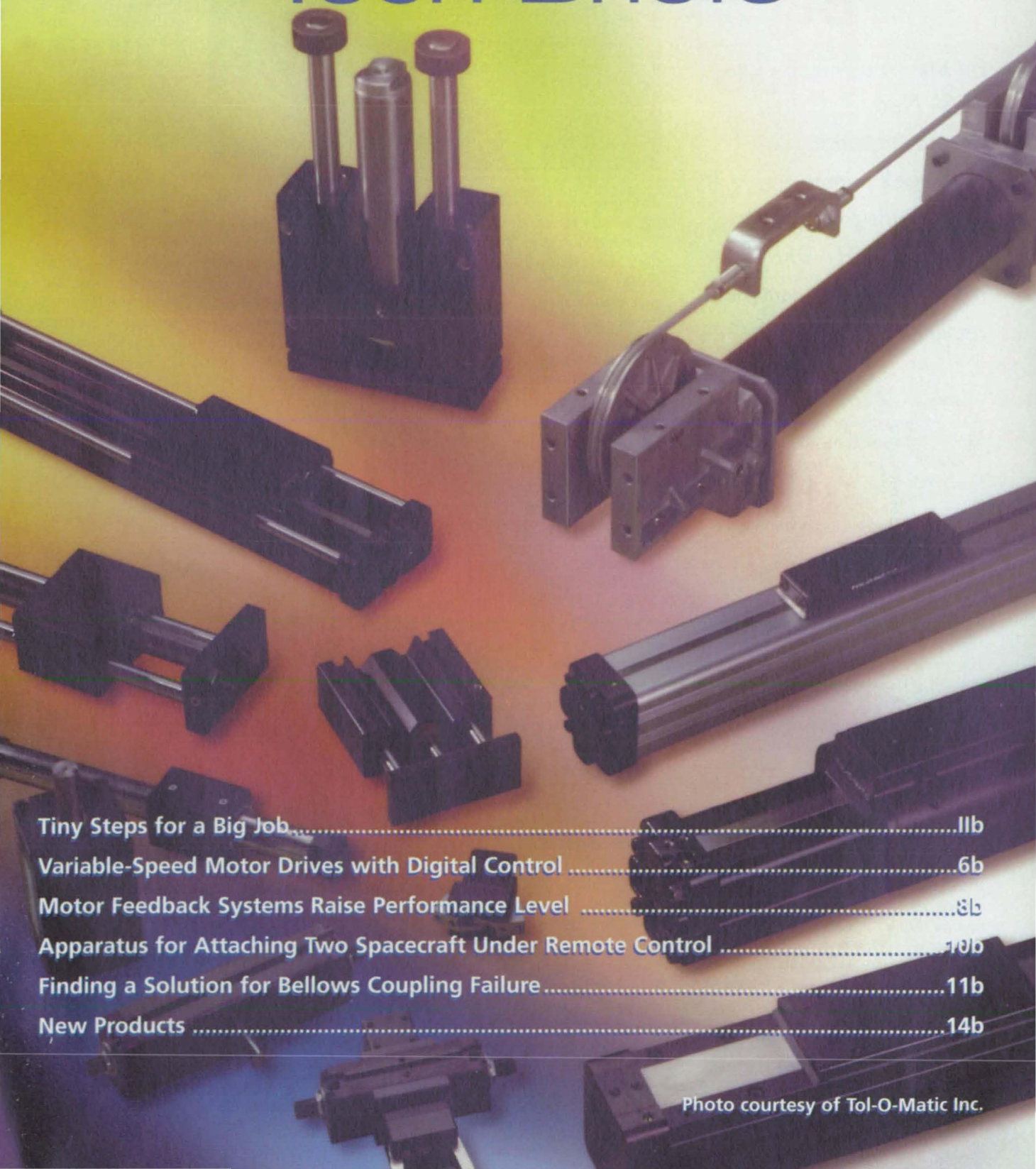


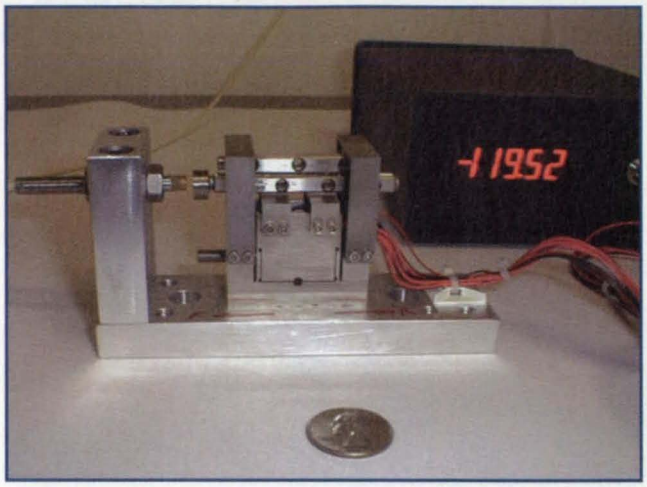
Photo courtesy of Tol-O-Matic Inc.

Tiny Steps for a Big Job

For the NASA Next Generation Space Telescope's primary mirror, Burleigh's specially designed INCHWORM® motor will provide nanometer resolution.

One of the most ambitious space projects on NASA's agenda for the coming years is the Next Generation Space Telescope (NGST). Its goal is to observe the universe's composition more than 12 billion years ago, when stars and galaxies were starting to form. The light dating from the most distant and oldest structures of our universe cannot be imaged by visible-light telescopes, such as Hubble or ground-based observatories, because it is red-shifted into wavelengths in the far infrared. Detecting those wavelengths will be the job of the NGST.

But there are hurdles in the path to the NGST's success. It will have a large segmented primary mirror that must be deployed and aligned in deep space using hundreds of computer-controlled actuators. The telescope has to be folded for launch into space and will operate far from Earth. No astronauts will be aboard to make adjustments, so the precision, reliability, and stability of the motors that will align the reflective surfaces are critical to the mission. Furthermore, cryogenically cooling the telescope to temperatures as low as 20 K (approximately -400 °F) is required in order to minimize internal infrared noise that might interfere with the targeted radiation. That is where Burleigh Instruments of Fishers, NY, since 1974 a prominent manufacturer of high-precision piezoelectric (PZT) nanopositioning products, comes in.



Earlier this year, Burleigh announced that, after the successful completion of a Phase I contract last fall, the company received a fresh research and development contract from NASA's Langley Research Center. The Phase II agreement calls for Burleigh to develop a new INCHWORM® nanopositioning motor to precisely position the mirror's many segments. Worth almost $600,000, the agreement was made under the federal government's Small Business Innovation Research (SBIR) program. Burleigh expects to complete work on this contract by 2001. The development of NGST flight hardware is planned to start in 2003, with an anticipated launch date of 2007 or 2008.

Burleigh's INCHWORM motor, manufactured for 25 years, is a patented stepping motor with nanometer resolution and many millimeters of travel. Its high precision makes it suitable for demanding positioning applications in aerospace and defense. Its compact PZT ceramic actuators are electromechanical devices that undergo dimensional changes when voltage is applied to them. The conversion of electrical energy into mechanical motion takes place without generating any significant magnetic field or the need for moving electrical contacts. Dimensional changes are proportional to the applied voltage and can therefore be adjusted with extremely high resolution.

The principle of operation of the INCHWORM is shown in Figure 1, and the photo shows the Phase I prototype. Based on a clamp-extend-clamp-contract cycle, the design routinely produces more than 15 N of axial force at speeds greater than 1.5 mm/sec. The solid-state movement has zero backlash and very high stiffness. The construction materials are inherently nonmagnetic and vacuum-compatible. But the classic INCHWORM will not work for the NGST, for two reasons. The first is that the operating temperature range is limited to 0-70 °C, because the clamp and shaft materials have different thermal expansion coefficients. As temperatures drop into the cryogenic region, the shaft-to-clamp fit gets tighter and the clamps will break. (At higher temperatures the fit gets looser and the motor will stop operating.) In addition, the piezoelectric material loses 80 percent of its strain and thus its capacity for movement at 20 K. *Continued*

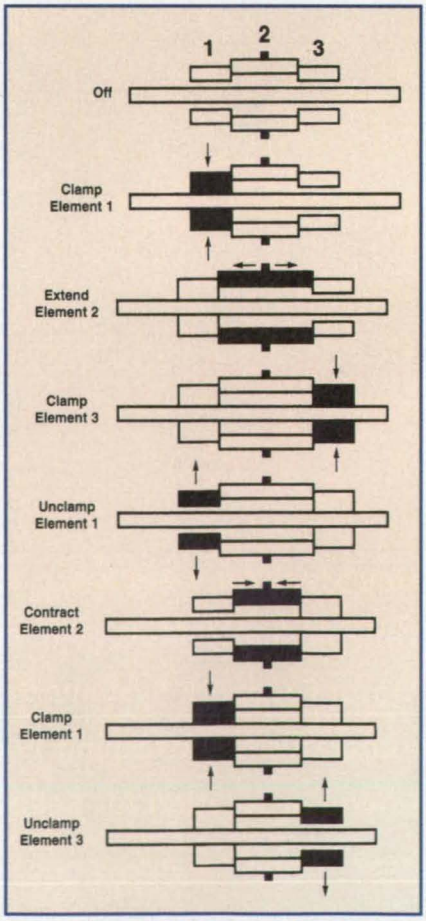


Figure 1. Sequential clamping, unclamping, extension, and contraction of the PZT elements create a smooth linear motion profile.

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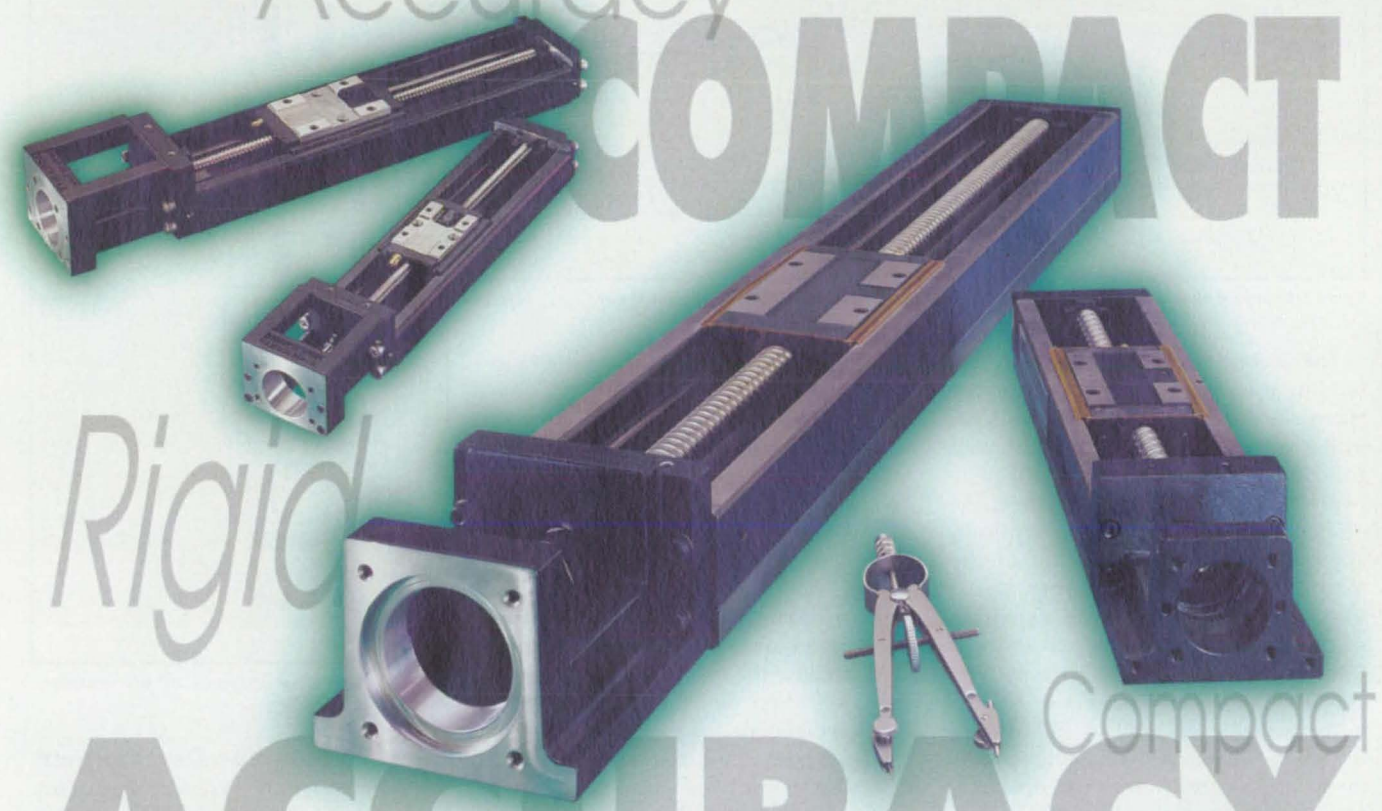

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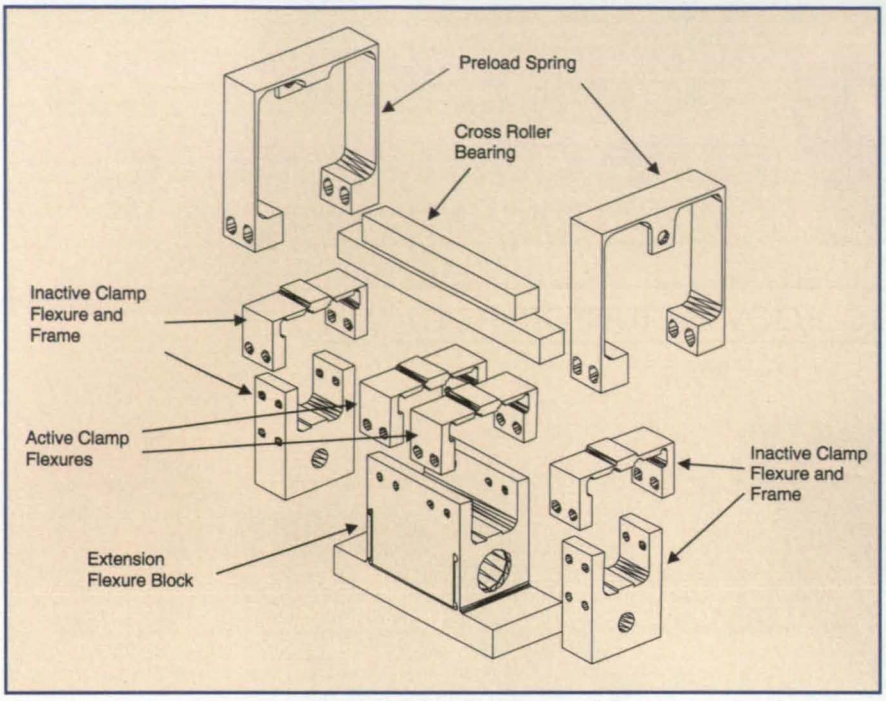


Figure 2. Exploded view of the prototype NGST INCHWORM assembly (PZT stacks not shown).

The second reason is that off-power holding force is not stable, because the clamps are honed to match the shaft with a small interference fit at zero volts (off power). This fit changes with temperature and wear, and this changes the off-power holding force, which typically approaches zero over the life of the motor. Additionally, removing power from the motor causes the extension stack to change length, which changes the shaft position by a few micrometers.

NASA's requirements for the NGST's mirror actuators (Type 2) are summarized in Table 1. The most challenging requirements are the resolution, the operating temperature, and the heat dissipation. Though the number of actuators to be used has not been set, it could range from 240 to 3000. Even the lower quantity will require that the drive electronics be multiplexed between many actuators. The ideal actuator will not change axial position more than two nanometers when the multiplexed switching removes power. The NGST actuator must also be compatible with ultrahigh vacuum, and have a clamp-extend-clamp cycle life of at least 50 million, with a low-frequency duty cycle (<25 Hz).

The NGST Concept

The NGST INCHWORM concept uses an "inside-out" design with spring-loaded clamps. Only one clamp channel and one extension channel are needed, in contrast to the three channels required by the classical Inchworm. The clamps support the load when activated (extended) and the extension stack moves the load forward or backward. When the clamp is deactivated the inactive frame supports the load.

Compressive spring preload eliminates tensile stresses in the clamps and creates a reliable holding force when power is removed and the clamps are discharged to zero volts. The output force is proportional to the preload force, and the spring loading inherently compensates for temperature changes and wear. Another significant advantage of this approach is that, because the inactive frame supports the load when power is removed, PZT creep is eliminated as an error source.

But several technical challenges must be overcome before the concept can become reality. An efficient spring preload mechanism and guide for the rails must be constructed. The mechanism must keep the clamp surfaces coplanar within 0.5 µm as the actuator is cooled to 20 K. And the clamp "glitch"—the axial motion forward and backward when a clamp occurs that nominally sums to zero—must be reduced to a few nanometers.

But the biggest challenge, according to David Henderson, director of positioning products at Burleigh, is demonstrating a cryogenic design that compensates for changes in size and loss of performance of PZT materials at low temperatures. "We plan to use a new type of PZT material that has more strain per volt than conventional materials," Henderson says. "Our approach can work continuously from room temperature to cold temperatures, which gives us a significant advantage over alternate technologies. This means that the same hardware can be ground tested at room temperature and flown in space."

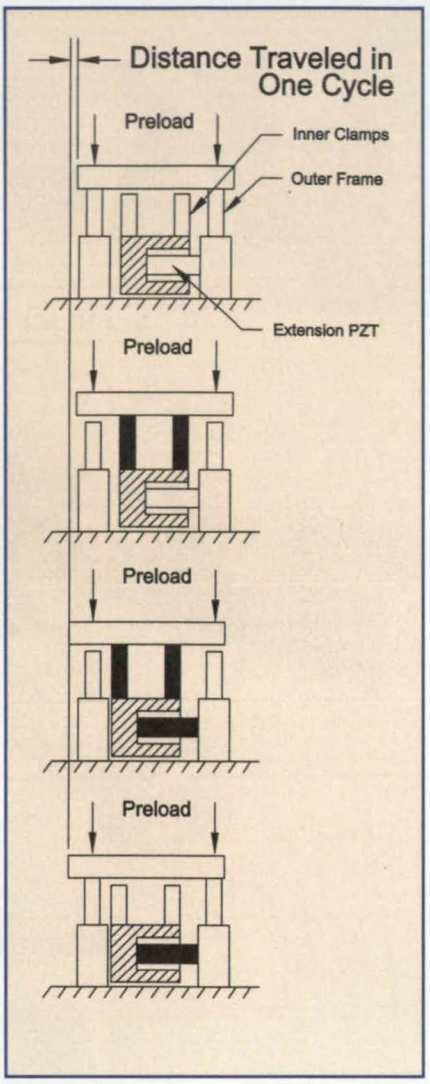


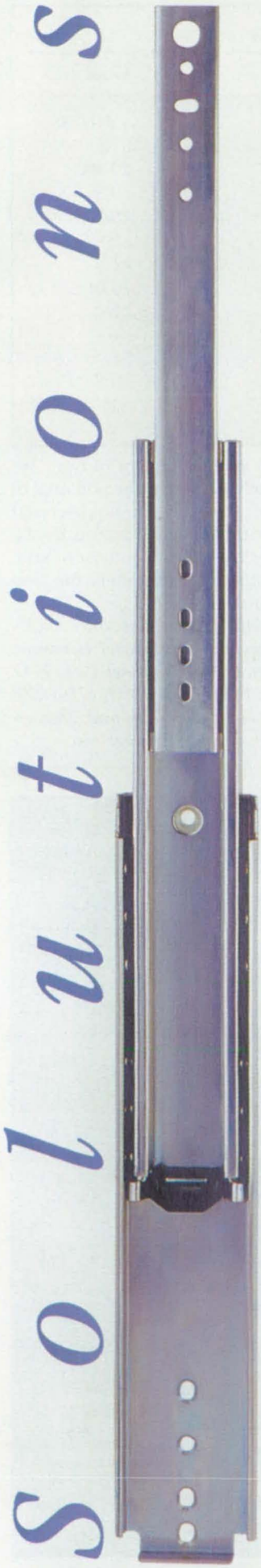
Figure 3. Operating sequence of the prototype NGST INCHWORM.

Phase I Prototype Development

Figure 2 shows an exploded view of the NGST INCHWORM prototype, and Figure 3 its operating cycle. The clamps are now one-sided and supported by parallelogram flexures. The clamps press against a stainless steel crossed roller-bearing rail that moves in the direction of travel and is connected to the external load. U-shaped preload springs compress a stationary bearing rail that presses against the moving rail through crossed rollers. The length of the moving rail determines the amount of travel. A critical requirement of the springs is sufficient strength and flexibility to maintain adequate preload as the mechanism is cooled from room temperature to 20 K.

All four clamps are identical to insure they change in height by the same amount during cool-down. The outer clamps are inactive but still have PZT stacks and flexures to insure thermal symmetry.

To deal with clamp glitch, the PZT stack in the NGST is mounted in a flexure that has very high stiffness in the direction of travel (axis) and low stiffness



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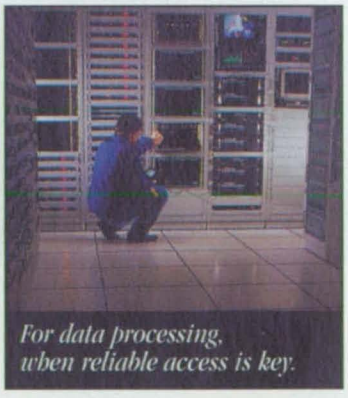

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in the clamping direction. This arrangement maintains a compressive load on the PZT stack under all operating conditions without restricting the clamp motion. The high axial stiffness limits axial movement as the clamp is extended and retracted and prevents shear loads from damaging the PZT stack.

As for the PZT material problem, additional material is added to the clamps and the extension mechanisms to insure that at least 2 µm of movement are available after cool-down. The result is a substantially larger and heavier motor than would be needed for room-temperature operation only. This additional PZT material also adds extra capacitance and electrical losses that increase thermal dissipation.

Table 1. NGST Type 2 Actuator Requirements

Property	Goal
Resolution (nm)	<10
Lifecycles	>100,000
Stroke (mm)	>10
Operating Temperature Range (Kelvin)	20-300
Calibration Mode Heat Dissipation (mW)	<0.5
Operation Mode Heat Dissipation (mW)	<0.005
Mass (grams)	<20
Outside Diameter (cm)	<1
Creep, Operating Mode (nm/day)	<0.01
Thermal Stability, Operating Mode (nm/K)	<20
Axial Force, Set & Hold, Operating Mode (N)	>1
Axial Stiffness (N/µm)	>1
Power Consumption, Calibration Mode (W)	<0.1
Bandwidth	<25 Hz

Plans for Phase Two Development

The results described above and the figures show the first-generation prototype, which was developed in 1998 under the Phase I SBIR grant. These first prototypes are being used to validate the critical design concepts for the NGST unit: cryogenic operation and repeatable off-power holding capability. Burleigh is currently developing a second-generation prototype that will be ready for cryogenic testing late this year or in early 2000. The second-generation prototypes will use a simpler mechanism design that is less sensitive to thermal changes and manufacturing tolerances.

Even more significant is the use of new ferroelectric single-crystal actuators, supplied by TRS Ceramics Inc. of State College, PA, that offer up to five times more movement than conventional polycrystalline PZTs. By using this new material, the size and mass of the actuators and the INCHWORM motor can be reduced by at least a factor of five. "We are extremely excited by the potential of integrating ferroelectric single-crystal actuators with Burleigh's proven INCHWORM technology," Henderson said. "We feel this approach offers the best solution for the NGST."

For more information on the NGST INCHWORM program, contact David Henderson of Burleigh Instruments, Burleigh Park, 7647 Main Street, Fishers, NY 14453; (716) 924-9355; fax: (716) 924-9072; e-mail: dhenderson@burleigh.com; www.bureligh.com.

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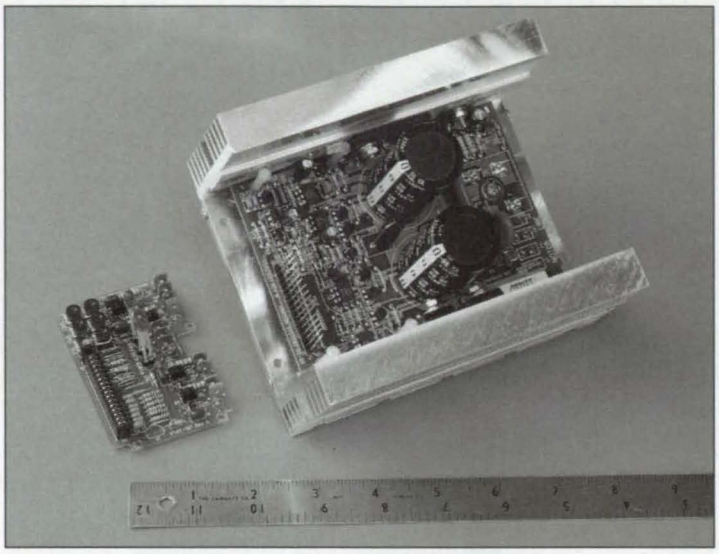
Energy efficiency is a continuing focus of the power electronics industry. Motors consume the most electricity in commercial and industrial applications (followed at a distant second by lighting). More than 85 percent of electric motors are single-phase motors that are installed in numerous applications—fans, pumps, compressors—that would benefit from variable speed control. Traditional approaches have been to complicate the motor design by tapping the motor windings and using electromechanical switches to change the number of windings, thus changing speed.



Electronic approaches have focused on using triac bridges that are phase-controlled. These systems generate significant power losses and conducted noise, making them limited in application. The drive industry has therefore been pushing for conversion of new systems to full three-phase motors with sophisticated three-phase drives. Such drives require not only a more expensive motor but also an electronic drive that is both complex and expensive. As these drives need to be set up by professionals, many users shy away from them.

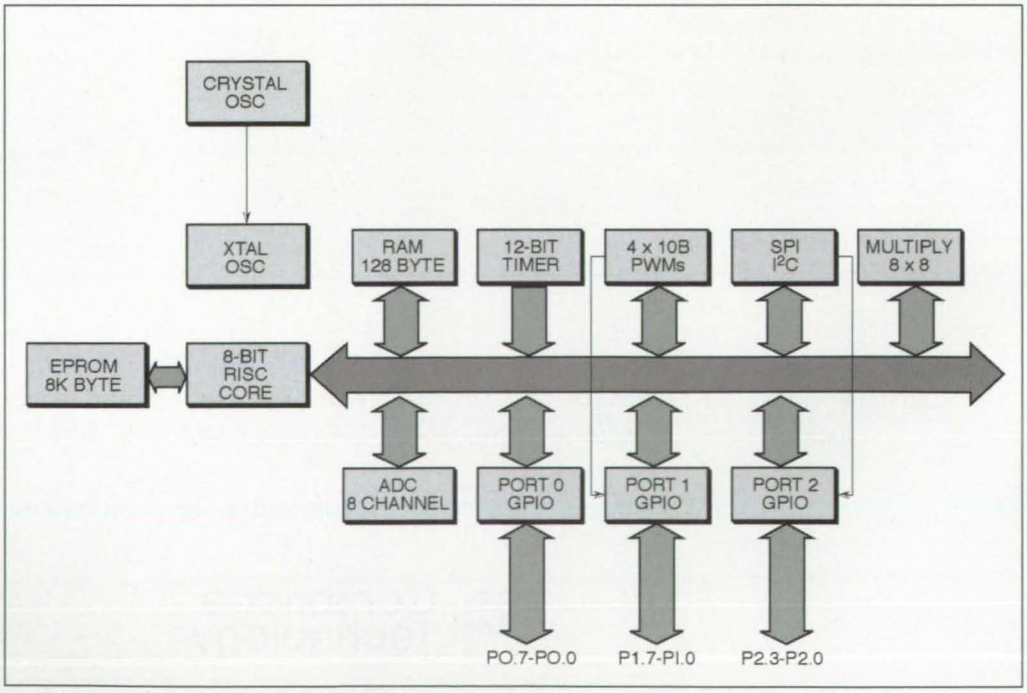
Anacon Systems has taken the underlying technology of three-phase motor drives and applied it to single-phase motors. Using the latest IC technology—RISC-based processors—Anacon has developed a controller IC that meets the stringent performance requirements along with the lowered cost target. The ASIC uses an 8-bit RISC microcontroller with 128,000 SRAM, an 8-x-8-bit multiplier, analog-to-digital converter, four 10-bit pulse width modulators (PWMs), a 12-bit timer and a comparator to monitor faults and perform system shutdown. Design innovations also provide customization through programmability. The ASIC also includes an 8-kbyte EPROM and an SPI or PC serial port to allow for external programmability. The ASIC has digital outputs that can be used to signal operating or fault conditions using LEDs.

The resulting motor controller is created using this ASIC (see the figure). A power electronics design using all through-hole mount techniques results in a low-cost hardware platform that is easy to customize for unique market applications. The motor control uses an H-bridge power stage configuration containing power MOSFETs or IGBTs switching at 18 kHz to keep switching noise above the audible range. The driver stage interfaces with the ASIC and translates the PWM waveform into H-bridge on/off signals. Aside from the controller the only other function needed is a bias supply, providing the 12- and 5-volt power feeding off the input AC line, eliminating a low-frequency transformer or high-frequency power supply. With these few blocks — bias supply, controller, H-bridge, and driver stage—the motor controller can be realized.

The resulting product is:

- programmable through external software changes;
- rugged and flexible;
- energy efficient, because a heating-system blower working at 70 percent of full speed uses 50 percent less energy and also provides more comfort through continuous air flow and destratification.

The finished drive is not complicated to control. Firmware can be provided that sets the shape of the V/f tradeoffs. Trip points for idle speed and maximum speed can be set externally. Trip points



Block diagram of the **Motor Controller's ASIC.**

New, Hollow Shaft Gearing SHF Series

Featuring a through-bore up to 70 mm in diameter, the SHF Series component sets and gearheads enable the design engineer to pass shafting, wire bundles, or other components directly through the center of the gear. The new SHF Series provides high accuracy in a compact design. This unit design is both axially shorter and lower in weight, as compared to conventional harmonic drive gearing. This is accomplished by using HD Systems patented "S" tooth profile. Rated torques up to 6590 in-lb and positional accuracy better than 2 arc-min can be achieved. Gear reduction ratios of 50:1 through 160:1 are available in a single stage.

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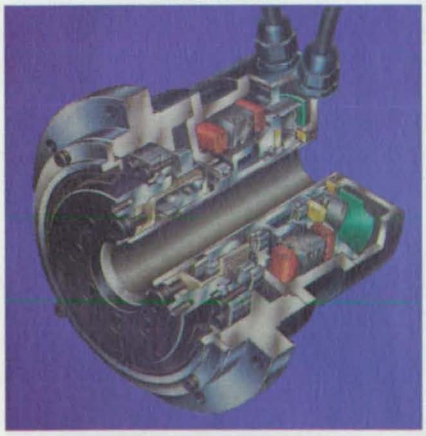

Hollow Shaft DC Brushless Actuators

The FHA Series of actuators feature a through-bore up to 45 mm in diameter and provide high torque and exceptional positioning accuracy. This performance is achieved in a compact design using a patented "S" tooth harmonic drive gear coupled to a DC brushless pancake motor with integral electronic commutation and a high resolution encoder. Rated torques up to 1730 in-lb and positional accuracy better than 1 arc-minute can be achieved. The FHA Series is available in five frame sizes, ranging from 128 to 300 mm in diameter, and 116 to 248 mm in length.

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Miniature DC Servo Actuators Mini RH Series

HD Systems offers a line of miniature DC servo actuators for use in applications such as robotics, instrumentation, and factory automation where precise motion control is required. The actuators combine zero backlash harmonic drive gearing with rare-earth magnet DC servo motors to provide both high torque and positional accuracy better than 2 arc-minutes. Rated torques of 2.6 thru 56 in-lb and rated speed of 15 thru 60 rpm are available depending on frame size and gear ratio. The smallest actuator measures just 20 mm in diameter. Encoders and/or tachometers are available as an integral part of the actuator.

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for system protection can also be set externally. Thus, for a given application like a blower control, a simple DC voltage (0-5 V) can be used to control the motor speed while several potentiometers can provide the customer flexibility to set the critical trip points.

For more information, contact **Anacon Systems Inc.** *'s corporate headquarters at 1043 Shoreline Blvd., No. 202, Mountain View, CA 94043; phone toll free 888-456-3398 (sales and applications center, Austin, TX); E-mail: info@anaconsystems.com; www.anaconsystems.com.*

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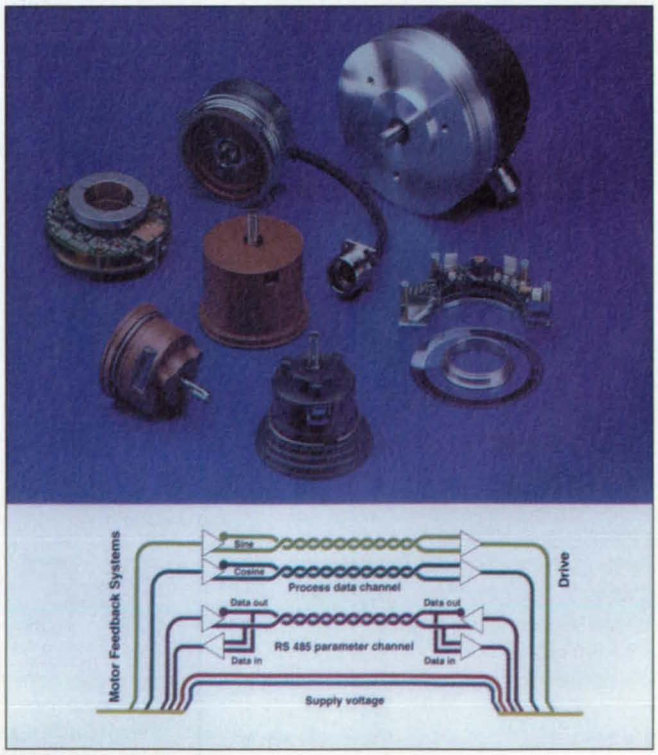
They provide all the signals needed to operate a drive at levels that far exceed resolvers and conventional incremental encoders.

Stegmann Inc., Dayton, Ohio

Servomotor drive manufacturers agree that the performance of today's digital drive is largely determined by the performance of its feedback device. Clearly, previous feedback solutions, such as resolver technology and conventional encoders, no longer meet the increasing market demands for higher accuracy and resolution, lower P factors, and easily adjustable commutation information—all of which must be available in a single small, easily mountable package. An innovative approach by Stegmann Inc. for its Hiperface™ compatible feedback systems meets and exceeds these demands.

The Sin/Cos by Stegmann is a Hiperface compatible feedback device developed for the drive market, offering better resolution and improved performance over traditional encoder technology. Benefits over an incremental encoder include a resolution of 4-8 million counts, well above the 20,000 count of most encoders. Accuracy is ±2-3 arcsec, compared to ±2 arcmin for incremental



A **Schematic of Hiperface**, an eight-wire interface standard that makes it possible to get commutation, speed regulation, and position information from a single device.

encoders. At 50 mm in diameter, the Sin/Cos is the smallest multiturn absolute encoder in the world when compared with devices that have similar performance ratings. It has an optional mechanical gearing system that lets it keep track of up to 4096 shaft revolutions.

Hiperface is an eight-wire interface standard that makes it possible to get commutation, speed regulation, and position information from a single device. The physical interface includes two wires for an RS-485 link, four wires for sine and cosine signals, and two wires for the power supply, a reduction from as many as 19 leads in traditional systems.

These innovative systems combine the functions of both incremental and absolute encoders. The absolute value in these systems is calculated only when the device is initially turned on, and is then transmitted via the RS-485 interface to a counter in the drive. The drive in turn uses this initial absolute value for the commutation of the motor and also as a pointer to identify the exact period of the sine/cosine signals that it is currently evaluating. The drive then increases the base resolution of the sin/cos signal by interpolating these signals in the drive with an A/D converter. The final result after 12-bit interpolation, when using a feedback system with 1024 periods per turn, is more than 4 million counts.

An advantage of using sine and cosine signals to transmit the position information is that a very low-frequency signal can be used to provide extremely high resolutions. This is because the incremental signal is not transmitted in the common digital data format of A-quad-B, as with conventional encoders, but rather as analog sine-cosine voltage over the process data channel. This signal is then interpolated inside the drive unit's input circuitry to get the increased resolution. This low-frequency signal can be transmitted without difficulty over considerable distances.

The resulting benefit is that the drive circuitry can be designed to handle only as much bandwidth as is required; this range in actual practice depends on the shaft speed at which the feedback device will operate. For instance, a servomotor using digital signals at speeds of up to 6000 rpm, and a desired resolution of 20,000 pulses per revolution, needs a bandwidth of 2 MHz. If a Sin/Cos motor feedback system from Stegmann is used, a bandwidth of only 102.4 kHz is required.

Hiperface compatible motor feedback systems also outperform existing feedback devices in accuracy. Motor feedback systems provide signal linearity of the sine/cosine signals down to ±5 arcsec, resulting in total system inaccuracies (including mechanical mounting of the encoder and A/D conversion in the drive) of less than ±30 arcsec. This is at minimum a tenfold increase in accuracy over today's conventional incremental encoders and resolvers.

By integrating a nonvolatile memory device into the system, important data can be stored in the feedback device and accessed over the RS-485 link by the drive when needed. As an example, the electronic label of the motor can be stored during manufacture, then accessed by the drive during system initialization and used to automatically configure the drive, eliminating the need for keyboard entry of this data. Other information, such as routine diagnostic information and internal device temperature, can also be accessed. These features add another dimension to drive systems that incremental A-quad-B encoders or resolvers cannot hope to match.

Other Hiperface products are available for differing applications and mounting arrangements.

For more information contact Andrew Monnin, the author of this brief and sales and marketing manager for **Stegmann, Inc.**, *7496 Webster St., PO Box 13596, Dayton, OH 45413-13596; 800-811-9110; fax 937-454-1955; E-mail: amonnin@stegmann.com.*

Apparatus for Attaching Two Spacecraft Under Remote Control

Toroidal bladders are inflated to grasp a rocket nozzle from the inside.

Lyndon B. Johnson Space Center, Houston, Texas

An apparatus called a "pneumatic stinger" has been developed to enable a first spacecraft, operating under remote control, to grasp a second spacecraft that is in orbit or other unpowered flight. The pneumatic stinger, which is mounted on the first spacecraft, is inserted in a rocket-engine nozzle of the second spacecraft, then actuated to grasp the nozzle from the inside, as explained below. Both NASA and the Department of Defense could use this apparatus for servicing satellites. The design of the pneumatic stinger might also be adaptable to soft-docking mechanisms or grappling mechanisms for use on Earth.

The pneumatic stinger offers advantages over an older stinger-type apparatus used to attach a first spacecraft to a rocket nozzle on a second spacecraft. In operation of the older apparatus, an astronaut on the first spacecraft had to position the stinger mechanism in alignment with the nozzle on the second spacecraft, then actuate a trigger mechanism to initiate attachment. In addition, it was necessary for the second spacecraft to be equipped with a structural surface, adjacent to the nozzle, that mated with an interface ring on the stinger and that carried loads. Often, it was not possible to equip a satellite-type spacecraft with a structural surface of this type. In the cases of satellite-type spacecraft that could be equipped with such structural surfaces, the surfaces were required to be of specific shapes and designs. In contrast, the pneumatic stinger is fully automated in that it can be operated without intervention by an astronaut, functions without need for precise initial alignment, and can be used without expensive structural modification of the spacecraft to be grasped.

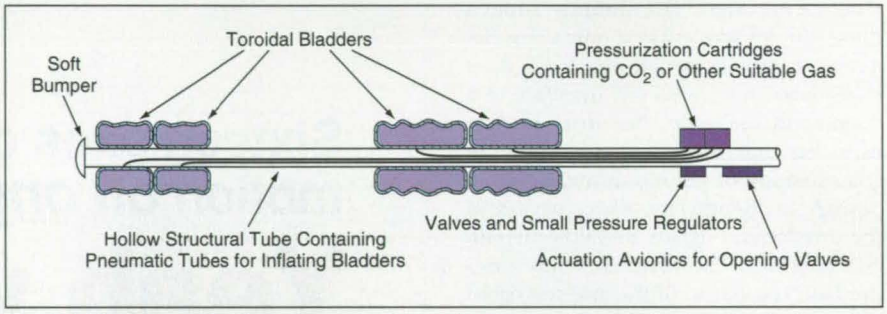


Figure 1. The **Pneumatic Stinger Protrudes** from a first spacecraft, ready for insertion in the rocket nozzle of a second spacecraft.

Figure 1 shows the pneumatic stinger in its preactivation state. A soft bumper on the insertion end of the stinger prevents damage to the combustion chamber associated with the nozzle. A pair of bladders (two are used for protective redundancy) is located near the insertion end. After insertion of the stinger in

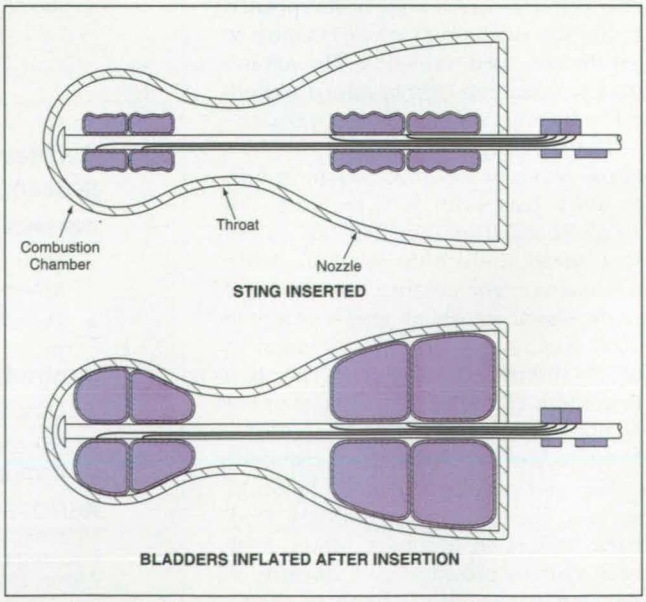


Figure 2. The **Bladders Are Inflated** after insertion of the stinger, so that the stinger grasps the nozzle and combustion chamber firmly yet gently from the inside.

the nozzle and combustion chamber, these bladders are inflated into contact with the interior wall of the combustion chamber, thereby capturing the second spacecraft. Two larger bladders are located about midway along the stinger (the exact location depending on the size of the nozzle); these bladders are inflated (see Figure 2) to center the stinger and react loads through the nozzle to the structure that attaches the nozzle to the second spacecraft. The gas for inflation is supplied from redundant pressurization cartridges through valves and regulators controlled by electronic circuits.

The inflated inner and outer bladders trap the throat between them. The axial reaction of the inner (combustion-chamber) bladders is balanced by the opposite reaction of the outer (nozzle) bladders; this balance serves to preload the stinger into controllable contact with the nozzle. The contact between the bladders and the nozzle is soft; it does not damage the nozzle because the bladders hold the nozzle at relatively uniform pressure, which the nozzle is designed to withstand. Moreover, the preload is applied in all directions, so that axial loads and moments can be applied to and through the stinger and nozzle to control the orientation of the second spacecraft.

In addition to the advantages mentioned above, the pneumatic stinger offers two other advantages over the stinger in the older docking apparatus:

- After insertion of the stinger, the only action required is opening of pressurization valves. Consequently, it is easy to fully automate the operation of the pneumatic stinger.
- Use of the pneumatic stinger is relatively inexpensive.

This work was done by William C. Schneider of **Johnson Space Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Mechanics category.*

This invention has been patented by NASA (U.S. Patent No. 5,735,488). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center, (281) 483-4871. Refer to MSC-22745.

Finding a Solution for Bellows Coupling Failure

Careful analysis of the problem leads to a custom solution.

Servometer Corporation, Cedar Grove, New Jersey

When a problem such as breaking bellows couplings threatens to halt a machinery production line, it is necessary to look beyond the obvious. In an application in which the coupling works on a Heidenhain encoder for an X-Y table that positions circuit boards, representatives of the user company and of Servometer determined that it was a flexing type failure rather than a torquing failure. There were two couplings per handling machine, and calculation showed that the peak torque transmitted through the coupling was 0.22 in.-oz. After a thorough analysis, it was clear that the existing bellows coupling was failing because of offset, since the failure was in the first convolution closest to the end piece.

The engineers followed up by determining the maximum offset, and a Servometer bellows coupling was chosen that could handle the offset, the small amount of possible bending, and the small mount of torque. The choice was confirmed by another division of the same company, which had been using the recommended coupling without encountering a problem. Servometer says the company is using the couplings for new handling-machine production.

This work was done at **Servometer Inc.** *For more information, contact Tom Guarino, Engineering Sales Manager, 501 Little Falls Rd., Cedar Grove, NJ 07009-1291; (973) 785-4630, ext. 243; fax: 800-785-0756 or 973-785-0756.*

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How to Develop a Successful Business or Product

Engineers and other technical professionals are becoming increasingly important as business drivers. Most, however, know few of the skills required to turn a good idea into a successful business. This course will focus on the knowledge, skills, and behaviors needed to "Make it Happen." It will deal primarily with nontechnical issues, as most projects fail due to "people issues."

BENEFITS

You will learn:

- how to recognize an opportunity
- how to sell and market an idea
- how to effectively manage enterprise projects
- how to assemble, motivate, and manage a team
- how to prepare a business plan
- fatal flaws that kill projects
- a roadmap for a successful project.

Most importantly, you will get an understanding of how people really work together, what motivates them, and how the use of simple people skills can make you more efficient and effective.

WHO SHOULD ATTEND

The course will address the needs of both those who run major development projects within an organization (intrepreneurs) and those who want to do it on their own (entrepreneurs).

INSTRUCTOR

Leslie M. Gray, an entrepreneur and engineer, started Airflow Research and Manufacturing Corp. in 1980 to market quiet cooling fans for automobiles; ten years later, when he and his partners sold Airflow to the Robert Bosch Corp., it had grown to $55 million in annual sales. He continues to consult to Bosch while teaching entrepreneurship and serving on the boards of several startup firms.

SC100 $150 prereg/$195 on-site
Mon., Sept. 20: 9:00 am to 12:30 pm

Introduction to Rapid Prototyping and Tooling Technologies

As product design and manufacturing cycles have become more and more compressed, new timesaving tools have emerged to help engineers meet their production challenges. This course will provide an overview of the latest technologies in the areas of rapid prototyping, rapid tooling, and high-speed machining; illustrate practical examples of how these technologies can save time and increase productivity; and discuss which of the technologies make sense for various product design and tooling applications. Topics will include:

- 3D CAD — the starting point
- traditional prototyping vs. rapid prototyping:
- reverse engineering
- rapid prototyping methodologies (Stereolithography, Solid Ground Curing, Laminated Object Manufacturing, Selective Laser Sintering, Fused Deposition Modeling, etc.)
- 3D printing
- rapid desktop and office modelers
- introduction to rapid prototyping applications
- plastic and metal rapid prototyping
- sheet metal fabrication
- high-speed machining vs. rapid prototyping
- RP service bureaus

BENEFITS

In this course you will learn:

- how to slash time and drive down product development costs
- the range of rapid prototyping and tooling technologies available today, how they work, and their cost
- the advantages and limitations of each technology
- which technologies are appropriate for your applications
- new advances on the horizon.

WHO SHOULD ATTEND

Engineers and managers involved in product design, prototyping, and development; individuals involved in making decisions on incorporating rapid prototyping technology into existing design and manufacturing processes; anyone interested in gaining comprehensive knowledge of these emerging technologies.

INSTRUCTOR

A pioneer in the rapid prototyping industry, **Merlin C. Warner** has more than 15 years experience in engineering and manufacturing, and has worked for companies involved in tooling design, rapid prototyping, and rapid manufacturing. He is president of Warner Technologies, Waterford, MI, and is an internationally renowned expert, consultant, and speaker in the field of rapid prototyping, high-speed machining, and their applications.

SC101 $175 prereg/$225 on-site
Mon. Sept. 20: 9:00 am to 1:00 pm

Technology Commercialization Strategies/Finding Niche Markets

Whether your product or service is just an idea, recently patented, emerging or mature, this workshop will help you evaluate the potential opportunities and risks and find the most profitable niche commercial markets.

BENEFITS

You will learn through discussion and brief exercises:

- how to evaluate new product ideas and minimize your risk
- what key factor has the most influence in the acceptance of technology in the commercial marketplace
- the "new" metrics in commercialization success
- specific techniques for targeting your best opportunities

- cost-effective ways to find the commercial value of your product
- how to launch products on tight budgets
- how to prepare a commercialization plan that gets attention.

WHO SHOULD ATTEND

Engineers and other technical professionals, business managers/owners, entrepreneurs and others involved in marketing and selling technologies, products and services.

INSTRUCTOR

William J. Dorman is President of Dorman Associates Inc., Lambertville, NJ. Dorman Associates Inc. is a marketing strategies, management engineering, consulting and research company established in 1976.

SC102 $150 prereg/$195 on-site
Mon., Sept. 20: 1:30 pm to 5:00 pm

Fast and easy online registration: www.techeast.net

Speeding the Innovation Process: How to Improve the Performance of Engineering Systems

This course will review product and process analysis to correctly define and solve product concept design problems. Attendees will examine the resource limitations that impede innovation, how the world's patent collection can be applied to improve product development, and how to predict novel solutions.

BENEFITS

During this course, you will learn:

- how to avoid design mistakes made by other companies
- how to apply the laws and trends that govern engineering systems to your own projects
- how evolutionary practices can predict innovation to be used to improve current systems
- how to use these trends to guarantee success in product design initiatives.

WHO SHOULD ATTEND

Design and R&D engineers, product development managers, leaders of major development projects within organizations

INSTRUCTOR

Dr. Sergei Ikovenko, Director of Training and Services for Boston-based Invention Machine Corp., has conducted more than 300 courses on design innovation and technology optimization. In addition to working with Fortune 500 companies worldwide, Dr. Ikovenko has taught seminars at MIT, Harvard, Carnegie-Mellon, and other leading engineering schools. Dr. Ikovenko has received 76 patents in various field of engineering and authored more than 30 scientific papers.

SC104 $150 prereg/$195 on-site
Tues., Sept. 21: 9:00 am to 12:30 pm

Course registration includes workbook, complimentary tickets for coffee and dessert breaks, and entry to all exhibits. For questions or information on group discount rates, call Melissa Hinnen at (212) 490-3999; melissa@abptuf.org

SBIR as a Business Development Resource: A workshop for SBIR-active and interested firms

With over $1.2 billion in annual funding from TEN federal agencies, the Small Business Innovation Research Program is the largest U.S. source of early-stage technology development financing. Over 9,500 firms have been funded for almost 50,000 projects in every field of endeavor; and some 4,500 new projects are selected each year involving several hundred new firms as well as previous winners.

With strong emphasis on bringing technology to full use-condition, SBIR must now be understood as involving far more than simply having a good idea and getting an award. The scale and scope of federal participation itself has changed in important ways, as has the expectation of what awardees must subsequently address to be judged "successful."

For SBIR awardees and newcomers alike, this all-day, highly interactive, workshop will provide information, analysis, tools and insight into effective SBIR participation and long-term business achievement.

BENEFITS

Featuring leading federal procurement and business development experts, the workshop will cover:

- SBIR's changing dynamics (and the opportunities therein!)
- how the program REALLY works...and making it work for YOU
- effective project design and proposal development
- understanding the government as a customer
- factoring to current (changed) business circumstances
- identifying and valuing technology assets
- critical issues in bringing technology to market-use condition
- tools and strategies for exploiting your technologies

WHO SHOULD ATTEND

Those with a well-established SBIR presence as well as those just getting started will profit from this workshop, as will ANY company seeking to bring technology from lab to market.

- The morning session will address issues highly relevant to both SBIR veterans and newcomers;
- Two afternoon tracks will target, respectively: the practical needs of SBIR involvement, and appropriate and profitable market penetration.

IMPORTANT BONUS

An online interactive roundtable will support post-conference continuing discussion and materials exchange (access included in the workshop fee).

INSTRUCTORS

Ann Eskesen will lead a team of respected, experienced experts from industry, business and government. Since 1983, Ms. Eskesen has been President of Inknowvation Development Institute. She is a dynamic public speaker with a substantial reputation as an SBIR advocate.

SC103 $195 prereg/$245 onsite
Tues., Sept. 21: 8:30 am - 5:00 pm

Marketing For Survival: Creating Opportunities and Solving Problems through the POWER of Marketing

Marketing isn't a choice. We all do it every day. To survive in today's fast-paced world, we need to convince management to support, investors to risk, and customers to buy. As professionals in other disciplines with little time to spare, we need practical, proven marketing tools that get the job done right.

BENEFITS

- **Clarity:** About who our "customers" are and why they buy, fund, and invest
- **Value:** The ability to define the value of our products and services to each customer segment
- **Discipline:** Mental tools that help maintain a focus on satisfying customers in a competitive environment
- **Confidence:** When interacting with our customers, management, and investors
- **Power:** Abilities to use the disciplines and processes of marketing to reach goals and manage change
- **The Book:** "Marketing for Survival"

WHO SHOULD ATTEND

Anyone serving "customers" with technologies, products, services, projects, investment opportunities, or time as employees in professional disciplines

INSTRUCTOR

Dr. Gary Lundquist transitioned from scientist to marketer while converting a service company into an INC 500 software company. He helps high-tech companies and R&D labs nationwide to manage change with marketing. He has marketed technologies, products, and services ranging in price from one hundred to half a billion dollars.

SC105 $150 prereg/$195 on-site
Wed., Sept. 22: 9:00 am to 12:30 pm

Intellectual Property: Protection, Licensing, and Government Technology Transfer Issues

This course will provide an overview of three critical areas of concern when bringing technology to the marketplace: protecting intellectual property; dealing with the government in technology transfer matters; and licensing technology.

BENEFITS

This easy-to-understand course will bring you up to speed on:

- trade secret, patent, copyright, and trademark protection and their relevance to commercializing technology
- the Federal Technology Transfer Act and Cooperative Research & Development Agreements (CRADAs), one of the primary mechanisms for government-industry partnerships and tech transfers
- intellectual property issues when dealing with the government — pitfalls to avoid and proven paths to success
- licensing agreements, in particular the key differences between licensing from the government and from the private sector
- how to determine royalties.

WHO SHOULD ATTEND

Industry, government, and university technology managers; engineers; scientists; and entrepreneurs who want to learn how to effectively protect and license their ideas.

INSTRUCTOR

Jacob N. (Jesse) Erlich, a partner with Perkins, Smith, & Cohen, LLP, specializes in intellectual property matters. Previously, attorney Erlich served as Chief Patent Advisor for the U.S. Air Force. He holds a BS in Mechanical Engineering from Worcester Polytechnic Institute and a Juris Doctor degree from Georgetown Law School. A Past-President of the Boston Patent Law Association, Erlich recently coauthored a book entitled "Technology Development and Transfer — the Transactional and Legal Environment."

SC106 $150 prereg/$195 on-site
Wed: 9:00 am to 12:30 pm

New Products

Zero-Backlash Plastic Nut

Ball Screws & Actuators (BSA) Inc., San Jose, CA, makes available its XC Series of patented plastic antibacklash nut assemblies. BSA's ActiveCAM™ design utilizes a rigid stainless steel cam that automatically rotates and produces higher axial rigidity without sacrificing life, torque, or positional accuracy. It automatically compensates for wear, and produces zero backlash and consistent minimal drag torque up to the nut's rated load capacity. BSA says that it delivers exceptional repeatability throughout the life of the nut. The XC Series load capacities range from 10 lb. maximum for the quarter-inch diameter up to 250 lb. for the three-quarter-inch diameter, with leads from 0.012 in. to 2.00 in. The series is available in thread or flange mounts.

For More Information Circle No. 761

Linear Brushless DC Motors

Axsys Technologies Inc., Englewood Cliffs, NJ, introduces a new line of linear brushless DC motors. The company says that its ALM family uses a new modular coil design (patent applied for), which maximizes winding density and increases linear motor force. It utilizes a full complement of field magnets on both sides of the coil. The ELM family of low-cost motors uses the same coil design with a single row of field magnets. The company attributes its motors' smooth performance to these shaped commutation magnets, which when coupled to linear Hall sensors provide a sinusoidal output.

For More Information Circle No. 762

Ethernet Standalone Controller

Galil Motion Control Inc., Mountain View, CA, offers the DMC-2100 standalone motion controller that uses the Ethernet communication protocol. The series is available in 1- through 8-axis formats, enabling control of both step and servo motors on any combination of axes. It comes standard with the 10Base-T baseband signal that is common for the Ethernet, but it is also available with the 10Base-F fiber optic option for noisy industrial environments. Other features include sinusoidal commutation for brushless motors, two encoder inputs for each axis, 64 configurable I/O, and optoisolated forward and reverse limits and home inputs for each axis.

For More Information Circle No. 763

Solenoid-Operated Dispensing Pumps

Valcor Scientific, Springfield, NJ, says that its SV600 Series solenoid-operated dispensing pumps employ an exclusive O-ring pumping system that seals the piston while allowing the pump chamber to refill. The piston is retracted when the solenoid is energized, allowing liquid to enter the volume above the O-ring. A return spring pushes the piston back down when the coil is de-energized. The rugged SV600 Series is capable of operating through several million cycles without maintenance, according to the company. Valcor says repeatability is within 2 percent.

For More Information Circle No. 764

Microcontroller for Motor Control

STMicroelectronics Inc., Lexington, MA, introduces the ST92141, which it calls a high-performance 8/16-bit microcontroller designed to simplify the control of three-phase induction motors. The unit has a dedicated induction motor control (IMC) peripheral cell that minimizes both software complexity and processor overhead. The cell's 25-MHz operating frequency allows switching frequencies above the audible range, while the dedicated tachogenerator and six pulse width modulation outputs reduce the external interface requirements. The sinewaves generated to drive the motor windings have 1024 resolution levels, which the company says reduces current ripple and harmonic losses.

For More Information Circle No. 765

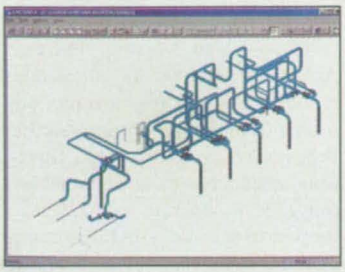
Programmable DC Power Supplies

Sorensen Division of Elgar, San Diego, CA, adds 37 new models to its DHP series of DC power supplies, bringing the total number of models to 141. The series, which comes in a thin rack-mount profile (2U to 6U), provides DC output power from 2 kW to 30 kW. A new feature in models with 80 V or more is Down Programming, which will program the output voltage from 100 percent to 10 percent (no load condition) in less than one second. The new models allow the user to store and recall all programmable voltage, current, and auto-sequence settings.

For More Information Circle No. 766

New on DISK

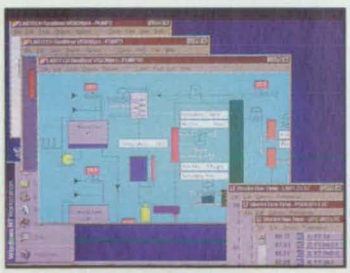
Pipe Stress Analysis



COADE, Houston, TX, has released Version 4.10 of CAESAR II Windows 95/98/NT software for pipe stress analysis and design. Enhancements include recent piping-code updates, the British TD/12 transmission piping code with fatigue analysis, and an online user's guide. The software is designed to increase by 200 percent the limit on the number of thermal, pressure, and force sets. It also expands categories for input review and edit; increases load cases from 20 to 99; and adds more reports for fatigue analysis and cumulative damage. CAESAR II encompasses pipe stress analysis, component evaluation and databases, and automatic underground pipe modeling. **Circle No. 700**

Analysis Software

ANSYS/Professional™ analysis toolkit for structural and thermal simulation and analysis has been introduced by ANSYS, Canonsburg, PA. It is designed for users who are faced with intermediate analysis projects, but lack experience with the ANSYS product line. The Mechanical Toolbar, a streamlined graphical user interface (GUI) component, provides an entry point into ANSYS for basic analysis tasks. The sequential tabbed menus and drop-down boxes are designed to make setting up and running an analysis as accessible as using familiar Windows applications. **Circle No. 701**



Data Acquisition/ Process Control

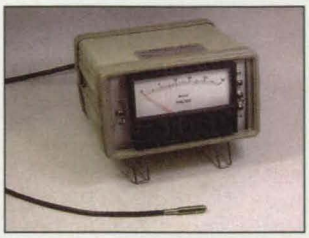
LABTECH Corp., Andover, MA, offers Windows NT/Windows 2000 versions of LABTECH NOTEBOOK™, NOTEBOOKpro™, CONTROL™, and CONTROLpro™ instrumentation and control software. Features include multiprocessing capabilities, priority-based scheduling, and a new open-architecture design. The multiprocessing feature allows multiple copies of NOTEBOOK and CONTROL to run on the same system. Priority-based scheduling is set up to provide a deterministic design delivering predictable performance at the application and I/O level. By utilizing Microsoft's COM technology, the software offers an open standard allowing interoperability with a wide variety of I/O devices. **Circle No. 704**

Graphical Programming Tool

GEDAE™ Version 3.0 from Lockheed Martin Advanced Technology Laboratories, Camden, NJ, is an advanced graphical programming and automated code generation tool designed for multiprocessor applications. New control features include "Valves" for efficient data flow; "Eval" and "Trigger" for processing parameters rather than data stems; a GUI primitive library supporting GUI building as part of an application; and an Application Interface Builder to simplify the interface to external control software. Also available is an Algorithm Development Version of GEDAE, designed to enable engineers to develop algorithms using the full primitive library and to execute the algorithm on a single workstation. **Circle No. 705**

New on the MARKET

Ultrasonic Vibration Meter



The UV40 from Philtec, Annapolis, MD, is an ultrasonic vibration meter for production testing of ultrasonic equipment. Its reflectance-compensated fiber-optic displacement sensor enables the gage to operate without calibration to specific target materials. Features and capabilities include fiber-optic transducer, analog display, 100 microns FS; 1 micron resolution; scaling for 20 KHz and 40 KHz; 0.25-mm standoff to target; and 0.25-mm linear operating range. **Circle No. 708**

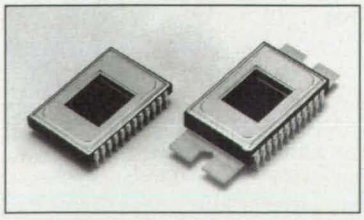
Contact Springs

Flexible, miniature bellows contact springs from Servometer Corp., Cedar Grove, NJ, are intended for critical applications requiring contact with a delicate component or material. The contacts are designed to have low insertion forces/losses, and low D.C. resistance. The contact springs are manufactured from electrodeposited nickel, and are gold-plated for improved conductivity. Most end cups fit over standard-sized pins or into recesses, so that they connect to other components without soldering. Contacts are available in stock diameters down to 0.037" (1 mm). Parts can be designed to customer specifications. **Circle No. 719**

Silicone Sheeting

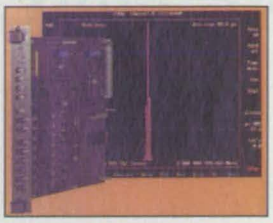
B-stage silicone adhesive system from NuSil Technology, Carpinteria, CA, is available in sheet form and with a wide variety of physical properties. Thermally conductive and electrically conductive sheets are available for dissipation of heat or electrical current; optically clear sheets are available for adhesion of glass to various substrates such as kapton, aluminum, and other metals. The materials cure at room temperature and can be heat-accelerated for faster assembly. The adhesives can replace liquid silicones in many applications, eliminating mixing and de-airing. **Circle No. 717**

CCDs for Scientific Imaging



Hamamatsu Corp., Bridgewater, NJ, offers the S7170-0909 and S7171-0909 series of back-thinned FFT-CCDs that feature greater than 90% quantum efficiency (QE). The CCDs are designed for scientific applications such as measuring instruments, optical analyzers, and UV imaging. The CCDs feature stable spectral response curves over the 200-nm to 1100-nm spectral response range. Dynamic range of the Multi Pin Phase (MPP) mode CCDs is 37,500 to 1 in area-scanning mode. Both CCDs are mounted in a 24-pin ceramic package measuring 50 x 22.9 x 7.7 mm. A sapphire window protects the active area. **Circle No. 710**

Time Measurement Module



Highland Technology, San Francisco, CA, offers the Model V980 16-channel, time-to-digital converter, which is designed to record the time of occurrence of 16 independent electrical-pulse inputs. Each is measured relative to a single, common user-set reference input, up to 6,800 seconds before or after the common trigger, or 0 to +13,700 seconds after trigger. In addition, it can be used as a 17-channel independent time stamper, with a measurement range of 0 to 13,700 seconds. Jitter typically is below 40 ps RMS. The converter also is suitable for time interval counting in radar, lidar, laser range-finding, shockwave analysis, and X-ray crystallography applications. **Circle No. 714**

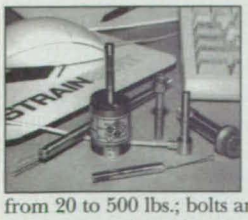
FireWire™ Data Acquisition

The DAQPad™-6070E from National Instruments, Austin, TX, is a data acquisition device (DAQ) for the IEEE-1394 serial bus, or FireWire. This multifunction I/O device connects directly to Windows 98 PCs equipped with an IEEE-1394 serial port or PCI-to-1394 adapter. The device is designed to provide a portable solution for computer-based measurement applications. The device is hot-pluggable and comes with NI-DAQ™ driver software. Other features include 1.25 MS/s sampling rate, 12-bit A/D resolution, 16 analog inputs, 2 analog outputs, 8 digital I/O lines, two 24-bit counter timers, and mass termination or BNC-equipped option. **Circle No. 715**

Dual-Channel Process Meter

OMEGA Engineering, Stamford, CT, has introduced the DP3300 Series of dual-channel process meters, which provide pulse or square wave inputs on one channel and an analog signal on the other. The device is designed to monitor analog signals such as 4-20 mA loop current, volts, millivolts, or temperature signals from thermocouples, RTDs, or thermistors. On channel one, analog signals are linearized and displayed in degrees Celsius or Fahrenheit. Voltage and milliamp signals are displayed in engineering units corresponding to the process being monitored. Channel two is designed to serve as four monitors in one: up/down counter, rate, RPM, or frequency. **Circle No. 716**

Miniature Force Transducers

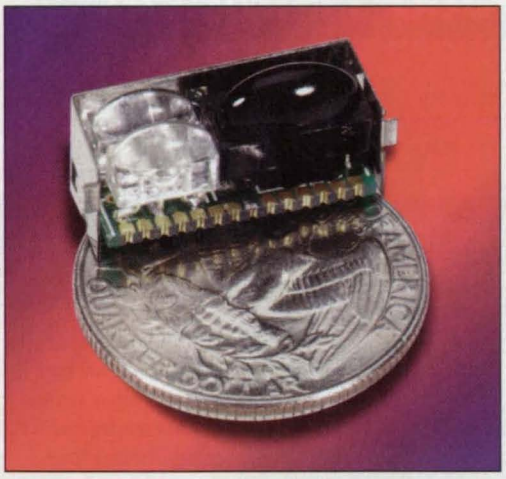


Strainsert, West Conshohocken, PA, offers miniature force transducers designed and manufactured with the company's patented Internally Gaged Technology. The transducers include clevis pins down to 1/4" diameter with capacities from 20 to 500 lbs.; bolts and studs down to 1/4" diameter and smaller; and custom miniature tension links. Internal gaging is designed to provide increased measurement accuracy. The gages are bonded to the transducer neutral axis, thereby mitigating the effects of bending and torsional extraneous loading on the desired measurement. Applications include corrosive, harsh, or high-pressure environments; aerospace; antenna and clamp band joints; and engine attachments. **Circle No. 718**

Wireless Networks: Confusion and Promise

Steven S. Ross

There's a revolution brewing in wireless networks — a revolution that promises a wide variety of network options: different speeds, operating systems, ranges, and number of network nodes. The ultimate goal — wireless networking so ubiquitous and seamless that all you have to do to connect is to bring your laptop, palmtop, or data collection appliance into the room — is still elusive.



IBM's Air transceiver compared in size to a US quarter. The range is 15 feet under normal conditions.

Some devices aim for interoperability by formatting data into Internet-compatible packets. Intel has its Wired for Management (WfM) initiative, a hardware standard that allows any Windows "management" software (Excel, Word, WordPerfect, etc.) to communicate with a WfM-enabled PC.

The next step is the much-discussed Bluetooth, which is expected to start delivering products by mid-2000. There are more than 800 companies in the Bluetooth SIG (Special Interest Group), which aims at delivering a royalty-free open wireless specification. The idea is to embed tiny short-range transceivers into just about any mobile device. The transceivers may cost $20 to start, but the price will soon fall to about $5. Data throughput is a so-so 721 kilobits per second, along with three voice channels (voice and data use the same equipment). The transceivers use the unlicensed 2.45-GHz radio band and require 1/10 watt to transmit (at 8 to 30 milliamps). Standby power consumption should be as little as 1/1000 of that. This should make it possible to add Bluetooth to cameras, palm computers, pocket phones and other basic equipment (www.bluetooth.com).

Proxim's "Symphony" devices using that band (PCMCIA card, network base stations, and so forth) already are on the market. Typical throughput is 1.6 megabits per second with ranges up to 150 feet.

For shorter ranges and higher data throughput, there's infrared. Microsoft has pretty much run the standard there; its IrDA 1.2 driver kit is used by most vendors. Even so, you will find two versions of infrared transmission technology. There's Fast IR, which is on most of the newer laptops and on many printers. It transmits at up to 4 megabits per second. The older standard, serial IR, at 115 kilobits/second, is still in use as well. The range is about two feet, and the IrDA transceivers have to be lined up carefully. IrDA, the Infrared Data Association, does consist of many companies aside from Microsoft.

IrDA's next standard is Advanced Infrared, or AIr. It promises infrared connectivity up to 15 feet. The AIr ports can be offset by up to 120 degrees, far more than the 30 degrees allowed by the older standard. That's good, because you don't have to be as fussy about aligning the IrDA ports. It could be bad, because many transmitters can be "sensed" by one receiver, but software logic reduces or eliminates the potential for interference. The data transmission speed, for Fast IR, is 4 megabits per second. IBM is already selling AIr modules — transceiver, single-chip controller, controller macro, and software (www.chips.ibm.com/products/infrared). The software is as impressive as the hardware. With an AIr-equipped laptop, users can download a file to a palmtop via infrared while also responding to hardwire network requests.

What's Next in Wireless

This year's PC Expo in New York also underlined the work of hardware and software developers who intend to use these new wireless technologies for data collection, internet connections, and other functions that once required hardwire installations.

Novatel Wireless of San Diego has a wide range of products based on CDPD — Cellular Digital Packet Data — also known as Wireless IP. CDPD uses the existing cellular phone network (strictly speaking, it is a network overlay that coexists with regular "AMPS" cellular) to transmit small packets of data. If you lose the connection during a session, a CDPD "modem" automatically reconnects. Each one comes with its own IP address; service is available in most metropolitan areas. The "modem" is really a network interface connector.

Sierra Wireless introduced its CDPD AirCard 300 for Windows CE, 95, 98, and NT

The new AirCard from Sierra Wireless is PCMCIA Type II.

at PC Expo. It, too, is really a network interface card, not a modem. When used in a notebook computer, it automatically connects to the cellular network when the notebook is turned on. Sierra Wireless also has encryption software for its wireless devices (www.sierrawireless.com).

Qualcomm uses CDMA (Code Division Multiple Access, for PCS cellular) for a range of wireless "phones" for home and office. Just plug them into a power outlet — no phone needed (www.qualcomm.com/cdma).

Novatel has wireless modems on Type II PCMCIA cards (its Merlin line), and for Palm and Windows CE machines (the Minstrel line). The Minstrel E-15 wireless IP Modem is strictly for the Casio E-15 Palm PC. Its lightweight "Expedite" modem module can be embedded into OEM equipment. A larger version, the NRM-6812 line, can operate under a wider range of temperatures and voltages. Typically, devices using the Wireless IP network can expect throughput around 19.6 kilobits per second — adequate for most e-mail and data collection needs (www.novatelwireless.com).

Xircom also has CompactFlash-size modems for Windows CE and will soon release wireless GSM "cellular" modems (www.x ircom.com). Want to stick to ethernet? WinNet sells 100-megabit-per-second wireless fast ethernet cards (www.winnetmcs.com). Socket Communications offers one-stop shopping for "battery-friendly," low-power wireless networking cards and other devices (www.socketcom.com).

Palm Computing's Palm VII Organizer comes with Internet access right out of the box. It started selling in the New York City area, with sales rolling out nationally through 1999. The wireless network services are provided by OpenSky, a joint venture of Palm's maker, 3Com, and Aether Technologies. The company is marketing network services to Windows CE devices as well. At PC Expo, 3Com ran a convincing demonstration for the press, with Palm devices communicating via network and by beaming messages from machine to machine through infrared.

The Palm has a wide variety of data acquisition options. The more widely used Palm III and Palm IIIx, as already noted, can be equipped with a modem or cellular modem. There are also bar code readers and other devices that fit into the Palm's CompactFlash slot (www.palm.com). If you only need messaging and paging, look at the Blackberry from RIM (Research in Motion) and various paging devices such as eLink from American Mobile (www.blackberry.net; www.ammobile.com). On the e-mail side, and if you need to connect to printers via wireless infrared, look at Hewlett-Packard's CapShare 910 "information appliance," a Windows CE device. IBM's Lotus division has developed a pager gateway that extends Domino and Notes servers to handheld devices.

Puma's code editor helps create thin-client forms easily.

The Software Question

If palm-size devices are to be used collecting data in the plant or in the field, as wireless networkers expect will increasingly be the case, some changes will have to be made in software architecture. The key to using small computers for collecting information is to have as little software on them as possible. Most of the work is done at the server instead, with the palmtop or similar device handling only the fill-in form. To put it another way, the Palm Pilot IIIx, with 4 MB of RAM, is as "thin" a client as can be easily imagined by modern programmers.

Cardiff Software inadvertently illustrated the problem. Its TELEform PDF+Forms allow developers to create fill-in-the-blank forms in the Adobe Acrobat 4.0 format. The forms can be programmed to sense incorrect or inappropriate data. Validated data is sent automatically to a Microsoft Access 2000 database or Excel 2000 spreadsheet for analysis or further processing. The software is flexible, stable, and easy to use. But if you install it on a mobile platform, the platform has to be running Windows and have plenty of disk space (www.cardiff.com).

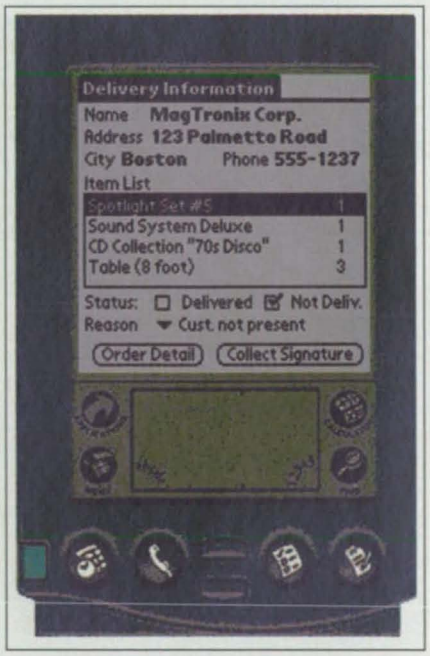
In contrast, Abaco, which exhibited in the Microsoft "partner pavilion" at PC Expo, has ten years' experience with thin client terminal software for small devices. It offers some devices of its own, along with many software tools (www.abacoinc.com).

Another company with offerings in this area is AvantGo, which sells software running on the Palm OS and Windows CE. It networks using Internet protocols. As an example, it works well with Novatel's Minstrel wireless devices. AvantGo has licensed Certicom's security technology for mobile enterprise customers with Windows CE and Palm Computing handhelds (www. avantgo.com).

Extended Systems has what it calls Enterprise Harmony '99 for synchronizing data among windows, Windows CE, and Palm devices — and even the Casio Pocket Viewer (www.extendedsystems.com).

Puma Technologies, with its Intellisync line of synchronization software and its Satellite Forms software for Palm OS devices, also has made a splash (www.pumatech.com).

With all these tiny devices connected only by thin air to anything, you probably are worrying about the consequences of gravity. After all, who would want to risk dropping a $300 Palm Pilot as you collect data? Oddly enough, we found only one vendor working on the problem. Concept Kitchen sells a wrap-around rubber bumper that surrounds and cushions the Pilot's edges (www.conceptkitchen.com).



The completed Puma form, running on a Palm Pilot Professional.

Steven S. Ross is an associate professor at Columbia University's Graduate School of Journalism in New York. With an undergraduate degree in physics, he has written several books on product design.

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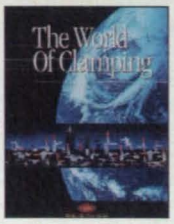

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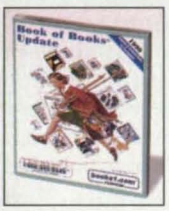

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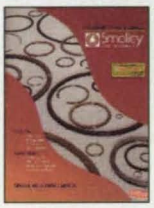

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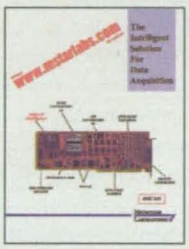

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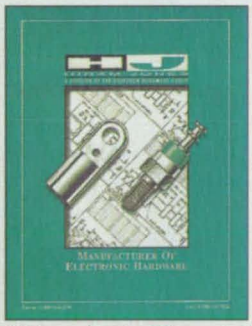

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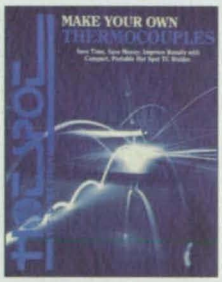

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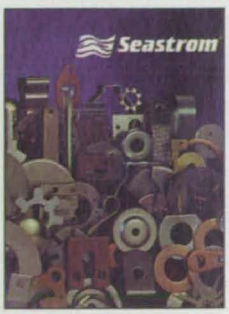

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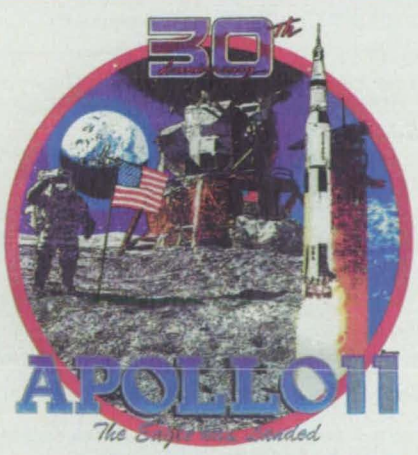

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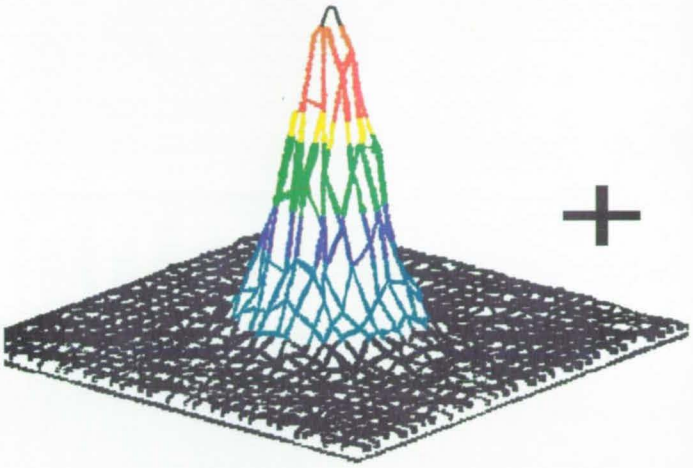

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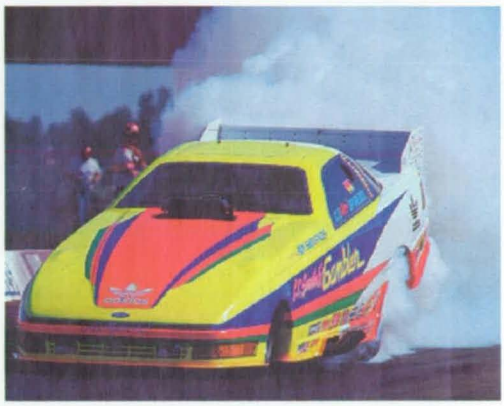

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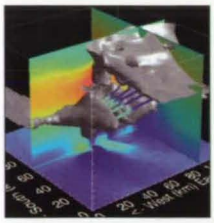

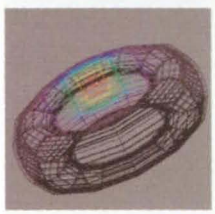

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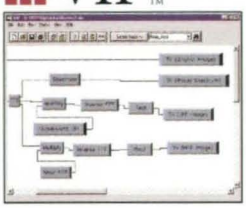

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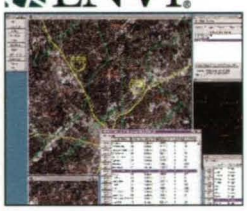

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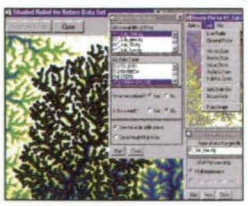

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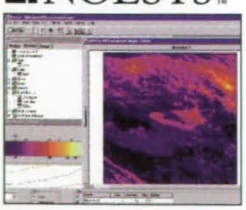

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