July 1996

Vol. 20 No. 7

NASA Tech Briefs

The Design/Engineering Technology Digest

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Instrumentation Software News.

NEW LabVIEW® 4.0 – Graphical Programming for Instrumentation

LabVIEW Version 4.0 is here and it's designed just for you! Whether your application is large or small, simple or complex, LabVIEW 4.0 has features designed to improve your productivity, simplify your development tasks, and integrate your application throughout your organization. LabVIEW 4.0 features a customizable development environment, powerful editing and debugging tools, open connectivity tools through OLE Automation, and the new CodeLink utility to import C code directly into your VIs.

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LabWindows/CVI, an interactive C programming environment to build virtual instruments for data acquisition and instrument control, now extends its powerful tools to other C/C++ programming environments. LabWindows/CVI Version 4.0 libraries work with compilers from Microsoft, Borland, Symantec, and WATCOM. In addition, you can automatically compile your C code in LabWindows/CVI into dynamic link libraries (DLLs) for use with C/C++, Visual Basic, or LabVIEW.

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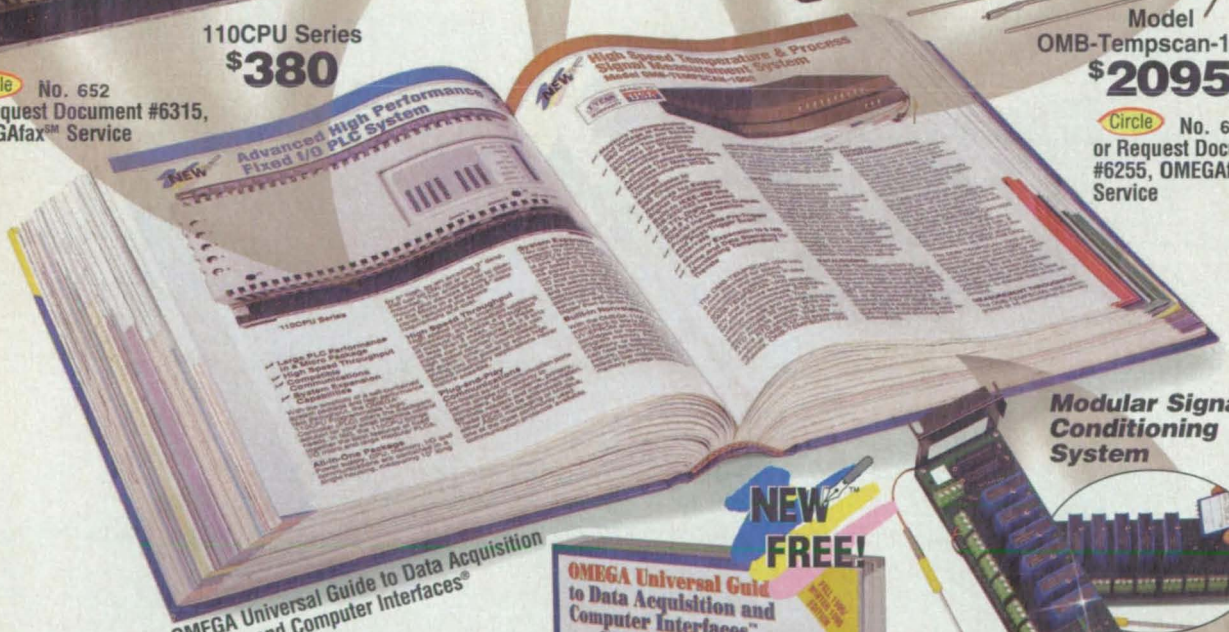

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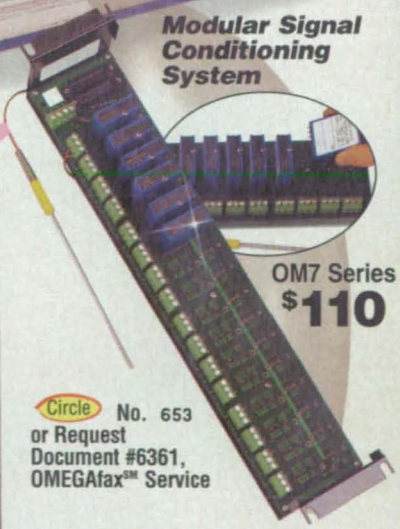

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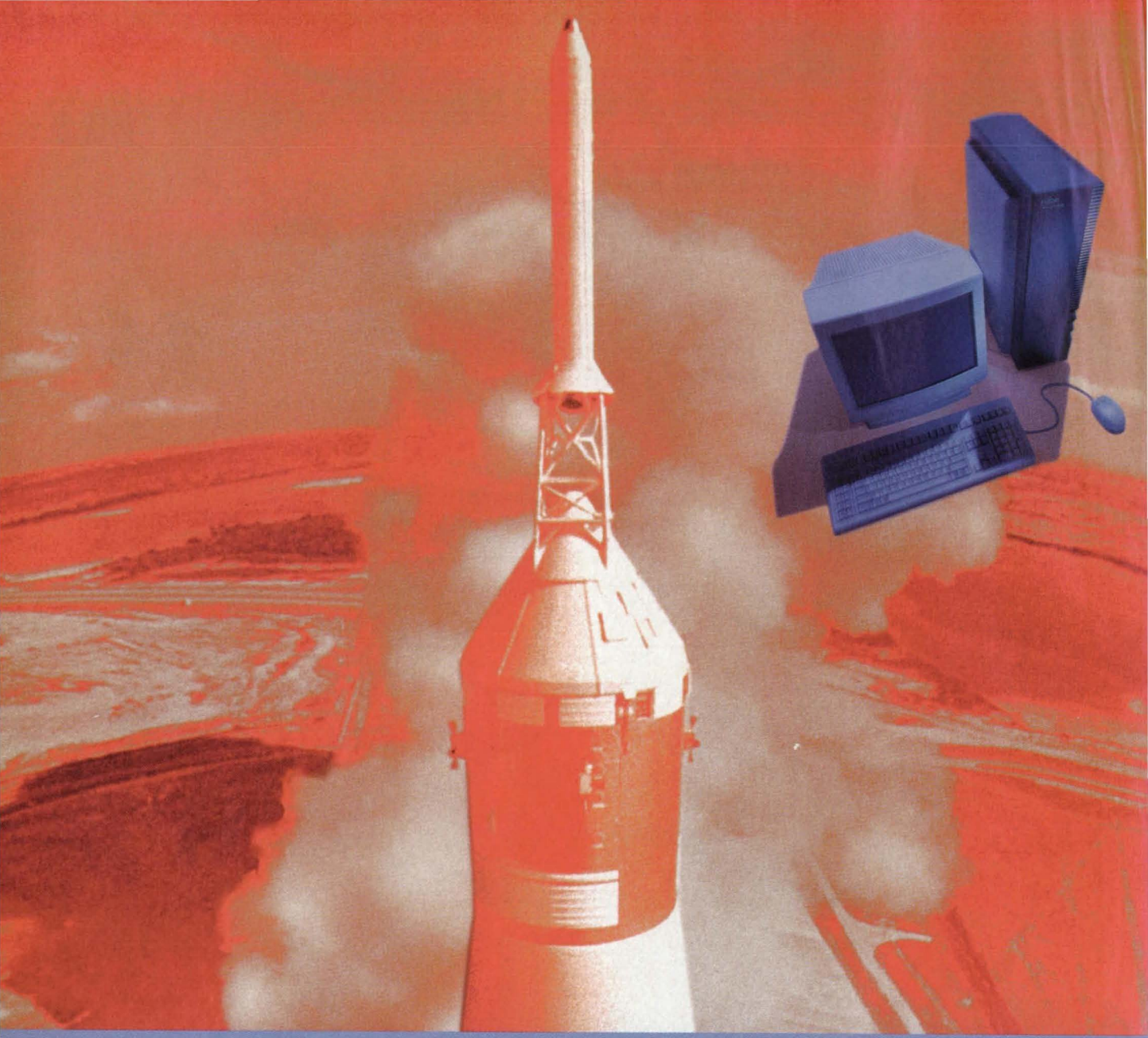

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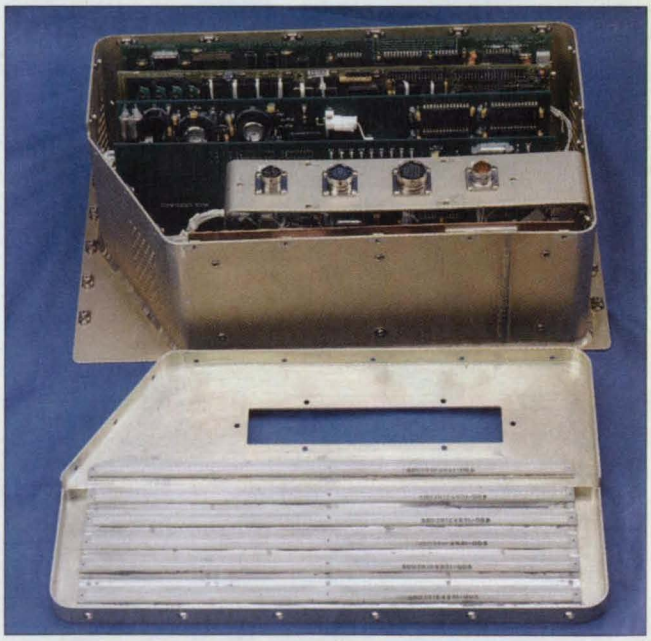
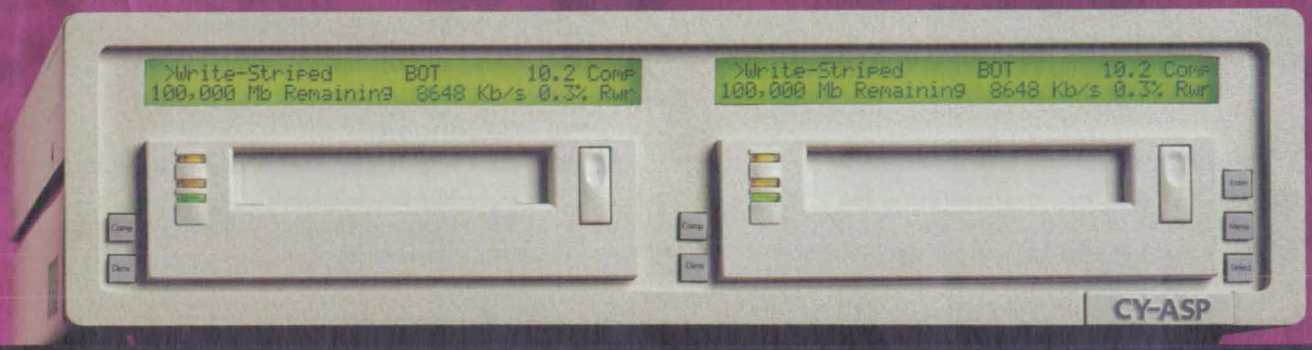


This PC-based speech-recognition unit for voice control of non-critical spacecraft or terrestrial equipment can be reconfigured by updating its software while remaining on-line. The system adapts itself to the voices of different speakers and to changes in the voice of each speaker. Developed at Johnson Space Center, the rugged unit provides visible and audible feedback through an alphanumeric display and earphones. For more information, see the Tech Brief on page 52.

Photo courtesy of Johnson Space Center

Write 200 GB At 18 MBS



The CY-8900 8mm tape drive delivers a rare thing: a 185% increase in capacity, a 500% increase in speed, and backward read compatibility with earlier generations.

Now, you can store 20 GB per tape at 3 MBS, uncompressed.

Up to ***100 GB*** per tape at ***9 MBS*** with optional data compression.

With the technology that has set the standard in reliability and data integrity since 1987.

But performance and flexibility hit the ceiling when two or more drives work together with the Advanced SCSI Processor.

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Striping Write data to two or more tape drives at a time, to maximize throughput

Mirroring Write the same data to multiple tapes, to add fault tolerance or to make duplicate tapes

Cascade Data automatically writes to the next tape when the previous tape is full

Independent Write data to one drive while you restore with another

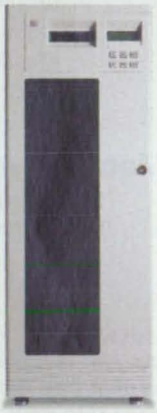
Offline Copy/Verify Make duplicate tapes without tying up the host

With the Advanced SCSI Processor, up to six drives can be configured in a powerful desktop tape array. Striping data, you can achieve an 18 MBS throughput uncompressed — up to 40 MBS with data compression.

No other tape drive can match it.

Other options include Accelerated File Access to speed file restore; Data Encryption to protect sensitive corporate data; and the Digital Data Recorder Interface, for data collection applications.

With a Fast SCSI interface, the CY-8900 is plug compatible with virtually every computer system and network running. It's available in a single or multi-drive desktop or rack mount configuration, or as part of an automated tape library with a capacity of up to ***12 terabytes***.



The CY-TL8-2020 features up to two drives and 20 tapes and can store between 400 GB and 2 TB.

The complete family of turnkey storage solutions includes 8mm, 4mm, half-inch, magneto-optical, and RAID subsystems.

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On the cover:

The parts and components that make mechanical systems work are featured in this month's Special Focus. Mechanical components such as screws, latches, motors, and slides — including magnetostrictive actuators from ETREMA Products of Ames, IA — are featured. For more information, see the Special Focus beginning on page 25.

Photo by Mark Davitt/Davitt Photo Alliance, courtesy of ETREMA Products

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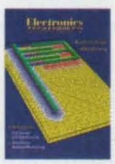

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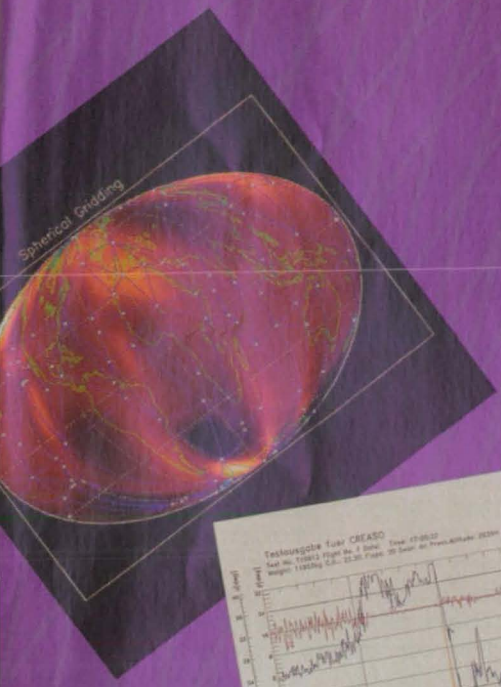

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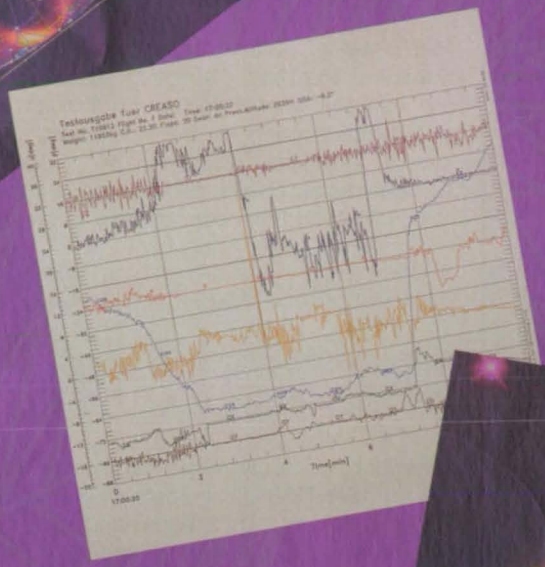

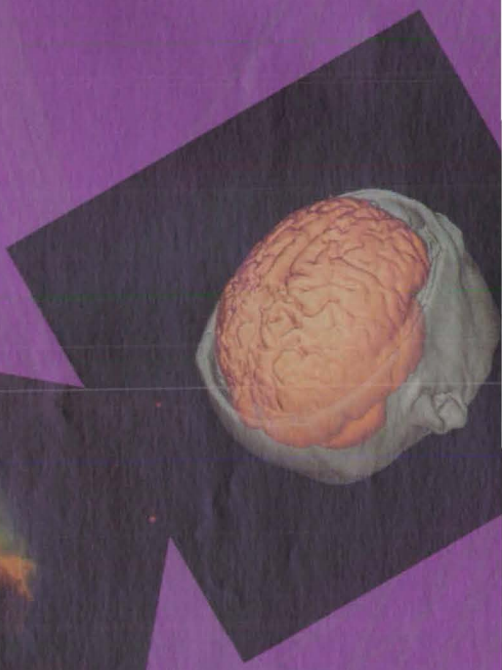

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This is your chance to ask a question, provide a solution to a fellow reader's problem, reply to an information request, or give the editors feedback on what you'd like to see more or less of in NASA Tech Briefs. *We'd also like to hear about specific instances where* NASA Tech Briefs *has helped you solve a problem or improve a process or product.*

I would like to thank you for the cover picture of the Source Coder for Enhanced Data Compression on the April 1996 issue of NASA Tech Briefs *(NASA's Government Invention of the Year). It's nice to see, in print, some of the hard work that subcontractors go through to ensure high-reliability components for their customers.*

As a long-time employee of United Technologies Microelectronics Center (UTMC) and a contributor to this project, I'm proud that our company is making a difference.

Thank you.

Gregory Cox
Product Engineer
UTMC
Colorado Springs, CO

The Tech Brief "Lightweight Cathodes for Nickel Batteries" (January 1996 NASA Tech Briefs, *page 35, LEW-15817) has helped us decide to go ahead with design work on a large, multi-engine, electric-powered model airplane. This may become a major production item for us.*

The key to its feasibility will be lightweight, high-capacity batteries like those mentioned in the Tech Brief.

Dan Cahill
Roosevelt Field Model
Glen Head, NY

In the Spring 1996 edition of NASA Technology Today *[distributed with the April 1996 issue of* NASA Tech Briefs*], I read an article on Eagle 475 advanced sunglasses made by Biomedical Optical Company of America, but the article did not include an address for the company.*

I would appreciate it if you could provide me with their address so that I can obtain additional information on the product.

Thank you.

Norman Leet
Enon, OH

(Editor's Note: Biomedical Optical Company of America is located at 23945 Calabasas, Ste. 201, Calabasas, CA 91302; Tel: 818-225-7765.)

Send your letters to the Editor at:
Reader Forum, *NASA Tech Briefs,* 317 Madison Ave., Ste. 921, New York, NY 10017.
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Please include your name, company (if applicable), address, and phone number or E-mail address.

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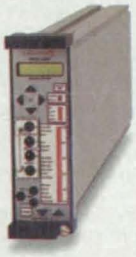

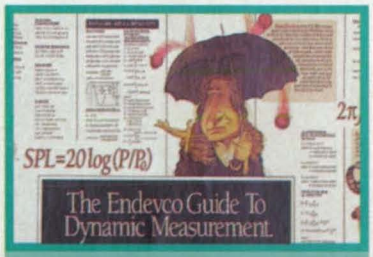

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For More Information Write In No. 556

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). We encourage all businesses with technical needs to contact the appropriate organizations for more information. For those who have access to the Internet, general information can be accessed with Mosaic software on the NASA Commercial Technology Home Page at URL: http://nctn.oact.hq.nasa.gov. Instructions regarding how to acquire the free Mosaic software can be obtained by sending an e-mail request to: innovation@oact.hq.nasa.gov.

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.
Syed Shariq
(415) 604-1919
syed_shariq@qmgate.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.
James Rooney
(818) 354-2240
james.a.rooney@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: Emissions and Contamination Monitoring; Sensors; Corrosion Protection; Bio-Sciences.
Bill Sheehan
(407) 867-2544
billsheehan-1@ksc.nasa.gov

Langley Research Center
Selected technological strengths: Aerodynamics; Flight Systems; Materials; Structures; Sensors; Measurements; Information Sciences.
Dr. Joseph S. Heyman
(804) 864-6005
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
ann.o.heyward@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
(202) 544-5419
harry.craft@msfc.nasa.gov

Stennis Space Center
Selected technological strengths: Propulsion Systems; Test/Monitoring; Remote Sensing; Nonintrusive Instrumentation.
Anne Johnson
(601) 688-3757
ajohnson@wpogate.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.

Ismail Akbay
National Technology Transfer Center
(800) 678-6882

Robert Stark
Far-West Technology Transfer Center
University of Southern California
(213) 743-2353

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

J. Ronald Thornton
Southern Technology Applications Center
University of Florida
(904) 462-3913

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

Lani S. Hummel
Mid-Atlantic Technology Applications Center
University of Pittsburgh
(412) 648-7000

Chris Coburn
Great Lakes Industrial Technology Transfer Center
Battelle Memorial Institute
(216) 734-0094

Easy Access To The FLC: Call (206) 683-1005 for the name of the Federal Laboratory Consortium Regional Coordinator in your area. The Regional Coordinator, working with the FLC Locator, can help you locate a specific laboratory to respond to your needs.

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.

Gene Pawlik
Small Business Innovation Research Program (SBIR)
(202) 358-4661
gpawlik@oact.hq.nasa.gov

Robert Norwood
Office of Space Access and Technology (Code X)
(202) 358-2320
rnorwood@oact.hq.nasa.gov

Philip Hodge
Office of Space Flight (Code M)
(202) 358-1417
phodge@osfms1.hq.nasa.gov

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

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

Bert Hansen
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.

Dr. Stephen Gomes
American Technology Initiative
Menlo Park, CA
(415) 325-5353

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

John Gee
Ames Technology Commercialization Center
Sunnyvale, CA
(408) 734-4700

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 **NASA's 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. If you have questions...**NASA's Center for AeroSpace Information** can answer questions about NASA's Commercial Technology Network and its services and documents. Use the Feedback Card in this issue or call (410) 859-5300, ext. 245.

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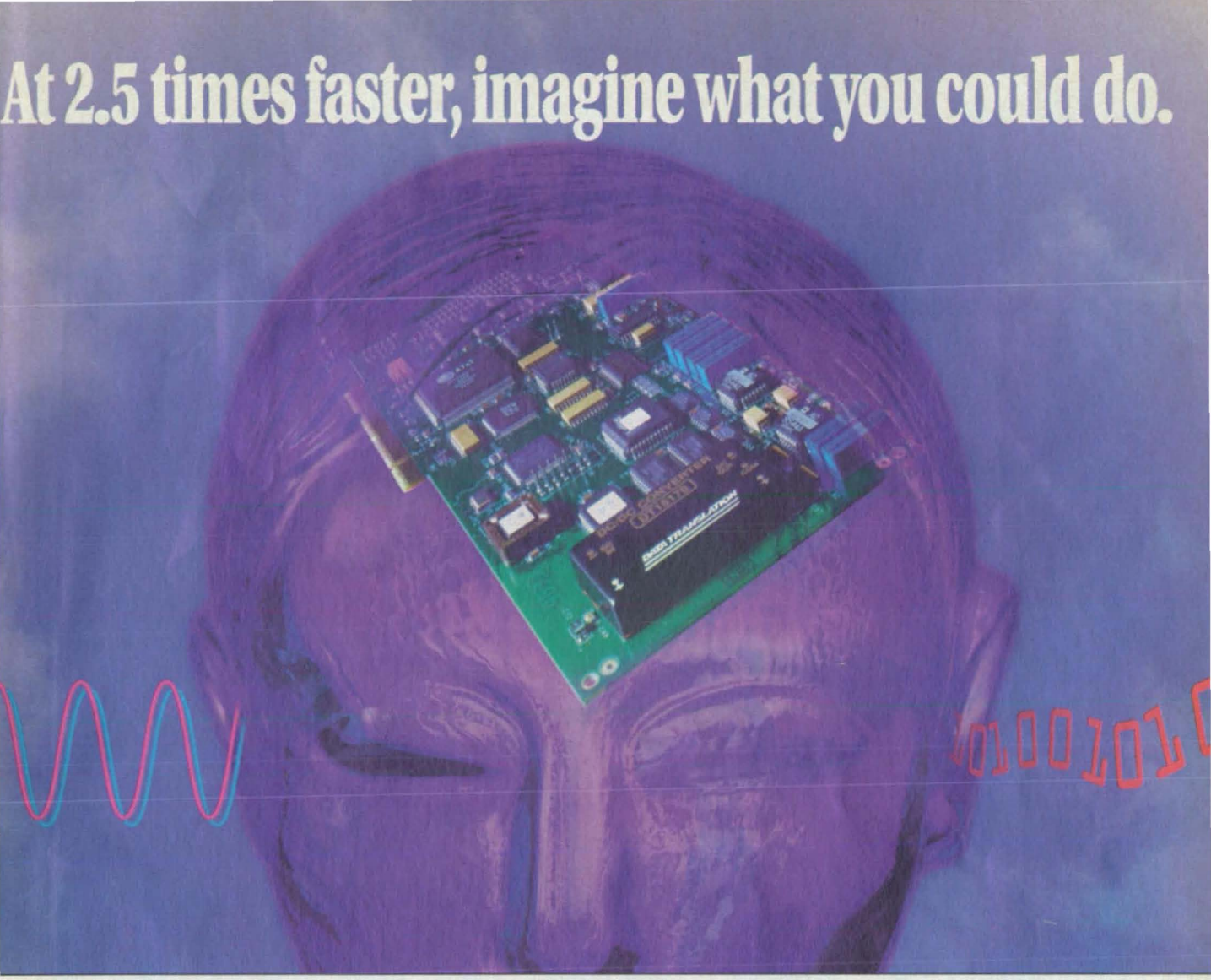

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For More Information Write In No. 617

New Product Ideas

New Product Ideas are just a few of the many innovations described in this issue of *NASA Tech Briefs* and having promising commercial applications. Each is discussed further on the referenced page in the appropriate section in this issue. If you are interested in developing a product from these or other NASA innovations, you can receive further technical information by requesting the TSP referenced at the end of the full-length article or by writing the Commercial Technology Office of the sponsoring NASA center (see page 14).

Carrierless Antibacklash Planetary Gear Assembly

Unlike a traditional planetary gear drive, this assembly can multiply torque by a large factor and it compensates for backlash. The entire drive train is very efficient, involving essentially rolling friction.
(See page 28.)

Cueing Lights for Maneuvering Helicopters at Low Altitudes

Cueing lights mounted on a helicopter project narrow beams of light on the ground to form bright spots that guide the pilot in low-altitude maneuvers. These systems are particularly helpful for landing or flying over featureless terrain, such as desert, or over water under conditions of poor visibility.
(See page 48.)

Adaptive Speech-Recognition Unit

A new unit is designed to function with some flexibility and adaptability. Compared with earlier units, this model can be reconfigured more easily by updating its software while remaining online, and it adapts itself more readily to the voices of different speakers as well as to changes in the voice of each speaker.
(See page 52.)

High-Speed Fluid-Mixing Device

This device mixes a liquid with a gas at high pressure. The device can be used for cleaning, spray coating and painting, humidification, and atomization. It can also be used to create a vacuum in a container.
(See page 76.)

Telerobotic Plant Tender

A proposed telerobot would tend plants in a hydroponic growth chamber. Use of such a telerobot would be important in plant-growth experiments to prevent contamination of the chamber by the exterior atmosphere and to prevent disruption of set temperature, humidity, and airflow conditions required by an experiment.
(See page 79.)

Small Implantable Pump Would Assist Circulation of Blood

A new ventricle-assist device is a small rotary pump with a built-in motor. The device is designed to pump blood efficiently with minimal damage to blood cells.
(See page 79.)

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For More Information Write In No. 575

Vespel® parts can handle some of the toughest jobs.

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Everyone knows that Vespel® polyimide parts improve performance in severe service applications by withstanding extreme heat, friction, pressure and contamination – with minimal or no lubrication. But now manufacturers who use Vespel parts in general applications are beginning to notice improvements somewhere else: *the bottom line*. That's because the reliability and long life of Vespel parts can make them the most cost-effective choice for general applications in the long term.

If your applications require parts that can withstand extreme temperatures (-350°F to 550°F), Vespel should be your first choice. Vespel should

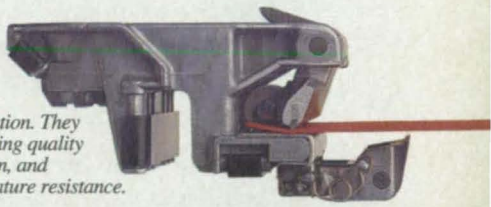
Insulators. *In plasma-arc cutting torches, Vespel insulators provide superior strength and durability at high temperatures up to 550°F, lasting up to six times longer than fragile ceramic insulators.*

Seal Rings. *In the assembly of automobile transmissions, Vespel seal rings reduce costs by replacing expensive metal rings, which can fracture or deform during assembly. They also reduce warranty costs by producing a better seal.*

Thrust Washers. *In farm tractor transmissions, Vespel thrust washers reduce costs and manufacturing time by eliminating the need for secondary machining. Vespel washers also exhibit high performance and low wear with limited or no lubrication.*

Bearings. *In photocopiers, Vespel composite idler gear hub bushings are a cost-effective alternative to metal. The Vespel parts provide ultra-high temperature resistance and dimensional stability while offering a low coefficient of friction, as well as long life without lubrication.*

Bushings. *In aircraft engine vanes, Vespel bushings withstand high-frequency vibration dithering and offer excellent stability and lubricity at high temperatures. They also reduce assembly time.*



Wear Strips. *In textile equipment, Vespel tenter frame clip wear strips reduce costs by eliminating the need for lubrication. They also improve textile manufacturing quality by eliminating oil contamination, and provide good wear and temperature resistance.*

also be considered if you have parts that rub together, if metal parts are too noisy, or if fluid flow needs to be controlled.

Superior strength and reliability aren't the only ways Vespel can save you money. Often, you can consolidate two or more existing parts in one Vespel piece. And Vespel parts can be direct-formed, which eliminates machining costs.

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20th Anniversary Letter-Writing Contest

NASA Tech Briefs debuted as a magazine in 1976, evolving from NASA's dissemination of single-sheet reports detailing its novel, commercially-viable technologies for transfer to the engineering community. Through privatization (beginning in 1985), the magazine's circulation has nearly tripled – from 75,000 to over 207,000.

Help us celebrate these first two decades by entering a contest just for you – the readers of *NASA Tech Briefs* – who have made this success possible. To enter, write a letter of 500 words or less describing how *NASA Tech Briefs* has impacted your work and your life. For example:

- How have the technologies and products featured in *NASA Tech Briefs* helped you to solve specific problems and grow your business?
- As a result of information found in *NASA Tech Briefs*, have you or your company established partnerships with NASA or licensed NASA technology?
- Have you or your company benefitted from the *NASA Tech Briefs*-sponsored Technology 2000 national tech transfer conferences?
- Which technologies or products you are reading about today in *NASA Tech Briefs* do you think will drive important innovations in the next two decades?

Prizes

Three Grand Winners each will receive a trip (transportation and hotel) to Anaheim, CA for the Technology 2006 conference (October 29-31, 1996) at the Anaheim Convention Center. The Grand Winners also will be our guests at the prestigious 1996 Technology Transfer Awards Dinner for the formal announcement and presentation of their awards.

The Grand Winners and five finalists each will receive the *NASA Tech Briefs* CD-ROM, a resource of searchable databases and computer programs representing the best of the past 20 years of NASA technology, and will have the opportunity to receive a free company profile on the *NASA Tech Briefs* World Wide Web site.

The three winning letters will be printed in their entirety in the December issue of *NASA Tech Briefs*, which will be distributed to all members of Congress and the White House. All entrants will receive a Certificate of Recognition, and will appear in an Honor Roll in the December issue.

Your letter must be no more than 500 words, and must include how many years you've been reading *NASA Tech Briefs*, as well as your name, address, and daytime phone number.

Send your letter to:

NASA Tech Briefs
Letter-Writing Contest
317 Madison Ave., Ste. 921
New York, NY 10017

Fax: 212-986-7864
E-mail: ntb_edit@interramp.com

Your letter **MUST** be postmarked (or date-stamped for E-mail entries) by:

September 1, 1996

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NASA NEWS BRIEFS

Apollo 13 Commander Jim Lovell officially launched Mission HOME (Harvesting Opportunity for Mother Earth), a multi-year drive to captivate and educate the American public about the benefits and wonders of space. Lovell, who serves as chairman of Mission HOME, was joined by representatives of two non-profit space organizations and 16 corporations that have created the initiative to "Take Up Space."

MISSION HOME™
Harvesting Opportunity for Mother Earth

The campaign seeks to teach and learn from the American people how space endeavors can help improve life on Earth, through activities such as a series of meetings called "Town Halls in Space." The national campaign will stress the excitement of space through space-themed entertainment and marketing initiatives. A Mission HOME Space Education Alliance has been established to encourage the use of space studies as a tool to interest children in math, science, and technology.

Mission HOME encompasses all aspects of the American space community, including NASA; the National Oceanographic and Atmospheric Administration; the commercial community, including the private satellite industry; and military space.

For more information, contact Mission HOME at 1-800-SPACE-US.

NASA's Lewis Research Center and Battelle's Great Lakes Industrial Technology Center are launching a consortium for the design and analysis of composite materials. The multi-industry consortium draws on the technical expertise of a federal administration and a commercial research organization. During Phase I, Lewis and Battelle experts will work with participating companies to evaluate the applicability of predictive software to specific design processes. At the conclusion of Phase I, the company will know the impact the software could have for business and what will be required for its acquisition and integration.

In Phase II, the NASA/Battelle experts will work with companies to customize the software code for individual applications. At the project's end, the company will have a proprietary design tool that it can use in-house and license. Members will have direct access to NASA and Battelle staff and technology. The consortium is open to all U.S. companies. Phase I costs $5000; the cost for Phase II is negotiated on the basis of work performed.

For more information, contact Priscilla Diem of Battelle at 216-734-1186; Internet: diem@batelle.org.

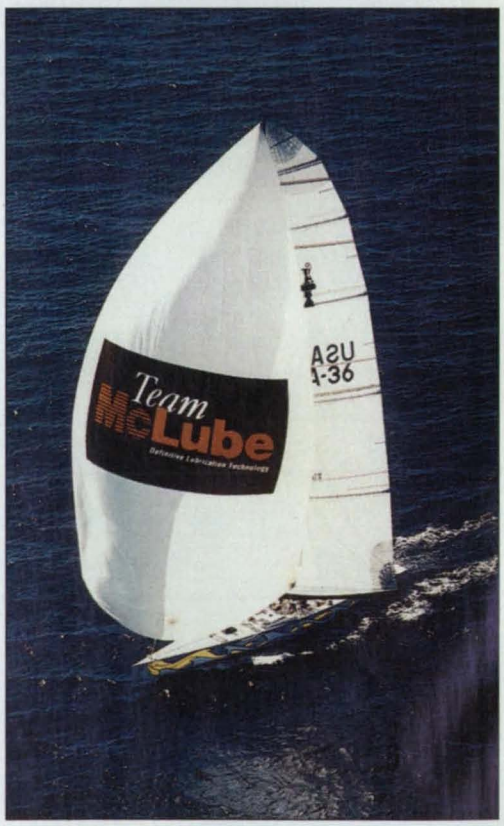
The July 1994 issue of *NASA Tech Briefs* featured a Mission Accomplished story describing how DuPont Krytox® temperature-resistant lubricants used in life-support systems for firefighters originally were used by NASA to protect aerospace materials such as rubber, plastic, and metal surfaces. Developed in 1958, Krytox had been used by NASA since the 1960s. Following the 1967 Apollo disaster in which three astronauts died when their command capsule was engulfed by fire, NASA began a search for nonflammable materials for aerospace use. That search led them to Krytox.

DuPont continues to expand the Krytox line into new commercial applications. Industrial- and high-performance lubricant manufacturer TEAM McLube Division of McGee Industries, Aston, PA, is the official lubricant supplier and sponsor for PACT 2000 and the U.S. Sailing Team. It is McLube's priority to ensure that SailKote, a Krytox-based bonded dry film lubricant, reduces the coefficient of friction across the sail, increasing sail efficiency. SailKote also is used to protect and lubricate masts, spars, shrouds, and riggings.

For more information, contact Mark Gullo, Market Manager for DuPont's Krytox dry film, at 302-239-8181.

In the future, astronauts will have to supplement their food supplies by planting and harvesting crops. The first crop developed specifically for growth in space–a wheat variety called Apogee–has been developed by Dr. Bruce Bugbee at Utah State University in Logan, UT. Bugbee heads the Utah Agricultural Experiment Station, a NASA-supported university research facility which develops food crops for space. The new wheat took more than a decade to develop.

Apogee produces the equivalent of almost 600 bushels of grain per acre–three times the top yield from most fields.



Krytox lubricants from DuPont have been used by NASA since the 1960s to protect aerospace materials such as rubber, plastic, and metal surfaces. A Krytox-based bonded dry film lubricant called SailKote is now used to protect and lubricate masts and reduce friction across sails.

It thrives where artificial sun always shines, carbon dioxide levels are high, and space is tight.

For more information, contact Doug Ming of NASA's Johnson Space Center at 713-483-5839.

Three NASA technologies recently were inducted into the United States Space Foundation's Space Technology Hall of Fame for their contributions to enhancing the quality of life on Earth: anti-shock trousers, flame-resistant seat materials, and radiant barrier technology. The anti-shock trousers were developed during the Apollo program at NASA's Ames Research Center for astronauts and pilots who undergo fluid shifts in their bodies due to changing gravity levels. The suit contained pneumatic bladders to counteract the fluid shifts. In the late 1960s, the suit was adapted to help control internal bleeding. The resulting suit is required equipment in most ambulances and emergency medical vehicles and has been used more than two million times.

Ames researcher Demetrius Kourtides invented the flame-resistant seat technology after the Apollo fire in 1967. It is now in use on civilian and military aircraft. Also developed as a result of the Apollo program was NASA's radiant barrier, a thin polymeric film now used on virtually all spacecraft to protect instrumentation from extreme temperatures.

For more information, contact the U.S. Space Foundation, 2860 South Circle Drive, Ste. 2301, Colorado Springs, CO 80906-4184; Tel: 719-576-8000.

Thanks to the U.S. Space program, nearly 13,200 jobs have been added to the nation's job bank or saved from elimination, according to Harry Craft, manager of NASA's Marshall Space Flight Center's Technology Transfer Office. Assistance from the space program has enabled American industry to introduce 775 new products for sale here and abroad, with the value of this assistance to American business estimated at $1.2 billion. The figures were determined by a survey conducted by NASA's Southeast Technology Transfer Alliance, which pools the scientific and engineering research and development of Marshall with Stennis Space Center, Kennedy Space Center, and the Southern Technology Applications Center in Alachua, FL.

For more information, contact Harry Craft at 205-544-5419; harry.craft@msfc.nasa.gov.

GLOBE students discuss with their teacher a computer visualization of world temperature created by NASA Goddard for the GLOBE program. (Photo by Greg Crist)

The GLOBE (Global Learning and Observations to Benefit the Environment) Program, a Washington, DC-based international environmental education program initiated by Vice President Gore, has teamed with NASA to help students, teachers, and scientists study and understand the global environment and help students reach higher standards in science and math. Involving more than 116 countries, GLOBE is a public-private partnership supported by the National Oceanic and Atmospheric Administration, NASA, the National Science Foundation, the Environmental Protection Agency, the Departments of State and Education, and the Foundation for Global Environmental Education.

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For more information, contact Jean M. Fitch, Public Affairs Specialist, The GLOBE Program, 744 Jackson Place, Washington, DC 20503; Tel: 202-395-7600.

Maps produced from an airborne sensor developed by NASA's Jet Propulsion Laboratory (JPL) are cutting costs and helping speed hazardous waste cleanup at a Superfund site in Leadville, CO. The Bureau of Reclamation, Environmental Protection Agency, and the U.S. Geological Survey (USGS) are using the maps to find sources of acid mine drainage and heavy-metal contamination at the California Gulch Superfund site.

The maps were produced by the USGS using data from NASA's Airborne Visible and Infra-Red Imaging Spectrometer (AVIRIS), which was developed by JPL and is managed by JPL for NASA's Office of Mission to Planet Earth. AVIRIS flies aboard a NASA ER-2 airplane and makes measurements related to global climate-change research in geology, oceanography, snow hydrology, and cloud and atmospheric studies. The maps have saved about $500,000 and a year's time in identifying the areas that need attention.

For more information, contact JPL's Infrared and Analytical Instrument Systems Section at 818-354-6817.

NASA's Ames Research Center and Kaiser Electronics of San Jose, CA, have partnered to provide four cooling systems to the Multiple Sclerosis Association of America (MSAA). Engineers at Ames will interface cooling carts donated by Kaiser with liquid-cooled garments, like those used by astronauts, in an effort to alleviate symptoms of MS sufferers. NASA has been working with the MSAA under a Memorandum of Understanding signed May 23, 1994, although it has been nearly 30 years since research began into the application of NASA life support technologies to medical problems.

The cooling suits appear to alleviate the symptoms of MS patients by reducing spasticity and lowering fatigue. The suits also have been used experimentally to aid paraplegics and quadriplegics.

For more information, contact David Morse of Ames Research Center at 415-604-4724.

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Special Focus: Mechanical Components


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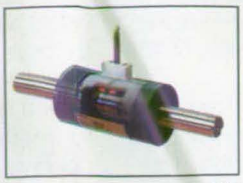
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Quick connect/disconnect rotary latch would join structures
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Planetary gear assembly compensates for backlash
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Fan size and weight reduced with conical-foil air bearings
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Bearings with Teflon liner are joined without adhesives
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Spring-energized seals provide alternative to O-rings and U-cups
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Quick-Connect/Quick-Disconnect Rotary Latch

Crossed slots would hold a latch pin stably, preventing inadvertent release.

Lyndon B. Johnson Space Center, Houston, Texas

The figure shows a proposed rotary latch that would be mounted on a structure and would be used to passively capture and restrain a latch pin that was part of another structure. The rotary latch would thus quickly join the structures. The configuration of the latch would be such that no load that could be applied to it by the latch pin could cause inadvertent release. However, release could be effected quickly and easily, by use of either a rotary solenoid, paraffin actuator, or a manual release lever. There is no theoretical limit to the sizes and masses of structures that the latch could be designed to join. Moreover, the force needed to actuate the latch would be nearly independent of the load to be borne.

In the configuration shown, the latch would include a rotor that would be connected to a rotary solenoid. The solenoid would contain a latching or detent mechanism with two stable positions, and the rotor would be connected to this mechanism via a torsional spring. Ordinarily, the solenoid would be in the stable position corresponding to a closed latch; in this position, the torsional spring would bias the rotor into the closed-latch position with a torque of 10 to 15 lb·in. (1.1 to 1.7 N·m).

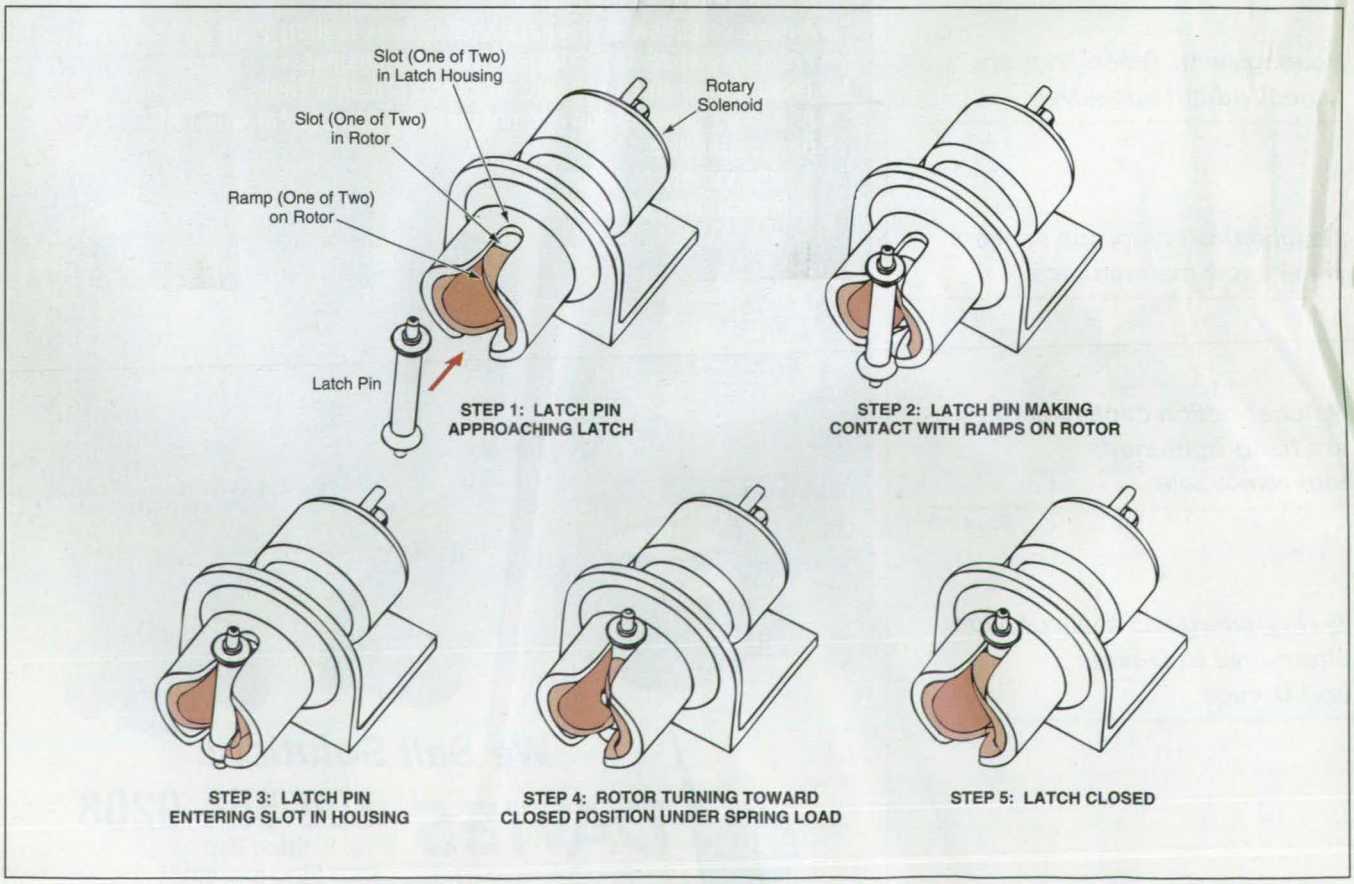
At the beginning of a capture sequence, the latch pin would move toward slots in the latch housing. This motion would eventually result in contact between the latch pin and ramps on the rotor at the outer ends of the slots in the latch housing. Continued movement of the latch pin into the slots in the latch housing would cause the rotor to turn, against the spring load, to the open position. Eventually, the pin would reach the rounded tips at the ends of the ramps and the spring load would snap the rotor back to the closed position, capturing the pin in slots in the rotor. Thus, the pin would be captured simultaneously in the slots on both sides of the housing and the slots on both sides of the rotor. Because the rotor and housing slots would be perpendicular to each other, the pin would thus be captured at two locations in two sets of crossed slots, making a highly stable structural joint.

To open the latch, an electrical pulse would be sent to the solenoid, causing it to rotate to the open-latch detent position. The latch pin could then be removed from the latch. To reset the latch for another capture, a pulse of opposite polarity would be sent to the solenoid to turn the rotor to the closed-latch position.

If remote electrical actuation were not needed, the solenoid could be eliminated. The latch could then be reduced to a rotor, return spring, and manual release lever. With small modifications, the rotary latch could be used as a grappling device on a robot manipulator.

This work was done by Joel M. Kramer of McDonnell Douglas for **Johnson Space Center**. *For further information,* ***write in 86*** *on the TSP Request Card.*

This invention has been patented by NASA (U.S. Patent No. 5,464,301). 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-22321.



The **Latch Pin Would Approach the Rotary Latch**, enter the slots in the latch housing, and finally be captured by the slots in the rotor.

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Carrierless Antibacklash Planetary Gear Assembly

This assembly also provides high torque multiplication.

Goddard Space Flight Center, Greenbelt, Maryland

A gear assembly that can handle large loads is based partly on the planetary gear concept, but departs from the traditional planetary drive configuration in ways that confer significant advantages. Unlike a traditional planetary gear drive, this assembly is capable of multiplying torque by a large factor, and it compensates for backlash. Also unlike a traditional planetary gear drive, this assembly does not include a planet carrier.

The assembly (see Figure 1) includes a lower annular gear that is part of a lower housing and an upper annular gear that is part of an upper housing. The lower housing is grounded or otherwise held stationary, while the upper housing is connected to the output shaft. The input shaft turns a sun gear, which drives four lower planet gears in the lower housing. Each of the lower planet gears is connected to a slightly larger upper planet gear through angled interlocking splines designated as preload splines. Except for small relative motions that compensate for backlash as described below, the preload splines constrain each upper planet gear to turn with its associated lower planet gear. The upper planet gears engage a speeder gear, which serves to prevent the upper planet gears from being pushed inward or tipped when the assembly is subjected to large loads.

When the sun gear turns clockwise, for example, the lower planet gears rotate counterclockwise while orbiting clockwise around the common input/output shaft axis. Because the upper planet gears must turn counterclockwise with the lower planet gears, they drive the upper annular gear (and thus also the upper housing and the output shaft) counterclockwise. However, the counterclockwise motion of the upper annular gear is reduced by the clockwise orbiting motion of the lower planet gears, so that the net rotation of the output shaft is much slower than the rotation of the input shaft, and the output torque is multiplied accordingly. The entire drive train is very efficient, involving essentially rolling friction. The speed-division factor, which equals the torque-multiplication factor in the case of zero friction, is given by

$$\text{speed in/speed out} = 2R_{pl}(R_s + R_{pl} + R_{pu})/[R_s(R_{pl} - R_{pu})],$$

where R_s, R_{pl}, and R_{pu} denote the pitch radii of the sun, lower planet, and upper planet gears, respectively.

Figure 2 illustrates the preload splines on a planet gear. The planet gears in a pair are assembled with a preload

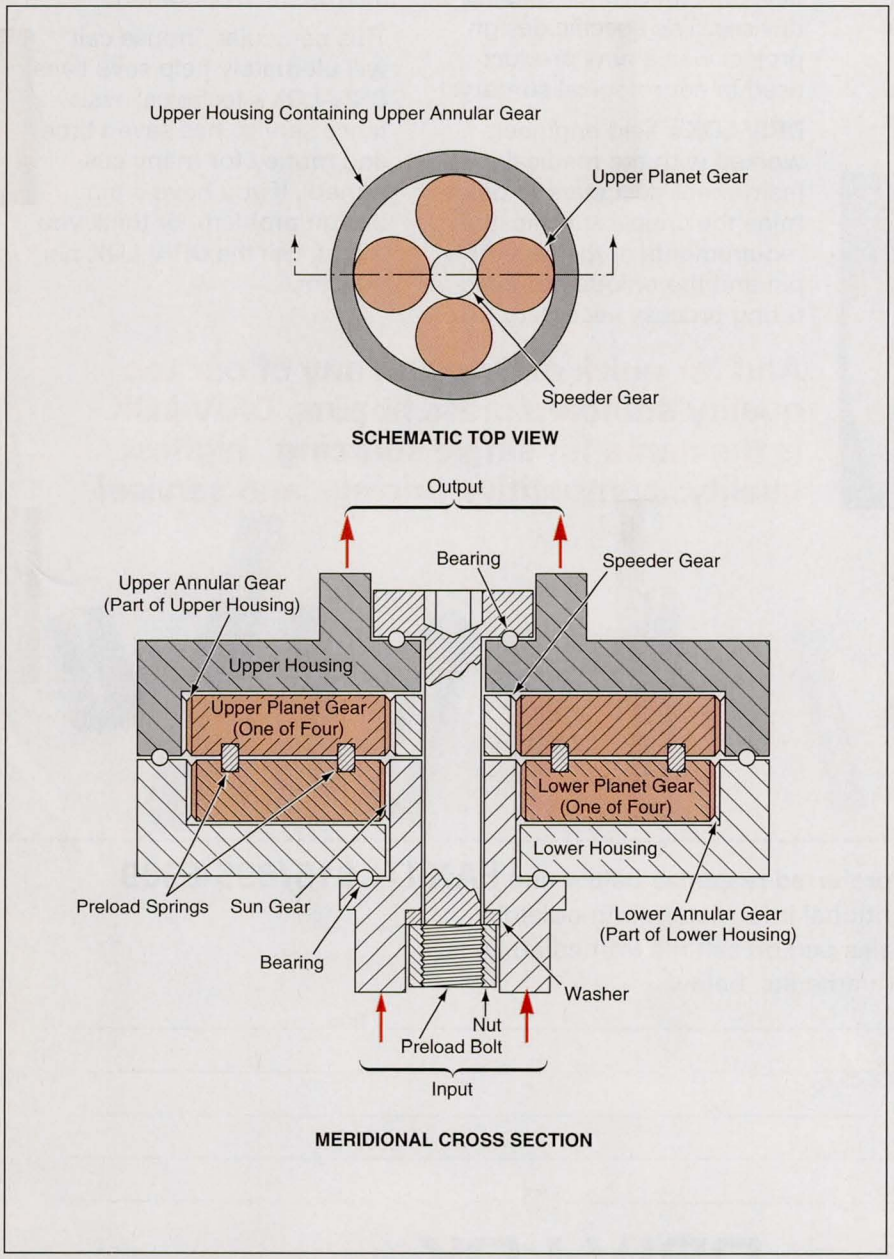

Figure 1. This **Planetary Gear Assembly** differs from a traditional planetary gear assembly in that it has an antibacklash capability and does not include a planet carrier.

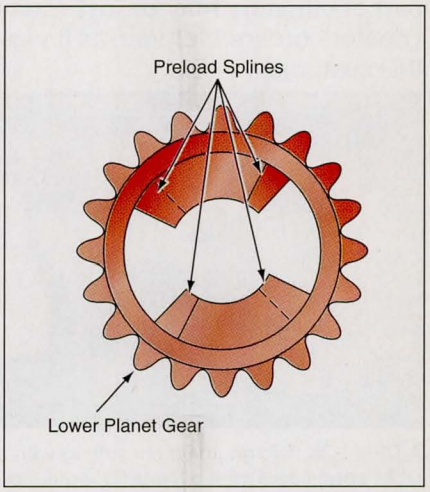

Figure 2. The **Preload Splines** on each upper and lower planet gear engage similar preload splines in an associated lower planet gear.

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spring that tends to spread them apart. Because the splines are slightly spiralled (typically at an angle of about 6° from the axis), the spreading action of the preload spring causes the planet gears to rotate slightly with respect to each other to provide antibacklash contact. Because the angle of the preload splines is so small, it is a locking angle in the following sense: When the output shaft encounters opposing torque, frictional forces between mating splines build up faster than do forces that tend to counter-rotate the planet gears. As a result, the upper and lower planet gears remain locked together in the relative position of initial contact.

To compensate for backlash in both clockwise and counterclockwise rotation, it is necessary to provide pairs of planet gears with opposed preloads; that is, with each pair biased oppositely to its nearest neighbors. It is also necessary to use an even number of pairs of planet gears, the minimum being four, because only half the pairs of planet gears are transmitting torque at any given time.

This work was done by John M. Vranish of **Goddard Space Flight Center**. *For further information,* ***write in 26*** *on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Goddard Space Flight Center; (301) 286-7351. Refer to GSC-13608.

Axial-Flexure-Shaft Poppets for Quick-Disconnect Couplings

These poppets would be less susceptible to jamming by solid residues.

Lyndon B. Johnson Space Center, Houston, Texas

The poppets in some valves, including those in some quick-disconnect fluid couplings, would be modified, according to a proposal, to reduce wear and reduce susceptibility to jamming by small particles and by solid residues that can build up on sliding surfaces. In the original application, the poppets are incorporated into female quick-disconnect couplings to prevent loss of fluid upon disconnection from the mating male couplings. When a male and female coupling are connected, a probe from the male coupling pushes against a poppet that is spring-loaded into the sealing position in the check valve in the female coupling. Thus, the valve is opened upon connection. As the probe is withdrawn upon disconnection, the spring load closes the valve, preventing loss of fluid.

In an unmodified valve of the type used in the original application (shown in simplified form in Figure 1), the poppet slides axially within the valve housing. To maintain the precise alignment needed for proper sealing, the faying surfaces of the housing and poppet are machined for a precise sliding fit. The sliding surfaces are thus highly susceptible to jamming by loose particles and by surface residues thicker than the precise, small poppet/housing gap. In addition, sliding causes wear, which generates loose particles. If the wear is severe enough, the poppet can become so misaligned that it does not seat properly, causing the valve to leak when nominally closed.

In the proposed design, sliding would be eliminated, and the gap between the housing and the moving side of the poppet would be made so large as to eliminate susceptibility to jamming. The axially sliding poppet of the older design would be replaced by a poppet with an axial-flexure shaft (see Figure 2). In essence,

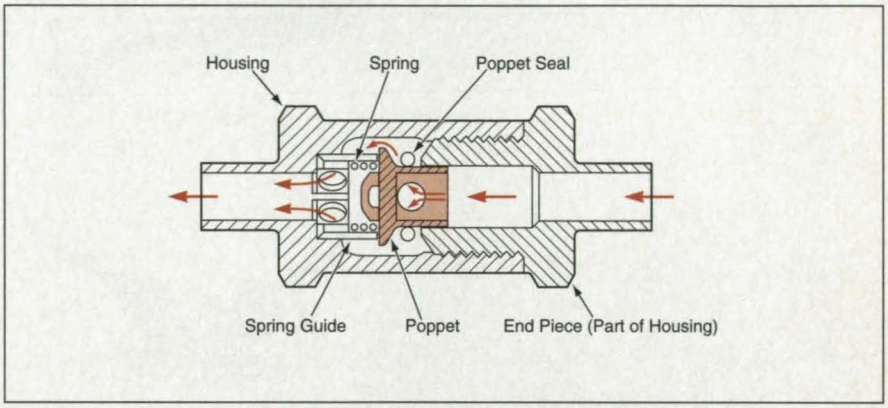


Figure 1. In the **Unmodified Design**, sliding of the poppet in the housing causes wear, and the sliding parts are susceptible to jamming by solid particles.

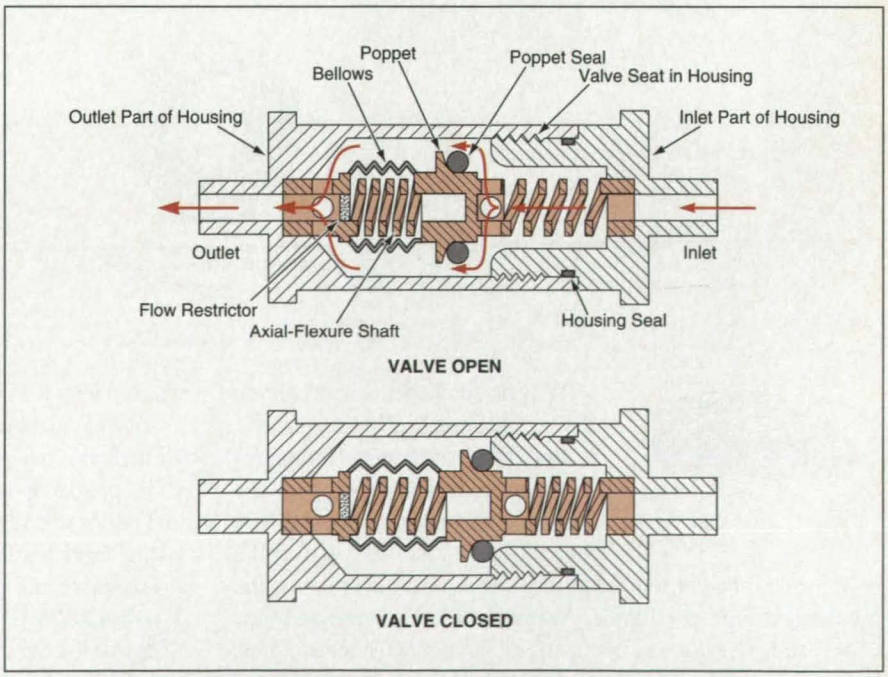
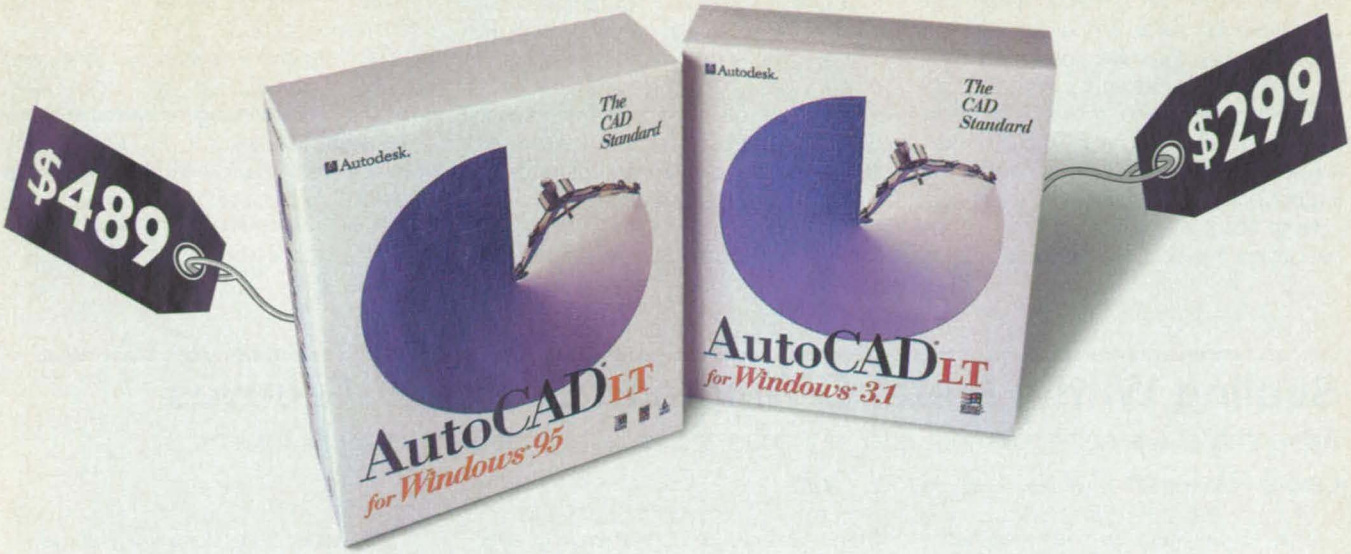


Figure 2. In the **Modified Design**, there would be no sliding parts. The poppet would be supported by an axially flexible shaft made by cutting a spiral groove in a tubular shaft. The gaps between the turns of the spiral would be large enough to allow the normal flow to sweep away contaminant particles.



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the shaft would be a helical spring that would provide axial spring loading and flexibility to bias the valve closed and allow the valve to be opened by inlet pressure on the poppet acting against the spring bias. The shaft would be sufficiently radially (more precisely, laterally) stiff to center the poppet in the housing.

In an alternate application of this poppet design, the concept would be applied to a check valve. The spring part of the shaft at the outlet end would be enclosed in a bellows, and flow into and out of the bellows would have to pass through a restrictor, which could be a porous metal disk or a small orifice. The bellows and flow restrictor would function together as a damper to suppress chatter.

This work was done by Joseph S. Cook of **Johnson Space Center**. *For further information,* ***write in 51*** *on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center; (713) 483-4871. Refer to MSC-22422.

Sealing With a Metal O-Ring and Double V-Grooves

Advantages are self-alignment and four lines of contact instead of the usual two.

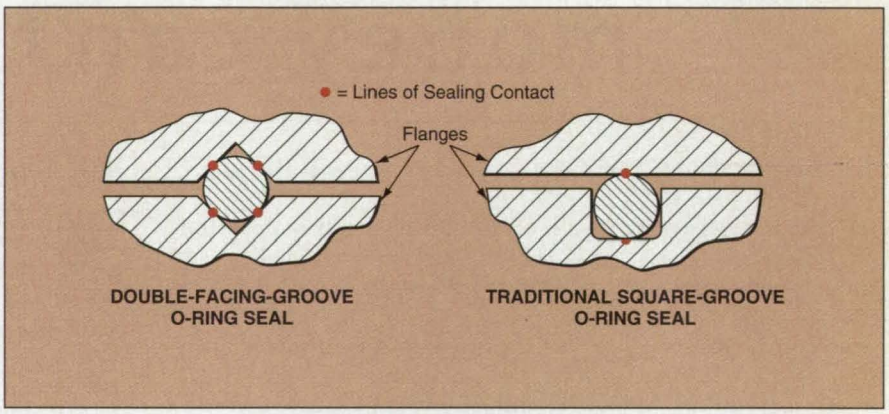
Lewis Research Center, Cleveland, Ohio

The O-ring-and-groove geometry illustrated in the figure provides a high-quality metal-to-metal seal. A polytetrafluoroethylene-coated metal O-ring with a minor diameter of 0.125 in. (3.18 mm) is squeezed into facing V-grooves in two flanges to be sealed to each other. The V-groove in one flange is 0.040 in. (1.02 mm) deep; the V-groove in the other flange is 0.060 in. (1.52 mm) deep.

The use of facing V-grooves provides four lines of sealing contact, whereas the use of the traditional square groove provides only two lines of sealing contact. An additional advantage of this geometry is that hard contact between the grooves and the O-ring automatically aligns the flanges with each other, without need for a pilot alignment lip on the flanges.

The metal O-ring is squeezed into a diamond shape and is not reusable. Metal O-rings are commercially available. For sealing at temperatures above 400 °F (204 °C), an O-ring should be coated with silver instead of polytetrafluoroethylene.

This work was done by George A. Repas of **Lewis Research Center**. *For further information,* ***write in 66*** *on the TSP Request Card. LEW-16079*



The **Double-V-Groove O-Ring Seal** provides self-alignment and four lines of contact versus no self-alignment and only two lines of contact for traditional square-groove O-ring seals.

Reverse Multipad Conical-Foil Air Bearings

Sizes and weights are less than those of conventional bearing combinations.

Marshall Space Flight Center, Alabama

Reverse multipad conical-foil air bearings are undergoing development, with a view toward using them in efficient, long-life, high-speed fans. These bearings offer a desirable combination of reliability, efficiency, and effectiveness in damping noise.

A single conical air bearing offers both the axial-load-bearing capacity of a conventional thrust bearing and the radial-load-bearing capacity of a conventional journal bearing. Conical air bearings offer high radial and axial load capacities and are highly stable. The parameters of the conical configuration (radii and cone angle) can be chosen to tailor the radial and axial load-bearing capacities. Thus, two conical air bearings can be used in place of the four conventional bearings (two of journal type, two of thrust type) that would otherwise be needed to support a fan shaft. This change from four to two bearings enables a reduction in the overall size and weight of the fan assembly, reduces power loss, and increases reliability. Moreover, in comparison with rigid-pad-type conical air bearings developed previously, the present reverse multipad conical-foil air bearings offer increased resistance to shock and vibration, and increased ability to accommodate misalignments and manufacturing tolerances.

A reverse multipad conical-foil air bearing (see figure) includes a set of spring foils (corrugated conical foils), plus two additional layers of foils. When a load is first applied or changed, the spring foils and the foils in one layer slide azimuthally in one direction (e.g., counterclockwise), while the foils in the third layer slide in the other direction (e.g., clockwise). The friction of sliding between foils provides the desired damping of shocks and vibrations.

This work was done by Giridhari L. Agrawal of R&D Dynamics Corp. for

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SCOPE HINT 1

An Easy Way to Isolate the Cause of Noise Problems.

Noise (or cross talk) is tricky to analyze on a scope. Typically the scope is triggered on a signal other than the noise itself. Figure 1 shows a noisy ground signal with the scope auto triggered.

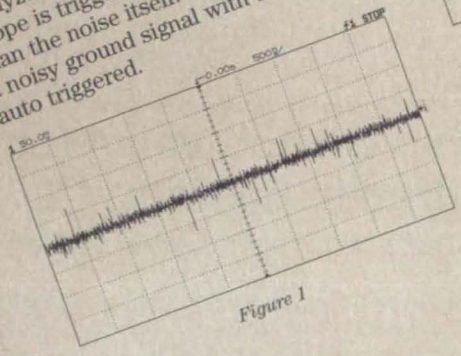

Figure 1

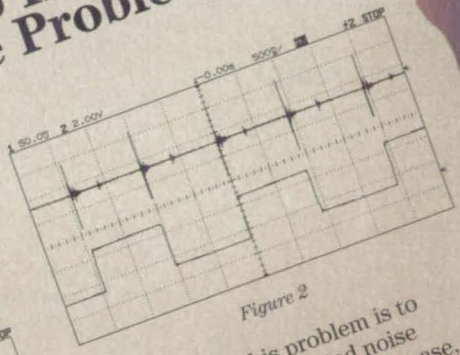

Figure 2

A solution to this problem is to trigger on the suspected noise source. See Figure 2. In this case, triggering on the 516 kHz clock signal on channel 2 results in a trigger synchronous to the noise. Now you can use averaging to average out the asynchronous noise. Using this technique, it's easy to see that this noise is indeed due to the 516 kHz clock.

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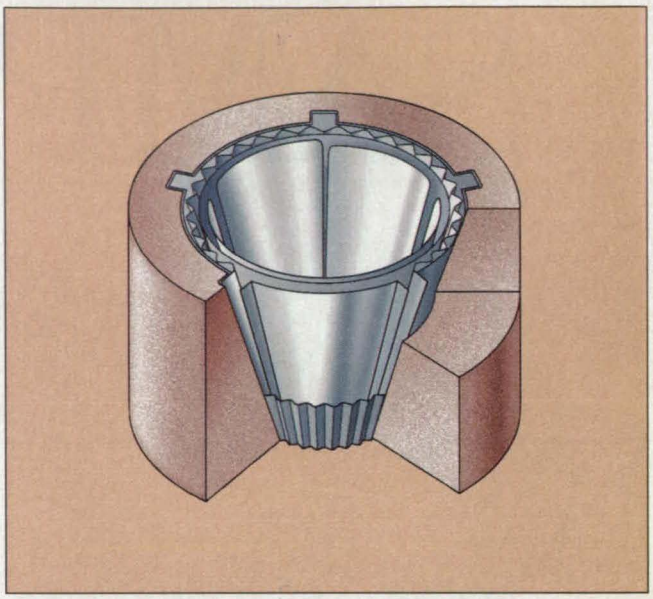

In a **Reverse Multipad Conical-Foil Air Bearing,** coulomb damping is obtained by friction between foils in different layers sliding on each other.

Servo Switch Valve for a Hydraulic System

Marshall Space Flight Center, Alabama

A switching servo valve for a hydraulic-actuator system is used to select either of two redundant upstream servo valves that control the position of the hydraulic actuator. This switching servo valve comprises an electromechanical first stage and a hydraulic second stage. The first stage converts an electrical input to a change in hydraulic pressure. The second stage contains a spool valve, in which the change in pressure generated in the first stage causes spools on a shaft to slide to either of two extreme positions to select one or the other of the two upstream servo valves; at one extreme, the spools are positioned so as to uncover ports to the tubes that lead to one upstream servo valve, while covering the ports to the tubes that lead to the other upstream servo valve. One of the advantages of this switching servo valve is that all conversion of electrical input to mechanical switching takes place in one unit; as a consequence, it is possible to eliminate a separate shuttle valve, which previously effected the upstream-valve-selection function of the second stage of this valve. In the specific application for which this valve was devised, the eliminated shuttle valve had been found to be susceptible to galling.

This work was done by Mario Padilla of Rockwell International Corp. for **Marshall Space Flight Center.** *For further information,* ***write in 20*** *on the TSP Request Card.*

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-30112.

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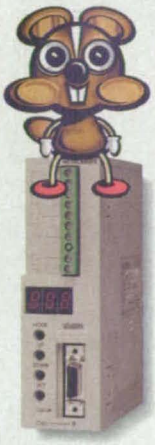
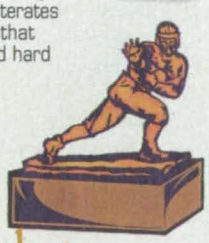
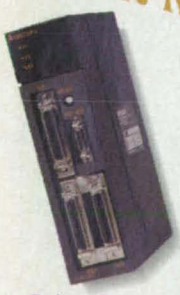
Like our mascot, small, quick and agile, the MR-C provides the high precision, high performance of a servo system at the price of a stepper. With automatic real-time tuning and easy set-up, the MR-C obliterates any misconceptions that servos are costly and hard to use!





All The Right Moves...



Only takes one slot in a PLC rack

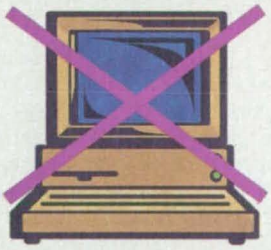
D75 Working off its own operating system, the D75 is a PLC based stepper/servo motion controller capable of up to 3 axes of position control. Motion profiles including S curves are easily programmed using the menu driven software package. And with up to 600 positions per axis, you make all the right moves too.

NO PROGRAMMING REQUIRED

MR-HAC

All the features of the MR-H, plus up to 256 positions and 8 speeds can be entered (EEPROM) through the keypad or through our optional Windows™-based set-up software.

ABSOLUTELY NONE



Tune A Piano

Tuna Fish

But Not Our MR-H

MR-H

Are You Performing Tuning Gymnastics?

Now let the MR-H do all the work for you. Using a 32-bit RISC processor and a patented real-time adaptive control, the MR-H continuously detects disturbances and automatically compensates, optimally tuning the system while the machine is in operation. This eliminates the need for any manual adjustments, so you can save your workouts for the gym.

Motors Galore

We've got small motors, small larger motors, small smaller motors, medium large motors, humongous motors. Wall-to-wall motors. **(DID WE ALREADY SAY WE HAVE A LOT OF MOTORS?)** Motors with absolute or incremental feedback. Fail-safe break motors. What we're trying to say is we have a ton of motors to choose from.

From 14 oz-in to over 300 ft-lbs of torque

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4299 14th Avenue
Markham, Ontario L3R OJ2
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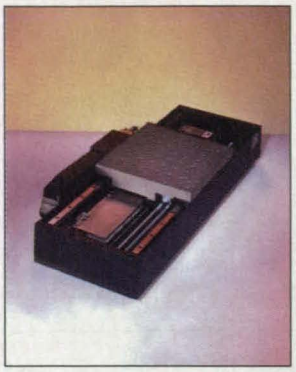
MITSUBISHI
INDUSTRIAL AUTOMATION DIVISION

For More Information Write In No. 519

EPI HY-LOAD metal-backed Teflon® **bearings** from Engineering Plastics, Westboro, MA, are mechanically joined to perforated metal backings, eliminating the need for adhesives. The bearings can be used for high-load, low-speed applications in open/close devices, and are resistant to acids and caustic fluids. The two-ply bearings withstand loads to 15,000 psi at low speeds on shafts with an RMS 16-20 finish.

The bearings can incorporate 304 or 316 stainless steel, monel, titanium, or other metal backings with virgin or glass-filled TFE or UHMW-PE liners. Available as cylinders from 1/2" to 10" diameters and as flat shapes, they permit circumferential rather than radial thermal expansion.

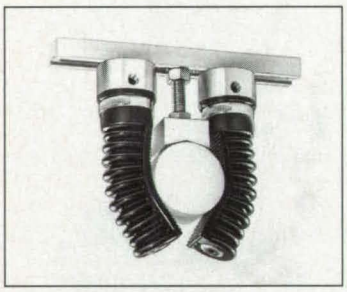
For More Information Write In No. 740



Aerotech, Pittsburgh, PA, has introduced ALS20000 series **linear positioning stages**, which feature the company's BLM series rare earth linear brushless servo motor instead of a conventional ball screw drive. By replacing the ball screw with a linear motor, mechanical vibrations produced by recirculating balls in the screw nut are eliminated. The stages can be used in applications requiring high acceleration and high duty cycle, including imaging, test and inspection, and precision positioning.

Acceleration rates to 4 g and velocity of 2 m/second are achievable. The stages are available in travel lengths from 100mm to 600mm. The non-contacting nature of the motors eliminates ball screw wear and requires no lubrication. Brush wear and brush particle contamination also are eliminated, making the stages suitable for use in cleanrooms.

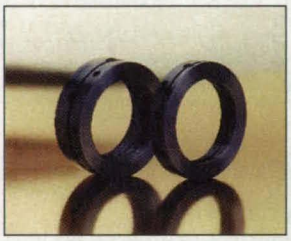
For More Information Write In No. 741



The GF40 **rubber finger gripper** from Techno-Sommer Automatic, New Hyde Park, NY, holds a variety of part shapes, including round, oval, tubular, and square. Applications include transferring molded plastic or sheet metal parts, bottles, and delicate products. Using air pressure to 2 bar, the gripper's individual rubber fingers can be adjusted to bend and surround the workpiece, even if the workpiece is not a clearly defined shape.

The gripper also can hold different items in sequence; rather than having a separate gripper for each item, it can hold a number of items without undergoing set-up for each one. For molded plastic parts, the gripper's rubber jaws conform to the shrinkage of the part, and the large knobbed rubber surface will not mar the part. An optional combination finger/part holder is available.

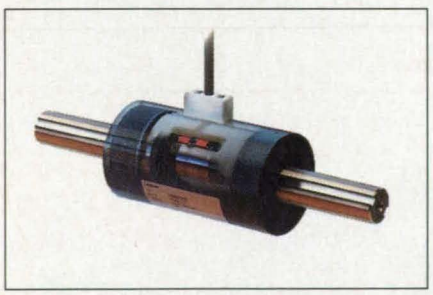
For More Information Write In No. 742



Advanced Machine & Engineering, Rockford, IL, has announced a line of **locknuts** that allow for radial adjustment and locking. The locknut width is divided into two sections by one internal and one external groove, providing a predetermined elasticity. Radially arranged tapered screws engage in both portions of the nut; when the screws are tightened, the nut portions are spread, locking the thread flanks against the shaft threads. By evenly tightening the screws, the centerline of the nut aligns itself with the male thread and establishes a square contact position when the thread clearance is eliminated.

The locknuts are available in a Slim Line version with the same width as a type AN or N bearing locknut with lockwasher, and a Heavy Duty version with twice the thickness of an AN or N locknut. The adjustability of squareness allows frequent assembly and disassembly, and 360° contact with the thread flanks is achieved. The locknuts were designed for vibration and shock-load force applications.

For More Information Write In No. 743



TorqStar™ **reaction and rotary torque sensors** from Eaton Corp.'s Lebow Products, Troy, MI, are noncontact, magnetoelastic sensors for use in applications such as dynamometers, engine test stands, tension controls, viscosity controls, torsional test equipment, and machinery monitoring and control. They are accurate to 0.5 percent.

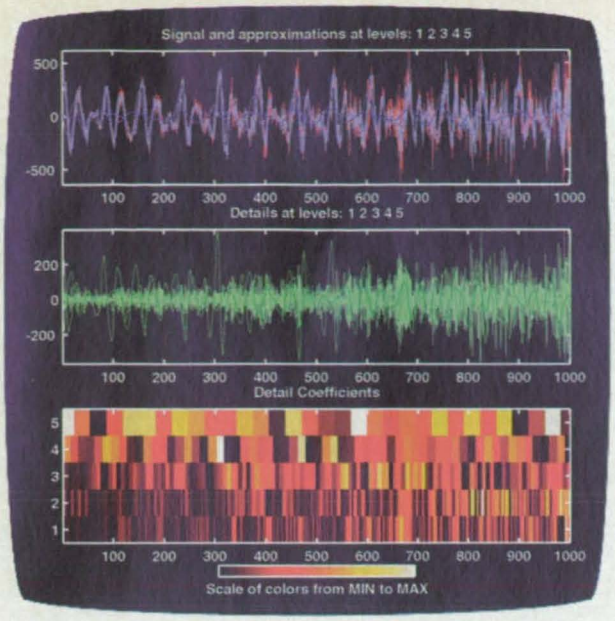
The sensors are about half the size of strain gauge sensors, allowing installation flexibility. They operate at 120V AC in temperatures from -10 to 100°C. Overload capacity is 150% full scale, maximum speed is 10,000 RPM, and full scale capacity ranges from 50 to 1000 lb/in.

For More Information Write In No. 744

Southco, Concordville, PA, has announced a ratchet-action **captive screw** for applications requiring restricted access to areas near electrical equipment or machinery. The ratchet-action screw is tightened by hand, but if a technician attempts to loosen the screw by hand, the head ratchets in the opposite direction without rotating or disengaging the screw thread.

The screw is used in applications requiring that only a door or cover be tool-removable. Since it can only be removed using a tool, the screw meets UL 1950 and IEC 60950 specifications for restricted access areas.

For More Information Write In No. 745



This image from the MATLAB Wavelet Toolbox shows a five-level decomposition of a voice signal. Wavelet analysis is producing breakthroughs in the development of communications signal processing algorithms. Data courtesy of U. S. Robotics Mobile Communications Corp.

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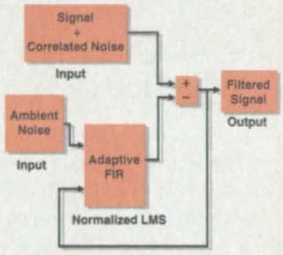

This SIMULINK block diagram shows the use of adaptive filtering to improve signal quality.

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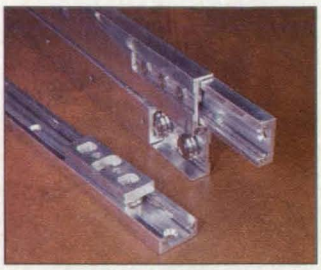
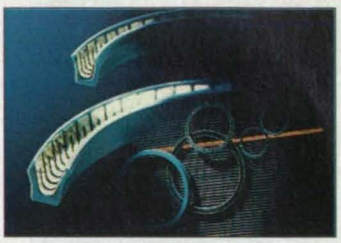


Pacific Bearing Co., Rockford, IL, has introduced a family of lightweight, low-friction, corrosion-resistant **linear guiderail systems**, including drawer slides and linear rail systems that are suited for high-speed, quiet-running linear motion applications. The systems can be customized for specific performance requirements. Power sources include hand motion, ball or ACME screws, pneumatics, hydraulics, and belt drives.

The systems are made of 6061-T6 aluminum with hardened, ground, and polished steel raceways. They are available in three widths–22.2 mm, 32.5 mm, and 38.1 mm–with a maximum load capacity from 400 to 1600 pounds. Rail lengths to 2400 mm are available, and may be joined to form longer rails. Drawer slides are available in 22.8 mm, 28 mm, and 38.1 mm lengths and have a load capacity from 100 to 1000 pounds. Slide lengths to 48" are offered with a stroke length to 49".

For More Information Write In No. 746



American Variseal, Broomfield, CO, offers Variseal® **spring-energized seals** as alternatives to conventional O-ring and U-cup seals. Made with Turcon® engineered-polymer compounds and corrosion-resistant spring-energizers, the seals can be used in rotary and reciprocating applications. The Turcon compound is made by blending Teflon® resin with graphite, carbon, glass fiber, or polyimide fillers.

The seals are machined to form a U-shaped jacket, into which a corrosion-resistant spring-energizer is inserted. Fluid pressure and spring load combine to provide a positive seal with minimum friction. The spring-energizers are available in three types–a Slantcoil Spring, a Cantilever Beam Spring, and a Helical Spring–in a variety of sizes, spring loads, and metals. The chemically inert seals withstand pressures to 10,000 psi. The seals can withstand temperatures from -196 to +300°C, and can be used with virtually any media.

For More Information Write In No. 751

Micro Mo Electronics, Clearwater, FL, has introduced the Series 1727 **industrial micromotor**, which measures 0.68" x 1.06" and weighs 1.1 ounces. It delivers up to 2.2 watts of power, and stall torque in most voltages exceeds 1.4 oz-in. Standard versions can run in a temperature range from -30 to +100°C; special versions for operation to 125°C are available.

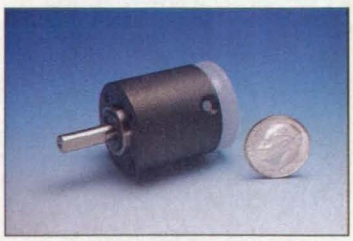
The motor's construction features a copper-graphite brush systems with ball bearings for increased current-carrying and load-carrying capabilities. It can withstand radial shaft loads to 18 ounces. Applications include medical electronics, laboratory automation systems, test and measurement equipment, and inspection systems. The motor is available with both planetary gearing and encoder feedback. An optional gearhead with preloaded ball bearings also is available. Other options include special shafts, adapters, and wiring terminations and lengths.

For More Information Write In No. 748

Litton Poly-Scientific, Blacksburg, VA, offers **motion control components**, including Clifton Precision® brush and brushless DC, permanent-magnet, and DC torque motors; synchros; multispeed, brushless, and brushless pancake resolvers; and slip rings, which are electromechanical devices for transmitting power or data from stationary to rotating objects.

Also available are Servotechnik incremental and absolute mechanical encoders for applications including robotics, handling systems, machinery, and position-controlled devices. They are available in miniature, industrial, and standard designs, and feature an LED light source, precision bearings, and 0-300 kHz frequency range.

For More Information Write In No. 749



The GPO26A precision **planetary gearhead** from Maxon Precision Motors, Burlingame, CA, incorporates all-metal construction and ball bearings for high torque output and high radial load. It is available in 1.02" diameter in six different ratios ranging from 4.3:1 to 199.3:1. Depending on the ratio, length varies from 1.13" to 1.76" and weight ranges from 2.9 ounces to 4.6 ounces.

Maximum continuous torque ranges from 28 oz-in. to 255 oz-in. and maximum intermittent torque ranges from 70 oz-in. to 425 oz-in. Maximum recommended input speed is 5000 RPM. The gearhead has a recommended temperature range from -30 to +90°C with an efficiency of 80 to 94%, depending on the number of stages. It is compatible with six different moving coil motors that range in power from 4 to 20 watts.

For More Information Write In No. 750

ETREMA Products, Ames, IA, offers a line of **actuators** using ETREMA TERFENOL-D® magnetostrictive alloy for power, speed, and control in applications such as micropositioning, active anti-vibration, seismic imaging, and vibrators and shakers.

The actuators feature magnetic circuits, ruggedized housing materials, and a new electrical connection. They are available for frequencies from DC to 6000 Hz and include base and top mounting provisions for any mounting orientation. The TERFENOL-D solid-state alloy converts electrical inputs into corresponding mechanical outputs, providing high-power linear or oscillatory motion in response to a low-voltage electric current.

For More Information Write In No. 747

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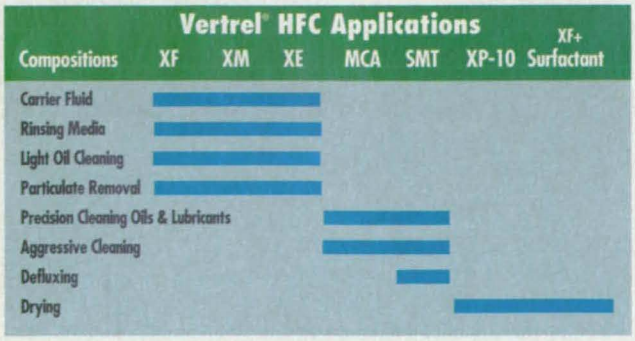

Advanced DuPont HFC-4310 technology allows the versatile Vertrel® family of replacement cleaning solvents to offer exceptional cleaning performance in an environmentally acceptable formulation. Vertrel® is safe to use because of its low toxicity and nonflammability.

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Lewis Research Center, Cleveland, Ohio

Noncontact electromagnetic probes are being developed for use in nondestructive determination of the spatial distributions of electrical resistivities and other electromagnetic properties of conducting, semiconducting, and insulating material samples. In use, a probe of this type is scanned in a raster or other pattern in a plane close to (but not touching) the sample, in the manner of a scanning electron or tunneling microscope. One of the outstanding features of a probe of this type is that it can resolve spatial variations in measured quantities on a scale much less than half the vacuum wavelength of the probing electromagnetic signal; resolution as fine as 10^{-3} wavelength is achievable. This would not be remarkable except for the fact that it has traditionally been assumed that probing with electromagnetic fields cannot yield resolution finer than about half the wavelength.

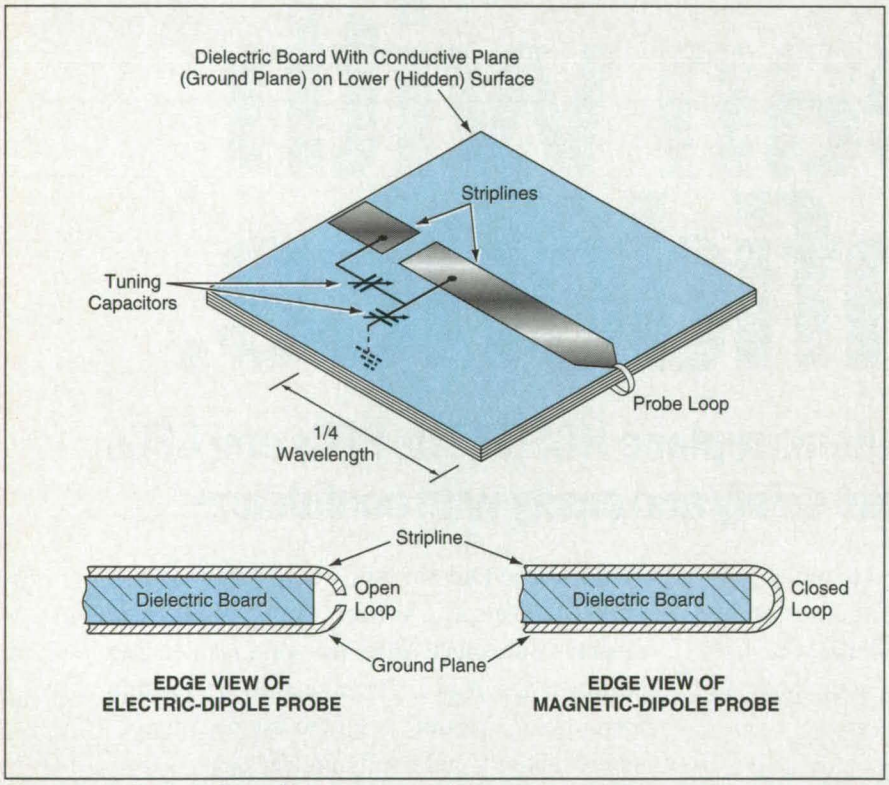

Figure 1. An **Open or Closed Loop** at one end of a stripline resonator constitutes an electric or a magnetic dipole probe tip.

The key to achieving fine resolution is to configure a probe to generate a highly concentrated electromagnetic field at its tip and to exploit the evanescent waves generated in the sample by the interaction between this probing field and the sample: the characteristic lengths of evanescent-wave phenomena (e.g., the skin depth in the classical skin effect) are typically much less than a half wavelength. As shown in Figure 1, a probe includes a quarter-wavelength stripline resonator with a short impedance-matching taper down to a small (much smaller than a wavelength) open or closed loop of wire at the probe tip. A closed-loop probe tip acts as a magnetic dipole, whereas an open-loop tip acts as an electric dipole.

The probe is brought near the sample and excited at a suitable microwave frequency. The interaction of the electromagnetic field with the sample alters the frequency of resonance, the input admittance of the probe, and the reflection coefficient of the resonator. An electric-dipole probe, because of relatively high impedance, is suitable for studying insulating and semiconducting samples, whereas a magnetic-dipole probe has a lower impedance that yields better results in studying low-resistivity samples. To map the sample with respect to the electromagnetic property of interest, the variation in the amplitude of the reflected wave is measured as a function of position as the probe is scanned across the sample at a known distance.

In one of several experiments, a prototype magnetic-dipole probe was excited at a frequency of 0.9 GHz (vacuum

(continued on page 44)

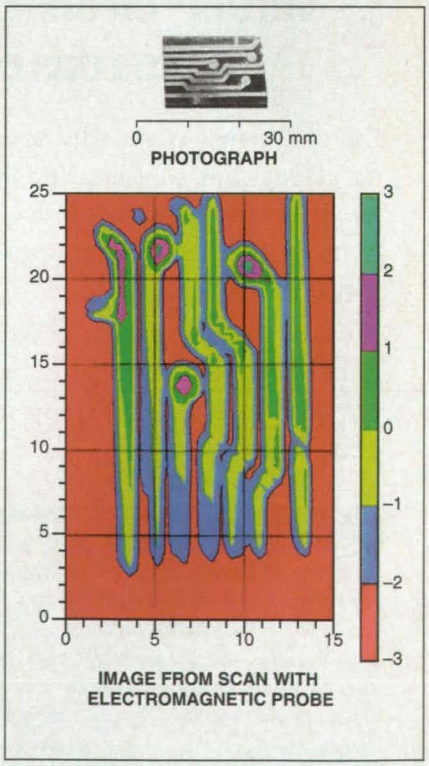

Figure 2. The **Image of a Printed-Circuit Board** generated from a two-dimensional scan with a probe like that of Figure 1 resembles the photograph of the board. Note that the scan image reveals via holes that are hidden by an intervening layer of solder in the photograph.

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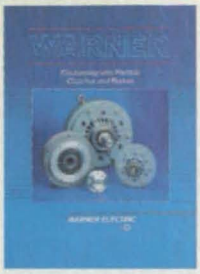

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For controlled starts and stops, tension control, torque limiting and cycling applications. High thermal ratings.Smooth, quiet, frictionless operation. Torque ratings from .72 to 578 lb.ft. Request Tech Fax Document 460 or Catalog P-1107.

For More Information Write In No. 674

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For More Information Write In No. 671

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and enter the document number of the product you are requesting. Or call 815/389-6691 to request a specific catalog.

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DANA

449 Gardner Street, South Beloit, IL

Enclosed UniModule®

Warner Electric's new Enclosed Uni-Module (EUM) packages the hard-working components from the UM in a new modern enclosure. This rugged enclosure keeps the wear particles in and contaminants out and provides dependable, quiet clutch/brake indexing. Available in 5 sizes 16-95 lb.ft., 2 configurations, and 3 voltages. The washdown units use stainless steel shafting, USDA approved coating and many special sealing features. Request Tech Fax Document 205 or Catalog P-1040. **For More Information Write In No. 675**

Tension Control Systems

Warner Electric's new 48 page catalog of tension control systems features new clutches for tension wind-up, with continuous slip capacity in excess of 8 thermal HP as well as an improved and expanded line of modular tension brakes designed for better performance and longer life. Request Tech Fax Document 250 or Catalog P-771.

For More Information Write In No. 672

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Formsprag overrunning clutches deliver thoroughly proven, dependable power transmission. Instantaneous action, no backlash. Infinitely changing wear points. More torque, less space. Full sprag complement. Overrunning clutches handle torque loads up to 700,000 lb.ft, (949200 Nm). Request Tech Fax Document 367 or Catalog P-956.

For More Information Write In No. 673

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For More Information Write In No. 676

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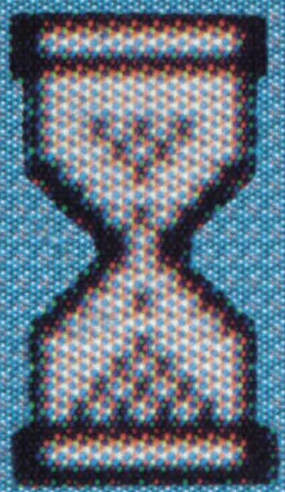

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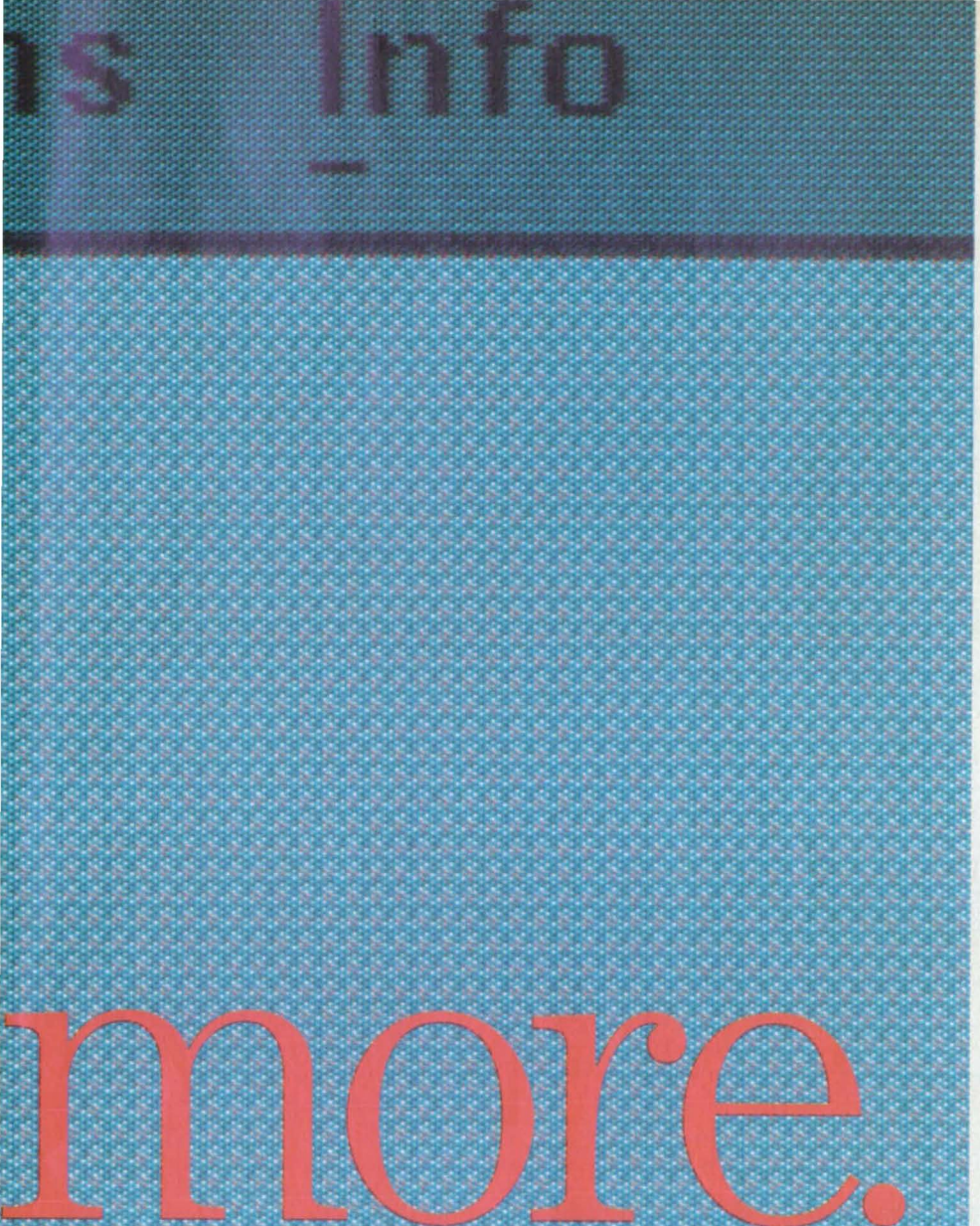

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HEWLETT® PACKARD

(continued from page 40)

wavelength ≈ 33 cm). The experimental value for the spatial decay of the evanescent waves at the tip of the probe was between 100 and 150 μm — about 1/2,000 × the vacuum wavelength. The probe was used to map the microwave conductivity of metallic lines on glass and printed-circuit boards, and to investigate variations in conductivity across a 5-cm-diameter n-doped silicon wafer. As shown in Figure 2, scanning with the probe revealed via holes in the printed-circuit board that were covered with solder and were not detectable otherwise.

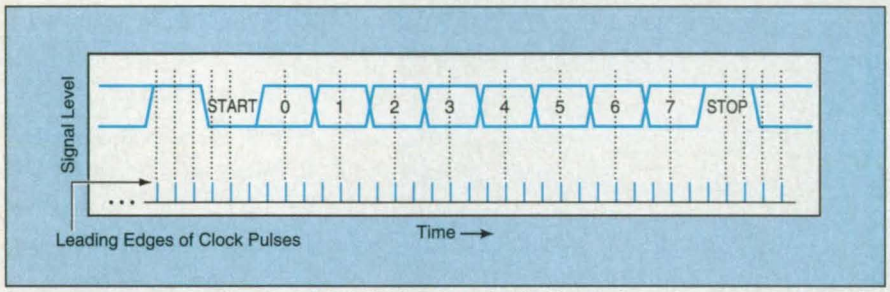
This work was done by Massood Tabib-Azar, Neil S. Shoemaker, and Stephen Harris of Case Western Reserve University for **Lewis Research Center**. *For further information,* ***write in 2*** *on the TSP Request Card. LEW-15488*

Incorporating a UART Into an EPLD

Insight into the functions of a digital system can be gained without using additional circuitry.

NASA's Jet Propulsion Laboratory, Pasadena, California

A universal asynchronous receiver/transmitter (UART) can be incorporated into an erasable programmable logic device (EPLD) to provide diagnostic access to internal subsystems, components, and functions of a digital electronic system in which the EPLD is installed. Typically, the larger the system, the greater the fraction of EPLD circuitry that is not used. The UART is implemented within this otherwise unused part of the EPLD. In a prototype system based partly on this concept, the UART comprises 48 flip-flops — about 7 percent of the particular EPLD used.



Sampling Occurs During the Middle Third of each bit. This timing scheme accommodates a 3-percent error in the baud rate error — a tolerance that is ample for crystal-controlled clocks.

A UART of this type provides an RS-232 port between the system to be diagnosed and the outside world, thereby serving as the electronic analogue of a window into the system for diagnosis of hardware and software. It gives access to registers, memory locations, statuses of processors or programs, intermediate process results, and diagnostic programs, for example.

The prototype UART was implemented by use of a commercial EPLD development system that includes a schematic editor, compiler, and simulator, which make it possible to adapt the details of the UART to the requirements of the system to be diagnosed. The particular design with 48 flip-flops was chosen because it provides for the highest possible baud rate (9,600 in this case) and minimum interaction with the processor of the system to be diagnosed. The receiver and transmitter sections each contain a 3- or 4-bit shift counter, an 8-bit shift register, an 8-bit holding register, a parity generator and checker, an interrupt-flag flip-flop, and a 3-bit state machine.

The operation of the UART is synchronized by use of a clock signal with a frequency of three times the baud rate (see figure). Between characters of a received signal, the UART looks for a "start" bit at each leading edge of each clock pulse. When it finds a "start" bit, it looks again for the same "start" bit at the leading edge of the next clock pulse. If the "start" bit is not found again, the character-input process is aborted and the circuit goes back to looking for the first instance of a "start" bit. If the same "start bit" is detected on the leading edges of two adjacent clock pulses, the circuit starts shifting the character bits

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in, sampling at the leading edge of every third clock pulse. This timing scheme places the input sampling shift clock in the center third of each bit.

For transmission, every third leading edge of the clock signal is used to shift data out. When the transmitter is idle, an output sequence can begin on any leading edge of the clock signal.

This work was done by Steven W. Cole of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 16*** *on the TSP Request Card.*
NPO-19326

Circuit Protects Against Reversed Power-Supply Polarity

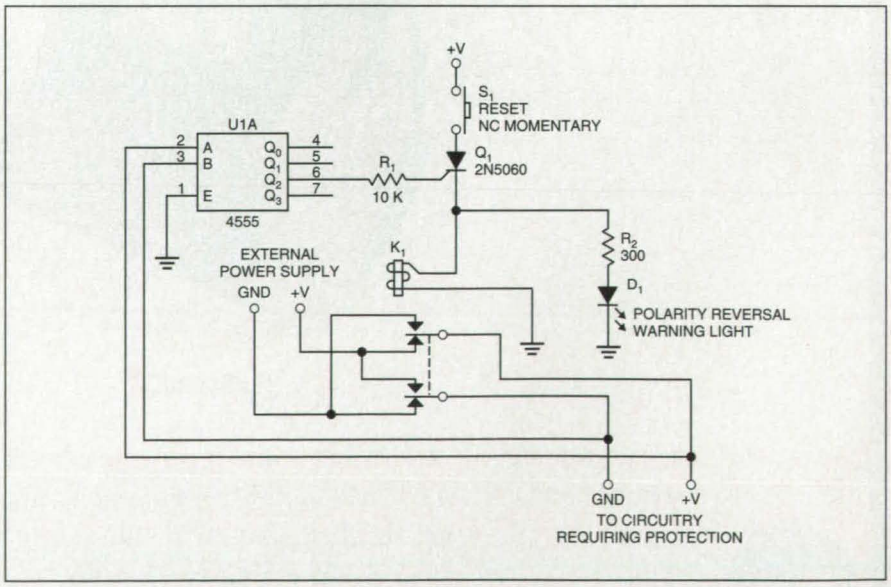
When polarity is reversed, this circuit switches to correct polarity and gives a visual warning.

Lyndon B. Johnson Space Center, Houston, Texas

A circuit (see figure) containing seven components has been designed to sense a power-supply output (to other circuitry) and detect a reversed-polarity condition. The circuit consists of a complementary metal oxide semiconductor (CMOS) decoder (CD4555B), which monitors the output of an external power supply for proper polarity. If the power-supply polarity is incorrect, the CD4555B detects that condition and triggers a 2N5060 silicon-controlled rectifier (SCR) (Q_1). After triggering, the SCR supplies current to a relay (K_1) which upon activation, changes the external power-supply connections (to the external circuitry) to the correct polarity and illuminates a light-emitting diode (LED) to provide a visual warning of the polarity-reversal condition. After the reversed-polarity condition is remedied, pressing the contact switch (S_1) momentarily will reset the circuit to its original state.

In its present configuration, the circuit can accommodate standard positive power supplies with dc voltages of +5, +10, +12, and +15 V. The decoder was designed to operate at these different voltages. With some modifications, the circuit can monitor and correct anomalous power-supply outputs from +3 V, +28 V, negative-polarity power supplies, or voltages that are to either too high or too low.

This work was done by Timothy E. Roth of Lockheed Engineering and Sciences Co. for **Johnson Space Center.** *To obtain a copy of the report, "Circuit Provides Protection From Incorrect Power Supply Connections,"* ***write in 83*** *on the TSP Request Card.*
MSC-22363



This **Circuit** can be utilized in any application requiring protection from incorrect power-supply connections. The circuit can also be used where the polarity of supply or signal voltages (or currents) need to be reversed as may be the case in some instrumentation possessing thermoelectric heating/cooling devices, such as temperature-controlled quartz-crystal microbalances (TQCM).

Capacitance Test for Solar Cells

This test is more sensitive than a dark forward IV test.

NASA's Jet Propulsion Laboratory, Pasadena, California

A simple capacitance test can be performed to detect cracked or otherwise seriously damaged photovoltaic cells in solar arrays. Although this test does not yield detailed information of the type provided by full current and voltage performance measurements in a laboratory solar simulator, it is nevertheless useful for quick field inspections. Unlike a full performance test, this capacitance test does not require illumination or dc biasing of solar cells. Moreover, this capacitance test is relatively insensitive to variations in temperature.

This capacitance test is needed because a full performance test is usually difficult or impossible to perform once the array is in the field or mounted on a spacecraft. A full performance test should be done immediately after fabrication of a solar array. The capacitance test should also be done along with the full performance test to generate capacitance data for comparison with data from any subsequent capacitance test to determine whether any capacitances have changed.

In this capacitance test, a stable, precise resistance/capacitance/inductance (RCL) meter is used to measure the capacitance of each series string in a solar photovoltaic array, without illumination or dc bias. The capacitance that is measured is the series combination of the junction capacitances of all the cells in the string. The temperature coefficient of capacitance for a gallium arsenide cell is 5×10^{-4} °C^{-1} while the temperature coefficient of the same cell in a dark forward IV test is 2.2×10^{-3} °C^{-1}. The dark-forward-IV-test sensitivity to a 25-percent area loss in one cell of a 40-cell string is 0.02 percent change, while the capacitance-test sensitivity is 0.03 percent change. Thus, the capacitance test is more temperature-stable and much more sensitive than the dark forward IV test. If a cell is cracked or a portion of it has broken away, then the capacitance of the cell is correspondingly reduced, and this reduction manifests itself in a reduction of the capacitance of the series string.

Thus, by comparing the present capacitance reading (with temperature correction if necessary) with the initial capacitance reading that was taken along with the full performance test when the cells were new, it should be possible to determine whether a cell in the string has been damaged. For example, if a string contains 40 cells of nominally identical capacitance and about one quarter of one cell has broken away, then the series string capacitance decreases by a little less than 1 percent. A decrease of this magnitude can be determined from the reading of the RCL meter.

This work was done by Robert L. Mueller, Matthew T. Wallace, and Dale R. Burger of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 64*** *on the TSP Request Card. NPO-19624*

Cueing Lights for Maneuvering Helicopters at Low Altitudes

Bright spots that provide guidance are projected on featureless terrain.

Ames Research Center, Moffett Field, California

Systems of cueing lights have been invented to facilitate maneuvering of helicopters at low altitudes. These systems can be particularly helpful for landing on or flying low over featureless terrain (e.g., desert) or over water under conditions of poor visibility. The cueing lights project beams onto the ground to generate patterns of bright spots. These patterns suggest corrective maneuvers and give qualitative indications of altitude and ground slope.

Figure 1 illustrates a helicopter equipped with a system of seven cueing lights. These lights are mounted in two groups at plane A: an upper group of three and a lower group of four. These sources of light can be of any convenient type that emit bright, narrow beams; for example, they can be commercially available laser aiming lights.

Three of the lights (one in the upper group and two in the lower group) are aimed so that when the helicopter is at a nominal altitude, *H*, in level flight above flat, level ground, three spots of light are projected on the ground at plane B: one spot straight ahead, one slightly to the right, and one slightly to the left. Typically, *H* is chosen to be about 30 m and plane B is chosen to be about 280 m ahead of plane A. Another three of the lights (again, one in the upper group and two in the lower group) are aimed to produce a similar pattern of bright spots on the ground under the same conditions, except that this pattern is formed at plane C, which is typically chosen to lie about 125 m ahead of plane A. The remaining light in the upper group is aimed straight ahead and slightly downward (typically, at a downward angle of about 1°) to illuminate obstacles that may suddenly come into view ahead.

The mounting and aiming geometry of the cueing lights causes the patterns of spots projected on the ground to deviate from the two nominal straight-line patterns depending on the altitude of the helicopter and the slope of the ground. Figure 2 illustrates some typical cases:

1. When the helicopter is above the nominal altitude, the right and left spots in each group of three are projected ahead of the middle spot, forming two three-cornered patterns suggestive of arrowheads that point downward and thus indicate to the pilot that to return to the nominal altitude, it would be necessary to descend.
2. Similarly, when the helicopter is below the nominal altitude, right and left spots in each group are projected behind the middle spot, forming similar arrowheadlike patterns that indicate the need to ascend to the nominal altitude.
3. When the helicopter is at the nominal altitude but the ground ahead of plane

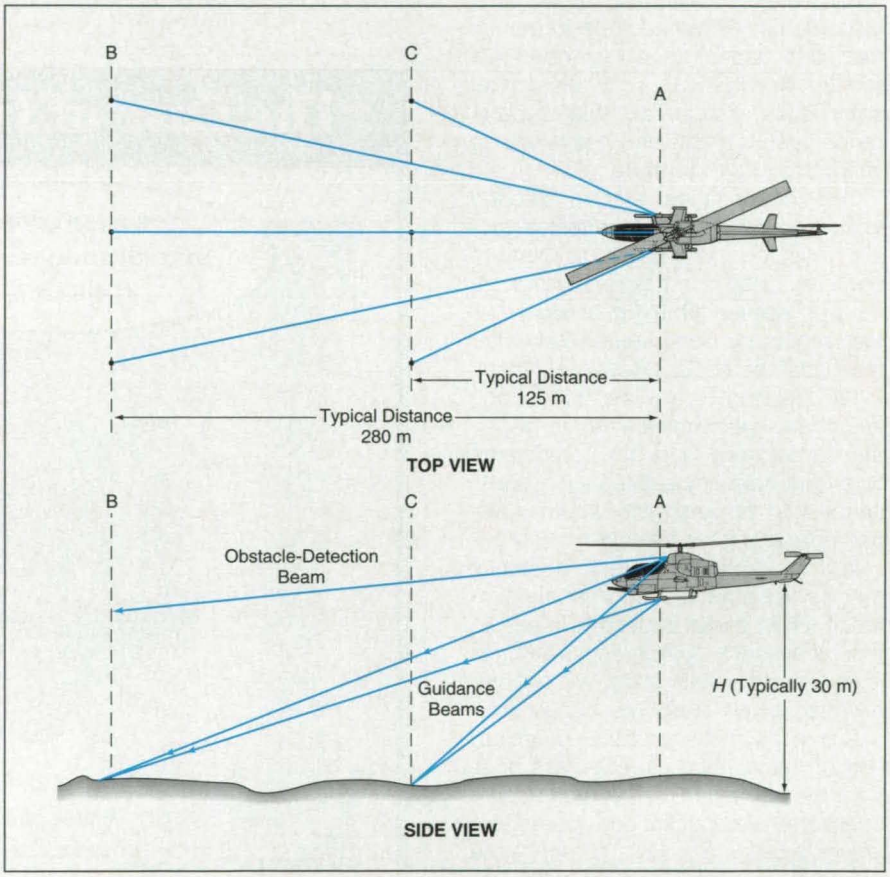


Figure 1. **Cueing Lights Mounted on a Helicopter** project narrow beams of light on the ground to form bright spots that guide the pilot in low-altitude maneuvers. (Two of the beams are shown unrealistically passing through the cockpit and fuselage for the sake of simplicity, but in practice, the cueing lights are mounted on the sides, so that this does not occur.)

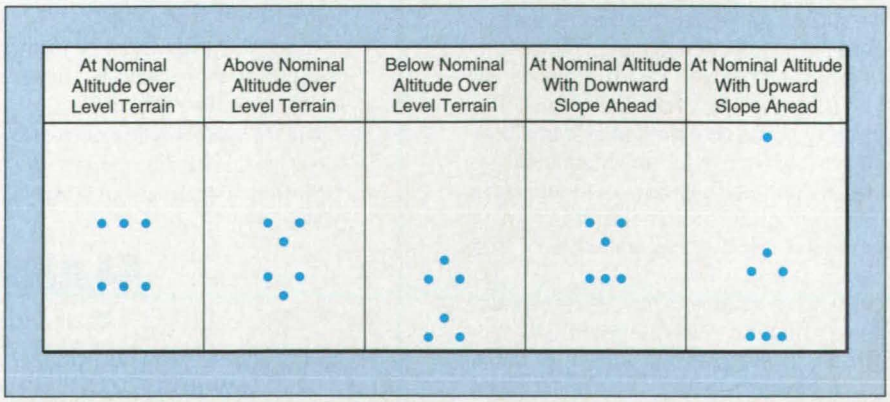


Figure 2. The **Spots of Light as Seen by the Pilot** are formed in patterns that indicate both the altitude of the helicopter above the local terrain and the slope of the terrain ahead.

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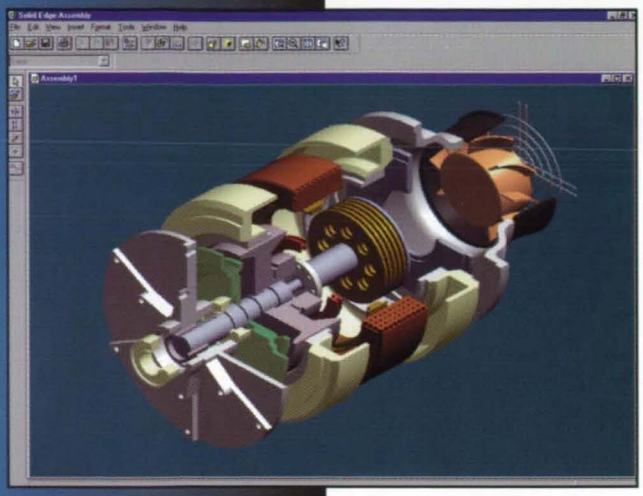

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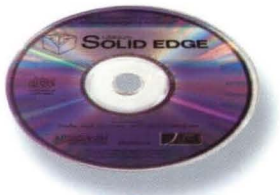

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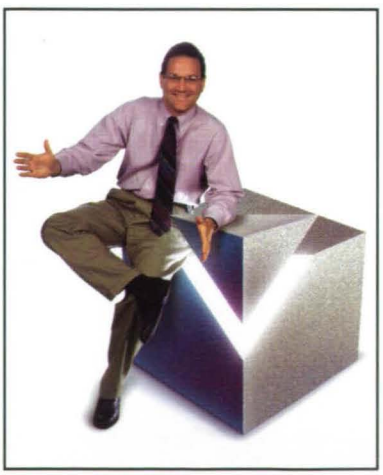

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C slopes downward, the rear three spots of light remain in a straight line, while the front three spots of light go into the downward-pointing arrowhead pattern, indicating that it will soon be necessary to descend to maintain the nominal altitude above the ground.

4. When the helicopter is at the nominal altitude but the ground ahead of plane C slopes upward, the obstacle spot comes into view and the front group of three spots goes into an upward-pointing arrowhead pattern, indicating the need to ascend to maintain the nominal altitude above the ground and to avoid striking the slope ahead.

This work was done by Mary K. Kaiser and Walter J. Johnson of **Ames Research Center.** *For further information,* ***write in 5*** *on the TSP Request Card.*

This invention has been patented by NASA (U.S. Patent No. 5,315,296). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Ames Research Center; (415) 604-5104. Refer to ARC-11982.

Current-Memory Cell With Reduction of Switch Feedthrough

Switch feedthrough is reduced by use of error feedback.

NASA's Jet Propulsion Laboratory, Pasadena, California

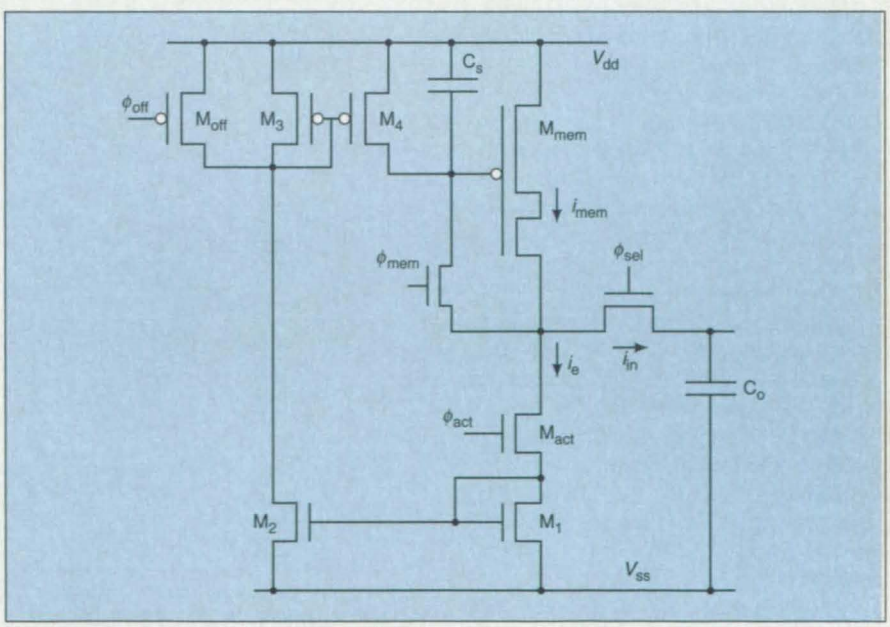
An improved current-memory cell includes error-feedback circuitry that suppresses switch feedthrough, which is a spurious component of output that arises from a switching signal used in sampling the current to be memorized. The improved current-memory cell is capable of memorizing a current as low as 10 nA with an error of less than 0.1 percent. The memorization time is less than 50 μs. The error-feedback part of the cell consumes negligible power and can be laid out in a relatively small area. Current-memory cells like this one could enhance the performances of focal-plane arrays of infrared detectors that include focal-plane readout electronic circuits and must operate under low-power, high-background-signal conditions; more specifically, an accurate current-memory cell like this one could be incorporated into the readout circuitry of each pixel for use in estimating and then subtracting the background current.

A current-memory cell is essentially a sample-and-hold circuit that indirectly samples the current flowing through a metal oxide/semiconductor field-effect transistor (MOSFET). The cell operates in a cycle that includes a sample-and-hold phase and a readout phase. During the sample-and-hold phase, the gate-to-source voltage of the MOSFET is stored in a capacitor while the current to be memorized is flowing. During readout, the stored gate-to-source voltage is applied to the MOSFET to drive a readout current that resembles the current to be memorized.

Because the same MOSFET is used to both record and read out the sample of current, unit-to-unit variations in the parameters of different MOSFETs contribute only slightly (typically fractions of $< 10^{-4}$) to the difference between the memorized and readout currents. However, switch feedthrough can contribute substantial error. Switch feedthrough results from injection of charge into the storage node when a MOSFET switch (containing a MOSFET separate from the current-memorizing MOSFET described above) is shut off. The component of error attributable to switch feedthrough increases with decreasing current to be memorized, reaching its maximum (as high as 25 percent) when the memory cell is biased in weak inversion; this severely limits the utility of the cell in low-power applications.

The improved current-memory cell (see figure) includes current-memorizing MOSFET M_{mem}, associated voltage-storage capacitor C_s, and switching MOSFET M_{sw}. The cell also includes a feedback network that contains *n*-channel MOSFET current mirrors (M_1, M_2) and *p*-channel MOSFET current mirrors (M_3, M_4) respectively, MOSFET feedback activation switch M_{act}, and MOSFET feedback control switch M_{off}.

After the current is initially memorized in M_{mem}, ϕ_{mem} is pulsed low, causing feedthrough to the storage node. M_{sw} is an *n*-channel MOSFET, so that the readout current in M_{mem} following the switch feedthrough exceeds the current to be memorized. Shortly after ϕ_{mem} goes low, the feedback network is activated by pulsing the gate of M_{act} low. As a result, the error current i_e (defined as the difference between the drain current of M_{mem} and the current to be memorized) flows through M_1 and is mirrored by the (M_1, M_2) and (M_3, M_4) pairs. The width-to-length ratios of the current-mirror MOSFETS are chosen so that only a fraction, α, of i_e flows through the output transistor (M_4) of the composite current mirror.



The **Improved Current-Memory Cell** includes error-feedback circuitry that suppresses switch feedthrough.

MOSFET M_4 is directly connected to C_s, completing the feedback loop. Once the feedback network is activated, the drain current of M_4 is integrated in C_s, causing a change in the gate voltage of M_{mem}. This change is in the direction to reduce the current flowing in M_{mem}, causing i_e to diminish. This negative-feedback process continues until i_e goes to zero. Ideally, the current stops flowing in M_4 once the error reaches zero. In practice, M_{off} is pulsed low to restrict the amount of residual tail current in M_4 once the error is below a given accuracy limit.

This work was done by Bedabrata Pain and Eric R. Fossum of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 50*** *on the TSP Request Card. NPO-19274*

Magnetic Antennas Using Metallic Glass

Solid metallic-glass cores offer advantages over ferrite cores.

Goddard Space Flight Center, Greenbelt, Maryland

Magnetic antennas (search coils) can be made with hollow metallic-glass cores instead of the traditional ferrite cores. Magnetic antennas are typically used in measuring natural magnetic fields that alternate or fluctuate at frequencies in the approximate range of 10 Hz to 500 kHz. The core of a magnetic antenna serves as a loading device, increasing the output of the antenna by concentrating more of the ambient magnetic flux into an induction coil that constitutes the transducer element of the antenna.

Figure 1 illustrates a magnetic antenna with a metallic-glass loading device. Typically, the induction coil consists of 2,000 turns of wire wound in a circumferential coil-form groove with an axial length 0.4 in. (1.0 cm) and a diameter of 0.875 in. (2.2 cm). The coil form is made of a dielectric material. The side and parts of the ends of the coil can be covered with metal foil or other suitable electrically conductive material to suppress electric fields that could contribute spurious components to the output of the coil.

Components of a buffer amplifier are conveniently mounted on the coil form. The buffer amplifier isolates the coil from the external signal-processing circuitry; this isolation is necessary because the real and imaginary impedance associated with the external circuit can undesirably alter the frequency response of the antenna.

The loading device protrudes axially from both ends of the coil form and is typically at least 6 in. (15.2 cm) long, with a diameter of 0.5 in. (1.3 cm). This antenna is sensitive to the component of the magnetic field along the axis of the coil and loading device; for complete characterization of the three-dimensional magnetic field, three magnetic antennas like this one must be mounted orthogonally to each other in an assembly.

In comparison with ferrite cores that offer comparable performance, hollow metallic-glass cores weigh only about 7 percent as much. Moreover, hollow metallic-glass cores are easier to fabricate and more likely to withstand rough handling in use: Ferrite cores are brittle, whereas hollow metallic glass is supplied in flexible sheets. A hollow metallic-glass core can be fabricated by simply wrapping a sheet of metallic glass around a lightweight dielectric (e.g., plastic or wood) rod, then fastening the sheet in place with an adhesive. The structural integrity of such a loading device is limited only by the integrity of the adhesive bond.

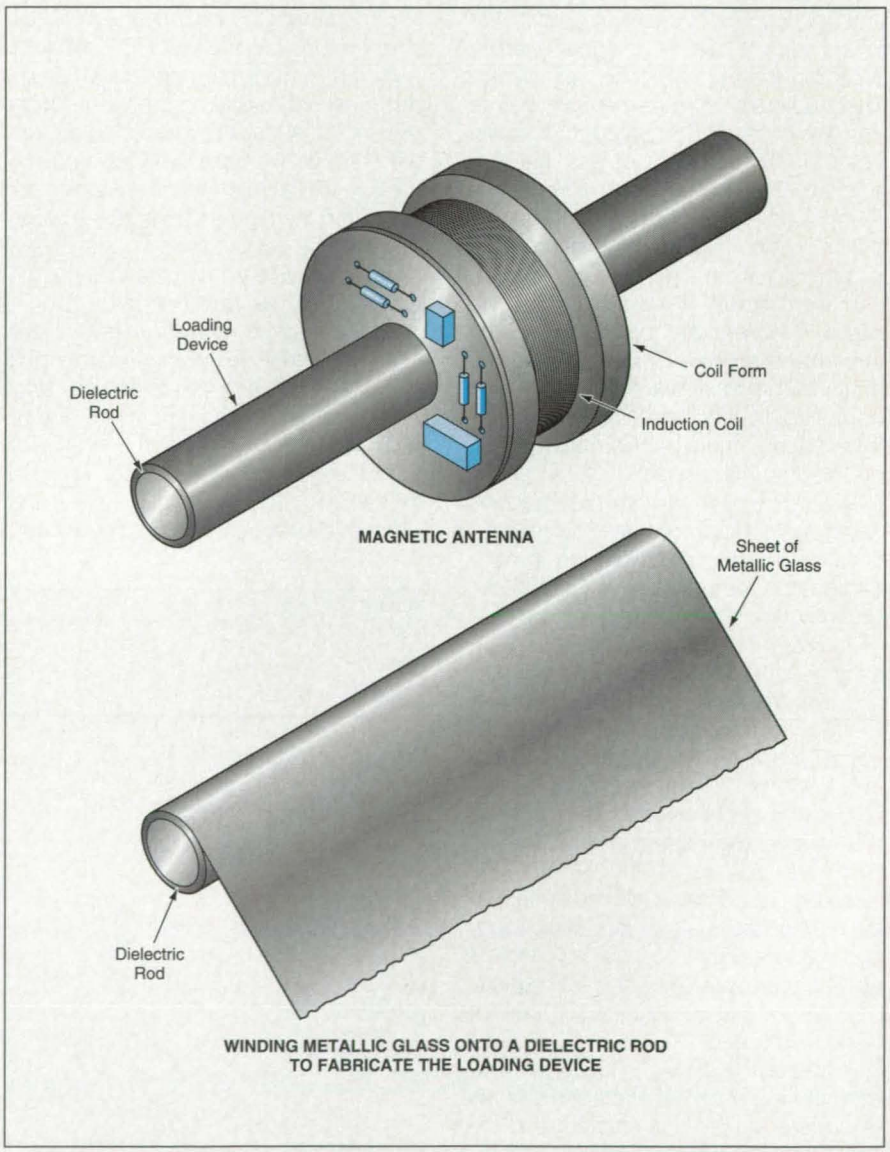


Figure 1. A **Cylindrical Layer of Metallic Glass** made by winding a sheet of metallic glass on a lightweight dielectric rod serves as the loading device in this magnetic antenna. The principal advantages of such a loading device over a ferrite core are lighter weight and greater ruggedness.

The figure of merit for the performance of a magnetic antenna is called the "effective height" and is defined as the length of the short electric-dipole antenna that would produce the same output voltage. The effective height depends on the frequency, the effective magnetic permeability of the loading device, the size of the wire in the coil, the number of turns, and the dimensions of the coil. To the degree to which these parameters bear upon the inductance, capacitance, and resistance of the coil, they affect the resonance parameters and frequency response of the antenna. Figure 2 shows the effective

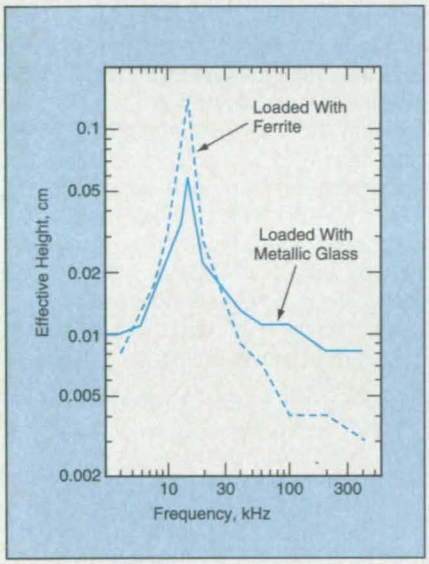


Figure 2. The **Effective Heights of Two Magnetic Antennas** were determined as functions of frequency.

height of two representative magnetic antennas as functions of frequency, the only difference being that one antenna was loaded with a ferrite core, the other with a hollow metallic-glass core. In this example, the ferrite-loaded antenna is more sensitive at frequencies of about 10 to 20 kHz, whereas the metallic-glass-loaded antenna is more sensitive at frequencies above 30 kHz.

This work was done by William M. Farrell, Michael D. Desch, and Jeffrey G. Houser of **Goddard Space Flight Center.** *For further information,* ***write in 15*** *on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Goddard Space Flight Center; (301) 286-7351. Refer to GSC-13612.

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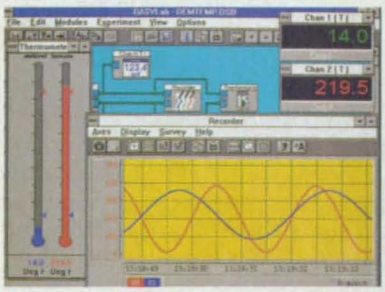

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Adaptive Speech-Recognition Unit

Designed flexibility provides for use by different speakers in a variety of applications.

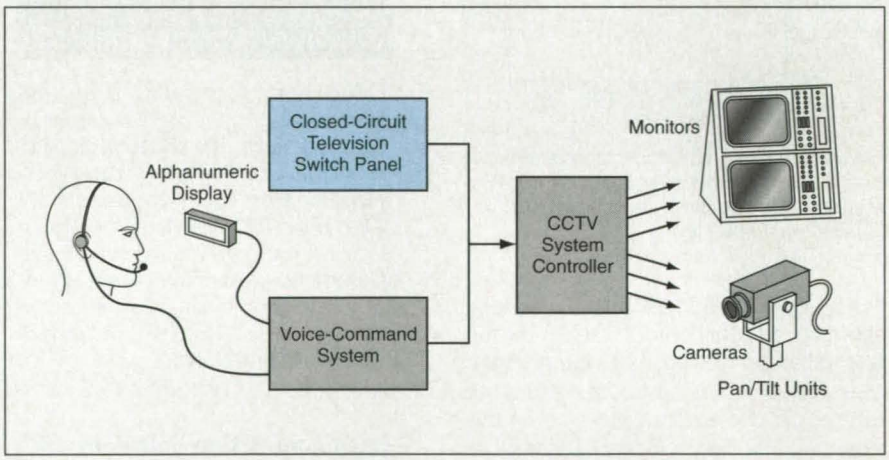
Lyndon B. Johnson Space Center, Houston, Texas

A rugged, personal-computer-based speech-recognition unit has been developed for use in voice control of noncritical spacecraft or terrestrial equipment. Older rugged speech-recognition units (e.g., those for military applications) are rigid with respect to modes of operation and are speaker-dependent and vulnerable to malfunction upon changes in vocal characteristics. In contrast, this unit is designed to function with some flexibility and adaptability; it can be reconfigured more easily by updating its software while remaining online, and adapts itself more readily to the voices of different speakers as well as to changes in the voice of each speaker. The ruggedness of the unit is made possible, in part, by a mechanical design that incorporates an innovative packaging scheme for restraining standard PC-AT (or equivalent) circuit boards to withstand the severe accelerations encountered in spacecraft and military environments.

The operation of the unit is best described by reference to the original application, in which it is used to control the closed-circuit television (CCTV) system aboard the space shuttle (see figure). The unit is installed in a voice-command system (VCS) chassis that is panel-mounted in the aft flight deck of the space shuttle. The unit includes seven circuit boards, a passive PC-AT (or equivalent) backplane where the boards plug in, and a metal enclosure that houses the circuit boards, protects against electromagnetic interference, incorporates a cooling vent for forced air, and contains a circuit-board-restraining bracket. The seven circuit boards are (1) a commercial PC-AT (or equivalent) processor board that controls the overall unit, (2) a commercial speaker-independent voice-recognition board that determines which word in the command vocabulary was spoken, (3) a CCTV-specific interface board that sends digital signals to a VCS-to-CCTV interface board under the control of the PC-AT (or equivalent) processor, (4) an input/output board that acts as an interface to lights and switches on the front panel of the VCS chassis and to send discrete signals to the CCTV system, (5) an analog circuit board that acts as an interface with the microphone and earphones, (6) a memory circuit board that records raw voice samples, and (7) a power-supply board.

The user simply issues verbal commands and the unit responds by sending the appropriate discrete commands to the system under control. The unit provides visible and audible feedback to the user through a 32-character alphanumerical display and earphones, respectively. The unit operates in four modes: acquisition of voice prints for creating the application vocabulary, recognition of speech in real time including confidence check (to verify how well the system will recognize a user prior to entering an application) and adaptation of vocabulary, downloading and uploading of software, and creation of audio messages for feedback to the user.

The design of the unit provides a macro-command capability, such that the recognition of one word by the unit can trigger a series of discrete commands. A macro can, for example, be used to create predefined camera and monitor scenes. The design implements speaker-independent voice-recognition techniques. One of these techniques includes asking the user for clarification in interpreting questionable spoken command words. Thus, voice-print templates are updated in real time as the user's voice changes over time. Confidence check allows the user to step through the entire vocabulary for initial adaptation of vocabulary should the user have difficulty with certain words. Other features include voice-amplitude calibration and compensation for background noise, which help to optimize recognition of spoken words when the position of the microphone or the level of background noise changes.



The **Adaptive Speech-Recognition Unit** is incorporated into a voice-command system that controls video cameras, pan/tilt units, and monitors.

This work was done by George A. Salazar and Dena Haynes of **Johnson Space Center** *and Hector DeLeon, Eric Kuehnel, and Marc Sommers of Lockheed Engineering and Sciences Co. For further information,* ***write in 74*** *on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center; (713) 483-4871. Refer to MSC-22532.

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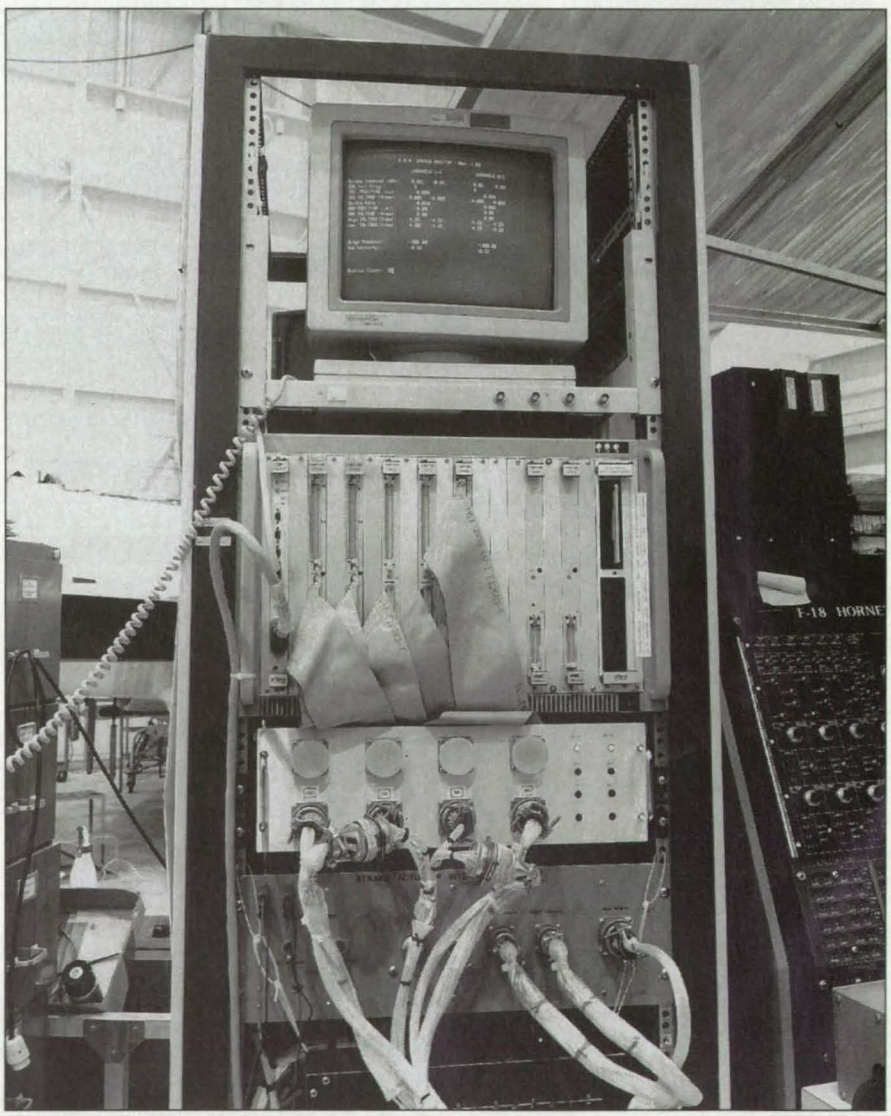
Electronic System Models HARV Nose Strake Actuators

This system exemplifies a better, faster, cheaper, easier way to model all flight-control surfaces.

Dryden Flight Research Center, Edwards, California

Researchers at the Dryden Flight Research Center have developed a special-purpose digital/analog electronic system that simulates, according to mathematical models, the responses of the forebody strake actuators in the NASA F-18 High-Alpha Research Vehicle (HARV) and produces electrical outputs equivalent to those expected of the actuators. [The NASA F-18 High Alpha Research Vehicle (HARV) is an airplane used to test and demonstrate technology in the high-angle-of-attack flight regime. Symbol "α" (alpha) is commonly used in aeronautical engineering to denote the angle of attack.] The system, called the "Strake Actuator Model" (SAM), was designed according to the airplane and strake-actuator manufacturers' specifications.

The SAM (see figure) enables faster development and reduces maintenance for high-fidelity hardware-in-the-loop simulations. The SAM was built to reduce the time and effort necessary for development of highly accurate actuator models for use in verification and validation of systems critical to flight.



The **Strake Actuator Model** is a digital/analog electronic system that provides, to researchers, means to develop and test control laws and flight-control surfaces, and to evaluate the safety of the flight-control system.

Analog circuits had previously been developed to model each system. The development of these analog circuits entailed the time-consuming build-up of system and interface circuits. In contrast, the SAM makes it possible to develop models in software, most of which is reusable. The advent of relatively inexpensive, readily available computer systems with external analog interfaces has made it possible to reduce development and support time. As models change and/or greater accuracies are required, the necessary changes can be made fairly simply in software. When working with analog models, such changes often necessitate rebuilding of entire circuits.

An interface with the F-18 flight-control-computer test console is established by connecting the front panel of the SAM to the strake-actuator interface box. The SAM works well with the F-18 simulator, gives accurate output data, and runs at a rate of 800 Hz. Both the SAM hardware [including its chassis, central processing unit (CPU), and input/output circuit boards] and the SAM software (in C language) are designed to be modular to facilitate troubleshooting and modification. Thus, the SAM can easily be adapted to modeling of actuators for any or all other flight-control surfaces.

Once the SAM software is started, the "SAM STATUS MONITOR" page is displayed on a video screen and the data are updated to reflect every change made to all inputs and outputs of the SAM; this facilitates troubleshooting and use. The actuator model includes representations of a servo valve, and of the CAS (Control Augmentation System) and ram positions and voltages in normal operational mode or trail-damp mode. SAM receives strake commands as inputs from the flight-control computer and hinge moments from the simulation, and gives out the CAS and ram positions, voltages, and ram velocity to the flight-control computer and to the simulation.

For the purpose of verification that the system is initially operating properly, the overrun count is the main indicator for software malfunction. Light-emitting diodes for detection of failures are located on the front panel of a cable converter box.

This work was done by Eddie Zavala, Gary Kellogg, Travis Aragon, and Linda Kelly of **Dryden Flight Research Center** *and Lyle Ramey, Anh Bach, and Jim Disbrow of Analytical Services & Materials, Inc. No further documentation is available. DRC-95-36*

The High Heat Flux Facility at Stennis Space Center

Structures, components, and materials can be tested in flows of various hot gases.

Stennis Space Center, Mississippi

NASA has constructed its High Heat Flux Facility at Stennis Space Center for research on actively heated and/or cooled structures, materials, and components subjected to heat fluxes as high as 2,500 Btu/ft^{2}s (29 MW/m^2). The facility (see Figure 1) contains an open-air, 20-ft by 20-ft (6-m by 6-m) covered test cell with a blast wall on two sides. The facility is supplied with liquid and gaseous hydrogen, liquid and gaseous nitrogen, liquid and gaseous oxygen, gaseous helium, high-pressure industrial water for hydraulic use, deionized water, and the electrical power necessary for test operations. The facility is also capable of handling gaseous fluorine. Potable water is available for deluge. Additional features include a hydrogen-detection system and a video system. Natural gas is readily available if needed for a particular test program.

The heart of the facility is a unit that comprises a gas generator and a pebble-bed heater (see Figure 2), which is housed in a pressure vessel with a wall 4 in. (10 cm) thick that can withstand a pressure of 6,600 psig (46 MPa). The pebble bed consists of more than 640,000 7/16-in. (11-mm) stainless-steel balls resting on a grating near the bottom. In preparation for a test, the bed is heated by passing hot nitrogen gas from 65-kW electric heaters through the bed for eight hours. During the test, the pressurized gas is passed through the preheated bed and then on to the test cell. The unit has a dual rating: outlet hydrogen at (1) a temperature of 1,300 °F (978 K) and pressure of 5,000 psi (35 MPa); or (2) a temperature of 6,000 °F (3,589 K) and pressure of 6,600 psi (46 MPa). The design rate of flow is 5 lbm/s (2.3 kg/s). As the heat stored in the pebbles is used up, the outlet temperature decreases, reaching ambient temperature in about 150 seconds.

The facility includes a host-computer-based data-acquisition system that includes personal computers, a parallel disk farm, a front-end low-speed data-acquisition subsystem, and a front-end high-speed data-acquisition subsystem, all protected by uninterruptible power supplies. Both front-end data-acquisition subsystems are located in a signal-conditioning building, which provides termination points for facility and test article data and control devices. The front-end data-acquisition subsystems include signal-conditioning equipment that provides excitation, filtering, amplification, and digitization for resistance temperature devices, thermocouples, strain gauges, and other sensors as needed. The front-end low-speed data-

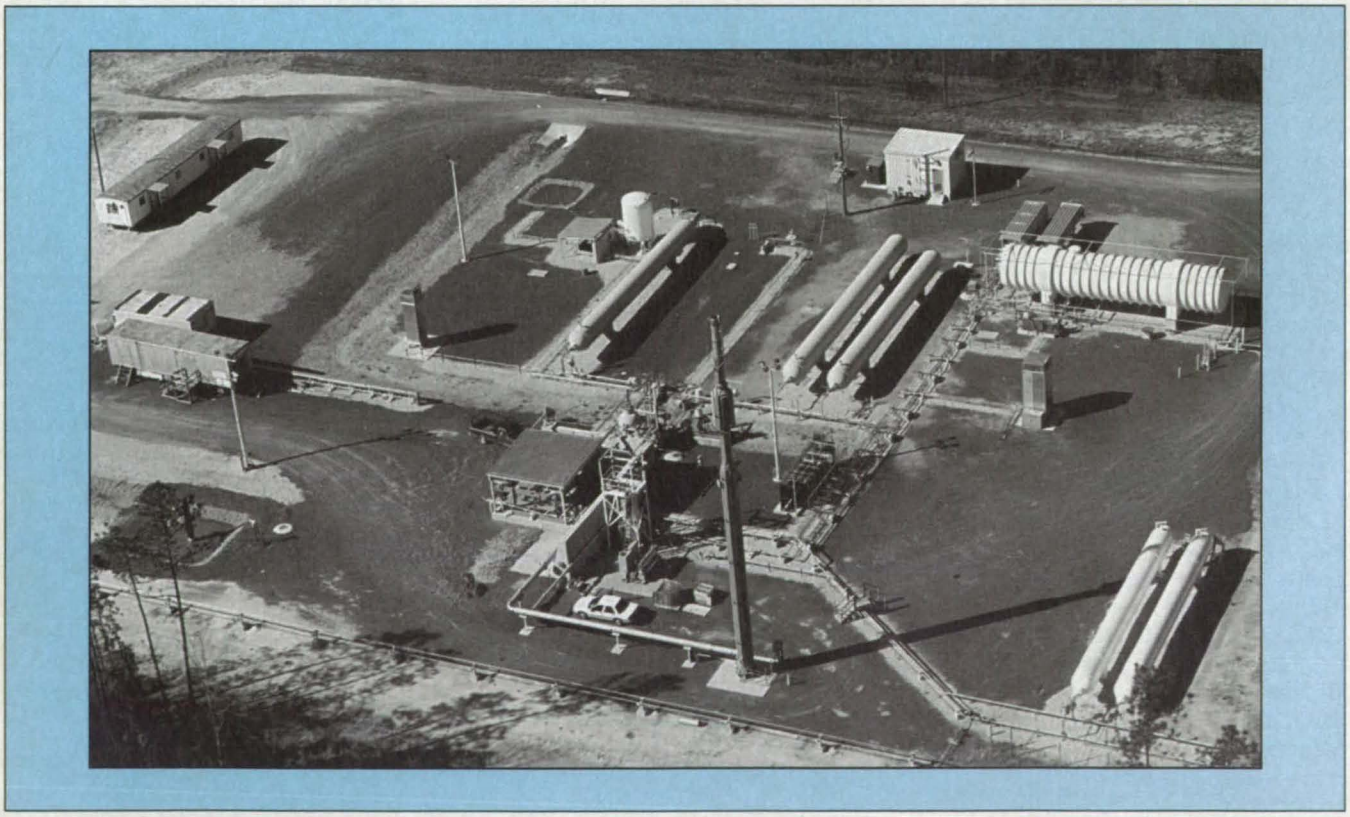


Figure 1. The **High Heat Flux Facility** is a versatile system with capability for testing a variety of structures, components, and materials in flows of hot gases.

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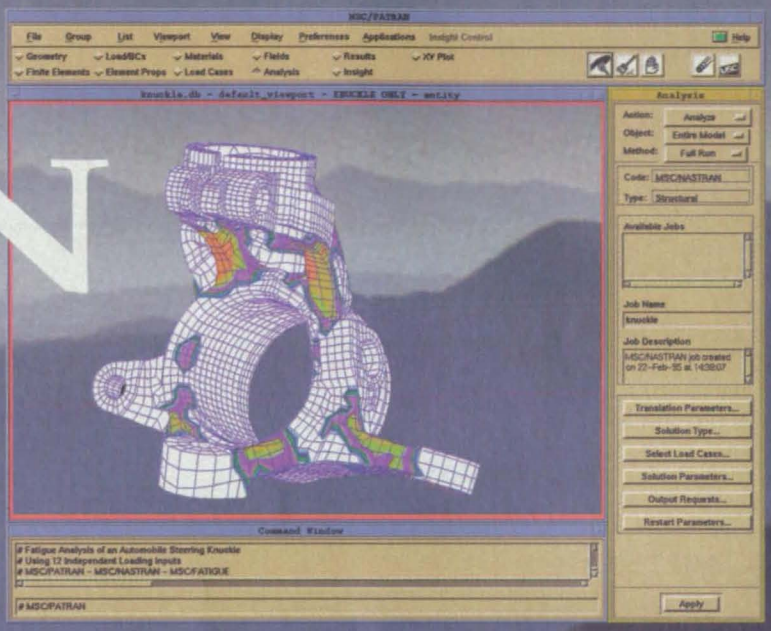

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acquisition subsystem contains an analog-to-digital converter with 192 analog input channels that operates at a composite data-sampling rate of 2×10^5 samples per second. The front-end high-speed data-acquisition subsystem contains an analog-to-digital converter with 96 analog input channels that operates at a composite data-sampling rate of 3×10^6 samples per second. This high-speed subsystem is expandable to 1,024 channels at 3×10^6 samples per second by use of plug-in units.

Macintosh computers are used for low-speed acquisition and manipulation of data. The disk farm provides high-speed storage for a total of 2 GB of data and includes a parity disk for recovery of data. The Macintosh workstations display real-time data to the operator. Communication between the front-end data-acquisition subsystems and the host computer (which is located in a test-control center in another building) is via high-speed, noise-free fiber optics. After a test, the low- and high-speed data are processed by use of two HP720 workstations and five high-speed dedicated printers. Quick-look analysis is available, typically within 30 minutes after the test, while the standard reports are processed simultaneously.

The test-control center houses part of the control system as well as the above-mentioned host computer of the data-acquisition system. The control system contains high-performance industrial programmable logic controllers (PLCs)

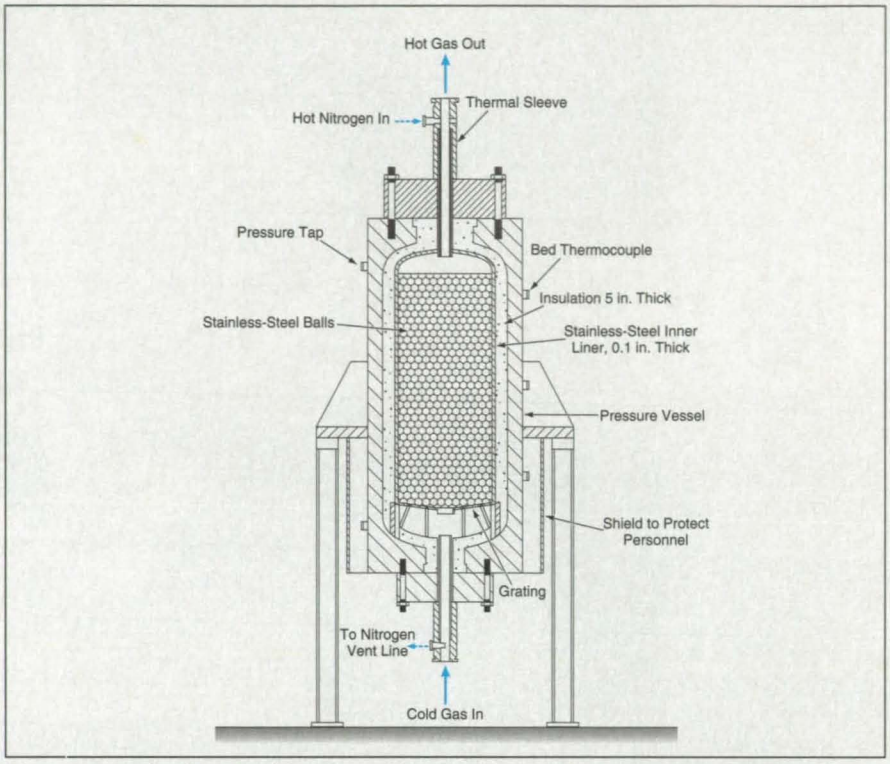

Figure 2. **Heat Is Stored** in the bed of steel balls, then suddenly released to flowing gas during a test; high test temperature can be maintained for times of the order of tens of seconds.

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and provides control of the facility, pretest setup, run-time displays, automated monitoring of the facility, and shutdown. The control system provides real-time, closed-loop control of the flow of coolant in the test article, the operation of the gas generator, and valve schedules. Each loop controller in this system can operate with 5-ms update intervals.

The control system is said to be distributed in the sense that the PLCs are at several locations throughout the facility and communicate over a dedicated, high-speed, fiber-optic communication network. All signal-conditioning and digitization are done at the signal-conditioning building. The resultant digitized values and indications of status are transmitted over the fiber-optic network to the test-control center as required.

The interface between technicians and equipment is provided by computer workstations running operator-interface software for displaying system diagrams, equipment status, and alarms, and for entering commands. These workstations communicate with the PLCs via the fiber-optic network. Closed-circuit television monitors and recorders enable surveillance of the test cell. Audio communications and a fail-safe manual system for aborting tests are also provided. An automatic control subsystem monitors critical test functions and initiates corrective action or terminates the test as needed. Overall, with respect to control, the facility is a highly flexible system that can be efficiently adapted to either open-loop or closed-loop control scenarios with minimal hardware changes.

This work was prepared by Edwin P. Russo of the University of New Orleans for **Stennis Space Center** *and the National Research Council. For further information,* ***write in 57*** *on the TSP Request Card. SSC-00033*

Improved Covers for Nonvolatile-Residue Witness Plates

John F. Kennedy Space Center, Florida

Improved covers for storage and transport of nonvolatile-residue witness plates have been devised. These covers are specially designed to close tightly, in spite of size variations in the witness plates. These plates are exposed to the air at test sites to collect nonvolatile residues of suspected contaminants. Before the development of these covers, it was common practice to cover witness plates with food-grade aluminum foil during transportation between the lab and the test sites. The disadvantage of this practice is that the foil can accidentally be mashed or torn during handling, which may cause erroneous readings. The improved covers are boxlike trays with handles. They are made largely of stainless-steel sheet 0.030 in. (0.76 mm) thick, and incorporate simple spring-loaded, press-and-lock mechanisms that make them secure and tolerant to variations in the sizes of the nominally 1-ft (30.48-cm)-square witness plates.

This work was done by Paul A. Mogan of **Kennedy Space Center** *and Christian J. Schwindt and David E. Counts of I-NET. For further information,* ***write in 12*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Kennedy Space Center; (407) 867-2544. Refer to KSC-11801.

Determining Properties of Materials From Impact Flashes

Spatial and spectral patterns give clues to chemical and physical properties.

NASA's Jet Propulsion Laboratory, Pasadena, California

A method of determining the chemical composition and some of the rheological and other physical properties of materials involves the examination of impact flashes by a combination of spectroscopic and imaging techniques. The method is closely related to spectroscopic and imaging methods that have been used for many years to determine physical conditions and relative abundances of chemical elements in such fields as astronomy, plasma physics, and chemistry. The method was conceived for use in remote measurement of the compositions and physical properties of the surfaces of planets via light emitted by impacts of projectiles on those surfaces at speeds of ≥ 1 km/s. On Earth, the method might prove useful in research on materials under high stresses at high temperatures, with potential applications to industrial explosive forming processes.

When a projectile strikes a body at high speed, the material in the initial contact zone becomes highly compressed. The rapid high compression places this material into a shock state, in which some of the kinetic energy of the projectile has been transformed into strain energy. As material begins to expand at the free surfaces, the compressive stresses created by the impact are released by rarefaction stress waves that originate at the free surface. Some of the energy released in this rarefaction process appears as heat, which can melt, vaporize, and ionize the material and excite the electronic states of the atoms and ions present.

The electronic excitation causes the atoms and ions to emit radiation at their characteristic wavelengths. Thus, by use of an appropriately designed spectrometer, each chemical element present can be identified by its characteristic emission spectrum and the relative abundances of the elements can be determined from the relative intensities of the corresponding emission spectra. Some aspects of the rheological and other physical properties can be extracted from temporally resolved images of the impact flash by use of a high-speed camera. Still more information can be extracted from images that are resolved not only spatially and temporally but also spectrally, by use of a high-speed imaging spectrometer.

This work was done by Marc A. Adams and Henry M. Harris of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 82*** *on the TSP Request Card. NPO-19448*

Near-Infrared Spectral Measurement of Surface Contaminants

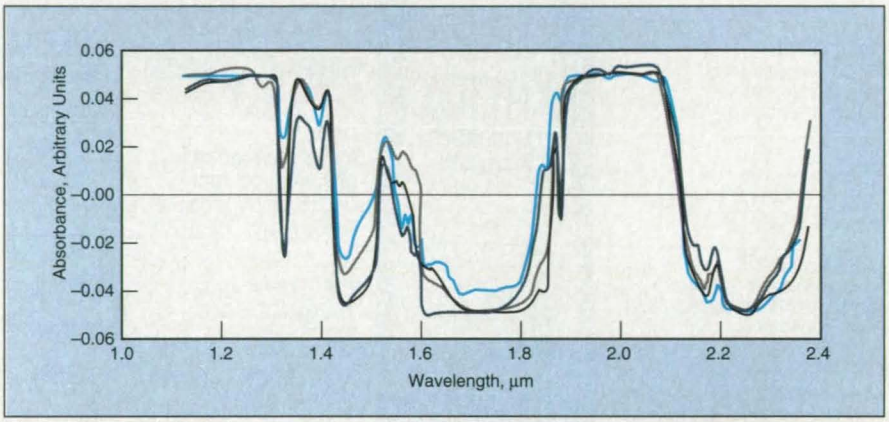
Data from spectral scans are processed by multivariate analysis techniques.

Marshall Space Flight Center, Alabama

A method of near-infrared spectral quantitative analysis has been devised for identifying and measuring trace quantities of such contaminants as greases, waxes, and tape residues on surfaces that are required to be clean in preparation for subsequent adhesive bonding. In this method, a surface to be inspected is scanned by use of a fiber-optic probe coupled to an infrared spectrometer; the scanning mechanism and spectrometer are controlled by a computer, which processes the spectral data for each increment of position along a scan. This method can be used to complement optically stimulated electron emission (OSEE), which is a technique for detecting contamination via the photoelectric effect. In comparison with the present method, OSEE is faster but gives qualitative indications of changes in surfaces and does not indicate amounts and types of contaminants.

The spectrometer operates at near-infrared wavelengths; specifically from 1 to 2.5 μm. This wavelength range contains harmonics and other spectral features associated with vibrations of contaminant molecules of interest; e.g., stretching vibrations of -OH and -CH bonds in tape residues. Spectroscopic observations in this region thus yield data that can be used to distinguish among these residues. Although the raw spectral data are complicated by intricate reflection, absorption, and scattering interactions at the inspected surface, multivariate analysis makes it possible to extract spectral features indicative of the contaminant molecular species (see figure).

The software algorithm combines the raw spectral scan data into one large data matrix of spectral intensities (rows) and scans (columns). Multivariate analysis then reduces the number of variables to only the most influential ones that contribute to the variance of the data.



These Spectral Absorbances were extracted from near-infrared spectral measurements of residues from four different tapes. The similarity of the spectra indicates chemical similarities, likely including similar plasticizers.

Commercial software packages widely used by many research and production engineers to analyze large sets of data are used. The analysis methods implemented in these packages are principal-component analysis (PCA), principal-component regression (PCR) analysis, and partial least-squares (PLS) analysis. Each method involves the generation of a scores matrix that depends on the molecular species and a loading matrix that depends solely on the intensity relationships in the spectra. Principal-component regression analysis and partial least-squares analysis also predict values from known or hypothetical inputs for use in determining the goodness of fit of a mathematical model to a set of measurements.

This work was done by Gary L. Workman, W. F. Arendale, and C. Hughes of the University of Alabama in Huntsville and Bob Mattes of Thiokol Corp. for **Marshall Space Flight Center**. *For further information,* ***write in 14*** *on the TSP Request Card.*

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-26342.

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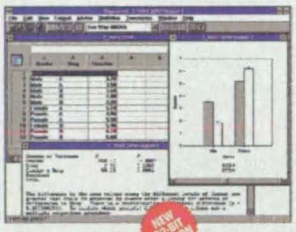

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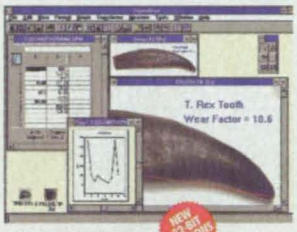

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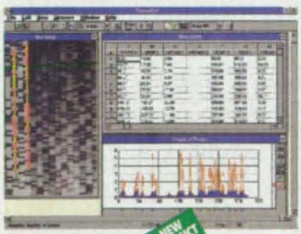

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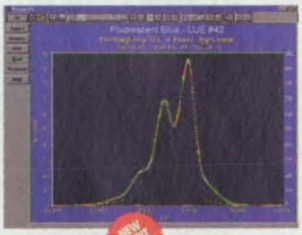

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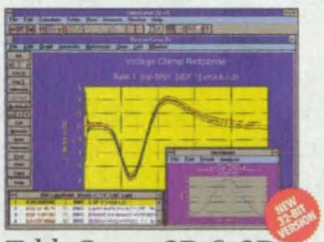

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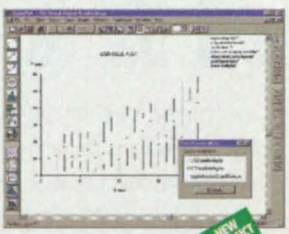

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Measuring Surface Tension and Viscosity of a Levitated Drop

The frequency and rate of decay of resonant vibrations yield the desired information.

NASA's Jet Propulsion Laboratory, Pasadena, California

A method of determining the surface tension and the viscosity of a liquid is based on measurement of the frequency and rate of decay of resonant vibrations of a spherical drop of the liquid that is electrostatically levitated in a vacuum. Neither electrostatic levitation of a liquid drop nor extraction of physical properties from vibrations of a spherical sample is new in itself; what is new in the method is a particular combination of techniques that, taken together, are well-suited for characterization of a high-purity sample of a molten material (typically, metal or a semiconductor).

Heating the sample while levitating it in a vacuum helps to ensure high purity of the sample in two ways; it removes volatile impurities and it prevents contamination that would otherwise be caused by contact of the sample with a solid crucible. High purity is essential in this method because contamination can affect the surface tension that one seeks to measure. High purity is also essential because it is often necessary to measure the surface tension and viscosity of the sample in an undercooled state. Contaminants introduce nucleation sites for solidification, making it difficult or impossible to achieve the desired undercooling. Yet another feature of electrostatic levitation in a vacuum is that it provides a quiescent drop; this is advantageous because the absence of flow within the drop helps to ensure accuracy of the measurements.

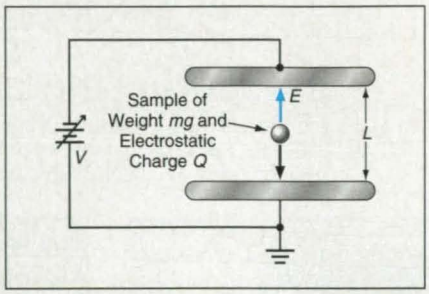


Figure 1. An **Electrically Charged Sample** is levitated by applying an electrostatic field.

Figure 1 illustrates the electrostatic-levitation scheme. A sample of mass m and bearing electric charge Q is levitated in the gravitational field g between two horizontal electrodes. The vertical distance between the electrodes is L, and an electrostatic potential V is applied between the electrodes to produce a vertical electric field $E = V/L$. The magnitude and polarity of V are adjusted so that the upward electrostatic force QE equals the weight mg. When the value of V for stable levitation has been found, one can compute $Q = mg/E$.

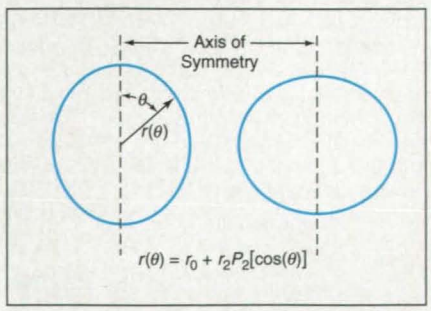


Figure 2. The **Molten Sample Is Made To Vibrate** in a mode in which the local deviation of the radius of the surface from the constant radius of a perfect sphere is proportional to the Legendre polynomial P_2 (cos θ).

Once the levitated sample has been melted into a spherical drop, it is set into vibration by modulating the levitating electrostatic field. The vibrations of a spherical drop of liquid of radius r_0, surface tension σ, and mass density ρ are understood in the sense that the vibrational modes can be represented by use of the well-known spherical-harmonic equations. The frequency of the modulation is swept until one finds the resonance frequency, f_2, at which the drop vibrates in a specific known mode; namely, one in which it alternates between prolate and oblate extremes (see Figure 2). Then making use of the spherical harmonic for that mode, one can compute the surface tension from $\sigma = (r_0^3\rho/8)[(2\pi f_2)^2 + Q^2/8\pi^2 r_0^6 \rho\varepsilon_0]$, where ε_0 is the permittivity of the vacuum.

Once this resonance has been found, the modulation is abruptly terminated and the rate of decay of the resonant vibrations is measured. The rate of decay of a given spherical harmonic and the viscosity, η, are related. For the particular spherical harmonic, one can compute $\eta = \rho r_0^2/5\tau_2$, where τ_2 is the characteristic decay time of $P_2(\cos\theta)$ mode; that is, the time it takes for the vibrations to decay to $1/e$ of their initial amplitude.

This work was done by Won-Kyu Rhim and Aaron J. Rulison of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 54*** *on the TSP Request Card. NPO-19458*

High-Temperature Promoted-Combustion Test Chamber

Material specimens are heated and burned in oxygen to assess flammability.

Lyndon B. Johnson Space Center, Houston, Texas

The figure illustrates an apparatus for heating and burning specimens of materials in a fully contained, high-pressure oxygen atmosphere. The chamber is particularly useful for assessing the flammabilities of materials that are used or are candidates for use in oxygen-handling equipment.

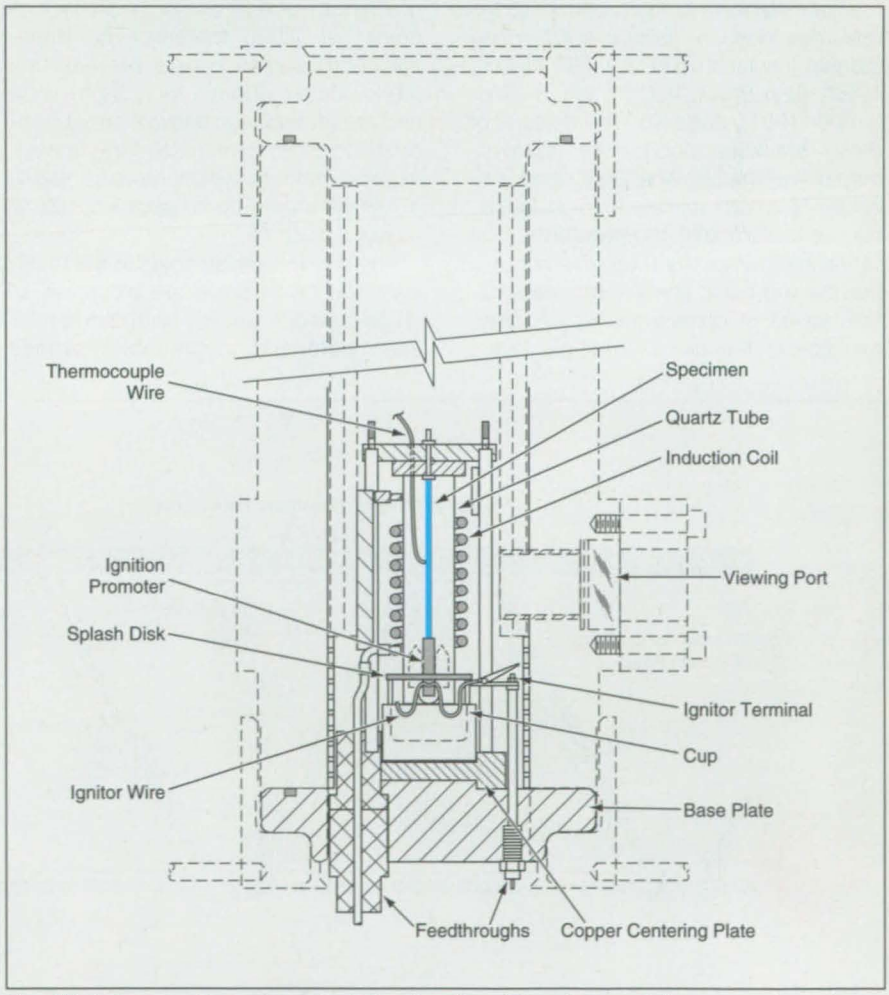
This apparatus is a modified version of a prior one described in "High-Pressure Promoted-Combustion Chamber" (MSC-21470), *NASA Tech Briefs*, Vol. 14, No. 9 (September, 1990), page 46. The specimen and the hardware for holding, heating, and igniting it are mounted on a modified base plate that fits into the chamber of the prior apparatus.

The specimen-holding hardware provides for upward or downward propagation of combustion along the specimen and for electrical insulation of the specimen from the remaining hardware. The specimen can be heated by use of a commercial induction heating coil, which is connected to an external power supply via a feedthrough assembly that provides both (a) electrical insulation of the coil from the wall of the chamber and (b) a seal to retain pressurized oxygen in the chamber. A bare-wire thermocouple, connected to the outside through another pressure-seal feedthrough provides a temperature-feedback signal for control of the induction-heating power supply.

A copper cup located below the specimen catches falling, burning debris. A quartz tube is placed around the specimen, inside the induction coil, to protect the coil against burning debris from the specimen. A copper centering plate under the cup and copper sleeves lining the inside vertical surface of the chamber wall protect the wall against burning debris.

The specimen is ignited electrically by use of an ignitor wire, via electrically insulated terminals and feedthroughs. When electrically heated, the ignitor wire burns and thereby provides ignition energy directly to the specimen or, optionally, to an ignition promoter. An ignition promoter is made from a flammable metal (usually aluminum, titanium, or magnesium) and, if used, provides ignition energy to the specimen and ensures the propagation of the fire from the unheated portion to the heated portion of the specimen.

This work was done by Joel Stoltzfus of **Johnson Space Center** *and Subhasish Sircar, James A. Daniel, and Frank Flores of Lockheed Engineering and Sciences Co. For further information,* ***write in 75*** *on the TSP Request Card. MSC-22464*



The **High-Temperature Promoted-Combustion Chamber** contains an oxygen atmosphere, in which the specimen is ignited electrically and burned to assess its flammability.

Improved Flexible Ceramic Insulating Blankets

These blankets endure intense noise as well as high temperatures.

Ames Research Center, Moffett Field, California

The figure is a schematic cross section of a flexible insulating blanket that contains an integral woven three-dimensional trusslike ceramic fabric structure filled with bulk fibrous ceramic insulating material. Blankets of this type provide thermal insulation at temperatures up to about 2,500 °F (about 1,400 °C) while enduring aeroacoustic loads that are strong enough to disrupt ceramic blankets of older design. Developed to protect spacecraft against heating upon reentry into the atmosphere, these blankets might also prove useful in advanced aircraft and in industrial applications that involve both high temperatures and noise.

These blankets are successors to the ones described in "Tailorable Advanced Blanket Insulation (TABI)" (ARC-11697), *NASA Tech Briefs,* Vol. 11, No. 8 (September 1987), page 45. The designs of these blankets incorporate improvements over the baseline TABI designs to enable them to withstand high aeroacoustic loads at high temperatures. One of the most important improvements is that the top fabric sheet comprises multiple layers of continuous woven ceramic fibers; the use of multiple layers (instead of a single layer as before) toughens the surface against aeroacoustic loads. The top multilayer fabric sheet is woven integrally with the bottom single-layer fabric sheet and with the single-layer angled sheets that constitute the ribs of the trusslike structure.

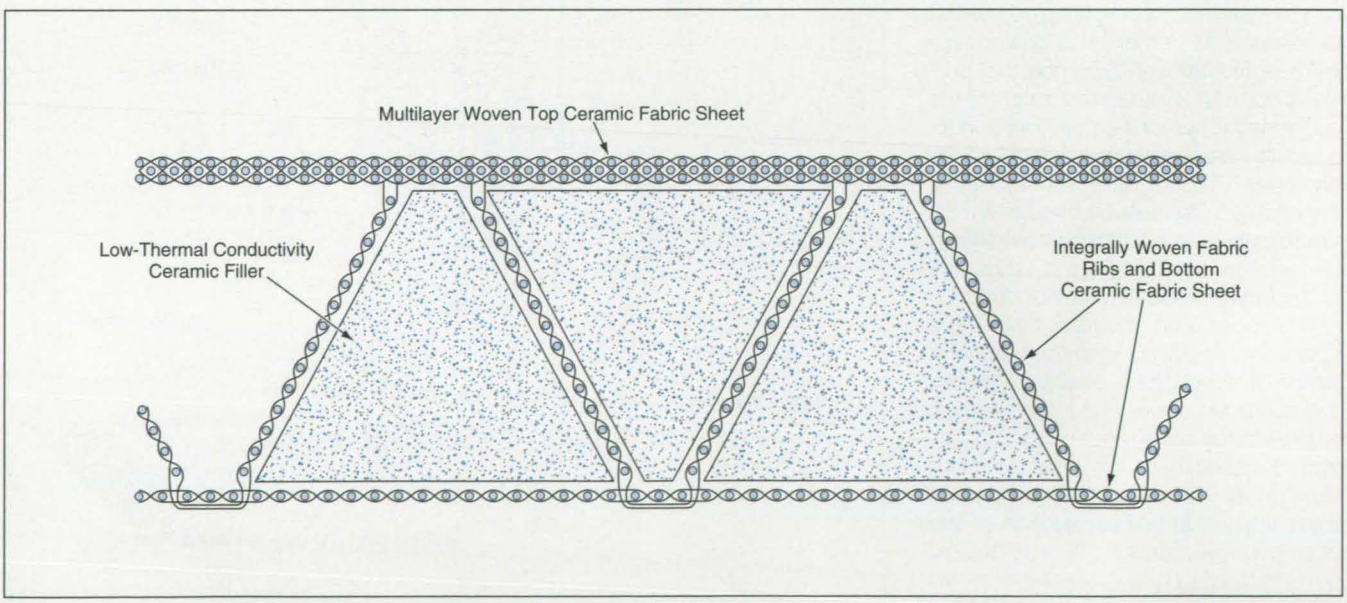
These blankets can be made from any of a variety of fibrous ceramic materials, including alumina, aluminoborosilicate, silicon nitride, silicon boride, silicon boronitride, and a commercial formulation containing silicon, titanium, carbon, and oxygen. In a representative blanket of this type, the ceramic fabric sheets are woven from silicon carbide yarn with a mass per unit length of 600 denier (1 denier = 1 gram per 9,000 meters). The trapezoidal-cross-section cells between the fabric ribs are about 1 in. (2.5 cm) wide and are stuffed with a low-thermal-conductivity ceramic material; for example, alumina batting, which remains stable at temperatures up to about 2,800 °F (about 1,500 °C).

The silicon carbide fibers in the multilayer top fabric sheet are woven in an angle interlock pattern to obtain a relatively tight and tough fabric surface that resists damage during exposure to intense aeroacoustic loads and prevents movement of the insulating filler material in the cells. The thickness of the multilayer top fabric sheet is 0.032 in. (0.81 mm). The overall mass density of the blanket is 10 lb/ft^3 (160 kg/m^3).

In a test, this blanket was first radiantly heated for 2 minutes at a temperature of 2,500 °F (1,371 °C), then survived a 15-minute exposure to an acoustic load characterized by a sound pressure of 170 dB. Presumably, the blanket could survive the intense noise for a longer time at a lower temperature.

This work was done by Paul M. Sawko, Dominic P. Calamito, and Anthony Jong of **Ames Research Center**. *For further information,* ***write in 61*** *on the TSP Request Card.*

This invention has been patented by NASA (U.S. Patent No. 5,451,448). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Ames Research Center; (415) 604-5104. Refer to ARC-13385.



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Silicon Nitride Coatings on Polymer-Matrix Composites

Under limited conditions, these coatings increase thermooxidative stability.

Lewis Research Center, Cleveland, Ohio

Experiments have shown that under selected conditions, protective coatings of amorphous silicon nitride will retard the thermooxidative degradation of polymer-matrix composite substrates. The choice of amorphous silicon nitride as a candidate material was based on the results of previous experiments that showed that amorphous silicon nitride coatings can be a diffusion barrier to oxygen, resist oxidation at the maximum temperature a PMC can tolerate (400 °C), exhibit a high yield strength, are hard, and resist wear. Furthermore, amorphous silicon nitride coatings (a-SiN) can be applied by plasma-enhanced chemical vapor deposition (PECVD) at temperatures low enough (<400 °C) to avoid damaging the polyimide matrix resin. The a-SiN coating completely covers substrates with complex shape and rough surfaces.

The composite substrate used in these experiments was a polyimide-matrix/graphite-fiber composite made from 12 plies of graphite-fiber tape impregnated with PMR-II-50 oligomer (a precursor to the polyimide). To assess the effects of surface finish and method of fabrication, the composites were fabricated in two groups using two different techniques: those in one group were fabricated by compression molding, while those in the other group were fabricated by a simulated autoclave vacuum-bagging technique.

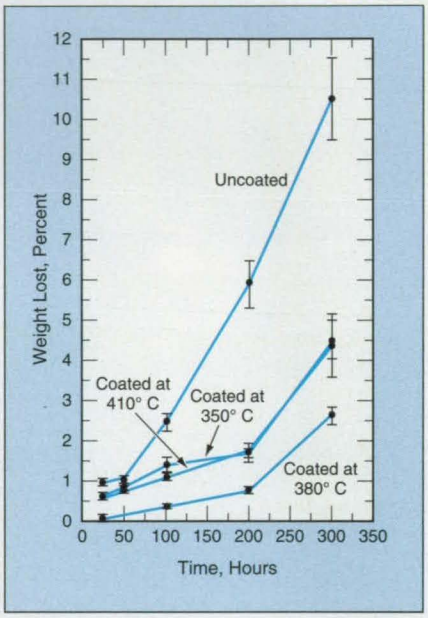
Representative test specimens from each group were coated with amorphous silicon nitride and aged in air with uncoated (control) specimens for 500 hours at 371 °C. Unaged coated PMCs were thermal-cycled from –18 °C to 232 °C: the coating did not crack after 1,000 thermal cycles.

The weight lost by each specimen was measured during aging at 371 °C. The weight lost by the coated autoclaved specimens was significantly less than that lost by the uncoated specimens (see figure); this demonstrates the ability of the amorphous-silicon-nitride coatings to protect against thermooxidative degradation.

However, the coatings did not afford similar protection to the compression-molded specimens, which lost about as much weight as the uncoated specimens. This weight-loss difference is attributable to the difference between composite-surface finishes. While the simulated autoclave vacuum-bag process produced a rougher composite surface than the compression-molded composite, the vacuum-bagged composite surface was resin-rich, and free of the exposed fibers and larger craters that are prevalent on compression-molded surfaces. Exposed fibers provide conduits for rapid diffusion of oxygen along fiber/matrix interfaces into the bulk of the matrix and oxidative weight-loss results.

This work was done by James K. Sutter of **Lewis Research Center**. *No further documentation is available.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Lewis Research Center; (216) 433-2320. Refer to LEW-15994.



Weight Loss of uncoated and coated specimens with amorphous silicon nitride is measured during aging at 371 °C. The coatings were applied by PECVD from SiH_4 and N_2 precursor gases at the indicated substrate temperatures.

Three-Dimensional Ion-Conducting Graphite for Lithium Cells

Molecular-structure modification would enable three-dimensional intercalation of lithium.

NASA's Jet Propulsion Laboratory, Pasadena, California

Modified graphite that would act as a quasi-three-dimensional conductor for lithium ions has been proposed for use as an anode material in rechargeable lithium-based electrochemical cells. In ordinary graphite, the intercalation of lithium is restricted to two-dimensional motion of lithium ions in the spaces between basal planes. In the modified graphite, some of the carbon atoms would be removed, leaving holes in the basal planes. Lithium ions could then move through these holes; that is, they could move in a third dimension through the basal planes. This modification of graphite is intended to increase the reversible Li capacities and charge/discharge-rate capabilities.

The process for modification of graphite would involve the addition of impurities such as nickel, titanium, or silicon, which would substitute for some of the carbon atoms. The graphite containing these impurities would be subjected to chemical and heat treatments that would remove the impurity atoms and/or a small fraction of carbon, yielding the desired molecular structure containing holes through the basal layers.

This work was done by Chen-Kuo Huang, Jeff Wolfenstine, and Subbarao Surampudi of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 53*** *on the TSP Request Card. NPO-19686*

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Mathematics and Information Sciences

Hybrid Decision-Tree/Kernel-Density Classification Software

A computer program has been developed to implement a novel method of combining decision trees and kernel-density estimators for classification of data. The program derives a decision-tree classifier from labeled training data and uses statistical density-estimation techniques to estimate class probabilities. Standard classification trees, or class-probability trees, provide piecewise-constant estimates of class posterior probabilities. Kernel-density estimators can provide smooth non-parametric estimates of class probabilities, but scale poorly as the dimensionality of a problem increases. In the present method, a decision tree is used to find the relevant structure in a high-dimensional classification problem, then local kernel-density estimates are used to fit smooth probability estimates within this structure. The method is particularly useful for solving classification problems in which class probability estimates are important and in which there are relatively few training data relative to the dimensionalities of the problems, as frequently occurs in practice. Experimental results on simulated data indicate that the method provides substantial improvement over trees or density methods alone in some classes of problems. The method could be useful in various applications as diverse as analysis of medical images, electronic recognition of speech, and analysis of marketing data.

This work was done by Padhraic Smyth, Usama M. Fayyad, and Alexander Gray of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 95*** *on the TSP Request Card.*
NPO-19664

Mechanics

Program Models Noise and Vibrations in Ducts

Vibration and noise transmitted by and generated within the fluid flowing in a complex ducting system can exert a significant effect on many aspects of the design of the system. The need for an accurate method for predicting the vibration and noise effects of unsteady pressure inputs at remote locations within the fluid systems has become increasingly important in the design of ducting systems. The Fluid Acoustic Wave Propagation Algorithm Enhancement 2 (FLAPR2) computer program can account for the different ways in which fluids react in a fluid-ducting system subject to unsteady pressure or flow rate inputs at various locations in the system. The program can be useful in providing the dynamic response of a very general ducting system to a variety of inputs.

FLAPR2 separates the ducting system into a number of one-dimensional segments interconnected at discrete nodes. The applied forcing function generates acoustic waves that propagate through the system at the speed of sound. These waves are tracked as they propagate in order to determine the response of the system to the forcing function, as a function of time. In addition, there are accurate and consistent methods for generating frequency-domain results. A major advantage of the frequency-domain results is that they show the acoustic modes of the system being analyzed.

This program provides a computationally inexpensive one-dimensional mathematical model of fluid-dynamic transients. The model incorporates an "external resistance" boundary condition, which affords the user a great deal of flexibility in the specification of real impedances at system boundaries. It also provides for a simple mechanical system (spring, mass, and damper) as a system boundary. This system has shown significant promise in the area of fluid/structure interaction. FLAPR2 makes it possible to perform rough analyses quickly and cheaply on a wide variety of problems; these include analysis of propagation of noise in ducts, determination of the acoustic modes of fluid systems, water-hammer analyses, and other fluid-dynamic-transient analyses.

FLAPR2 is written in FORTRAN 77 for IBM PC-series and compatible computers and requires at least 640K of random-access memory. The included sample executable codes were written under the assumption that the PLOT88 plotting software package (Plotworks, Inc.; La Jolla, CA; 619-457-5090) is installed in the computing system and that either a Hewlett-Packard Laserjet printer or an Epson dot-matrix printer is available for printing results. Also, the provided source code can be linked and executed properly only if the PLOT88 plotting software package is installed in the system. However, the source code can be modified to work with other plotting software packages and printers. FLAPR2 also provides output in ASCII-format data files, affording the user a wide range of postprocessing options. The standard distribution medium for this program is a 3.5-in. (8.89-cm), 1.44MB, MS-DOS-format diskette. Sample input data are included on the distribution medium.

This program was written by Timothy C. Hanshaw of Rockwell International Corp. for **Marshall Space Flight Center.** *For further information,* ***write in 39*** *on the TSP Request Card.*

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-29968.

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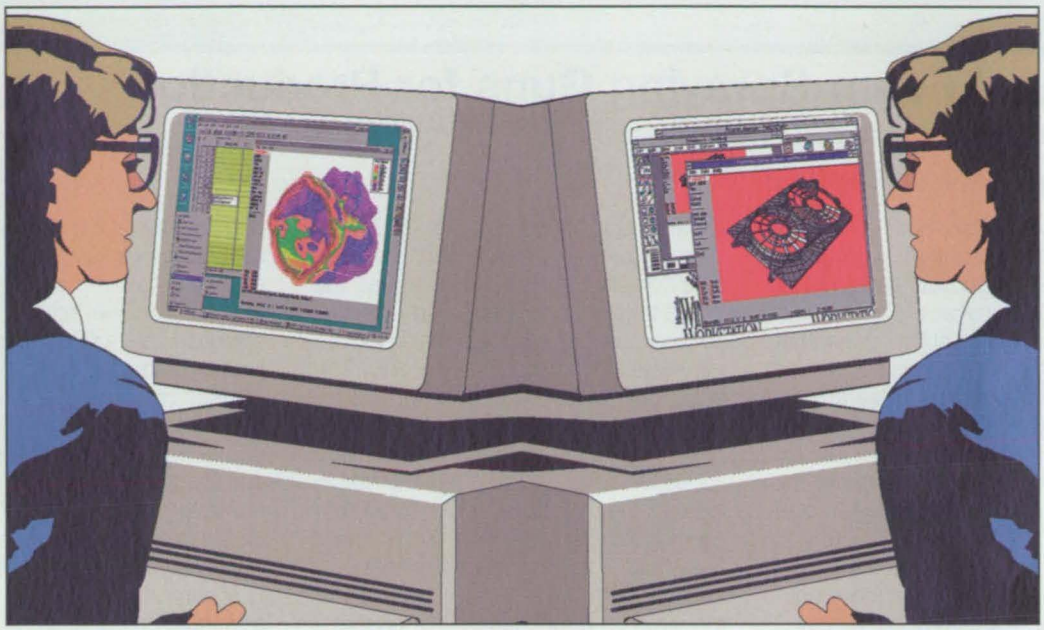

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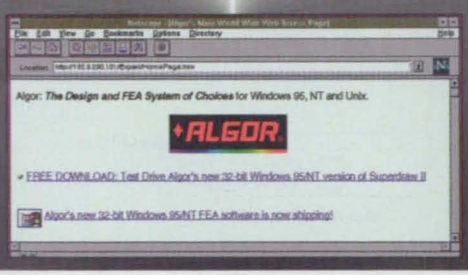

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Improved Foam-Spraying Guns for Production

Proposed units would supplant trouble-prone commercial units.

Marshall Space Flight Center, Alabama

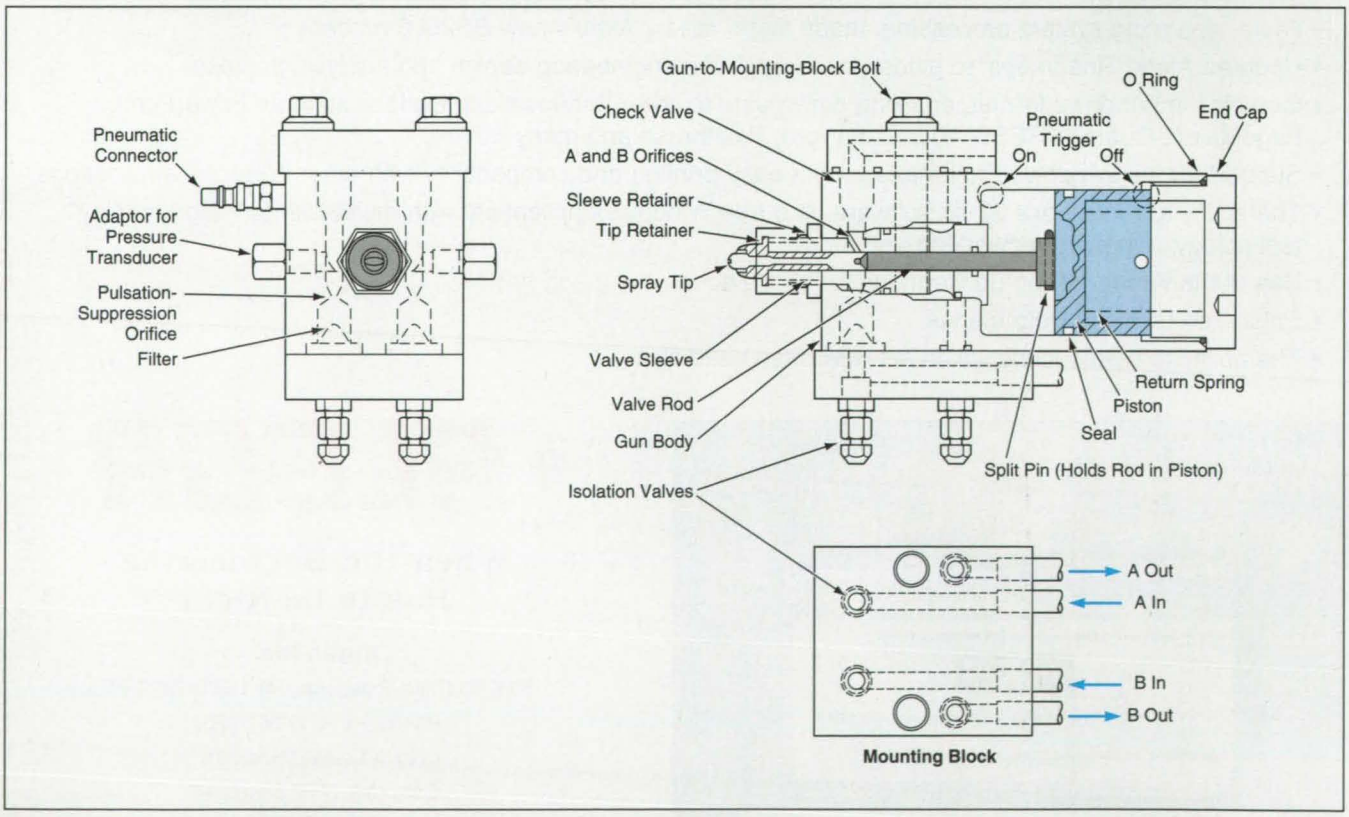
An improved design has been proposed for spray guns that apply foam insulation in a production setting. The improved spray guns would be used in place of commercial spray guns that have proven to be inconsistent in use and difficult to clean and reassemble. A gun of the proposed type would mix two chemical components (A and B) to form the foam mixture and would spray the foam at a chosen rate between 20 and 60 lb./min. (between 9 and 27 kg/min.)

When a gun was not spraying, the A and B component liquids would be circulated continuously from the A and B storage tanks, through thermostatically controlled heaters, through A and B channels in the gun, and back to the A and B storage tanks. This circulation would continuously purge the gun and maintain the gun and the chemical components at a specified temperature. Two pneumatically actuated valves, one in each A and B component fluid lines downstream of the spray gun, are actuated "closed" at the same time as the gun is triggered "on." Therefore, the flow (and ratio) from the proportioning pumping system flows to the gun only. The spray gun would be turned on by supplying the same pressurized air to the pneumatic actuator that would move a valve in the gun body, against spring loading, from an "off" position to an "on" position (in which the valve would divert the A and B flows to mixing orifices).

Each gun (see figure) would be mounted on a mounting block so that it could be located precisely to ensure control over the direction of the spray. The A and B components would be circulated through passages in the mounting block. For removal of the guns, isolation valves would be mounted in the mounting block at the junctions with the A and B supply and return hoses.

To complete the flow circuits, a recirculation block (which would contain A and B turnaround passages) would be mounted on the side of the gun body opposite the mounting block. Alternatively, another gun (or guns) could be stacked on a first gun, in which case the recirculation block would be mounted on the outermost side of the outermost gun body. The advantage of stacking multiple guns would be that a fresh gun could be put into operation immediately when one of the guns became clogged.

A gun body would be made from an aluminum block, 3 in. (7.6 cm) square and 7 in. (17.8 cm) long. A valve bore, passages for the A and B components, and bore for the cylinder of the pneumatic actuator would be machined into the block. If required, pressure transducers in the passages would monitor the upstream pressures of the A and B components. Check valves in the outlet sides



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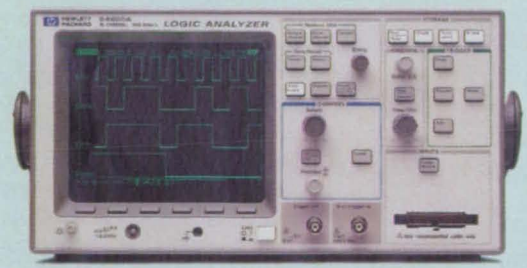

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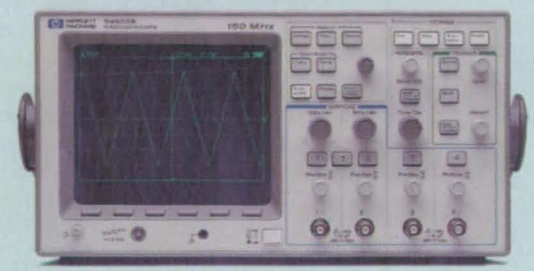

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of the A and B passages would protect against crossover of each component to the passage of the other component.

The most critical part of the gun would be a valve sleeve assembly, which would consist of a sleeve, a matching valve rod, a spray tip, and retainers for the sleeve and spray tip. The basic valve-sleeve-assembly design could accommodate a variety of mixing-chamber configurations. The valve sleeve would contain the two sets of A and B mixing orifices (one set for mixing, one for circulation). The configuration of the spray tip would minimize the area on which foam could accumulate and would provide easy access for a tip-cleaning tool.

This work was done by Peter B. Allen of Martin Marietta Corp. for **Marshall Space Flight Center.** *For further information,* ***write in 22*** *on the TSP Request Card.*

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-31016.

Software for Analysis and Selection of Pipes

Two programs incorporate stress-analysis equations, material-strength data, and industry standards.

John F. Kennedy Space Center, Florida

Two computer programs have been developed to facilitate and accelerate the analysis of stresses in pipes and the selection of pipe sizes and materials to withstand given pressures. Heretofore, pipes have usually been analyzed and selected by time-consuming, tedious, and error-prone manual calculations, which often become even more tedious and time-consuming because of the need to try several pipe sizes and materials. The older computer programs available for this purpose have been large, expensive ones like finite-element programs, which were created to solve more complicated problems; these programs take long times to learn, to set up, and to change pipe sizes.

Input	Output
Outside Diameter, Wall Thickness, and Pressure	Stress at Inner and Outer Walls
Outside Diameter and Pressure	Required Wall Thickness
Outside Diameter and Wall Thickness	Allowable Working Pressure
Data File: Outside Diameter and Wall Thickness	Data File: Working Pressure

The **Software Offers the User the Choice** of these combinations of inputs and outputs.

The present two programs incorporate stress-analysis equations from the established theory of elasticity, plus data on the strength and elastic properties of commonly used pipe materials. In addition, the programs can accommodate data on other materials added by the user. The programs also incorporate the American Society of Mechanical Engineers/American National Standards Institute (ASME/ANSI) B31.1 and B31.3 piping codes and the Joint Industry Committee (JIC) code commonly used for hydraulics; these codes are used to set factors of safety for the yield and tensile strengths of materials. Optionally, the user can enter different factors of safety. The only difference between the two programs is that one uses English units while the other uses metric units.

Once the user has selected the applicable program and pipe material (and provided data if the material was not previously listed in the data base), the program calculates the stress, working pressure, or pipe-wall thickness, as required by the user (see table). In so doing, the program analyzes the pipe according to the ASME and JIC codes.

The programs are written entirely in FORTRAN 77 on a DEC VAX VMS system. The source code should be compatible with most other FORTRAN 77 compilers with little modification. Each program consists of about 530 lines of source code. Sample input files are included for the user's convenience. The executable files are included, so that a

user who has the same computer system can run the programs directly.

This work was done by Eric A. Thaxton of **Kennedy Space Center**. *For further information,* ***write in 63*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Kennedy Space Center; (407) 867-2544. Refer to KSC-11692.

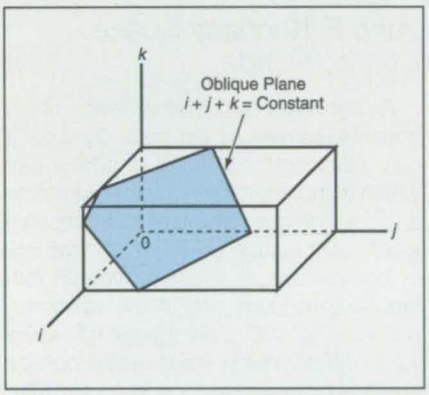
An LU-SGS Implicit Algorithm for Incompressible Flow

The algorithm offers additional advantages when the flow equations include source terms.

Ames Research Center, Moffett Field, California

An algorithm solves the Navier-Stokes equations of three-dimensional, incompressible flow, partly by use of the concept of pseudocompressibility. The algorithm executes a lower-upper symmetric-Gauss-Seidel (LU-SGS) implicit numerical-integration scheme. It offers additional advantages when applied to flow equations with source terms. Source terms of particular interest include centrifugal- and Coriolis-force terms for flows in rotating reference frames — for example, in turbomachines.

The spatial differencing in the numerical integration is done by a semidiscrete finite-volume method that is accurate to second order, augmented by a numerical-dissipation method that is based on the spectral radius of a Jacobian matrix and is accurate to third order. A nonreflecting boundary condition based on characteristic variables is used.



Oblique Planes of Sweep through the three-dimensional computational space that corresponds to the three-dimensional physical space are used in the INS3D-LU computer program because the LU-SGS numerical-integration scheme is completely vectorizable on such planes.

The LU-SGS scheme is not only unconditionally stable but also completely vectorizable in three dimensions on oblique planes of sweep characterized by $i + j + k$ = constant (see figure). The algorithm is implemented in the INS3D-LU computer program, which takes advantage of this vectorizability by use of two-dimensional arrays in three dimensions. The form of such an array is **Q** (point, plane) = **Q** (i, j, k), where **Q** is a vector quantity of the flow, "point" is a number that denotes the address of a point on the oblique plane of sweep, and "plane" denotes the serial number of the oblique plane of sweep. The program requires only 8 μs of computing time per grid point per iteration on a Cray YMP supercomputer.

The program has been applied to the flow in a modified version of the inducer of the liquid-oxygen turbopump in the main engine of the space shuttle. It has also been applied to the flow in a duct of square cross section with a 90° bend at a Reynolds number of 790, for which experimental data are available. The computed and measured streamwise velocities were found to be in acceptably close agreement.

This work was done by Seokkwan Yoon, Leon Chang, and Dochan Kwak of **Ames Research Center**. *For further information,* ***write in 18*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Ames Research Center; (415) 604-5104. Refer to ARC-13174.

High-Speed Fluid-Mixing Device

This device mixes a liquid with a gas at high pressure.

John F. Kennedy Space Center, Florida

An improved fluid-mixing device offers advantages over similar older devices. It can inject and mix a liquid into a gas within a short distance. It can also create a vacuum in gas flowing at high pressure [>300 psig (gauge pressure >2.1 MPa)]. In comparison, a subsonic venturi can create a vacuum only if the upstream pressure is <30 psig (gauge pressure <0.21 MPa). The present device can be arranged to maintain a constant mixing ratio; that is, the rate of flow of a liquid to be blended with a gas in this device can be made proportional to the rate of flow of the gas.

Heretofore, low-speed venturis have been used to decrease gas pressures to inject liquids into gas streams, the liquids being injected at the throats of the venturis. Uniform mixing of gases and liquids has been achieved by turbulence in the pipes downstream from the throat.

The present device includes a liquid-injecting nozzle placed at right angles to a supersonic gas-injecting nozzle. The gas nozzle can be either a simple orifice or it can be a converging/diverging nozzle similar to a venturi with a significant exception; the throat is narrow enough to produce choked (sonic) flow, which differs from flow through a venturi.

The liquid nozzle is located downstream (with respect to the flow of gas)

from the throat of the gas nozzle and controls the quantity of liquid entering the gas stream. The downstream distance of the liquid nozzle is chosen according to the pressure required for injection of the liquid.

The original application of this device was in mixing air and water in a cleaning system that replaces a cleaning system in which a chlorofluorocarbon solvent was used. The device is especially well-suited for cleaning, spray coating and painting, humidification, and atomization. In addition to its principal use for mixing gases with liquids, this device can be used to create a vacuum on a container; for example, as part of an aspirator or vacuum cleaner. It can also be used to mix two gases.

This work was done by Eric A. Thaxton and Raoul E. Caimi of **Kennedy Space Center**. *No further documentation is available. KSC-11715*

Incompressible, Viscous Flows Around Airfoils

Flows over single- and multiple-element airfoils are computed.

Ames Research Center, Moffett Field, California

Two-dimensional flows of an incompressible, viscous fluid around single- and multiple-element airfoils (which include various combinations of trailing-edge flaps and sometimes leading-edge slats) have been computed. These computations were intended to add to knowledge of the physics of flows in high-lift takeoff and landing configurations of airplanes. The increased knowledge may contribute to the design of the next generation of transport airplanes that could carry heavier loads, make less noise, and shed smaller wakes.

The flow was taken to be incompressible for the purpose of this study because there is one less equation to solve for incompressible flow than for compressible flow. The approximation of incompressibility is justified by the fact that effects of compressibility are generally small at speeds much less than that of sound, and that speeds at takeoff and landing are generally less than mach 0.2. In this study, the Reynolds-averaged Navier-Stokes equations of flow of an incompressible, viscous fluid were solved numerically by use of the INS2D computer code, which implements the method of pseudocompressibility with an upwind-differencing scheme for convective fluxes and an implicit line-relaxation iterative numerical-integration scheme.

One version of the flow was computed by use of patched coordinate grids; another version was computed by use of an overlaid chimera system of grids. Steady-state flows around two-, three-, and four-element airfoils at various angles of attack were computed with the help of the one-equation Baldwin-Barth mathematical model of turbulence. In addition, the Baldwin-Barth model and Baldwin-Lomax algebraic model of turbulence were compared by using them in computations of flow around a single-element airfoil. Pressures at various locations on the surfaces of the airfoils were extracted from the computed flow fields and compared with pressures measured in experiments.

In computing each flow, the computer code was found to converge in fewer than 200 iterations, taking about 1 minute on the central processing unit of a Cray YMP (or equivalent) computer. The Baldwin-Barth model yielded pressures more accurate than those of the Baldwin-Lomax model — an advantage in that the Baldwin-Barth model is easier to use. Both the overlaid- and chimera-grid approaches yielded pressures that agreed closely with measured values; the small remaining common discrepancies between the computed and measured values involve separated flows. The results of the single-airfoil computations can be interpreted as signifying that the deficiencies of the mathematical models of turbulence are the most likely causes of the small inaccuracies in the computed flows.

This work was done by Stuart Rogers, N. L. Wiltberger, and Dochan Kwak of **Ames Research Center.** *For further information,* ***write in 1*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Ames Research Center; (415) 604-5104. Refer to ARC-13181.

Lightweight Strain-Gauge Device Measures Small Displacements

Marshall Space Flight Center, Alabama

A lightweight device is designed to measure small lateral expansions or contractions of material specimens in compressive or tensile tests for determining the Poisson's ratios of the materials. The device is essentially a strain-gauge-instrumented, elastic, rectangular-U-shaped caliper. Screws in threaded holes near the tips of the "U" provide for adjustment of contact with the specimen. The "U" is thinned at its midlength to provide elasticity. Strain gauges are mounted on opposite faces of the thinned section and connected in a Wheatstone bridge circuit with four active strain gauges. Thus, displacements of the tip screws in contact with the specimen cause the midsection to bend, giving rise to strain that is measured by the strain gauges. Tests have shown that with proper adjustment and calibration, the device can indicate displacement with a repeatability of $\pm 3 \times 10^{-4}$ in. (7.6 μm), and that the gauge reading varies nearly linearly with the displacement.

This work was done by James R. Thompson, J. M. Nelson, and Kenneth P. Sorensen of Thiokol Corp. for **Marshall Space Flight Center.** *For further information,* ***write in 28*** *on the TSP Request Card. MFS-31065*

Quick-Release Tether Hook

Lyndon B. Johnson Space Center, Houston, Texas

An improved quick-release hook for a safety tether is more easily operable with a gloved hand than was an older hook designed for the same purpose. To initiate release, the user presses a button, unlocking a slider that can then, in turn, be pressed to open the bail of the hook. When the button and slider are released, a spring returns the bail to its original closed and locked position.

This work was done by Scott A. Swan of **Johnson Space Center.** *For further information,* ***write in 32*** *on the TSP Request Card. MSC-22576*

Telerobotic Plant Tender

A plant-growth chamber could be kept closed to maintain its special atmosphere.

NASA's Jet Propulsion Laboratory, Pasadena, California

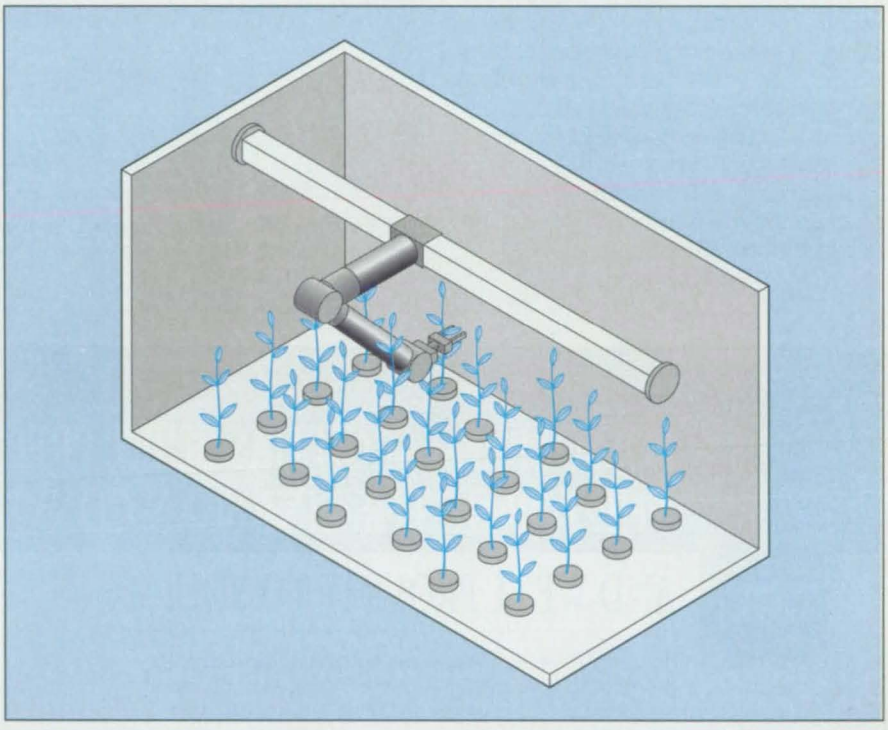
A proposed telerobot would tend plants in a hydroponic growth chamber. Once a plant-growth experiment had been started in the chamber, it would not be necessary to open the chamber to tend the plants. Thus, it would be possible to prevent contamination of the chamber by the exterior atmosphere and to maintain a special atmosphere (typically, a high-humidity atmosphere) with controlled temperature and airflow as required for the experiment.

The telerobot would perform a variety of tasks. For example, it would take samples by clipping of fruits, flowers, and leaves and by pulling whole plants out of their growth medium by the roots, then placing the samples thus extracted in sampling slots at the bottom of the chamber for removal and external examination. The robot would move video cameras, pick up and replace tools and sensors, and keep the chamber tidy by transferring debris into disposal slots similar to the sampling slots.

According to an initial design concept, the chamber would be approximately 1.5 m wide, 0.8 m deep, and 0.8 m high. The plants would grow out of a hydroponic medium through disks on the floor with openings, toward lights on the ceiling. The telerobot would move around and between the rows of plants (see figure), the motions being controlled so that any disturbance of the plants would be minimal.

The robot would feature a multiple-link configuration with seven degrees of freedom. The joints between links would be equipped, variously, with pitch (P), translation (T), and roll (R) actuators in the overall sequence PTRPRPR, starting from the base of the linkage on the wall of the chamber. This linkage configuration was selected from among a number of alternative configurations because it would provide the required agility, access to all parts of the chamber, small size, light weight, and adequate forces and torques.

This work was done by Paul G. Backes and Mark K. Long of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 55*** *on the TSP Request Card. NPO-19410*



The **Telerobotic Plant Tender** would move among plant stems to tend them without damaging them. Two joint actuators — one for pitch and one for translation — would be located just outside the chamber; the remaining five actuators could be mounted in the linkage (or outside the chamber if cable drives were used).

Program for Redesigning a Radial Diffuser in a Turbopump

A program for designing impeller blades has been adapted to design of diffuser vanes.

Marshall Space Flight Center, Alabama

A computer program for redesigning the vanes of a radial diffuser in a turbopump was formulated to satisfy new operating requirements while not changing either the number of vanes or the radial locations of the leading and trailing edges of the vanes (see figure). The new operating requirements include specified levels of performance in off-design operation.

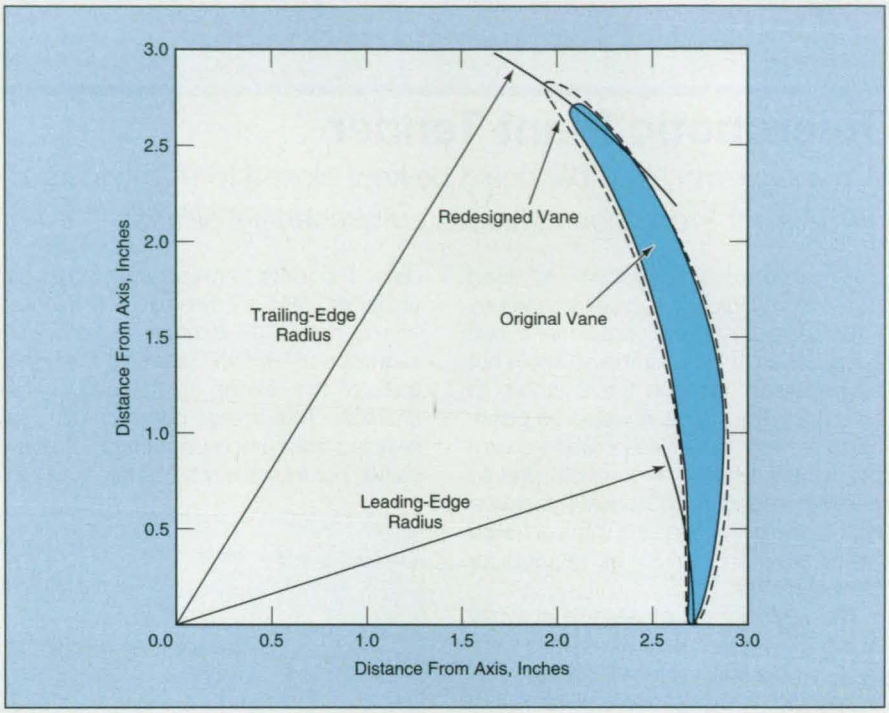
The computer program is a modified, upgraded version of a program devised previously for designing blades of centrifugal pump impellers. That program was described in two previous articles in *NASA Tech Briefs*; "Computer Program Aids Design of Impeller Blades" (MFS-29783), Vol. 16, No. 2 (February, 1992), page 93, and "Simplified Computation of Blade-Surface Coordinates" (MFS-29875), Vol. 17, No. 10 (October, 1993), page 100.

To recapitulate: By use of two coordinates called "*G*" and "*H*", the complex three-dimensional surface of a blade (in

this case, a diffuser vane) can be described as though it were two-dimensional. The definitions of these coordinates are $G = \int dm$ and $H = \int r d\theta$, where m denotes meridional length, r denotes radial length, and θ denotes circumferential angle. The mean line of the blade is generated in the G–H plane with the inlet and discharge blade angles specified and the hub and shroud contours defined. Then the coordinates of the pressure and suction sides of the vane are computed from the mean line and a specified elliptical or other distribution of thickness along the mean line from the hub to the shroud.

The foregoing computation of the shape of the vane is performed by one of several subprograms that are executed sequentially in an iterative design-and-analysis procedure. The vane-shape-generating subprogram generates input data for use in computing distributions of pressure and velocity in a subprogram that analyzes the design. If the resulting blade loading and performance as computed by the design-analyzing subprogram are acceptable, the design is structurally analyzed. A design that satisfies both performance and structural requirements is passed to a final subprogram that generates a practical vane design for fabrication.

This work was done by Kevin J. Lunde and Wei-Chung Chen of Rockwell International Corp. for **Marshall Space Flight Center**. *For further information,* ***write in 94*** *on the TSP Request Card. MFS-30049*

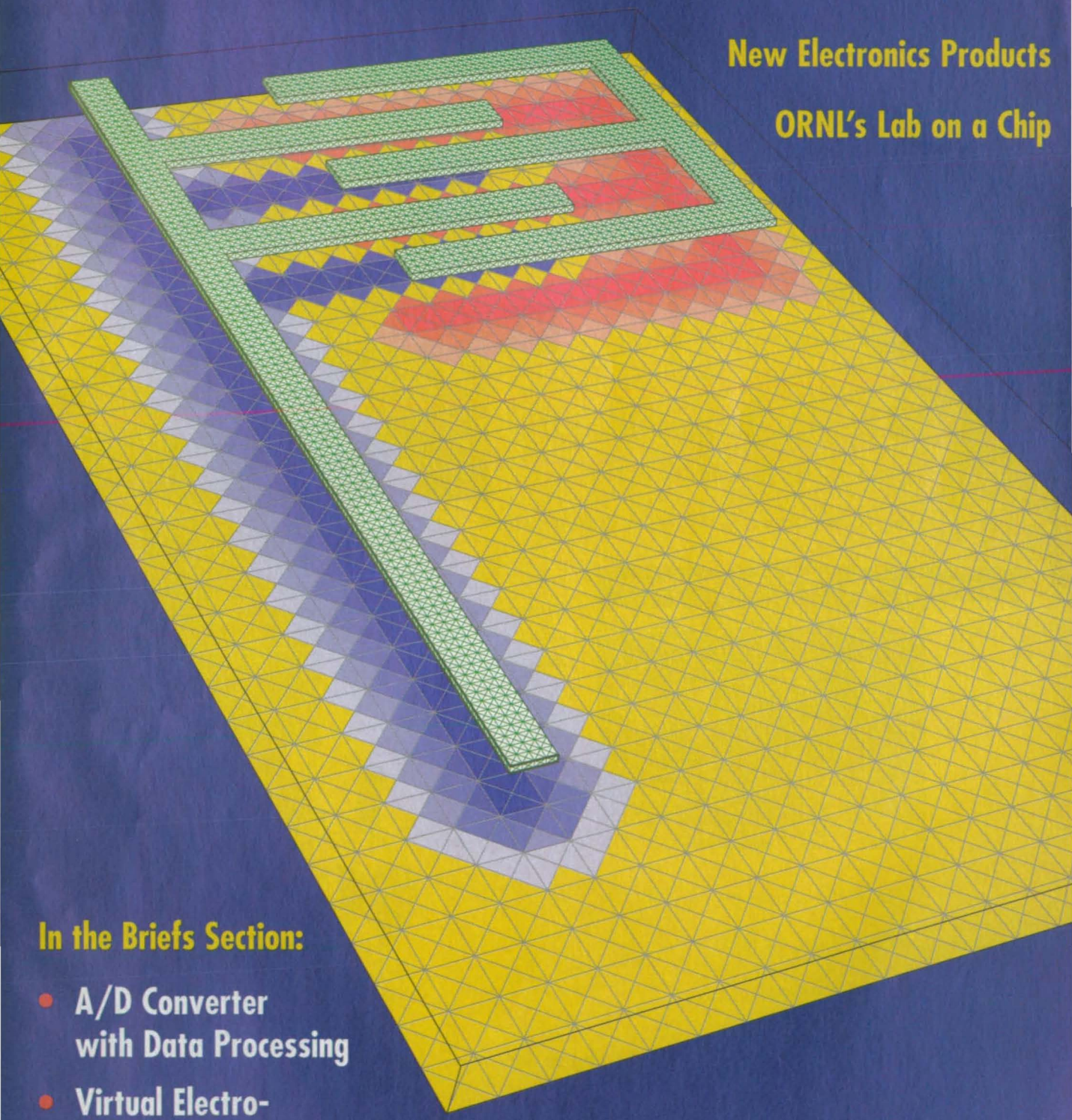


The **Leading and Trailing Edges** of a redesigned diffuser vane were constrained, as an explicit condition of the redesign, to lie at the same radii as in the original design.

Electronics TECH BRIEFS

New Electronics Products

ORNL's Lab on a Chip



In the Briefs Section:

- A/D Converter with Data Processing
- Virtual Electro-Mechanical Manufacturing

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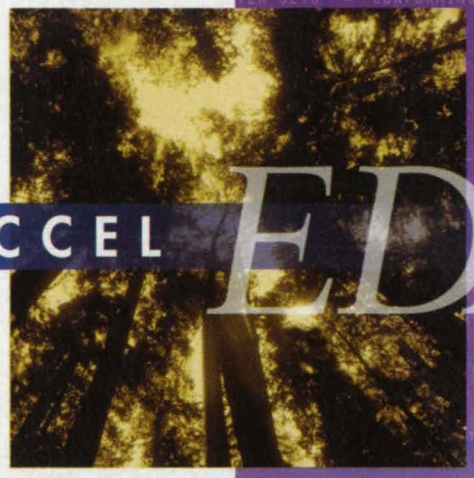

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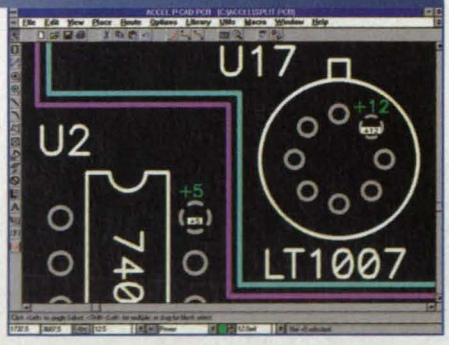

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Federal Lab Electronics Tech Briefs Supplement to *NASA Tech Briefs* July 1996 Issue Published by Associated Business Publications

ELECTRONICS TECH BRIEFS

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20a Thin-Film Electrodes with Integral Current-Collecting Grids
21a Heavily Fluorinated Resins for Electronic Applications

DEPARTMENTS

2a News Briefs
22a New Products

On the cover:

The cover shows a comb drive, a common element in microelectromechanical systems (MEMS) design. This silicon structure requires both electrostatic and mechanical problem-solving techniques to simulate device behavior accurately. The structure shown was modeled with Microcosm Technologies' MEMCAD, a fully integrated design suite for MEMS. See "New Products," page 22a.

Photo courtesy Microcosm Technologies Inc.

NEWS BRIEFS

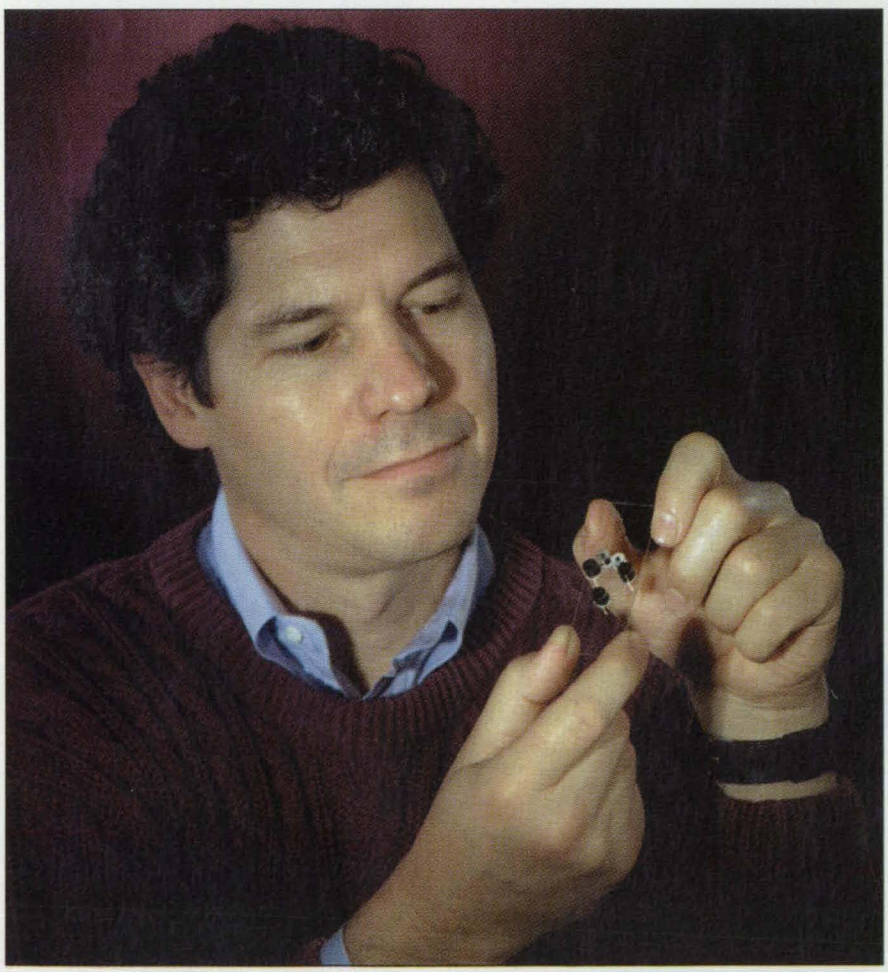
Notes from Industry and the Federal Laboratories

Two scientists at Oak Ridge National Laboratory (ORNL), Mike Ramsey and Stephen Jacobson of the Chemical and Analytical Sciences Division, have developed a microchip for analyzing DNA and for other kinds of molecular screening and research. Called MicroBioLab, the tiny device has several advantages over current methods: the sample amounts—often of expensive or hard-to-get materials—are as much as 10,000 times smaller than those of conventional instruments, it is completely computer-controlled, and it can do a DNA analysis using enzymes in just 5 minutes instead of the hour required by the conventional technique.

The glass microchip, thin as a microscope slide, is etched to form interconnected chambers and channels just beneath the surface. Electrodes near the chip apply an electrical field to pump the charged molecules of the minuscule liquid sample, mixed in the chambers, through the channels—a process called electrokinetic transport.

The molecules are saturated with a fluorescent dye and then enter a separation channel, where they are sorted by size and electric charge. When a laser beam shines on them, the dye in the molecules emits light: the larger the separated fragment, the stronger the fluorescence. A detector records the various light intensities, and the information is sent to a computer as a profile of the molecular structure. The MicroBioLab has been used for the common DNA analysis technique called restriction fragment length polymorphism.

Ramsey says the chips could be adapted for use in genetic diagnosis, DNA fingerprinting, and drug research, where candidate compounds could be tested using the smallest possible samples. The Micro-BioLab, he notes, could be used to screen people for genes that predispose them to breast cancer, obesity, or bearing children with cystic fibrosis. "To make such an analysis," he says, "we eventually hope to require only a few white blood or skin cells in a tiny liquid sample. A finger-prick blood sample is a huge volume of material for us."



Mike Ramsey shows the MicroBioLab chip he and his ORNL colleagues have developed. (Photo ORNL/John Smith)

The National Institute of Standards and Technology (NIST), the microcircuitry consortium SEMATECH, and five companies have joined in an effort to develop instrumentation to support the effort to pack more and more onto semiconductor chips. Participants in the Scanning Capacitance and Electromagnetic Sensor Consortium plan to research ways of accurately measuring the relative location, or overlay, of features in successive chip layers. Successful feature placement requires metrology accurate down to below 10 nm, so the consortium will examine and compare two new methods capable of such accuracy: scanning capacitance probes and electromagnetic sensors. Corporate members are Ansoft, Bio-Rad Laboratories, Digital Instruments, KLA Instruments, and Optical Specialties Inc.

For technical information, contact Michael Cresswell, consortium project director and an engineer in NIST's Electronics and Electrical Engineering Laboratory, at B360 Technology Bldg., NIST, Gaithersburg, MD 20899-0001; (301) 975-2072; E-mail: michael.cresswell @nist.gov.

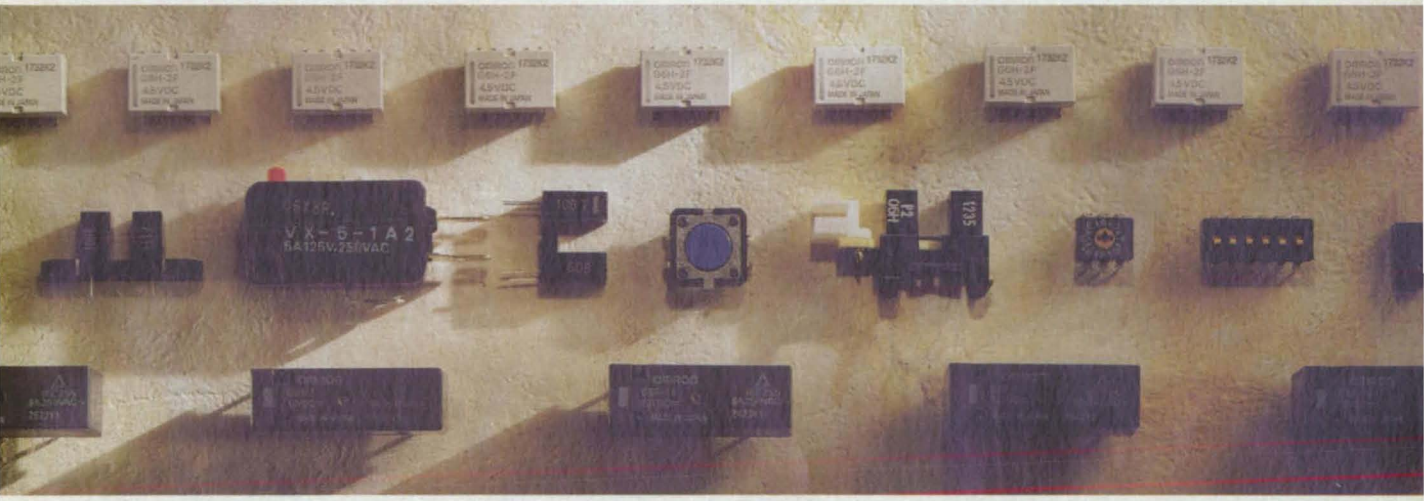
Armed with a new process to separate the carbon isotopes ^{12}C and ^{13}C from each other, NanoDynamics of New York, NY, has teamed with SI Diamond of Houston, TX, a leading producer of diamond coatings, to make improved heat spreaders for microelectronic devices. Along with better heat sinks (^{13}C isotopes in diamond can reduce its thermal conductivity), the process may lead to greater use of a new magnetic resonance imaging procedure.

The process, called solar-wind separation for the time-of-flight separation of elements observed in solar flares, uses less energy and separates isotopes faster than conventional distillation processes. NanoDynamics says it should lower the cost of enriched ^{12}C from $500 per gram to under $10 per gram.

The leftover ^{13}C from the separation process will also cut the cost of medical diagnostic studies that rely on the isotope's excellent nuclear magnetic properties. By injecting ^{13}C-glucose into a patient, doctors can study the metabolic activity of the brain and other organs, and a ^{13}C-urea pill can help detect ulcer-causing bacteria in the stomach. For more information, contact Dr. Chia-Gee Wang of NanoDynamics at (212) 249-2232.

The Materials Science and Technology Division of Los Alamos National Laboratory and the Minnesota Mining and Manufacturing Co. (3M) will cooperate in a CRADA to come up with a new electrode structure for polymer electrolyte membrane fuel cells. Researchers in the lab's Electronic and Electrochemical Materials and Devices Group are focusing on the implementation of a unique catalyst layer configuration, which may have substantial advantages in direct methanol-fueled fuel cells.

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



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Electronics
TECH BRIEFS

Virtual Factories for Electro-Mechanical Device Manufacturing

An integrated toolkit aids in design, planning, and partner selection.

Institute for Systems Research, University of Maryland, College Park, Maryland

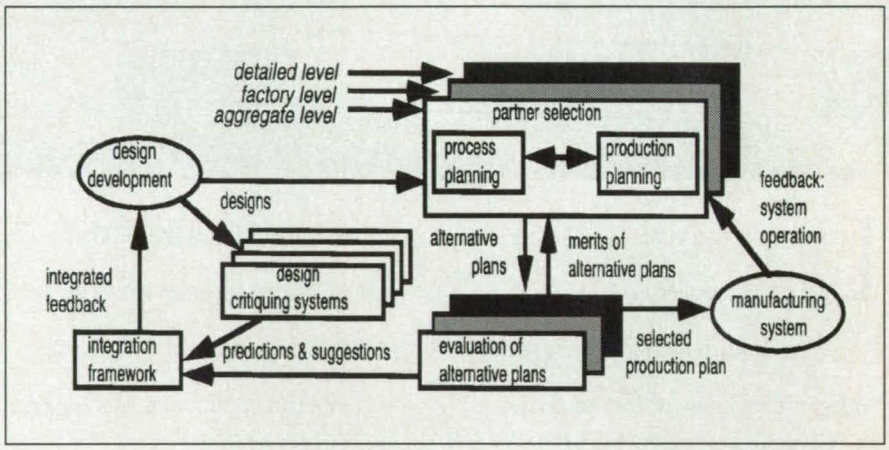
US industries are relying increasingly on virtual manufacturing enterprises organized around multi-enterprise partnerships. The Institute of Systems Research (ISR) is developing an integrated toolkit for use in the manufacture of complex electromechanical assemblies. It is cooperating with several companies and government agencies and solicits further collaborations to help diffuse the results into the industrial base.

The resulting system will assist in the concurrent performance of design critiquing, process planning, production planning, and partner selection. It will provide feedback on design performance, manufacturability, and production alternatives, taking into account the capabilities of potential partners. This will aid industrial competitiveness by providing ways to rapidly assess the cost, performance, and time to market of proposed designs.

Traditionally, manufacturing planning is done at two levels: the factory level (abstract machines and processes) and the detail level (specific machines). For virtual manufacturing, planning (and sometimes design) must also be done at a third level: the aggregate level, which involves partners and their capabilities. ISR is developing integrated methods for reasoning at all three levels, as outlined below:

• **Design.** Recently there has been a proliferation of tools for critiquing various aspects of a design (performance, manufacturability, assembly, maintenance, etc.). ISR is building a framework for integrating multiple design-critiquing systems, using tradeoff analysis to give consistent feedback to the designer. This work capitalizes on experience in building similar tools for other domains.

• **Process Planning.** To overcome the limitations that variant and generative techniques have individually, ISR is developing a hybrid variant-generative approach. By extending previous work on variant planning for microwave T/R modules, ISR is developing object-oriented variant techniques for classification, indexing, and retrieval of process plans. Using hierarchical task-network planning techniques, the retrieved plans are used as starting points for synthesizing new ones.



ISR's **Integrated Toolkit System** for electromechanical device manufacturing planning.

• **Evaluating Manufacturability.** Existing approaches are usually confined to a single plant. ISR is extending them to incorporate aggregate-level evaluation, by developing a unified model containing information on each partner's responsiveness, equipment availability, product quality, cost, and lead time. This is a decisive step towards a much-needed exchange standard for data about the capabilities of manufacturing firms.

• **Database Environment.** ISR is developing a data environment in which integrated models can have easy access to disparate data sources. By modelling various decision-making steps (e.g., product design, processing planning) as OO processes, OO constructs can be used to build decision-support capabilities such as feedback loops and man-machine interaction, and ISR techniques for integrating heterogeneous databases allow easy access to legacy systems.

• **Partner Selection and Production Planning.** ISR is extending previous approaches, providing ways to develop aggregate-level plans incorporating multiple partners. The system will synthesize alternative production plans, using an optimization model to evaluate them for product cost, quality, lead time, etc. It will suggest (near-)optimal plans to the user, and monitor the manufacturing environment to enable replanning as exceptional conditions may require.

This work is being done at the University of Maryland by faculty from several departments, including the **Institute for Systems Research,** *the Computer Science Department, the Mechanical Engineering Department, and the College of Business and Management, with funding from the National Science Foundation and the US Army Tank and Automotive*

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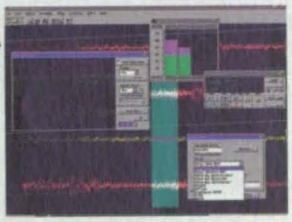

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Command. Participating faculty include Dana S. Nau (project leader), Guangming Zhang (coleader), Michael Ball, John Baras, Michael Fu, Ramesh Karne, Ioannis Minis, and V.S. Subrahmanian. Inquiries concerning rights for the commercial use of this invention should be addressed to Bob Karig, Institute for Systems Research, University of Maryland, College Park, MD 20742; (301) 405-6604; E-mail karig@isr.umd.edu.

DRAM Retention Times as Measures of Effects of Radiation

This method exploits the physical mechanisms of leakage and changes in threshold voltages.

NASA's Jet Propulsion Laboratory, Pasadena, California

The lengths of time during which the cells of a dynamic random-access memory (DRAM) retain bits without being refreshed have been found to be useful as measures of the effects of ionizing radiation (see Figure 1). This concept is the basis of an improved method for characterizing the effects of ionizing radiation on advanced, high-density DRAM integrated circuits.

A DRAM is typically implemented in metal oxide/semiconductor (MOS) circuitry. A basic DRAM cell (see Figure 2) consists of a capacitor in series with an n-channel MOS access transistor that is connected to a word line (row-address line) and a bit line (column-address line). A bit of information is stored as a charge on the capacitor. Because this charge dissipates during a time of the order of milliseconds to seconds, it is necessary to restore the charge periodically (refresh the cell) so that the cell retains its information content. In each cycle of operation, the contents of the cell are read and refreshed via the word and bit lines and the access transistor. If too much charge leaks out (equivalently, if the cell is not refreshed within a characteristic retention time, τ, then the next time the cell is read and refreshed, its readout and restored content will end up in the opposite (and erroneous) binary state.

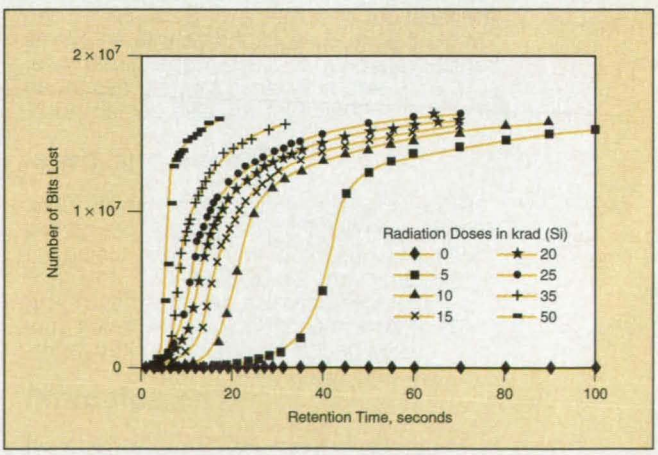

Figure 1. This **Series of Data-Loss Curves** show the effect of increasing radiation dose on the retention times of cells in a commercial 5-V, 16-MB DRAM exposed to γ rays from a ^{60}Co source at a temperature of 40 °C. The data-retention time is very sensitive to ionizing radiation and indicates internal damage, even before other electrical parameters change significantly.

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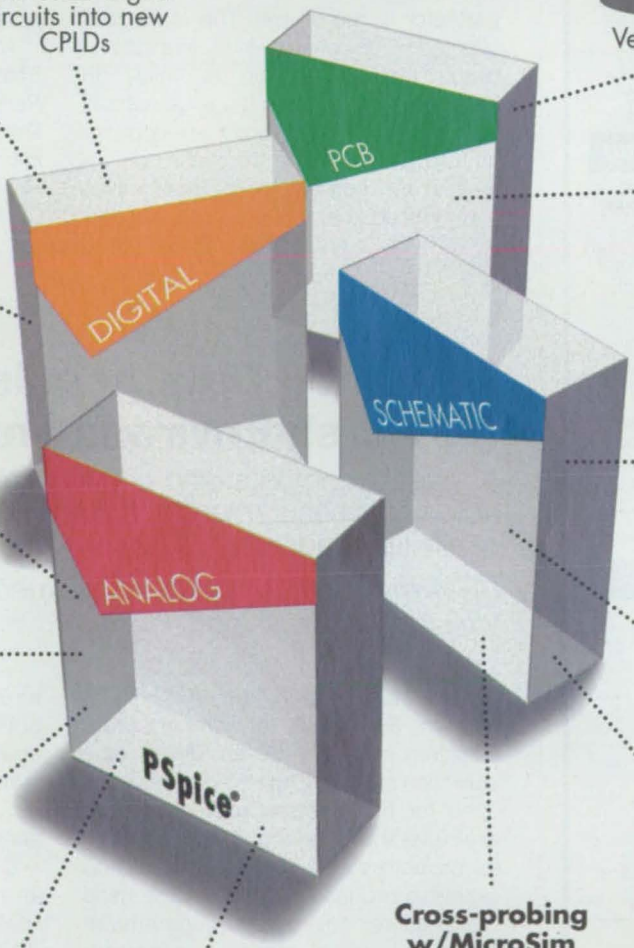

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The effects of radiation on an entire DRAM (as distinguished from a single cell of the DRAM) can be summarized in a figure of merit that amounts to an effective retention time. Either of two figures of merit can be used; the time until the first loss of a bit in the absence of refreshing, or the time until half of all bits in the DRAM are lost in the absence of refreshing.

Damage caused by ionizing radiation can affect the operation of a DRAM cell in several ways, including degrading the capacitor, altering some of the characteristics of the peripheral circuitry, and shifting the threshold voltage (V_T) of the access transistor. For the purpose of the present method, the most important component of leakage from the capacitor is assumed to be subthreshold leakage through the channel of the access transistor to the bit line. This leakage is affected by any change in V_T. In a case in which the assumption is valid, an increase or decrease in the subthreshold leakage current produces an approximately proportional decrease or increase, respectively, in τ. Thus, radiation-induced changes in V_T can be related to changes in τ via the relationships among leakage current, V_T, and other parameters.

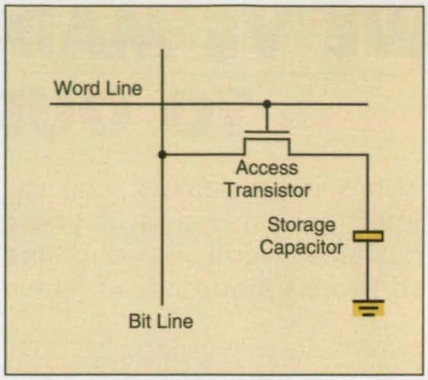

Figure 2. A **DRAM Cell** stores a bit of information in the form of charge on a capacitor. The content of the cell is read and refreshed via an access transistor.

This work was done by David C. Shaw, Gary M. Swift, and Dwayne J. Padgett of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 91*** *on the TSP Request Card. NPO-19691*

Hardened Data Acquisition System for Harsh Environments

A rugged, compact, and economical system allows accurate measurement of dynamic forces in explosive or similar conditions.

US Army Engineer Waterways Experiment Station, Vicksburg, Mississippi

The Hardened Data Acquisition System (HDAS) is a self-contained miniature shock-hardened digital data collection system. The HDAS was developed for two primary applications: for explosive/shock testing and for penetrator projectiles (see Figures 1 and 2) and explosive ordnance. But it can be used to measure any physical parameter (pressure, stress, strain, acceleration, velocity, displacement, or vibration) that is normally measured by conventional systems that require cabling. Because of its compact size, HDAS is portable and can be taken into areas where other equipment, such as instrumentation vans, cabling, etc., cannot go.

The system consists of a transducer, recorder, and two internal battery packs, and will easily fit inside a circular canister 40 mm in diameter and 150 mm deep. Such compactness was accomplished by using the latest miniature surface-mount components on both sides of a six-layer printed circuit board. Miniature high-density programmable logic devices significantly reduced the number of discrete components required.

Currently there are a single-channel and a four-channel version of the HDAS. The single-channel unit has a resolution of 11 bits and the multichannel unit 10 bits. The maximum sampling rate of both is 100,000 samples per second, and the memory size is 131,072 words per channel.

The sensor and recorder in the HDAS can be placed right at the measurement point, even if that point is very close to the explosion. The components are assembled, then covered with a semi-rigid epoxy resin to protect them from the extreme shock environments they are exposed to under test conditions. The system can withstand 100,000 g's

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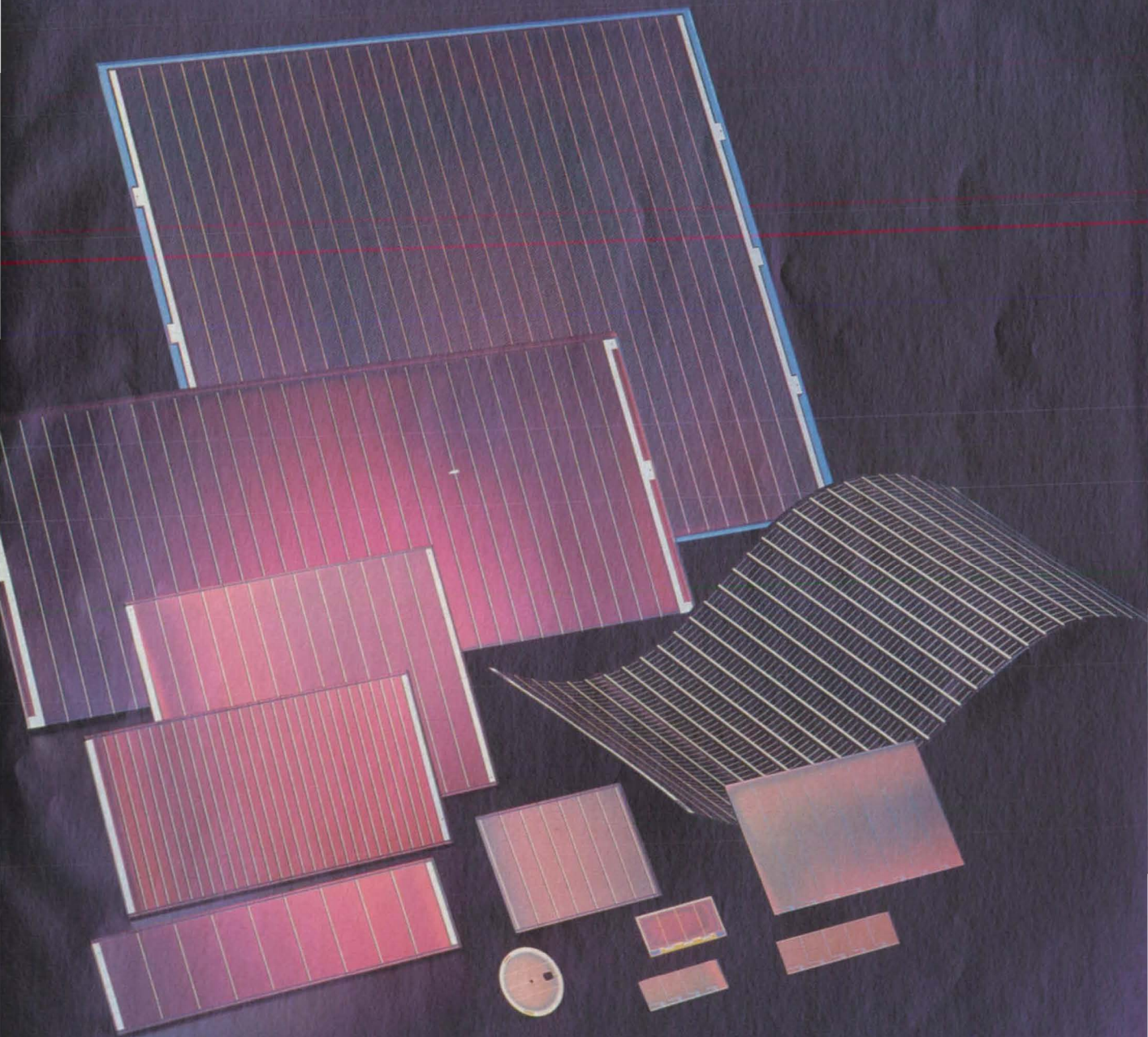
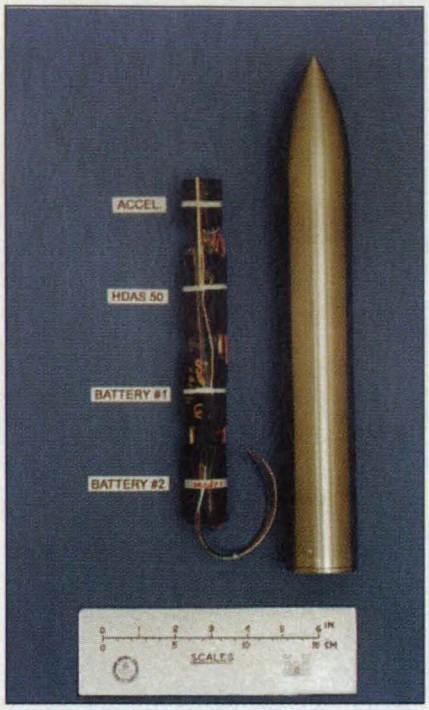


For More Information Write In No. 469

of shock and gives extremely accurate data measurements.

Approximately 10% of the system's memory is allocated for pretrigger data.



The compact **Hardened Data Acquisition System** can be placed inside a canister as small as 40 mm in diameter.

Low recorder stand-by current allows placement of the system weeks before a test is conducted. The unit will retain its memory for a period of six months after acquisition. Data is recovered via an IBM-compatible PC and report-quality engineering plots can be produced within minutes.

HDAS can be installed quickly by only two men for most explosive tests, whereas conventional data systems require much more time and manpower to install the connecting data cables, recorders, power systems, and other equipment.

Other potential uses of the HDAS system include crash tests for cars or other equipment, vibration tests, safety tests, monitoring in hazardous work areas, and use in flight recorders.

The HDAS was developed by Dr. Ray Franco for the blast-effects research work of the **US Army Engineer Waterways Experiment Station.** *For more information about the HDAS, contact Dr. Franco at (601) 634-3814.*

A patent has been issued on the Hardened Data Acquisition System (5,317,914). Inquiries concerning rights for commercial use of this invention should be addressed to the Patent Counsel, Waterways Experiment Station, 3909 Halls Ferry Rd., Vicksburg, MS 39180-6199: (601) 634-2757; or the Office of Technical Programs and Plans: (601) 634-4113.

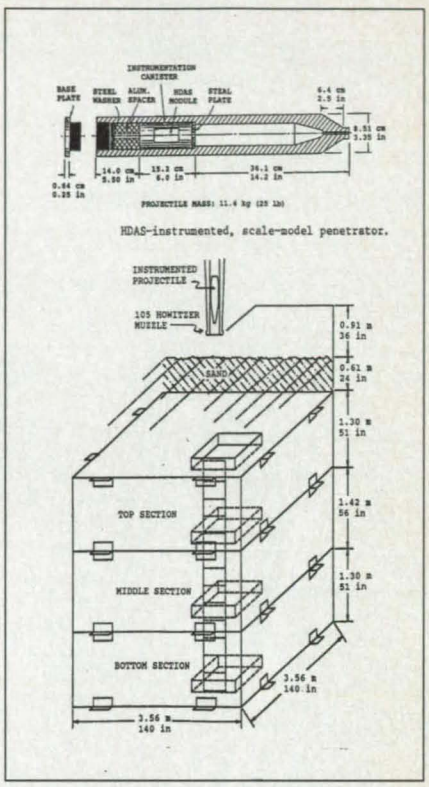


Figure 1. HDAS-instrumented **scale-model penetrator.**

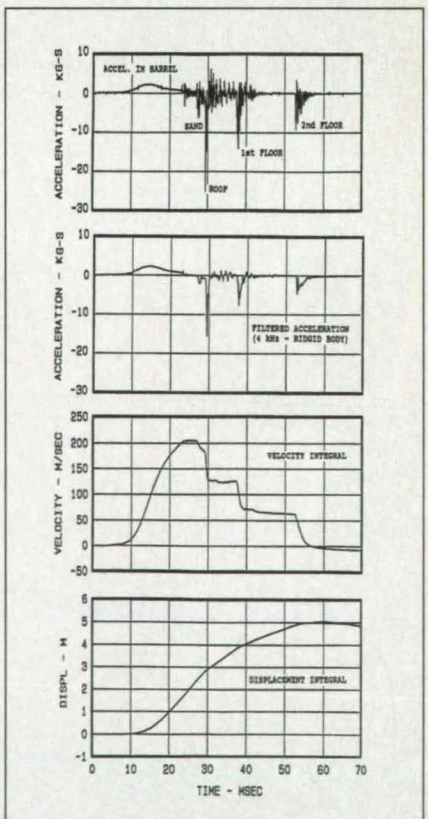


Figure 2. Measured and derived **penetrator test data.**

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• AC volts	100nV – 750V	100nV – 1100V pk	100nV – 1100V pk	100nV – 750V
• Ohms	1μΩ – 100MΩ	100nΩ – 1GΩ	1μΩ – 1GΩ	100μΩ – 120MΩ
• DC amps	10nA – 3A	10pA – 2.1A	10pA – 2.1A	10nA – 3A
• AC amps	1μA – 3A	100pA – 2.1A	100pA – 2.1A	1μA – 3A

Two Algorithms for Faster Acquisition of Carrier Signals

Acquisition and tracking would be enhanced, even without detailed advance knowledge of signal parameters.

NASA's Jet Propulsion Laboratory, Pasadena, California

Two digital-signal-processing algorithms have been proposed to accelerate the acquisition and enhance the tracking of received radio carrier signals at low signal-to-noise ratios (SNRs), even when the carrier frequencies are shifted (e.g., by the Doppler effect) in unknown amounts and at unknown rates. These algorithms are improved versions of the conventional adaptive-line-enhancer (ALE) algorithm, which offers the desired acquisition and tracking capabilities, in two modes of processing: In the acquisition mode, it functions as a band-pass filter; in the tracking mode, it functions as a low-pass filter. In either mode, the filtering accelerates acquisition or enhances tracking by increasing the effective SNR. By use of either of the two proposed algorithms, it should be possible to achieve an effective SNR 3 dB greater than that of the conventional ALE, with consequent further improvement in acquisition and tracking performance.

Figure 1 shows major functional blocks of a conventional adaptive line enhancer (as implemented by the conventional ALE algorithm). The basic ALE strategy is to compare samples of a present input signal with samples delayed from a slightly earlier time; the basis for this strategy is the assumption that the delay will cause the noise components of the current and delayed samples to become decorrelated, while the carrier-signal components will remain correlated. When a conventional ALE is functioning ideally, its output is an enhanced version of the received carrier-signal component; that is, the SNR is increased over that of the raw input signal.

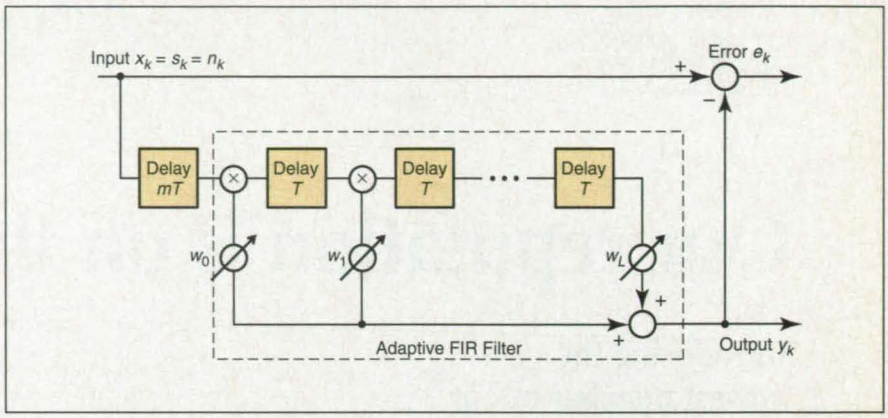

Figure 1. A **Conventional Adaptive Line Enhancer** includes an FIR filter, the weights of which are optimized and updated. The subscript k is an integer that denotes sampling time kT. The symbols xk, sk, nk, yk, and ek denote the digitized samples of the total input, the input signal, the input noise, the output signal, and the output error signal, respectively, at time kT.

The signal in the delay branch is initially delayed by an amount mT, where T is the digital-sampling period and m is chosen large enough that the broadband components of noise become decorrelated by the delay. The delay branch includes a finite impulse response (FIR) filter: Following the initial delay of mT, the signal is multiplied by a filter weight w_0, then delayed by an additional amount T, then multiplied by filter weight w_1. This process is repeated to obtain a total of L stages of multiplication by filter weight w_{i-1} (i = 1 to L) accompanied by additional delay of T. The FIR filter is adaptive: the conventional ALE algorithm includes a least-mean-squares subalgorithm that optimizes and updates the filter weights by the method of steepest descent, repeatedly striving to minimize the output error signal, e. When the adaptive filter converges to a steady state, each filter weight fluctuates about its optimal value.

From the basic ALE equations, it can be shown that the optimal steady-state gain in SNR provided by the ALE is given by $SNR_{output}/SNR_{input} = L + 1$; that is, the increase in SNR would be proportional to the length of the filter. Thus, for example, one could double the gain in the SNR by doubling the length of the filter. The two proposed ALE algorithms are intended to double the gain in SNR without as large an increase in computational load as would be incurred by doubling the length of the filter.

The first proposed algorithm is called the "adaptive line enhancer with double filtering" (ALEDF) algorithm. As shown in the top part of Figure 2, the ALEDF would include an FIR filter cascaded with the ALE as the second stage. The coefficients of the second-stage FIR would be real-time copies of those of the adaptive FIR filter in the ALE. By processing the received signal through the two identical filters, the overall gain (not to be confused with the gain in SNR) would be squared (equivalently, its decibel or other logarithmic measure would be doubled). The overall processing time would be $2(L + 1)T$. Because of the double filtering, the magnitude response of the ALEDF would feature a frequency cutoff sharper and sidelobes much lower than those of the conventional ALE.

The second proposed algorithm is called the "adaptive line enhancer with coherent accumulation" (ALECA) algorithm. As shown in the bottom part of Figure 2, this algorithm would provide a conventional ALE cascaded with a closed feedback loop containing (a) an FIR filter with coefficients copied in real time from the adaptive filter in the ALE and (b) an mT-delay unit with a gain of c. To ensure the stability of the ALECA system, c must lie between 0 and 1. The ALECA would become a conventional ALE when c = 0.

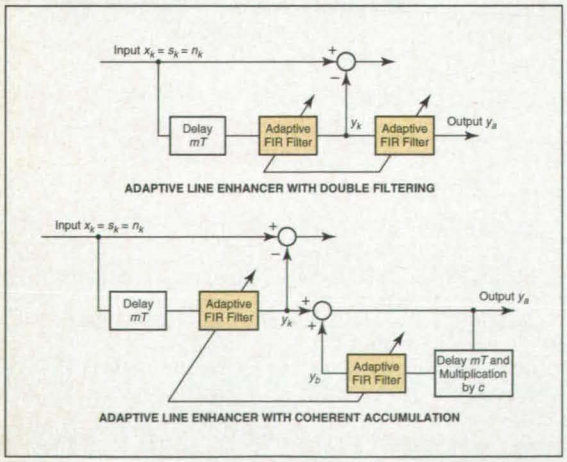

Figure 2. These **Proposed Adaptive Line Enhancers** would double the gain in SNR over that achievable by the conventional ALE, with a moderate increase in computational load.

This work was done by Hen-Geul Yeh and Tien M. Nguyen of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 84*** *on the TSP Request Card. NPO-19553*

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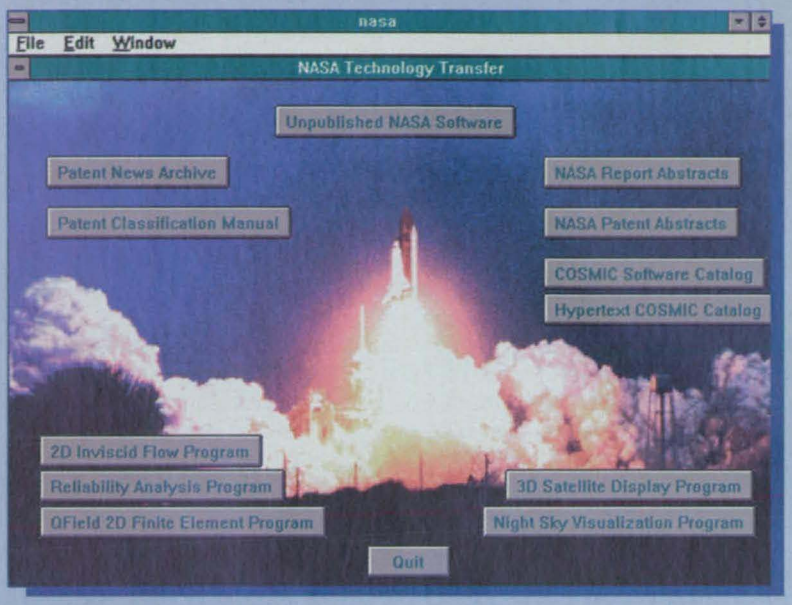

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Analog-to-Digital Converter with Data Processing

Digitized data can be processed as it is generated.

Superconducting Super Collider Laboratory, Waxahachie, Texas

A new device incorporating an analog-to-digital converter can be used to process digitized data as it is generated, off-line from the system processor.

It consists of the analog-to-digital converter for generating discrete digital data representative of an input analog signal, a data bus coupled to receive the digital data as it is generated, a 512-kilobyte memory RAM to store the data, a processing element to perform a predetermined operation on the data, and a system bus coupled to the data-processing element for outputting the results of the operation.

This is the first device to combine analog-to-digital converters and memory, the first module to be designed to the VXIbus format, and the first to incorporate an averaging circuit in the design. It has a sealed analog module (it outputs the sum and difference of the log signals for both X and Y axes of the beam-position module), memory channels, four averaging channels, a programmable trigger and digitizer clock logic, and a VXIbus interface.

The device is useful in the fields of data acquisition, data processing, communications, and electronics.

This work was done by Alan Jones for the **Superconducting Super Collider Laboratory (SSCL).** *For further information contact Dr. LeRoy H. Graw, Contracts and Technology Transfer Manager, Office of Research and Technology Applications, MS/1092, SSCL, 2275 Highway 77 North, Waxahachie, TX 75165; (214) 708-1069; FAX (214) 708-2863.*

Redundancy Protects Against SEUs in Flip-Flops in FPGAs

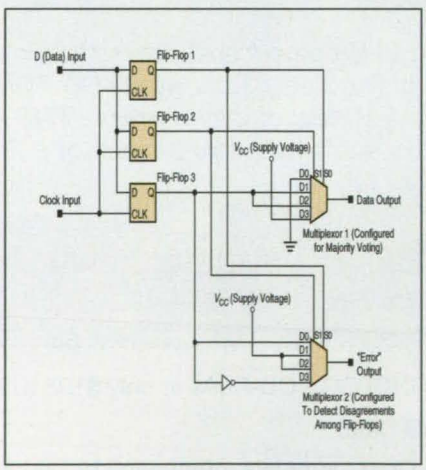
A majority-voting logic scheme is used.

Goddard Space Flight Center, Greenbelt, Maryland

Triple modular redundancy combined with a majority-voting logic scheme has proven to be highly effective in protecting against single-event upsets (SEUs) in flip-flop circuits in field-programmable gate arrays (FPGAs). [A single-event upset is a spurious change of logic state (from 1 to 0 or from 0 to 1) caused by a single impact of ionizing radiation.] Designing FPGAs to incorporate triple modular redundancy and the ancillary circuitry needed to implement the majority-voting scheme increases the sizes and power consumptions over those of the corresponding nonredundant versions. However, the disadvantage of these increases should be more than offset by the high densities, low costs, and adaptability of state-of-the-art FPGAs. Furthermore, the redundancy-based approach costs much less and results in smaller increases in circuit size than does designing nonredundant circuits to be less sensitive to ionizing radiation.

The figure illustrates an application of triple modular redundancy and majority voting to one of many D flip-flops in an FPGA. In this case, the single D flip-flop is replaced by three D flip-flops. The outputs (from the Q terminals) of flip-flops 1 and 2 are fed to the "select 0" (S0) and "select 1" (S1) terminals, respectively, of the multiplexors. [S0 and S1 denote the least-significant and more-significant bits, respectively, of the binary input that selects the data-input gate (D0, D1, D2, or D3) from which the signal is allowed to pass through to the output terminal of a multiplexor.]

The output of flip-flop 3 is fed to the D1 and D2 input terminals of multiplexor 1 and to the D0 input terminal of multiplexor 2; this signal is also inverted and fed to the D3 input of multiplexor 2. The D0 terminal of multiplexor 1 is grounded; the D3 terminal of multiplexor 1 and the D1 and D2 terminals of multiplexor 2 are connected to the power-supply voltage.



Triple Modular Redundancy and majority voting protect against an SEU or other source of error in one of the flip-flops. Optionally, an error detector (more precisely, a disagreement detector) can be activated.

The net effect of the connections to multiplexor 1 is to implement the majority-voting scheme: the output of multiplexor 1 is high (logic 1) or low (logic 0) if the outputs of two or all three flip-flops are high or low, respectively. The net effect of the connections to multiplexor 2 is to implement an error detector or, more precisely, a disagreement detector: Multiplexor 2 puts out an "error" signal if the output of one of the flip-flops disagrees with the outputs of the others. That is, an "error" signal is generated if the outputs of the flip-flops are anything other than (1,1,1) or (0,0,0).

The benefit of this scheme is that an SEU in one of the flip-flops would not affect the outcome of the majority vote. It would take a highly improbable combination of SEUs in at least two of the flip-flops during the same clock cycle to change the outcome.

The effectiveness of the scheme was confirmed in radiation tests on commercial FPGAs containing several different kinds of flip-flops in the redundant/majority-voting configuration. Of a total of 44,539 SEUs observed, only one was associated with an erroneous majority-vote outcome; furthermore, there was reason to believe that the recording of that error might, itself, have been an erroneous result caused by a spurious test signal. Register elements and J-K type flip-flops have also been designed. These circuits use self-scrubbing techniques to hold "corrected" data indefinitely.

This work was done by Richard B. Katz of **Goddard Space Flight Center** *and Rodney L. Barto of Intelsat. For further information,* ***write in 36*** *on the TSP Request Card. GSC-13659*

Three-Phase Zig-Zag Transformer with Neutral Choke

A transformer and choke combination can effectively correct overheating problems caused by closely installed nonlinear loads.

Fermi National Accelerator Laboratory, Batavia, Illinois

A three-phase 60-Hz AC distribution zig-zag transformer and choke combination suppresses harmonic currents caused by nonlinear loads in AC distribution systems.

Nonlinear loads, including switch-mode power supplies and AC drives, often cause harmonic currents in AC distribution systems. The combination of a zig-zag transformer and choke installed near loads like these helps reduce the higher harmonic currents and confines them to the neutral between the zig-zag transformer and the load, effectively reducing the amount of load current circulating through the distribution wiring and transformer.

The use of zig-zag transformers to localize neutral harmonic currents is well known, but the addition of a small choke installed in the neutral between the three-phase source and the transformer is new. For systems where the AC source impedance is substantially larger than the zig-zag transformer impedance, harmonic currents generated by other loads connected to the same AC distribution system will also flow into the low-harmonic-impedance zig-zag transformer. When that happens, little is gained in reducing harmonic currents in the distribution system. With the addition of the choke, the impedance for remotely created harmonics is increased relative to the AC source. The choke must be designed to saturate at possible fault-current values and have a harmonic impedance value several times larger than that of the AC source.

Combining the zig-zag transformer and choke can alleviate AC distribution overloads, especially in the neutral, caused by harmonics in existing installations. The IEC 555-2 standard will eventually mandate the use of nonharmonic-producing loads, but it will not be economical to replace existing equipment. The zig-zag transformer/choke combinations to limit harmonic currents can be designed into new systems.

Most modern office and data-processing equipment installations employ nonlinear switch-mode power supplies that create substantial harmonic currents in the AC distribution system and therefore cause overheating of the distribution wiring and power distribution equipment. The transformer/choke combination can be designed into existing systems or retrofitted into troubled distribution networks, both more economically and faster than other solutions, making it possible to localize harmonics much more effectively in a wide variety of systems. The addition of a choke improves the performance of a zig-zag transformer substantially.

The inventors developed the three-phase zig-zag transformer as they sought a solution to overloaded AC branch circuits in an electronics data processing room at Fermilab. But anyone who designs, specifies, and/or manufactures electrical distribution equipment could benefit from the system. Zig-zag transformers for harmonic reduction are offered by several commercial manufacturers, but none supplies transformers with an integral choke. One transformer product does not localize or reduce AC harmonics, but it is designed to withstand the extra heat losses caused by harmonic currents.

The closest competitive products to the zig-zag transformer/choke combination are harmonic trap filters made by several different companies. Such filters, which contain tuned circuits, are estimated to cost two to three times more, to be larger

in physical size, and to have a shorter life expectancy than a similar-sized zig-zag transformer/choke combination. Typically, compared with these filters, the zig-zag transformer with a choke is simpler, will last longer, and at $1100 per 5kVA unit, will cost less.

This work was done by L. Beverly, R. Hance, A Kristalinski, and A. Visser, electrical engineers at **Fermi National Accelerator Laboratory.** *Inquiries concerning rights for the commercial use of this invention should be addressed to John Venard, Head, Office of Research and Technology Applications, MS/200, Fermilab, PO Box 500, Batavia, IL 60510-0500.*

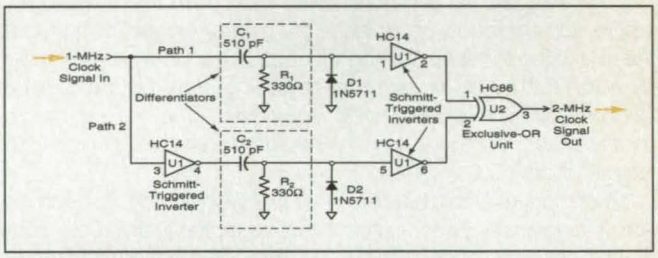
Circuit Doubles Frequency of a Digital Clock Signal

The circuit provides a stable frequency reference with no frequency jitter.

Goddard Space Flight Center, Greenbelt, Maryland

The figure illustrates a circuit that doubles the frequency of a digital clock signal. The circuit is designed to produce a stable frequency reference in the sense that its frequency-doubled output contains no significant frequency jitter beyond that of the input single-frequency clock signal.

Starting from the input terminal, the clock signal is processed simultaneously along two separate paths. On path 1, the input signal is differentiated by capacitor C_1 and resistor R_1. The designer must select the appropriate values of C_1 and R_1 as a function of the frequency; the values shown in the figure are for the example frequency of 1 MHz. A Schottky diode clamps the negative portion of the differentiated signal to protect the next signal-processing unit along the path.



The **Clock-Frequency Doubler** sharpens the leading and trailing edges of the input clock signal in two branches a half input cycle out of phase with each other, then uses the sharpened pulses to produce new clock pulses at half-input-cycle intervals (double the input frequency).

This next signal-processing unit is a Schmitt-triggered inverter. Its output is a signal at the same frequency as that of the input clock signal, but with a longer "on" period, a correspondingly shorter "off" period, and sharper leading and trailing edges on the clock pulses.

Path 2 is identical to path 1 except that the input clock signal passes through an additional inverter on its way to the differentiator. As a result, the output of path 2 is identical to, but half a cycle out of phase with, the output of path 1.

The outputs of paths 1 and 2 are fed to the input terminals of an exclusive-OR unit. Because of the half-cycle difference between the two inputs, the exclusive-OR circuit is triggered on twice during each input clock cycle, so that it puts out two clock pulses for each input clock pulse.

This work was done by David Galosky of **Goddard Space Flight Center.** *For further information,* ***write in 69*** *on the TSP Request Card. GSC-13668*

Aerosol Sampling and Concentration by SCAEP Technology

Several orders of magnitude of detection capability are achieved by combining aerosol capture technologies.

Tundra Corporation, Newton Upper Falls, Massachusetts

The Space Charged Atomizing Electrostatic Precipitation (SCAEP) air sampler/concentrator was developed to produce increased sensitivity and detection for trace aerosols. These include minute airborne concentrations of explosives, accelerants, chemical residues, and biologics.

The instrument combines conventional aerosol scrubbing with high-charge electrostatic precipitation. Air is sampled into a glass collection tube countercurrent to a fine liquid spray. The spray is produced by a two-fluid nozzle in which high-pressure air is directed at small drops of liquid exiting a stainless steel needle.

The needle is connected to a variable 0-25 kV DC power supply, producing a high positive charge on the spray. The walls of the collection tube are grounded, which attracts the charge spray and collected aerosol to the tube walls. The liquid flows by gravity to a well at the bottom of the tube and exits at a single collection point. A small centrifugal blower produces the sample air train, and a pressurized liquid reservoir and rotometer control the liquid feed rate.

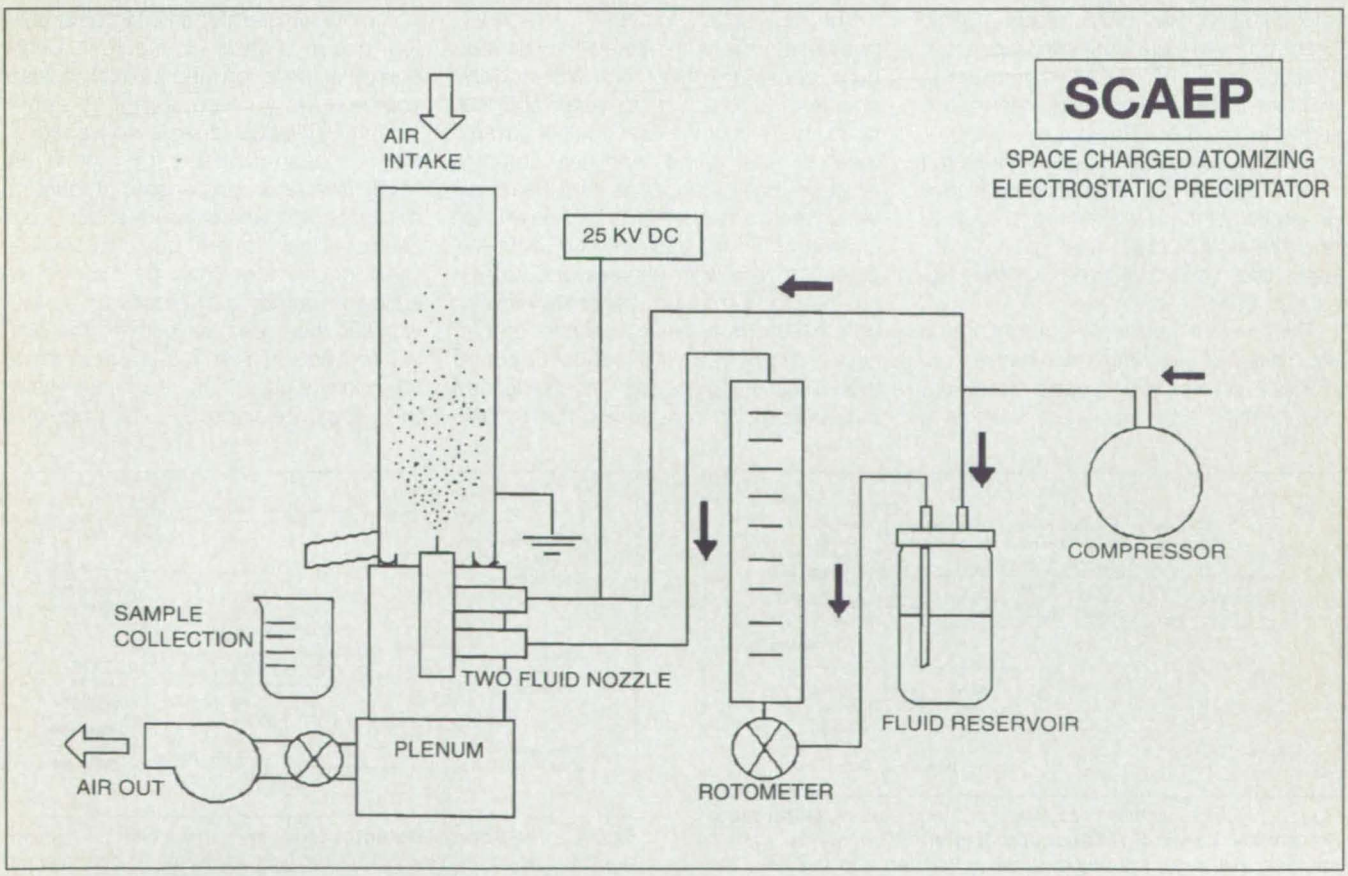
The combination of various mechanisms—impaction, diffusion, interception, adsorption, etc.—results in high collection efficiencies. Micron to submicron particle capture efficiencies are generally 75 percent to 95 percent, depending on particle size and air and liquid flow rates. Capture efficiencies for gases are 65 percent to 100 percent, depending on target gas, collection fluid utilized, and air and liquid flow rates.

Most importantly, the relatively high air sampling rate (300 liters per minute) and low liquid feed rate (0.5-2.0 cc per minute) result in aerosol concentration factors of greater than 105:1. This affords the analyst five orders of magnitude increased detection sensitivity on any mating instrumentation or analytical technology.

The collection fluid chemistry can be adjusted to reflect the target aerosol contaminant. Liquid dwell time in the collection tube is less than 30 seconds. This provides rapid response to aerosolized challenges and real-time knowledge of aerosol content.

The instrument was specifically designed for field use. It is self-contained and portable, and weighs less than 50 lbs. The unit requires only a 110/220 V AC, 50/60 Hz power source.

This work was done by Robert L. Imbaro, Erich A. Dieffenbach, and Jeffrey B. Imbaro of Tundra Corp. under the Small Business Innovation Research (SBIR) program for the **U.S. Department of Transportation's Federal Aviation Agency.** *Inquiries concerning potential commercial partnerships to develop this product should be addressed to Robert L. Imbaro, Senior Project Manager, Tundra Corp., 90 Oak St., Newton Upper Falls, Mass. 02164; (617) 964-1330; FAX (617) 332-7407.*



Schematic of the **Space Charged Atomizing Electrostatic Precipitator.**

Difference-Frequency Laser Spectroscopy in the Mid-Infrared

A source-detector module uses nonlinear optical conversion probes for organic gaseous mixtures coming out of a hollow fiber membrane.

FAA Technical Center, Atlantic City International Airport, New Jersey

Optical absorption spectroscopy has been employed in the past for detecting small levels of certain trace species in the gas phase that are present in a fixed cell volume. Single-wavelength lasers and long-multipass white cells have in the past directly and with great sensitivity detected light atmospheric pollutants with narrow absorption linewidths at reduced pressures. However, no tunable diode laser absorption spectroscopy techniques currently exist for probing for the structure of large organic molecules in the mid-infrared (MIR) region, where certain groups have their fundamental bands of absorption and where chemical spectral interference from common atmospheric constituents is less likely to be a problem.

This is primarily due to the unavailability of good-quality laser sources that are tunable over a wide enough spectral range (i.e., 6 to 8 μm) and the difficulty of implementing quantum-noise-limited detection for high sensitivity. FAA researchers have made this possible first by concentrating the more dilute organic species over the background constituents into a small cell volume, using gas-permeable hollow fiber membrane separators. Then the sample's absorbance over its broad structure is measured in the cell by the difference-frequency generation of narrow laser lines produced from the inputs of two near-infrared (NIR) lasers and the output of a nonlinear optical converter.

This system has wide applications in the areas of environmental monitoring, process control, contraband detection, and forensic analysis, where there is a need to quickly screen in the field for certain complex organic compounds that can be easily identified through the absorption spectra of their functional groups in the mid-infrared.

The choice of chemical species to be targeted for detection makes the greatest impact upon instrument design and performance specifications. For explosives, which represent molecules of interest, the source-detector module first has to overcome the limitations posed by conventional frequency-modulation spectroscopy techniques: tunability of a single diode laser source is not available to cover the range of the strongest optical absorption bands in the mid-infrared (1600 to 600 cm^{-1}, or 6-15 μm); frequency modulation is not feasible for features that are as broad as 100 cm^{-1}; solid-state laser sources available in this spectral region require cryogenic cooling, making them difficult to work with; and the sensitive detectors available in this spectral range also require cryogenic liquids, and are bandwidth-limited.

The new source system has broader tunability in the mid-infrared through the quasi-phase-matching properties available from a nonlinear converter and the tuning of the input lasers. It takes advantage of the same nonlinear mixing process that produces a third beam at the difference frequency of two beams to convert MIR light back into NIR light for detection. The laser sources and detectors needed to produce the energy flow in both directions are much cheaper and of higher quality in the NIR region, and the processes are practically instantaneous, thus possessing outstanding bandwidth. In addition, the characteristics of explosive molecules that lead to large losses prior to detection during sample-handling include low vapor pressure, polarity, and high adsorptivity. This makes the spectral acquisition from low levels of these compounds in a conventional cell more difficult, because of the lack of an adequate concentrator design matched with a cell.

The new system separates out most of the air, water, and carbon dioxide that can produce a broader background for spectroscopic analysis from the sample by a solution-diffusion process through a thin polymer coated onto a capillary tube or small fiber. Bundles of these fibers are grouped orthogonally to the direction of the air stream to reduce the incoming sample by differential permeation to a very small flow rate, one that can be introduced into a cell of very small volume. In order to make any laser spectroscopy system truly usable in the field, these technologies have to be merged to provide a reliable, confident analysis of trace levels of these types of molecules.

A block diagram of an integrated system design is shown in Figure 1. Under computer direction and control, a laser source emits a beam of light at around 1.6 μm. This light then is converted by the nonlinear converter to light in the MIR. This light propagates through a multipass cell where the retentate (concentrated gas stream) out of a capillary fiber concentrator flows by through the action of pumps and blowers. The MIR signal is then reflected back to the optical converter where it is upconverted to 1.6 microns again. The resultant beam is then easily detected by a NIR detector,

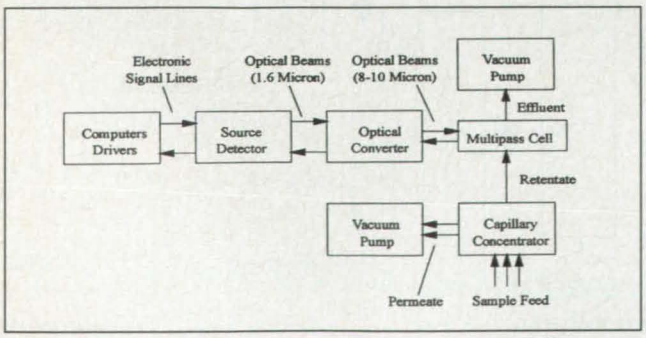


Figure 1. Block diagram for the room-temperature **Difference-Frequency Laser Spectroscopy System.** The optical system consists of the source-detector, the converter, and the cell. The sample passes through the hollow fiber capillary concentrator and then into the cell.

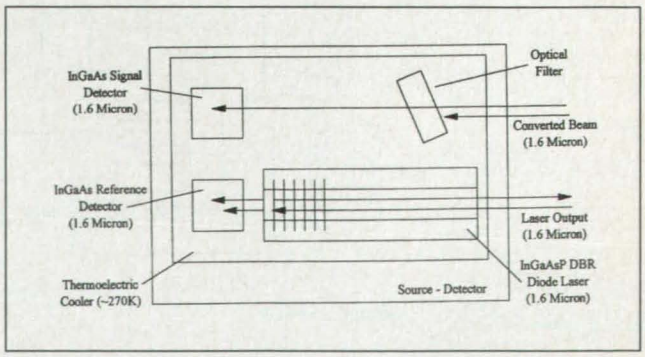


Figure 2. The **Source-Detector Module** will have both a single frequency laser to produce 1.6-micron light as well as detectors capable of receiving both the converted signal and the reference output from the laser.

and the signals are processed by circuitry and computers.

A detail of the source-detector is shown in Figure 2. All the semiconductors in this module are based on 1.6-micron operation. For detectors, this implies simple InGaAs-on-InP photodiodes. For the laser, this implies InGaAs/InGaAsP quantum-well devices. These both operate at or about room temperature, so the need for cryogenic temperature operation is gone if they are both mounted on the same cooler. The widespread availability of these devices makes it possible to implement this source and detector with a nonlinear crystal rather easily and economically.

One crystal whose phase-matching curves were measured for its potential use as a nonlinear converter in this type of device was silver gallium sulfide (AGS). Output wavelengths from 3.35 up to 5.4 µm were produced from the difference-frequency mixing of a NIR input source at 0.807 µm with the intracavity field of a low-power Nd:YAG diode laser. Single-input devices such as this, where the mixing is done in the cavity of the laser source, have been shown to produce output powers of 250 µW in the mid-infrared. By using the high nonlinearity and wide phase-matching window properties of crystals such as AGS with higher-power dual-input sources in the NIR, enough laser lines with output powers exceeding 1 mW can be generated at wavelengths that match the maximum absorption cross sections of the molecule. For an explosive molecule such as 2-Nitrotoluene (2-NT), the rotational/ vibrational bands of its functional groups are very strong from 1800 cm^{-1} to 1200 cm^{-1}, when their vapor-phase spectra were measured in a large cell (typically 100-cc volume) at elevated temperatures. This type of cell would only be used as the sample calibrant cell for the source and detector reference signal, or for storage as a reference spectrum, taken at high signal-to-noise ratios.

The monitoring of trace species was performed in a stainless steel single-pass cell of 12 cm in length and very small inner diameter (0.156 in.), using a 4.57-µm laser that was frequency-modulated to match a strong N_2O absorption line, a common decomposition byproduct of explosives. When a concentrated sample of explosives was blown through the center inlet line of the cell in a helium carrier, detection on the order of 1 pg/cc of the parent molecular concentration in the original flow was obtained with the N_2O signal produced in this cell. The linearity of the signal, measured as a fraction of the N_2O calibrant cell signal, was demonstrated over an order of magnitude.

Prior to the molecular detection in the cell, the sample had to be concentrated from a more dilute level present in a helium flow rate greater than 100 cc/min that was going into the membrane module. A cutaway view of the fiber concentrator that would be used for difference-frequency spectroscopy is shown in Figure 3.

The maximum concentration of the sample on the output side was obtained when greater than 96-99% of the incoming flow was cut to the pump side through the

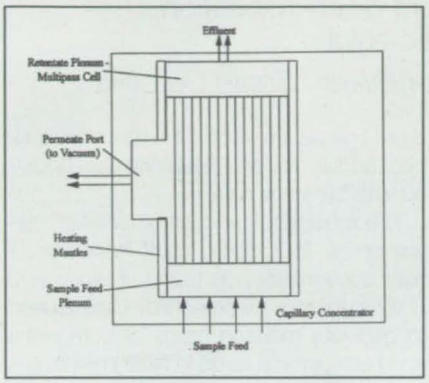


Figure 3. The **Capillary Concentrator** will pass the sample feed gas with the explosive through a bundle of permeable hollow fibers 200 microns in diameter. The majority of small molecular constituents diffuses through the walls of the fibers through the action of a pressure differential exerted by a pump, leaving the concentrated nondiffusive retentate available for spectroscopic analysis.

action of a diverter valve located downstream of the effluent. This same valve would control the residual concentrated flow rate coming out and switch it into the cell for a time interval that would match the cell volume. The concentration of 2-NT produced with a module that had enough fibers for a surface area of 100 cm^2 was 37, as measured by the increase in signal response of a chromatographic detector after switching in the sample contained in a 1-cc sample loop or volume.

It is expected that the various components of the system can be further optimized in performance with an integration scheme that suits the application. Some of the components can be scaled in size or the difference-frequency source tuning range changed if the targeted species have different absorbance properties. The time for an analysis is variable depending on the need for either better qualitative information down to 0.1-cm^{-1} resolution or quicker analysis in less than 1 second, which is possible with the various options for laser input sources that are available for this type of system. The source-detector module can be made even more compact and efficient, with no moving parts, if a dispersive waveguide is used as the nonlinear converter to phase-match the input light on a common substrate, using III-V semiconductors.

This work was done by Alvaro G. Mercado of FAA Technical Center and Frank Effenberger of Discovery Semicon-

ductors for **FAA Technical Center** *with supporting work done by SRI International, MIT, and Membrane Technology and Research for FAA Technical Center. For further information, contact Ms. Jennelle Derrickson, DOT/FAA Technical Center, ACL-1, Office of Technology Transfer, Atlantic City International Airport, NJ 08405; (609) 485-5096; FAX (609) 485-6509.*

Stored Waste Autonomous Mobile Inspector (SWAMI)

In search of safer and more efficient drum inspection, scientists have developed a robotic solution.

Savannah River Technology Center, Aiken, South Carolina

A mobile robot named SWAMI, developed by scientists at the Savannah River Technology Center, is making the tedious and potentially dangerous job of drum inspection safer and more efficient.

Department of Energy sites store tens of thousands of drums containing low-level radioactive, hazardous, and mixed wastes around the country. Regulations require weekly inspection of these drums, a monotonous, time-consuming task workers perform in hostile environments.

The robotics system improves the efficiency, documentation, and accuracy of drum inspections and inventory, while greatly reducing personnel exposure to hazardous materials.

With decommissioning of closed nuclear facilities expected to generate more waste, robotic systems will play a crucial role in future waste inspection and inventory.

SWAMI performs inspections autonomously after an inspector operating the host computer sends the robot on its way. The robot captures an image of each drum and reads the bar codes, storing the data it gathers on an on-board computer. SWAMI also transmits data back to the host computer to allow operators to monitor the vehicle's location, condition, and other relevant information in real time. After the inspection, drum images are studied to detect any suspect containers, and inventories are updated with bar-code data.

The robot also conducts a radiation survey of the floor during each inspection. If high contamination is found, it stops and notifies appropriate personnel. Data is used to generate radiation maps of both alpha and beta/gamma levels in facility aisles.

SWAMI is a modified version of the HelpMate robot produced by Transitions Research Corporation of Danbury, CT. Until now, the HelpMate has been used for hospital applications such as meal delivery to patients. Technology Center additions to this robot include off-board control and display, on-board control, radio Ethernet communications, image recording, bar-code reading, and radiation survey and radiation data display.

The on-board control system, developed by the University of South Carolina, supervises all of SWAMI's subsystems and conforms to the Generic Intelligent System Control. This computer architecture is used throughout the Dept. of Energy's robotics program to cut costs and development time and to maximize reuse and compatibility of software.

A second-generation SWAMI is under development. SWAMI II will feature an image-analysis system to identify rust spots and streaks, a structured light system and analysis system to identify drum dents and blisters, and an interface with drum computer database. The robot also will be able to navigate backward in a dead-end aisle.

Floor plans of existing and planned waste storage sites can be integrated into the robot's control and guidance components to allow it to operate in many different facilities.

This work was done by Clyde Ward for the **Savannah River Technology Center.** *The Center, operated for the Dept. of Energy (DOE) by Westinghouse Savannah River Company, is the applied research and development laboratory serving the Savannah River Site.*

The SWAMI project is part of the DOE's technology transfer initiatives and is coordinated among several federal, academic, and commercial entities. Technology Center innovations resulting from this effort are available to the private sector for commercialization.

Inquiries concerning rights for the commercial use of this invention should be addressed to the Economic Development Division, Westinghouse Savannah River Company, 227 Gateway Drive, Aiken, SC 29803; (800) 228-3843; FAX: (803) 652-1898.

Thin-Film Electrodes With Integral Current-Collecting Grids

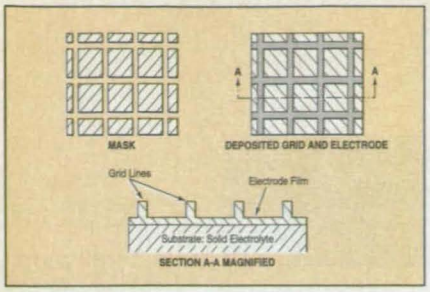
Electrodes and grids are deposited photolytically on solid electrolytes.

NASA's Jet Propulsion Laboratory, Pasadena, California

Thin-film electrodes with integral current-collecting grids can be formed on solid electrolytes by photolytic chemical-vapor deposition. Heretofore, such electrodes on solid electrolytes and the associated current-collecting grids were fabricated in steps by photolytic or sputter deposition of grids, followed by sputter deposition of electrodes. Grids and electrodes may or may not have been made of the same material. The disadvantages of that approach include contact electrical resistance between the electrodes and grids, and the potential for electrode/grid peeling and/or buckling caused by thermal-expansion mismatches.

Because an electrode and its grid according to the present concept are made of the same material in an integral unit, there is no contact electrical resistance between the electrode and grid and no electrode/grid peeling or buckling caused by a thermal-expansion mismatch. The electrode film is thin enough to allow vapor to diffuse through it while the grid lines are thick enough to provide the electronic conductivity needed to improve the performance. Electrode/grid structures of this type should prove useful in fuel cells, electrolysis cells, and alkali-metal thermal-to-electric converters, and in microdevices that include metal coatings and current-collection networks.

The technique for photolytic fabrication of an integral thin-film electrode/grid structure is based on the increase in the rate of pho-



Metal Is Deposited Thicker in the areas destined to become the grid lines, where the mask lets light through at full intensity. Elsewhere, the mask attenuates the light to cause metal to be deposited thinner.

todeposition of metal from an organometallic vapor with increasing intensity of incident light. A mask used to make this structure allows light to pass through freely in the areas where it is desired to form grid lines and attenuates light in the areas between the grid lines where it is desired to form the thin electrode film (see figure). In addition, a self-catalytic effect has been observed in photolytic chemical-vapor deposition; the rate of deposition is greater in areas where photolytically liberated metal atoms have already been deposited. This self-catalytic effect thus enhances the thickness contrast beyond that attributable to masking alone.

Thus far, the method has been used to make two sample thin-film electrode/grid structures; one of tungsten metal and one of a rhodium/tungsten alloy. In both samples, the electrode portions were 0.5 to 1 μm thick, while the grid portions were about 5 μm thick.

This work was done by Margaret A. Ryan, Roger M. Williams, Barbara Jeffries-Nakamura, and Dennis O'Connor of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 52*** *on the TSP Request Card. NPO-19444*

Heavily Fluorinated Resins for Electronic Applications

The liquid precursors have low surface tensions and high thermal resistance.

Naval Research Laboratory, Washington, D.C.

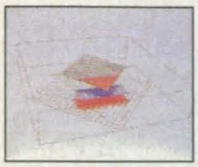
Polymers that have dielectric constants below 3.0 and can be easily produced from liquid resin precursors are of exceptional value to the aerospace and electronic circuit industries. This is because present computer operations are limited by the coupling capacitance between circuit paths and integrated circuits on multilayer boards, reducing computing speed and increasing power requirements in such circuits. Introducing fluorocarbon into the polymeric components of electronic circuit boards can reduce such parasite capacitance. This must be accomplished, however, in a manner consistent with manufacturing requirements of processability, dimensional stability, thermal tolerance, etc.

Several series of heavily fluorinated liquid resins have been synthesized for this application, of the epoxy, acrylic, allylic, cyanurate, and fluorosilicone types. In some cases dielectric constants as low as 2.10 have been obtained, which are very close to the lowest known minimum values, for the polymers produced upon *in situ* polymerization of the resins. In addition to the direct electronic properties obtained by the introduction of fluorocarbon, these liquid resins have low surface tensions, which aid in the wetting process of the fibers used for printed circuit board reinforcement, and the resulting products after resin cure are relatively insensitive to the effects of moisture. Fluorocarbon materials are resistant to surface wetting by water and form excellent barriers to molecular penetration by water molecules.

Considerable attention has been devoted to high thermal resistance in these fluorocarbon resin-polymers because of requirements in the manufacturing process. Not only is the soldering process for metallic connectors in a printed circuit board stressful to the organic components, but also the matrix polymers must withstand an annealing required of the electronic elements for a substantial period of time. For this reason heavily crosslinked systems have been emphasized, and to the greatest extent possible only molecular bonds of high intrinsic thermal stability have been selected for the cure reactions.

This work was done by James Griffith, Arthur Snow, and Leonard Buckley of the **Naval Research Laboratory** *and Henry Hu of GeoCenters Inc. Inquiries concerning rights for the commercial use of this invention should be addressed to Dr. Richard H. Rein, Head, Technology Transfer Office of the Naval Research Laboratory, 4555 Overlook Ave. SW, Washington, D.C. 20375-5320; (202) 767-3744.*

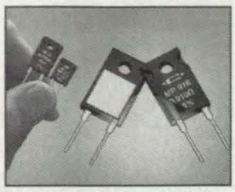
NEW PRODUCTS



MEMS Software for Next-Generation Projects

Microcosm Technologies Inc., Cary, NC, has unveiled MEM-CAD, its software for design and analysis of microelectromechanical systems (MEMS). Developed at MIT and licensed to Microcosm, the software initially is being made available to Ford Microelectronics and Texas Instruments through the company's CAD Partnership Program. The products will address 3D visualization of devices from mask and process input, general structural analysis, electromechanical analysis for capacitance-based sensors (accelerometers, gyros, and pressure sensors), and electromechanical analysis for electrostatic actuation (valves and force-balanced sensors).

For More Information Write In No. 800



TO-220 Power Resistor Extends Range Downward

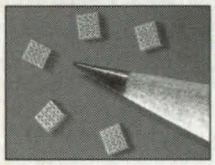
Caddock Electronics, Riverside, CA, adds the MP916 to its heat-sink-mountable power resistor family in the TO-220 package. The MP916, which extends the available resistance range down to 0.010 ohm (+/-5%), is rated at 16 W (40 A continuous current) at 25 °C case temperature. Its inductance of <10 nH suits it for critical current-sense applications for motor-control feedback, power supplies, and other power control circuits. Other models are the MP930 (0.20 ohm-5 kohms/30 W) and the MP925 (up to 100 kohms/25 W).

For More Information Write In No. 801

Photomicro-sensor Design Suppresses Backgrounds

The EE-SY 190/191 photomicrosensors from Omron Electronics, Schaumburg, IL, use miniature Fresnel lenses and angled emitters and detectors to enhance capabilities. Because the deflected beam is tightly focused, background surfaces beyond the 7-mm sensing range are suppressed, so even translucent objects can be detected. Operating ambient temperature range is -25 to 85 °C. Omron offers top-view (EE-SY 190) and side-view (EE-SY 191) models: the first is 18 (l) X 6 (w) X 9 mm (h), the second 18 (l) X 9 (w) X 6 mm (h). Each costs $7.61 and is available from stock.

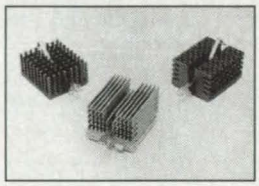
For More Information Write In No. 802



Low-Inductance Capacitor Arrays

The family of low-inductance capacitor arrays (LICA®) from AVX Corp., Myrtle Beach, SC, is specifically designed to reduce voltage spikes that occur during high-speed, high-current switching. With inductance values as low as 50 pH, LICAs do high-speed decoupling for multiple signal paths in high-frequency switching applications. Optimized to operate at 60 °C, they are available in single, double, or quad capacitor configurations. Capacitance range is from 130 nF per section in single-cap design down to 18 nF per section in the quadruple design. Inductance specifications range from 50-100 pH depending on design.

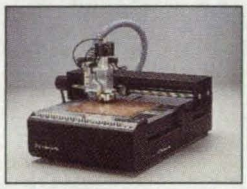
For More Information Write In No. 803



Micro-processor Heat Dissipators and Clips

IERC, Burbank, CA, has introduced a line of unidirectional heat dissipators and clips designed for Intel's P54C/P55C 150-200-MHz microprocessors. The company says the design combines superior heat removal with a smaller, lighter-weight package. An omnidirectional dissipator is also available for high-speed microprocessors offering universal airflow. IERC also offers a family of clips for a variety of circuit-board and socket applications.

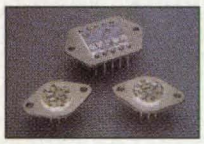
For More Information Write In No. 804



PCB Plotter for Fine-Pitch Technology

LPKF CAD/CAM Systems, Beaverton, OR, says its new Protomat 95S plotter creates accurate prototype circuit boards in one-third to one-half the time of other plotters. The unit has an automated worn-tool-change device, and full programmability of the motor and NC speed. Isolation channels as small as 4 mils can be made in such materials as FR3, FR4, Teflon, and Duriod. The air-bearing Z-axis reference foot never touches the PCB material. Price is $39,900.

For More Information Write In No. 805



Hybrid PWM Amplifiers for High Power

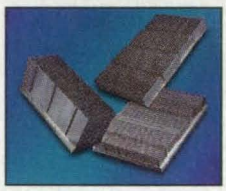
Apex Microtechnology, Tucson, AZ, offers what it calls the industry's first line of hybrid pulse-width modulation (PWM) amplifiers. With efficiencies up to 97%, the amps require less heatsinking and circuit-board space. The SA50 and SA51 come in hermetic TO-3 packages and the SA01 in a 10-pin hermetic power-dip package that requires only 2 sq. in. of board space. The SA01 switches at 42 kHz and produces 20 A of continuous output on a 16-100-V single supply, up to 2000 W of power to the load. The SA50 and SA51 produce 5 A continuous on a 16-80-V supply for up to 400 W to the load. The SA50 switches at 45 kHz, but switching frequency for the SA51 can be as high as 500 kHz.

For More Information Write In No. 806

Spring Return Selector Switch

Called by Electroswitch Electronic Products, Raleigh, NC, ideally suited for test/measurement, audio, avionics, and industrial applications, the C1 Spring Return is just 0.8 in. square, and features a return that breaks contact when released. It has three selector positions, and can be mounted in solder-lug, vertical, and rear PCBs. Variations include shaft and bushing lengths, and shorting and nonshorting versions. Pricing ranges from $5.25 to $6.50 in quantities of 5000-25,000.

For More Information Write In No. 807



Unique Heat Sinks for High-Power Electronics

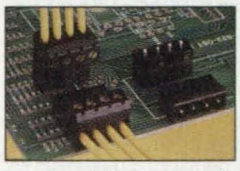
The Augmented-Fin line of heat sinks from Aavid Thermal Technologies, Laconia, NH, employ a design that substantially increases air-flow turbulence in forced-air cooling systems. According to the company, the design increases thermal performance and lowers temperature rises by 15-25% over traditional flat-fin types. The sinks are available in all custom-bonded fin sizes. Price for the smallest, suitable to cool microprocessors, is $10.00 per 500 pieces.

For More Information Write In No. 808

Current Probes with DC-100-MHz Bandwidth

Tektronix, Beaverton, OR, says that its new A6312 current probe is the first to provide a DC-to-100-MHz bandwidth. Designed to work with the Tektronix AM503 series amplifiers, the probe combines maximum continuous input current of 20 A DC and peak AC current of 50 A. It is available separately to existing owners of AM503 series amplifiers, or as Option 5 to the AM503 current measurement system. Base price is $995, or $145 as Option 5.

For More Information Write In No. 809



PCB Connectors Offer Compatibility

The Type 249 printed circuit board connectors from RIA electronic Inc., Eatontown, NJ, are designed to be compatible with industry-standard square or round pin headers. The pluggable connector, with 5.08-mm (0.200") pin spacing, can be connected horizontally or vertically to the PC board and enables easy board replacement in the field. Integral latches provide secure connection to the headers. The 2-24-position devices are rated at 15 A/300 V. Lift system contacts handle wires of 28-12 AWG.

For More Information Write In No. 810

Polyethylene Film with High Conductivity

The D/W 552 ultrahigh-molecular-weight (UHMW) polyethylene film from DeWAL Industries, Saunderstown, RI, has 100 times the conductivity of the company's conventional conductive UHMW polymer film (D/W402B). With a tensile strength of 3000 psi and an elongation of 60%, the film can be used as shielding for low-noise cable and for other electronic applications. It is available in thicknesses of 0.005-0.020 in.

For More Information Write In No. 811

Reusable Union for Joining Tubes

A mechanical connector can be tailored to preserve the flow pattern in joined tubes.

Lyndon B. Johnson Space Center, Houston, Texas

Reusable unions have been designed especially for joining tubes that contain gases at high pressures. Unlike older mechanical connectors, the reusable unions do not alter the internal geometries of the joined tubes and thus leave the original internal flow patterns undisturbed.

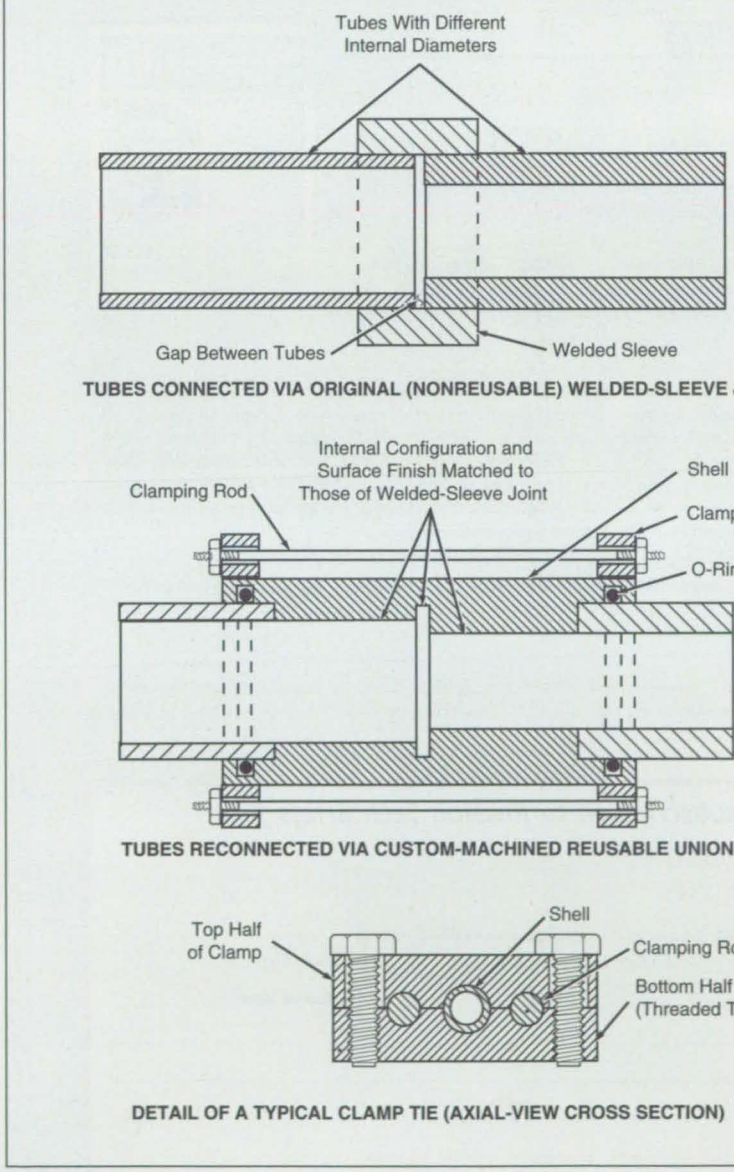
The reusable unions can be used in place of standard flared tube fittings, swaged fittings, and welded connections. They can be installed and removed easily, even on tubes or pipes of various hardnesses and dissimilar wall thicknesses. They include O-ring seals that create leaktight connections.

A representative union of this type (see figure) consists of a shell with clamp ties and O-rings at its ends. The interior of the shell is machined to match the external contours of the tubes to be joined. For example, if two pipes of different inside and/or outside diameters had previously been joined by a welded sleeve that has since been removed, the shell of the reusable union is machined to accommodate the outside diameters of the tubes and simulate the internal configuration of the original sleeve. Unlike in older mechanical connectors, there is no flaring or other distortion of the outsides or insides of the tubes. Thus, the internal configurations and surface finishes of the tubes and original sleeve are preserved.

Each clamp tie consists of halves bolted together around the shell of the union. If necessary, a pair of clamp ties can be joined by clamping rods that extend on opposite sides of the union and tubes parallel to them.

In one of many possible versions, a union of this type can be configured to provide an ultrasmooth turbulence-free flow path between pipes. In this case, it would be internally machined to eliminate edges. This version would be especially useful in a flow meter or a pressure transducer. Another version could be used to obtain a desired internal shape for an experimental study of flow in a component of that shape: for instance, if a prototype connection is not available for testing, its internal configuration can be fabricated in the union. Unions can also be configured to accommodate tubes or other components that have noncircular cross sections.

This work was done by Joseph S. Cook, Jr., and Scott W. Burge of **Johnson Space Center**. *For further information,* ***write in 37*** *on the TSP Request Card. MSC-22079*



The **Reusable Union** is machined to preserve the internal configurations of the joined tubes or of a previous nonreusable joint (here, a welded connection). The clamp ties at its ends hold the tubes securely without damaging them. The clamp bars help to secure clamp ties and to bear tensile loads.

Liftoff of Epitaxial InP by Preferential Etching of $In_xGa_{1-x}As$

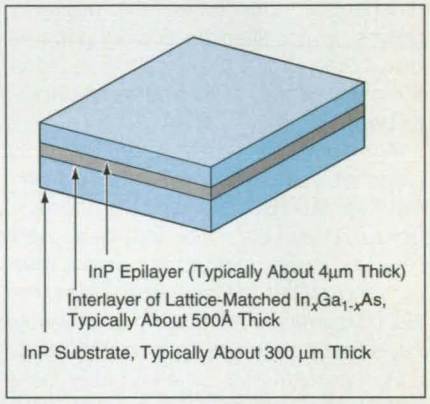
Thin InP films can be made for a variety of electronic devices.

Lewis Research Center, Cleveland, Ohio

Thin indium phosphide films can now be grown epitaxially on substrates, then lifted off in a preferential-etching process and transferred to other substrates for incorporation into a variety of electronic devices. The combination of epitaxial growth and preferential etching is called the "preferentially etched epitaxial liftoff" ("PEEL") technique.

Previously, the PEEL technique had been applied to GaAs thin-film devices, but not to InP devices. Application to InP was inhibited by lack of a suitable preferentially etchable material for the interlayers between InP substrates and the InP epitaxial thin films to be fabricated. An interlayer is required both to serve as a sacrificial release layer and to be lattice-matched to InP so that a defect-free thin epitaxial film of InP can be grown upon it.

The figure illustrates one aspect of the PEEL technique as applied to InP. First, an interlayer is deposited on an InP substrate, then the desired thin film of InP is grown epitaxially on the interlayer. $In_xGa_{1-x}As$ has been found to be a suitable interlayer material. When $x = 0.53$, the lattice constant of $In_xGa_{1-x}As$ is matched to that of InP. Thus an interlayer of $In_xGa_{1-x}As$ can be deposited as thick as desired, without adversely affecting the InP epilayer that is formed subsequently.



A **Thin Epitaxial Film of InP** is deposited on the $In_xGa_{1-x}As$ interlayer. Subsequently, the interlayer is etched away to obtain a free-standing InP film.

In preparation for separation of the epitaxial InP film from the underlying layers, black wax dissolved in trichloroethylene is sprayed onto the epitaxial layer and allowed to dry, forming a top wax layer about 1 mm thick. The evaporation of the trichloroethylene causes the wax deposit to shrink; this puts the wax in tension so that it tends to peel the InP epilayer up from the edges.

Next, the layered structure is immersed in an acid solution that selectively etches the $In_xGa_{1-x}As$ interlayer much faster than it etches the InP layers. One suitable etching solution is a mixture of 1 part HF, 1 part H_2O_2, and 10 parts H_2O. At room temperature, this solution slowly removes the $In_xGa_{1-x}As$ interlayer without etching the InP layers. As the etch proceeds inward from the edges, the tension in the wax peels the InP epilayer up from the corners; this helps to expose more of the interlayer to the solution, thereby accelerating the etch-and-liftoff process. When the inter-

layer has been removed entirely, the wax peel floats away in the solution, carrying the InP film with it.

The wax peel carrying the InP film is retrieved and handled carefully so as not to damage the film, which is fragile. After washing in deionized water to remove any remaining etching solution, the wax peel is placed on filter paper and the InP film is gently separated from the wax. Any wax residue on the InP film is dissolved in trichloroethylene. Finally, the InP film is transferred to the destination substrate.

The major advantage of the PEEL technique is that it expands the options for the design and fabrication of electronic devices that contain thin films of GaAs or InP. For example, in some cases in which monolithic growth of optoelectronic devices was difficult, the devices could be fabricated more readily if some components could be made separately by the PEEL technique, then inserted in monolithic substructures. The PEEL technique does not require sophisticated deposition equipment and thus has greater potential for commercialization, in comparison with other fabrication techniques that do require such equipment. Yet another advantage of applying the PEEL technique to InP is that the InP substrates can be reused.

This work was done by Sheila G. Bailey, David M. Wilt, and Frank L. DeAngelo of **Lewis Research Center.** *For further information,* ***write in 87*** *on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Lewis Research Center; (216) 433-2320. Refer to LEW-15760.

Crash Protection for a Welding-Filler-Wire Feeder

Marshall Space Flight Center, Alabama

A mechanism for positioning a welding-filler-wire feeder provides some protection against collisions with other welding equipment or with the workpiece. The mechanism includes a linear slide, along which the feeder can move backwards up to 1 in. (25.4 mm) against a spring load that normally keeps the feeder in the nominal position. The spring thus acts as a shock absorber in the event of a collision between the feeder and something in its path. Optionally, a limit switch could be added at the extreme of travel to stop all movements of the welding equipment and to turn off the welding power.

This work was done by David G. Emerich and Stephen S. Gordon of Nichols Research Corp. for **Marshall Space Flight Center**. *For further information,* ***write in 90*** *on the TSP Request Card.*

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-26346.

Impedance Control of a Robot With Multiple Control Inputs

The inputs are merged to compute a resultant manipulator command.

NASA's Jet Propulsion Laboratory, Pasadena, California

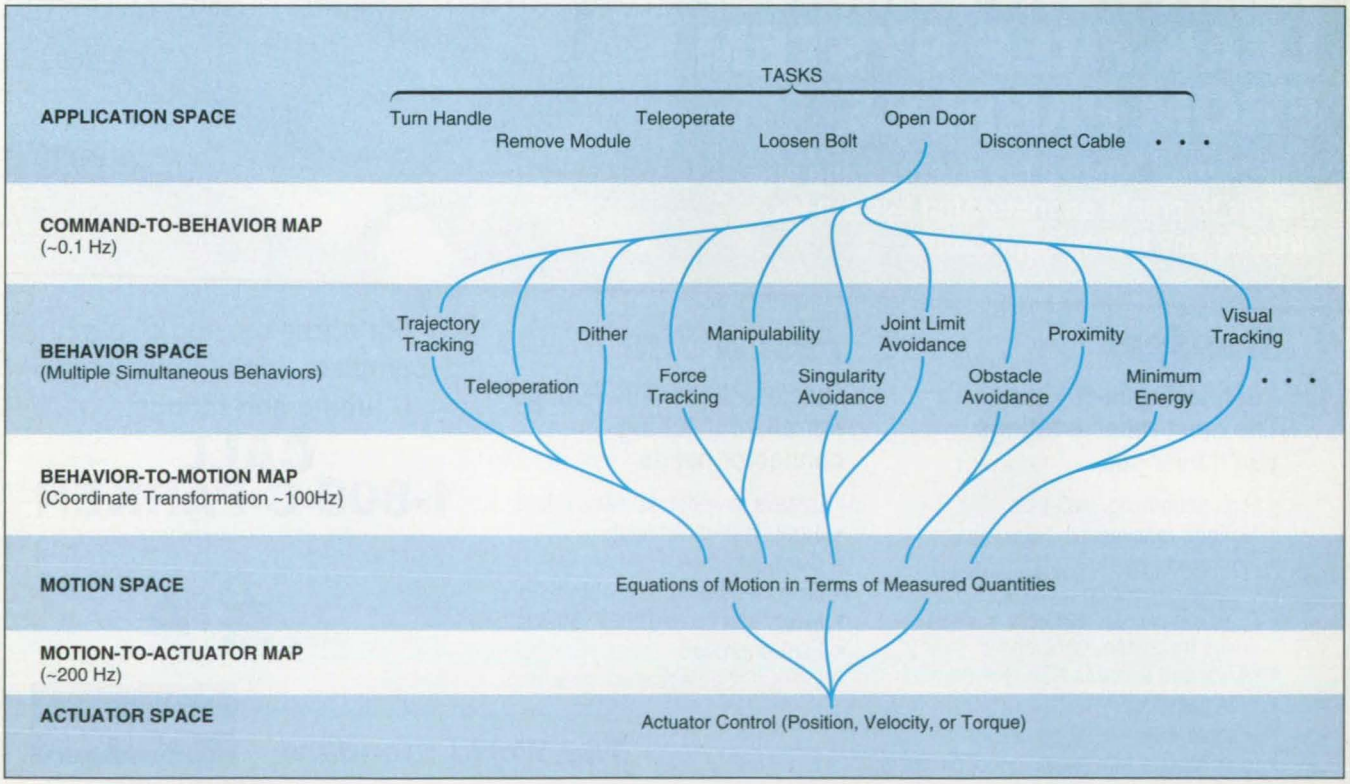
A control system based on an impedance-control concept with simultaneous inputs from multiple control sources has been developed for a kinematically redundant telerobotic manipulator. The control system has been successfully tested on a seven-degree-of-freedom manipulator.

For purposes of analysis and computation of control commands, a task is decomposed into multiple simultaneous behaviors, the combination of which results in the manipulator motion that executes the task (see figure). Each control source demands a behavior of a different type. The input from each source is generated by task-space parameterization of the corresponding desired behavior. By use of the impedance-control formalism, the inputs from all the sources are merged into a set of commands in task space, then these commands are mapped into commands specific to the task and to the manipulator mechanism(s) needed to execute the task. Each software module can be developed independently and replaced with a new one. The resulting system is independent of the specific kinematic structure of the manipulator mechanism(s).

This data-driven control architecture provides a large suite of available control modes by use of a variety of real and virtual sensors within the practical constraint of a single software system. The architecture provides a flexible remote-site controller that is well-suited for supervisory telerobotic applications. The abstraction between task behaviors and manipulator-specific mappings makes it possible to apply this architecture to a variety of mechanisms that feature task-space parameterization specified by the users. Furthermore, the number of degrees of freedom of the task space is independent of the number of joints in the manipulator.

In the present approach to control of kinematically redundant manipulators, the task-space parameterization is fixed and is of the same number of degrees of freedom as that of the robot: this is desirable for the purpose of directly controlling all degrees of freedom and eliminating uncontrolled internal motions that can pose problems of safety, collision, and cyclic motion. In addition, it is desirable to utilize all available degrees of freedom to complete kinematically challenging tasks that make unplanned demands upon the capabilities of the manipulator and/or that take place in unplanned environments or circumstances.

This work was done by Paul G. Backes and Mark K. Long of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 70*** *on the TSP Request Card. NPO-19470*



A **Task Is Decomposed** into multiple simultaneous behaviors, each of which is specified by a separate control input.

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Small Implantable Pump Would Assist Circulation of Blood

The design minimizes damage to blood cells.

Lyndon B. Johnson Space Center, Houston, Texas

The figure shows the ventricle assist device (VAD), which is a rotary pump designed to assist in pulmonary or systemic circulation of blood. The prototype VAD is only 3 in. (7.6 cm) long and 1 in. (2.5 cm) in diameter. It would be connected to the left or the right ventricle of a human heart to provide additional flow of blood to the aorta or the pulmonary artery, respectively. VADs are intended for temporary use before heart-transplant operations, or as permanent implants to assist circulation in patients whose heart outputs are chronically low. VADs may also prove useful in portable blood-pumping units for field service, and in other applications in which miniature pumps are needed.

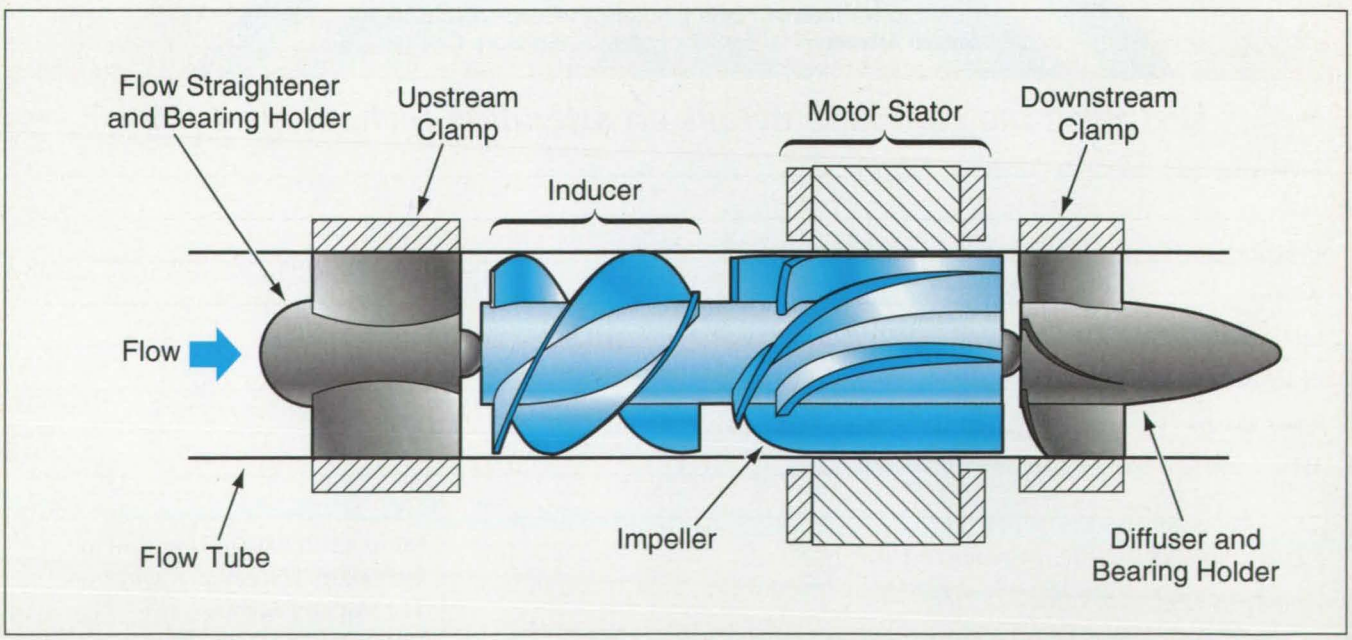
The parameters of the pump design were chosen carefully to minimize hemolysis (essentially, rupture of blood cells). The choice of parameters was guided by the results of a series of experiments on model pumps, using bovine blood. To minimize the number of experiments, each pump parameter was independently optimized for minimum hemolysis, then used in the design during experiments to optimize the remaining unoptimized parameters.

The pump features an impeller and inducer on a shaft with sapphire bearings at both ends. The impeller/inducer combination provides a two-stage pumping effect for high efficiency in a small package. Blood enters the VAD through a flow straightener, which also serves as a structural support for the bearing at the upstream end of the rotor shaft. The inducer imparts some axial momentum to the blood and sets the blood into rotation to reduce the damage that occurs in the subsequent encounter between the blood and the impeller. After receiving additional impetus from the impeller, the blood flows past the vanes of a diffuser, which decelerates the rotational component of flow, redirecting the outflow in the axial direction. The diffuser also acts as a structural support for the bearing at the downstream end.

Rare-earth magnets are placed within the impeller blades. These magnets serve as the rotor magnets of a built-in brushless dc motor. An external electronic motor-drive circuit supplies power to a three-phase stator winding on the outside of the pump. The feedback used to control the commutation of the windings is obtained from the back-electromotive force in the windings. Electric power can be obtained from a battery or other source with a potential between 12 and 32 V. The VAD can pump blood at a nominal rate of 5 L/min against a pressure of 100 mm of Hg (133 kPa) while drawing a power of 9 W; it can pump at a greater or lesser rate, depending on the patient's need.

This work was done by Richard J. Bozeman, James W. Akkerman, and Greg S. Aber of **Johnson Space Center,** *George A. Van Damm of Baylor College of Medicine, James W. Bacak and Paul A. Svejkovsky of Lockheed Engineering and Sciences Co., and Robert J. Benkowski of McDonnell Douglas. For further information,* ***write in 76*** *on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center; (713) 483-4871. Refer to MSC-22424.



The **Ventricle Assist Device** is a small rotary pump with a built-in motor. It is designed to pump blood efficiently, with minimal hemolysis.

Improved Growth of Viruses in Vitro

Viruses are grown in more lifelike artificial environments.

Lyndon B. Johnson Space Center, Houston, Texas

An improved process for the in vitro propagation of viruses in human cells is effected in a horizontal rotating bioreactor like that described in "Simplified Bioreactor for Growing Mammalian Cells" (MSC-22060) *NASA Tech Briefs*, Vol. 19, No. 12 (December 1995), page 24. The process shows potential for supplying ample viral material for research on viral infection mechanisms, transportation of viruses from one host to another, and chemical and immunological treatments. In the past, lack of adequate supplies has hindered viral research in many areas.

By selective use of cells in which the virus thrives, the process yields large quantities of viral material that faithfully replicates the parent virus. The process cultures viruses that are difficult or impossible to propagate, or that mutate excessively, in the conventional methods that involve the use of live animal cells, standard cell lines, or explants from cadavers. Among such difficult-to-culture organisms are the hepatitis virus and the AIDS virus.

In a demonstration of one version of the process, a bioreactor vessel with a volume of 110 mL was filled initially with a culture medium to which microcarrier beads had been added at a concentration of 20,000 per milliliter. Fibroblast cells from a human small intestine were added at a concentration of 200,000 cells per milliliter.

As the vessel was continuously rotated, the cells attached to and eventually covered the beads and continued to grow until the cells and beads joined together in aggregates containing groups of four to ten beads each. Then normal small-intestine epithelial cells were added at a concentration of 200,000 cells per milliliter. When the aggregates were fully covered by epithelial cells, a sample of viruses was injected into the vessel. At intervals of 24 hours during the subsequent incubation time of 20 days, half the culture medium was replaced by fresh medium and the part removed was assayed for viral products. The assays showed that the viruses had infected the cells and continued to reproduce themselves throughout the 20 days.

This work was done by Glenn F. Spaulding of **Johnson Space Center** *and Thomas J. Goodwin of Krug Life Sciences. For further information,* ***write in 23*** *on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center; (713) 483-4871. Refer to MSC-22122.

Books & Reports

These reports, studies, and handbooks are available from NASA as Technical Support Packages (TSPs) when a Request Card number is cited; otherwise they are available from the NASA Center for AeroSpace Information.

Materials

Making Porous Polymeric Materials

A brief report discusses an extension, to porous polymeric materials, of a method for making distributed-pore-chemistry (DPC) solids. DPC solids display pore-surface chemistries, which vary as a function of location in the porous solid. A porous membrane, which is hydrophobic on one side and hydrophilic on the other, is a simple example of a DPC solid.

This work was done by Steve Koontz of **Johnson Space Center.** *To obtain a copy of the report, "Microporous Structure With Layered Interstitial Surface Treatment, and Method and Apparatus For Preparation Thereof: Porous Polymers,"* ***write in 3*** *on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center; (713) 483-4871. Refer to MSC-22419.

Mechanics

Remedy for a Yaw-Control Irregularity in GPS Satellites

A report discusses the remedy for a yaw-control irregularity that arises in satellites of the Global Positioning System (GPS) when their orbits take them into solar eclipse (in the shadow of the Earth). The attitude-control system (ACS) of a GPS satellite measures yaw by use of a pair of Sun sensors, the outputs of which fall to zero during eclipse; when this happens, the ACS becomes driven by noise, causing the satellite to yaw unpredictably.

The remedy includes superimposing, on the outputs of the Sun sensors, a bias equivalent to a yaw error of 0.5°.

A complete model for the yaw attitude of GPS satellites with biased ACS is provided.

This work was done by Yoaz E. Bar-Sever of **NASA's Jet Propulsion Laboratory**, *and Joseph A. Anselmi of the Aerospace Corp. To obtain a copy of the report, "Fixing the GPS Bad Attitude: Modeling GPS Satellite Yaw During Eclipse Seasons,"* ***write in 58*** *on the TSP Request Card. NPO-19627*

New on the Market

Product of the Month

Fluke Corporation, Everett, WA, has introduced the handheld ScopeMeter® B 100 MHz **dual-channel test tool**, which features a cold-cathode, fluorescent backlit display that is ten times brighter than previous ScopeMeter displays. It incorporates a 5 MHz true-rms digital multimeter that allows users to view waveforms and meter readings simultaneously. The unit features a 30k memory in ScopeRecord™ mode, allowing it to record and show events as long as 125 scope screens. The tool comes with a rechargeable NiCad battery pack, power adapter/battery charger, two 600V probes, test leads, probe set, and accessory case. Selected models include FlukeView software, serial interface cables, and a built-in signal generator.

For More Information Write In No. 730

National Instruments, Austin, TX, has introduced two SCXI I/O **remote data acquisition systems**, the SCXI-2000 chassis and the SCXI-2400 RS-485/232 interface module. Both include NI-DAQ® driver software and are compatible with LabVIEW®, LabWindows®/CVI, and CompentWorks™ instrumentation software. The modules provide a long-distance communications link to PCs for monitoring temperature, pressure, load, flow, and displacement.

For More Information Write In No. 725

The ACR6000 and ACR8000 **servo/stepper motion controller boards** are available from Acroloop Motion Control Systems, Chanhassen, MN. The servo and stepper outputs can be mixed and matched from the same controller. Features include 16-bit DAC outputs; a programmable logic controller; 5 Khz data acquisition; 4 MHz open or closed loop stepper; floating point electronic gearing; programmable limit switch; and C, C++, Windows, Visual Basic, and Windows NT libraries.

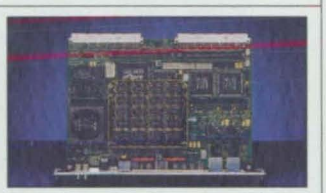
For More Information Write In No. 726

A **head-mounted optical projection system** (HOPROS) designed to replace desktop computer and video display monitors, is offered by Applied Technologies International Corp., St. Louis, MO. The device operates with a belt-pack-mounted battery and controls, and interfaces with standard computer (VGA) and video (NTSC) devices. It uses a mirrored prism in front of one or both eyes, enabling the user to see through the imagery and maintain a view of the surroundings or workpiece.

For More Information Write In No. 727

The Super LX™ **large-format digitizing system** is available from GTCO, Columbia, MD. The digitizer can be configured for different software applications. It features a composite glass fiber core and a choice of a cordless stylus pen or cordless 4- or 16-button cursor.

For More Information Write In No. 729



Force Computers, San Jose, CA, has introduced the microSPARC®-II based CPU-5VT **VME board** for embedded applications that provides VMEbus throughput and redundant I/O. Features include dual SCSI-II interfaces for connection to scanners, disks, tapes, and CD-ROM drives.

For More Information Write In No. 728

Engineering Environments System **modular engineering furniture** from Wright Line, Worcester, MA, organizes computers, instruments, cables, and other electronic components. The ergonomic system is built on a steel frame structure available in nine widths and four heights, and can support up to two tons of equipment.

For More Information Write In No. 731

Elmo Mfg. Corp., New Hyde Park, NY, has introduced the TSE-270S 1/3" black and white **CCD camera** with outside-panel controls and a four-pin square auto iris lens connector. It features an automatic electronic shutter to 1/50,000 second.

For More Information Write In No. 732

Science Accessories, Columbia, MD, has released portable **digitizer volume detector arrays** for Freepoint 3D™ three-dimensional digitizers. The arrays can be disassembled and collapsed down to a small size for transport to the object being digitized. The arrays are available in three models.

For More Information Write In No. 733

New on Disk

Metrica, Winchester, MA, has announced Release 4.2 of Metrica **data management, analysis, and visualization toolkit software**, which includes new technical graph types and tools, a database health check, online table repair, and a database lock facility. The Kingfisher graphics package allows users to configure graphs to provide statistical and numeric detail without performing additional analytic steps. The UNIX program includes an RDBMS optimized for engineering and scientific applications.

For More Information Write In No. 712

Poly Software International, Salt Lake City, UT, has released ProStat for Windows **statistical analysis and technical plotting software** for scientists and engineers. The program features a data management and analysis module; basic and advanced multivariate statistical methods; conversion of area probabilities and critical values; and mathematical methods for numerical integration and differentiation. The 16-bit edition for Windows 3.1 and the 32-bit edition for Win32, Windows 95, or Windows NT each cost $299.

For More Information Write In No. 711

Ascent Logic Corp., San Jose, CA, has introduced RDD-100 Release v.4.1 **systems engineering software** for modeling requirements and behavioral characteristics of large, complex systems. The new version features a user-configurable graphical interface, including schema aliasing and task-based visibility; customizable dictionaries; and simplified line drawing routines. It runs on UNIX platforms and will be available for PCs and Macintosh.

For More Information Write In No. 713

Mechanical Solution for Windows **design software** bundle is available from Ashlar, Sunnyvale, CA. The bundle contains Vellum 3D for Windows, a 3D drafting program; DRAFT-PAK, for dimensioning, tolerancing, and detailing machine parts; an MCAD symbol library of more than 6700 mechanical symbols; and a bidirectional DWG translator based on AutoCAD release 12 that enables Vellum to read and write .DWG files directly to and from AutoCAD. The Mechanical Solution bundle costs $1495.

For More Information Write In No. 714

Omega Engineering, Stamford, CT, offers Collect for Windows **data collection software**, which allows data collection from virtually any RS-232 instrument. Multiple applications can receive data simultaneously from different instruments. As data is received, calculations can be performed and the results displayed. The data is captured, modified for application, and sent to a keyboard buffer without affecting keyboard operation. The program can be combined with other Windows programs to provide real-time charting and plotting.

For More Information Write In No. 716

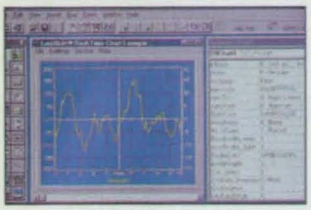
FIELDVIEW for Windows **CFD post-processor software** from Intelligent Light, Lyndhurst, NJ, is a native port to the Windows/NT environment and provides seamless integration with Microsoft Word and Powerpoint. Three-dimensional graphics are provided by Microsoft's version of Silicon Graphics' OpenGL. Other features include interactive animation of cutting planes and streamlines; support for 2D, 3D, structured, unstructured, and hybrid grids; 2D plotting; and support for NASA's PLOT3D function calculations. The program is priced at $2695.

For More Information Write In No. 715

The MacNeal-Schwendler Corp., Los Angeles, CA, has released version 5 of MSC/PATRAN **pre- and post-processing software** for MSC/NASTRAN. Enhancements include the ability to transfer geometry, FEM, and group data between users; MSC/NASTRAN interface improvements; beam modeling enhancements; a new test meshing algorithm; and an improved graphical user interface that provides a redesigned selection mechanism, a larger graphics viewport, and pop-up help. The program is available for Digital, Hewlett-Packard, IBM, Silicon Graphics, Sun SPARC, AIX, IRIX, and Solaris workstations.

For More Information Write In No. 721

New on Disk



LabOBJX Real Time Chart **data charting software** from Scientific Software Tools, Paoli, PA, is a Visual Basic control for charting real-time data in Windows. It maximizes visual display rates for creating realistic oscilloscope and strip chart displays, and works with Visual Basic, Delphi, and C++ compilers. Users assign values to the control's properties to customize axes, grids, color, drawing styles, resolution, and number of channels. The software supports up to 32,767 channels and viewports, and 16,384 points/channel screen updating. The program is priced at $199.

For More Information Write In No. 717

IOtech, Cleveland, OH, has released DaqView Version 5.0 **data acquisition and display software** that requires no programming to verify signal connections and acquire and view data in real time. New features include a display feature that incorporates any combination of display functions, including a strip-chart recorder, dial meter, bar graph, or digital display. The Version 5.0 upgrade is available for $100; a software add-on version for Excel is priced at $195.

For More Information Write In No. 718

LapCAD for Windows R6 **finite element modeling software** from LAPCAD Engineering, San Diego, CA, serves as a front-end for MSC/pal2 on PCs and MSC/NASTRAN on workstations. It runs on Windows 3.1, Windows 95, and Windows NT to simplify the creation of finite element analysis models. It can be used as a solids modeler or 3D visualization program, and accepts CAD data in DXF and IGES ASCII files. A 2500-node version is available for $295; a 5000-node version is $395; and a 15,000-node version is $595.

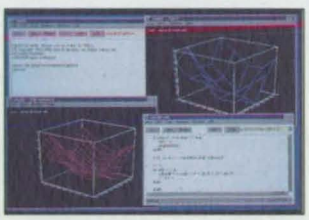
For More Information Write In No. 719

Salix Systems, Schiller Park, IL, has introduced release 2.2 of DocStor **document management software**, a UNIX-based program that provides graphical administrative functions, end-user customization options, and application integration capabilities. The release features expanded information search capabilities and more detailed query and viewing of multiple versions of historical documents. Prices start at $4995.

For More Information Write In No. 720

Tecnomatix Technologies, Novi, MI, has introduced ROBCAD/Man **human operations simulation software**, which provides manufacturing engineers the ability to simulate human operations for ergonomic improvement. It uses biomechanical human models of various heights, weights, and ages to enable predictions of how humans will function in manufacturing environments. Engineers can locate potential hazards as the human models move between workstations and perform tasks. Video output can be used for training purposes.

For More Information Write In No. 723



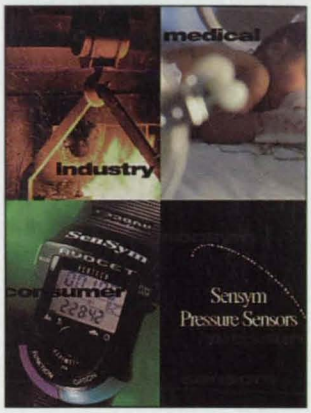
DesignCAD 3D for Windows 95 **design and drafting software** from ViaGrafix, Pryor, OK, provides .DWG file transfer capability, OLE automation for increased speed, digitizer support, an improved user interface, and customization capabilities. It offers solid modeling, surface construction, design, realistic rendering, 3D animation, and 3D text and dimensions. A 2D drafting mode for creating and working on drawings also is offered. The program is available for $499.95.

For More Information Write In No. 722

A 32-bit native version of GAUSS **mathematical and statistical system software** for Windows 95, Windows NT, and OS/2 is available from Aptech Systems, Maple Valley, WA. The GAUSS programming language performs computationally intensive tasks such as solving large-scale problems. The basic unit of analysis in GAUSS is a matrix, resulting in a syntax closely resembling common mathematical expressions. The software features a source-level debugger; a function library; enhanced data handling capabilities; foreign language interface; and 2D, 3D, surface, and contour graphing options. DOS versions are priced from $995; OS/2 and Windows versions begin at $1295; and UNIX versions start at $1995.

For More Information Write In No. 724

New Literature

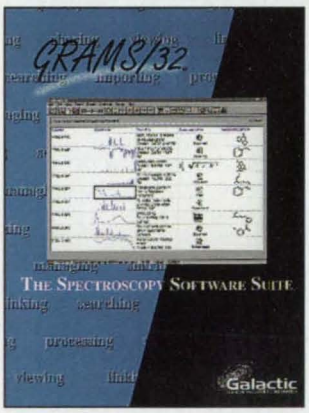


A six-page brochure from SenSym, Milpitas, CA, describes **pressure sensors and transducers** made of plastic, ceramic/zinc, metal, and stainless steel. Technical specifications are included for each type of sensor. Applications include medical diagnostics, instrumentation, and process control.

For More Information Write In No. 706

Reid Tool Supply, Muskegon, MI, offers a Spring/Summer 1996 catalog of **tools**, including clamps, tooling components, knobs and wheels, latches and hinges, leveling and vibration mounts, and positioning devices. Fasteners, instruments, bearings and couplings, springs, hand and power tools, and reference books also are featured.

For More Information Write In No. 700



Galactic Industries Corp., Salem, NH, offers a 12-page brochure on GRAMS/32 **spectroscopic software**, an integrated suite of scientific software tools. Described are program features such as data importing, processing, viewing, and organizing; the Macro Wizard visual programming tool; and Spectral Notebase, which enables storing of information and graphics.

For More Information Write In No. 709

Jensen Tools, Phoenix, AZ, has released a 72-page catalog of **electronic tools**, including test equipment, computers, network equipment, hand tools, power tools, and lighting products.

For More Information Write In No. 705

A 320-page catalog of **electronic hardware** is available on CD-ROM, diskette, or in print from Accurate Screw Machine Co., Fairfield, NJ. The CD and diskette versions allow users to import ANSI standard drawings into their CAD software. The catalog contains captive screws, locking fasteners, spacers, and washers.

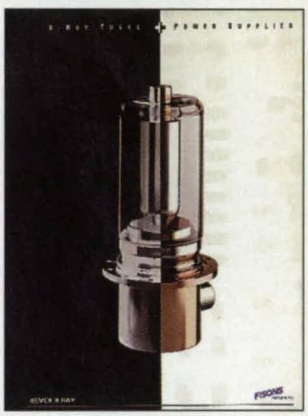
For More Information Write In No. 701

Lauren Manufacturing Co., New Philadelphia, OH, offers a 32-page guide to designing **extruded seals, gaskets, and weather stripping**. Sections on the extrusion process, selecting materials, and seal and gasket design are included.

For More Information Write In No. 703

Technical Necessities, Saugerties, NY, has introduced a 176-page Buyers Guide of **audio and video products**, including cables, connectors, adapters, amplifiers, generators, and test equipment. Product specifications and pricing are provided.

For More Information Write In No. 707



Kevex X-Ray, Scotts Valley, CA, has released an eight-page brochure describing **x-ray tubes and power supplies**, including KM Series tubes and microfocus power supplies, and PXS and PSM x-ray sources.

For More Information Write In No. 702

A four-page brochure describing **measurement systems** using ultrasonic technology is available from Ultrasonic Arrays, Woodinville, WA. Bond, thickness, and distance measuring systems incorporating ultrasonic sensors are featured, as well as inspection software.

For More Information Write In No. 704

Industrial computer systems are described in a 12-page brochure from Pro-Log Industrial Computers, Monterey, CA. The systems are based on the CompactPCI, PCI Bus, ISA Bus, or STD Bus. Available services include design, printed circuit board layout and assembly, and failure analysis.

For More Information Write In No. 708

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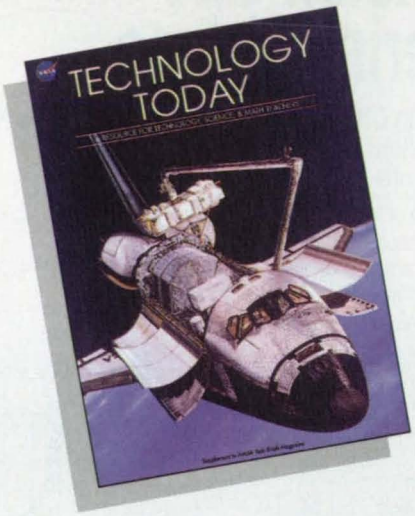

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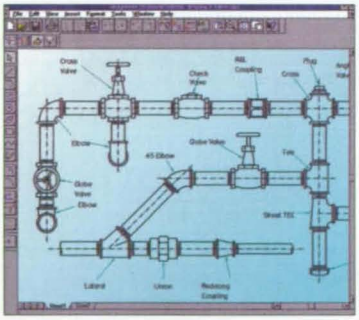

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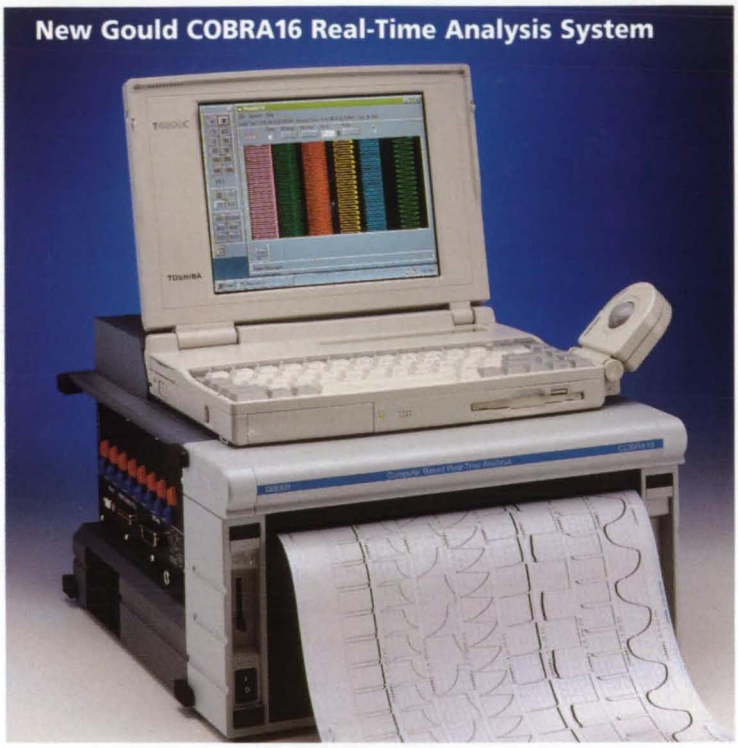

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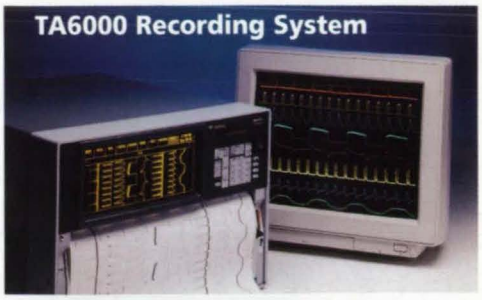

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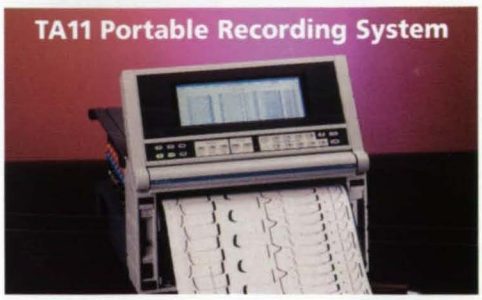

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