ovember 1997 www.nasatech.com Vol. 21 No. 11

TECH BRIEFS

THE DESIGN/ENGINEERING TECHNOLOGY DIGEST

Test & Measurement

NASA Tracks El Niño

Electronics Tech Briefs

Product of the Month "UpFront" Page 16

Instrumentation Software News

Acquire Data with Excel
Control GPIB, serial, and plug-in DAQ boards with Measure®

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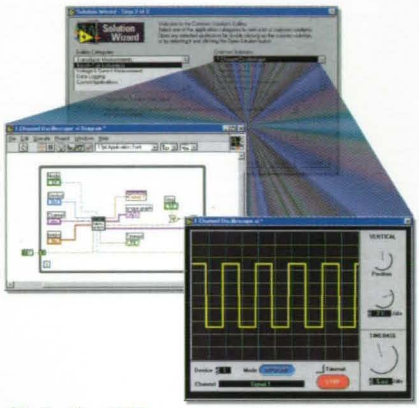

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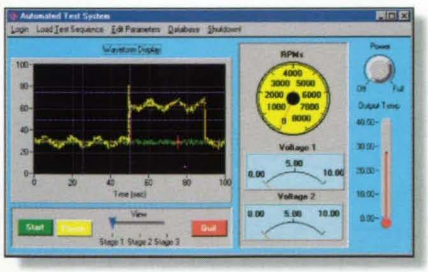
Circle No. 569

Powerful C/C++ Libraries for Instrumentation



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- Easy-to-use GUI editor
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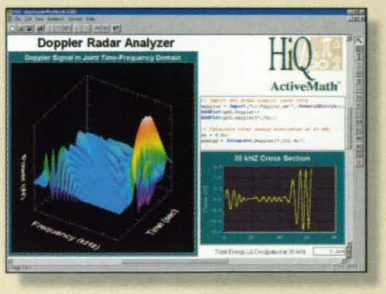
3D Visualization, Analysis, and Report Generation



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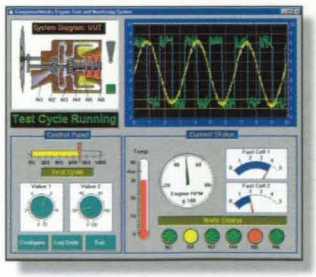

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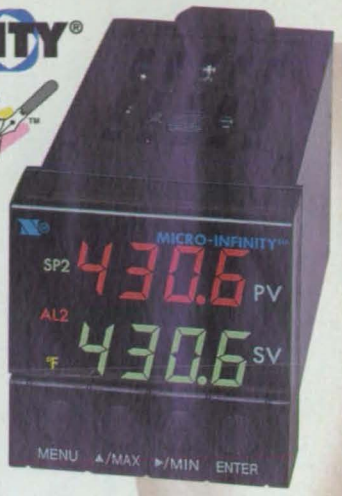

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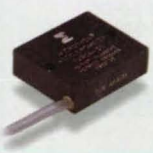

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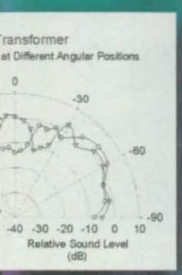

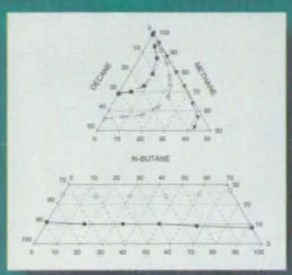

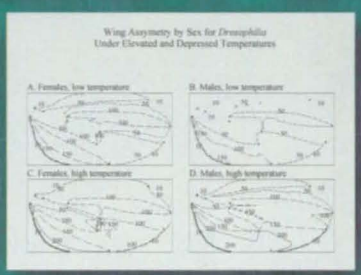

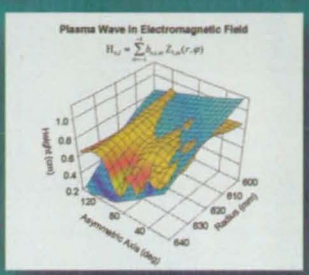

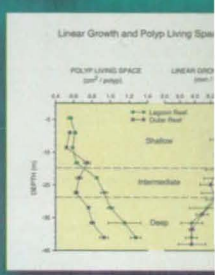

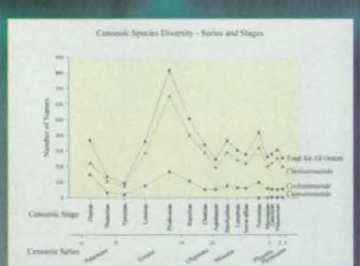

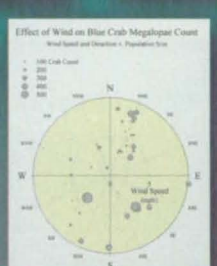

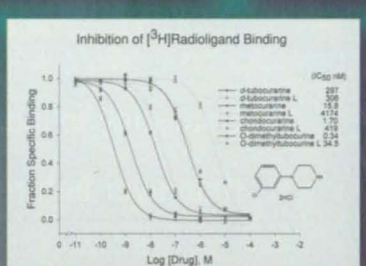

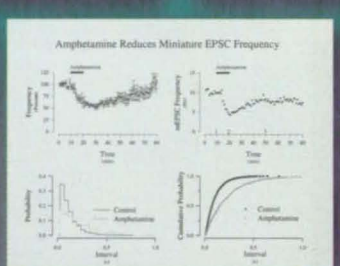

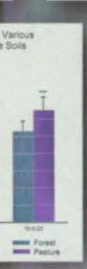

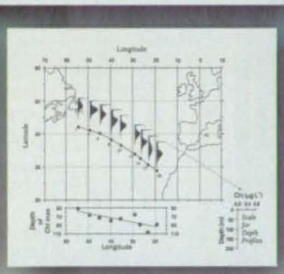

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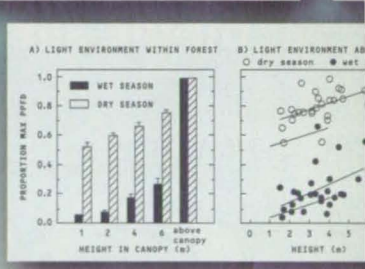
Review of eleven competitive products
Desktop Engineering Magazine,
September 1996



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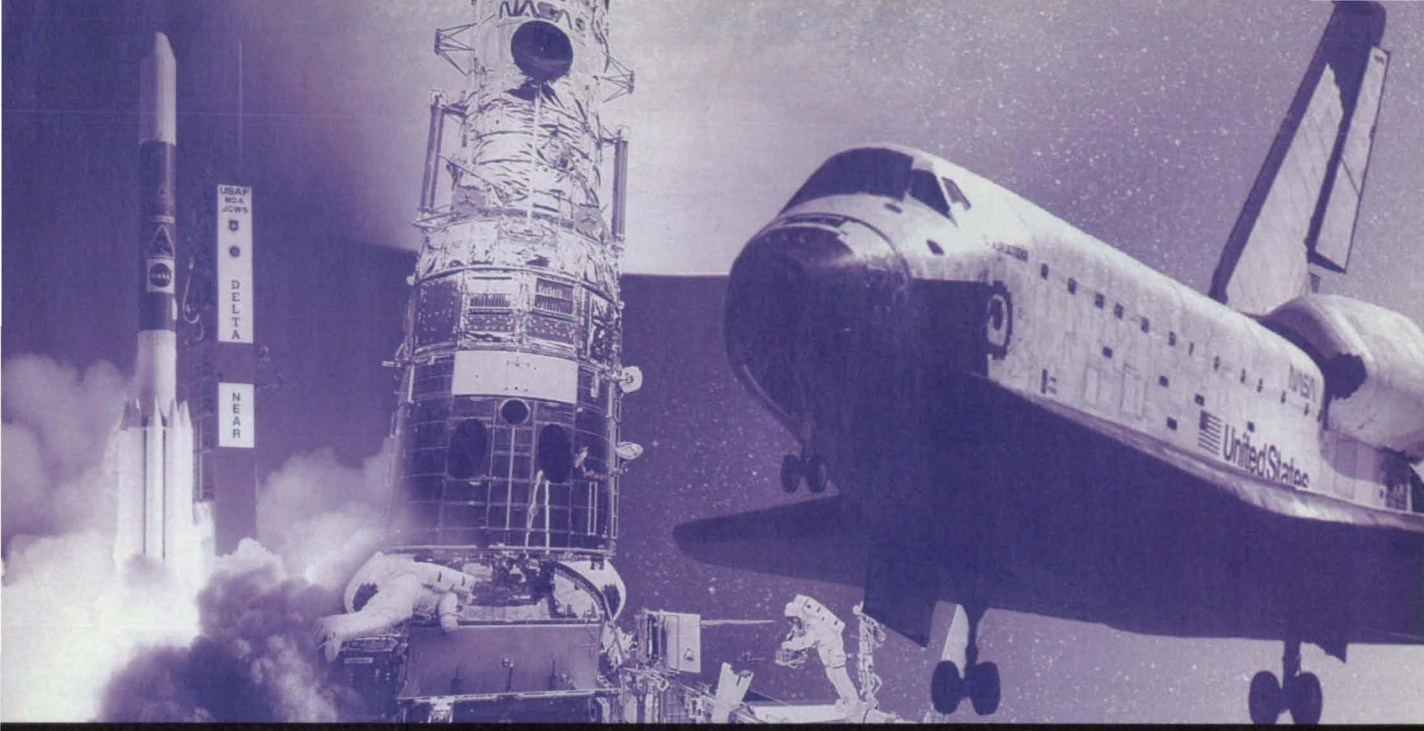

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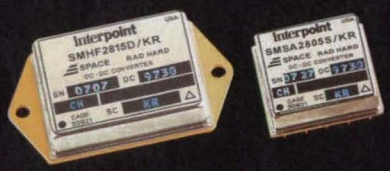

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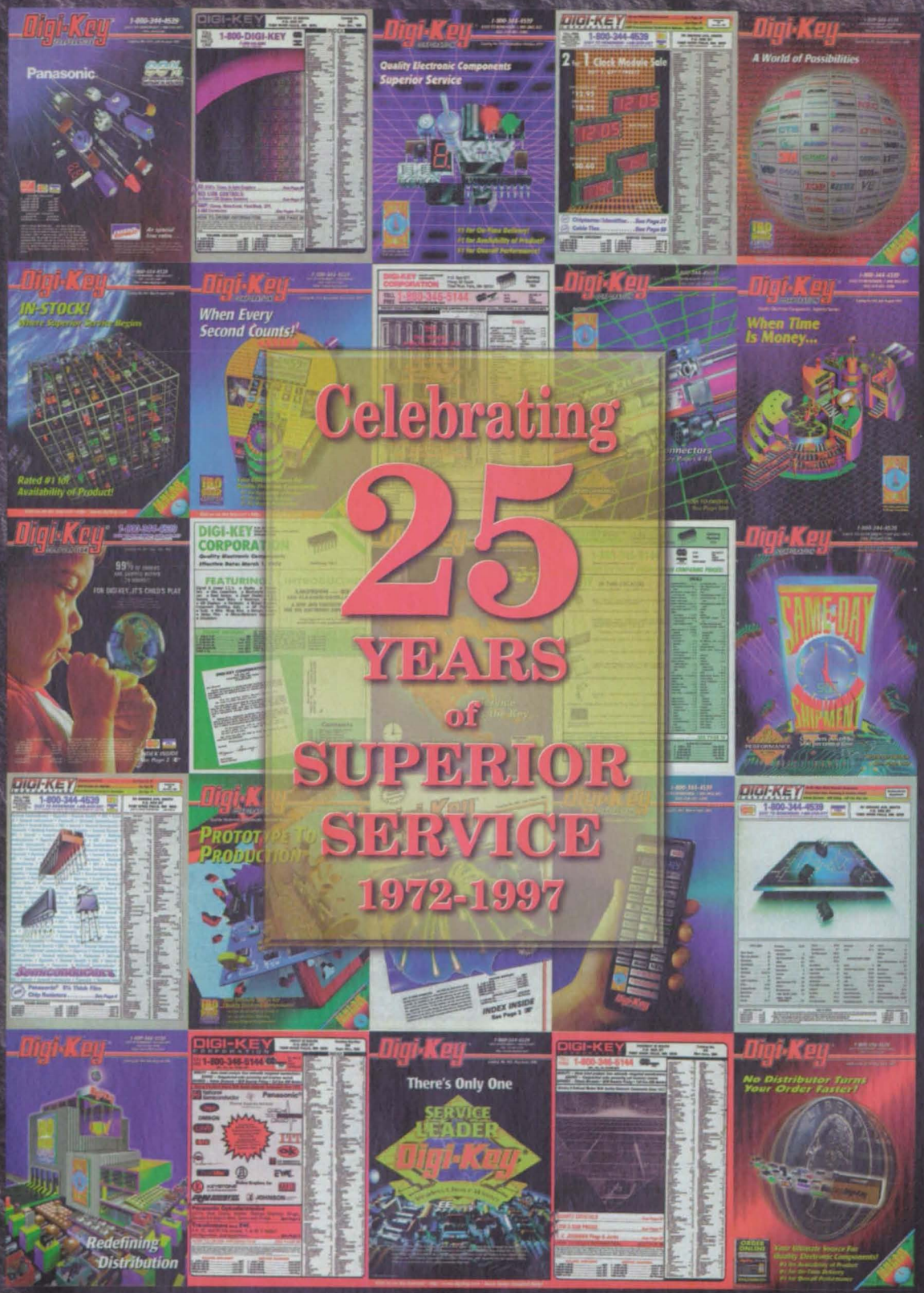

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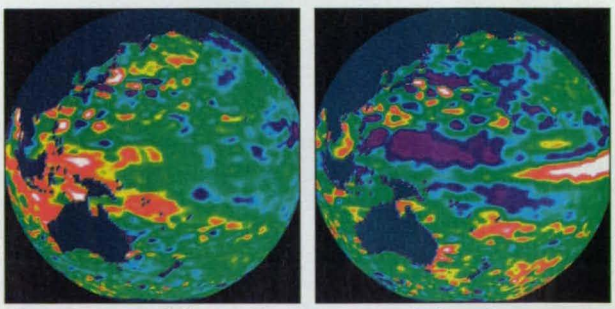
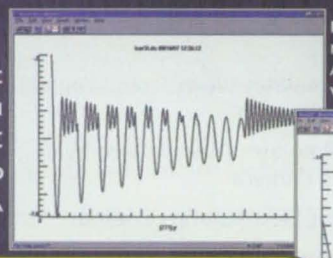


These images of the Pacific Ocean near Indonesia were produced using sea-surface height measurements taken by the TOPEX/Poseidon satellite. In December 1996 (left image), red and white areas indicate the presence of warm, higher-than-average sea level; by August 1997 (right image), sea level dropped well below average as shown by purple areas. This data has helped determine the presence of the extreme weather condition known as El Niño. For more information on NASA's El Niño research — and other important innovations on display at Technology 2007 — see the highlights beginning on page 24.

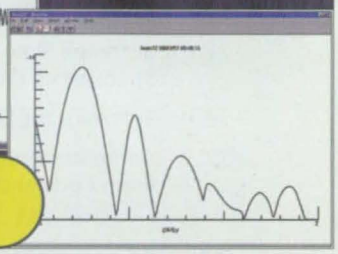
Images courtesy of NASA's Jet Propulsion Laboratory

LINEAR STATIC FEA IS FINE IF YOU MAKE STONE STRUCTURES WHICH AREN'T GOING TO MOVE FOR THOUSANDS OF YEARS.

IN THE REAL MECHANICAL WORLD REAL THINGS EXPERIENCE DYNAMIC LOADS THROUGH IMPACT AND OTHER CHANGES IN MOTION AND ARE NEVER COMPLETELY RIGID. ACCUPAK/VE SIMULATES REAL EVENTS WITH FLEXIBLE BODY MOTION AND PREDICTS IF AND WHEN A PART WILL FAIL AND PRODUCES A COMPLETE ANALYSIS OF STRESS VS. TIME.



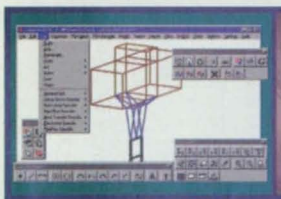
PYRAMID ENGINEERS DID NOT NEED TO PLOT SUCH THINGS AS ACCELERATION OR STRESS VS. TIME.



ACCUPAK/VE IS NOT LIMITED TO "RIGID BODY" MOTION.

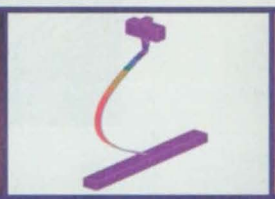
FLEXIBLE BODY MOTION AND FEA IN ONE PROCESS!

BELOW, SCENES FROM A RECENT ALGOR VIDEO SHOW ACCUPAK/VE PREDICTING WHAT HAPPENS TO AN ALUMINUM BAR WHEN A WEIGHT IS PLACED ON ITS END. THE EVENT SIMULATION INCLUDES BUCKLING, THE COMPLETE POST-BUCKLING SCENARIO AND CONCLUDES WITH PERMANENT DEFORMATION.



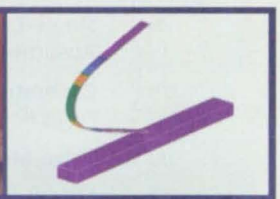
PRECISION MODELED WITH ALGOR'S SUPERDRAW III

EXPERIMENT SET UP IN LAB



SIMULATING THE EVENT WITH ACCUPAK/VE

POST-BUCKLING SCENARIO IN THE LAB



FINAL PERMANENT DEFORMATION SHOWN IN ACCUPAK/VE

Event simulation is the easy-to-use alternative to linear static and dynamic FEA.

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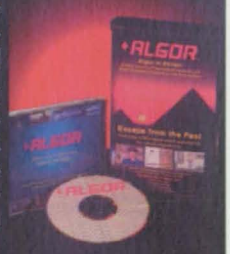

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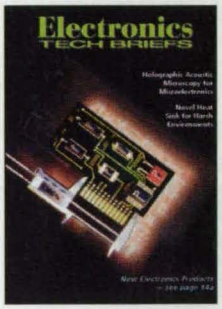

Electronics Tech Briefs

Follows page 72 in selected editions only.

On the cover:

VM Motori S.p.A. of Pieve di Cento, Italy, created this image of a turbo charger using Eureka Gold three-dimensional mechanical design software from Cad.Lab, Santa Clara, CA. The native Windows 95/NT software enabled VM Motori, an automobile engine manufacturer, to integrate surfaces, wireframes, and solids seamlessly with flexible parametrics. This month's Product of the Month, Eureka Gold is described in more detail in UpFront, a new monthly editor's page premiering in this issue on page 16.

Image courtesy of Cad.Lab

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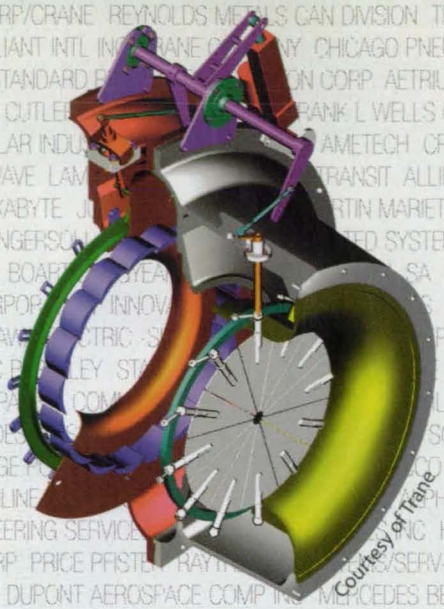

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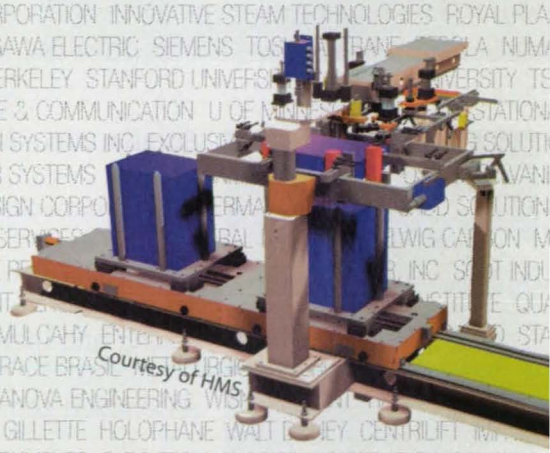

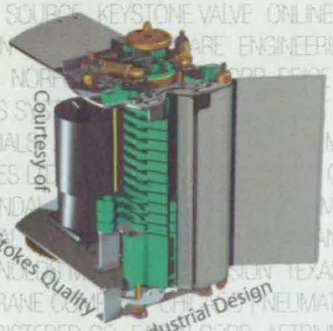

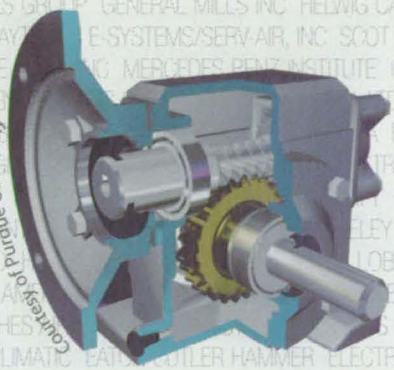

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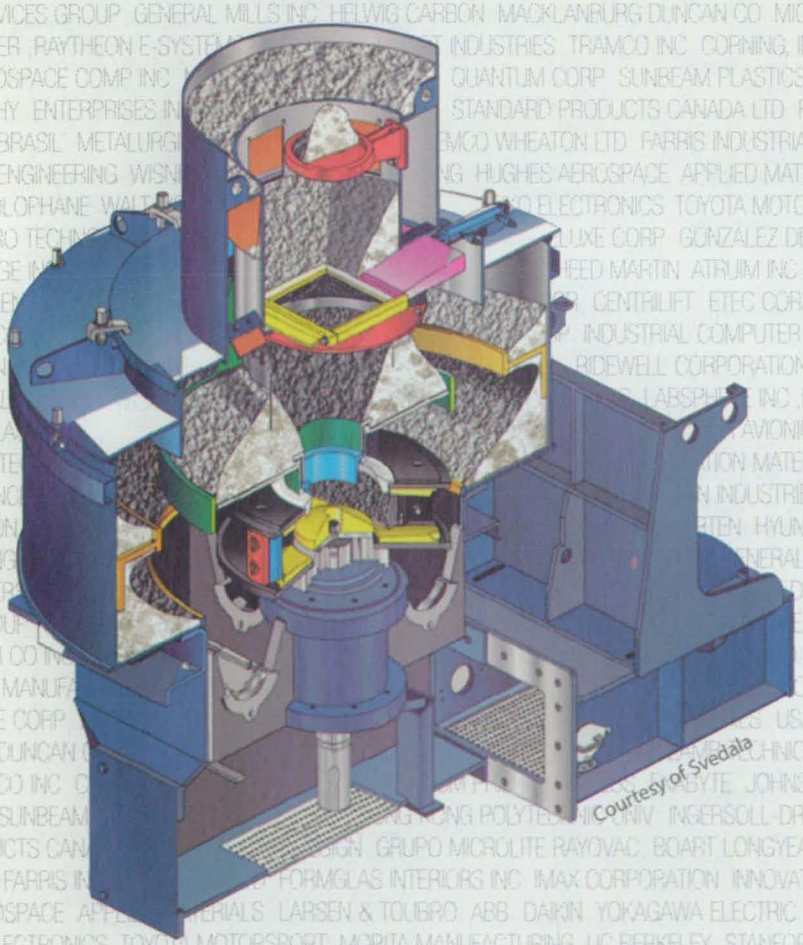

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NASA Commercial Technology Team

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 (206) 683-1005 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.
Bruce Webbon
(415) 604-6646
bwebbon@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
duke@louie.dfrf.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
(713) 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) 867-8035
galeallen-1@ksc.nasa.gov

Langley Research Center
Selected technological strengths: Aerodynamics; Flight Systems; Materials; Structures; Sensors; Measurements; Information Sciences.
Dr. Joseph S. Heyman
(804) 864-6006
j.s.heyman@larc.nasa.gov

Lewis Research Center
Selected technological strengths: Aeropropulsion; Communications; Energy Technology; High Temperature Materials Research.
Ann Heyward
(216) 433-3484
cto@lerc.nasa.gov

Marshall Space Flight Center
Selected technological strengths: Materials; Manufacturing; Nondestructive Evaluation; Biotechnology; Space Propulsion; Controls and Dynamics; Structures; Microgravity Processing.
Harry Craft
(205) 544-5419
harry.craft@msfc.nasa.gov

Stennis Space Center
Selected technological strengths: Propulsion Systems; Test/Monitoring; Remote Sensing; Nonintrusive Instrumentation.
Kirk Sharp
(601) 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.

Dr. David Moran
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
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(216) 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)
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Gerald Johnson
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Office of Microgravity Science Applications (Code U)
(202) 358-1958
bhansen@gm.olmsa.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.

Karen Robbins
American Technology Initiative
Menlo Park, CA
(415) 325-5353

Dr. Jill Fabricant
Johnson Technology Commercialization Center
Houston, TX
(713) 335-1250

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

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

Dan Morrison
Mississippi Enterprise for Technology
Stennis Space Center, MS
(800) 746-4699

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. For software developed with NASA funding, contact the **Computer Software Management and Information Center (COSMIC)** at phone: (706) 542-3265; Fax: (706) 542-4807; E-mail: http://www.cosmic.uga.edu or service@cosmic.uga.edu.

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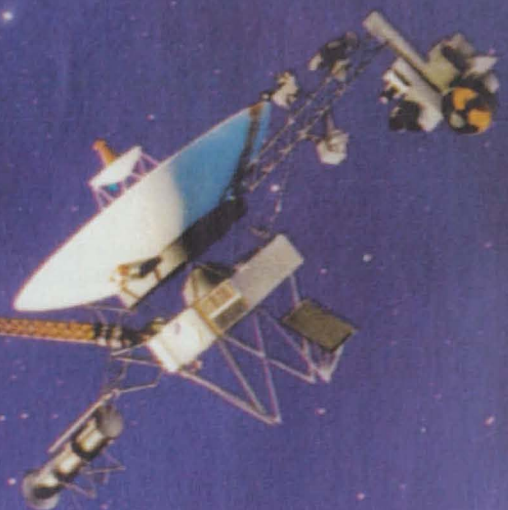

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For More Information Circle No. 517

UpFront

Welcome to UpFront, a new monthly editor's choice page that features the Product of the Month, NASA news, reader comments, and other items of importance to our engineering audience. Please e-mail your comments to me at linda@abptuf.org
— Linda L. Bell, Chief Editor

Product of the Month

Cad.Lab, Santa Clara, CA, has introduced Eureka Gold 97 3D mechanical design software operating in a native Windows environment. Features include integrated conceptual design, engineering, and documentation that allow users to design within a single software environment. Surfacing capability for styling and concept design phases is integrated with 3D solids modeling. Unrestricted legacy data usage enables access and reuse of existing CAD geometry, and flexible parametrics allow for partially constrained or unconstrained geometry of features, parts, and assemblies. Product data management is enabled using the optional TeamManager™ through support of relational data management systems such as Oracle.

For More Information Circle No. 748

Toy Story

It rocks and rolls, just like the real one. Mattel's Hot Wheels JPL Sojourner Mars Rover Action Pack Set, a toy version of the Mars Pathfinder Sojourner rover, recreates the real rover's distinctive, six-wheeled "rocker-bogie" locomotion system. The die-cast metal toy is available nationwide and was created by Mattel through the Technology Affiliates Program at NASA's Jet Propulsion Laboratory (JPL). Through the program, corporations like Mattel form strategic alliances with JPL to license intellectual property. The toy is an exact model in exterior appearance of the Sojourner, and features many working, moving parts. "We hope this does indeed turn out to be a big hit," said Merle McKenzie, manager of JPL's Commercial Technology Office. "After all, what better way to inform the public about the space program and get everyone enthused about the marvelous technology it has inspired?"

For More Information Circle No. 750

Current JPL-SCIGN GPS monitor stations and major Southern California fault lines.

Shake, Rattle, and Roll

Earthquake researchers measuring the movement of the Earth's surface with the Global Positioning System (GPS) have concluded that the Northridge, CA earthquake has continued in a "quiet" way, and the Granada Hills have risen about 16 centimeters (approximately 6 inches) since the first jolt in January of 1994. The Southern California Integrated Global Positioning System Network (SCIGN) is conducting the research. Scientists from NASA's Jet Propulsion Laboratory, the Scripps Institution of Oceanography, the U.S. Geological Survey, and the Southern California Earthquake Center are collaborating on efforts to increase the number of permanent GPS receivers in Southern California.

For More Information Circle No. 753

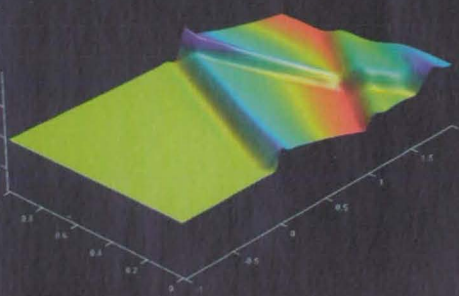
Reader Comments

"We are currently bidding the Land Transportation Office Information Technology Project, which will utilize massively parallel processing computers, employ data warehouse technology, and use Internet/Intranet strategies to provide wider access by external and internal users compared to traditional client/server technologies in the LAN/WAN environment. We would appreciate very much any recent information, especially the Next Generation Internet's path within the next ten years."

Renato Tababa, Director for Operations and IT Project
Land Transportation Office, Dept. of Transportation & Communications
Quezon City, Manila, Philippines

*(**Editor's Note:** Renato, there is a wealth of recent information available on the Next Generation Internet (NGI). Initiated by President Clinton on October 10, 1996, the NGI was designed to help create the foundation for the Internet and networked applications of the 21st century. NASA is one of six federal agencies backing the NGI project, which should improve the end-to-end performance of the Internet by 100 to 1000 times. You can find more information by accessing the NGI web site at: http://www.ngi.gov)*

Don't forget to cast your vote for *NASA Tech Briefs'* 1997 Product of the Year. You'll find a ballot in the December issue.



Technical Graphics

MATLAB 5 lets you visualize physical phenomena like this shock wave propagating in a fluid.

Mapping

The new MATLAB Mapping Toolbox can be applied to environmental, oceanographic, and defense applications.

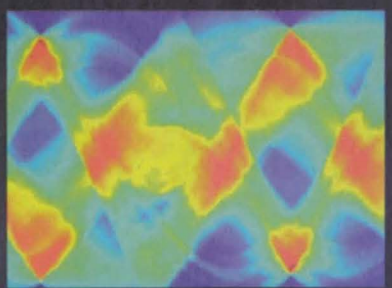


Image Processing

This Radon transform of a spine X-ray illustrates one of the many uses of the Image Processing Toolbox.

Now see what you think.

New MATLAB 5, now with advanced visualization and a complete language for application development.

New Visualization Power

Now you can quickly create more informative and revealing 2-D and 3-D graphics directly in MATLAB 5. Gain insights into complex systems using capabilities like lighting and shading, camera control and texture mapping. Efficient new algorithms make even irregularly-sampled data display faster and easier.

Application Development

A host of language and data management enhancements make algorithm and application development fast and intuitive.

We added:

- visual debugger/editor
- function performance profiler
- point-and-click GUI builder
- object-oriented programming

Multidimensional Arrays and Structures

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New Toolboxes

Companion toolboxes offer application-specific graph types, analysis functions, and interactive interfaces. New and updated toolboxes include:

- NEW Mapping Toolbox
- UPDATE Image Processing Toolbox
- UPDATE Signal Processing Toolbox
- UPDATE Control System Toolbox

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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.

Cal Poly Space Systems currently is designing payloads for Nike Orion rockets. Information that we have received from NASA Tech Briefs *has helped us in the areas of RF design, data acquisition testing and design, power supply options, software, design solutions, and transducer selection.*

Roman Devengenzo
Cal Poly Space Systems
San Luis Obispo, CA

I am trying to locate a source for an electronic slope sensor (inclination/inclinometer), also called a clinometer. Any help would be appreciated.

Dr. John Morrison
U.S. Dept. of Agriculture
Agricultural Research Service
Temple, TX

We have used some ideas from NASA Tech Briefs *and currently we have NASA engineers working on some problems with us. I would like some information on computer programs that show water flow past a body or shape. Thank you.*

Ivan L. Reddington
Bagley Bait Co.
Winter Haven, FL

I read the brief in the June 1997 issue entitled "Window Units for Solar-Assisted Heating and Cooling" (page 54). It described thermostatic devices similar to devices we have developed. In one of our applications, the position of a damper controlling air flow across a heat exchanger was modulated in response to coolant temperature flowing through the actuator. The actuator is the engine liquid cooling air flow control flap actuator on the Theseus, a remotely-piloted twin engine aircraft now being developed for NASA. I continue to enjoy NASA Tech Briefs *and appreciate the importance of their technology sharing mission.*

Nick Tallos
Engineering Manager
valves@thermomegatech.com

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.

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b. Root canal

c. Opera

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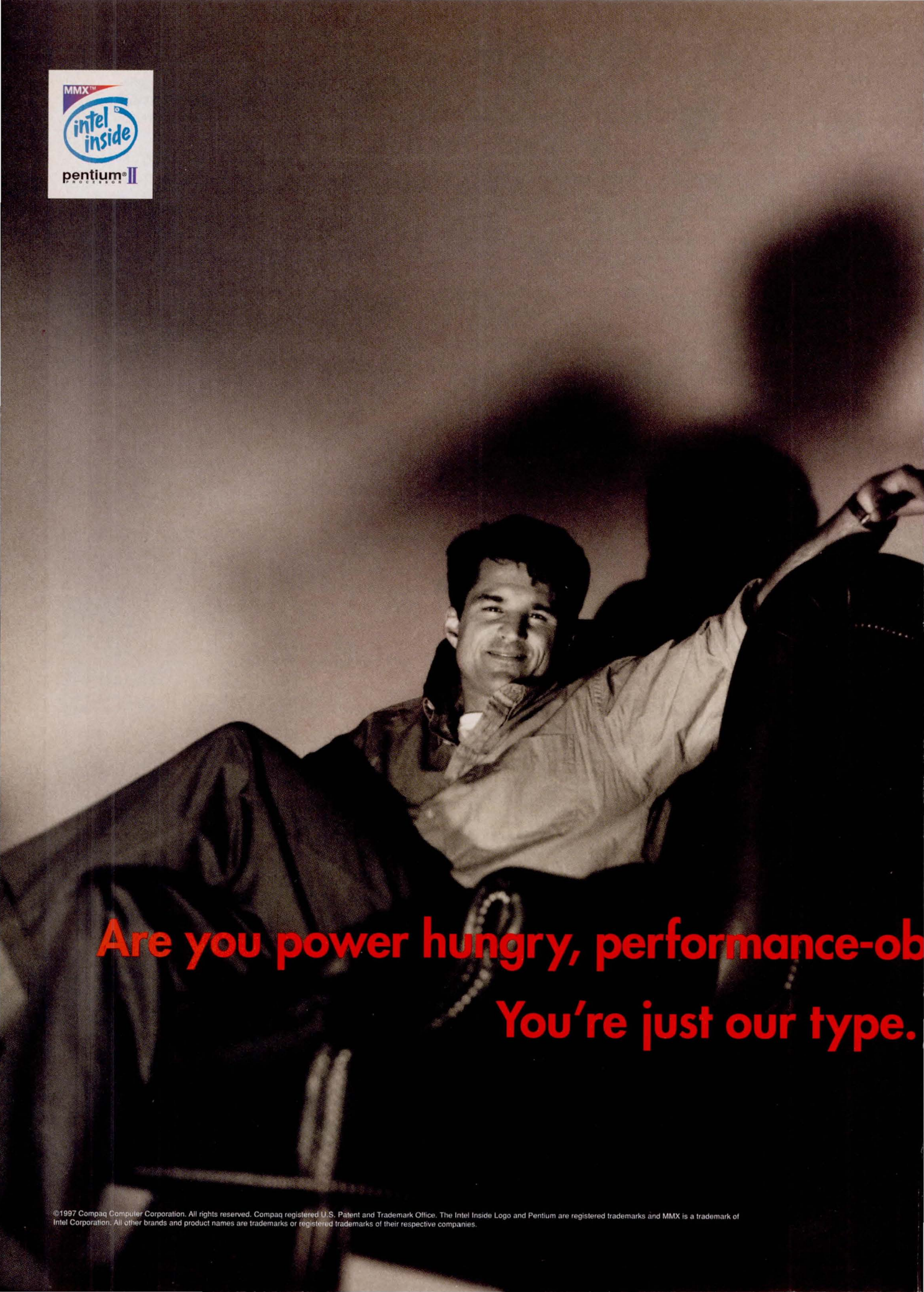

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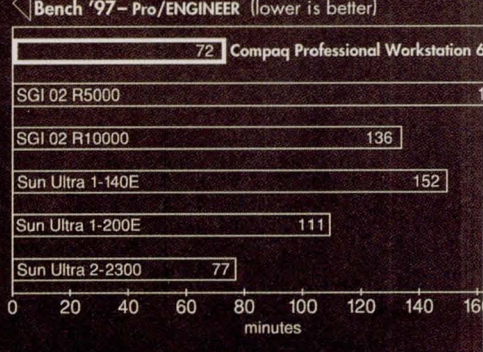

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COMPAQ

For More Information Circle No.

Sensor Helps Keep Shuttle Fuel Tank Safe

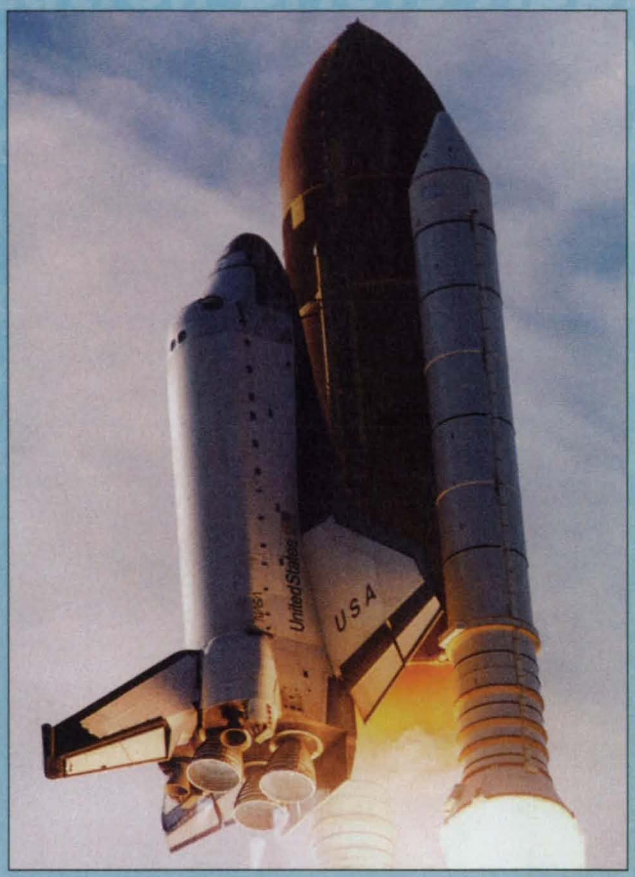
S2 two-stage chilled mirror sensor
EdgeTech
Milford, MA
508-478-9500
Fax: 508-478-1456
www.edgetech.com

The large orange external fuel tank of the Space Shuttle is constructed of an ultra-lightweight aluminum-lithium and consists of two smaller tanks that are filled with liquid oxygen and liquid hydrogen. Before delivering the tanks to NASA for use, Michoud Space Systems, a Lockheed Martin company that manufactures and supplies the tanks, performs a number of acceptance tests, including one that verifies the dew point level inside the tanks before they are pressurized.

The tank measures approximately 154 feet in length and 28 feet in diameter, and holds 1.3 million pounds of liquid oxygen and 227,000 pounds of liquid hydrogen. Test engineers first pressurize the tank to 6 psig and check for leaks. The tank is then purged with nitrogen gas over a three- to four-hour period, after which a dew point reading is taken. NASA specifies that the dew point level of the gas must be -15°C or less. If a higher dew point reading is indicated, the tank is purged again and another gas sample is taken. If excess moisture remains in the tank after it has been purged, corrosion could result, weakening the external tank.

The two-stage chilled mirror sensor is capable of achieving dew points exceeding NASA's specification — it can measure from -50°C to 100°C. The heart of the sensor is a hermetically sealed module containing a rhodium mirror attached to a two-stage thermoelectric cooler. The mirror module is designed as an integral unit to eliminate intermittent signals. A chilled mirror measurement also does not need to be compensated for temperatures that might vary during the dew point verification procedure.

For More Information Circle No. 757



The space shuttle's large brown-orange external fuel tank, shown here on the Shuttle Columbia, requires a battery of acceptance tests before use, including testing of the dew point level inside before pressurization. (Photo courtesy of NASA)

Space Station Design With Windows Program

FEMAP analysis modeling/visualization software
Enterprise Software Products
Exton, PA
610-458-3660
Fax: 610-458-3665
www.femap.com

Boeing Defense & Space Group, the prime contractor to NASA for the design, development, and on-orbit performance of the U.S. components of the International Space Station, has outfitted all major Integrated Project Teams with FEMAP software for modeling and visualizing their design analysis studies. The teams use the Windows/Windows NT environment software to solve the required stress and dynamics analyses.

The International Space Station, an orbiting laboratory that will enable beneficial scientific research that cannot be performed on Earth, is scheduled to be placed in orbit in 1998. It will sprawl across an area nearly the size of two football fields, and be visible to the naked eye as it passes overhead at an altitude of about 220 miles.

Boeing evaluated FEMAP on a limited basis last year, and proceeded with a ramp-up of the software early this year. Now, essentially all mechanical analyses for the Space Station are modeled, visually interpreted, and documented using FEMAP, which was integrated with Boeing's Windows 95 and Office 95 information systems environment.

For More Information Circle No. 756

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September 1997, *BackOffice Magazine*

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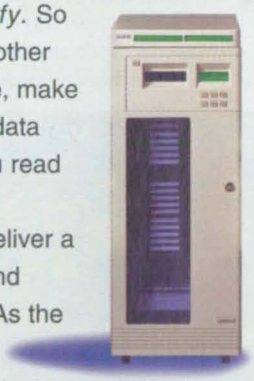

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Fax (757) 833 - 9300

CYBERNETICS

Technology 2007: The Future on Display

More than 6,300 engineers, scientists, and government and industry leaders attended Technology 2007 in Boston from September 22-24. Held in conjunction with the Photonics East and Electronics Imaging International conferences and exhibitions, Technology 2007 featured new products and technologies on display by nearly 200 exhibitors. Here are some of the innovative technologies highlighted at the show.

Stormy Weather

One of NASA's most comprehensive programs, Mission to Planet Earth, was highlighted at the NASA pavilion. Since NASA was created in 1958, it has been studying the Earth and its environment by observing the atmosphere, oceans, land, ice, and snow, and how they influence our climate and weather. In 1991, Mission to Planet Earth was launched by NASA to study Earth as an environmental system. The program comprises three components: Earth-observing satellites, an advanced data system, and a team of scientists who will study the data.

Phase I of the program is comprised of focused, free-flying satellites; Space Shuttle missions; and airborne and ground-based studies. Phase II begins next year with the launch of the first Earth Observing System (EOS) satellite, which will generate a 15-year environmental database focused on climate changes. This information will help scientists understand the world's oceans and their effects; measure harmful ultraviolet radiation; predict regional seasonal and annual precipitation for agriculture; document the success of international ozone protection treaties; and show how the Earth's surface is changing due to volcanoes, earthquakes, wind, and rain.

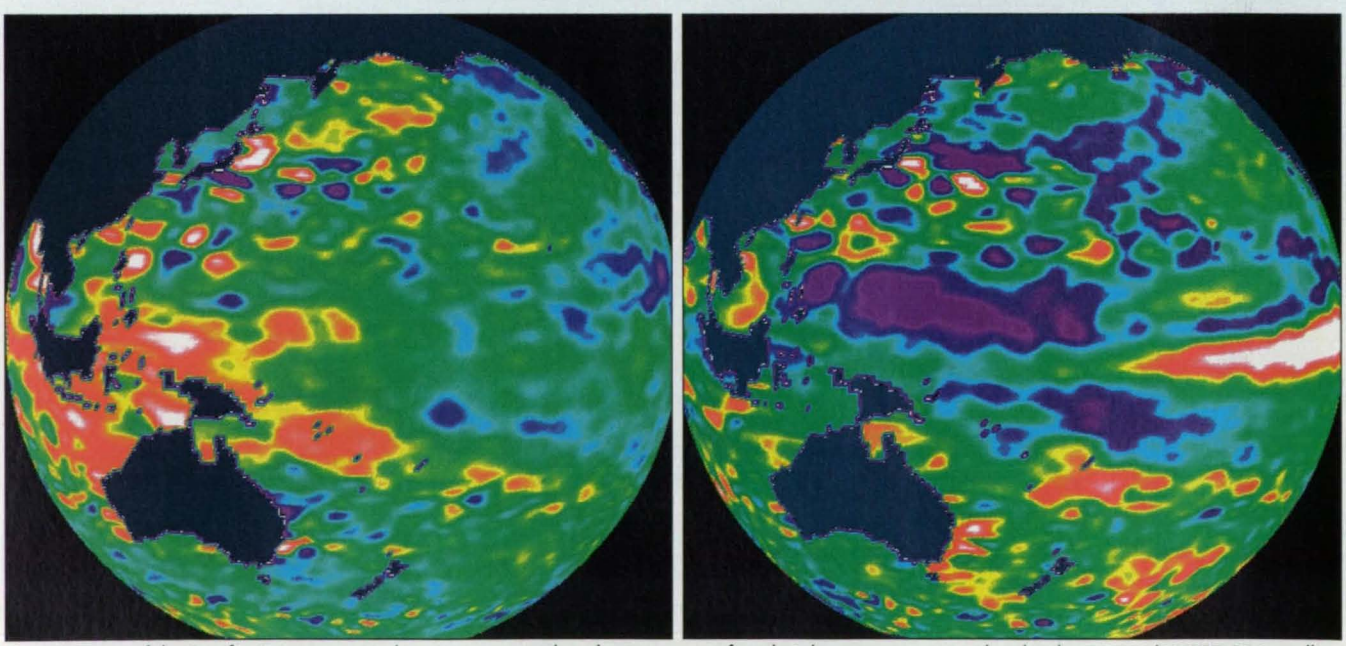
Taking advantage of the wealth of data already obtained since the program's launch in 1991, scientists have been able to understand the weather-disrupting phenomenon called El Niño and what processes produce these extreme weather conditions. The key element of the El Niño phenomenon is the interaction between the winds in the atmosphere and the sea surface. The El Niño is thought to be triggered when steady westward trade winds weaken and reverse their direction, allowing the large mass of water usually located near Australia to move eastwardly along the Equator until it reaches the South American coast. The displaced water mass affects evaporation where rain clouds form, and alters the typical atmospheric jet stream patterns, impacting global weather. These episodes usually occur every two to seven years.

Past El Niño events have caused unusually heavy rain and flooding in California, unseasonably mild winters in the Eastern U.S., and severe droughts in Australia, Africa, and Indonesia. Scientists believe that El Niño conditions in 1993 were responsible for $8 billion in damages in 33 countries.

Launched in 1992 as part of MTPE, the U.S.-French TOPEX/Poseidon satellite has been observing global ocean topography. The Pacific Ocean sea-surface height measurements and atmospheric water vapor information obtained have provided convincing evidence that El Niño is back and as strong as ever. "The new data collected since April 1997 confirm what we had earlier speculated upon and what the National Oceanic and Atmospheric Administration (NOAA) has predicted — a full-blown El Niño condition is established in the Pacific," said Dr. Lee-Lueng Fu, project scientist for TOPEX/Poseidon at NASA's Jet Propulsion Laboratory, Pasadena, CA.

Fu reported that the "sea-surface height off the South American coast is ten inches higher than normal, which is comparable with the conditions during the so-called 'El Niño of the century' in 1982-83." NASA's Upper Atmosphere Research Satellite (UARS), managed by NASA's Goddard Space Flight Center, has recently collected atmospheric water vapor data that supports the presence of El Niño conditions.

For more information on NASA's Mission to Planet Earth, visit the web site at http://www.hq.nasa.gov/office/mtpe or call 202-358-0706.



These images of the Pacific Ocean near Indonesia were produced using sea-surface height measurements taken by the TOPEX/POSEIDON satellite. They show sea-surface height relative to normal ocean conditions during December 1996 and August 1997. In December (left image), red and white areas indicate the presence of warm, higher than average sea level around Indonesia. By August 1997 (right image), sea level dropped well below average as shown by purple areas. White and red areas indicate patterns of unusually high heat storage; in white areas, sea surface is between 6 and 13 inches above normal; in red areas, it is about 4 inches above normal.

"Cool" Drive

Positive Variable Drive Corp. (PVD), Penfield, NY, demonstrated its Positive Variable Drive™ transmission and Infinitrac™ drive system. Based on a two-way roller clutch, the transmission has no slippage and no time interval between shifts, and — perhaps most importantly — creates no heat. The unit represents a significant weight savings over conventional transmissions, and uses only two to three quarts of synthetic oil for shifting and lubrication. PVD says that the entire range of up shifts is available for down shifting, making it easy on the brakes and keeping the vehicle under control. In tomorrow's electric vehicle, according to the company, this will allow for the most efficient recharging of the batteries, and add to the overall efficiency, since an electric motor runs most efficiently at a constant speed. For fossil fuel engines, the company estimates "conservatively" that increased gas mileage would be 20 percent when the transmission is coupled with the Infinitrac drive line.

The Infinitrac drive system has all four axles turning at the same speed. The system permits free wheeling until the standard hydraulic brakes are applied, at which time the down shift is actuated via the control computer. Neutral is achieved by means of an electrically controlled hydraulic clutch that completely disengages the engine and transmission. Handling is improved overall because there is no intermittent torque transfer from one axle to the other on either front or rear wheels.

All the system's components are completely mechanical except for the varying-velocity synthetic oil used to shift the transmission. PVD has U.S. patents on the major components of the two systems, and says that these have been constructively reduced to practice.

For more information, contact PVD at 185 Pleasant Way, Penfield, NY 14526; Tel: 716-381-0728.

Bridging the Gap

A special program track featured Carol G. Cohen, program manager of assistive technology for the National Institute on Disability and Rehabilitation Research (NIDRR), part of the U.S. Department of Education. "Solutions for Persons with Disabilities: Bridging the Assistive Technology Gap" brought together representatives from federal labs, NASA, R&D organizations, industry, and the consumer market to discuss how they can collaborate to develop solutions to assistive technology problems.

Assistive technology (AT) is defined as "any device, item, piece of equipment or product system, whether acquired commercially off-the-shelf, modified, customized, or developed that is used to increase, maintain, or improve the functional capabilities of an individual with a disability," according to the Technology-Related Assistance for Individuals with Disabilities Act Amendments of 1994.

A number of assistive technology-related organizations already have joined to locate partners and collaborators to move sophisticated technologies into the disability market. The Consumer Assistive Technology Transfer Network (CATN) is a central network that identifies links to resources for consumers requiring solutions to difficult assistive technology problems. The CATN also helps developers, researchers, and engineers identify resources for commercialization of prototypes and technology applications. NIDRR supports the CATN as an initiative to expand consumer involvement in assistive technology transfer. The network is funded by NIDRR and represents:

- the Federal Laboratory Consortium (FLC), which consists of more than 500 research and development federal labs;
- the Rehabilitation Engineering and Assistive Technology Society of North America (RESNA), which promotes the exchange of ideas and information for the advancement of assistive technology;
- the Rehabilitation Engineering Research Center on Technology Evaluation and Transfer (RERC-TET), which works with inventors of assistive devices to turn them into commercial products;
- the Department of Education, which funds NIDRR through the Office of Special Education and Rehabilitation Services;
- the Department of Defense, through the Computer/Electronic Accommodations Program (CAP), which provides assisitive technology to allow DoD employees with disabilities to access computer and telecommunications systems;
- the Department of Veterans Affairs, Rehabilitation Research & Development Service Technology Transfer Section, which manages a program of identifying and facilitating the clinical application and commercial availability of R&D that impact positively on veterans' rehab.

NASA's objective is to serve as a technology resource and become a model for effective transfer and commercialization of technology to benefit people with disabilities, according to Dr. Alfred Pappano, manager of the Commercial Development Office at NASA's Jet Propulsion Laboratory in Pasadena, CA. Pappano is spearheading NASA's involvement through funding by the agency's Commercial Technology Division. He stressed that NASA does not seek to enter the assistive technology product manufacturing arena. Rather, NASA's goal is to find ways in which its technologies can be used in the assistive device market, and to successfully transfer those technologies to the manufacturers.

NASA's advances in the fields of imaging, electrical stimulation, and computer equipment already have been commercialized for use by people with disabilities. Pappano said he hopes awareness of the potential benefits of NASA technologies will grow, helping to get new products into the hands of the consumers.

For more information, contact the following: CATN at 505-989-9409 or http://www.rt66.com/catn.org; RESNA at 703-524-6686 or http://www.resna.org/resna/reshome.htm; RERC-TET at 716-829-3141; CAP at 703-681-8811 or http://www.ha.osd.mil; Dept. of Veterans Affairs at 410-962-1800; Dr. Al Pappano, NASA JPL, at 818-354-5007.

Small Businesses — Big Innovations

The Small Business Innovation Research (SBIR) Pavilion offered wide-ranging and innovative technology on display. Aerodyne Research of Billerica, MA, demonstrated its plant fluorescence sensor, developed under Phase I and Phase II SBIR contracts with NASA Stennis Space Center, Mississippi. The goal of the project was a robust Fraunhofer spectral line discriminator for the *in situ* sensing of sunlight-excited fluorescence, especially from plants. Aerodyne's patented device collects light from a target and passes it through a cell containing oxygen at low pressure, which absorbs light at exactly the wavelengths strongly absorbed by atmospheric oxygen. Thus, the absorbed energy is a measure of the intensity of target fluorescence, with minimal response to incident sunlight. Because these bands also happen to be close to features of chlorophyll's fluorescence spectrum, the device efficiently measures emissions from green plants, providing a measure of plant stress, and indicating a lack of water or nutrients, the onset of disease, or pest damage. The sensor's applications include irrigation/water conservation, precision farming, forest management and health monitoring, and the

impact of farming on greenhouse gases.

For more information, contact Aerodyne Research at 45 Manning Rd., Billerica, MA 01821-3976; Tel: 508-663-9500; Fax: 508-663-4918.

Theseus Logic, St. Paul, MN, displayed its NULL Convention Logic™ (NCL™), described as a unique delay-insensitive logic that transcends the need for clocks to control microcircuit functioning. Theseus said the patented NCL, supported with SBIRs from the Ballistic Missile Defense Office and the Defense Advanced Research Projects Agency, represents a paradigm shift. Tomorrow's microprocessors are likely to be so complex and their features so small that global synchrony may give way to asynchronous design. Until now, approaches to asynchronous design have axiomatically assumed that Boolean logic, the basis of virtually all digital design today, is fundamental. But with NCL, Boolean logic is replaced with a logic that integrates data transformation and control into a single expression, yielding inherently clockless circuits.

For more information, contact Theseus Logic at 1080 Montreal Ave., Suite 200, St. Paul, MN 55116-2325; Tel: 612-699-6622; Fax: 612-699-6933.

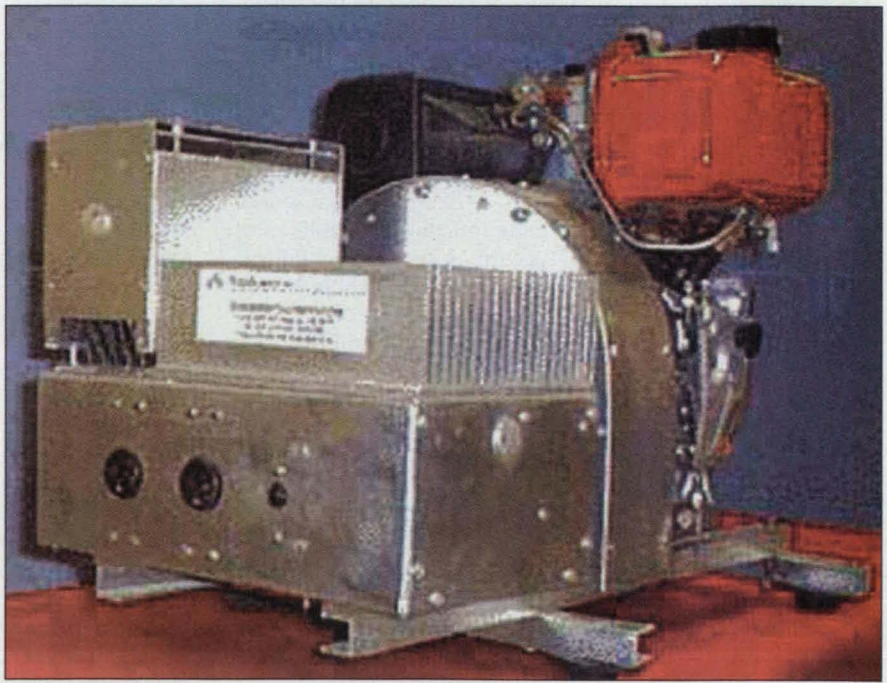
Advances in electronics have led to extensive use of communication and computing in the field. As a result, the demand has increased for portable electric power beyond what can be supplied by batteries. InterScience of Troy, NY, has developed a line of lightweight, diesel-powered electric generators in the 3 kW to 10 kW range to address this need.

The generator design makes use of advanced permanent magnet and power electronics technologies to achieve lighter weight and greater output. The design of the generators is modular; the output power of each module is a function of the diameter of the module and the frequency of the prime drive. The modules also can be stacked to scale up the total power output for larger engines. A standard 9-inch diameter module that outputs 1 kW at 3,600 RPM has been developed for a 3 kW generator that weighs less than 100 pounds. A 12-inch diameter module that can output 2 kW each at 3,600 RPM is under development for a 6 kW generator that will weigh less than 150 pounds. Both generators are man-portable, requiring no towing.

The units are configurable to output single- or three-phase AC power at 120, 208, and 240 volts at 60 and 400 Hz, and DC power at 12 and 28 volts. Both units use commercial off-the-shelf (COTS) air-cooled, single-cylinder diesel engines as the prime drive. InterScience is developing a 10 kW unit with a water-cooled COTS diesel engine and sound suppression that will weigh less than 250 pounds.

The generators weigh significantly less than those currently in use by the military that weigh from 350 to 1,250 pounds and require a trailer for transportation. Other potential applications include regenerative brakes on electric and hybrid vehicles, as automotive and motorcycle alternators and starter motors, and as emergency power.

For more information, contact David Connoly, Dir. of Mktg. of InterScience at 518-283-7500 or visit the company's web site at http://www.intersci.com



InterScience's lightweight generators are coupled with small diesel engines to form a complete, man-portable, diesel-driven generator set for mobile electric power.

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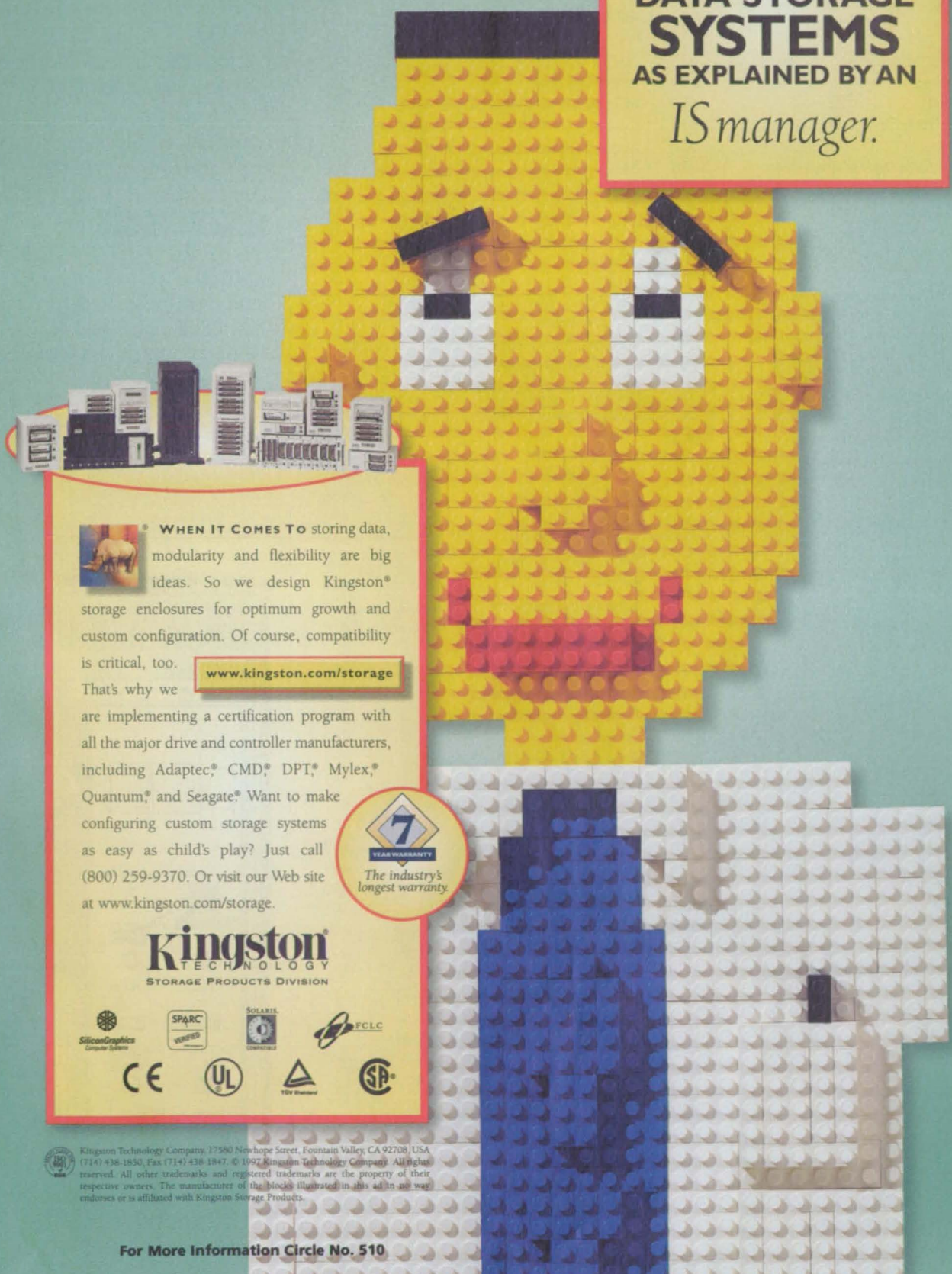

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If You Missed These Exhibitors at Technology 2007

Circle their Reader Service numbers on the Free Information Request Form (preceding page 89) for more information. For details on the products and services exhibited at the show, see the August issue of *NASA Tech Briefs* (pages 18-29), or consult the official Technology 2007 Show Program. (Copies of the Show Program are available for $10 each (postage paid) from the Technology Utilization Foundation, 317 Madison Ave., Ste. 1900, New York, NY 10017; Tel: 212-490-3999.)

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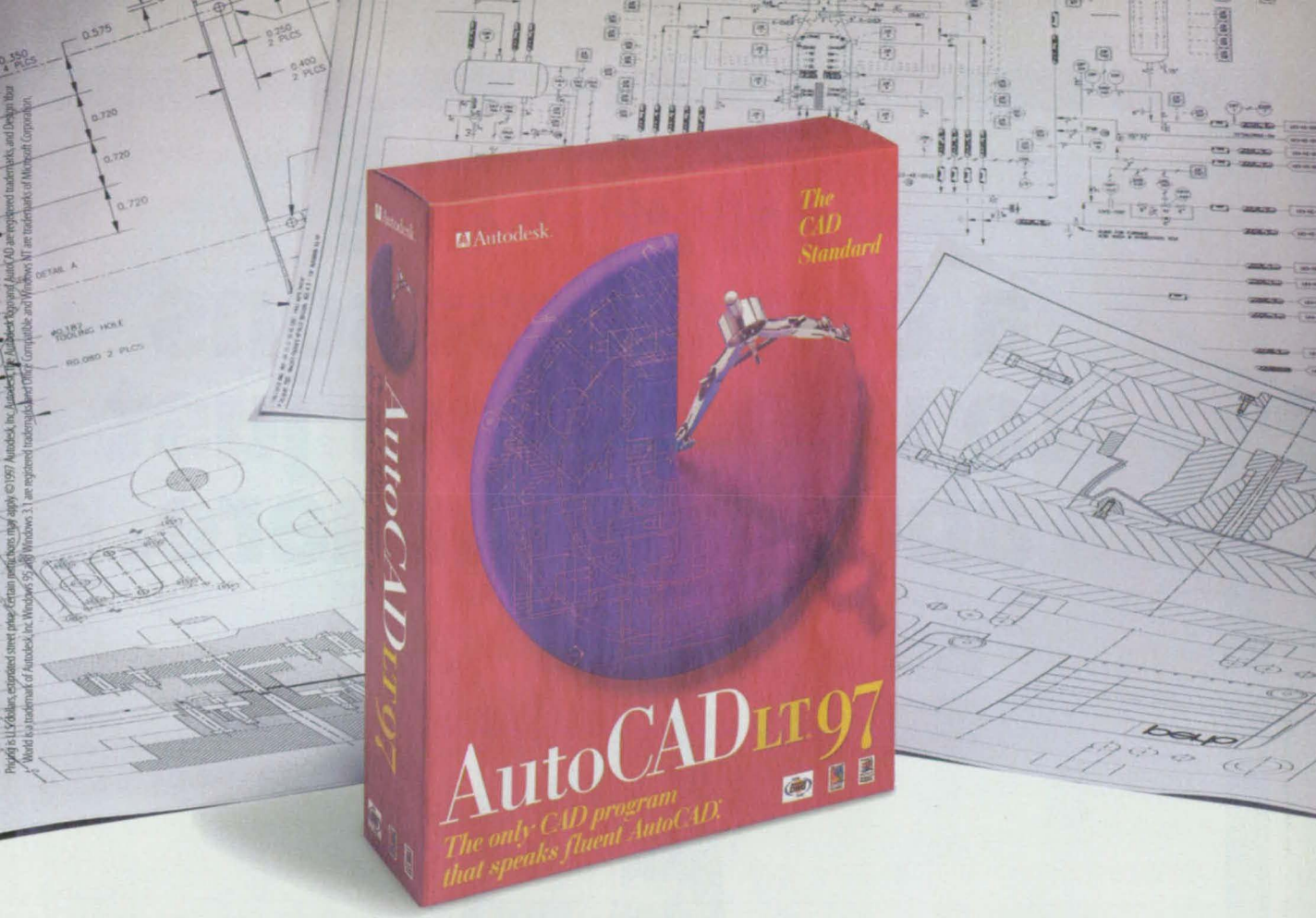

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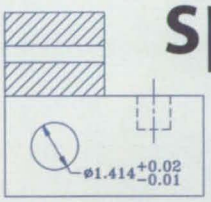

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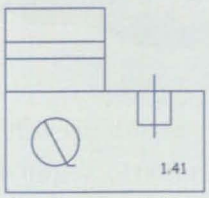

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Commercialization Opportunities

Signal-Decay Technique for Determining Qs of Power Inductors

An improved resonant-signal-decay technique is used for measuring electrical losses in quasi-linear inductors in modern electronic power-supply circuits operating at frequencies of up to 100 kHz.

(See page 39.)

Biometric Instrument Measuring Neuromuscular Disorder/Performance Degradation

An instrumented pen connected to a personal computer is used to analyze an individual's motor-skill control level. The instrument can be used to evaluate the effectiveness of treatments of patients suffering from Parkinson's disease, alcohol impairment, or other diseases affecting the neuromuscular actions.

(See page 40.)

Portable Instrument Measures Ice Profiles

A fast, accurate optoelectronic instrument is used to determine the profiles of ice deposits on the leading edges of airfoils in wind-tunnel experiments. The instrument will simplify the study of dangerous ice formation on the surfaces of aircraft.

(See page 41.)

Programmable Switch Assembly for Aircraft Systems

An autonomous programmable switch assembly is a practical answer to some of the complex and varying system-control requirements of research aircraft. As many as 16 individual cockpit switches and indicators can now be reduced to one.

(See page 56.)

Laser-Based Techniques for Research on Combustion

Laser-induced incandescence and laser-induced fluorescence are combined to analyze the images of concentrations of polycyclic aromatic hydrocarbons and of soot in flames and exhaust gases. The combination forms a powerful tool for evaluating various combustors and in determining ways of reducing atmospheric pollution.

(See page 62.)

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(See page 65.)

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Heterodyne Interferometers for Subpicometer Metrology

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NASA's Jet Propulsion Laboratory, Pasadena, California

Improved heterodyne interferometric gauges are undergoing development for use in monitoring distances within root-mean-square (rms) errors of the order of a picometer or less. Heretofore, state-of-the-art commercial and custom-made interferometers have been capable of monitoring distances to within rms errors no smaller than about 1 nanometer.

One of the improved gauges, denoted a null-metrology gauge, includes two interferometers with spatially coincident light paths (see Figure 1). The distance to be monitored is also required to be maintained constant to high precision. To maintain constancy, this distance is servoed to the null of one interferometer. The other interferometer is used as a readout device. The use of spatially coincident light paths makes it possible to eliminate the effect of air-density fluctuations, which would otherwise give rise to a minimum achievable rms error of the order of 10 nm.

The single source of light for both interferometers is a frequency-stabilized He/Ne laser. A 45° linear polarizer and a polarizing beam splitter separate the laser beam into two beams with orthogonal polarizations (denoted "S" and "P"). Each of these beams is routed through one of two acousto-optical modulators. A frequency of f exists on the radio frequency signal applied to only one of the modulators. A signal with frequencies of f + 10 kHz and f + 20 kHz is applied to the other modulator. As a result, the photodetector output that sees only the "beat" frequencies contains 10-kHz, 20-kHz, and 30-kHz signals. Among these, only 10 kHz and 20 kHz are real signals; 30 kHz is a spurious signal. The modulated beams are recombined by another polarizing beam splitter, then spatially filtered in a pinhole assembly.

By use of another polarizing-beam-splitter-and-polarizer combination, a small part of the recombined beam is diverted to a photodiode denoted the "reference" photodetector. The rest of the recombined beam enters a beam-launching assembly that comprises a polarizing beam splitter and two quarter-wave plates. Half of the recombined beam passes directly through the polarizing beam splitter, then through a 45° polarizer, and strikes another photodiode, which is denoted the "unknown" photodetector. The other half of the recombined beam makes a round trip between two corner-cube reflectors separated by a nominal distance of about 75 cm, then follows along the path of the preceding half of the beam to the unknown photodetector.

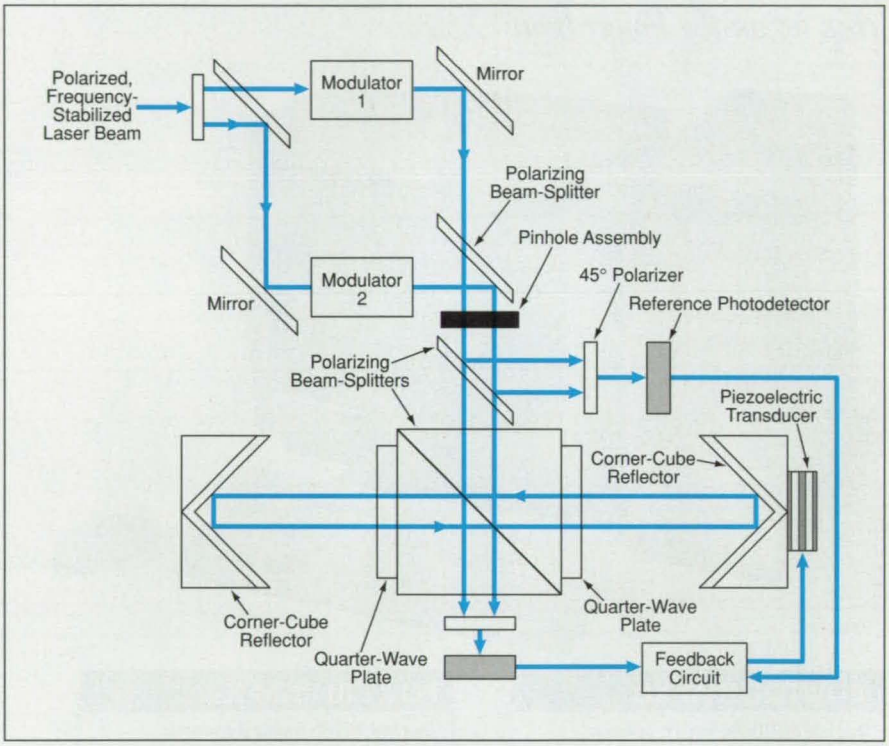

Figure 1. The **Null-Metrology Gauge** includes two interferometers implemented with modulated, polarized light beams from the same laser propagating along spatially coincident paths.

The outputs of both photodetectors contain signals at frequencies of 10, 20, and 30 kHz. (The two different combinations of modulating frequencies make it possible to distinguish between the two interferometers in subsequent processing of these signals.) For each frequency, the difference between the phases of the signals from the unknown and reference photodetectors is a measure of the distance between the corner-cube reflectors. (This is the distance that one seeks to monitor and maintain constant.)

The signals at the three frequencies are processed by a combination of analog and digital circuitry to obtain, from one interferometer, a digital relative-phase signal and an analog phase-feedback signal that is applied to a piezoelectric transducer to translate one of the corner-cube reflectors to hold the interferometer at null. The signals are also processed to obtain a distance-monitoring relative-phase signal from the other interferometer. During an observation, the digital relative-phase signals from both interferometers are recorded for subsequent analysis.

Another of the improved gauges, denoted a relative-metrology gauge, includes two interferometers with spatially separate light paths (see Figure 2). One interferometer is used to servo the distance between two corner-cube reflectors to a slowly varying separation, while the other interferometer is used as a readout device. Unlike in the null-metrology gauge, the spatial separation of interferometers makes it unnecessary

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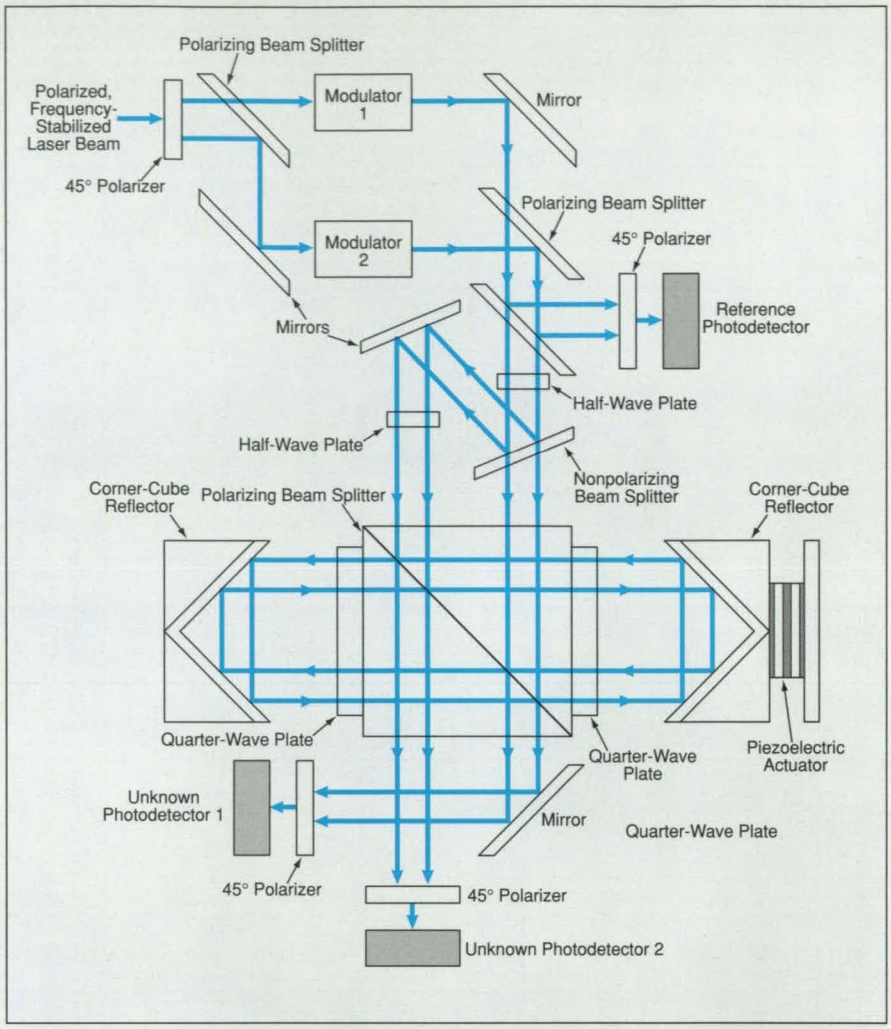


Figure 2. The **Relative-Metrology Gauge** includes two interferometers also implemented with polarized, modulated light beams from the same laser, but in this case, the beams propagate along separate paths.

to use different combinations of signal frequencies to distinguish between the two interferometers; accordingly, each acousto-optical modulator is driven at a single frequency that differs by 10 kHz from the frequency applied to the other modulator.

The relative-metrology gauge is designed to classify and eliminate various systematic errors that are not present in a null-metrology gauge. The principal systematic errors are (1) periodic errors associated with polarization leakage in imperfect optical components and (2) errors associated with temperature gradients. The temperature-gradient errors are minimized by actively stabilizing the temperatures of optical components and performing measurements quickly, before significant drift can accumulate. The polarization-leakage errors are eliminated by a method called "cyclic averaging," which involves either using a piezoelectric transducer to modulate the distance to be measured or sweeping the laser frequency at a rate that is fast in comparison with the changes in distance being measured. The amplitude of the modulation is chosen to be several wavelengths of light. The output of each interferometer is recorded at a rate sufficient to guarantee many readings during one wavelength of motion due to modulation. The true output of the interferometers at the center of modulation is computed to be the average over one exact wavelength around the center of modulation.

The null- and relative-metrology gauges have exhibited unprecedented precision: In tests, the null-metrology gauge performed with rms errors as low as 0.6 pm over observation times of 2,500 s. In other tests, the relative-metrology gauge operating in a vacuum exhibited rms errors as low as 0.13 pm over observation times of a few minutes.

This work was done by Yekta Gursel 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 Electronic Systems category,* ***or circle no. 105*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge).*
NPO-20046

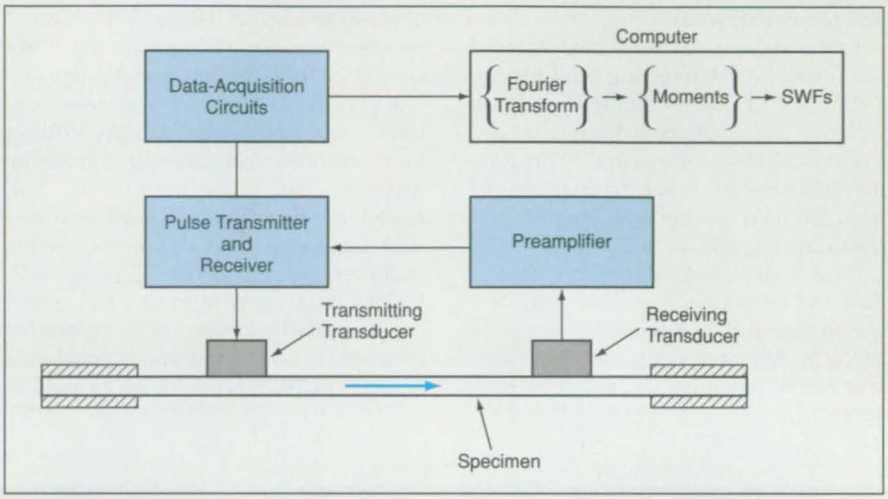
Acousto-Ultrasonic Monitoring of Ceramic Composites

The progression of damage under dynamic loads can be monitored during tests.

Lewis Research Center, Cleveland, Ohio

The acousto-ultrasonic (AU) technique has been found to be useful for assessing the state of damage and for real-time monitoring of the progression of damage in specimens of ceramic composite materials subjected to dynamic loads. The real-time AU technique could be used, for example, in fatigue tests to study the growth of subcritical flaws and other failure mechanisms in ceramic composites. Though the tests may be destructive, the AU technique is nondestructive.

Developed previously for non-real-time applications, the AU technique is a hybrid of acoustic-emission and ultrasonic techniques. The figure schematically illustrates a typical AU laboratory setup and the associated flow of information. Repeated ultrasonic pulses are excited at one location along a specimen by use of a broad-band transmitting transducer. The stress waves associated with these pulses propagate along the specimen to a receiving transducer; along the way, the stress waves interact with the microstructure and flaws present between the transducers. The received signal can be analyzed to evaluate the damage and flaws.



Ultrasonic Stress Waves that propagate from the transmitting to the receiving transducer are altered by the intervening specimen material. The output of the receiving transducer is analyzed to extract information on damage and flaws along the propagation path.

The analysis is formulated to yield parameters called "stress wave factors" (SWFs), which can be related quantitatively to the mechanical performance of the specimen material. An SWF is a measure of stress-wave energy transmission and of the efficiency with which dynamic strain energy is transferred in the material. In a comparison with a material that exhibits given SWF values, a material that exhibits greater SWF values is more capa-

ble of transmitting dynamic stress or redistributing loads and thus can be expected to be stronger. Conversely, lower SWF values indicate regions where dynamic strain energy is likely to become concentrated and promote fracture.

In the present AU technique, the output voltage of the receiving transducer as a function of time is digitized and converted to an amplitude-vs.-frequency spectrum via a Hartley transform. Various statistical moments of the frequency spectrum are then computed; these moments constitute the SWF values.

Prior to the development of the real-time AU technique, it was common practice to interrupt a mechanical test, then perform AU and other nondestructive tests before resuming the test at the next load level. In the real-time AU technique, one continues to excite pulses and process the output of the receiving transducer throughout a mechanical test, which is performed without interruption. The progression of damage is monitored by observing the changes in the SWFs computed from the received AU signals.

A mathematical model of acousto-ultrasonic stress-strain response (AUSSR) in unidirectional and cross-ply composite materials has been formulated. The model utilizes real-time AU data and classical laminated-plate theory to predict strain responses to increasing stress levels. Weibull parameters in the AUSSR model can be used to calculate design stresses for thermostructural applications. Real-time AU and the AUSSR model can be used to study failure mechanisms in specimens under quasi-static and fatigue loads.

This work was done by George Baaklini of Lewis Research Center and Anil Tiwari and Edmund G. Henneke of Virginia Polytechnic Institute and State University. For further information, access the Technical Support Package (TSP) ***free on-line at www.nasatech.com*** *under the Physical Sciences category,* ***or circle no. 102*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge).*

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Continuous Measurement of Delay Bias in a GPS Receiver

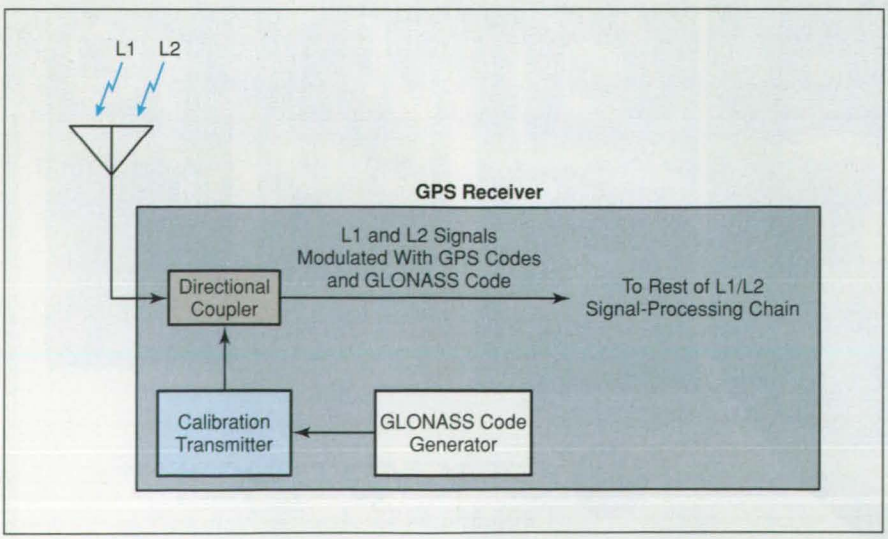
Occasional manual calibration, which is disruptive, is replaced by a continuous automated process.

NASA's Jet Propulsion Laboratory, Pasadena, California

A technique has been devised to enable a Global Positioning System (GPS) receiver to automatically and continuously measure its own delay bias. "Delay bias" signifies the difference between the times of propagation, through the receiver, of the information modulated onto two L-band signals. These signals are called "L1" (with a carrier frequency of 1.57542 GHz) and "L2" (with a carrier frequency of 1.2276 GHz) and are phase-modulated with pseudorandom-noise codes that contain GPS information. The L1 and L2 signals are fed through a signal-processing chain that includes common parts as well as parallel but separate L1 and L2 parts. Delay bias arises from (1) differences between times consumed in processing in the separate L1 and L2 parts and (2) frequency dispersion in the common parts.

It is necessary to measure and correct for delay biases in order to be able to measure densities of electrons integrated along GPS-signal-propagation-paths through the ionosphere. In turn, the electron-density information can be used to increase the accuracy of GPS mapping and related scientific functions. An older technique for measuring delay biases involves occasional manual calibration, which disrupts what would otherwise be continuous GPS-data-taking operations.

The technique for continuous automated calibration involves the use of a calibration transmitter that phase-modulates a pseudorandom code onto the L1 and L2 carriers (see figure). This code is used in the Russian Global Navigation Satellite System (GLONASS) and is similar to, but distinct from, the GPS codes. At the point of introduction into the L1/L2 signal-processing chain, there is negligible differential delay between the L1 and L2 versions of this signal. This point is as far as possible downstream while still being upstream of the parts of the chain where delay bias arises. By use of software developed for the purpose, the receiver continuously determines the delay bias by tracking the L1 and L2 versions of the GLONASS signal.



The **GLONASS Pseudorandom Code** serves as a signal marker that can be used to measure the delay bias between the L1 and L2 signals.

This work was done by Courtney B. Duncan, Thomas K. Meehan, and Donovan J. Spitzmesser 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 Systems category,* ***or circle no. 109*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge).*

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Refer to NPO-20058, volume and number of this NASA Tech Briefs *issue, and the page number.*

Signal-Decay Technique for Determining Qs of Power Inductors

There are no switches in the test inductor/capacitor loops.

Lewis Research Center, Cleveland, Ohio

An improved resonant-signal-decay technique has been devised for measuring electrical losses in quasi-linear inductors of the type that are used in modern electronic power-supply circuits and that are typically operated at frequencies up to about 100 kHz. The basic resonant-signal-decay technique has been used since the early years of electronics. The essence of the basic technique is to connect an inductor with a low-loss capacitor in a simple loop resonant circuit, apply a one-shot pulsed signal to excite oscillations at the resonance frequency, and measure the rate of decay of the signal to determine the electrical loss in the circuit at the resonance frequency. [Customarily, electrical loss is expressed in terms of a resonance quality factor, $Q = \pi f/\alpha$, where f = the resonance frequency and α = the rate (reciprocal of characteristic time) of exponential decay.] The outstanding feature of the present improved resonant-signal-decay technique is that unlike in older such techniques, extraneous switching electrical losses are minimized by avoiding the connection of any switches in series with the inductor and capacitor in the loop. Electronic switches in the form of metal oxide/semiconductor field-effect transistors (MOSFETs) are still present, but the circuit is configured and operated in such a way that the losses introduced by the MOSFET switches are negligible in comparison with those introduced by the inductor and capacitor.

Figure 1 illustrates the circuit used in the improved technique. The terminals of a low-loss, polypropylene-film-dielectric capacitor are connected directly to the terminals of the inductor to be tested. Excitation from an ac source is supplied in a parallel-resonant configuration via a back-to-back pair of high-voltage power MOSFETs. Though it is not strictly necessary to do so, it is desirable to set the excitation frequency at or near the resonance frequency of the inductor-and-capacitor loop. The excitation is applied during a brief pulse, using the same trigger pulse to turn both the MOSFETs and the ac source on momentarily. (It is necessary to turn the ac source off after applying the excitation to prevent spurious coupling of the excitatory signal through the internal capacitances of the MOSFETs.) At resonance frequencies ≤100 kHz, the radiative losses, like the losses in the MOSFETs, are much smaller than are the losses in the inductor and capacitor.

The trigger pulse is also used to trigger a digitizing oscilloscope, which measures the voltage waveform to capture the decaying oscillation (see Figure 2). The Q of the circuit is then computed by means of a polynomial fit to the peaks of the decaying voltage waveform; experiments have shown that 10-degree polynomials give good fits in most cases.

This work was done by Janis M. Niedra and Scott S. Gerber of NYMA, Inc., for **Lewis Research Center.** *For further information, access the Technical Support Package (TSP) **free on-line at www.nasatech.com** under the Electronic Components and Circuits category, **or circle no. 104** on the TSP Order Card in this issue to receive a copy by mail ($5 charge).*

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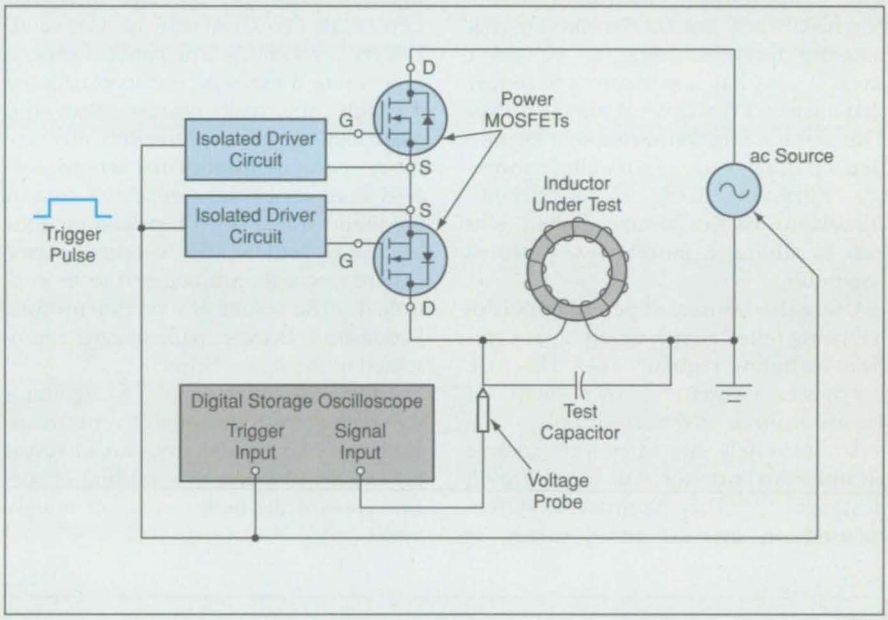


Figure 1. A **One-Shot Transient Signal Is Excited** in the inductor-and-capacitor resonant loop by momentary application of an ac signal during a trigger pulse. The digital oscilloscope records the resulting decaying oscillation.

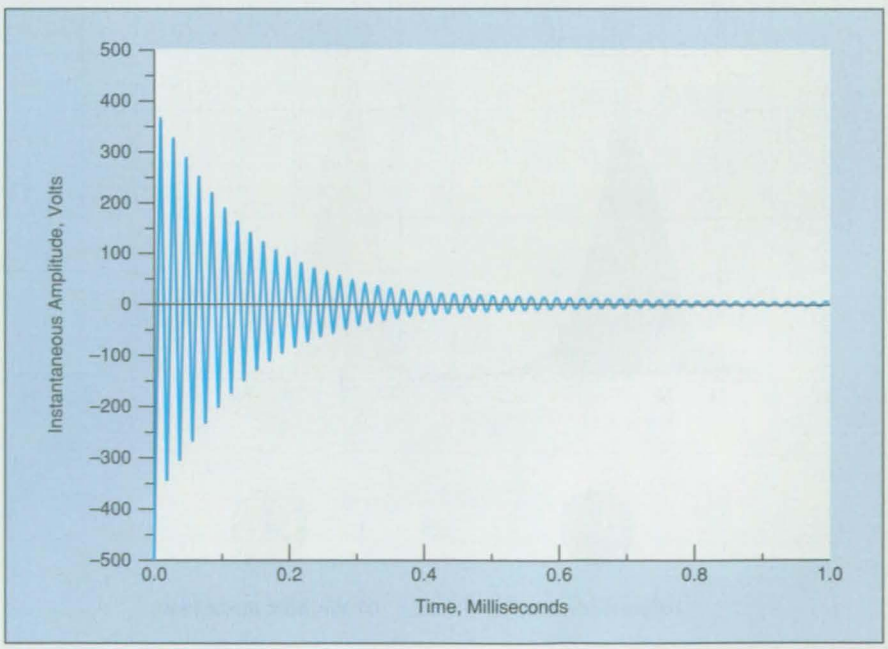


Figure 2. This **Decaying Oscillation** was recorded in the circuit of Figure 1 with a test capacitor of 0.22 μF and a ferrite-core inductor of 35.6 μH.

Biometric Instrument Measuring Neuromuscular Disorder/Performance Degradation

Novel "neuromuscular thermometer" gives researchers insight into fine neuromuscular control in humans.

Marshall Space Flight Center, Alabama

A new device to gather quantitative information about fine neuromuscular control in humans measures deterioration of stability, smoothness, and synchronization of handwriting movements.

This device, the Neuroskill, is an ordinary-sized instrumental pen (with accompanying software), attached to a parallel port of a personal computer. The motor-sensing electronics of the Neuroskill pen has accelerometers that measure motions along the X and Y axes. It also has a pressure transducer that measures dynamics along the Z axis. The pen is easily connected to a PC by a flexible cable, such as a parallel connector normally used for a printer. Installation of the Neuroskill pen is as easy as adding a mouse to a personal computer.

Using the Neuroskill pen, the individual being tested simply writes on any surface, including regular paper. The writing may be a signature, any sequence of cursive writing, or drawn symbols.

To accurately and effectively analyze an individual's motor skill control level, designers of the Neuroskill system focused on *how the person* writes, as opposed to *how the writing looks*. The Neuroskill pen translates the written dynamics of accelerations and pressure into complex signals, each represented by 1000 data points.

Patients with Parkinson's Disease and volunteers in alcohol impairment experiments were tested with the Neuroskill device at the Colorado Neurological Institute and the Alcohol Research Center at the University of Colorado, Denver, respectively. The medical experts supervising these experiments concluded through the test results that the Neuroskill system can precisely measure the results of neuromuscular actions initiated from either the cerebellum area of the brain (where often repeated motions are controlled) or the cerebral cortex (where new tasks are believed to be controlled). The results of experiments with Parkinson's Disease patients are represented in the figure below.

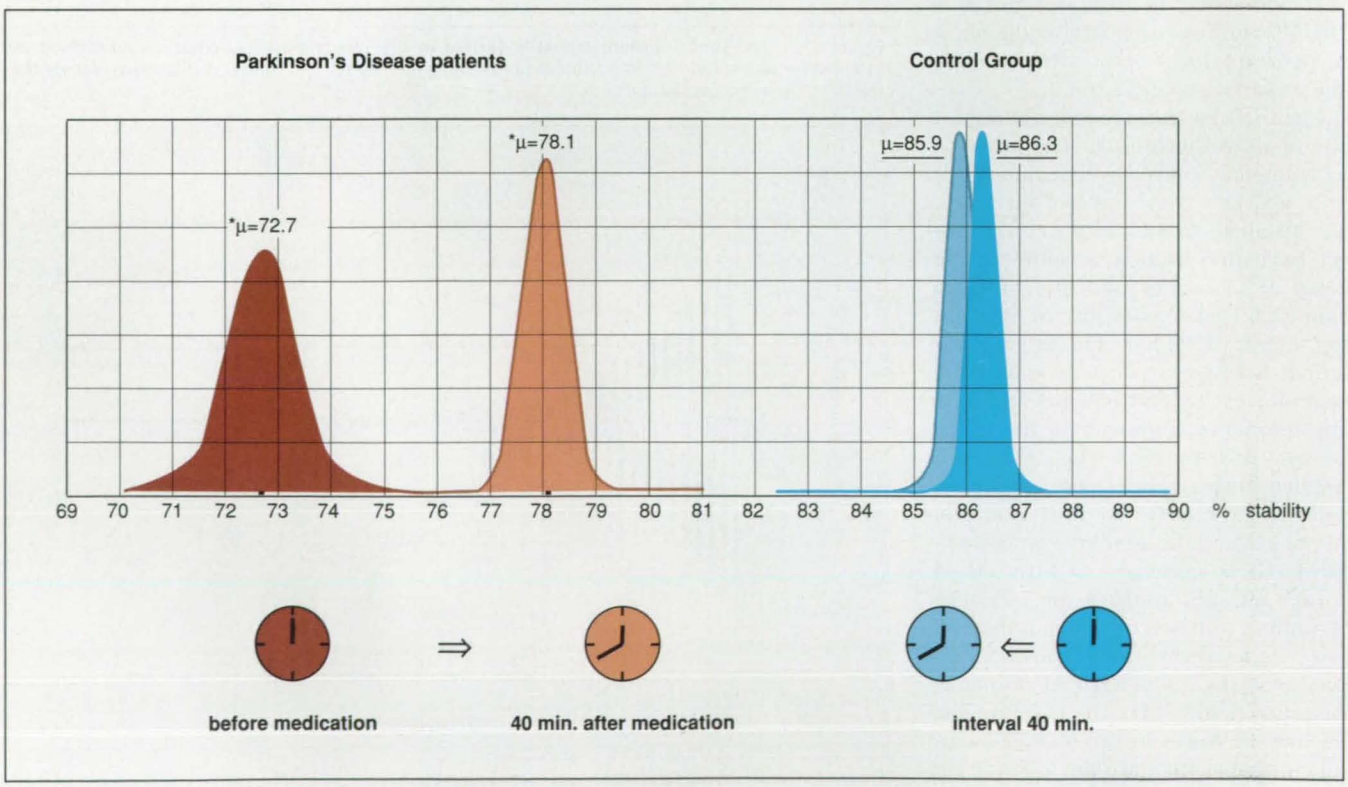
Analysis of activities such as signing a signature or reproducing different cursive symbols can help the clinician to reveal the degree of damage or healing of specific parts of the brain, nerve, or muscle tissue.

With the Neuroskill device, current levels of motor skill control can be compared with previously stored results, allowing the researcher to follow the changes in motor skill control over time and choose the most effective treatment. The device also has the potential to be used as a tool in the development of neuromuscular targeted pharmaceuticals by providing real time, quantified data for use in clinical trials.

The Neuroskill device is inexpensive, non-invasive, and easy to use. The researcher or practitioner can administer the test in the work area. Additionally, the patient can continue to monitor his own condition at home between medical visits.

This work was done by Dr. Ruth Shrairman and Alexander Landau of VeriFax Corporation for **Marshall Space Flight Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Life Sciences category,* ***or circle no. 127*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge).*

MFS-26449



The **Biometric Instrument** is capable of measuring changes in fine neuromuscular control levels of patients with Parkinson's Disease.

Portable Instrument Measures Ice Profiles

Accurate measurements can be performed rapidly, with minimal labor.

Lewis Research Center, Cleveland, Ohio

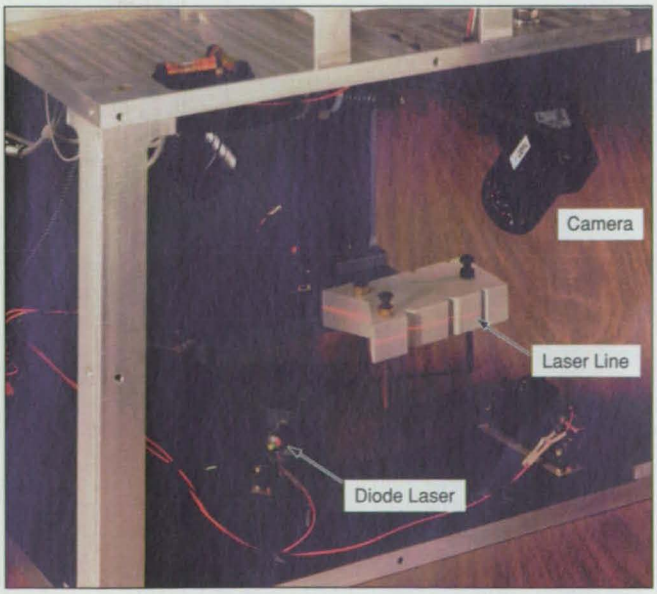
A portable optoelectronic instrument measures profiles of ice deposits that have formed on leading edges of airfoils in the Icing Research Tunnel at Lewis Research Center. Previously, technicians working in the cold, wet environment of the tunnel measured these profiles in a tedious manual procedure: An aluminum block was used to melt a section of ice so that a card could be placed against the ice, then a pencil was used to trace the profile of the ice onto the card. The melting affected the profile, and the tracing process was time-consuming and subject to human error.

The instrument satisfies a need to measure the ice profiles accurately and rapidly, and to be readily operable by technicians, with minimal labor. The instrument (see figure) includes four low-power, eye-safe laser diodes that project a thin red (wavelength 670 nm) line onto the ice to be measured. Three computer-controlled charge-injection-device video cameras and a frame grabber capture the image of the ice shape (as illuminated by the diode lasers) from three different positions.

A microcomputer (Compaq 80386, or equivalent) running custom software merges the images from the three cameras and corrects for distortions associated with the camera angles. The profile is displayed on the computer screen and saved in an ASCII file on hard disk. The technician has the option of printing a 1:1-scale profile of the ice shape. The profile is accurate to within 1 percent. The entire profiling process takes about one minute.

This work was done by Mario Vargas of **Lewis Research Center** *and Edward A. Hovenac of NYMA, Inc. No further documentation is available.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Lewis Research Center, Commercial Technology Office, Attn: Tech Brief Patent Status, Mail Stop 7-3, 21000 Brookpark Rd., Cleveland, OH 44135. Refer to LEW-16117.



An **Illuminated Line** on the surface to be measured is imaged in three video cameras. The image data are processed to quantify the profile of the surface.

Fluke Corp., Everett, WA, has introduced the 70/20 Series III **digital multimeters**, which are ergonomically designed with a larger, high-contrast screen and feature a segmented bargraph. The automatic Touch Hold® feature allows users to focus attention on the test probes while the meter automatically freezes the reading and beeps when the measurement is captured.

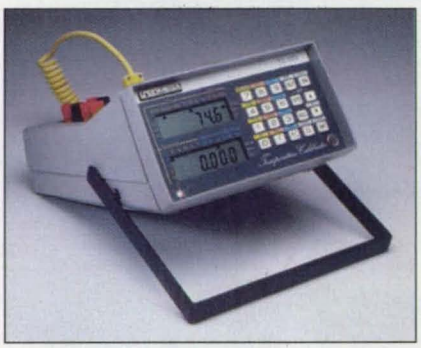
The meters are designed to protect the user against power surges and voltage transients up to 6 V, and offer true RMS, capacitance, frequency, and low ohms capabilities. They measure volt, millivolts dc, ac/dc volts, ohms, and amps and perform diode and continuity tests. Overmolded cases protect the meters, which have lifetime guarantees. The battery and fuses can be replaced without breaking the internal calibration seal.

For More Information Circle No. 724

The KNM-DYN12 SmartLink™ **miniaturized instruments** from Keithley Instruments, Cleveland, OH, obtain laboratory-grade measurements of force, acceleration, and dynamic pressure. The 6.7 x 1.3 x 1.1" unit accepts up to eight transducer or digital inputs, and can accommodate up to four inputs of very low frequency or static acceleration using capacitive sensors. Possible measurement configurations include eight two-wire analog inputs of pressure, force, and acceleration using low-impedance, voltage-mode piezoelectric sensors.

Measurements can be linked to a remote PC or controller, or the user can display/store results for local monitoring and debug via a digital readout device or palmtop PC. The instruments feature an onboard microcomputer that provides data acquisition, signal processing, and communication capabilities.

For More Information Circle No. 725



Omega Engineering, Stamford, CT, offers the CL523 **temperature calibrator** that allows on-site and workshop calibration of temperature and electrical instruments. The unit can measure and generate thermocouple signals, RTD signals, ohms, millivolts, volts, and milliamps. It reads input and output signals simultaneously.

The calibrator features a step and ramp output mode, as well as a large, backlit LCD display. The unit is available with an optional 24 VDC loop supply or with a switch test function option. It was designed for process maintenance applications and is priced starting at $3,395.

For More Information Circle No. 726

The Easy Count series of **electronic counting scales** from Setra Systems, Boxborough, MA, is available in six- and two-key versions. Featuring variable capacitance technology, the scales are available in capacities of 500 grams, 2000 grams, and 5000 grams. Standard features include an LED display, bi-directional RS-232 communications, and a stainless steel weighing pan.

The EZ6 model, with six keys, features an RS-232 communications port, allowing results to be printed in text on a receipt printer. The scale offers weighing in grams, ounces, pounds, and user-definable x-unit. The EZ2 features a zero and a count key, and displays weight in grams or a count.

For More Information Circle No. 729

Raytek Corporation, Santa Cruz, CA, has introduced the Marathon™ MR1F **fiber-optic ratio thermometer**, which measures temperature in hot or hostile environments, in high electromagnetic fields, or in other applications where line of sight of the target is obscured. The unit consists of a small optical head, a field-replaceable fiber-optic cable, and a separate electronics enclosure with built-in user interface.

Features include remote sensor set-up, real-time display of target temperature, and field calibration software. A digital signal processor in the sensor electronics allows two-way serial communications. The thermometer is available in three models covering temperature ranges from 650 to 3000°C. Priced at $4,400, the thermometer features a 10-millisecond response time.

For More Information Circle No. 728

Wavetek Corp., San Diego, CA, offers the Model 9500 **oscilloscope calibration workstations** available in 400 MHz, 600 MHz, and 1.1 GHz bandwidth versions. The workstations come with PC-based automated calibration software and are capable of automating the calibration of analog- and digital-storage oscilloscopes. The units deliver calibration waveforms directly to the oscilloscope's BNC input connectors.

The calibration software runs all calibration procedures and allows the user to archive calibration results, generate ISO9000-compliant calibration certificates and reports, and write new procedures. The software includes a library of tested procedures for commonly used oscilloscopes. Pricing starts at $13,490.

For More Information Circle No. 731

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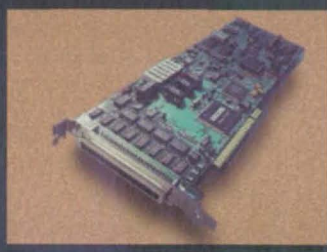

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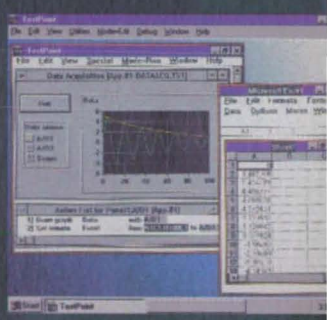

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*Universal serial bus, available with SmartLink Fall '97
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International Light, Newburyport, MA, has introduced the IL1400A **radiometer** and the SPL025Y **luminance pen probe** that matches human eye response for measuring the brightness of any CRT or backlit display. Featuring a photopically corrected "Y" filter, the probe distinguishes colors the way a human eye does. The radiometer provides direct readouts in fL, cd/m^2, and other units on an LCD display.

The units can operate over a dynamic range of 1 x 10^{-3} to 2.5 x 10^6 fL and a spectral range of 400 to 700 nm. The radiometer operates on four AA batteries and the probe has an apertured hood for luminance or contact luminance measurements. The units are priced at $1,132.

For More Information Circle No. 723

The Ultraprobe™ 100 **ultrasonic detector** from UE Systems, Elmsford, NY, translates ultrasounds produced by operating equipment and by leaks into the audible range, where they are heard through headphones and seen as intensity increments on a ten-segment LED bargraph indicator. Received signal intensity is adjusted via an eight-position precision attenuator.

It is used for leak detection and mechanical and electrical inspection in applications such as leak detection of compressed gas systems, vacuum systems, steam traps, and valves; mechanical inspection of pumps and compressors; and detection of arcing, tracking, and corona in electrical equipment. The detector is available as a kit with interchangeable modules for scanning and contact modes.

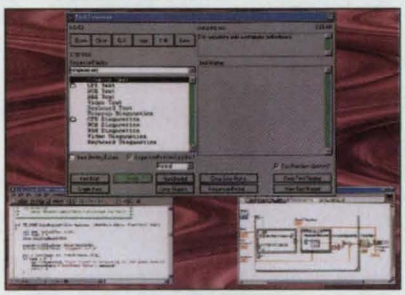
For More Information Circle No. 721

Doric Instruments Div. of Vas Engineering, San Diego, CA, offers the Series 460/461 **bench thermometers** with inputs for RTDs, thermocouples, and thermistor sensors. Six RTDs, 14 thermocouples, and two thermistors can be connected to the units, which have accuracy near 0.01% of reading. Housed in a rugged carrying case, the units offer resolution of either 0.1 or 1.0 degrees F/C. All connections are made by screw terminals on the back of the instrument.

Both units have shielded outputs and use an integrating voltage-to-frequency technique for analog to digital conversion. Options include dual alarms, analog output and serial/parallel outputs of RS-232C or IEEE-488, and isolated DC power of 8 to 32 VDC. Standard power is 115 VAC. All channels can be recorded via a scan option.

Prices start at $679.

For More Information Circle No. 722



National Instruments, Austin, TX, has introduced Test Executives for LabVIEW and LabWindows/CVI **test development instrumentation software**. The modules feature an open model for customization so developers can install and run the modules out of the box or with modifications. User-modifiable areas include the operator interface, test report generation, log-in procedures, test set-up and clean-up routines, and test pass/fail operations.

The software modules can call tests written in LabVIEW, LabWindows/CVI, or any Windows development environment capable of building dynamic links libraries, such as C/C++ or Visual Basic. Users can build multitiered, hierarchical sequences for advanced testing models, set breakpoints in test sequences, and have access to sequence files in ASCII format.

For More Information Circle No. 730

Cole-Parmer Instrument, Vernon Hills, IL, offers the Digi-Sense® Models 91100-00/10/20/40 **thermocouple thermometers** available in types J, K, or T. Model 91100-40 accepts one or two type J, K, T, or E thermocouple probes. The intrinsically safe thermometers have a ±0.05 conformity to NIST ITS-90 calibration tables.

A field calibration feature allows the probe to be calibrated to nearly any known temperature standard, such as freezing or boiling water, by using a two-point manual calibration. All models feature an ergonomic design, sealed silicone rubber keypad, and an IP54 splash- and dust-resistant case.

For More Information Circle No. 720

The Model 7102 Spirahelic® **pressure gauge** from Dwyer Instruments, Michigan City, IN, measures pressure with ±1/2% full span accuracy. The gauge features Inconel® Bourdon tube to eliminate complex moving parts. A nickel-plated brass connection block has both bottom and back 1/4" NPT female openings. The unit is shock- and vibration-resistant.

Thirty-four ranges are available from 60 to 10,000 psig, 400 to 6000 kPa, 10 to 60 MPa, and 4 to 600 bar. The gauge is housed in a mineral-filled black nylon enclosure that conforms to ASME B40.1 for gauge replacement. The 18-oz. gauge is calibrated for vertical mounting and operates between -54 and 82.2°C. One 1/4" NPT brass plug is included.

For More Information Circle No. 727

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For More Information Circle No. 540

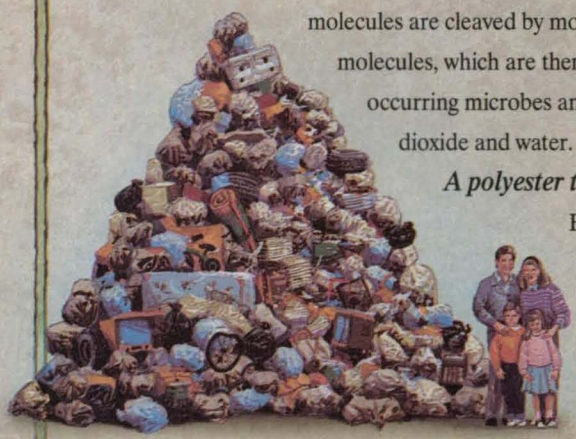
Efforts to develop a truly practical degradable material are reaching fruition. DuPont scientists have created an inexpensive polymer that decomposes without harm to the soil or the environment.

By now, the problems associated with overburdened landfills are widely recognized. Although recycling is the preferred solution, degradable materials can also play an important role. Yet, cost barriers and other issues have consistently blocked their wide-scale adoption in major consumer applications.

To meet this challenge, DuPont scientists have created a new family of highly versatile polymers based on polyethylene terephthalate (PET) technology and known commercially as DuPont Biomax® hydro/biodegradable polyester. Depending on the application, up to

Raised on a diet of plastic cups,

three proprietary aliphatic monomers are incorporated into the polymer. The monomers create weak spots in the polymeric chains, thereby making them susceptible to degradation through hydrolysis. The large polymer molecules are cleaved by moisture into smaller molecules, which are then consumed by naturally occurring microbes and converted to carbon dioxide and water.



The average American family generates 6,488 pounds of trash each year. The availability of products made with degradable polymers would reduce impact on the environment.

A polyester that microbes find tasty.

Biomax® can be recycled, incinerated or landfilled, but is intended mainly for disposal by composting and in-soil degradation. Researchers performed a series of tests to determine environmental impact, including plant germination and seedling emergence, earthworm weight gain and mortality, and microbial population density. In all tests, the materials were found to be harmless to the environment at every stage in the decomposition process. They are virtually undetectable to the unaided eye in about eight weeks.

Because Biomax® is a modified PET polymer, it can be manufactured with existing equipment using existing bulk monomers. This means that it is only marginally more expensive to produce than PET itself. Currently available degradable materials, on the other hand, can cost twice as much.

Degradable fishing line and fishing nets would help alleviate a serious problem for sea mammals who ingest or become entangled in aquatic trash.

How to make your products disappear. The sheer number of potential applications for Biomax® is immense. Because it can be made into fibers, films or resins, it is suitable for a range of single-use products, including domestic wipes, yard waste bags, the top and back sheets of disposable diapers, blister packs and disposable eating utensils. It can be used to create geotextiles, agricultural films, seed mats, plant pots and bags that cover ripening fruit. It can find application in coated paper products such as disposable plates and cups, aluminized films for food packaging and hot-melt adhesives. It is also suitable for thermoformed packaging, blown bottles and injection-molded objects.

snack bags and gum wrappers.

Product properties are diverse and customizable, but are generally tailored to mimic polyethylene or polypropylene. Biomax® is soft, pliable, low in noise and has a good hand. Melting points are high for a degradable material, generally around 200°C, which opens up a range of processing options. It can be formulated to be as low in strength as low-density polyethylene or as high as half the strength of DuPont Mylar® polyester film. Elongation can range from 50 to 500 percent.

Turf grass grown on a mat of degradable DuPont Biomax® weighs one-tenth as much as sod grown in soil.

A world with less trash. Share the dream.

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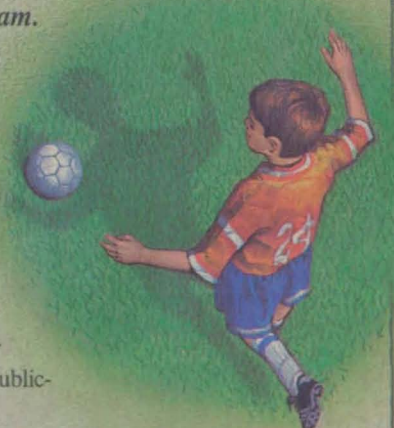

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Slotted Carbon/Carbon Grids for Ion Accelerators

These grids offer potential advantages over metal grids made with wires or circular holes.

NASA's Jet Propulsion Laboratory, Pasadena, California

Ion-accelerator grids made by machining long parallel slots into solid pieces of carbon/carbon composite material have been proposed to replace ion-accelerator grids made by chemically etching circular holes in hexagonal patterns in molybdenum sheets. The proposed slotted carbon/carbon grids would resemble the metal wire grids used in the first ion engine built in 1960, but would offer advantages over both the early wire grids and the chemically-etched-molybdenum-sheet grids now in use.

Several previous articles in *NASA Tech Briefs* have discussed various aspects of replacing metal ion-accelerator grids with carbon/carbon grids. Briefly, the potential advantages of carbon/carbon grids over metal grids include (1) a lower rate of erosion of carbon/carbon by charge-exchange ions; (2) low or negative coefficient of thermal expansion of carbon/carbon, with consequent reduction or elimination of thermal distortion at high operating temperatures; and (3) greater rigidity of carbon/carbon grids, with consequent greater ability to resist electrostatic deflection and maintain required precise geometry at high applied voltages.

The present concept of long, parallel slots in carbon/carbon sheets is an extension of the concept described in "Ion-Accelerator Grids With Elongated Holes" (NPO-19336), *NASA Tech Briefs*, Vol. 20, No. 1, (January 1996), page 34. One reason for choosing long, parallel slots instead of patterns of circular or elongated holes is that grids containing long, parallel slots are expected to endure erosion better. A hexagonal erosion pattern is formed by charge-exchange ions on a molybdenum ion-accelerator grid with a conventional hexagonal pattern of round holes. Structural failure occurs when the depth of erosion reaches the full thickness of the grid. However, in a slotted carbon/carbon grid (see figure), the erosion pattern is expected to consist of longitudinal trenches centered in the webs between slots. In this case, erosion completely through the thickness would not cause immediate structural failure; rather, it would divide each web into two narrower parallel webs. It has been estimated that a parallel-slot grid would last three times as long as would a round-hole/hexagonal-pattern grid of the same material; taking this factor in combination with the lower rate of erosion of carbon/carbon (expected to be less than 1/6 that of molybdenum), it appears that a slotted carbon/carbon grid should have an operational life 18 times that of a comparable round-hole/hexagonal pattern molybdenum grid.

In fabricating a slotted carbon/carbon grid, the slots would be machined parallel to the majority of carbon fibers in a carbon/carbon sheet. Machining in this pattern would leave a large number of uncut fibers extending across the full diameter of the grid, resulting in a substantial increase in the stiffness of the grid over that of a grid with a hexagonal pattern of circular holes. The cost of machining the grid slots has been estimated to be about 1/6 that of machining grid holes in a hexagonal pattern. The main reason for the decrease in cost is that for a grid of a given size (e.g., a diameter of 14 cm and thickness of 0.5 mm) the number of slots (about 50) would be much smaller than the number of holes (about 4,000).

This work was done by John R. Brophy, D. Kyle Brown, Juergen Mueller, and Charles E. Garner 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 Circuits category,* ***or circle no. 103*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge).*

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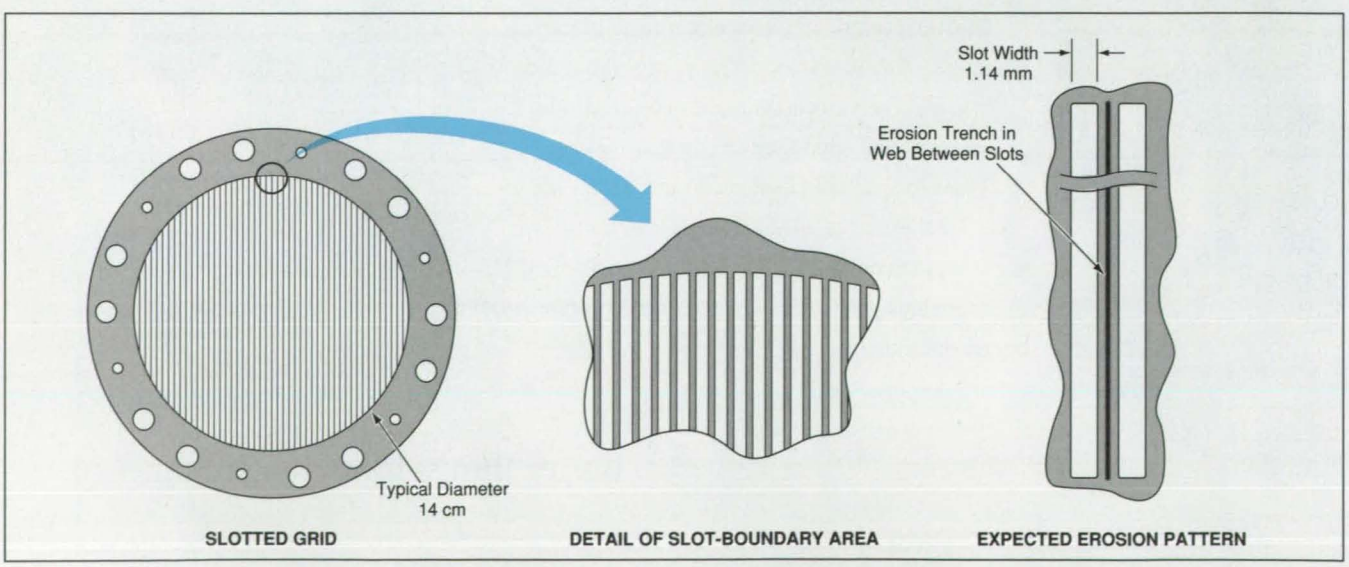
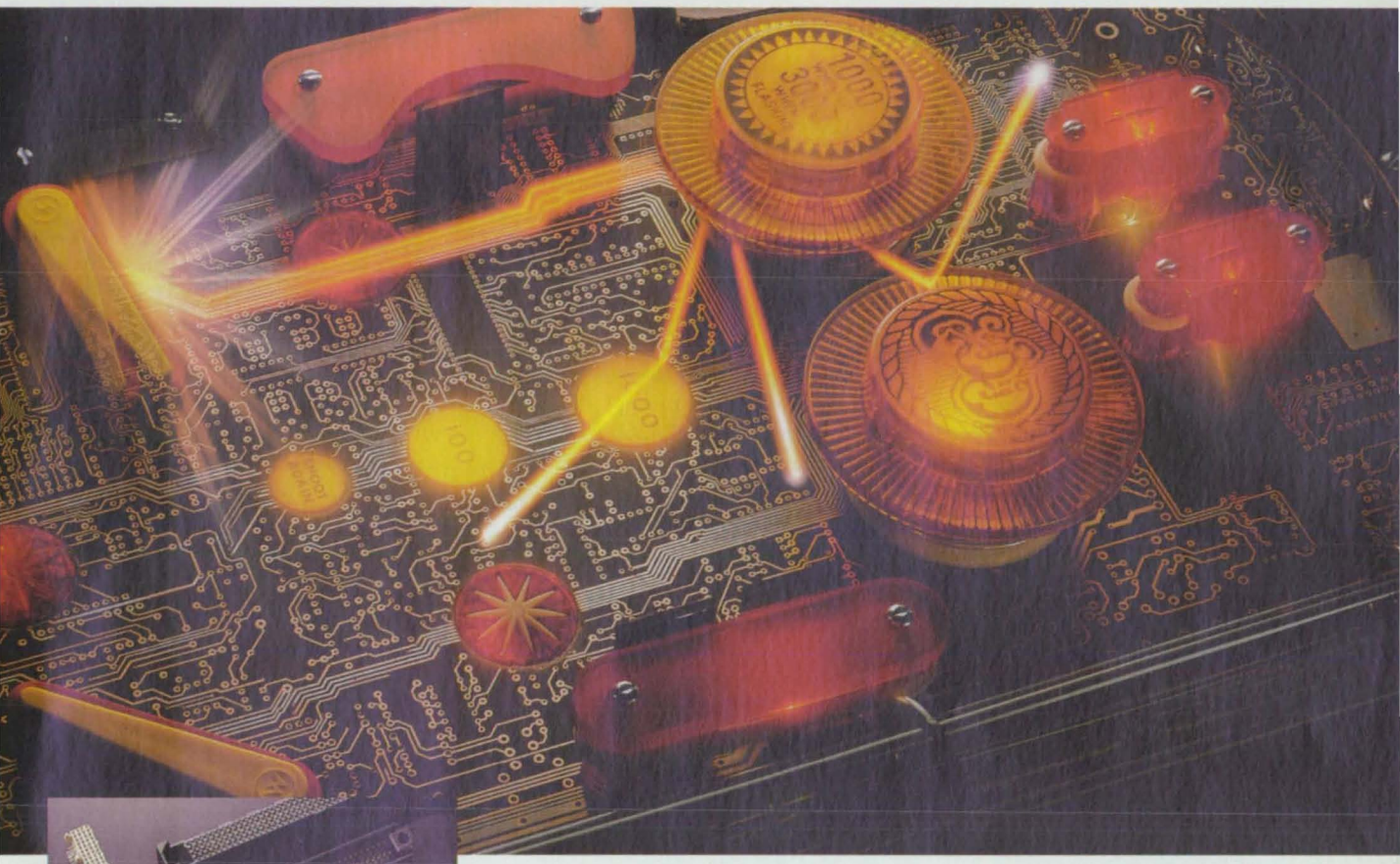


A **Slotted Carbon/Carbon Grid** could be machined at relatively low cost. The grid would erode along the center lines of the webs between the slots; this erosion pattern would delay structural failure.

At fast edge rates, the wrong interface takes on unexpected qualities.



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For More Information Write In No. 544

Bidirectional Electronic Circuit Breaker

Adequate precision is achieved with a relatively simple circuit.

Lewis Research Center, Cleveland, Ohio

An electronic circuit breaker is designed to trip at a nominal direct current of 5.6 A (or more, depending on temperature). The current can be of either polarity. Originally designed for use in a cross-feed link between two loads powered by a redundant pair of power sources, this circuit breaker could also be used in other applications in which protection against dc overcurrent of either polarity is needed.

Fuses were rejected for use in the original application because the overcurrent conditions under which they trip cannot be established with sufficient precision. Very precise electronic circuit breakers containing operational amplifiers, comparators, and other integrated circuits were also rejected because they were judged to be too complex for that application. The present bidirectional electronic circuit breaker was designed as a compromise between the two extremes, providing adequate precision with minimal complexity and a relatively small number of parts.

The bidirectional circuit breaker (see Figure 1) requires an isolated 24-Vdc power supply. During normal operation, the main load current is conducted through the two RM2423-001 metal oxide/semiconductor field-effect transistors (MOSFETs) and through the sensing resistor. The value (67 mΩ) of this resistor is chosen so that when the magnitude of the load current equals or exceeds the desired trip level, the voltage across this resistor equals or exceeds the turn-on threshold base-to-emitter voltage of one of the 2N2222A npn transistors.

The turning on of either 2N2222A npn transistor causes the turn-on of the 2N2907A pnp transistor, which is the active element of a latching circuit. When thus activated, the latching circuit lowers the voltages on the MOSFET gates below their conducting thresholds. Thus, the MOSFETs are turned off, interrupting the path for the load current.

The latching circuit includes a resistor/capacitor delay circuit that makes the circuit breaker insensitive to a current surge shorter than about 1 ms (see Figure 2). Once the circuit breaker has been tripped by overcurrent, and until it is reset, the latching circuit holds it in the "off" condition. Reset is accomplished by turning off, then turning on the isolated 24-Vdc power supply.

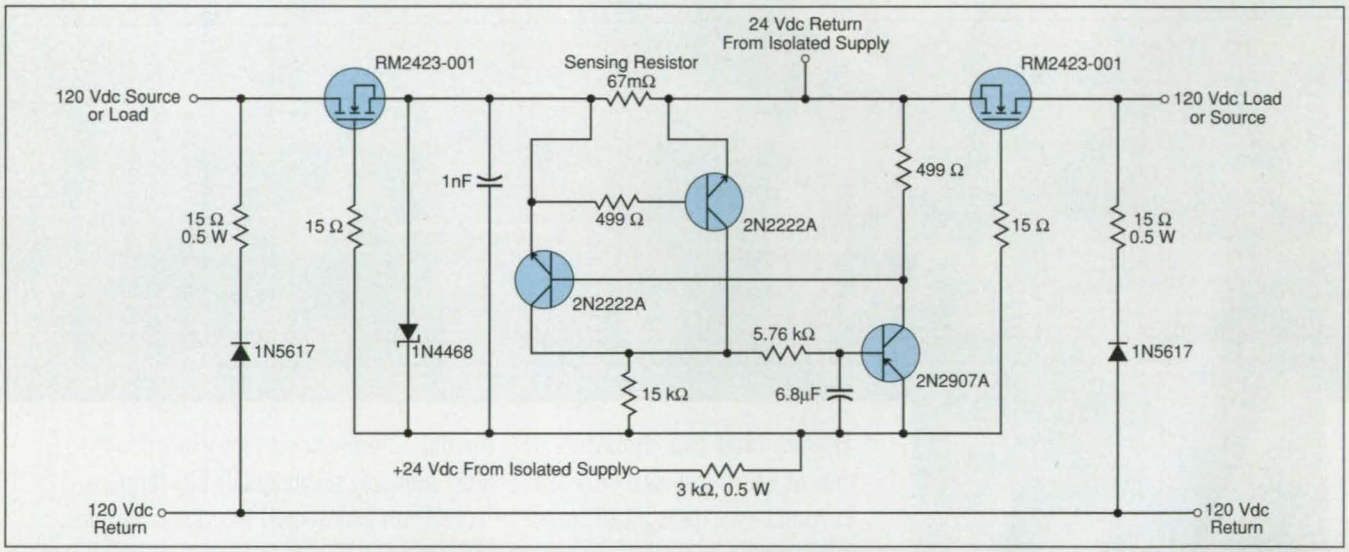

Figure 1. This **Bidirectional Electronic Circuit Breaker** contains fewer parts than do other electronic circuit breakers, yet is precise enough for its original purpose.

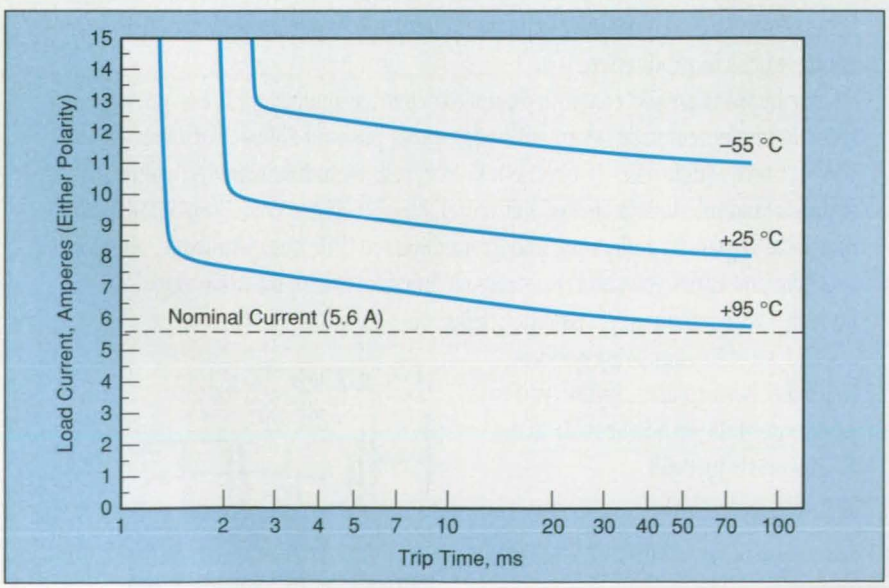

Figure 2. The **Circuit Breaker Is Tripped** into turn-off when the point that represents its operating condition lies on or above the curve for the operating temperature. Note that the circuit is not tripped by large current pulses shorter than about 1 ms.

This work was done by Tomasz Kachelski of Rockwell International Corp. for **Lewis Research Center.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Circuits category,* ***or circle no. 156*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge).*

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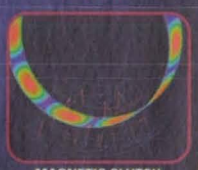
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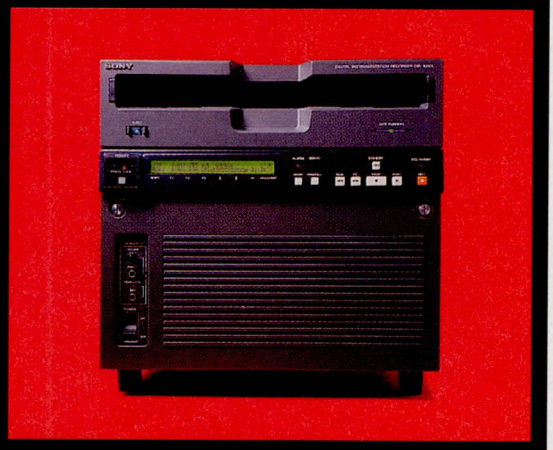

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Automated Tape Libraries for Mass Storage

Remote Sensing

For More Information Circle No. 542

SONY

Stabilizing a Photonic Heterodyne Microwave Oscillator

A frequency discriminator built around a fiber-optic delay line would be used.

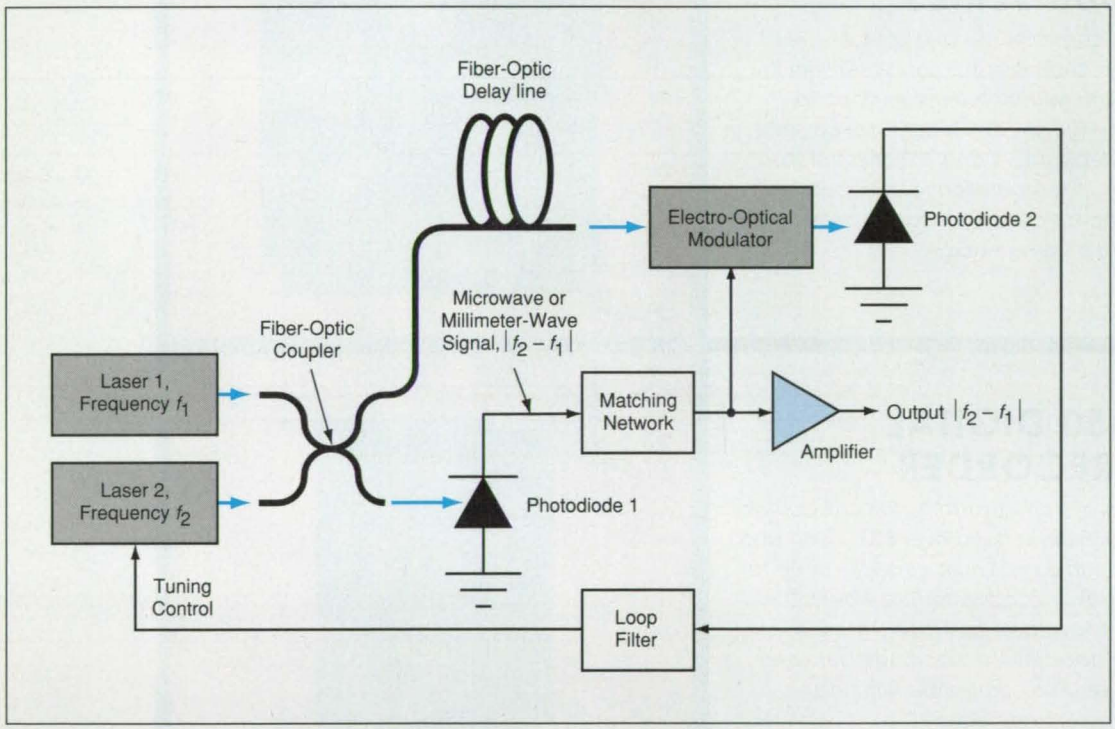
NASA's Jet Propulsion Laboratory, Pasadena, California

In a proposed scheme for generating a microwave or millimeter-wave signal as a heterodyne product of the outputs of two narrow-band lasers, the frequency of the signal would be stabilized by using a frequency discriminator based on a fiber-optic delay line to stabilize the frequency of one of the lasers. This scheme can be regarded as an extension of the use of such a frequency discriminator to stabilize an electronic microwave oscillator, as reported in "Fiber-Optic Discriminator Stabilizes Microwave Oscillator" (NPO-18375), *Laser Tech Briefs*, Vol. 1, No. 1 (September, 1993), page 24.

Despite their potential utility and potential commercial value, photonic heterodyne microwave oscillators have not yet come into widespread use because of excessive instability of frequency. The proposed scheme would overcome this limitation; theoretically it offers the potential to yield frequency stability equal to or better than that of currently available electronic microwave sources.

As shown in the figure, the outputs of the two lasers would be directed into optical fibers and heterodyned by use of a fiber-optic coupler and photodiodes. The coupler would produce two light-signal outputs. The output from one branch of the fiber-optic coupler would go directly to photodiode 1, which would perform the customary detection-and-mixing function, so that one of the components of the electrical output of photodiode 1 would be the desired microwave or millimeter-wave radio signal with a frequency equal to the difference between the two laser frequencies. This signal would be coupled through a matching network to the electrical input terminals of an electro-optical modulator. This signal would also be fed to an amplifier, and the amplified signal would constitute the desired output.

The other branch of the fiber-optic coupler would continue into a fiber-optic delay line to the optical input port of the electro-optical modulator. The output of the electro-optical modulator would be fed to photodiode 2. Provided that the length of the delay line was chosen to obtain phase quadrature at the radio frequency, the heterodyne action in the electro-optical modulator and photodiode 2 would cause the baseband component of the output of photodiode 2 to be proportional to the fluctuation of the phase and frequency of the radio signal during the delay. This baseband output would serve as a feedback error signal to tune one of the lasers to reduce the error and thus stabilize the output frequency.



A **Frequency Discriminator and Feedback Control Loop** based on a fiber-optic delay line and an electro-optical modulator would stabilize the frequency of a photonic heterodyne microwave or millimeter-wave oscillator.

This work was done by Ronald T. Logan, Jr., 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 Systems category,* ***or circle no. 113*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge).*

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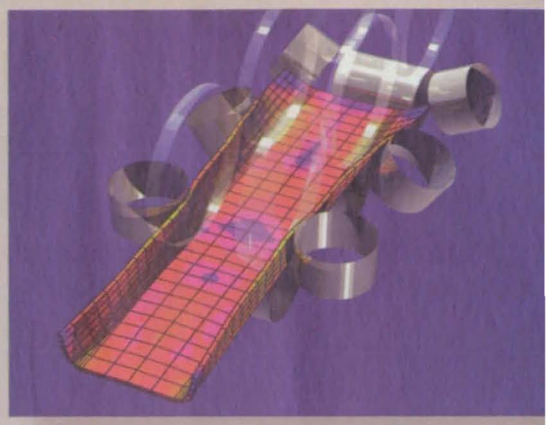

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For More Information Circle No. 519

Programmable Switch Assembly for Aircraft Systems

Feedback from controlled equipment results in visual indications of malfunctions.

Dryden Flight Research Center, Edwards, California

An autonomous programmable switch assembly (PSA) has been developed for use in the Research Instrumentation branch of NASA Dryden Flight Research Center to address the complex and varying system-control requirements of research aircraft. The PSA is now in flight-operational status in the NASA SR-71 airplane. The PSA includes four cockpit switches (see Figure 1) coupled to a microcontroller and to a relay board (see Figure 2) designed at Dryden Flight Research Center.

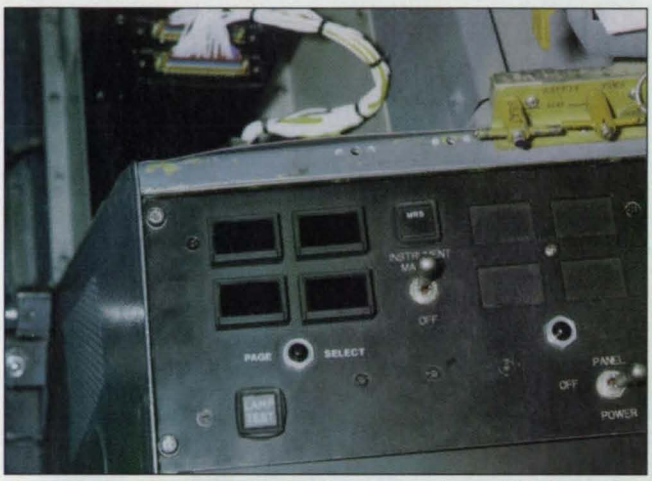


Figure 1. **Four Programmable Switches** equipped with LED displays are installed in the SR-71 cockpit.

One of the advantages of the PSA is that it provides engineers with the capability to reduce as many as 16 individual cockpit switches and indicators to one. In addition, the PSA provides feedback from controlled equipment, indicating the current state of the equipment. Individual changes in an installed control system consist of changes in software and wiring and are nominally accomplished within one-day turnaround times. The realm of applicability of PSA extends beyond research aircraft in that it provides capabilities for easily controlling other systems with feedback requirements.

The PSA includes three main components: the Vivisun 5000 (or equivalent) electro-optical display system, a Tattletale model 7 (or equivalent) computer (the microcontroller), and the relay boards mentioned above. The display system includes four 1-by-1.5-in. (2.5-by-3.8-cm) programmable multifunction pushbuttons (PMPs), which are the cockpit switches mentioned above. Each PMP contains 560 light-emitting-diode (LED) elements that are readable in sunlight. The display system also includes a refresh processor unit (RPU), which serves as an interface between the PMPs and the microcontroller. The RPU accepts data that are in RS-232 ASCII format and that include specified sequences of control characters that provide for textual and graphical displays on the PMPs. The capabilities for controlling the display include the ability to make one or all of the PMPs blink, turn all the pixels on, perform a self-test, clear the display, and select any of 35 levels of luminance.

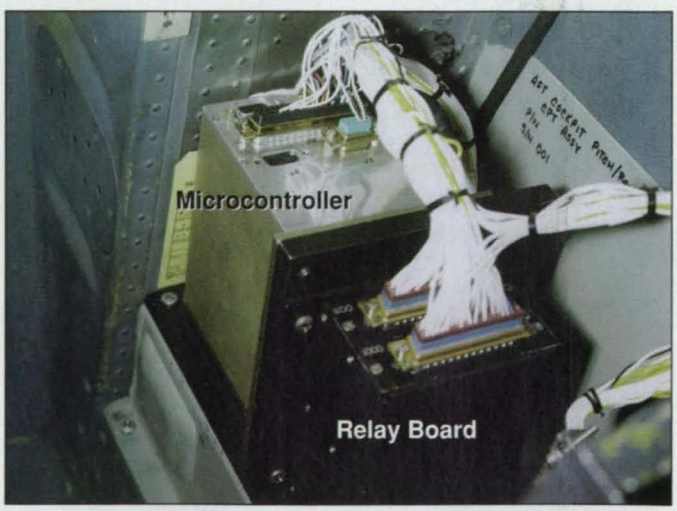


Figure 2. The **Microcontroller and Relay Board** are installed together as a set in the SR-71 cockpit.

The microcontroller is a high-performance data logger based on the Motorola 68332 (or equivalent) microprocessor. It is programmable in ANSI C; the program can be written on a personal computer and downloaded to a nonvolatile flash electrically erasable programmable read-only memory (EEPROM) in the microcontroller.

The microcontroller includes 12 general-purpose input/output (I/O) pins, nine of which are used for feedback from the relay boards. The feedback informs the microcontroller that a switch action has occurred. If there is a malfunction, the microcontroller causes the display on the appropriate switch to blink. The output from the microcontroller to the relay boards is in the form of eight-bit addresses transmitted via output pins of a time-processor unit in the microprocessor. These addresses are decoded by circuits on the relay boards and used to actuate the appropriate relays. The downloading of software from the personal computer is accomplished via a serial port by use of a terminal program.

Interface boards for the microcontroller were also developed at Dryden Flight Research Center and include the following: a basic operations board, a buffer board, and a serial I/O board. The boards serve as the interfaces among the RPU board, the relay boards, and the personal computer (which is used for monitoring activity as well as programming).

Each relay board holds a dc-to-dc power converter, eight relays, and an address-decoding circuit. The dc-to-dc converter supplies power at a potential of 5 V for the relay outputs and the address decoder. The relays are of the nonlatching, double-throw type. One of two outputs goes to the circuit or relay of interest; the other output provides feedback to the microcontroller. This is the feedback, mentioned previously, that results in a change in the switch display. If the change is intentional and is the result of pressing a switch, then the face of the switch displays the expected result. If the feedback is triggered by a failure, then the switch display blinks as mentioned before and indicates "FAIL" on the display.

This work was done by Michael Toberman of **Dryden Flight Research Center.** *For further information, access the Technical Support Package (TSP)* ***free online at www.nasatech.com*** *under the Electronic Systems category,* ***or circle no. 122*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge).*
DRC-97-04

Miniature Directional Hydrophones

Micromachined tunneling transducers are housed between titanium hemispheres.

NASA's Jet Propulsion Laboratory, Pasadena, California

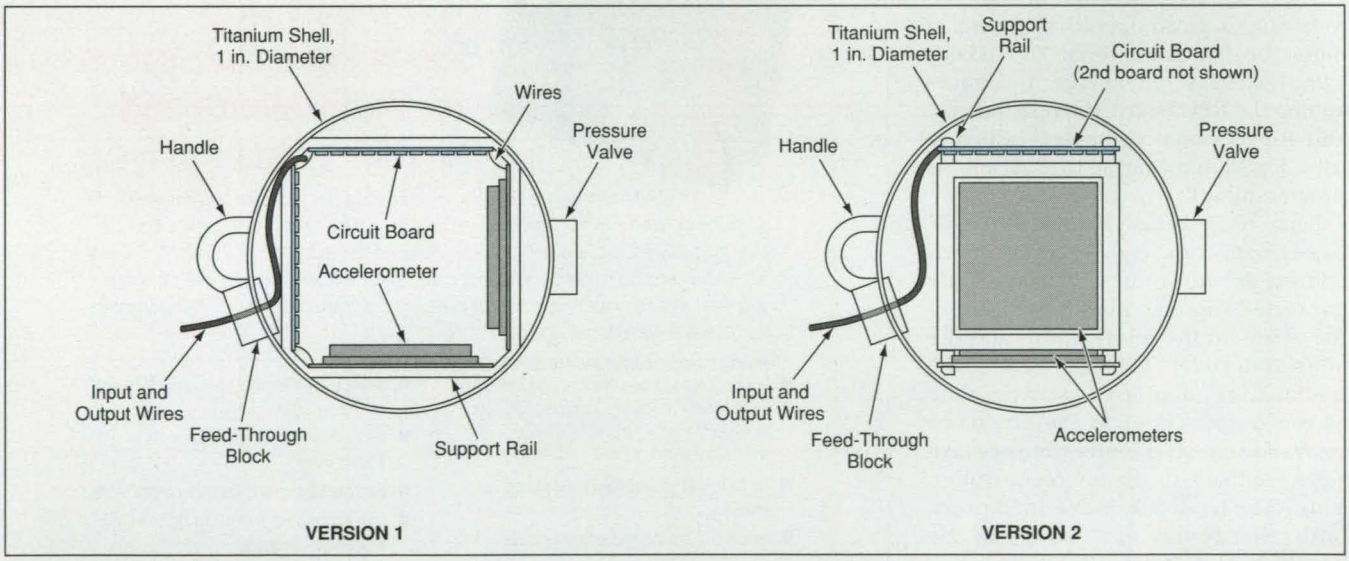
Miniature low-noise, neutrally buoyant, directional hydrophones are undergoing development. A prototype miniature hydrophone is contained in a spherical titanium shell (see figure) with a volume of about 0.52 in.^{3} (8.6 cm^3). These miniature hydrophones are intended to replace older hydrophones contained in packages with volumes of about 20 in.^{3} (328 cm^3).

The sensors in the miniature hydrophones are micromachined tunneling accelerometers like those described in "Dual-Element Tunneling Accelerometer" (NPO-18862), *NASA Tech Briefs*, Vol. 18, No. 11 (November 1994), page 36 and "Dual-Element Tunneling Accelerometer With Dual Feedback" (NPO-19259), *NASA Tech Briefs*, Vol.21, No. 2 (February 1997), page 55. The compactness, sensitivity, and low self-noise of the tunneling accelerometers makes it possible to achieve the desired miniaturization while retaining the desired level of performance.

In assembling the prototype miniature hydrophone, the accelerometers plus feedback control and other electronic circuits are mounted on or in a lightweight frame, and the resulting assembly is bonded inside one of two hemispherical titanium shells. Input and output wires pass through a feed-through block on the shell and are connected to the circuits inside the shell. The two hemispherical shells are then bonded together to make a single spherical shell that can be evacuated and can withstand external pressure of 1,000 psi (6.9 MPa).

This work was done by Thomas W. Kenny, William J. Kaiser, Howard W. Rockstad, Joseph K. Reynolds, Elaine Lindelef, and Timothy E. Cushing 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 Physical Sciences category,* ***or circle no. 157*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge).*

NPO-19678



A **Spherical Titanium Shell** contains a miniature directional hydrophone. The two versions differ in the configurations in which the accelerometers and circuit boards are bonded to the support rails. In this example, the two accelerometers provide sensitivity to accelerations along two orthogonal axes.

Compact Off-Axis Relay for Adaptive Optics

This design provides an accessible pupil location and simplifies alignment.

NASA's Jet Propulsion Laboratory, Pasadena, California

An optical relay has been designed to provide coupling between a deformable mirror and a Cassegrain astronomical telescope. The deformable mirror is part of a system of adaptive optics for real-time correction of optical wavefront distortions caused by turbulent variations in the index of refraction of the atmosphere. The relay is an unobscured optical subsystem with a magnification of –1. It provides a pupil plane conjugate to the primary mirror of the telescope, with proximate object and image planes. The pupil plane is intended to be the location of the deformable mirror.

The relay (see figure) includes a pair of off-axis paraboloidal mirrors and

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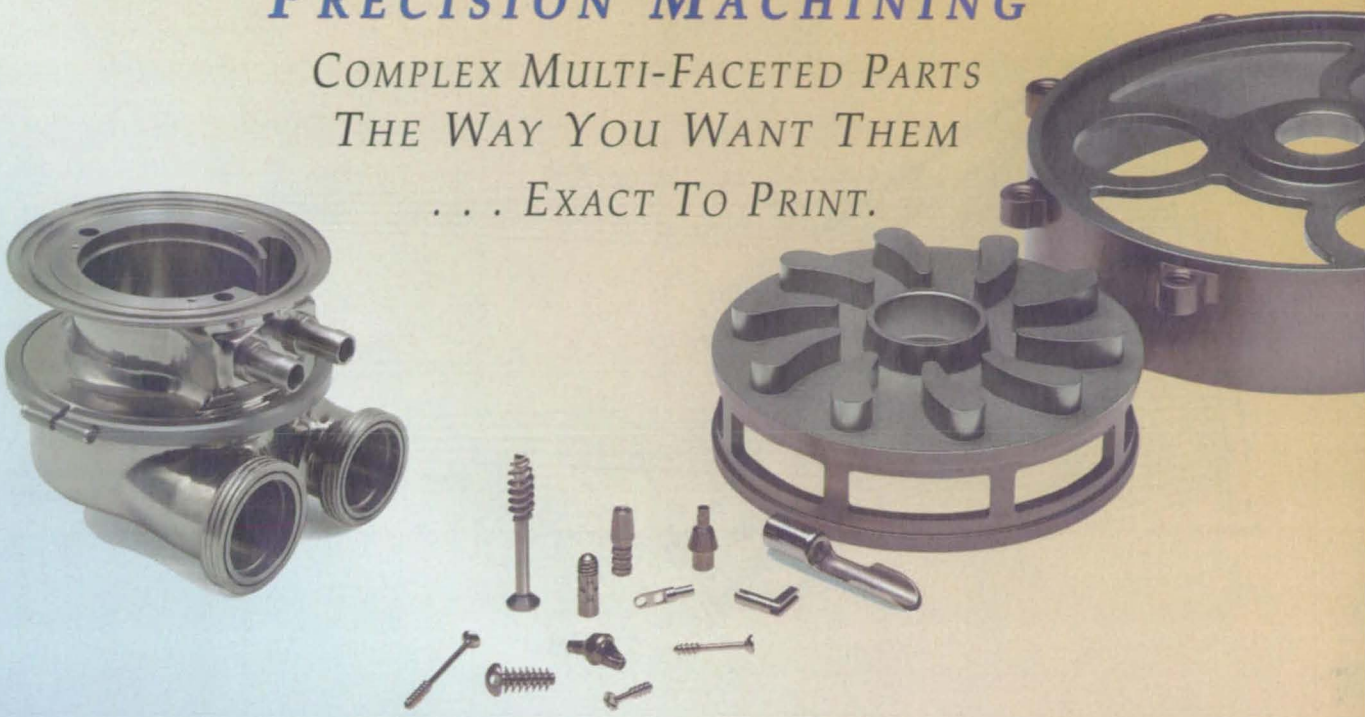

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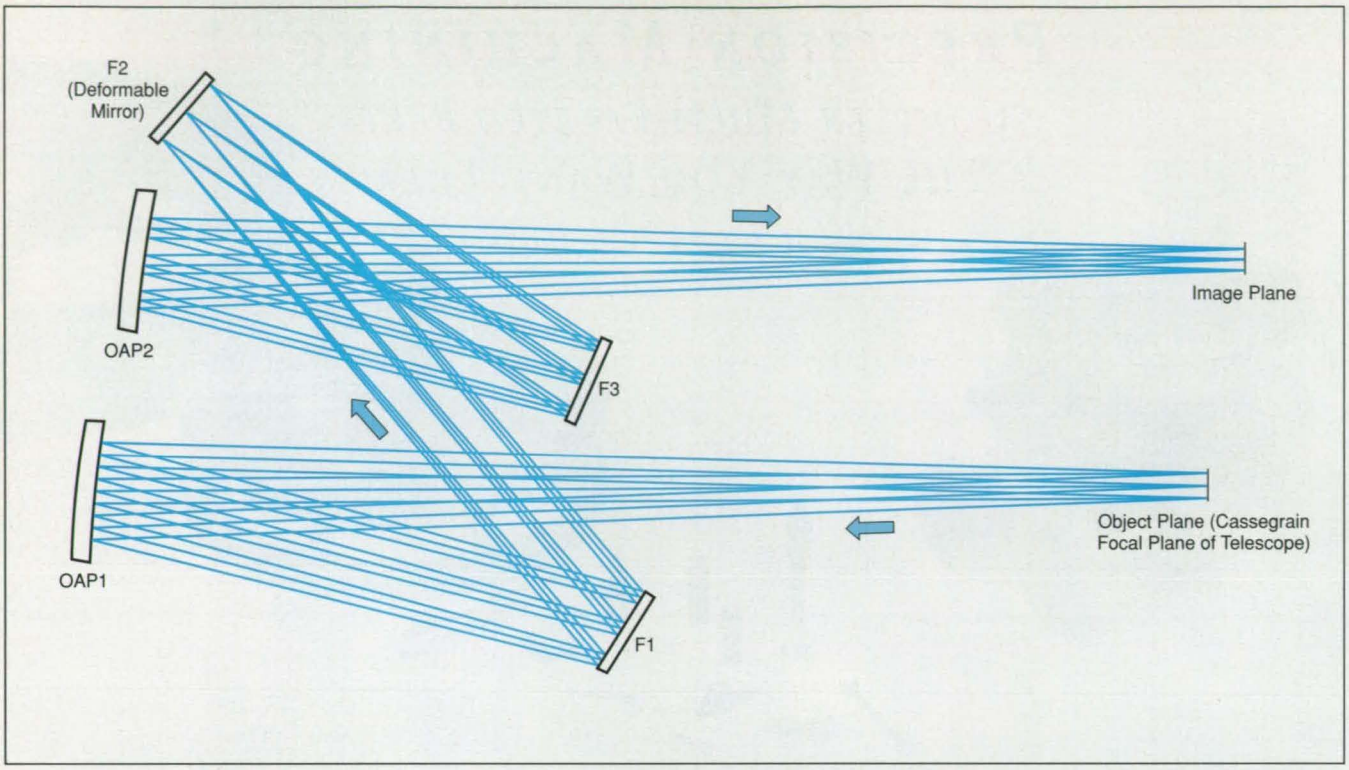


This **Ray-Trace Diagram** shows the layout of the relay, which features compactness, accessibility of pupil location, ease of alignment, and minimization of the number of reflections.

three flat mirrors in an unusually compact, folded arrangement. Rays coming from the Cassegrain focus of the telescope are recollimated by the first off-axis paraboloidal mirror (OAP1). The recollimated rays are folded by three flat mirrors (F1, F2, and F3) and are then reimaged at the original focal ratio by the second off-axis paraboloidal mirror (OAP2). In addition to recollimating the Cassegrain-focused rays, OAP1 also forms a pupil conjugate to the telescope primary mirror at F2, where the deformable mirror is placed.

Because of a limitation on actuator strokes in the deformable mirror, an independent tip/tilt mirror is usually needed: The location of F1 is an ideal location for the placement of this tip/tilt mirror. The location of F3 is also available for a second deformable mirror in a multiconjugate adaptive optical system, which can correct for atmospheric turbulence at different altitudes and thereby increase the angular size of the corrected field.

An auxiliary benefit of this design is that through appropriate selection of the angles of the flat mirrors, the axes of symmetry of the two off-axis paraboloids can be made parallel to each other. This parallelarity eases alignment in that it makes it possible to align the two off-axis paraboloids by use of a single jig that carries a retroreflecting mirror or other appropriate alignment apparatus, with a simple linear translation of the jig between the two axes. In another, related technique, a sufficiently wide alignment beam could be used to illuminate both off-axis paraboloids simultaneously, and the return signals would be used to align their respective axes.

This work was done by Richard G. Dekany 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 Physical Sciences category,* ***or circle no. 153*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge).*
NPO-19943

Improved Model for Hot-Electron-Bolometer Mixer

Electrons and phonons are characterized by two different temperatures.

NASA's Jet Propulsion Laboratory, Pasadena, California

An improved theoretical model has been developed to represent the photoresponse of a quasi-optical signal-mixing device of the hot-electron-bolometer type. More specifically, the model pertains to a device in which two input signals with frequencies of the order of 2.5 THz that differ by an amount of the order of 2.5 GHz impinge a submicron-sized bridge (microbridge) made of a film of the high-critical-temperature (high-T_c) superconductive material $YBa_2Cu_3O_{7-\delta}$ about 10 nm thick between normally conductive metal contacts on a highly thermally conductive substrate on a heat sink. The impinging signals cause nonequilibrium heating of the electron gas in the microbridge. Due to strong local oscillator pumping, the electron temperature is close to T_c; therefore, this nonequilibrium heating causes variations in the electrical resistance of the microbridge, resulting in mixing of the signals to generate a signal at the difference frequency of about 2.5 GHz.

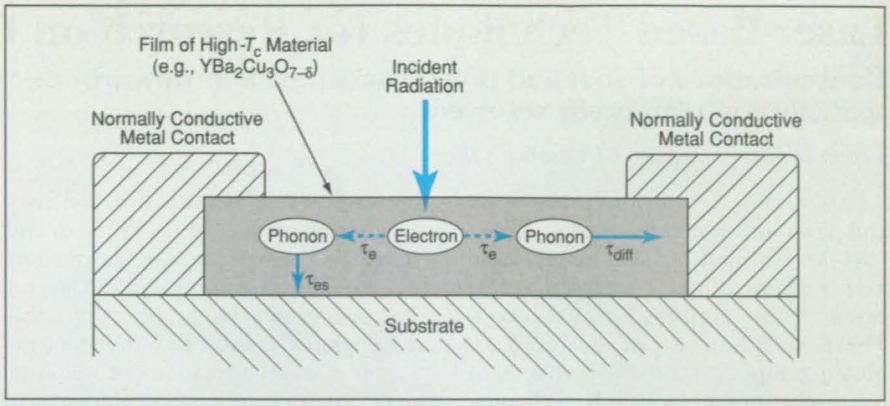
The model accounts for heating of both the electrons and the crystalline lattice of the $YBa_2Cu_3O_{7-\delta}$ film, and for

diffusion of heat through the film to both the substrate and the normally conductive metal contacts (see figure). The electron and phonon populations are characterized by temperatures T_e and T_p, respectively; in the nonequilibrium environment, these temperatures can differ from each other and from the temperature of the substrate.

The figure illustrates the principal heat-removal processes taken into account in the model. Unlike in Nb superconductive microbridges that operate at much lower T_cs (of the order of 5 K), electron diffusion contributes little to the removal of heat in the high-T_c case. Measurements have shown that the resistive response can be described in terms of (1) relaxation of the T_e via interaction with phonons with a characteristic time, τ_e, of about 1 to 2 ps at typical T_c between 80 and 90 K and (2) a slower relaxation of T_p by escape of phonons to the substrate with a characteristic time that depends on the dimensions of the $YBa_2Cu_3O_{7-\delta}$ film and the substrate material. Some nonequilibrium phonons escape from the $YBa_2Cu_3O_{7-\delta}$ film through the film/substrate boundary with a characteristic time τ_{es}, while others diffuse to the normal-metal contacts with a characteristic time τ_{diff}. Yet another thermal process that affects the relaxation time and the total thermal resistance of the microbridge is the diffusion of heat (via phonons) in the substrate.

The model incorporates coupled nonlinear differential equations for T_e and T_p as functions of time. These equations can be solved to evaluate the performances of microbridges with various design parameters under various operating conditions. In particular, the model has been used to study all important mixer parameters for a practical range of operating conditions needed for a 2.512-THz heterodyne receiver that would be used to measure the concentration of OH radicals in the upper atmosphere. It has been shown that a microbridge mixing device like the one described above could be made to exhibit a very low noise temperature (≈2,000 K) and to consume only microwatts of local-oscillator power.

This work was done by Boris S. Karasik, William R. McGrath, and Michael C. Gaidis 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 Physical Sciences category,* ***or circle no. 155*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge).*
NPO-20045



Electrons That Have Been Heated in nonequilibrium fashion by incident radiation and by dc transport are cooled by interaction with phonons, some of which escape to the substrate, others of which diffuse to the normally conductive metal contacts.

Laser-Based Techniques for Research on Combustion

Concentrations of soot and polycyclic aromatic hydrocarbons can be spatially and temporally resolved.

Lewis Research Center, Cleveland, Ohio

Laser-induced incandescence (LII) and laser-induced fluorescence (LIF) have been found to constitute a valuable combination of techniques for research on combustion processes. These techniques can be used to obtain temporally resolved images of concentrations of polycyclic aromatic hydrocarbons (PAHs) and of soot in flames and exhaust gases. Spatially resolved quantitative data on the concentrations can be extracted from the images. These data are important because concentrations of PAHs and soot are indicative of basic physical and chemical combustion mechanisms and of the performances of combustors. For example, soot necessarily forms from PAH precursors, and both soot and PAHs are major constituents of combustion-related atmospheric pollution.

LIF yields information on PAH concentrations, while LII yields information on soot concentrations. [The use of LII to measure the spatially and temporally resolved concentration of soot in a flame was reported previously in "Laser-Induced Incandescence for Research on Combustion" (LEW-16078), *NASA Tech Briefs,* Vol. 20, No. 12 (December 1996), page 16a.] Depending upon the specific experiment that one seeks to perform, one can use either LII or LIF separately, or one can use both techniques simultaneously to obtain more information than can be obtained by either technique alone, as explained below.

If a single pulse of ultraviolet laser light is used for excitation, then both LIF and LII signals can be detected during and shortly after the pulse. The LII signal decays more slowly than the LIF signal does; this feature can be used to distinguish between the LIF and LII responses. If a single pulse of near-infrared laser light is used for excitation, then only a LII response is observed during and shortly after the pulse. When infrared and ultraviolet pulses are used in measurements, then the difference between the combined ultraviolet-excited LIF/LII image and the infrared-excited LII (only) image can yield an LIF image.

LIF and LII can be observed and measured by use of images acquired by intensified cameras, relying on the excitatory laser pulses to provide temporal resolution. The use of LII and LIF in various excitation/detection schemes was demonstrated in experiments on a well-understood gas-jet diffusion flame, in which ethylene flowed out of a brass tube and burned in a surrounding co-flow of air. In each experiment, the laser beam was formed into a sheet to illuminate a cross section of the flame just above the end of the tube. A gated, intensified camera was used to view the LIF and/or LII coming from the illuminated cross-sectional plane. The figure contains three images acquired under different excitation/detection conditions, as follows:

The first image shows LII (only) excited by a laser beam at a wavelength of 1,064 nm and viewed through a

LII Excited by 1,064-nm Laser, Viewed at 400 nm

LIF and LII Excited by 266-nm Laser, Viewed at 400 nm

LIF and LII Excited by 266-nm Laser, Viewed at 600 nm

An Ethylene/Air Diffusion Flame just above the end of a tube was imaged by LIF and LII at various wavelengths. The small intervals of the ruler are millimeters.

band-pass interference filter centered at a wavelength of 400 nm. This image reveals soot in a thin annular region typical of diffusion flames.

The second image shows simultaneous LIF and LII excited by a 266-nm laser, also viewed through the 400-nm band-pass filter. This image reveals both the annular distribution of soot and the distribution of PAHs in the fuel-rich region surrounded by the annular soot shell.

The third image shows simultaneous LIF and LII excited by a 266-nm laser and viewed through another band-bass interference filter at a wavelength of 600 nm. The LII (soot) component of this image resembles that of the preceding image, but the LIF (PAH) component appears concentrated closer to the region containing the soot; this result is consistent with (a) the previous observation that larger PAH molecules tend to fluoresce at greater wavelengths, coupled with (b) the hypotheses that the basic physical and chemical mechanisms of the flame should result in concentration of larger PAH molecules toward the outer region where soot forms.

This work was done by Randy L. Vander Wal of NYMA, Inc., for **Lewis Research Center.** *For further information, access the Technical Support Package (TSP)* ***free online at www.nasatech.com*** *under the Physical Sciences category,* ***or circle no. 172*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge).*

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Two-Wavelength Pyrometry With Self-Calibration

Knowledge of instrument gain, emissivity, and transmissivity are not necessary for determining temperature.

Lewis Research Center, Cleveland, Ohio

An improved method of two-wavelength optical pyrometry provides for the determination of different temperatures of a specimen surface at different times. Unlike in other pyrometric methods, there is no need for explicit knowledge of such ancillary wavelength-dependent parameters as emissivity of the specimen surface (or ratios between emissivities at different wavelengths) and transmissivity of the optical path from the specimen to the pyrometer. There is also no need for explicit knowledge of the wavelength-dependent voltage response of the pyrometer; in other words, it is not necessary to calibrate the pyrometer. Instead, the method provides for self-calibration through the generation and use of implicit calibration information from pyrometer readings at two wavelengths and at two or more different temperatures.

The method requires a pyrometer in the form of a spectrometer, plus a computer to acquire and process the pyrometer readings. The method is based on (a) Planck's radiation law as modified for wavelength-dependent emissivity and transmissivity, and (b) the fundamental equation for the response of the pyrometer. Planck's radiation law can be expressed as

$$L(\lambda,T)=\frac{\varepsilon_\lambda \tau_\lambda c_1}{\lambda^5\left[\exp\left(\frac{c_2}{\lambda T}\right)-1\right]}$$

where $L(\lambda,T)$ is the spectral intensity of the radiation at wavelength λ arriving at the pyrometer, T is the absolute temperature of the emitting surface of the specimen, ε_λ is the wavelength-dependent emissivity of the specimen surface, τ_λ is the wavelength-dependent transmissivity of the optical path, and c_1 and c_2 are fundamental physical constants. The voltage response of the pyrometer to the incident radiation at wavelength λ is given by

$$V(\lambda)=g_\lambda L(\lambda,T)$$

Let the unknown wavelength-dependent parameters g_λ, e_λ, and τ_λ be lumped into one wavelength-dependent term via

$$A(\lambda)\equiv g_\lambda\,\varepsilon_\lambda\,\tau_\lambda$$

Let pyrometer readings be taken at wavelengths λ_1 and λ_2 at two different times $(0, t_1, t_2, \ldots, t)$ when the temperatures of the specimen $[T(0), T(t_1), T(t_2), \ldots, T(t)]$ are different. By combining and manipulating the foregoing equations, one can show that the four pyrometer readings are related by the following equation:

$$\frac{V(\lambda_1,0)}{V(\lambda_1,t)}=\frac{\left[1+\frac{A(\lambda_2)}{V(\lambda_2,t)}\right]^{\frac{\lambda_2}{\lambda_1}}+1}{\left[1+\frac{A(\lambda_2)}{V(\lambda_2,0)}\right]^{\frac{\lambda_2}{\lambda_1}}+1}$$

Least-squares curve fitting of the quantity

$$y(t)=\frac{V(\lambda_1,0)}{V(\lambda_1,t)}=\frac{\left[1+A(\lambda_2)x(t)\right]^{\frac{\lambda_2}{\lambda_1}}+1}{\left[1+\frac{A(\lambda_2)}{V(\lambda_2,0)}\right]^{\frac{\lambda_2}{\lambda_1}}+1}$$

versus the quantity

$$x(t)=\frac{1}{V(\lambda_2,t)}$$

from $t = 0$ to time $= t$ determines the quantity $A(\lambda_2)$. One can also formulate this equation with the roles of λ_1 and λ_2 interchanged and solve the equation to obtain $A(\lambda_1)$. Thereafter, one can compute the instantaneous temperature directly from a pyrometer reading at either wavelength, using

$$T=\frac{c_2}{\lambda\ln\left[1+\frac{A(\lambda)}{V(\lambda)}\right]}$$

This work was done by Daniel Ng of **Lewis Research Center.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category,* ***or circle no. 160*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge).*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Lewis Research Center, Commercial Technology Office, Attn: Tech Brief Patent Status, Mail Stop 7-3, 21000 Brookpark Rd., Cleveland, OH 44135. Refer to LEW-16182.

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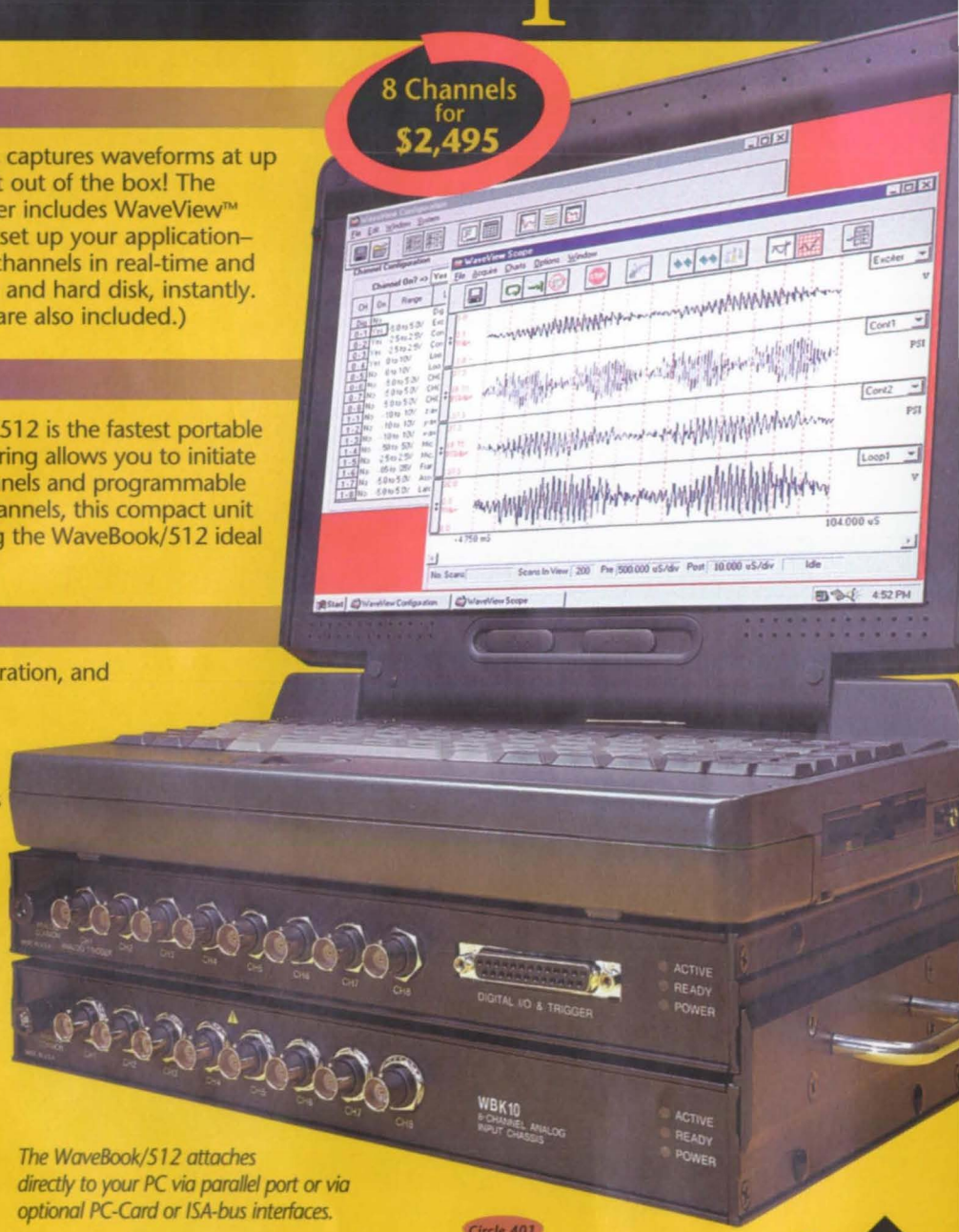

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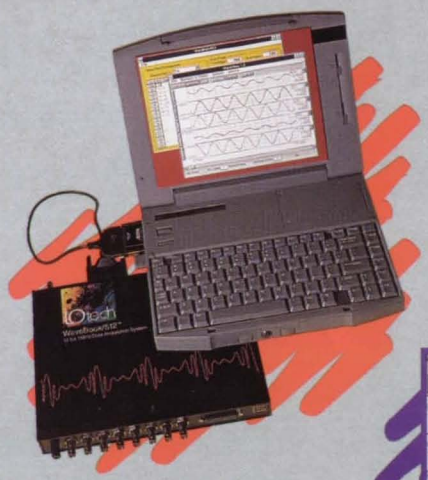

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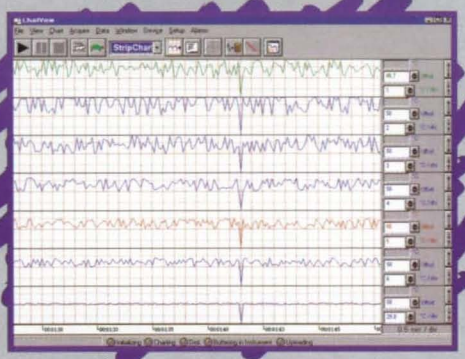

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Electrically Conductive Thermal-Control Coating Materials

The materials retain electrical conductivity during exposure to vacuum.

Marshall Space Flight Center, Alabama

Coating materials that consist largely of tin oxide exhibit a useful combination of solar absorptance, thermal emittance, and electrical conductivity. The materials are intended for use as thermal-control coats for spacecraft; they may also be useful on industrial or scientific vacuum-equipment surfaces that are required to exhibit their specific thermal-radiation and electrical properties. Unlike older materials used for the same purpose, these materials do not lose electrical conductivity during long exposure to vacuum.

A material of this type is made highly electrically conductive by incorporating antimony and indium via chlorides or oxalates in concentrations of 1 to 4 weight percent relative to the amount of tin oxide. The antimony and indium produce extrinsic defects within the crystal lattice of the tin oxide. These defects bring electrons in the valence band close enough to the conduction band to make the electrons highly mobile between the bands. This results in high electrical conductivity.

The ingredients are mixed in several steps of wet and dry ball milling. The mixture is heated to a temperature between 1,000 and 1,100 °C for four hours, then cooled, then milled again. Next, the material is mixed with a resin and solvents to form a liquid mixture that can be sprayed to coat the surface in question.

This work was done by Richard J. Mell of **Marshall Space Flight Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Materials category,* ***or circle no. 128*** *on the TSP Order card in this issue to receive a copy by mail ($5 charge).*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center; (205) 544-0021. Refer to MFS-28916.

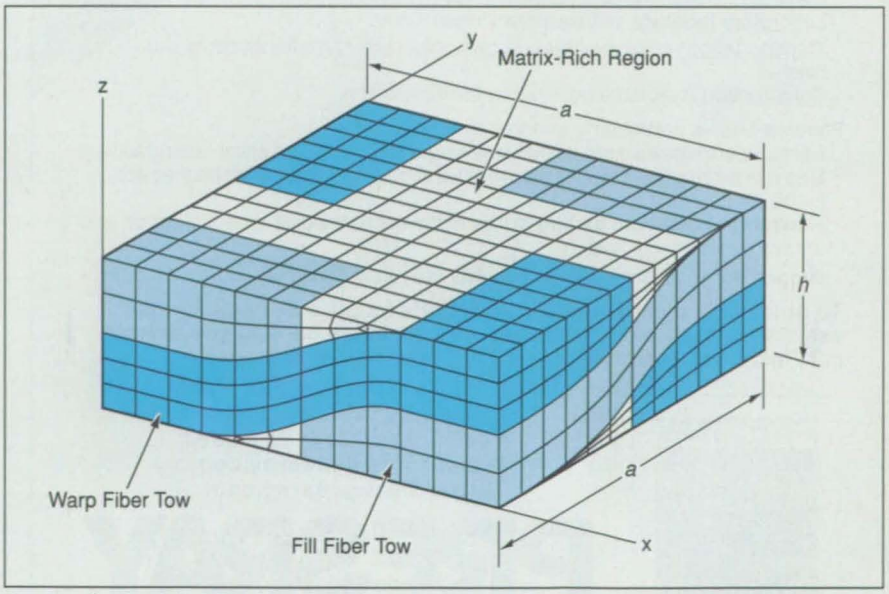
Simplified Micromechanics of Plain-Weave Composites

Mechanical, thermal, and hygral behavior can be estimated with less computation.

Lewis Research Center, Cleveland, Ohio

A micromechanics-based method has been developed to facilitate numerical simulation of the mechanical, thermal, and hygral responses of plain-weave matrix/fiber laminated composite materials. The equations obtained via this method are meant to be used in combination with micromechanics-based computer codes like Integrated Composite Analyzer (ICAN), which has been described previously in *NASA Tech Briefs*. Because it is based on micromechanics, this method affords the capability for mathematically modeling stresses and strains at any level of detail from a microscopic scale within an individual fiber or interfiber matrix to a macroscopic laminate. The main advantage of this method is that micromechanics is based on closed-form equations and thus offers high computational efficiency, relative to a detailed three-dimensional finite-element formulation.

As used here, "plain-weave" pertains to a fabric in which a warp or longitudinal fiber tow is interlaced with every second fill or transverse fiber tow. A representative volume element or unit cell (see figure) based on the repeating unit of the plain-weave-fabric component of a composite is used to construct a mathematical model of the micromechanics in this method. The model accounts for the undulations of the fiber tows and the distributions of fiber ends through the thickness. In applying the basic equations of micromechanics, it is assumed that the classi-



One-Fourth of a Unit Cell derived from the periodic structure of a plain-weave fabric is used in the micromechanics-based analysis. The rest of the unit cell is modeled by copying the results from this portion, invoking arguments of symmetry.

cal laminate plate theory is applicable in thin sections defined by slices orthogonal to the x axis. Each section is further sliced in its x–z plane, the properties of each slice are computed as though each were a ply in a laminate, then the properties of the stacked of slices are computed to obtain the properties of each section.

For a stress analysis, a laminate analysis is performed with an applied load to obtain equivalent slice stresses in warp and fill regions. Optionally, one can then perform a micromechanics-based analysis again to divide the stresses in the warp and fill regions into fiber and matrix microstresses. Thus, one can simulate responses at any level of detail. All the features that are already incorporated into ICAN or another composite-analysis code for modeling such phenomena as effects of processing, voids, environmental degradation, and effects of cyclic loads can be incorporated easily into an analysis by the present method. In a comparison involving a graphite/epoxy and a SiC/SiC plain-weave composite, the present method was found to yield predictions similar to those of detailed three-dimensional finite-element analyses and in reasonably close agreement with limited experimental data.

This work was done by Pappu L. N. Murthy and Christos C. Chamis of **Lewis Research Center** *and Subodh K. Mital of the University of Toledo. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Materials category,* ***or circle no. 115*** *on the TSP Order card in this issue to receive a copy by mail ($5 charge)*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Lewis Research Center, Commercial Technology Office, Attn: Tech Brief Patent Status, Mail Stop 7–3, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16435.

Micromechanics for Particulate-Reinforced Composites

Mechanical and thermal properties can be predicted faster and more easily than before.

Lewis Research Center, Cleveland, Ohio

The macroscopic mechanical and thermal properties of matrix/particle composite materials and the responses of such materials to applied loads can now be predicted by use of simplified equations derived from basic considerations of micromechanics. Typical bounding methods — and such numerical methods as finite-element analysis — provide bounds on the effective macroscopic thermal and mechanical properties of matrix/particle composites. These methods entail major disadvantages: either the bounds are far apart, or (when numerical techniques are used) the computations take too much time to be practical for frequent or routine analyses. In contrast, the simplified equations are highly computationally efficient and yield results within engineering accuracy.

The simplified equations predict the thermal and mechanical properties, averaged over volumes large enough so that the material appears homogeneous, on the basis of (1) the thermal and mechanical properties of the constituent materials and (2) such fabrication-related parameters as the sizes and volume fractions of the particles.

With the help of simple microstress equations, it is also possible to predict the stress and strain in each constituent. The simplified equations are usually in closed form and, unlike the equations of older methods, do not require either numerical integration or iteration. Thus, the equations are computationally efficient yet capable of adequately modeling the applicable physics.

The derivation of the simplified equations starts from a mechanics-of-materials approach at the microscopic scale — similar to the approach followed previously with respect to matrix/fiber composite materials. The particles are modeled as being spheres of equal diameter dispersed uniformly throughout the matrix or binder material on a cubic lattice. The diameter of the model particles is an average calculated from the distribution of sizes of the real particles. The distance between neighboring particles on the lattice is computed from the sizes and volume fraction of the particles. Each cell of the lattice is regarded as a representative volume element; the micromechanics equations are developed for this volume element and used to represent the macroscopic properties of the composite material.

The simplified equations have been tested by applying them to two materials; (1) a particulate composite with constituents that have properties representative of those of constituents of concrete, and (2) a metal-matrix/particle composite that is a candidate for use in some automotive applications. The predictions obtained from the equations were compared with bounds obtained by other methods and with experimental data, where available. The results of these tests confirmed the expectations of computational efficiency and of the excellence of the micromechanics predictions.

This work was done by Pappu L. N. Murthy and Robert K. Goldberg of **Lewis Research Center** *and Subodh K. Mital of The University of Toledo. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Materials category,* ***or circle no. 166*** *on the TSP Order card in this issue to receive a copy by mail ($5 charge).*

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Guanidine: a Unique Strong Organic Base

Guanidine can be used in place of NaOH and KOH in some applications.

Lewis Research Center, Cleveland, Ohio

Guanidine [$NH_2C(:NH)NH_2$] is an organic base with a strength equal to that of sodium hydroxide. Guanidine can be used as a substitute for alkali metal hydroxides in making ceramics in which residual sodium or potassium ash would be detrimental, because guanidine and its organic derivatives can be removed thermally, without leaving residues. Ceramics in which sodium or potassium ash would be detrimental include those in which resistance to oxidation must be combined with high strength, and ceramic superconductors, which must be pure to have high critical-current capacities. Guanidine can also be used in the recovery of cations (using the guanidine form of cation-exchange resins), as an additive for electroplating, and as a soap for lubricants.

Ceramic articles are generally fabricated from powders by a variety of processes that include slip casting, injection molding, and doctor blading. In most cases, ionic organic chemicals are used in these processes as deflocculants and binders to form "green" (unfired) bodies of adequate strength to permit handling prior to firing. Many organic processing aids contain alkali metal cations — usually sodium, which remains in ash in the fired products. These impurities degrade the high-temperature performances of the finished articles — a shortcoming that can be prevented by use of guanidine and guanidine derivatives instead of metal hydroxides.

The following three classes of guanidine derivatives have been found to be useful in making ceramics:

- Guanidine oxalate: useful as a reagent for making intimate oxide mixtures. The metal oxalates, which serve in this case as precursors to metal oxides, are coprecipitated in one step and then thermally decomposed into oxides: This technique can be used to make easily sinterable oxide powder mixtures. Guanidine oxalate coprecipitation has been used to produce high-grade $YBa_2Cu_3O_{7-x}$ superconducting powder, intimate Sr/La/Cu powder mixtures, and yttria-doped cerium(III) oxide.
- Guanidine polyelectrolytes (guanidine polyacrylate) and surfactants: These are excellent deflocculants and binders for making ceramics. Guanidine polyacrylate is a good deflocculant and binder for uncontaminated ceramic slurries used for slip casting, injection molding, and doctor blading. Such ionic polyelectrolytes as guanidine polyacrylate have been found to provide excellent "green"-body strength.
- Guanidine soaps, which are guanidine salts of organic fatty acids: These can be used as vehicles and binders for coating substrates with oxides and noble metals. The guanidine fatty acid salt guanidine 2-ethyl-hexanoate has been found to be a useful vehicle and binder for coating alumina (sapphire) fibers with zirconia and platinum. It has also been used to coat Haynes Alloy 130 with platinum to prevent oxidation at electrical contacts. Guanidine 2-ethyl-hexanoate wets oxides as well as most metal surfaces.

This work was done by Warren H. Philipp, Martha H. Jaskowiak, and Lisa C. Veitch of **Lewis Research Center**, *Joseph M. Savino of Cleveland State University, and Mark DeGuire of Case Western Reserve University. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Materials category,* ***or circle no. 121*** *on the TSP Order card in this issue to receive a copy by mail ($5 charge).*

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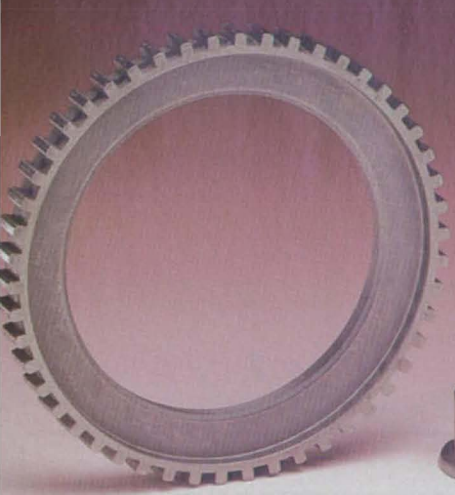

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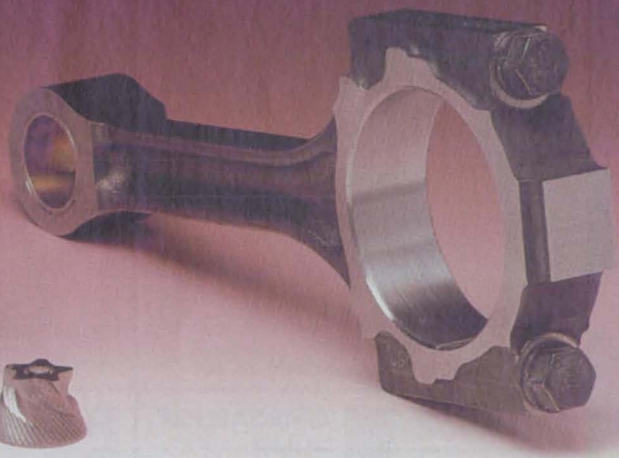

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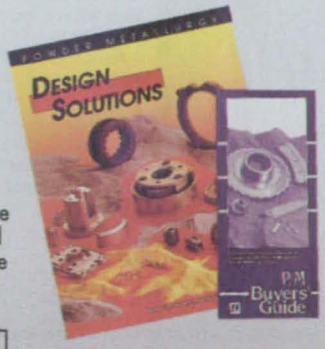

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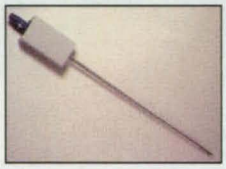

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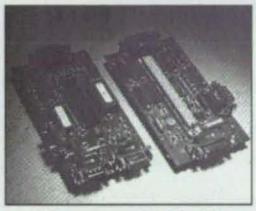

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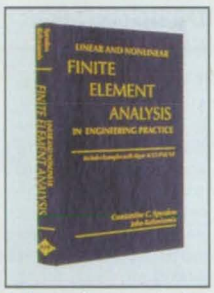

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Algor's Internet place has detailed information on four product lines. Discover Houdini, Algor's automatic CAD solid model to 8-node "brick" mesh converter. Learn about Algor FEA, including case histories. Preview engineering videos, books and multimedia. See all new integrated piping/vessel/plant design software. If you do not have Internet access, call for free info. Algor, Inc.; e-mail: info@algor.com; URL: http://www.algor.com; Tel: 412-967-2700; Fax: 412-967-2781.

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Design Engineering Product Showcase

NEW PRECISION MECHANICAL COMPONENTS CATALOG

PIC Design has published Catalog 44, their biggest ever. The catalog includes an expanded line of linear motion systems, modular framing elements, and belts and pulleys. Also featured are PIC Design positioning tables, ball slides, lead screws, precision gears, bearings, shafting, couplings, and hardware. Many components are available in both inch and metric sizes. PIC Design, Box 1004, Middlebury, CT 06762-1004; Tel: 800-243-6125; Fax: 203-758-8271; e-mail: info@pic-design.com

PIC Design

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IMAGINATION SYSTEMS' HYPERKERNEL

Hyperkernel is the first product that enables software developers to implement real-time system applications that execute with Windows NT. With Hyperkernel, software developers can integrate highly deterministic real-time application programs into Microsoft's Windows NT OS. Hyperkernel enables devices such as robots, process controllers, and machine control systems to be configured as application servers on any standard network system. Imagination Systems Inc., 5752 Princess Anne Rd., Virginia Beach, VA 23462; Tel: 800-331-2565 or 804-497-8200; Fax: 804-497-2062; http://www.imagination.com

Imagination Systems Inc.

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NEMATRON'S PENTIUM PRO ICC-7000

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Nematron Corporation

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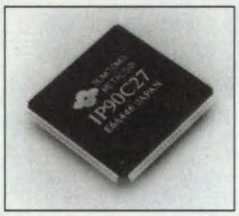

SMI ADDS NEW CONVOLVER TO FAMILY OF LSIS

A new 40-MHz convolver introduced by Sumitomo Metals (SMI) allows 8- or 16-bit data and coefficients. Dynamic access to the 50 internal multipliers lets SMI's new IP90C27 convolver to handle a variety of kernel shapes and sizes ranging from 7x7 to a linear 1x50. Multiple C27 convolvers can be cascaded to expand kernel size. For technical specs, contact Sumitomo Metals; Tel: 800-392-4447.

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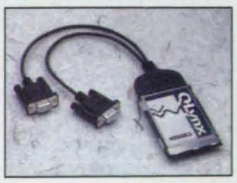

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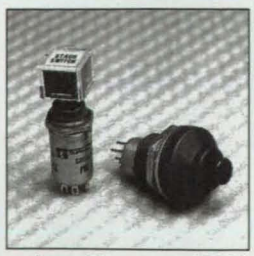

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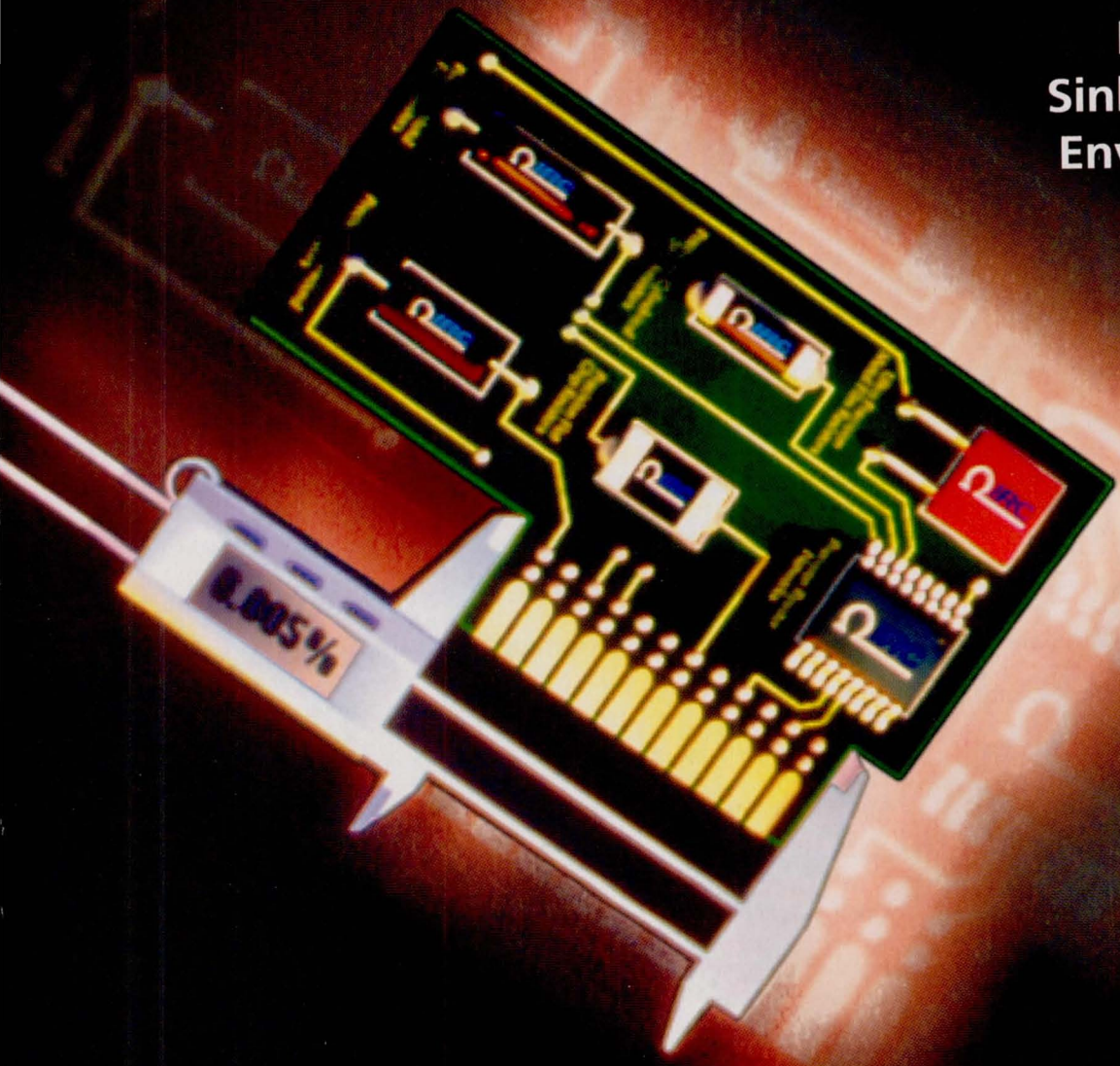
Electronics TECH BRIEFS

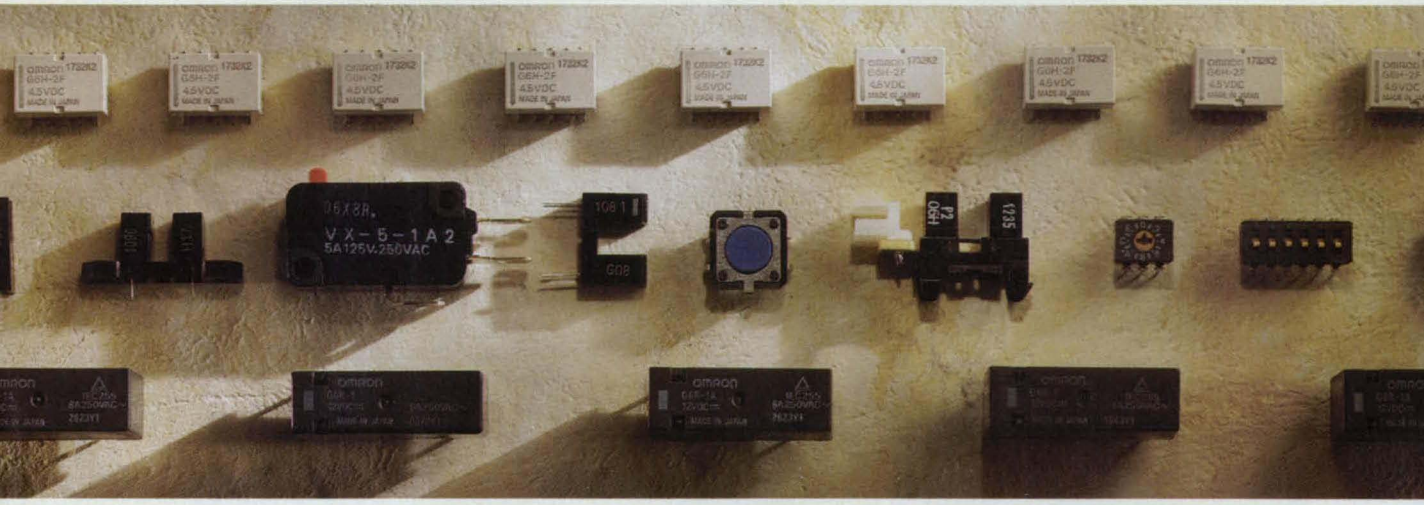
Holographic Acoustic Microscopy for Microelectronics

Novel Heat Sink for Harsh Environments



New Electronics Products — see page 14a

If You Think Omron Only Makes Relays Read Between Our Lines.



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Electronics TECH BRIEFS

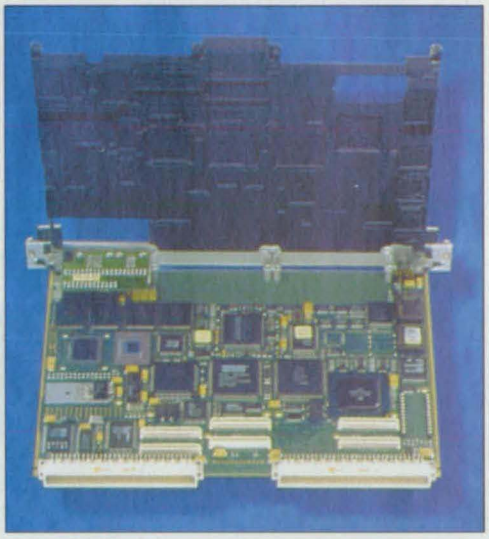
Electronics Tech Briefs Supplement to *NASA Tech Briefs* November 1997 Issue Published by Associated Business Publications

ELECTRONICS TECH BRIEFS

FEATURE

DEPARTMENTS

On the cover:
IRC Corp. of Corpus Christi, TX, has added the MAR40/42 Series to its precision resistor line. Calling the Series "the ultimate in precision metal film resistors," the company puts resistive tolerances at ±0.005 percent and temperature coefficient of resistance at ±2 ppm/°C. For more information, see "New Products," page 14a.



Increasingly industries such as aerospace, transportation, manufacturing, and oil exploration are demanding VME-based systems that can be easily and cheaply optimized for harsh environments. A team assembled by Thomson-CSF, including engineers from CETIA, the company's high-performance VME board subsidiary, developed the Ruggedizer® heat sink, seen at left mounted on a board, that allows commercial off-the-shelf designs to be upgraded to rugged specifications with an add-on technology. For more information, see the brief on page 11a.

Cast Your Vote for

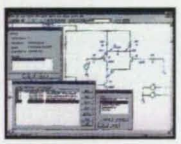
Electronics TECH BRIEFS

First Annual Product of the Year Award

Beginning in May, each issue of the *Electronics Tech Briefs* supplement to *NASA Tech Briefs* carried a Product of the Month—an electronics product the editors felt was of special interest and value to readers who work with electronics. This month *Electronics Tech Briefs* readers are invited to vote for the one product you deem the standout among the four described below. The product garnering the most votes will be named the 1997 *Electronics Tech Briefs* Product of the Year.

Please read the descriptions below of the Products of the Month, and choose the ONE you feel should receive the Product of the Year award. On the ballot below please clearly indicate your choice in the appropriate box, and fax or mail the completed ballot to reach the editors by January 15, 1998. The *Electronics Tech Briefs* Product of the Year will be announced in the March 1998 issue.

MAY: *Visual PCB Assembly Inspection System*
GenRad Inc., Concord, MA, offers the Viper Visual Inspection System, designed to provide a cost-effective solution for detecting and preventing defects in the component-placement process for printed circuit board (PCB) assembly. Targeted at PCB manufacturers who are placing tens of thousands of components per hour, the system employs line scanning and a shape-based approach. It provides a full suite of techniques for detection of device presence or absence on components as small as 0.04 by 0.02 in., device orientation, and x/y and rotational position of every board component. Boards as large as 14 × 18 in. can be inspected for all component placement defects.



JULY: *Desktop Electronic Design & Analysis*
MicroSim Corp., Irvine, CA, introduces Release 8, which it calls a tightly integrated start-to-finish desktop electronic design automation (EDA) system for mixed analog/digital designs. The company points to two new features as innovative: Design Journal™ and Design Manager. The first enables engineers to mark checkpoints at key crossroads, try alternative design directions, compare the results of all the alternative choices on a single graph, then proceed with the best option. Design Manager functions as an automatic organizer, linking together all files, even non-EDA documents and references to outside definitions, associated with the design into a single, self-contained entity. Symbols from Models, another key feature, allows engineers to download simulation models published by manufacturers on the Internet, and the system will create symbols for the models automatically in minutes.

SEPTEMBER: *Software/Platform for Semiconductor Inspection*
Cognex, Natick, MA, introduces the 8000 Series™, a new machine vision platform that incorporates its new PatMax™ software and plugs directly into the PCI bus of standard Pentium MMX™ computers. The series includes a range of products from the low-cost 8100 to the 8400, which incorporates a digital signal processor that enables operation up to 10 times faster than current Cognex products. The company also says that PatMax-equipped systems will locate and precisely align the new 300-mm generation of wafers before probing, metrology, inspection, and bonding. And because PatMax can accurately locate wafer and die patterns despite variances introduced by chemical mechanical processing and other processing steps, it will help manufacturers improve their wafer alignment yield. It will also improve yield by increasing speed and accuracy on production machines, including surface-mount-device pick and place equipment.

NOVEMBER: *"Smart Power" Pulse Width Modulation Device*
SGS-Thomson Microelectronics, Lincoln, MA, calls its new VIPer100 a unique monolithic combination of a state-of-the-art current-mode pulse width modulation (PWM) circuit and an optimized avalanche energy-rated high-voltage vertical power MOSFET. The company says the device is the first in a family of intelligent-power ICs being developed for switched-mode power supply applications. Key features include automatic burst-mode operation in standby condition, programmable switching frequency up to 200 kHz, and an inherent current limit of up to 3 A. The company says the device can deliver up to 100 W of output power while using more than 50 percent fewer components than a discrete solution.

1997 *Electronics Tech Briefs* PRODUCT OF THE YEAR BALLOT

Indicate your choice by clearly marking the appropriate box. Fax or mail your completed ballot to Robert Clark, Senior Editor, *Electronics Tech Briefs*, 317 Madison Avenue, Suite 1900, New York, NY 10017; Fax: 212-986-7864.

- ❑ **May:** GenRad Inc. Viper Visual PCB Inspection System
- ❑ **July:** MicroSim Corp. Release 8 Desktop Electronic Design Automation System
- ❑ **September:** Cognex 8000 Series Software/Platform for Semiconductor Inspection
- ❑ **November:** SGS-Thomson VIPer100 Pulse Width Modulation Device

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Advanced Electromagnetic Probes for Characterizing Materials

Properties of materials and thicknesses of subsurface layers can be measured nondestructively.

Goddard Space Flight Center, Greenbelt, Maryland

Two types of advanced electromagnetic sensors that operate in quasistatic spatial modes have been developed for use in nondestructive characterization of materials in surface and subsurface layers and for determining the thicknesses of the layers. Because the sensors are thin and flexible, they conform readily to curved surfaces, making it possible to inspect complexly shaped specimens (see Figure 1) that could include regions that would otherwise be accessible only with difficulty. The sensor outputs can be analyzed according to continuum mathematical models of the interactions between the sensor electromagnetic fields and the layered media to obtain repeatable quantitative measures of such physical and geometric properties as electrical conductivity, permeability, porosity, roughness, coating thickness, residual stress, and surface flaws.

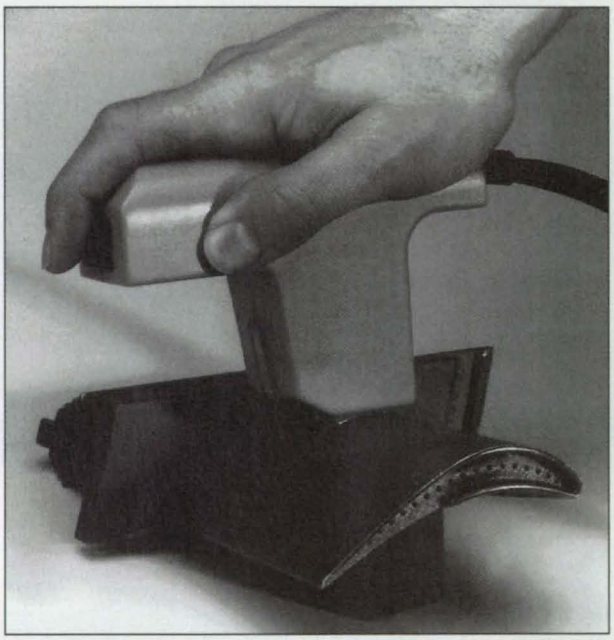

Figure 1. A **Probe Containing an MWM** can be used to inspect a specimen with a concave, convex, conical, or flat surface.

The sensors of one type, called "meandering-winding magnetometers" (MWMs), can be used as either (1) eddy-current sensors to measure electrical properties of conductive materials or (2) magnetic sensors to measure magnetic properties of conductive or nonconductive materials. Each MWM includes a primary (driver) winding that meanders (in a plane, except, of course, when the sensor is bent to conform to a surface). Secondary (sensing) windings meander along the primary winding on both sides (see Figure 2). The primary winding is driven by a known input current at a prescribed frequency. The voltage at the terminals of the secondary windings is measured and used to determine the magnitude and phase of an impedance that is defined as the ratio between the secondary voltage and the primary current. The magnitude and phase of this impedance yield information about the magnetic and conductive media penetrated by the applied magnetic field.

The sensors of the other type, called "inter-digital electrode dielectrometers" (IDEDs) enable the use of electric fields to measure the permittivities and the small residual conductivities of materials that are regarded as electrical insulators. Each IDED includes two electrodes laid out as interdigitated fingers on a polyimide substrate. While one electrode (the driving electrode) is excited with a known sinusoidal voltage at a prescribed frequency, the voltage on the other electrode (the sensing electrode) is measured. The phase shift and the ratio between the amplitudes of voltages on the two electrodes provide information about the dielectric materials penetrated by the applied electric field.

The depth of penetration of the electric field of an IDED depends only on the electrode spacing. Multiple IDEDs with different electrode spacings for different depths of penetration can be used to characterize dielectric properties and changes in those properties as functions of depth, even for such heterogeneous materials as composites.

Given (1) the geometries of MWM windings and IDED electrodes, (2) the driving frequencies, (3) the properties and dimensions of specimens, and (4) the MWM and IDED mathematical models, one can generate lookup tables, called "measurement grids," for calibration of sensor outputs. Measurement grids can be used to convert sensor outputs directly into estimates of layer thicknesses and electromagnetic properties. Layer thicknesses can include, for example, thicknesses of surface coatings, thicknesses of air gaps between metallic layers, and liftoff distances between sensors and specimen surfaces.

Applications of MWMs and IDEDs include the following:

- Characterization of coatings on metals, ceramics, and composites;
- Monitoring for fatigue, corrosion,

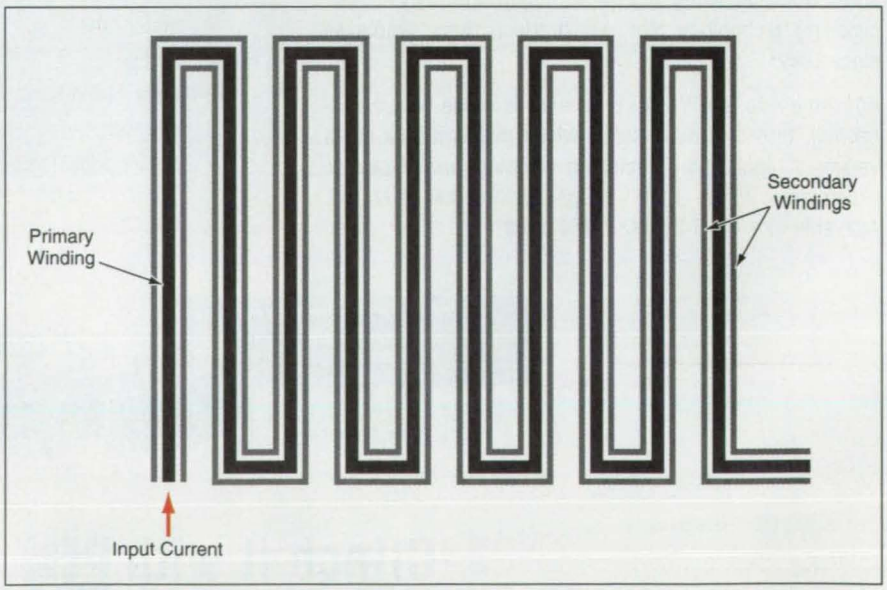

Figure 2. The **Conductors of an MWM** act as primary and secondary windings of a transformer, the magnetic field of which penetrates the specimen on which it is placed.

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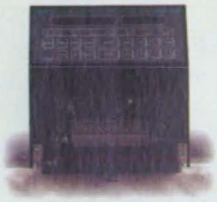

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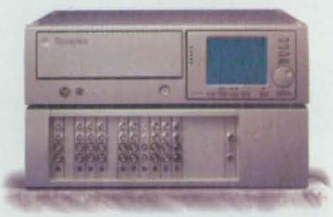

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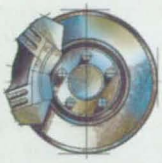

Safety Systems

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- Measurement of anisotropy of selected properties of heterogeneous materials under bidirectional loads.

Thickness measurements have been demonstrated on a variety of intermetallic and ceramic coatings, including a nickel/aluminum alloy on aluminum substrates and zirconia/yttria on 304 stainless-steel substrates. Potential uses of MWMs and IDEDs include inspection of turbine blades, reactor tubes, airframe structural components, and other critical components in the aerospace and power-generation industries.

This work was done by Neil J. Goldfine of JENTEK Sensors, Inc., for **Goddard Space Flight Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category,* ***or circle no. 176*** *on the TSP Order card in this issue to receive a copy by mail ($5 charge).*
GSC-13878

Interconnect Structures with Interfaces to Relieve Stresses

Semiconductor interconnect structures have patterned interfaces to minimize stress migration and related damage.

Cornell University, Ithaca, New York

An interconnect structure for semiconductors utilizes patterned interfaces to relieve stress in integrated circuit metallization by alternatively providing areas of good adhesion and poor adhesion between the metallization and surrounding layers. Good adhesion between the metal interconnects and the surrounding passivation or insulator layers is important to maintain structural integrity and facilitate the fabrication of the interconnect structure, and for good thermal contact to dissipate heat. However, adhesion of metal to these layers, which have inherently much lower coefficients of thermal expansion, will induce stresses, both tensile and compressive, as thermal cycling occurs. Large tensile stresses tend to induce voids in the metal, which increases line resistance or can even sever the interconnect. Large compressive stresses induce hillocks, which tend to fracture the surrounding passivation layer and cause short circuits.

By the method of this invention, the surface of the integrated circuit is selectively patterned with material that has poor adhesion to metal, prior to the deposition of the metallization. The metallization deposited over this material will not adhere to it, providing stress relief. Between the patterned areas, the metallization will adhere tightly to the underlying layer, providing structural integrity and thermal contact. Similarly, nonadhering areas are patterned over the interconnect prior to deposition of the covering passivation layer to relieve stresses along that interface.

The invention does not require the use of unconventional materials or processes. Several choices of materials exist for the creation of the nonadhering areas. For example, a thin interlayer of material can be deposited and its surface treated to make it nonadhering to the next layer. Alternatively, the surfaces of the passivation layers interfacing with a metallization may be modified by ion implantation to make them nonadhering. Interlayer materials may consist of polyimide or photoimagable polyimide, which is cured prior to the deposition of the next layer. Other materials, such as polymers, metals, semiconductors, and inorganic insulators such as ceramics or glasses may also be used.

The continued miniaturization of integrated circuits has necessitated a corresponding reduction in the size of metal interconnect. The fineness of the interconnect structures coupled with the increased packing density and power consumption has made them more susceptible to defects induced by stress due to thermal cycling. This invention provides a simple solution to the problem without requiring new equipment or expensive materials.

This work was done by Che-Yu Li at **Cornell University.** *For more information call Robert F. Schleelein, Technology Marketing and Licensing Specialist, Cornell Research Foundation Inc., 20 Thornwood Drive, Suite 105, Ithaca, NY 14850; (607) 257-1081; fax (607) 257-1015; E-mail: rfs4@cornell.edu; http://www.research.cornell.edu/crf.*

Holographic Acoustic Microscopy for Microelectronics

Acoustic diffraction and interference would be exploited to image features inside complex microelectronics.

NASA's Jet Propulsion Laboratory, Pasadena, California

Holographic acoustic microscopy (HAM) has been proposed as a method for inspection and analysis of dense microelectronic circuits. Whereas previous developments in acoustic microscopy have yielded a capability for generating two-dimensional images the proposed development would result in the generation of three-dimensional images, in which one could see features that previously would have been hidden by other features that cast acoustic shadows. For example, HAM could yield detailed images of cracks.

HAM would involve adaptation of concepts and techniques from both three-dimensional optical holography and scanning laser acoustic microscopy (SLAM). The imaging wavefronts would be generated according to the principles of optical holography, except that phonons would be used instead of photons, and the wavefront

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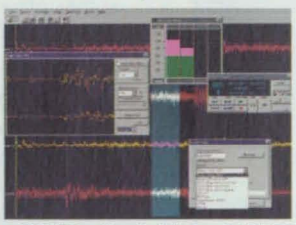

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Phone: +49 (711) 5858-253
Fax: +49 (711) 580715

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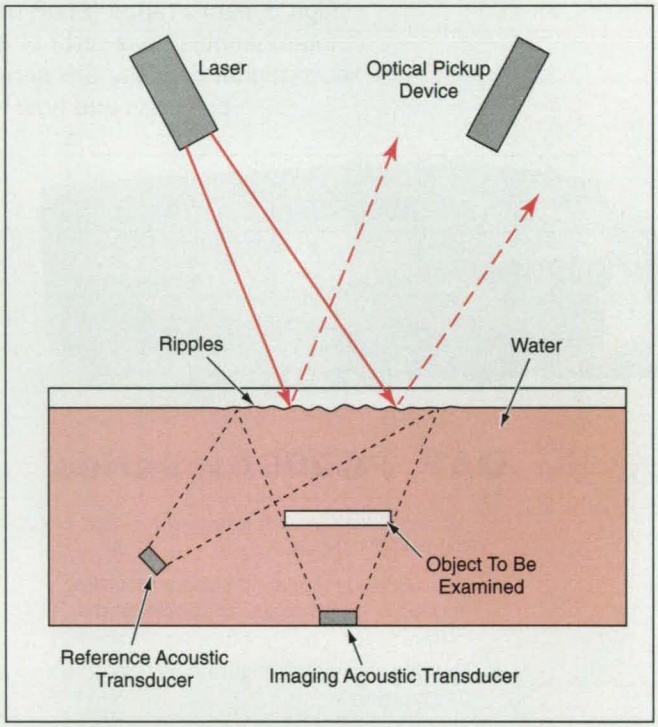
information would be recorded by use of modified SLAM transducers and a modified SLAM imaging system instead of a photographic plate.

The figure illustrates one of several alternative HAM setups. The microelectronic device or other object to be examined would be suspended in a liquid couplant — typically, water. Two acoustic transducers would be excited at the same frequency and in coherent in phase. One acoustic transducer would launch a reference acoustic signal, analogous to a reference beam in optical holography; this signal would not go through the object, but would pass unhindered to the surface of the water, where it would give rise to ripples. The other transducer would launch an acoustic signal that would pass through and be diffracted by the object on its way to the surface, giving rise to a second ripple pattern superimposed on the first one. The net ripple pattern would constitute the hologram.



In **Holographic Acoustic Microscopy**, sound waves diffracted on passage through the object would interfere with sound waves that did not pass through the object, producing a hologram in the form of a ripple pattern on the surface of the water.

A laser beam amplitude-modulated at the acoustic frequency would be rastered across the hologram and the light diffracted by the hologram would be detected by an optical pickup device. If the laser light were amplitude-modulated and optically manipulated such that the complex amplitude of its modulation at each point along the raster were proportional to the complex conjugate of the complex amplitude of the reference acoustic signal at that point, then the amplitude of the light diffracted by the hologram at that point would be proportional to the acoustic signal diffracted by the object and reaching that point. Alternatively, optical reconstruction could be effected in real time by use of reflection of coherent light from the surface of the water.

This work was done by John D. Olivas 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 Physical Sciences category,* ***or circle no. 177*** *on the TSP Order card in this issue to receive a copy by mail ($5 charge).*
NPO-20118

Heat Sink Converts VME Boards for Harsh Environments

Innovative design renders commercial off-the-shelf boards rugged.

CETIA Inc., Cambridge, Massachusetts

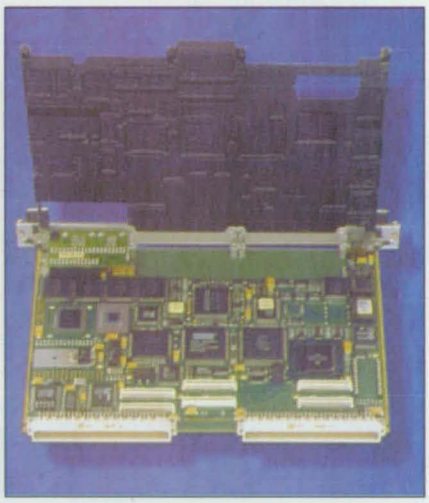
An increasing number of industries such as aerospace, transportation, manufacturing, and oil exploration are demanding VME-based systems that can be optimized in harsh environments without excessive increases in cost or time to deployment. Historically, ruggedized systems were often derived from commercial off-the-shelf (COTS) designs by screening components for wider operating ranges and redesigning boards for better cooling and improved mechanical integrity. This method, though an effective form of ruggedization, required a time-consuming and expensive redesign procedure.

A team assembled by Thomson-CSF, made up of engineers from the systems internal integration group and CETIA, the wholly owned high-performance VME board subsidiary, developed a solution that has been registered as The Ruggedizer®. While it satisfies ruggedization requirements, it can be added on at the board level. The team set the following criteria:

- The ruggedized board must be fully compliant with VME specifications, and retain its overall VME characteristics, in particular occupying the same number of physical VME slots as the commercial-grade version.
- The commercial-grade board must be totally reused. This allowed system integrators to deploy the most up-to-date technology with minimum design compromise or migration risk, and considerably reduced cost and time to deployment.
- To retain the full use of the base commercial-grade product, all enhancements must be added on as late as possible in the manufacturing process. In addition, any add-on enhancement must be removable to ensure access for maintenance and repair.
- To deploy the resulting rugged board in multiple programs, it must be manufactured at a low cost and in high volumes. This could only be achieved if standard manufacturing and support processes and practices are used.
- The enhancement must extend the operational characteristics of the board. In particular, significant increases must be achieved in mechanical and thermal ranges of operation. Additionally, rugged specifications must be satisfied for other environmental conditions.
- By adopting an add-on approach, the ruggedization technique must achieve substantial cost and schedule improvements over previous methods.

To meet these criteria, the team developed a board-level heat sink designed to lower the overall operating temperature of the board substantially in harsh environments. This solution achieves maximum heat dissipation by minimizing the space between each component and the heat sink, accomplished with a technique that exactly matches the heat sink to each design's components. The system allows commercial boards to be upgraded to rugged specifications with an add-on technology that can be attached under standard manufacturing practices.

To achieve the tight mechanical coupling between the heat sink and a board's components, data from a patented 3-D laser scan technique reproduces a precision-milled aluminum negative "image" of the board's entire top-side topology. The exposed top part of the heat sink features convention fins for dissipating heat into the system, but is designed to avoid protruding into an adjacent VME slot. The Ruggedizer is attached directly to the VME board using its existing VME connector and front-panel mounting holes, improving stiffness and vibration resistance without stealing precious board real estate.



The **CETIA Ruggedizer** mounted on a circuit board.

The mechanical design of the heat sink leaves a minute clearance between the Ruggedizer and the board components. Heat conduction between them and the heat sink is enhanced via a patented, electrically nonconductive thermal coupling agent — a paste that is applied directly to the board before the heat sink is attached.

The chemical design and application of the paste is critical to the success of the Ruggedizer. In addition to providing maximum heat transfer with no electrical conduction, the paste must retain its characteristics with age, and be pliable enough to permit differential expansion and contraction between the board and the heat sink. The thermal coupling agent also facilitates standard field repairs through its easy removal and reapplication.

Applications that occur in such harsh environments as to require the use of the Ruggedizer also dictate moisture and corrosion resistance. This is addressed by adding conformal coating to the circuit board before the thermal agent and the heat sink are applied.

Although the general industry trend is toward air-convection cooled systems, a number of applications will still have to operate under conditions of limited air flow. Such systems are designed for conduction cooling, where boards are cooled by conducting heat to a cold source, generally the walls of the rack. The Ruggedizer technology has already been adapted in specific cases for conduction cooling.

The Ruggedizer acts as a temperature equalizer, lowering operating temperature of the board's hottest regions and routing heat to cooler spots. The overall result is increased reliability at substantially elevated operational temperatures. Depending on the board, the operating temperature improvement with the heat sink attached can be up to 20 °C. Typically, standard commercial-grade products operating at 55 °C will operate from -20 °C up to +70 °C when equipped with the heat sink.

A board's mean time between failures (MTBF) typically deteriorates rapidly under the physical and thermal effects of extreme environments. Because it mitigates these conditions, the Ruggedizer has a very positive effect on MTBF — as much as doubling it.

The heat sink covers the entire face of a board, providing mechanical protection and robustness. The "sandwich" structure of the Ruggedizer-equipped board reduces the effects of violent shock and vibration. In particular, the characteristics of the aluminum mass eliminate the most damaging resonant frequencies.

For more information, contact Robert Negre, vice president of research and development; E-mail: rnegre@cetia.com; or **CETIA Inc.,** *58 Charles St., Cambridge, MA 02141; (617) 494-0987; fax (617) 494-8786.*

Thin Films by Jet Vapor Deposition

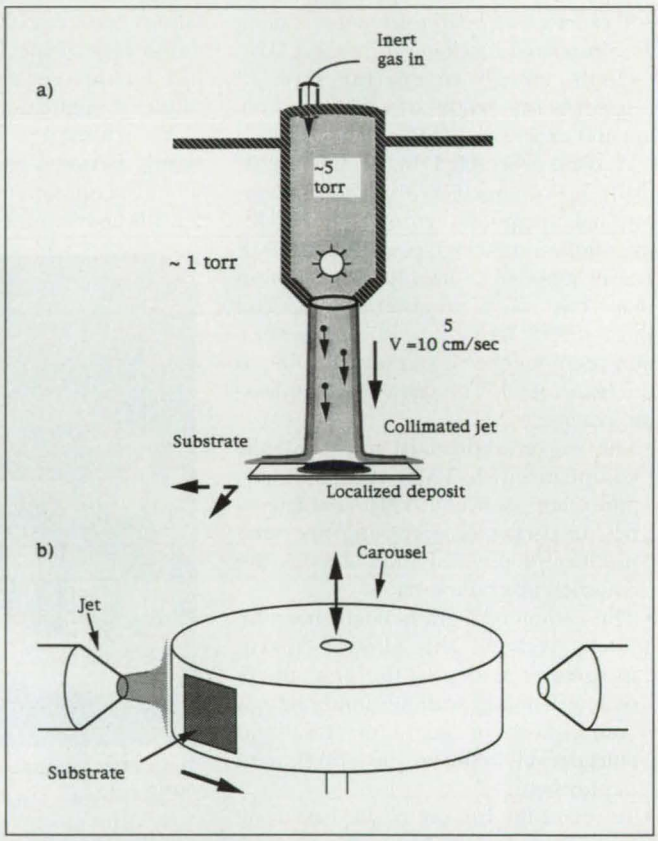
A novel patented technique offers low-vacuum, low-cost thin film solutions.

Jet Process Corporation (JPC), New Haven, Connecticut

Jet Vapor Deposition (JVD)™, a novel low-vacuum, low-temperature thin film technology based on sonic jets, has a variety of potential applications from semiconductor device fabrication to reel-to-reel continuous coating. Unlike conventional physical vapor deposition methods, which operate at 10^{-6} to 10^{-2} Torr and use high-vacuum equipment, JVD operates in a pressure environment of 1 Torr and uses inert gas jets to transport depositing materials directionally to the workpiece with minimum waste and at a high rate. In addition to being able to deposit a wide variety of materials and material combinations, JVD is environmentally "green," using no toxic precursors and generating no waste.

JVD's key elements are the patented jet sources and motion systems that allow uniform coating of large workpieces. These are mounted in low-pressure deposition chambers evacuated with mechanical pumps; no high-vacuum equipment is needed. A typical jet source has a nozzle of several millimeters in diameter. An inert gas such as Ar is supplied upstream of the nozzle. Pumping speeds and nozzle diameters are chosen to provide "critical flow" conditions: a ratio of nozzle pressure to chamber pressure exceeding two. Under such conditions, gas emerges from the nozzle at the speed of sound. Material generated in a vapor source placed near the nozzle throat becomes entrapped in the inert gas stream and is carried downstream to be deposited on the workpiece. Mechanisms for vapor generation include thermal evaporation, sputtering, and chemical decomposition. The figure is an illustration of JVD with representative operating parameters.

The jet source makes a Gaussian-like deposit on a stationary substrate. Relative motion is essential in JVD to uniformly coat large substrates. Depending on the application, either the source or the substrate, or both, can be moved. For example, as in (b) in the figure, a moving carousel scheme works well for small flat substrates in a batch job. With other motion strategies, substrates as large as 12 in. × 12 in., or 12-in. diameters, can be uniformly coated; available reel-to-reel coating mechanisms can provide continuous coating of metal or other substrates.

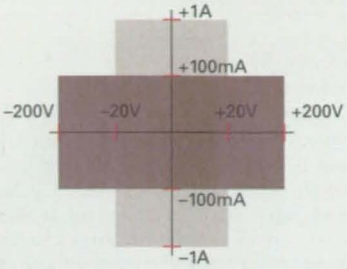


Jet Vapor Source (a): vapor is generated near the nozzle exit. Carousel (b): the combined spinning and axis motion results in uniform coverage and permits synthesis with multiple jets.

Multiple jet sources are used to make multilayer and multicomponent films. JVD sources operate independently under "critical flow" conditions as described above. Simple calibrations result in precise thickness and composition control.

Jet Process is currently pursuing several principal applications of JVD. It offers custom metal coating services and lease or sale of custom designed equipment for volume applications, including reel-to-reel continuous coating; JVD's operating pressure range permits vastly simplified air-to-vacuum seals, which results in continuous coating process equipment that is lower in cost and easier to operate. JPC is also developing materials and process equipment for next-generation semiconductor device fabrication. JVD's gate-quality silicon nitride has shown excellent dielectric properties and is a candidate material for next-generation logic and memory chips.

For more information, contact **Jet Process Corp.** *at (203) 777-6000; fax: (203) 777-6007. Jet Process is interested in joint development programs with industrial partners to address current and future thin film and coating needs.*



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Current	±1A/20V	±1A/20V	±3A/20V	To memory = 500µs	RS-232	Amps	0.02%
	±100mA/200V	±20mA/1100V	±1A/60V	To IEEE-488 = 1ms	Digital I/O	Ohms	0.04%
Power	22W	22W	66W	Range change = 13ms	Component handler		

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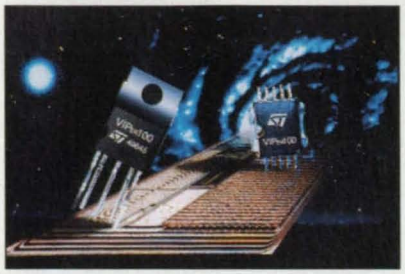
Product of the Month



"Smart Power" Pulse Width Modulation Device

SGS-Thomson Microelectronics, Lincoln, MA, calls its new VIPer100 a unique monolithic combination of a state-of-the-art current-mode pulse width modulation (PWM) circuit and an optimized avalanche energy-rated high-voltage vertical power MOSFET. The company says the device is the first in a family of intelligent-power ICs being developed for switched-mode power-supply applications. Key features include automatic burst-mode operation in standby condition, programmable switching frequency up to 200 kHz, and an inherent current limit of up to 3 A. The company says the device can deliver up to 100 W of output power while using more than 50 percent fewer components than a discrete solution.

For More Information Circle No. 795

Power MOSFETs for DC/DC Converters

The FDP7030L and FDB7030L 30-V power MOSFETs from Fairchild Semiconductor, Santa Clara, CA, are designed for dedicated DC/DC converters in desktop PCs, servers, and systems that use such microprocessors as those by Intel, AMD, Hewlett Packard, Digital Equipment, Sun Micro Systems, and others. The logic-level N-channel devices have 30-V breakdown voltage and 7-mOhm resistance (DS (on)), optimized for 25-40-W processor power supplies. Fairchild says their high-power TO-220 and TO-263 packaging maximizes current handling capability and simplifies thermal management. Prices begin at $1.55 in 10,000-unit quantities.

For More Information Circle No. 797

Hybrid Pulse Width Modulation Amps

Apex Microtechnology Corp., Tucson, AZ, adds a pair of full H-bridge models to its hybrid pulse width modulation (PWM) amplifier line that extend its supply range and current output performance by a factor of 2. The SA03 has 30 A continuous output and the SA04 20 A; the SA03's supply range is 16-100 V, while the SA04 extends that to 16-200 V. As a result of these higher power and voltage capabilities, the SA03 is capable of power delivery levels up to 3000 W and the SA04 of up to 4000 W. On both an internal oscillator supplies a 22-kHz switching frequency, requiring no external components. They are housed in a 12-pin hermetic power package occupying just 3 square inches of board space.

For More Information Circle No. 800

Gantry Platform for Sorting and Testing

Anorad Corp., Hauppauge, NY, introduces the G5300-VIP gantry platform, designed for use in the hard-drive and microelectronics industries. The machine provides 250 × 400 × 50-mm × 360° X-Y-Z-theta motion. Requiring only 24 in. by 36 in. of floor space, the G5300-VIP system can operate as a stand-alone machine or as a process cell integrated with in-line material transfer equipment. Typical sorting applications utilize the system's optical character recognition capabilities for reading small characters scribed on the component's edge.

For More Information Circle No. 803

Disk Flatness Inspection System

Veeco Process Metrology Group, Tucson, AZ, announces what it calls the first automated inspection system for data storage disks that improves process control by making two-sided flatness and parallelism measurements in a single pass. The WYKO DT4™ Disk Flatness Inspection System is a noncontact instrument built for manufacturing environments and can be used for inspection at any point in the process flow after the polish stage. A 1.06-micron laser measures global flatness of a disk with runout to 18.6 microns across one radius. The company says that the system provides fast throughput of up to 4.5 seconds per disk side, or 380 disks per hour.

For More Information Circle No. 798

SMT Board-to-Board Connectors

Elco Corp., Myrtle Beach, SC, has expanded its line of Super Microleaf 0.5-mm-pitch surface mount technology (SMT) board-to-board connectors up to 140 positions. Designated the 5087 series, the connectors feature board stacking heights as low as 2 mm for portable devices where space and weight are critical design factors. The Microleaf 5087 series connectors are available in tape-and-reel packaging and are designed with a redundant shrouded insulator that provides mechanical stability to meet the shock and vibration requirements of today's cellular phones, PDAs, pagers, and other portable electronic equipment.

For More Information Circle No. 801

Liquid Photoimageable Covercoats

Rogers Corp., Rogers, CT, introduces R/flex® 8080 LP liquid photoimageable covercoats, a line of materials designed for applications such as hard-disk drives and chip packaging where fine pattern resolution, moisture resistance, and creasability are important. The company says that the combination of an R/flex 8080 LP covercoat and an R/flex flexible circuit material can produce a high-resolution flexible circuit that withstands environmental rigors. All of the covercoat products are resistant to plating chemistries, and have high adhesion, heat resistance, and electrical insulation properties, Rogers says.

For More Information Circle No. 804

Multimeter with Adjustable Display

The new digital multimeter from Extech Instruments Corp., Waltham, MA, has a large LCD display that is adjustable over a wide viewing angle. Readings appear in a large 25-mm, 3-1/2-digit format. The multimeter measures DC voltage up to 1000 V with an accuracy of ±0.5 percent, AC voltage up to 750 V, AC and DC current, resistance, capacitance, and temperature selectable in degrees Fahrenheit or degrees Centigrade. Both diodes and transistors can be tested, and features include color-coded input terminals and auto power-off. The instrument comes with test leads, temperature probe, rugged heavy-duty drop-proof case, and a 9-V battery.

For More Information Circle No. 796

Metal Film Resistors

IRC Inc., Corpus Christi, TX, has expanded its precision resistor product line with three metal film types. The RC series offers resistive tolerances down to ±0.05 percent and temperature coefficient of resistance (TCR) as low as ±5 ppm/°C. It is packaged as an epoxy-coated axial leaded device. The CAR series has tolerances down to ±0.01 percent and TCRs of ±5 ppm/°C. It is also packaged as an epoxy-coated axial leaded device. The MAR40/42 series features tolerances down to ±0.005 percent and TCRs of ±2 ppm/°C, in values from 10 ohms to 1 megohms. It is a molded radial leaded device.

For More Information Circle No. 799

Single-Output DC/DC Converters

The new 16-20-W single-output A-Series DC/DC converters from Datel Inc., Mansfield, MA, are designed to meet the long-term reliability and low-cost requirements of such applications as telecomm, computer networking, and datacomm. Available output voltages for the A-Series are 3.3, 5, 12, and 15 V; input voltages are Datel's standard 4-1 range, including 18-72 V (48 V nominal) for the D48 model and 9-36 V (24 V nominal) for the D12 model. Total available output power ranges from 16 W for the 3.3-V models to 20 W for the 5-V models. All are subjected to the Highly Accelerated Life Test before release.

For More Information Circle No. 802

Power Modules/ Current Boosters

Power Trends, Warrenville, IL, releases its series of 18-A, +5-V-to-+3.3-V power modules and current boosters. The PT7705, called the "Big Hammer," is designed to supply low-voltage power to any of the new current-hungry megaprocessors and to work in parallel with one or more PT7749 current boosters; when added to two PT7749s, output current can be boosted to 54 A. Both devices are available in flexible 27-pin SIP packages that include vertical and horizontal through-hole and surface-mount pin-outs. In quantities of 1000, price for the PT7705 is $29.50 each and for the PT7749 $27.50 each.

For More Information Circle No. 805

Program Simulates Views From Simulated Flights Over Terrain

The Surveyor computer program generates images of terrain of the Earth and other planets as would be seen during simulated flights over the terrain. Some previously developed programs offer some of the same capabilities, but none can handle the large data sets that Surveyor can handle. Surveyor accepts elevation and surface-feature-texture data acquired by remote sensing during previous real flights over a given terrain, then processes the data to simulate the evolving view from a simulated flightpath. Surveyor provides a user interface for building simulated flightpaths; the user generates such a trajectory interactively, with the help of a real-time rendering capability that enables previewing. Once the flightpath has been generated, Surveyor generates sequential frames of data representing high-quality animation images that can be made to have various resolutions suitable for various film and video formats. Surveyor has been executed on a Silicon Graphics workstation with 256 MB of random-access memory, a 9-GB hard drive, and a 20-in. (51-cm) monitor. It can also be run on Sun workstations using the SunOS operating system.

This program was written by Zareh Gorjian, Steve Watson, Dave Kagels, Paul Asmar, Dan Stanfill, Bena Currin, and Gigi Yates of Caltech for **NASA's Jet Propulsion Laboratory.** *No further documentation is available.*

This software is available for commercial licensing. Please contact Don Hart of the California Institute of Technology at (818) 393-3425. Refer to NPO-20043.

Software Simulates Observations by a Spaceborne Camera

The SceneGen computer program simulates observational data that would be acquired by a video camera used for navigation aboard a spacecraft. SceneGen consists of two parts: a "virtual world" part that mathematically models the world that the spacecraft is expected to encounter and a camera-subsystem part that mathematically models the behavior of the camera and associated instrumentation. The virtual-world part of the software is based on physics and provides for the accurate simulation of light-path traces and photon counts. The camera-subsystem part of the software is further subdivided into a flight module and a support module. The flight module serves as part of a command-and-data-retrieval interface between the electronic circuitry of the simulated instrumentation and other subsystem modules of spacecraft flight software. The support module simulates the behavior of the camera subsystem and the generation of observational data during interactions with the virtual world.

This program was written by Meemong Lee, Ray L. Swartz, and Richard Weidner 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 Computer Software category,* ***or circle no. 180*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge).*

This software is available for commercial licensing. Please contact Don Hart of the California Institute of Technology at (818) 393-3425. Refer to NPO-20053.

Software for Electrostatic Levitation

JPL-HTESL-3D is a computer program for feedback control of the three-dimensional position of an electrostatically levitated sample in an experiment on high-temperature containerless processing of the sample material. The program also acquires and displays measurements of the temperature of the sample and of the high voltages on the levitating electrodes. In JPL-HTESL-3D, tasks are allocated to foreground and background modes. In the foreground are servo-control and data-collection tasks that must be performed in real time. In the background are second-priority tasks that arise in connection with a graphical display, mouse, and keyboard. JPL-HTESL-3D runs on a Macintosh, or compatible, desktop computer and utilizes the interrupt-request capability of that computer. When an interrupt signal is issued, the computer sets aside background routines, stores the present state of its registers in memory, and launches the foreground routine. During the foreground routine, JPL-HTESL-3D receives digitized outputs of a position sensor and processes them via a proportional, integral, and derivative control law that generates a digital command for adjusting the electrode voltages to counteract any deviation of the sample from the nominal levitation position. The command is sent out through a digital-to-analog converter, and a single frame of data is collected in a specified memory buffer. After the foreground routine has been executed, the computer recaptures its previous register values and resumes its background task. This process is set into a continuous loop with an interrupt frequency of 480 Hz.

This program was written by Sang K. Chung and Won-Kyu Rhim 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 Computer Software category,* ***or circle no. 106*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge).This software is available for commercial licensing. Please contact Don Hart of the California Institute of Technology at (818) 393-3425. Refer to NPO-19886.*

Computer Program Generates Software From Facts and Rules

The Automatic Code Generator (ACG) is a computer program that decreases the effort and thus the cost of developing ZIPSIM software. [ZIPSIM is a software system for constructing computer programs to test control software when the control computer and/or other electronic control hardware (e.g., an avionic system) is not available for testing.] The input to the ACG is a concise list of facts that must hold for the code that one seeks to develop, along with domain-specific knowledge like design rules and patterns. The application programmer writes only these facts, rather than the code. The design rules are provided by system architects. The ACG comprises two components: (1) a specification compiler, which translates specifications into facts for an inference engine and (2) the inference engine, which synthesizes C++ code from the facts and rules. The inference engine is based on the CLIPS expert-system software. The ACG is in daily use, supporting the development of mission-critical software within the ZIPSIM project. The increment of productivity afforded by the ACG is approximately equivalent to that of one human programmer.

This program was written by William K. Reinholtz 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 Computer Software category,* ***or circle no. 114*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge).*

This software is available for commercial licensing. Please contact Don Hart of the California Institute of Technology at (818) 393-3425. Refer to NPO-19981.

Estimating Repair-Weld Strengths Using Wide-Panel Specimens

Wide-panel specimens give better approximations of realistic stress patterns.

Marshall Space Flight Center, Alabama

A technique for determining the effect of a repair weld upon the strength of a previously welded workpiece involves tensile testing of a wide-panel specimen that is coated with photoelastic material to reveal strains. (As used here, "repair weld" denotes a portion of an initial weld that has been rewelded to remove a defect.) The technique provides for assessment of the effects of residual stresses that the repair weld introduces into the surrounding workpiece material, including the nearby portions of the initial weld not included in the repair weld. The invention has been used to assess the effects of residual stresses, degradation of strengths, and redistribution of loads in 2195 aluminum/lithium alloy repair welds in the Space Shuttle Super Lightweight External Tank program. The technique could easily be adapted to assessment of these effects in high-performance welded structures in other applications.

Heretofore, it has been common practice to cut relatively narrow [up to 2-in. (5-cm) wide] tensile specimens from a repair-welded test panel (see Figure 1), then test these specimens to failure to determine the strengths of the initial and repair welds. The major disadvantage of the narrow-specimen technique is that it cannot capture (1) the effects of residual stresses introduced by a repair weld and (2) redistribution of loads in a structure that contains a repair weld. This is because removing a narrow specimen (1) removes the constraint of surrounding material, which is the source of residual stresses and (2) removes any capability for sharing and redistribution of load in the surrounding material.

The present wide-panel testing technique is designed to capture the combined effects of residual stresses, degradation of strength, and redistribution of load around a repair weld. A wide-panel specimen represents a repair weld more closely than does a narrow tensile specimen because it is a welded test panel that contains the full length of a repair weld within a longer initial weld.

Figure 2 illustrates a typical wide specimen. After the specimen has been fabricated by welding and machining, a commercially available photoelastic material is bonded to it in the weld area. The specimen is then tensile tested. With the help of polarizing optical filters, the strains produced by the tensile test can be observed as a colored fringe pattern. Through this technique, differences among various repair welds and weld-material/parent-material combinations can be observed. The strain patterns made visible by the photoelastic material can also be compared and correlated with strain patterns predicted by finite-element structural-analysis computer programs.

This work was done by Patrick R. Rogers and Julian E. Bynum of **Marshall Space Flight Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Mechanics category,* ***or circle no. 130*** *on the TSP Order card in this issue to receive a copy by mail ($5 charge).*

MFS-31106

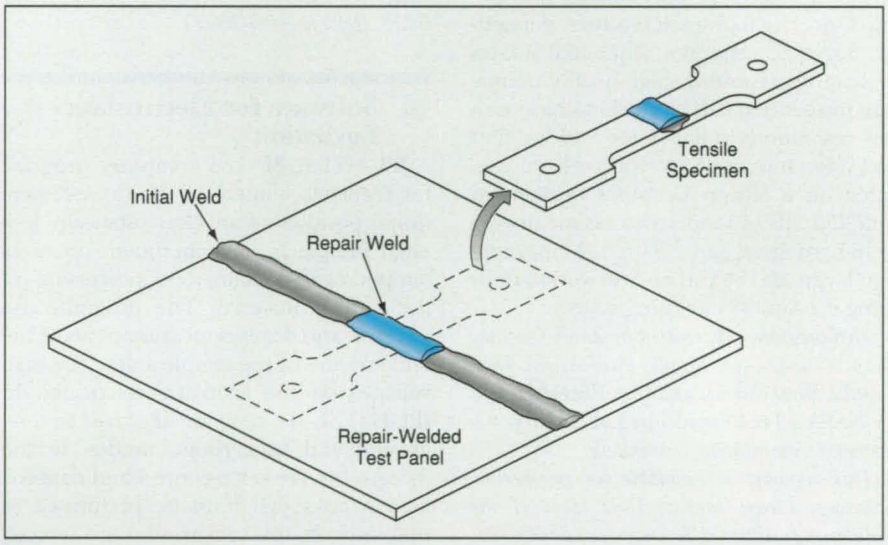


Figure 1. A **Narrow Tensile Specimen** cut from part of the repair weld in a repair-welded test panel yields incomplete information because it does not incorporate the effects of the surrounding panel material.

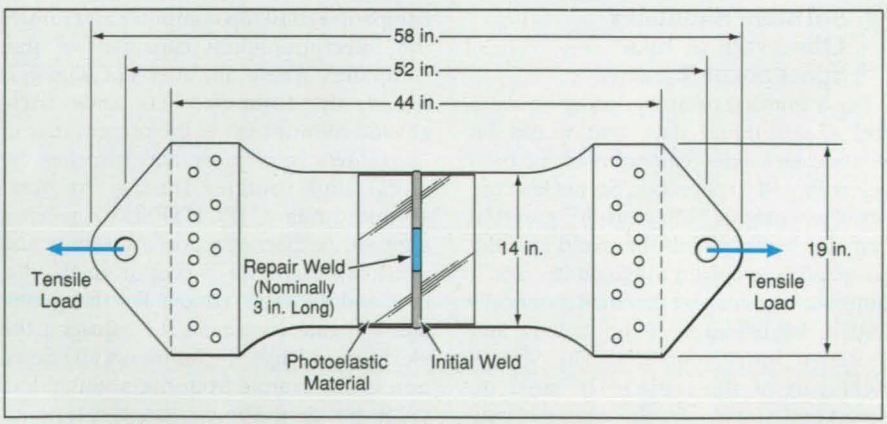


Figure 2. A **Wide-Panel Specimen** is a repair-welded test panel that contains both a repair weld and a substantial amount of surrounding material, as would typically be found in a practical repair-welded structure. In this case, the specimen includes clevis plates to facilitate tensile testing. The dimensions shown here are typical only.

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For More Information Circle No. 516

Single-Event, Low-Rebound Energy Absorber

Kinetic energy would be dissipated in cutting a solid material.

NASA's Jet Propulsion Laboratory, Pasadena, California

Single-event, low-rebound dampers have been invented to cushion spacecraft during planned landings on other planets and asteroids. Similar damping mechanisms might prove useful on Earth for protecting passengers and cargoes involved in aircraft and land-vehicle crashes.

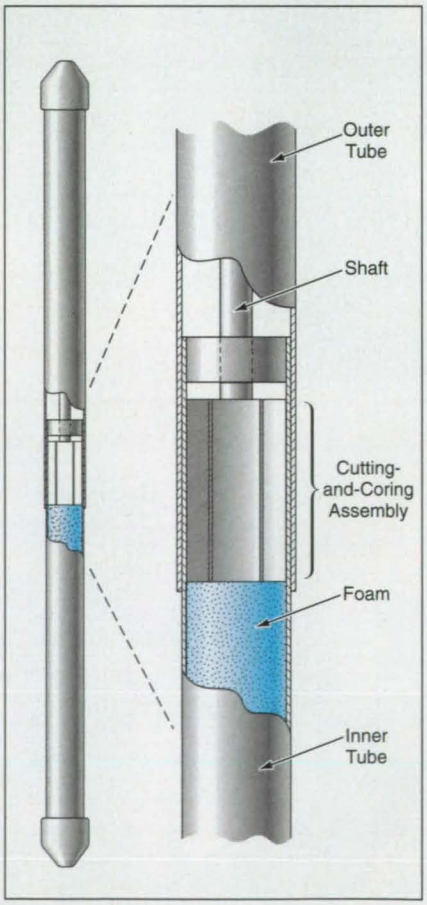
Typical damping mechanisms designed for one-time use utilize a crushable or deformable element to absorb impact energy. While this method is capable of significantly reducing impact energy, it stores some energy elastically in the crushed or deformed material, which is then returned to the system as a rebound force.

This damping mechanism absorbs energy by shearing material instead of crushing material. Energy is still stored elastically in the material, but it is not returned to the system as a rebound force.

The mechanism superficially resembles an automotive shock absorber in that it includes a tube sliding within a slightly wider tube (see figure). The inner tube is filled with a polyurethane foam. A cutting-and-coring assembly is mounted on the end of a hollow shaft within the outer tube and is partially embedded into the foam.

Pushing the two ends of the damper inward causes blades on the cutting-and-coring assembly to cut into the foam. Once the blades have penetrated to their full length, the cutting stroking force becomes constant, and so the energy dissipated in cutting the foam depends mainly on the length of the stroke. Because most of the energy is not spent in compressing the foam axially, there is little potential energy left to cause rebound once the stroking force is removed.

This work was done by Kevin Burke, Greg Gillis-Smith, Doug Henderson, Randel Lindemann, and Richard Rainen of Caltech for **NASA's Jet Propulsion Laboratory.** *No further documentation is available.*
NPO-20102



Energy Is Dissipated in cutting the foam when the ends of the tubes are pushed toward each other.

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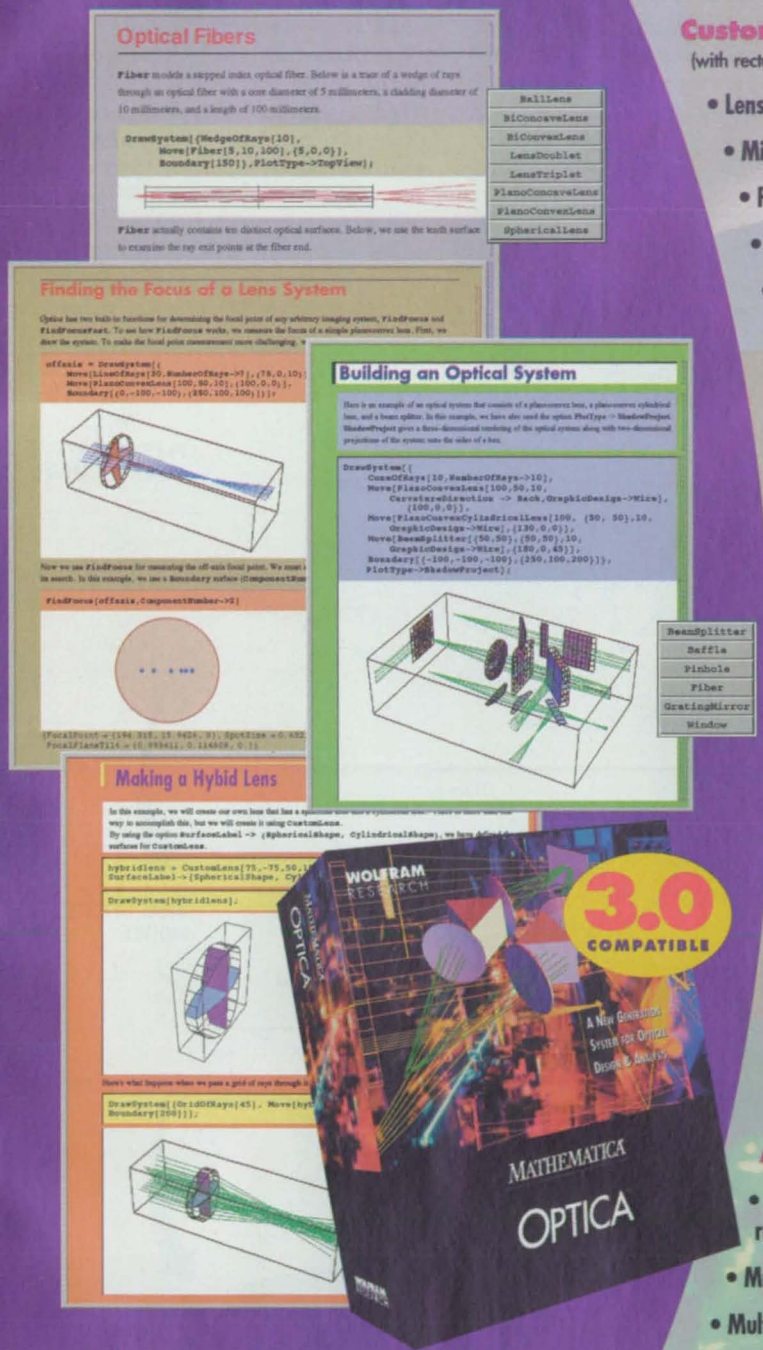

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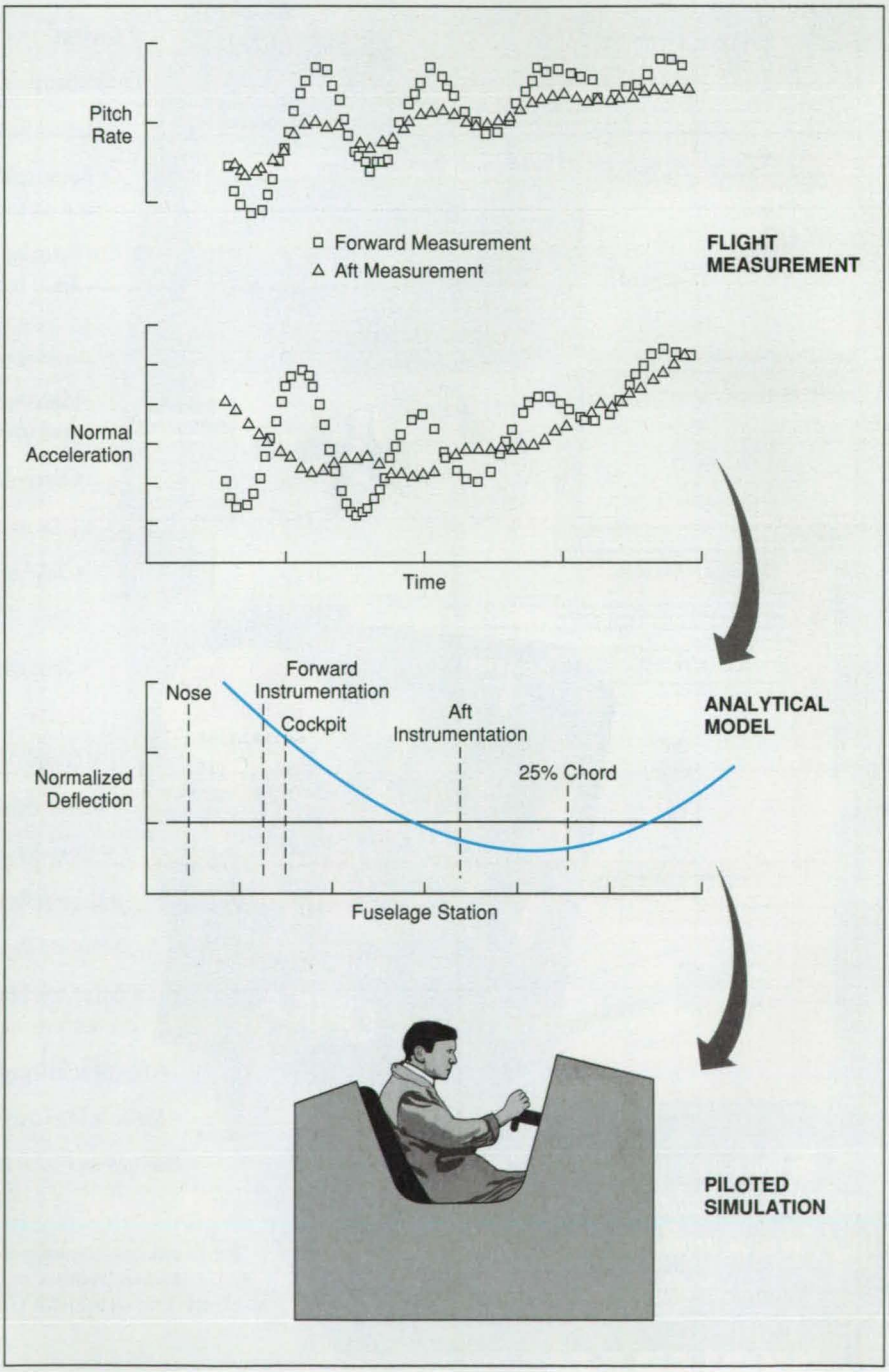
Calibrating Aircraft-Vibration Models From Flight Data

These models can be used in flight simulations and analyses of handling qualities.

Dryden Flight Research Center, Edwards, California

A methodology for constructing mathematical models of vibrations of aircraft has been developed with a view toward using such models in piloted flight simulations and in computational analyses of handling qualities of aircraft. The methodology provides for the extraction, from flight data, of vibrational-mode-shape information comparable to the information obtainable in a ground-based vibration test or in a



Pitch-Rate and Normal-Acceleration Data acquired by minimal instrumentation in minimal flight can be processed into mode-shape information with minimal analysis.

detailed computational analysis of the dynamics of an aircraft structure. A computer program that implements a model developed according to this methodology can then be incorporated into the flight-simulation computer program for the aircraft to obtain a good representation of flight characteristics for analyses of aircraft handling qualities and of the performances of aircraft control systems.

Performance requirements for advanced aircraft and aerospace vehicles generally give rise to design requirements for structures as lightweight as possible. For advanced cruise aerospace vehicles (e.g., the High Speed Civil Transport) and for single-stage-to-orbit aerospace vehicles, requirements for maneuvering are quite low and gross weights are high. As a result, structures are relatively flexible and frequencies of vibrational modes approach the frequencies characteristic of the rigid-body dynamics of the vehicles. It therefore becomes necessary to include the vibrational modes in analyses of control systems and handling qualities of the vehicles. The mathematical model used to simulate the vibrations and other relevant aspects of the dynamics of a vehicle must be modified further to reduce the model to one that is applicable to the frequency ranges of significance to the pilot.

Often in flight-test programs, the available mathematical models of structural dynamics do not correspond exactly to the aircraft structures in question. Data from conventional ground-based vibration tests can be used to update these models, but such tests are expensive and time-consuming and are rarely performed to support handling-qualities flight experiments.

The present methodology enables the construction of suitably reduced models from flight data in a fraction of the time and at a fraction of the cost of acquiring and processing data from ground-based vibration tests. This methodology was developed and demonstrated in conjunction with the NASA SR-71 handling-qualities flight-test program. Data obtained throughout the ranges of velocities and altitudes of the SR-71 airplane were processed to extract the characteristics of the first vibrational mode that involves bending of the longitudinal axis of the airplane. These characteristics have been incorporated into mathematical models that have, in turn, been incorporated into computer programs for piloted and batch flight simulations that will support analyses for the handing-qualities flight-test program.

The methodology provides for calibration of a simplified mathematical model of those modes of vibration of the aircraft structure that are of significance for piloted simulations. For the SR-71 airplane, the first longitudinal-axis-bending mode is the vibrational mode of greatest significance. This mode is represented by a second-order submodel, and modes of higher order are modeled by use of a delay. The modal responses at various fuselage locations are obtained from the distribution of such responses for a uniform-beam submodel that can be calibrated from flight data. More specifically, pitch-rate and normal-acceleration data (see figure) from at least two locations are needed to calibrate the solution for the uniform-beam submodel.

Mode shapes obtained by following this approach have been compared with mode shapes obtained from ground-based vibration tests, and the general form of the uniform-beam solution was found to be a good representation of the mode shapes in areas of interest. A technique of manual analysis and calibration has been developed and is applicable to the case in which the structural dynamic (vibrational) motion is not altered significantly by the aircraft control system. A parameter-estimation technique has been developed for the more difficult case in which there is a control-system interaction or a short-period interaction prevents a simple analysis; this technique can be implemented by use of standard parameter-estimation programs or by use of personal-computer spread-sheet analysis programs with equation-solving capabilities.

This work was done by Bruce G. Powers of Analytical Services and Materials, Inc., for **Dryden Flight Research Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Mechanics category,* ***or circle no. 165*** *on the TSP Order card in this issue to receive a copy by mail ($5 charge).*

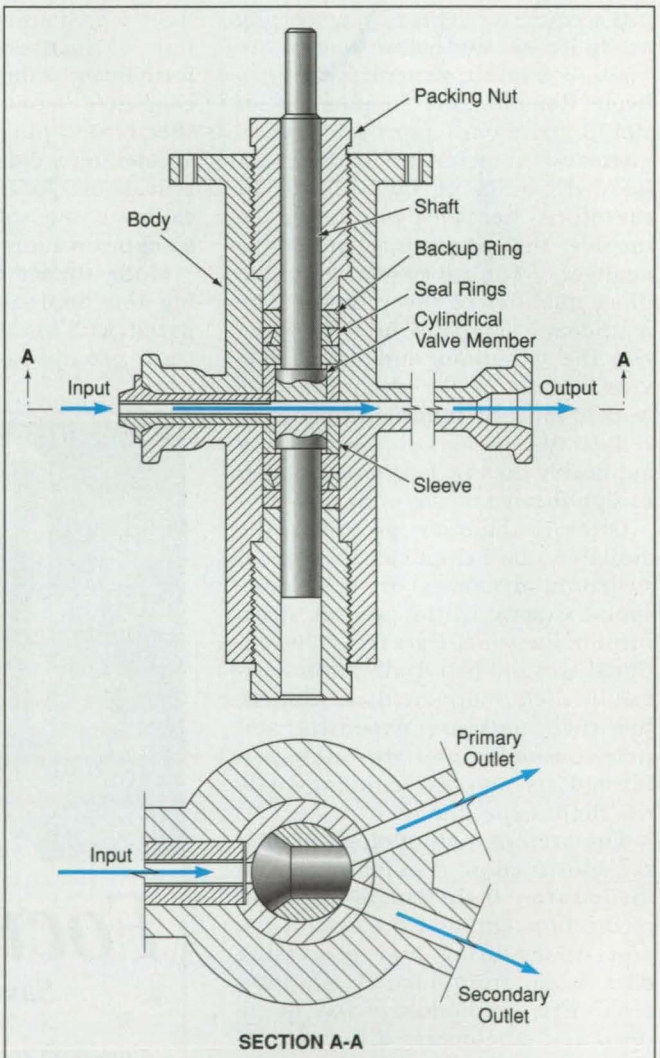
DRC-95005

Valve Meters Hot, Pressurized Oxygen

The design minimizes upstream disturbances and obstructions to flow.

Lyndon B. Johnson Space Center, Houston, Texas

The figure illustrates a valve, similar to a ball valve, that meters a flow of oxygen at temperatures up to 500 °F (260 °C) and pressures up to 10,000 psi (about 7 MPa). The valve is designed to minimize the pressure drop and the concomitant upstream-propagating pressure disturbances, and to keep the speed of flow nearly constant. Accordingly, the valve is configured not to restrict the flow but to direct all or part of it to a primary outlet (in which the metered flow is required) or to a secondary outlet (which could be connected to a return or recirculation tube).



The **Oxygen-Metering Valve** directs various proportions of a flow of hot, pressurized oxygen to the primary and secondary outlets.

The valve body, the shaft, and the valve member (which is machined integrally with the shaft) can be made of stainless steel(s) and/or suitable nickel alloy(s). The flow path is kept as straight as possible to minimize both turbulence and the cross sections presented by corners and other obstructions on which particles entrained in the flow can

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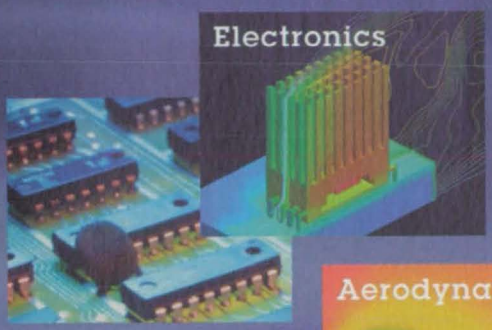

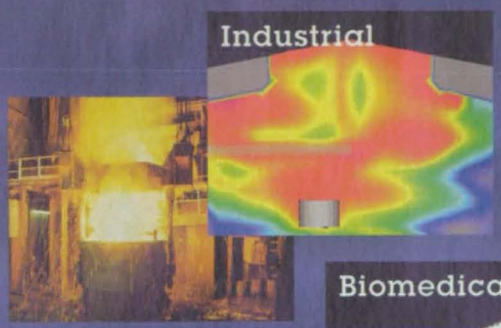

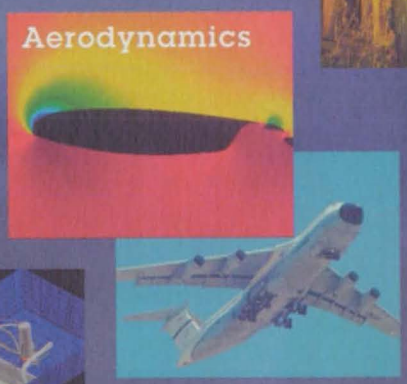

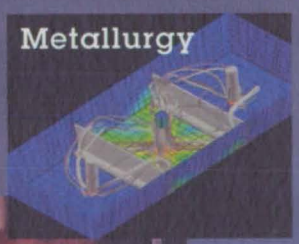

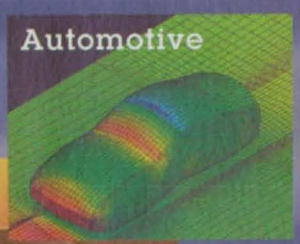

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impinge. This latter feature is particularly important because particles and valve surfaces are heated upon impact, and the particles are particularly susceptible to ignition in hot, pressurized oxygen.

The valve member is a cylinder (instead of a sphere as in a ball valve). It contains a single, straight flow passage of oval cross section that tapers to an enlarged opening at the inlet end. The opening in the valve member at its outlet end is large enough to straddle a wedge in the valve body that divides the flow into two parts, each going to one of the outlets. Thus, depending on the shaft angle, all or part of the flow can be directed to either or both outlet(s). The wedge divides the flow with minimal disruption of the flow and minimal back pressure, and presents a small cross section to oncoming particles.

The valve member turns in a closely fitting tubular sleeve in the valve body. Seals between the shaft and the valve body are formed by frustoconical seal rings made of a copper alloy or other deformable material. The seal rings are sandwiched between backup rings (which are basically thick washers) and squeezed axially against the tubular sleeve by use of packing nuts. The resultant wedging of the seal rings against each other forces the rings tightly against the shaft and valve body. Despite the tight seal, the frictional torque is relatively low, and the shaft can be turned easily: this is important because it enables the valve- actuating mechanism to adjust the valve quickly and accurately to the specified flow settings.

This work was done by Rollin C. Christianson, James A. Daniel, and Peter P. Lycou of Lockheed Engineering & Sciences Co. for **Johnson Space Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Mechanics category,* ***or circle no. 111*** *on the TSP Order card in this issue to receive a copy by mail ($5 charge).*

This invention has been patented by NASA (U.S. Patent No. 5,251,663). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center; (713) 483-4871. Refer to MSC-21823.

Modified Tether-Hook Mechanism With Locking Lever

Lyndon B. Johnson Space Center, Houston, Texas

A tether-hook mechanism that was previously somewhat difficult to unlock and release by hand has been modified to enable release by natural-feeling placement of a hand on the hook and simple squeezing. Incorporation of a lever operated by the hand to unlock the bail of the hook eliminates the cumbersome requirement, in the previous design, to align the index finger and thumb on corresponding locks in order to release the hook. The modified tether-hook design could be useful in such safety-hook applications as construction, window washing, and underwater operations that require a self-locking tether hook that is easy to operate.

This work was done by Robert C. Trevino of **Johnson Space Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Mechanics category,* ***or circle no. 187*** *on the TSP Order card in this issue to receive a copy by mail ($5 charge).*

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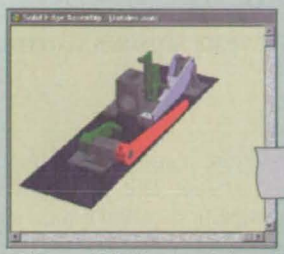

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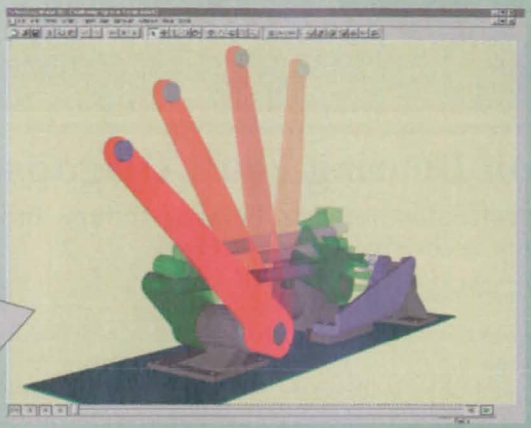

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Modeled by Sean Taffert, Vapor Canada Inc., Quebec, Canada

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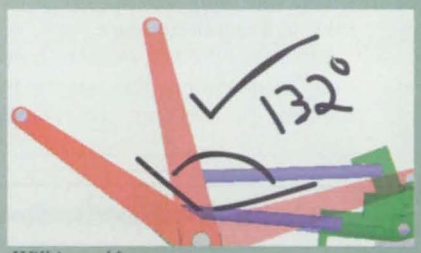
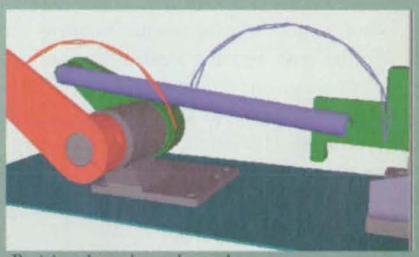
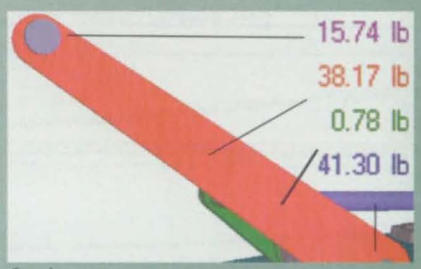


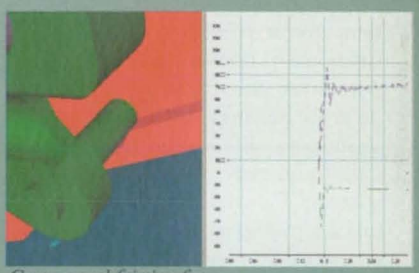
Will it work?



Positional tracks and envelopes

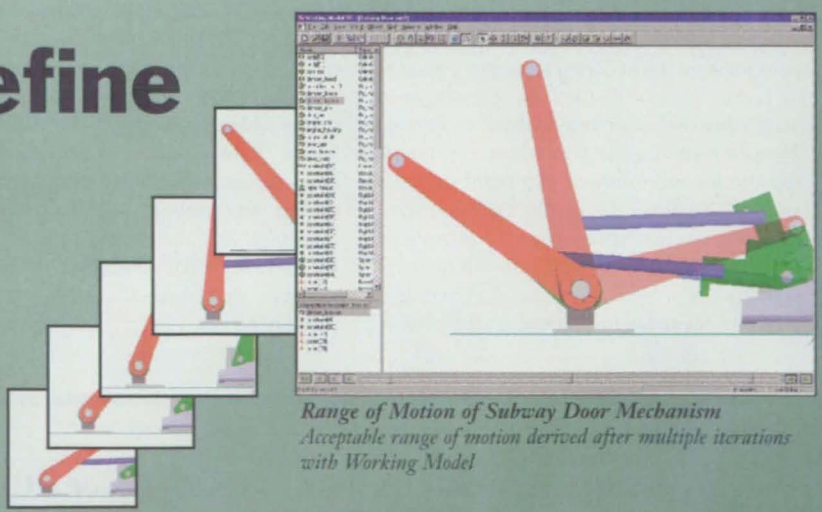


Loads on any part



Contact and friction forces

Refine



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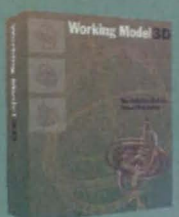

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Marshall Space Flight Center, Alabama

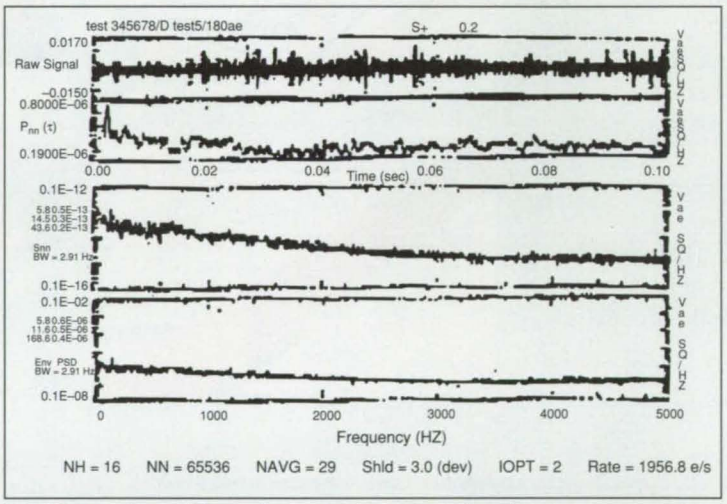
A new hardware and software system that uses a state-of-the-art, high-frequency Acoustic Emissions (AE) sensor and an innovative AE signal-processing technique, called Point Process Spectral Analysis (PPSA), has been developed to help prevent catastrophic failures and costly down time due to false alarms during bearing testing. In the past, bearing health monitoring and fault diagnosis within turbomachinery and drive-train systems have been a significant technical challenge for the aeronautics and transportation industries.

Previous techniques to detect bearing faults could not distinguish between transient events related to shaft rotational processes and the signatures associated with defective bearings. Also, these techniques did not involve high-frequency, real-time analysis. To overcome these unique problems, PPSA was developed to meet the high-frequency AE signal processing and fault detection requirements.

Conventional time series representation of an ultrahigh frequency AE signal requires all data to be sampled over the entire waveform at a high sampling rate. However, PPSA only uses the times occurrence of the transient events, along with their strengths, since these transient events contain the major dynamic information needed for bearing fault detection. As a result, PPSA requires much less data to analyze the frequency-domain behavior than conventional time-series representation. Additionally, PPSA overcomes the basic limitations of the fast-Fourier-transform-based spectrum for detecting signal components, such as widely spaced, narrow transient spikes that cannot be approximated effectively by a sum of sinusoids.

PPSA uses the first moment function of time to determine the rate of transient impulse, thresholding the temporal AE waveforms for structural failure detection. Next, a mean-lag-jump product, representing the second moment of a point process, provides a statistical estimation of the correlation between all pairs of event occurrences with common time lags. The frequency-domain representation of the second-moment mean-lag-jump product function is used to create a spectrumlike function of the point-process. This point-process spectrum provides a statistical estimation of the event occurrence rate and intensity distribution as a function of frequency.

The superior detection capability of PPSA over conventional envelope analysis in extracting bearing signatures from AE transient signal in a noisy operational environment was demonstrated with two computer-simulation examples and with NASA-provided test data from a bearing test rig. Three test conditions were used: a good bearing, an inner race defect, and a roller defect. PPSA successfully analyzed the data. The results of these proof-of-concept studies indicated that PPSA can provide high computational efficiency in processing ultrahigh-frequency AE signals and is highly suitable for real-time implementation. Using this analysis technique would significantly reduce the digital signal processor requirement in developing a low-cost, commercially viable, on-line bearing-diagnostic system.



Point-Process Spectral Analysis was used to extract these bearing signatures from an acoustic emissions transient signal during testing of a good bearing.

This work was done by Jen-Yi Jong of AI Signal Research, Inc., for the **Marshall Space Flight Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Machinery and Automation category,* ***or circle no. 118*** *on the TSP Order card in this issue to receive a copy by mail ($5 charge).*

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Thermoacoustic Refrigerator

Inert gases are used as working fluids in place of potentially harmful CFCs, HFCs, or HCFCs.

Lyndon B. Johnson Space Center, Houston, Texas

A thermoacoustic refrigerator produces high-amplitude sound waves in an inert gas mixture to pump heat without using chlorofluorocarbons (CFCs), which are dangerous when leaked into an enclosed environment. Chemical refrigerants such as CFCs and HCFCs are also known to destroy stratospheric ozone and, along with HFCs, are "greenhouse" gases which contribute to global warming.

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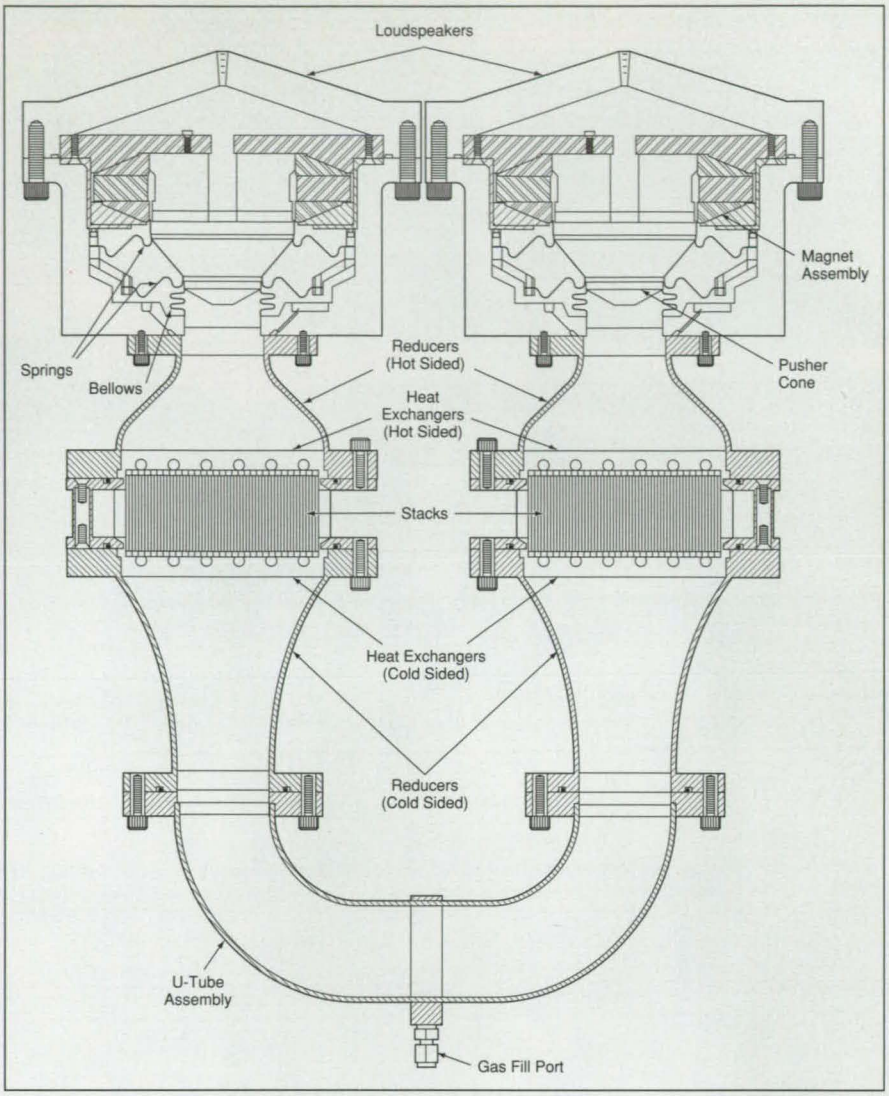

The **Two Loudspeakers Maintain a Half-Wavelength Standing Wave** at a resonant frequency of 320 Hz in a 20 atm. mixture of helium and argon gas. The two stacks are 11-cm-diameter spirals of 52-μm-thick plastic with a spacing of 204 μm. At either end of each stack are finned heat exchangers attached to tubing which allows the heat-transport fluids to deliver useful cooling to the refrigerated enclosure and to exhaust the waste heat plus work.

tic pressure of 20 atm. This sound wave causes compressions and expansions of the gas which are accompanied by oscillatory gas motion. The compressions and expansions raise and lower the temperature of the gas. Within the "stack" section of the refrigerator, these oscillating gas parcels can pick up heat from the stack and deposit heat to the stack at a different location. These gas parcels therefore act like a "bucket brigade" which removes heat from the cold heat exchanger and deposits it at the hot heat exchanger. Heat transfer fluids are pumped through the hot and cold heat exchangers to deliver useful cooling to an insulated sample enclosure and exhaust the waste heat plus work to the surroundings. The thermoacoustic device shown in the figure was designed to provide 700 Btu/h (205 W) of cooling at +4 °C and 400 Btu/h (117 W) of cooling at –22 °C with an exhaust temperature of +20 °C. In recent sea trials onboard the *USS Deyo* (DD-989), 1430 Btu/h (419 W) of useful heat load was removed from shipboard radar electronics while the destroyer was underway near Annapolis, MD.

This work was done by Steven Garrett of Sound Advice Acoustical Consulting for **Johnson Space Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Machinery and Automation category,* ***or circle no. 119*** *on the TSP Order card in this issue to receive a copy by mail ($5 charge).*

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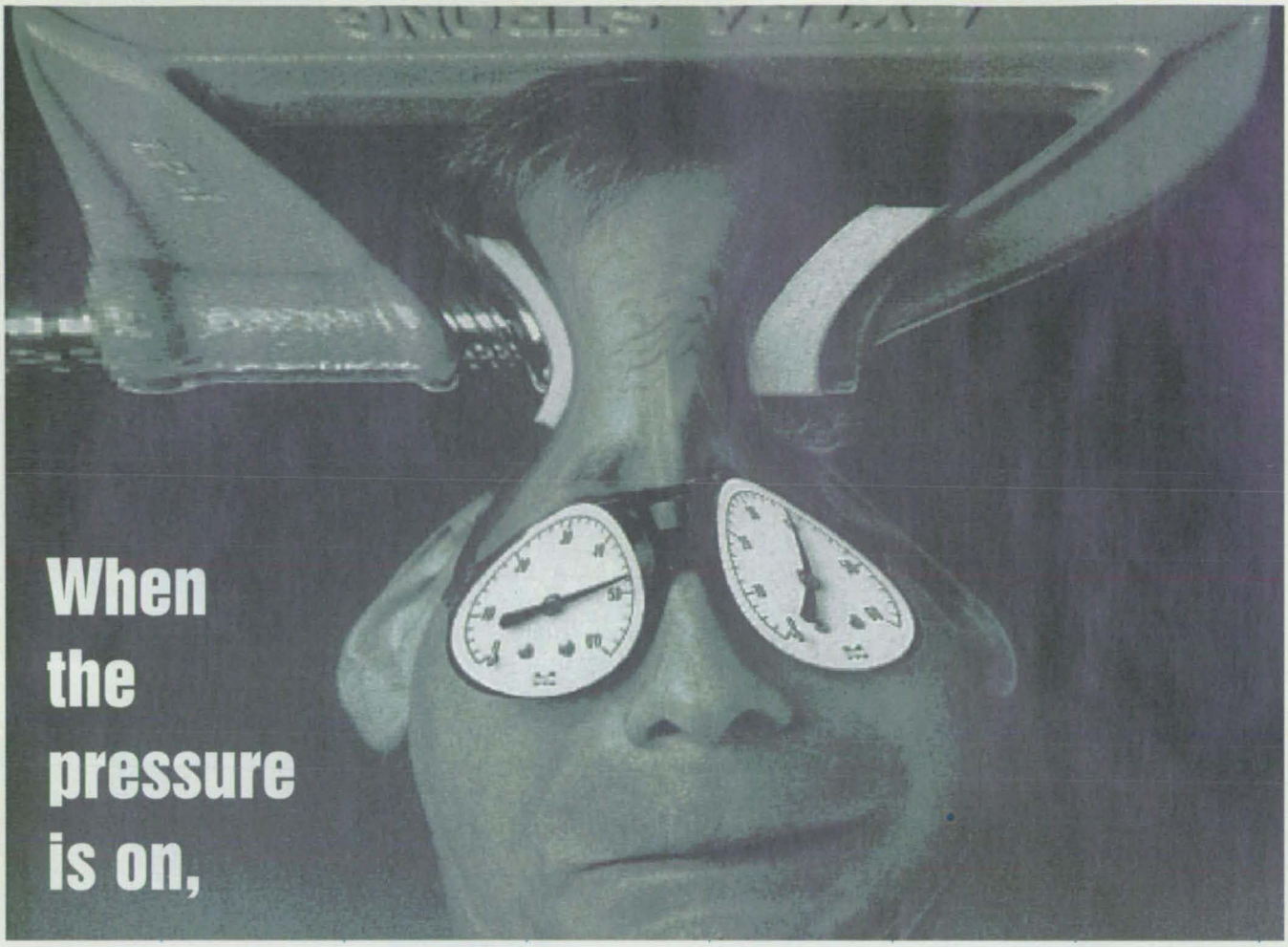

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Books & Reports

Oxidation-Barrier Coatings for Refractory Metals

A report reviews the technology of metal coatings for protecting refractory metal substrates against oxidation at high temperatures. Potential applications include gas-turbine engines, heat exchangers, equipment for handling molten metals, and high-temperature-resistant structural components.

This work was done by G.A. Malone and T. Walech of Electroformed Nickel, Inc., for **Lewis Research Center.** *To obtain a copy of the report, "High Temperature Barrier Coatings for Refractory Metals," access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Materials category,* ***or cirlce no. 189*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge).*

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Robust Numerical-Integration Schemes for Viscoplasticity

A report discusses the development of a general conceptual framework for implicit time-stepping numerical-integration schemes used to solve the equations of flow and of evolution of materials in generalized mathematical models of viscoplasticity. The general theoretical aspect of the framework is developed, starting from the unconditionally stable, backward-Euler difference scheme. The mathematical structure of this framework is sufficiently general to provide unified treatment of different classes of models of viscoplasticity with internal variables.

This work was done by Wei Li and Atef F. Saleeb of the University of Akron for **Lewis Research Center.** *To obtain a copy of the report, "Robust Integration Schemes for Generalized Viscoplasticity With Internal-State Variables," access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Mathematics and Information Sciences category,* ***or circle no. 143*** *on the TSP Order Card in this issue to receive a copy by mail ($5 charge).*

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Autonomous Navigation for Spacecraft Orbiting Earth

A report proposes a method of autonomous navigation of spacecraft in orbit around the Earth. The method, to be implemented by use of on-board computers and on-board Global

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Positioning System (GPS) receivers, would be applicable to a single spacecraft or to multiple spacecraft flying in formation as needed for some coordinated scientific observations. The main benefit of the method would be elimination of the need for ground operators to determine command sequences for orbit-adjustment and -maintenance maneuvers.

This work was done by Joseph Guinn, Mark Vincent, and Ronald Boain of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Spacecraft Autonomous Navigation for Formation Flying Earth Orbiters Using GPS," access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Mathematics and Information Sciences category,* ***or circle no. 137*** *on the TSP Order card in this issue to receive a copy by mail ($5 charge).*
NPO-20116

Tests of Thermal-Barrier and Wear Coats in Rotary Engines

A report describes experiments to evaluate combination thermal-barrier/self-lubricating coating layers on the internal sliding-contact surfaces of the housings of air-cooled rotary internal-combustion engines. These coatings were described in "Combination Thermal Barrier and Wear Coatings for Engines" (LEW-15356), *NASA Tech Briefs*, Vol. 19, No. 5 (May 1995), page 62. The tests demonstrated the benefits of the thermal-barrier coatings in that specific fuel consumptions of the engines with the coatings were consistently lower than those of the same engines without the coatings. The PS-200 wear coats proved to be very durable under severe test conditions.

This work was done by Paul S. Moller and Michael Weigart of Moller International for **Lewis Research Center**. *To obtain a copy of the report, "Evaluation of Thermal Barrier and PS-200 Self-Lubricating Coatings in an Air-Cooled Rotary Engine," access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Materials category,* ***or circle no. 175*** *on the TSP Order card in this issue to receive a copy by mail ($5 charge).*

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Secondary Electron Emission From Thin Diamondlike Films

A report describes experiments on secondary electron emission (SEE) from specimens comprising various thin diamond and diamondlike carbon films on molybdenum and silicon substrates. Since its completion, a lot of new research has been accomplished on SEE of diamond and diamond films. Any new related information can also be obtained via sources listed below.

This work was done by Isay L. Krainsky and James Dayton of **Lewis Research Center** *and Gerald Mearini of Case Western Reserve University. To obtain a copy of the report, "Study of Electrical Phenomena Associated With Thin Films," access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category,* ***or circle no. 192*** *on the TSP Order card in this issue to receive a copy by mail ($5 charge).*

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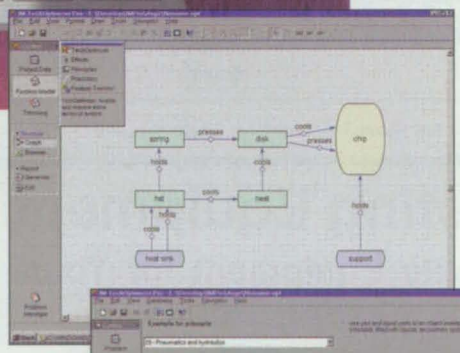

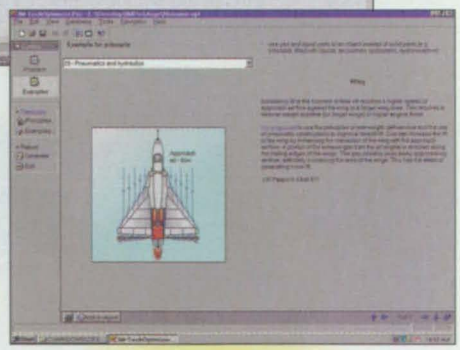

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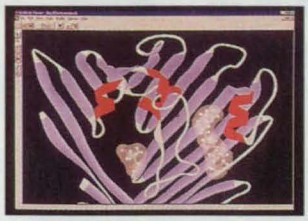
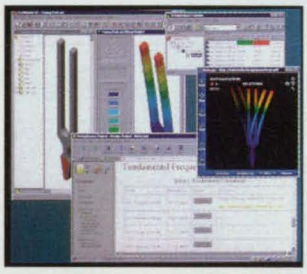


Molecular Simulations, San Diego, CA, has introduced WebLab Viewer Plus **molecular visualization and analysis software**, which can represent molecules, crystal cells, and protein structures. Features include tools to sketch molecules and optimize their geometry; import and export of chemical-structure files; and annotation, animation, and display options.

For More Information Circle No. 710



Ansys, Houston, PA, has announced DesignSpace™ 3.0 **design performance simulation software** for SolidWorks® 97Plus and Autodesk Mechanical Desktop™. Using the software and a standard web browser, engineers can review DesignSpace engineering reports in real time from any location. The Windows 95/NT software comprises three modules — DesignSpace Explorer, Stress Wizard, and Vibration Wizard — that provide stress- and vibration-analysis capabilities as plug-ins to the solid modeler.

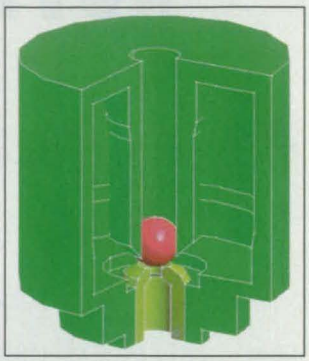
For More Information Circle No. 712

SinapsPlus™ Version 3.2. **graphical user interface software** from Cullimore and Ring Technologies, Littleton, CO, develops SINDA/FLUINT models and views the results. Enhancements include a debugging system that helps users locate problems in models or user logic. The program is available for Sun and HP workstations, and 386/486 PCs.

For More Information Circle No. 713

Superdraw III **finite element modeling software** from Algor, Pittsburgh, PA, allows building of 2D and 3D models in UNIX, Windows 95/NT, and DEC Alpha running Windows NT operating environments. The software can extend a CAD system into mechanical-engineering and event-simulation software, or it can serve as a standalone design tool using finite elements. It can be used to create models comprised of several element types.

For More Information Circle No. 716

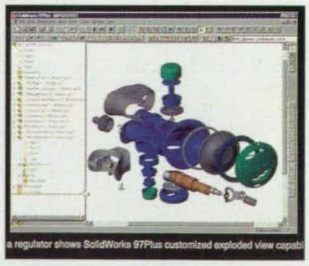


Ansoft Corp., Pittsburgh, PA, offers EMAS V4.0 (ElectroMagnetic Analysis System) **electromagnetic simulation software** that enables users to predict coupled electromechanical performance of various electrical apparatus. It accounts for effects of nonlinear electromagnetic fields, structural deformation, stress, and temperature. The program is available on workstations running Hewlett-Packard UX V10.10 or higher.

For More Information Circle No. 711

Cimatron, Burlington, ON, Canada, offers Cimagrafi Version 5.0 **CAD/CAM software**, which features OpenGL technology for continuous image display, and improved algorithms for surfacing, tracing, and picture-to-part. Enhancements to the 32-bit Windows program include legacy CAD/CAM systems, manufacturing wizards, and enhanced milling performance.

For More Information Circle No. 715



SolidWorks Corporation, Concord, MA, has released SolidWorks 97Plus **3-D mechanical design software**, which features more than 160 enhancements, including performance optimization for large assemblies; enhanced sweeping and lofting; ability to add 3D annotations to parts and assemblies; and a FeatureManager design tree.

For More Information Circle No. 714

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Director of Engineering
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For More Information Circle No. 548

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New on the Market

HTM Electronics Industries, Niagara Falls, NY, offers the Optex S Series **photoelectric sensors** with built-in amplifiers that are available in compact thru-beam, diffuse-reflection, retroreflection, and BGS types. The sensors feature background suppression functions, enabling stable detection against multi-colored workpieces, regardless of the material to be detected.

For More Information Circle No. 733

Vision1024 10-bit **digital camera** from Merchantek Electro-Optics, Carlsbad, CA, features capture rates to 120 Hz. Designed for machine vision, high-speed motion imaging, and remote sensing, the camera features a self-contained, palm-sized CPU that connects to a printer and external monitor.

For More Information Circle No. 734

Ampex Corp., Redwood City, CA, offers the DIS 120i and 160i **data/instrumentation recorders**. The systems use 19-mm, D-2 cartridge tape to capture digital data in real time, and process and manage the data. The DIS 160i, in instrumentation mode, captures data directly into a recording device and processes it through a SCSI-2, 16-bit interface; the DIS 120i captures the data into a recording device directly attached to a computer.

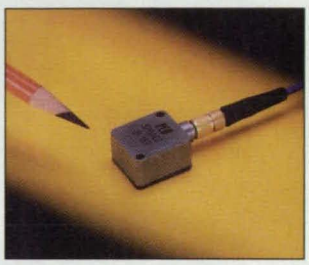
For More Information Circle No. 735

Steinbichler Optical Technologies, Novi, MI, has introduced the Comet/OptoTrak portable, tripod-mounted **digitizing system** with an unlimited measurement volume to capture 3D forms of designs. The system consists of the Model 400 Optical 3D Digitizing Sensor and the OptoTrak Optical CMM. The sensor digitizes 3D objects by separately measuring 16x16" patches of 420,000 X-Y-Z coordinates in 60 seconds per view.

For More Information Circle No. 736

The XC-333 1/4" color **CCD camera module** from Sony Electronics, Montvale, NJ, incorporates a digital signal processing chip and can be adjusted externally via an RS-232C link. The unit features a square-shaped camera head, an effective pixel area of 379,392, and an attached camera control unit. It utilizes a 17-mm Sony NF lens mount; a C-mount lens adapter is available.

For More Information Circle No. 740

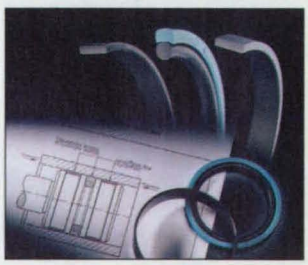


PCB Piezotronics, Depew, NY, offers the Series 370 DC **accelerometers** that feature variable capacitance sensing elements to measure low-level accelerations at low frequency or steady-state conditions. Available sensitivity is 100 mV/g. The units are equipped with air damping to exclude high-frequency ringing in the output signal.

For More Information Circle No. 737

I-CUBE, Crofton, MD, has introduced a video microscopy **image analysis workstation**, which performs video image capture, processing, analysis, storage, and data extraction. It can be interfaced to existing video microscopy setups, and is used in life sciences, industrial, and other laboratory and research applications. Image capture is achieved via a high-fidelity frame grabber that captures from RGB, S-Video, composite, and monochrome video sources.

For More Information Circle No. 739



Busak+Shamban, Ft. Wayne, IN, has announced the Zurcon® Wynseal **seal** that consists of a polyurethane seal ring with an o-ring as the energizing element. The seal edge profile features two external seal edges acting as the primary seal for pressures from both sides. Sealing effect is along the plane surface to activate the energizing o-ring. It operates at temperatures from -35°C to 80°C.

For More Information Circle No. 744

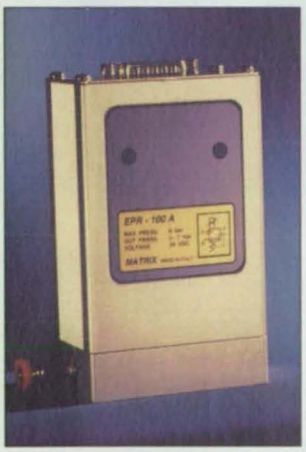
New on the Market

The Aerolatch™ lever-assisted flexible **draw latch** from Southco, Concordville, PA, is an over-center latch made of non-corrosive and UV-stable materials, and features a detent to keep the latch closed. An EPDM rubber latch body absorbs and reduces vibration.

For More Information Circle No. 743

Helical Products, Santa Maria, CA, offers flexible **couplings, u-joints, and precision-machined springs** incorporating HELI-CAL Flexure technology. When used as a coupling or u-joint, the HELI-CAL Flexure employs a curved beam to transmit torque while compensating for lateral, axial, and angular misalignments. Used as a machined spring, the beam provides controlled elastic performance in compression, torque, and lateral bending and displacement. The components can be made of aluminum, stainless, steel, titanium, or plastics.

For More Information Circle No. 741



Amatrix Corp., Farmingdale, NY, offers the Model EPR 100 electrically controlled **pressure regulator**, which features an on-board microprocessor. The unit processes signals and controls, executes functions, and communicates with control systems via RS-232 serial ports; the control signal can be analog or digital. The compact device features repeatability of less than 1% full scale and is powered by 24 VDC.

For More Information Circle No. 746

The Model 400 VGA **touchscreen monitor** from Eason Technology, Healdsburg, CA, was designed for applications requiring a separate monitor from an industrial PC machine controller. It is housed in a 12.75x11.5x2.5" cast aluminum enclosure that is NEMA 4/12 rated when panel-mounted, with NEMA 4X optional. Operator input is via a resistive touchscreen and/or via a ten-key tactile snap dome ridged keyboard.

For More Information Circle No. 745

Electric Indicator Co., Norwalk, CT, offers low-inertia DC **motors** constructed with a hollow, ironless, basket-wound armature over an internal stationary magnet structure. Accelerations to over 90,000 RPM in less than 1 msec. are possible. Ratings are available to 5 HP, 10,000 RPM with custom voltages of 12 to 240 VDC and frame sizes to 6.3" diameter.

For More Information Circle No. 738

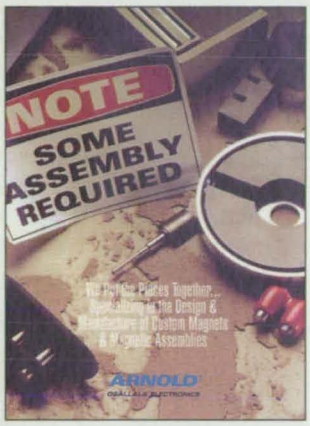
Greco Systems, El Cajon, CA, has introduced the Color Touch Station, an integrated **touchscreen computer** available in 586 (100Mz) with an external keyboard and printer ports. It was designed for keyboard- and mouse-free operation of Windows-based programs. A swivel base accommodates tabletop or machine-side placement.

For More Information Circle No. 742

New Literature

Velmex, Bloomfield, NY, offers a 40-page 1997-98 Manual UniSlide® catalog describing more than 950 **linear and rotary positioning fixtures**. Linear slide widths range from 1-1/2 to 9"; travel ranges from 1/2 to 90". Maximum load capacity is 400 lbs. for linear slides and 200 lbs. for rotary.

For More Information Circle No. 700



A brochure highlighting **magnets and magnetic assemblies** is available from Arnold Engineering, Ogallala Electronics Div., Marengo, IL. Magnet products include alnico, hard ferrite, samarium cobalt, and neodymium. Capabilities include assembly and packaging, adhesive bonding, brazing, soldering, plating, and painting.

For More Information Circle No. 701

A 256-page databook from Newport Electronics, Santa Ana, CA, describes **meters, controllers, and instruments**, including the INFINITY® series of microprocessor-based digital instruments. Digital panel meters, controllers, signal conditioners, and transmitters are included. Instrumentation covers signal inputs such as process voltage and current, thermocouple, RTD, strain gauge, frequency counters/timers, and AC/DC voltage.

For More Information Circle No. 705

An eight-page brochure from Versa Logic Corp., Eugene, OR, describes **embedded computer products** such as single-board computers, STD bus systems, and expansion modules. Also featured are rack-mount and desktop enclosures, and flat-panel displays.

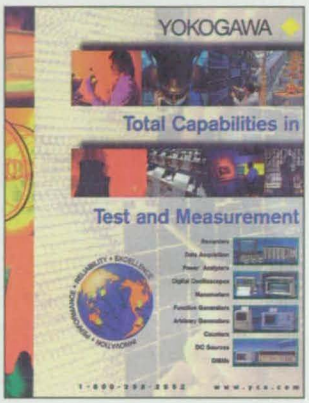
For More Information Circle No. 706

Mead Fluid Dynamics, Chicago, IL, offers a brochure on the Isonic® 4000 Series four-way **directional control valves** for fluid power systems. Also featured is information on the system's Quick-Change Manifold, as well as electrical connectors and blocking plugs.

For More Information Circle No. 708

Small Parts, Miami Lakes, FL, offers a 416-page catalog of **assembly components, tools, and fabrication supplies**. Among the 10,000-plus items are stainless steel and plastic tubing, bar and sheet metal, precision tools, and material test kits.

For More Information Circle No. 704

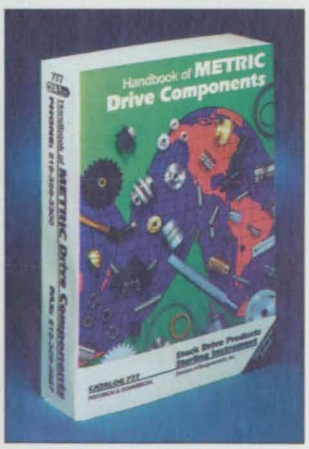


Yokogawa Corporation of America, Newnan, GA, has released a catalog describing **test and measurement products**. Included are recorders, data acquisition products, digital oscilloscopes, counters, DC sources, and digital multimeters.

For More Information Circle No. 707

Metal Powder Industries Federation, Princeton, NJ, has released a 120-page P/M Buyers Guide listing 112 manufacturers of **powder metallurgy (P/M) parts and products**. Products include gears and bearings, cutting tools, heat sinks, filters, titanium and superalloy parts, wear parts, P/M forgings, and biomedical products.

For More Information Circle No. 702



An 896-page catalog of metric mechanical **drive components** is offered by Stock Drive Products/Sterling Instrument, New Hyde Park, NY. It includes metric and commercial gears, belt and chain drives, shafts, bearings, couplings, brakes, and clutches.

For More Information Circle No. 703

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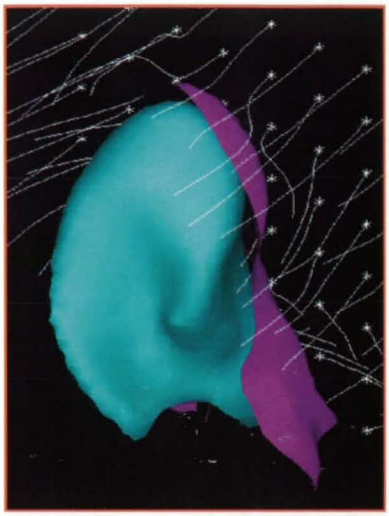

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