August 2000

Vol. 24 No. 8

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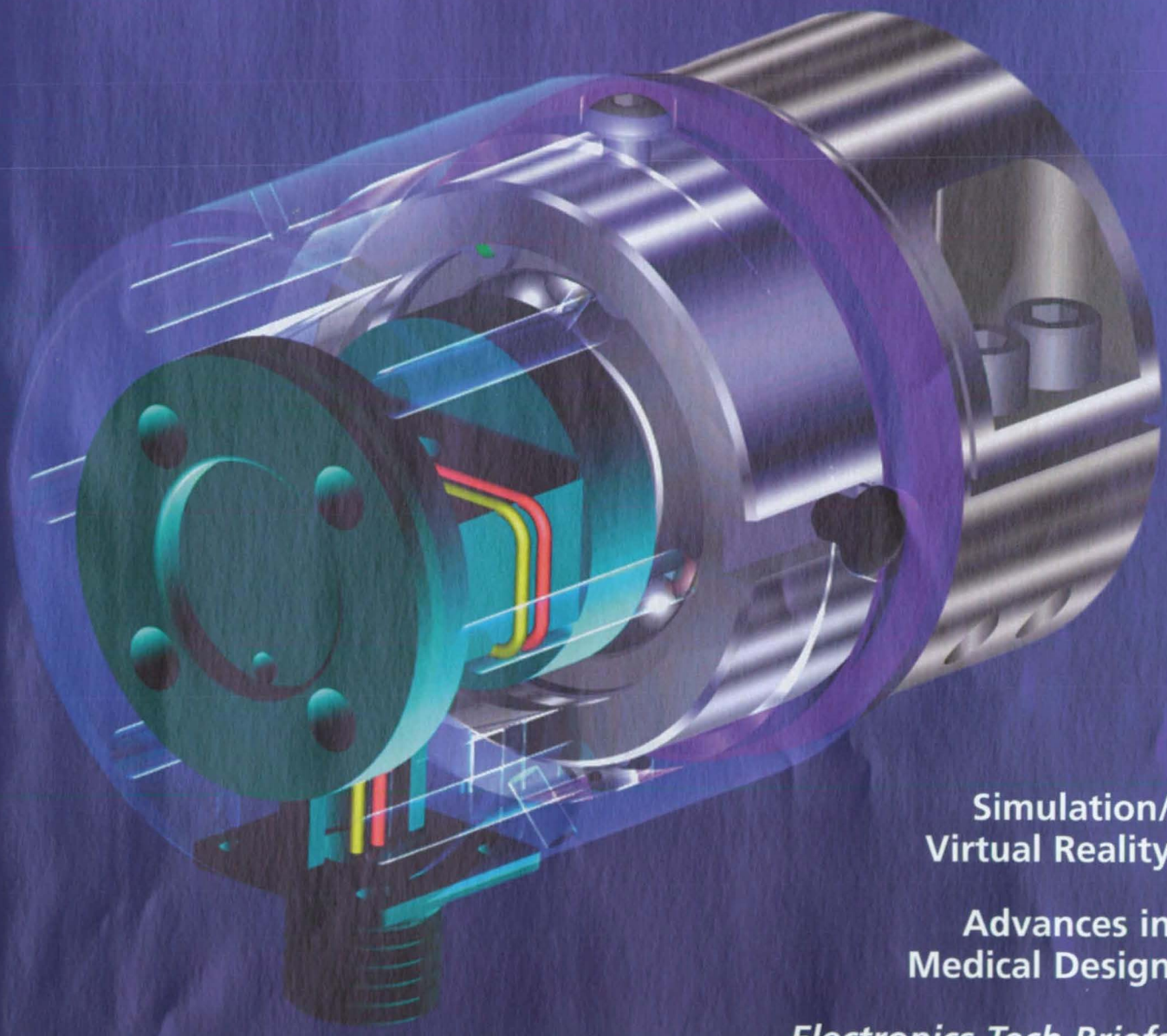
ENGINEERING SOLUTIONS FOR DESIGN & MANUFACTURING



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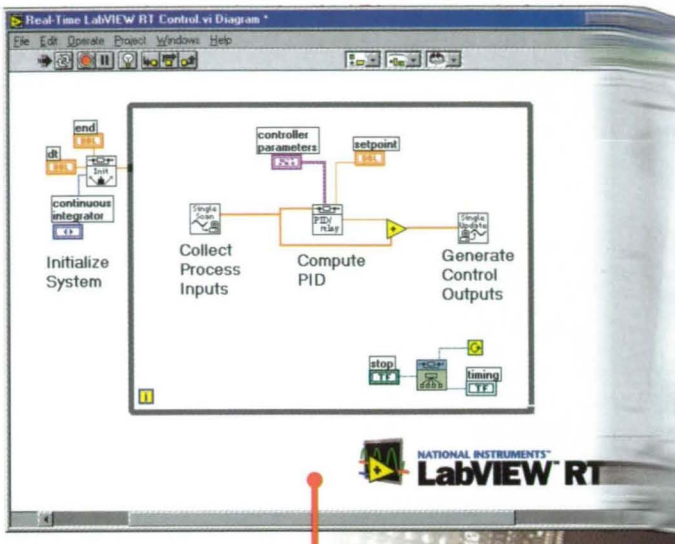

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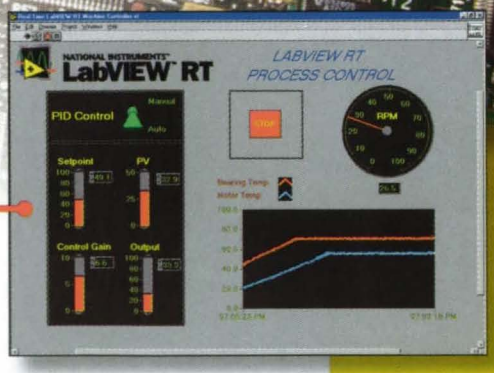

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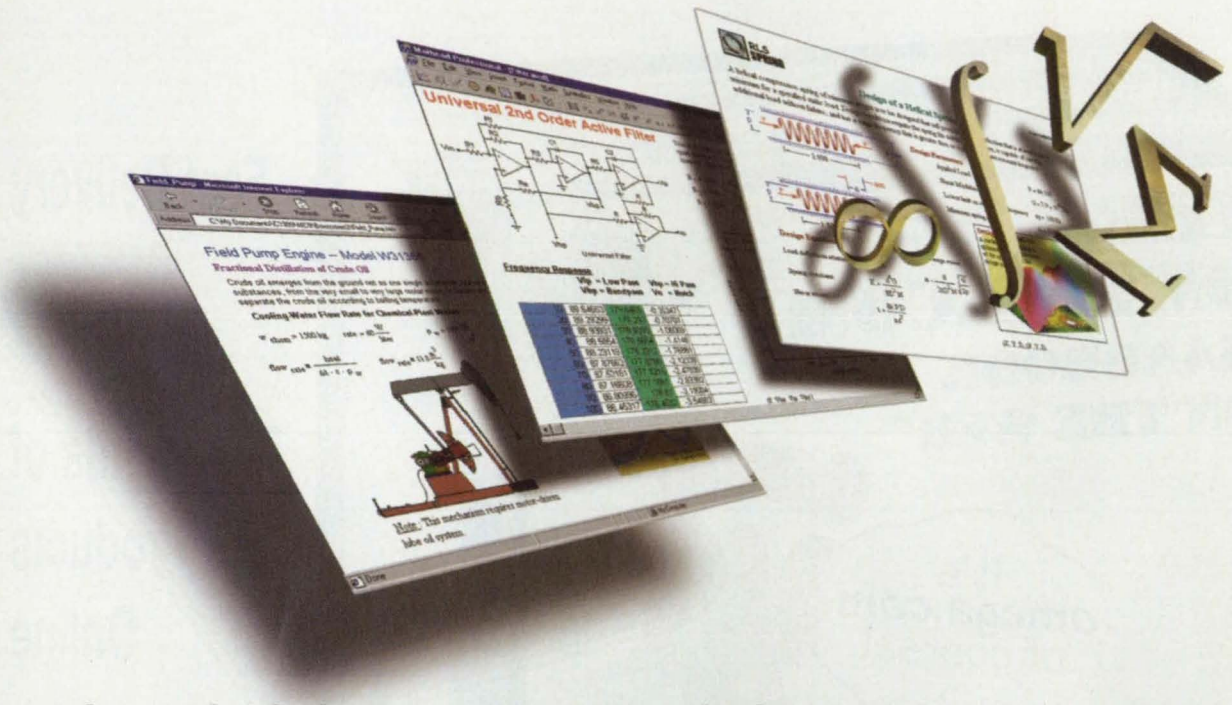

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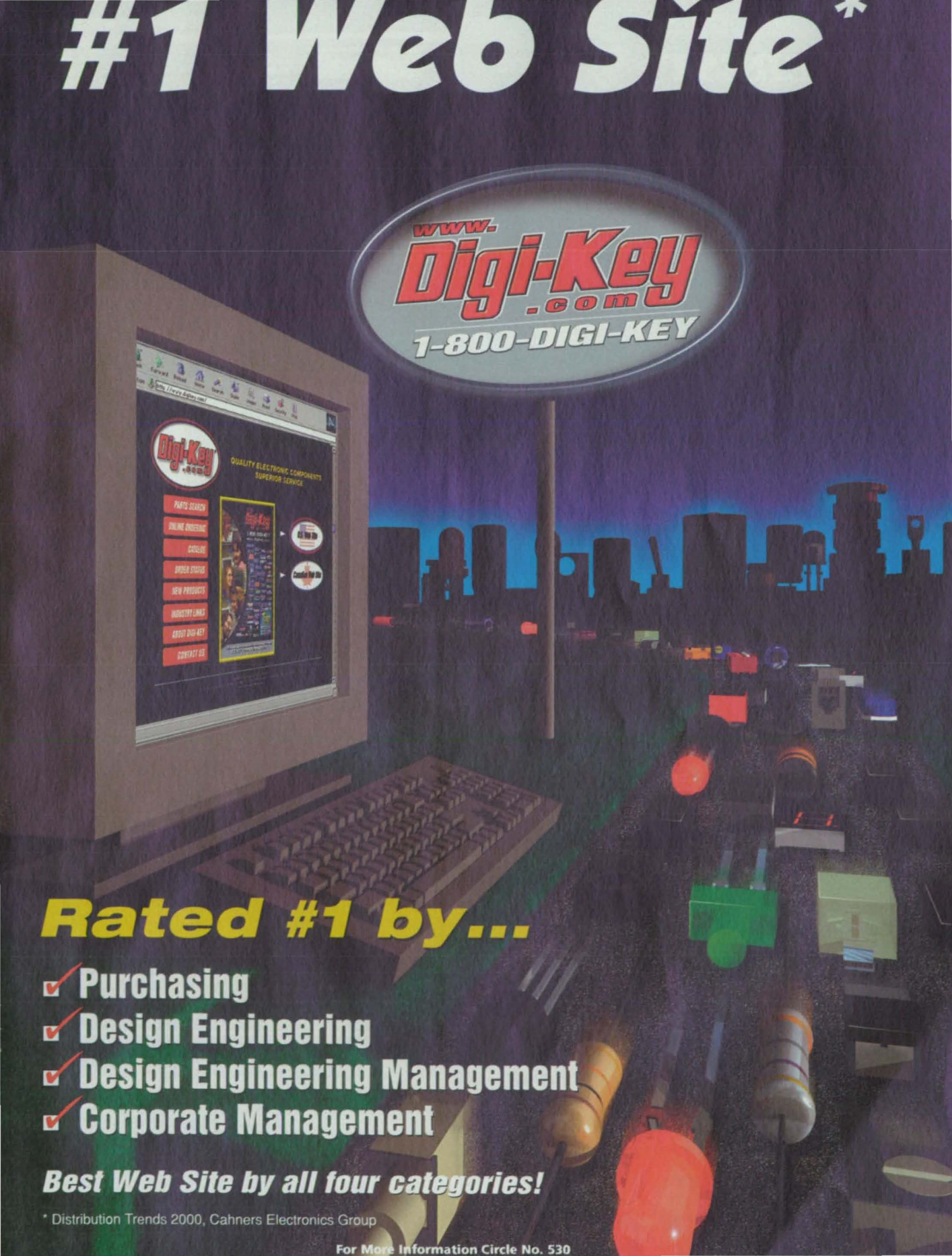

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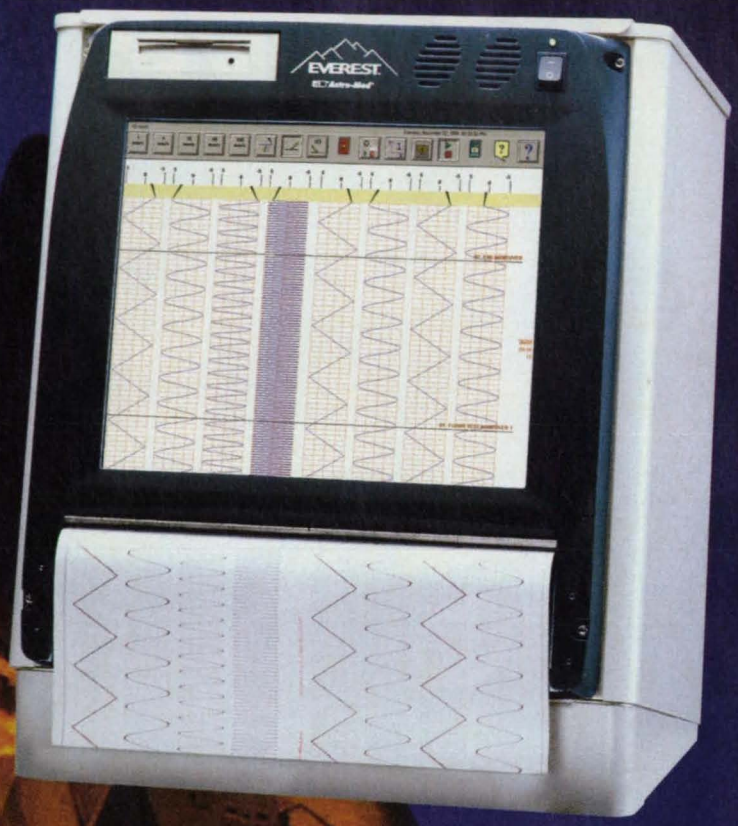

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BRIEFS

DEPARTMENTS

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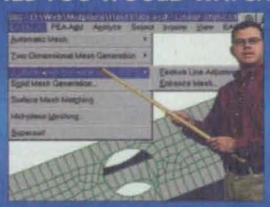
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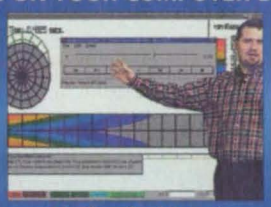
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Electronics Tech Briefs

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Motion Control Tech Briefs

Follows page 24 in selected editions only.

Motion CONTROL Tech Briefs

PRODUCT OF THE MONTH

Agilent Technologies (Colorado Springs, CO) offers the 54600 series oscilloscopes with multiple-channel configurations.

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ON THE COVER

This photorealistic image of an industrial web tension control device for the film, paper, and foil converting industries was designed using CADKEY 3D mechanical CAD software from CADKEY Corp. of Marlborough, MA. CADKEY Parametrics is a new design module that provides hybrid combinations of feature-based and freeform solid modeling. For more information on the new module, see New on Disk on page 61.

(CADKEY image courtesy of The Montalvo Corporation, Portland, ME)

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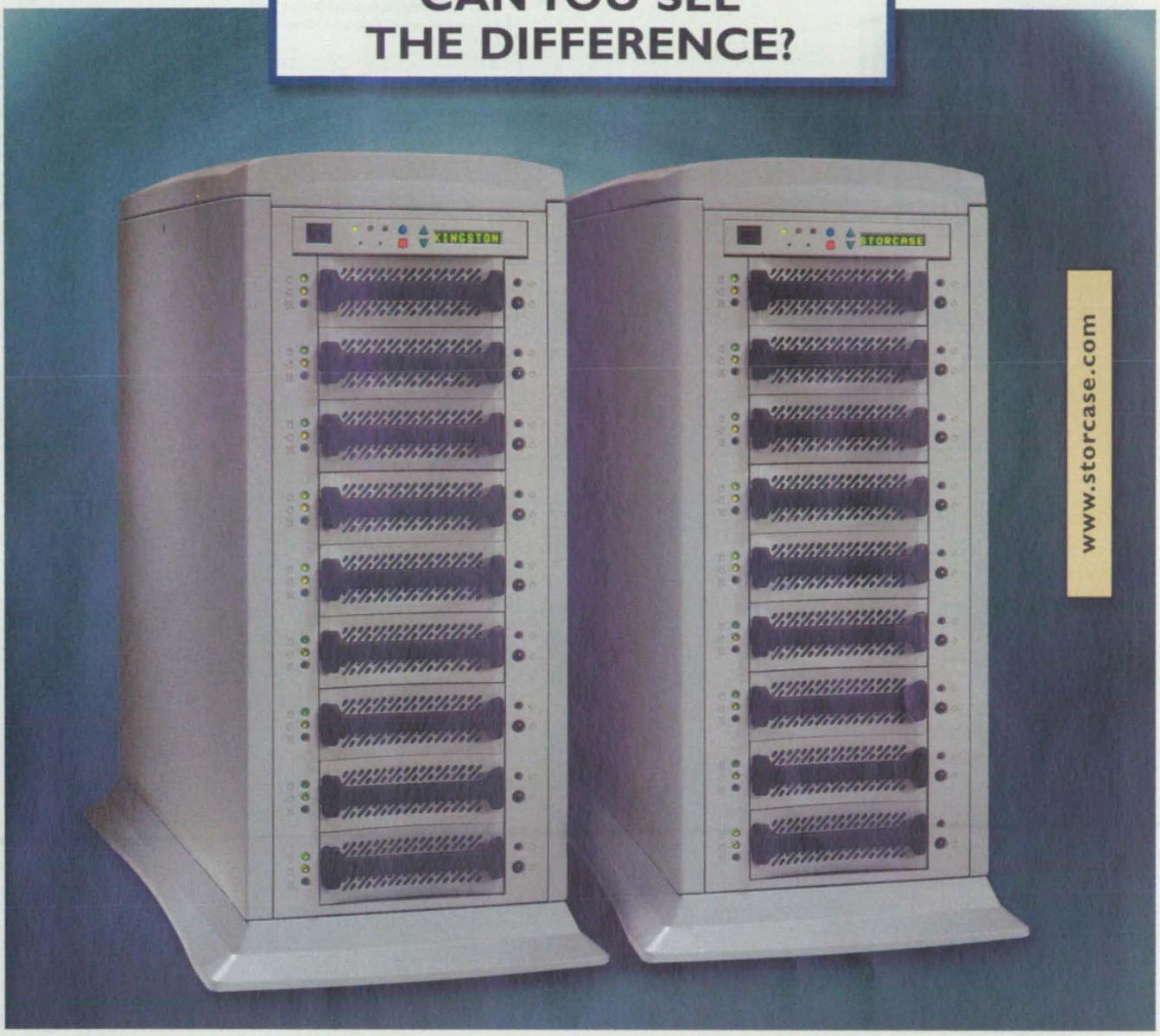

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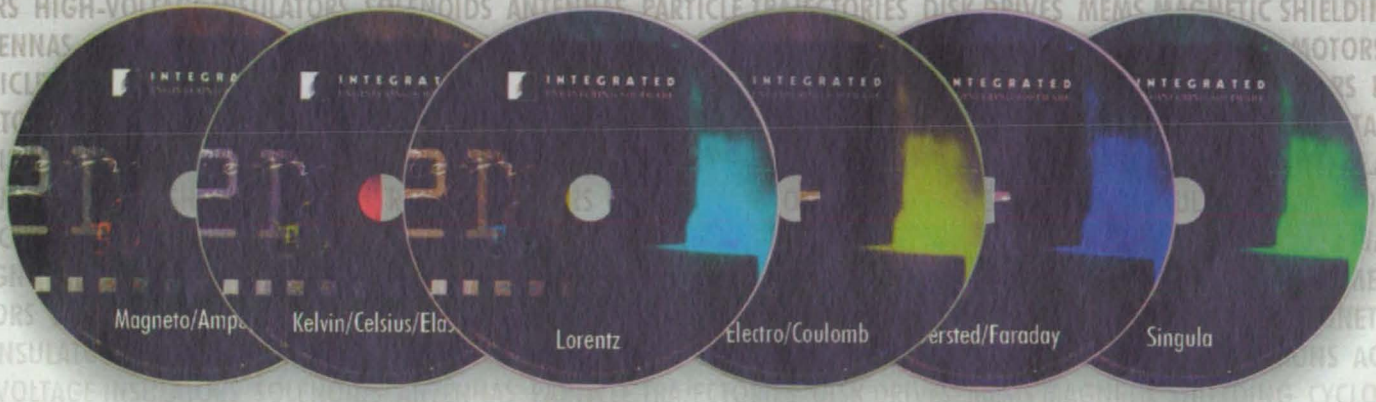

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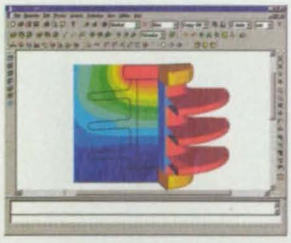

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I need to characterize the size and distribution of water droplets inside a heavy black oil emulsion. What are some of the lab instruments I can use? Are there any online measurement techniques for a production system of heavy black oil emulsions? Thanks for any suggestions.

Tom Houlihan
thoulihan@cleanfuelstech.com

Technologies Wanted

As a regular part of Reader Forum, we feature abstracts of Demand Pull Technology Transfer projects. These projects identify technology needs within an industry segment — such as Assistive Technology — and find technology solutions to meet those needs. The Rehabilitation Engineering Research Center on Technology Transfer has developed the Wheeled Mobility Project to identify market needs like those described below that represent significant business opportunities. For more details on the project — or to submit technology solutions — visit the project web site at www.rti.org/technology/wheelchairs.

Motor Technologies

Under light loading, the permanent magnet motor and its drivetrain can have an overall efficiency of about 60-70%. Under typical loads, the overall motor and drivetrain efficiency can drop to about 45%. Motor and drivetrain efficiency impacts battery performance and overall wheelchair performance (e.g., range, speed). An ideal motor must have an average efficiency of at least 75% under typical loading. It should allow a minimum range of 30 miles (from two fully charged, Group 24, 12-volt batteries) while improving access to difficult terrain and surfaces, and near-constant motor efficiency, independent of loading. The motor must generate high startup torque while dissipating heat well. Sensors should provide information to compensate for motor imbalance, diagnostics, steering, acceleration, and wear status. The motor should be located close to the wheels or part of the wheel design.

Geared Hub Technologies

Environmental and human factors can reduce a wheelchair user's ability to produce and apply the forces necessary to propel and brake a manual wheelchair. Geared hubs allow a user to select the appropriate propulsive force level. An ideal geared hub system must be part of a drive wheel that replaces a standard drive wheel. It must contain a pushrim, and should have continuously variable (linear) gearing, or at least four discrete gear ratios in the (approximate) range of 1-to-2 through 2-to-1. It must provide "reverse gearing" and should weigh 7 pounds or less. A single user interface (i.e., both wheels operate simultaneously) for gear ratio selection should require minimal user dexterity and force to operate. There should be no obtrusive levers, cables, or similar hardware.

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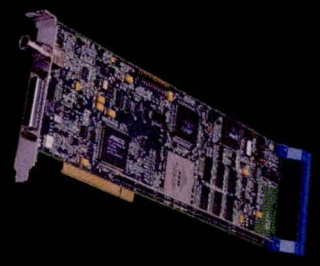

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NASA Patents

Over the past three decades, NASA has granted more than 1000 patent licenses in virtually every area of technology. The agency has a portfolio of 3000 patents and pending applications available now for license by businesses and individuals, including these recently patented inventions:

Thermally Regenerative Battery with Intercalatable Electrodes and Selective Heating Means

(U.S. Patent No. 6,042,964)

Inventors: Pramod K. Sharma, Sekharipuram R. Narayanan, and Gregory S. Hickey, Jet Propulsion Laboratory

The invention provides a more direct and efficient way of utilizing heat to store electrical energy than the solar panels most spacecraft rely on. The heat is directly converted at high efficiency into stored chemical energy in a battery containing a thermally regenerable electrode. The battery contains at least one electrode that intercalates a first species from the electrolyte in the first electrode compartment to form a thermally decomposable complex during discharge, while the other electrode supplies another species to the electrolyte in the second electrode compartment. The thermally decomposable complex is stable at room temperature but is decomposable at temperatures of 50-150 degrees C (preferably 50-100 degrees C, suitably 80 degrees C). The electrode compartments are separated by a selective ion-permeable membrane that is impermeable to the first species.

Method for Forming Fiber Reinforced Composite Bodies with Graded Composition and Stress Zones

(U.S. Patent No. 5,945,166)

Inventors: Mrityunjay Singh, Stanley R. Levin, and James A. Smialek, Lewis Research Center

Fiber reinforced silicon carbide matrix composites requiring thermal and environmental stability and good thermal shock resistance are commonly used for combustion and exhaust components in jet and rocket engines, ceramic burner inserts, and heat exchanger tubes. In order to serve their intended purpose, these have to be operated at high temperatures and undergo mechanical and thermal stresses. Prior-art matrix composites are often microcracked due to these stresses, and oxygen penetrates to the fiber-matrix interface through these cracks. The interface and the fibers become oxidized, thereby leading to the failure of the composites. The present invention provides silicon carbide matrix composites having means for sealing matrix cracks so as to prevent oxygen and corrosive gas ingress to the fibers and interfaces. The method provides a refractory fiber preform, infiltrates it with a mixture selected from polymer/resin, cures it at a temperature from about 60 °C to about 90 °C, heats it at about 600 °C to about 700 °C in an inert environment so as to convert the mixture to carbon, and infiltrates the preform with molten material selected from the group comprising molten silicon and binary silicon-refractory metal alloys.

Use of Ultrasound to Improve the Effectiveness of a Permeable Treatment Wall

(U.S. Patent No. 6,013,232)

Inventors: Jacqueline W. Quinn, Christian A. Clausen, Cherie L. Geiger, Debra R. Reinhart, and Nancy Ruiz, Kennedy Space Center

Remediating groundwater sites contaminated with halogenated hydrocarbons with technologies that attempt to remove the contaminant from the subsurface and pump it to a treatment system have had a limited degree of success. Thus recent efforts have focused on physical, biological, or chemical treatment in situ. A permeable treatment wall (PTW) is an alternative remediation technology that does not involve pumping. As contaminated groundwater is carried through the wall by the natural gradient, halogenated solvents are chemically altered to acceptable alternative species. Emerging on the downstream side of the wall is contaminant-free groundwater. The invention also provides for inserting an ultrasonic radiation-generating transducer into the subsurface in or near the wall. PTWs are designed to have a greater permeability than the surrounding soils, and are typically constructed using a high-permeability sand mixture bearing a zero-valent metal.

For more information on the inventions described here, contact the appropriate NASA Field Center's Commercial Technology Office. See page 12 for a list of office contacts.

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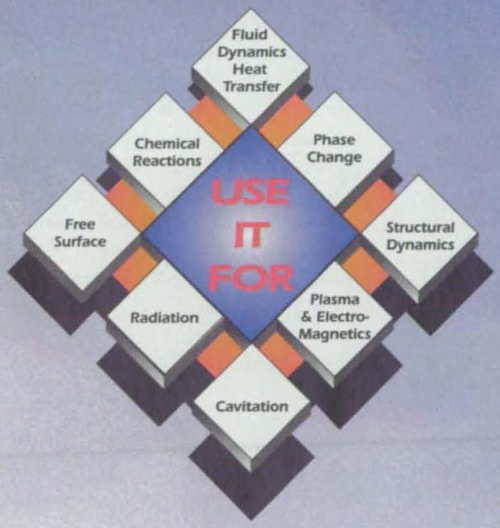

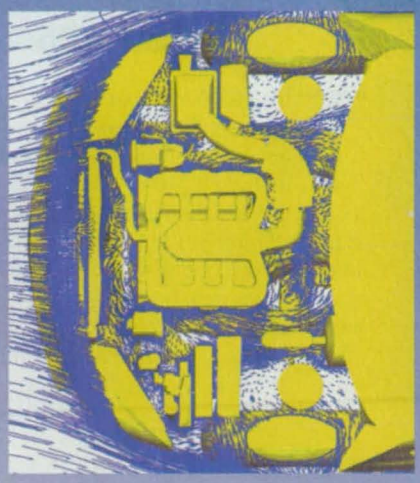

Underhood Cooling

Design Tool of Choice for:

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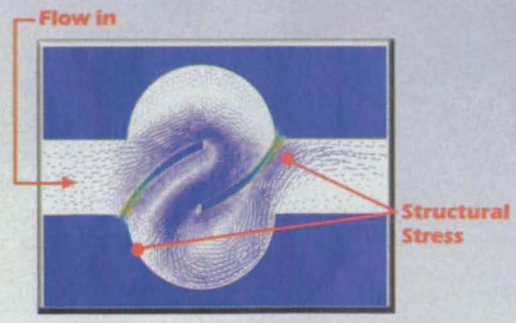
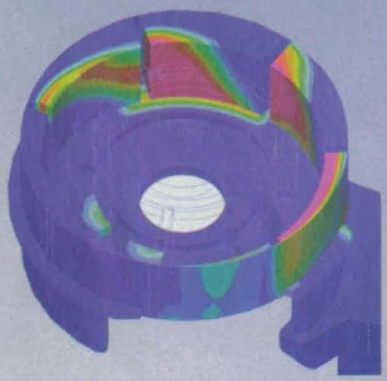
- Motorola
- Applied Materials
- U.S. Army
- U.S. Navy
- IBM
- Xerox
- Pratt & Whitney
- Siemens
- Caterpillar
- BMW-Rolls Royce
- ... and many others



Fluid-Structure Interaction in a MicroMixer

Geometry, Courtesy of Sarnoff Corporation



Cavitation in Vane Oil Pump

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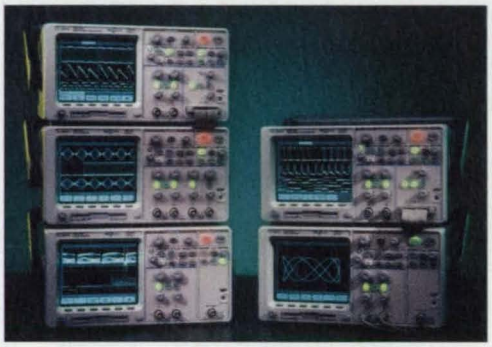
For More Information Circle No. 544

UpFront

PRODUCT OF THE MONTH



The 54600 series of oscilloscopes from Agilent Technologies, Colorado Springs, CO, offers multiple-channel configurations: 2- and 4-scope channels or the mixed-signal oscilloscope with 2 + 16 channels. The scopes also include 2 MB of MegaZoom deep memory behind every channel, and a high-definition display system that maps deep memory into 32 levels of gray scale at up to 25 million vectors per second. The 2 + 16 models combine the signal analysis of a scope with the multi-channel timing measurements of a logic analyzer. Users can view two analog and up to 16 digital signals simultaneously. The scopes' triggering capabilities include edge, pulse width, pattern, and sequence.

For More Information Circle No. 750

NASA Technology on the Move

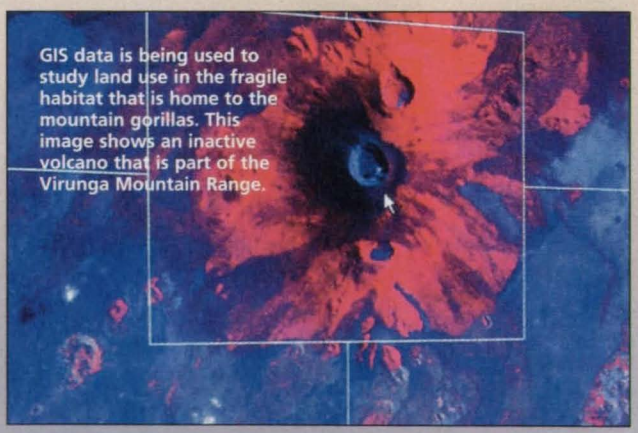
In an effort to move hundreds of technologies with commercial potential from a growing inventory to the private sector, NASA's Langley Research Center in Hampton, VA, has designated certain technologies eligible for expedited licensing — with nominal fees and minimal negotiations. The technologies are on display at the new Technology Portfolio web site at www.mtac.pitt.edu/tech/.

The web site contains a summary of each technology and links to the patent, as well as information on licensing and sample licensing agreements. Instructions on preparing a commercialization plan and license application are included. The web site was developed by the Mid-Atlantic Technology Applications Center (MTAC) to ensure that NASA's technology assets are quickly and effectively translated into production processes and marketable, innovative products.

Gorillas (and NASA) in the Mist

Dian Fossey's work has provided considerable insight into the life and behavior of mountain gorillas. Armed with a camera, binoculars, and a field journal, Fossey and a community of local trackers documented intimate details of what gorillas living in the Virunga Mountain Range of northern Rwanda did, where they went, what they ate, and how they interacted with one another. Now, thanks to a partnership between conservation organizations, the University of Rwanda, and Georgia Tech Research Institute, scientists are able to continue her work. The partnership will put technologies of remote sensing into the hands of field scientists working to protect the gorillas, and may also serve as a demonstration of how advanced technologies can boost the struggle to protect other endangered species.

The partnership also may receive help from NASA, whose Digital Earth initiative seeks to make the agency's data resources, imaging tools, and 25 years of expertise available to field scientists. According to Dr. Timothy W. Foresman, national executive manager for the initiative based at NASA's Office of Earth Science in Washington, DC, NASA would like to utilize its resources "to provide satellite imagery of the research area as a contribution to the project, so that we can better understand how GPS [global positioning system], remote sensing, GIS [geographic information system], and environmental modeling are being used to make decisions in Rwanda. We will learn what really works in the field so we can begin to take these global resources and make them relevant to the people who really need them."



GIS data is being used to study land use in the fragile habitat that is home to the mountain gorillas. This image shows an inactive volcano that is part of the Virunga Mountain Range.

Foresman explained that he wants to explore how different technologies can work together — especially now that data can be shared easily via the Internet. That could lead to the development of a global clearinghouse for data applicable to conservation, planning, and resource management. By using low-cost technologies and providing data, tools, and consultation at no cost, NASA's Digital Earth will make the resources widely available. NASA's next step will be to define the resources that the agency can apply to the project.

For more information on NASA's Digital Earth program, visit www.digitalearth.gov.

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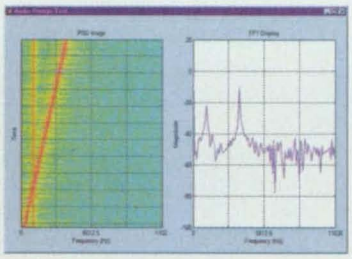

The new MATLAB Data Acquisition Toolbox lets you read data directly from acquisition hardware into MATLAB for analysis.

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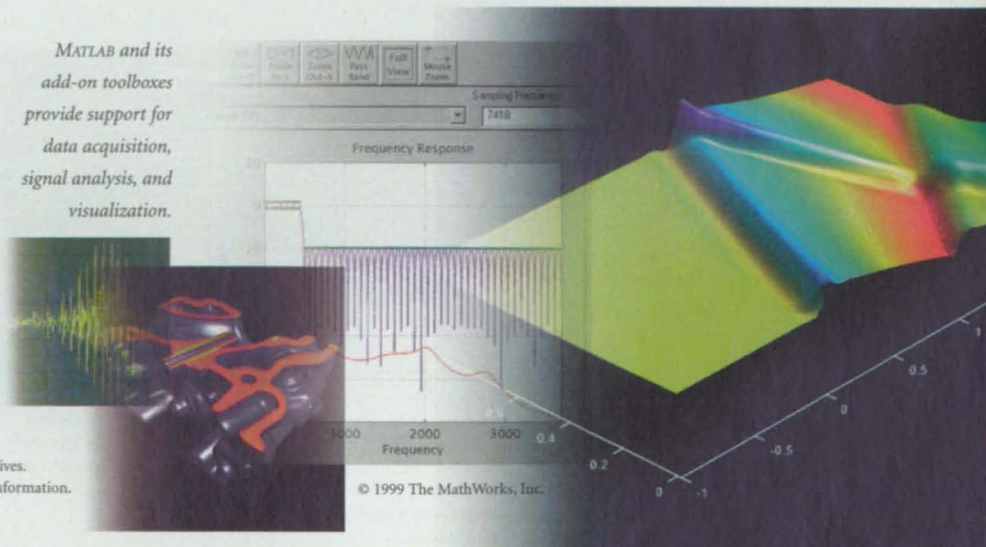

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For More Information Circle No. 516

NASA Gets a Boost in ESD Productivity

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Walking across a rug can induce a large static charge, which can be released upon contact with a doorknob. In an oxygen-rich atmosphere, one small spark can cause more than an annoying shock — it can result in a catastrophic explosion. Accordingly, every material that is used aboard any kind of space vehicle must be tested for the amount of static charge that it will hold under a variety of environmental conditions.

Without rigorous testing, NASA cannot ensure that an unwanted electrostatic discharge (ESD) doesn't threaten the International Space Station (ISS), or the Space Shuttle. Triboelectric testing (using friction to induce a static charge) has been the answer for decades. But the Material Science Laboratory (MSL) at NASA's Kennedy Space Center (KSC) in Florida received a major upgrade recently, resulting in greater efficiency and enhanced safety for current and future missions.

The MSL has customers including NASA Shuttle and Payloads, other NASA centers, government agencies, KSC contractors, and private industry worldwide. MSL had been using slow, antiquated equipment consisting of an electrometer, oscilloscope, and timer attached to NASA's own test stand to capture and record electrostatic decay rates. Materials are rubbed with a known medium on the triboelectric testing unit to determine what acquired electrical charge, in volts, will discharge to ground within five seconds. If materials hold greater than an amount regarded as "safe," then they may not fly. This includes materials from space suits, walls, doors, controls, and food containers.

A NASA scientist operates the Triboelectric Test Stand at Kennedy Space Center. A color printer is connected directly to the DEWE-3010 for report generation. (Photo courtesy of NASA)

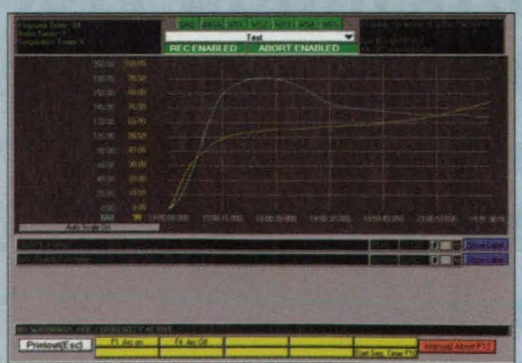
The recently acquired DEWE-3000 is a multipurpose data recorder/analyzer that replaces the oscilloscope, timer, and desktop PC in a box about the size of a briefcase. Dewetron application engineers worked closely with NASA engineers to create a graphical software application to automate all aspects of the data collection, including the timing of the experiment itself, the acquisition, data storage, and even report generation. With the Dewetron system, the data is recorded, stored to a disk, and a report is printed out in less than two minutes. Using Dewetron's graphical programming toolset, the application was created in hours instead of weeks, or even months, using traditional tools.

For More Information Circle No. 747

NASA Upgrades Heat-Shield Data Acquisition System

LabVIEW 5.1 graphical programming software
National Instruments
Austin, TX
800-890-6229
www.ni.com

NASA recently replaced several older acquisition and analysis systems with a single system to monitor, transmit, analyze, archive, and present data. The solution needed to be flexible and maintainable with off-the-shelf electrical and software components integrated into a system using a standard programming platform. The new system, created with data acquisition and SCXI hardware operating under an application written in LabVIEW, is rack-mounted with a networked client-server topology based on Windows NT. One PC acquires data, another PC acts as a data server, and five other PCs act as independent remote analysis and event triggering workstations.



The new data system archives setup information and raw data for each test. With raw data, tests can be replayed on an analysis workstation. When replaying the test, users can watch interactions between input channels after the initial test is complete.

The system simulates atmospheric reentry conditions for heat-shield material and consists of a plasma gas excitation shaft, specialized impact chamber, test mounting fixture, and vacuum generator. With the new system, NASA needed to archive test data while simultaneously archiving and tracking test setup parameters. By collecting setup parameters, test engineers and operators can identify the test, select available data acquisition channels, configure analysis from combinations of channels, define warning and abort alarm levels for channels, define channels for recording in report files, and convert data units using NIST standards or operator-defined limits.

The NASA application combines the power of ActiveX Data Objects (ADO) with familiar LabVIEW data flow programming by using ActiveX calls to manage the data objects. With the new system, NASA engineers and test operators have new flexibility in running tests while providing ability to repeat tests virtually with the same data integrity. The application is well poised to further exploit the benefits of high performance web-based technologies if the need arises to share the data, documentation, or test results.

For More Information Circle No. 748

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For More Information Circle No. 534

Fred Schramm, Engineer, Technology Transfer Office, Marshall Space Flight Center

Fred Schramm currently is manager of the Center Director's Discretionary Fund, a program for some of NASA's most advanced research, at Marshall Space Flight Center, Huntsville, AL. In 1997, Schramm received the Federal Laboratory Consortium (FLC) Southeast Region Award of Excellence for his efforts in facilitating the commercialization of compressed symbology for product identification.

***NASA Tech Briefs:* What is compressed symbology?**

Fred Schramm: It is a general term used to describe a category of identification symbols that can be encoded with information, can be marked directly on the surface of a product, and can be scaled up or down to fit the application. Compressed symbology usually involves symbols that do not use bar-code formats in their structure. Their structure is usually a matrix format resembling a checkerboard.

NTB: What advantages do matrix symbols have over conventional bar codes?

Schramm: Bar codes and matrix symbols both encode information so that a computer, through the use of a reading device, can understand the information directly. But bar codes are limited in size reduction due to certain ratios of wide and narrow elements that must be present for readers to decode them. They are also limited to paper labels and printed media due to the contrast required by laser scanners. A matrix symbol is read by a CCD camera, which captures the entire image to decode the pattern. This enables symbol capture from a wide variety of surfaces, including metals. Matrix symbols can be marked on microchips and read through a microscope, or cover the tops of large containers to be read from a great distance.

NTB: What applications has NASA considered for this technology?

Schramm: The original intent for studying this technology centered on improved configuration management of flight hardware and improved flight safety. Using Automatic Identification Tracking (AIT) was an approach to eliminate the data errors in NASA's vast databases, while making data capture as efficient as checking out at the grocery store.

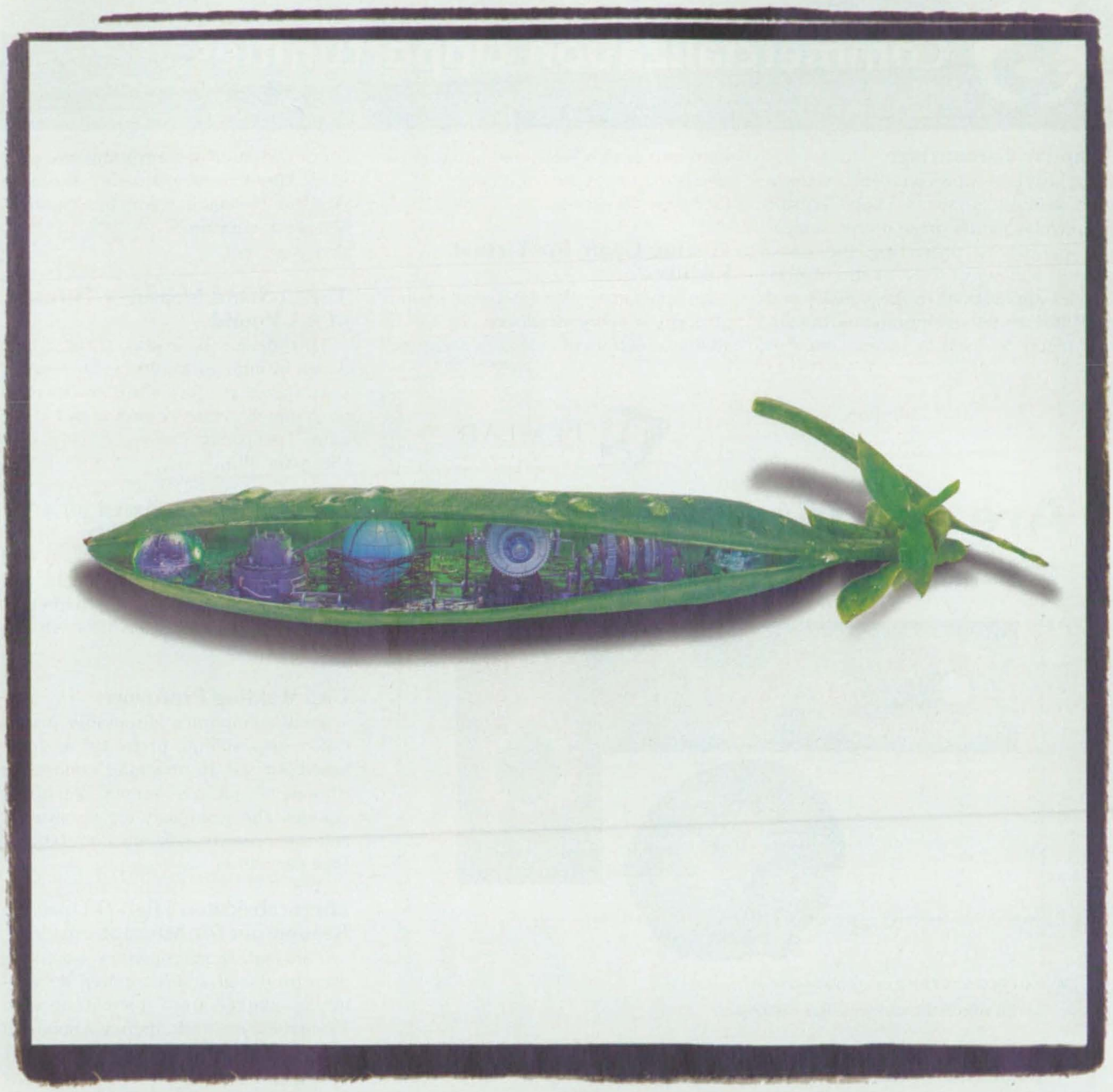
NTB: Why did NASA initially decide not to adopt the technology, and will it be implemented in the future?

Schramm: Most of the early methods developed for direct part marking of compressed symbology did not meet the criteria for safety. Studies showed that marking the surface of a part changed its characteristics, and the identification mark was considered a controlled defect. As the technology evolved, we continued to develop permanent marking methods for applying small matrix symbols that would be as safe as or safer than the processes that are accepted today. Tests are underway to deliver those processes during 2000. The NASA Direct Part Marking Standard and Handbook are expected to be made available this year. Direct part marking and AIT will play a future role in flight safety. And we even have answers to the questions about flight hardware that has been covered with paint or foam. We are developing marking methods and the prototype devices to read matrix symbols through coatings and even within the assembly.

NTB: What are some commercial applications?

Schramm: NASA findings spurred additional testing by the Department of Defense (DoD) and private industry that resulted in selecting the Data Matrix™ symbol for parts marking by the Automated Identification Manufacturers (AIM) and the American National Standards Institute (ANSI). Additional part-marking standards quickly followed as the automotive, electronics, pharmaceutical, and aircraft industries adopted the symbol. The symbol is found on many of their products, and its use is being required on first- and second-tier suppliers, for example, in the aircraft industry.

A full transcript of this interview appears online at www.nasatech.com. Mr. Schramm can be reached at fred.schramm@msfc.nasa.gov.



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For More Information Circle No. 540

Commercialization Opportunities

Adaptive Camouflage

Lightweight optoelectronic systems built around advanced image sensors and display panels make objects appear transparent by projecting the background scenery in front of the objects. Besides applications in the military and law-enforcement establishments, this system could be used to project outdoor views into windowless rooms and to show who is ringing at the front door.
(See page 28.)

Moving Chair for Virtual Reality

An apparatus called a personal motion platform is being developed for use in adding sensations of motion to computer-controlled simulated environments, popularly known as virtual reality. It can be used for biological research, education, and plain entertainment.
(See page 30.)

Thrust Stand Measures Thrusts of < 1 Pound

This device measures thrusts produced by miniature cold-gas thrusters in vacuum and air. Such thrusters are used on remotely piloted cameras and astronauts' backpacks.
(See page 40.)

Oxygen Batteries Based on a Solid Polymer Electrolyte

A derivative of the lithium-ion cell could prove useful in space flight and commercial applications. The theoretical specific energy of the cell is 5,200 Wh/kg.
(See page 48.)

Gap Welding Preforms

Small, temporary, disposable inserts called "gap welding preforms" are proposed for use in attaching conductive ribbons to radio-frequency electronic circuits. The advantages are consistency and faster time to make the connections.
(See page 49.)

Microfabricated High-Q Optical Resonators for Microphotonics

Ultra-high-Q microcavities would be mass produced and integrated by techniques adapted from microelectronics. Using these methods, there is a potential to obtain $Q \geq 10^{10}$.
(See page 50.)

Improved Unidirectional Cell-Stretching Device

This device has been developed for use in research on the effects of unidirectional loading on human and animal cells. It will mimic the loading or unloading experienced by skeletal muscles and other tissues of interest.
(See page 53.)

Device for Testing Susceptibility of Bacteria to Antibiotics

Using this device, one can determine the minimal inhibitory concentration of selected antibiotics against certain bacteria, without resorting to complex traditional laboratory testing equipment.
(See page 56.)

Motion CONTROL Tech Briefs

August 2000

A Flight Control Actuation System that Defies Convention

For the X-33, Thomson Saginaw designed a ball screw assembly for high performance.

At the heart of the X-33 Flight Control Actuation System (FCAS) is a state-of-the-art ball screw assembly designed specifically for this demanding application by Thomson Saginaw Ball Screw Company LLC of Saginaw, MI. Working with Honeywell of Tempe, AZ, integrator of the 270-VDC linear actuator system, Thomson Saginaw supplied a ball screw assembly that provides:

- Dual redundant drive capability;
- An "internal crossover" ball recirculation system, contained completely within the ball nut body;
- Custom multiple-circuit thrust bearings at each end (connection point) of the ball screw; and
- A combination of specialty stainless steels and plating technology for maximum environmental/high-temperature resistance.

The use of ball screws in flight control applications is well founded. Linear actuators incorporating ball screws are used in applications including the flaps and/or slats of many aircraft, including the B-747, B-757, A-310, and C-141 aircraft. They are also used in many horizontal stabilizer applications in many of the same aircraft and in others such as the B-777, Embraer 145, and KC-135. In addition, many space applications such as rocket engines and satellites utilize ball screws in linear actuation. The challenge of the X-33 design was to integrate all the necessary technology to meet unique requirements.

Performance requirements for the X-33 included a maximum operating load of 25,000 lb., a 48,000-lb. limit load, 0 to +350-°F operating temperature range, 5-minute exposures to 500 °F at the rod end, and dual-drive capability. Also required was a 90-percent minimum mechanical efficiency of the ball screw and 0.003-in. to 0.007-in. axial lash (free play) between rod end and ball nut. The harsh environment dictated that the materials used would need to be as inert as possible. Stainless steels were used wherever possible for all of the metallic components.

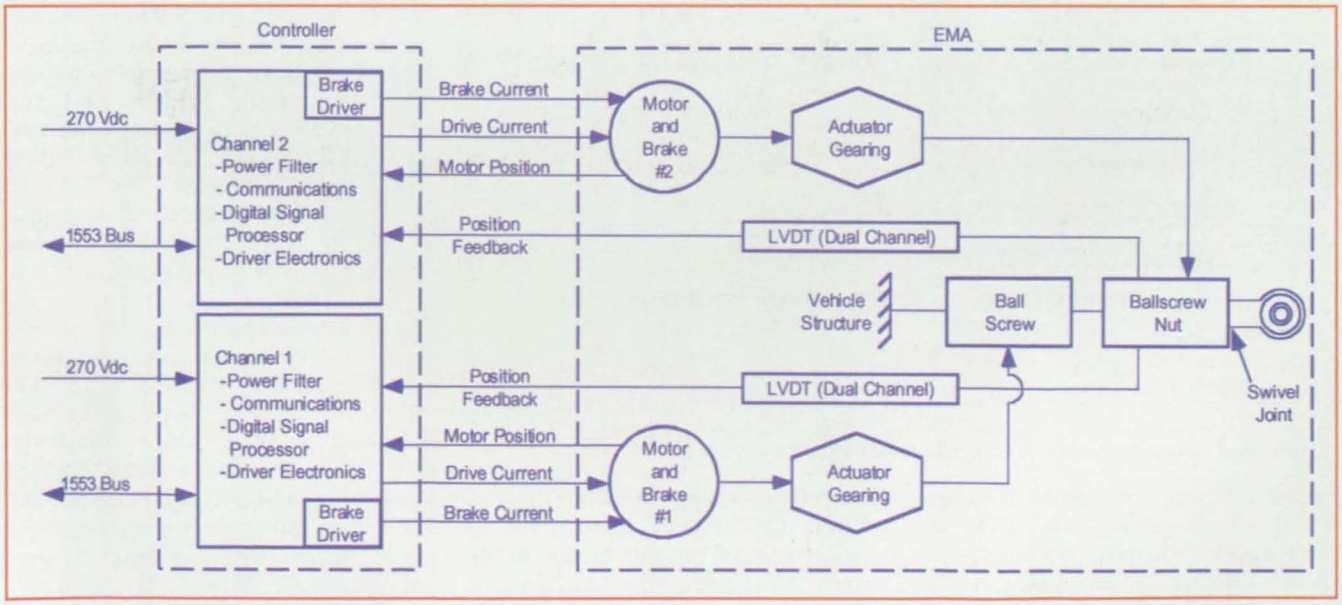

Figure 1. X-33 FCAS EMA/Controller schematic.

The 8 linear actuators used in the X-33 FCAS obtain dual-drive capability through two independent motor/brake systems on each ball screw. A dual-channel LVDT arrangement provides linear position feedback (see Figure 1). To accommodate the dual-drive requirement, the ball screw assembly was designed with system attachments at both the ball-screw end (drive system 1) and the ball nut outer diameter (drive system 2).

The screw shaft is "fixed" relative to either drive system, and the ball nut is always the translating member. For instance, operation of the first drive system will result in rotation of the screw shaft and translation of the ball nut. With the second drive system operating and the first stationary, the ball nut will rotate and translate simultaneously along the screw shaft. This is accomplished through a low-friction sliding interface between the ball nut outer diameter and the second drive system. At this interface, a silver-plated involute spline transmits operating torque and allows for sliding (see Figure 2).

Many conventional ball-screw designs use external steel tubes for recirculation of the bearing balls. In the X-33 assembly, internal "crossover"-type ball returns were used to minimize the diametral envelope and provide a mass-balanced assembly. This is particularly important in systems requiring that the ball nut be driven (rotated). The design called for an exceptionally long ball nut (to provide the required 7 inches of travel across the involute spline in the event that operation of the second drive system was required). For this reason, the two five-turn crossover "blocks" are positioned as far apart as possible for maximum ball-nut stability. The blocks are assembled into internal slots in the ends of the ball nut. Actuator overtravel is prevented by non-jamming mechanical stops at each end of the stroke (see Figure 3).

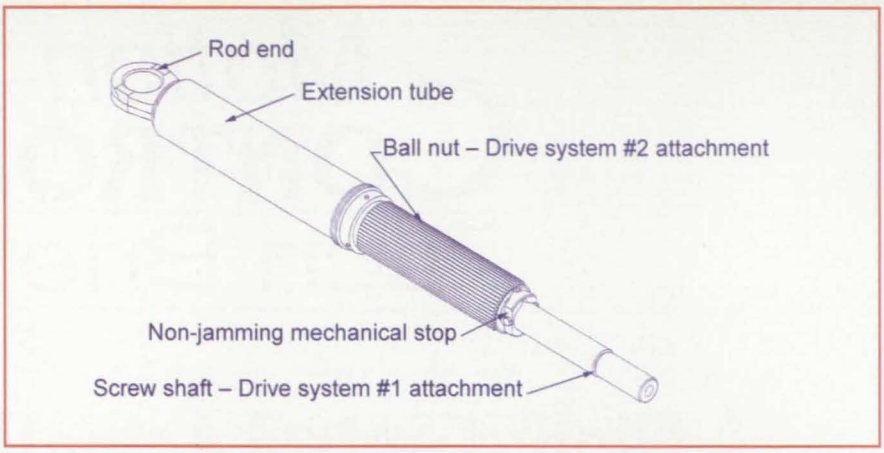

Figure 2. Isometric view of the X-33 FCAS ball screw assembly.

Because of the potential need to rotate the ball nut using the second drive system, it was necessary to provide a swivel joint between the ball-nut extension tube and the rod-end attachment to the spacecraft. For this purpose, nine circuits of bearing balls are inserted through retainers into bearing raceways ground into the extension tube's inner diameter and rod-end outer diameter. A stainless steel sleeve covering all retainers and a fluoroelastomer seal at the rotating interface keep contaminants out of the assembly. The ball-groove geometry, ball size, and ball quantity used in the swivel joint were "balanced" with that of the ball screw for equal load capacity and endurance life (see Figure 3).

During development testing, it was determined that conventional thrust bearing technology, originally used at the screw shaft drive attachment, was inadequate. Deflections in the original bearings and adjacent complex housing geometry caused performance degradation in the actuator. Considering the lessons learned during design of the swivel joint, this technology was borrowed for use at the screw shaft drive end. What resulted was the development of a nine-circuit thrust bearing that significantly reduced deflections down to an acceptable level (see Figure 3).

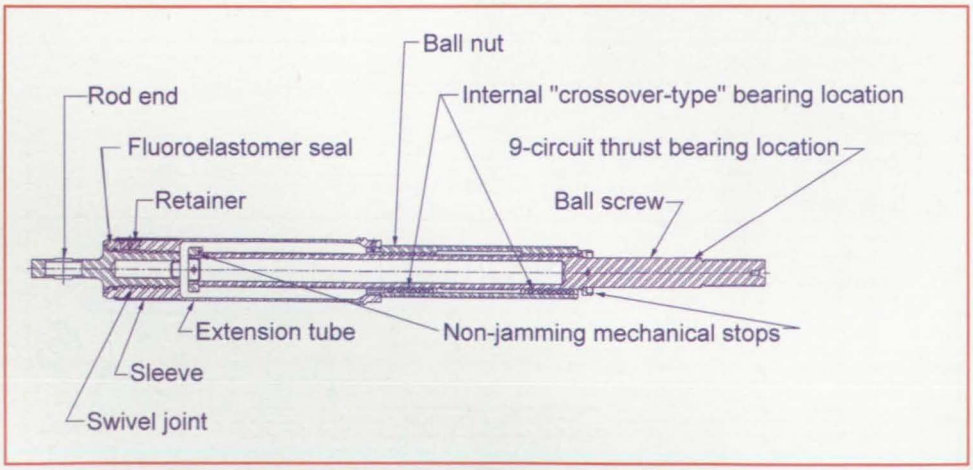

Figure 3. Cross-sectional view of the X-33 FCAS ball screw assembly.

Applied (dynamic) loads were predicted to range from several hundred pounds to 48,000 lb. on this actuator. This results in a large variation in mean Hertzian stresses, from less than 100 kSI to greater than 500 kSI, in the thrust bearing, swivel joint, and ball screw races. To understand operational characteristics across this stress realm, several developmental tests were conducted. Both mechanical efficiency (for the ball screw) and coefficient of friction (for the nine-circuit thrust bearing and swivel joint) were quantified across this range. From this data, the appropriate ball size, race geometry, and material condition were derived. The final design provided 90.5-percent minimum ball-screw efficiency and 0.00294 maximum coefficient of friction in the thrust bearing and swivel joint under a 48,000-lb. (535 kSI Hertzian stress) operating load.

Thomson Saginaw used its TSS-3165 stainless steel for the swivel joint/rod end, ball nut extension tube, and screw shaft. This material is an induction-hardenable martensitic stainless steel normally core-developed from R/C 34 (150 kSI UTS) to as high as R/C 40 (207 kSI UTS) and then selectively induction-hardened in the raceways only. This process results in a tough structural core condition. No platings are required with this material. End stops, swivel joint retainers, crossover blocks and retainer sleeves were also manufactured of stainless steel. The tough structural nature of the TSS-3165 material and heat-treat process resulted in a very lightweight assembly. In addition, further weight reductions were accomplished through (1) deep-hole drilling of the screw shaft; (2) drilling

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of the swivel joint body (under the bearing races); (3) "bottle" boring of the ball nut body between ball circuits; and (4) "bottle" boring of the extension tube up to the swivel joint ball races (see Figure 3).

The ball nut has integral stop jaws that would engage the extend or retract stops to prevent any potential overtravel. These stops are designed such that they arrest actuator travel by reacting the torsion between the ball nut and screw shaft—they do not load up axially. During development, stops were tested to ultimate load and beyond to verify integrity under the worst case.

The entire outer diameter of the ball nut is an involute spline, which forms the interface with the second drive system. This spline is silver-plated to provide an inert, low-friction surface. The remainder of the ball nut body is thin dense chrome-plated. The ball nut extension tube is threaded, shouldered, and pinned to the ball nut (see Figures 2 and 3).

Before the manufacture of any prototypes, the ball screw was completely modeled using Unigraphics V15 solids modeling software. Endurance life, operating load capacities, and Hertzian reactions were analyzed using ball-screw design software developed by Thomson Saginaw. A multisection column capacity model was developed, and compressive capacities of the actuator studied for various combinations of applied load and stroke position. Using this model, lateral deflections and unit stresses were predicted along the ball screw's length. Comprehensive static and fatigue analyses were also completed. Axial stiffness of the ball screw assembly was predicted and verified to support the overall system design. Stiffness in full retract was found to be 1.6×10^6 lb./in. and 1.5×10^6 lb./in. at full extend.

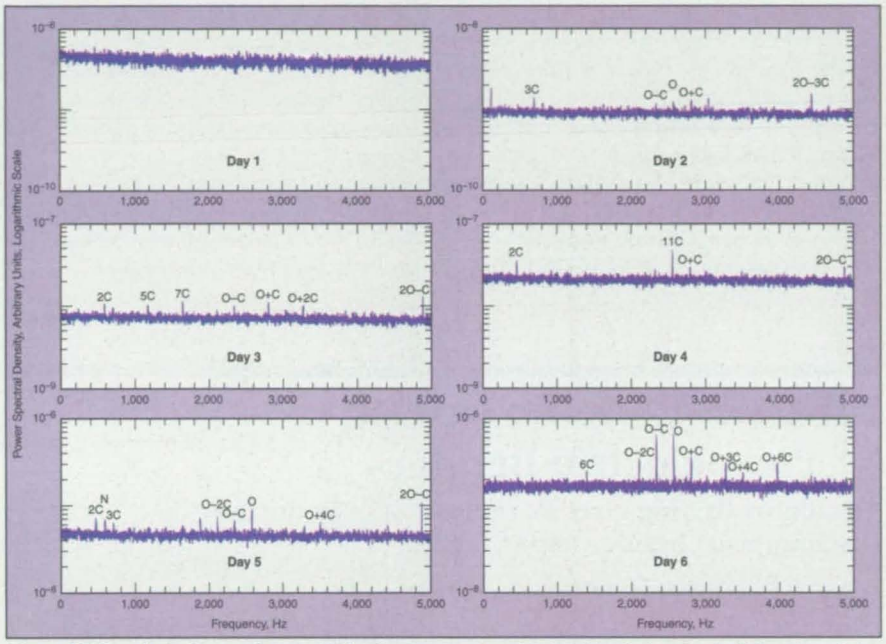
In addition to the development testing and analyses performed, each ball screw was subjected to an acceptance test plan (ATP) prior to shipment. This ATP included lash determination, loaded efficiency test, dynamic torque variation, stroke length verification, and recording of actual weight. Further development, qualification, and acceptance tests were performed by Honeywell at the actuator level.

For more information, contact the author of this article, David A. Lange, director of product engineering for aerospace, government, and defense at Thomson Saginaw Ball Screw Co., LLC, 628 No. Hamilton St., Saginaw, MI 48602; (517) 776-5111, ext. 8227; fax: (517) 776 0109; e-mail: langed@thomsonmail.com.

Acoustic-Emission-Analysis System for Diagnosis of Machinery

High-frequency acoustic signals are processed to extract indications of bearing defects.

Marshall Space Flight Center, Alabama



These **AE Envelope Power Spectral Distributions** were obtained in tests of a ball bearing. Even though the acoustic sensor did not sense low-frequency phenomena directly, the envelope analysis extracted low-frequency bearing information from the high-frequency sensor output. The succession of plots shows a wear trend in the bearing signature. The symbols "O" and "C" (some preceded by integers) signify the outer-race frequency and cage frequency (or a harmonic thereof), respectively. Combinations of "O" and "C" signify modulation products of the indicated frequencies. "N" signifies the shaft rotation frequency.

A personal-computer-based system has been developed as a prototype of electronic signal-processing and computing systems for diagnosis of turbines, motors, and other rotary machines through analysis of acoustic emissions. The system includes acoustic sensors that respond in the kilohertz-to-megahertz frequency range wherein acoustic energy tends to emanate from bearing defects. The system also includes a relatively inexpensive desktop computer and a 12-bit analog-to-digital converter that can acquire acoustic-sensor readings in as many as four channels at a sampling rate up to 5 MHz per channel.

The reason for choosing the kilohertz-to-megahertz frequency range is that when the digitized acoustic-emission (AE) signals in this frequency range are processed by suitable algorithms to obtain indications of deterioration of bearings, the resulting indications are more reliable than are those obtained by similar processing of the outputs of accelerometers that sense lower-frequency vibrations. The algorithms in question implement envelope analysis (see figure) and another signal-processing technique called "point process spectral analysis" (PPSA).

In a typical application, vibration sources other than a defective bearing that one seeks to diagnose can be expected to give rise to a variety of anomalous transient events, including random spikes, in the AE signal. These anomalous transient events can mask bearing signatures and prevent reliable detection of bearing faults. A common obstacle encountered in analyzing an AE signal is the inability to determine which transient events are related to shaft rotation and which are not. Conventional time-series and spectral analyses are ineffective in distinguishing between useful and useless signal features. In addition, a bearing defect in its early stage generates intermittent transient impulses with weak periodicities. It is difficult to detect these periodicities through conventional envelope spectral analysis. Furthermore, the need to process a high-frequency AE signal in real time imposes a severe computational requirement, which constitutes an impediment to the design of an inexpensive bearing-diagnostic system.

PPSA was summarized in "Acoustic-Emission Bearing-Fault Diagnosis

System" (MFS-26468), *NASA Tech Briefs*, Vol. 21, No. 11 (November 1997), page 84. PPSA provides high computational efficiency in the spectral analysis of transient events in a high-frequency AE signal. In turn, this computational efficiency enables the prototype bearing-diagnostic system to operate with a minimal processing gap (time delay), so that it can generate diagnostic indications in nearly real time. When pulses from sources other than a defective bearing corrupt the bearing-generated transient pulses, PPSA can provide a detection-and-discrimination capability superior to that of envelope analysis.

The prototype bearing-diagnostic system is programmed with an additional post-test vibration-signal-analysis software package called "PC-SIGNAL." This software is effective and easy to use for general applications in analysis of vibrations, monitoring the "health" of machinery, and diagnosis of faults. PC-SIGNAL also includes a number of subprograms designed especially for processing high-frequency AE signals.

This work was done by Jen-Yi Jong of AI Signal Research, Inc., for **Marshall Space Flight Center**. *For further information, please contact the company at* ***www.aisignal.com*** *or (256) 551-0008.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center; (256) 544-0021. Refer to MFS-31468.

Efficient Periodic Driving of Piezoelectric Benders

Oscillator driving circuits recover energy during discharges of bender capacitances.

Lyndon B. Johnson Space Center, Houston, Texas

Modified Hartley oscillator circuits are being developed for use in driving large piezoelectric benders in periodic motion, as in some piezoelectrically driven pumps. These circuits decrease the time-averaged consumption of power and thus increase energy efficiency by recycling large fractions of the energy stored in the capacitances of the piezoelectric benders.

The amount of energy involved is significant because the capacitances of some piezoelectric benders can be large. For example, the capacitance of a system of multilayer piezoelectric benders in one pump has been estimated to be about 160 μF. If all of the energy stored in such a large capacitance during the charge phase of the operating cycle is simply dissipated during the discharge phase, then the time-averaged power consumed is correspondingly large.

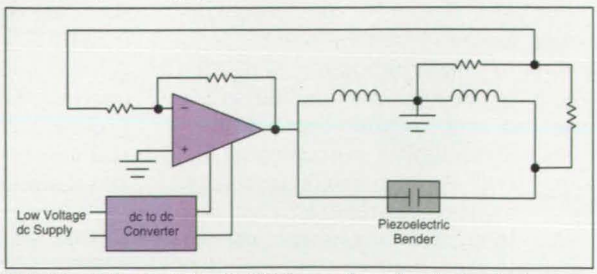
An oscillator circuit of the type undergoing development (see figure) can reduce the loss of energy during the discharge phase of the operating cycle when driving a piezoelectric bender. This is because the bender capacitance is the capacitive part of the capacitive/ inductive resonant circuit that governs the frequency of oscillation, and by virtue of the fundamental nature of the oscillator circuit, much of the electromagnetic energy handled by this circuit alternates between storage in the capacitance and storage in the inductance. The overall efficiency can be increased if the frequency of mechanical resonance of the pump is matched to the frequency of oscillation.

This work was done by Frank E. Sager and William C. Robertson of Oceaneering Space Systems for **Johnson Space Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Systems category.*

Title to this invention has been waived under the provisions of the National Aeronautics and Space Act [42 U.S.C. 2457(f)], to Oceaneering Space Systems. Inquiries concerning licenses for its commercial development should be addressed to

Oceaneering Space Systems
16665 Space Center Blvd.
Houston, TX 77058-2268

Refer to MSC-22556, volume and number of this NASA Tech Briefs *issue, and the page number.*



This **Circuit for Periodically Driving a Piezoelectric Bender** is a version of the classical Hartley oscillator.

Non-Inertial Calibration of Vibratory Gyroscopes

Coriolis forces would be simulated by electrostatic forces.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed method of calibration of micromachined vibratory gyroscopes would make it unnecessary to test the gyroscopes at known rates of rotation. At present, calibration entails inertial tests in which the gyroscopes are exposed to tumble and rotation maneuvers on multiaxis precise rotation tables, which are expensive. By eliminating the need for the rotation tables, the proposed method could reduce the cost of calibration. Moreover, inasmuch as the number of gyroscopes that a rotation table can hold is limited, the elimination of the rotation tables method would make it possible to test more gyroscopes simultaneously.

The proposed method is based on the unique principle of operation of a micromachined vibratory microscope. This principle involves electrostatic excitation, capacitive sensing, and feedback control of vibrations of a microscopic body designed so that its vibrational modes are affected by the Coriolis force. One of the feedback control signals is a negative feedback signal for generating an electrostatic actuation force that compensates for the Coriolis force. In the proposed method, one would superimpose a simulated Coriolis-force signal on the electrostatic actuation signal.

Because signals representing the real and simulated Coriolis forces would be at the same frequency and phase, the gyroscope circuitry would respond to the simulated Coriolis force in the same way in which it would respond to the real Coriolis force. Hence, rotational testing would not be necessary because one could simply inject the simulated Coriolis-force signal into the feedback control loop to make the vibrations and the associated electronic signals behave as though the gyroscope were undergoing rotation.

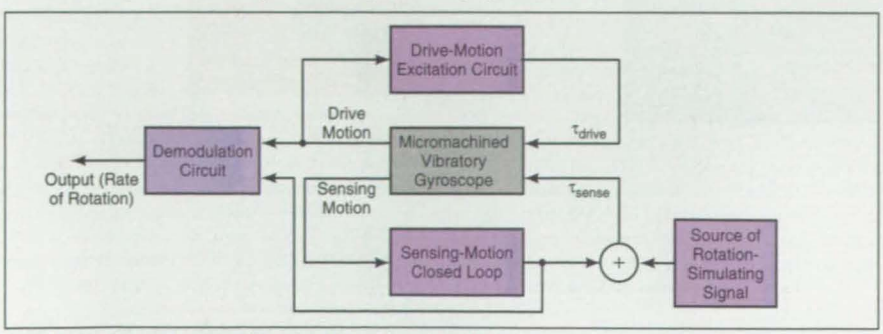
The figure is a block diagram of an electronic system for implementing the method. The drive-motion excitation circuit would measure the drive motion (one of two vibratory motions involved in the basic principle of operation) and would provide an excitation force to sustain this motion. The sensing-motion closed loop would provide electrical damping of the sensing motion (the other vibratory motion involved in the basic principle of operation). The feedback control signal, τ_{sense}, would produce an electrostatic actuation force equal to the real Coriolis force plus the simulated (rotation-simulating) Coriolis force. The demodulation circuit would demodulate a sensing-motion force-rebalancing signal with the drive-motion signal to generate a signal proportional to the rate of rotation. During the simulation of rotation, the sensing-motion closed loop and the demodulation circuit would respond as though to a real rotation signal.

Of course, the value of this method of calibration would depend on the accuracy with which the simulated Coriolis-force signals could be made to duplicate the effects of the real Coriolis force. It would be necessary to perform conventional inertial calibration to verify the proposed method.

This work was done by Roman Gutierrez and Tony K. Tang of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Systems category.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to Technology Reporting Office, JPL, Mail Stop 122-116, 4800 Oak Grove Drive, Pasadena, CA 91109; (818) 354-2240.

Refer to NPO-20659, volume and number of this NASA Tech Briefs *issue, and the page number.*



The **Effect of Rotation** would be simulated electronically by injecting a signal that would generate an electrostatic force to mimic the Coriolis force.

NEW PRODUCTS

Precision Rail Guides

SKF Motion Technologies, Bethlehem, PA, introduces new precision rail guides featuring an integrated anti-creep system. The company says SKF ACS-equipped rail guides reduce cage creep and provide accurate positioning, high-precision and high-speed capabilities. The guides consist of two precision rails and a cross-roller cage incorporating a small idler wheel. These rail guides are dimensionally interchangeable with existing cross-roller systems. Varying rail lengths and roller diameters are available.

For More Information Circle No. 765

Steel Converter Controls

Arens Controls Company LLC, Evanston, IL, offers converter control product lines featuring steel construction. These converter controls can be used for controlling dampers, vents, valves and switches in applications ranging from automotive heater and A/C controls to throttle controls for outdoor power equipment. These controls are available in a wide array of mounting designs and operating models, with both left- and right-hand units available. Units with clockwise and counter-clockwise rotations may be ordered, and the design requires only enough front-of-panel clearance to provide for the knob.

For More Information Circle No. 766

In-Line Cryogenic Valves

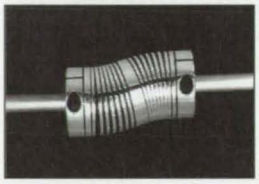
Valcor Scientific, Springfield, NJ, has developed a three-part "shear" or "floating" design to allow for high flow in its cryogenic valve series. This design offers a high-flow, high-pressure performance in a compact design with three parts: a plunger, a Teflon® seal disc, and a valve seat. These are positioned to handle higher flows of water or any noncorrosive fluid, light particulate liquid or gas, and compatible semicorrosive fluids. The "Shear Seal" provides a flow path that is directly in line with the tubing or connection to either side of the valve. The straight-through, line-of-sight flow minimizes pressure loss through the valve.

For More Information Circle No. 767

Linear Actuators with Linear Slide

Amacoil/Uhing, Aston, PA, announces that its RS linear actuator is available with an optional linear slide attachment for heavier, overhung, or off-center loads. The linear slide is useful for a range of positioning, indexing, materials handling, and other linear motion applications that have a heavy or off-center payload and require precise linear motion. The attachment facilitates the handling of off-center loads without creating rotational binding, stretching, or bending of the shaft. The linear slide counters radial forces and moments of force which may occur during heavy applications.

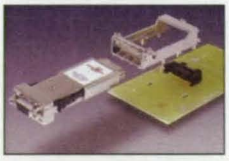
For More Information Circle No. 768



Flexure Coupling

Helical Products Company Inc., Santa Maria, CA, introduces the HELICAL® Flexure coupling that reduces parallel misalignment. Through lateral displacement, this coupling transforms an application's parallel misalignment problems into angular displacement within the coupling. The center coils of the Helical coupling become an intermediate shaft that can allow 10, 20, or 30 thousandths of an inch of parallel offset or more.

For More Information Circle No. 769



Low-EMI GBIC Guide Rails

The dataMate business unit of Methode Electronics Inc., Chicago, IL, announces a new line of guide rails for gigabit interface converters (GBIC). These rails are made of plated plastic and deliver electromagnetic shielding without the problems associated with metal rails. The rails can be loaded onto circuit boards and soldered along with the rest of the components on the boards. The GBIC rails are also much lighter in weight than metal rails, in addition to being less costly, according to the company. They are available from stock.

For More Information Circle No. 770

Clutch Triples Torque Ratings

Electroid, Springfield, NJ, has introduced Model XT-39C, a power-off clutch, in its XT series of clutches and brakes. This model is about one-third the size of a standard conventional clutch or brake. The XT series has demonstrated coefficients of function between 0.75 and 0.95. This provides an economical and space-saving solution for aerospace and military applications, robotics, computer-chip and clean-room handling equipment, automation machinery, medical applications, material handling equipment, and food handling machinery, among other things.

For More Information Circle No. 771

New Stepping Motor Cube

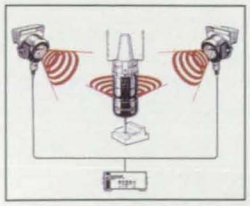
Whedco, Ann Arbor, MI, introduces the new stepping motor cube, which integrates a NEMA-23 stepping motor, drive, control, and communications capabilities into a single compact unit. This offers versatility, space savings, and improved productivity to machine builders and end users, Whedco says. The product's integral motor, drive, and networking power simplifies the automation of high-axis-count applications. It fits easily into systems where panel space is limited and can be used with up to 63 other industrial devices on a single network.

For More Information Circle No. 772

Planetary Gearbox

GAM, Chicago, IL, says its new NEMA Series planetary gearbox will provide a low-cost precision gearing solution. The series' ring gear is cut directly into the housing rather than press-fit into it. The input design allows for thermal expansion of the servo shaft. In addition, it is designed with high-carbon steel gears that are heat-treated. The NEMA Series is suitable for general-purpose motion control to increase machine throughput, GAM says.

For More Information Circle No. 773



On-Machine Probe System

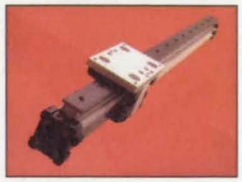
Renishaw Inc., Schaumburg, IL, says it brings CMM levels of probing performance and 10-fold probe life to industry's largest machine tools with a new MP700E high-power optical system. The new system, according to Renishaw, allows operators of very large 5-axis machine tools to verify critical features in process, achieve tighter tolerances for more precise fits, and even perform final inspection while the part is still on the machine tool. The system, which uses a high-power infrared transmitter, is designed for applications requiring transmission up to 12 meters.

For More Information Circle No. 774

New Plastic Nut with ActiveCAM

Ball Screws and Actuators Inc., San Jose, CA, has introduced an extension of its XC Series, the XCF-1800. This flange-mount plastic nut is designed for use with 3/16-inch and 1/4-inch lead-screws. A thread mount version is also available. The product features patented ActiveCAM technology to achieve zero backlash and consistent and minimal drag torque. It can be run without lubrication.

For More Information Circle No. 775



Guided Cylinder Is Improved

Bishop-Wisecarver Corp., Pittsburg, CA, introduces the HPS Powerslide-2, which utilizes a new and improved range of Hoerbiger-Oroga cylinders with an extensive use of plastics and a redesign of the aluminum barrel extrusion. Bishop-Wisecarver says this results in a stronger, lighter unit available in any length up to six meters as standard. Improved load-carrying capacity has been achieved, the company says, and the double row bearings also offer an improvement in system rigidity and performance in dirty conditions. A corrosion-resistant version is available.

For More Information Circle No. 776

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FREE NEWSLETTER

Building the Perfect Human

A NASA project integrates physical and virtual reality to help plan future space missions from the perspective of the most complex object ever launched — the human body. And the potential uses of this technology reach far beyond the limits of space.

Creating a realistic simulation of the human body represents a set of challenges as complex as the body it portrays. But scientists at NASA's Johnson Space Center (JSC) in Houston, TX, are doing just that — integrating computer software and virtual reality (VR) technologies to simulate an actual human. The project, known as the Somatic Sciences Simulation (S3) Project, is based on Virtual Interactive Anatomy (VIA) technology. VIA originates from the Visible Human Project commissioned by the National Library of Medicine. That endeavor produced a database representing digital imagery of the structure of male and female human bodies cut into precise sections.

VIA technology includes proprietary software and creative peripheral devices that produce a model with structural and functional attributes, an interactive design to customize anatomic and physiologic features, and the interactivity is multisensory. The virtual human and its environment appear photo-realistic, and one can move and touch the virtual human, thanks to a haptic computer interface device. Using the device, one can distinguish body parts by pushing on that part — and can even feel the pulse of the virtual human.

The shape change of a contracting muscle and the stretching of a ligament during vigorous activity are examples of human body characteristics that can be measured, mathematically described, and graphically modeled and displayed in VIA software routines. Simulations of internal events also are possible, such as the inflation and deflation of lungs during breathing. Virtual blood is of normal viscosity, and the virtual lungs contain air with a normal percentage of carbon dioxide.

Ultimately, the S3 Project will result in a virtual human with neuromuscular skeletal systems, organs, and tissues — a highly realistic human body simulation that can be adjusted to any environment. The S3 Project enhances and expands NASA's use of virtual reality to expedite a human-centered approach to future mission planning, training, and operations. The Project creates an alternative means to improve astronaut efficiency, mobility, comfort, and safety.

The project began in 1996 with an unexpected meeting at JSC's *Inspection96* event between Robert Rice, a biomedical educator and researcher, and Anthony Bruins, a NASA systems engineer. At the time, Rice was a Dean at the Texas Chiropractic College and went to the event on what he calls a "shopping mission" to see how virtual reality simulations of the human body were being used by NASA. Rice did not find what he was looking for, and eventually brought the idea of a virtual human to NASA. He and Bruins began discussing the idea with "anybody and everybody" at JSC. They were greeted with enthusiasm, and in early 1997, Rice founded the Institute of Somatic Sciences to create an official channel through which he could communicate with NASA. At the next *Inspection* event, Rice exhibited a virtual shoulder, which prompted Bruins to investigate how virtual design could support the design of new spacesuits. The technology has been developed as a result of a team effort at the Virtual Environment Research Institute, where Bruins worked with director Dr. Bowen Loftin, administrator Patricia Hyde, and computer scientist Hector Manuel Garcia Peña.

This virtual reality model of the glove currently used by NASA astronauts is combined with the S3 virtual hand and wrist to provide mobility, comfort, and task analyses based on individual hands.

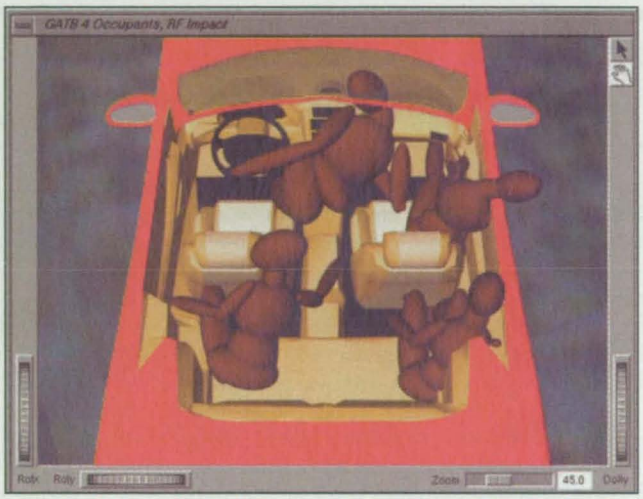
Safety in Space

In the next several years, more extravehicular activity (EVA) will be required of astronauts than ever before. Therefore, there is a need to create an advanced spacesuit and related support systems. The S3 Project uses computer software and data-capture/visualization technologies to provide modeling of virtual equipment and environments, as well as integration with the customized parameters of a virtual human. The result is a simulation tool that can be used to evaluate and train for an array of mission-specific goals, conditions, and variables. Said Bruins, one will be able to "go through failures on the computer," saving time and money.

For NASA, the S3 "human" will enable development of a new generation of spacesuits that will be much more efficient for astronauts building and maintaining the International Space Station and future advanced exploration systems. Current spacesuits have limitations that lead to early fatigue and pain. The current suits were designed around optimum engineering performance rather than around the human body. Bruins hopes to reverse the process, and "build from the human out," creating a custom suit around the natural movements of the human. In addition, a suit designed with this advanced simulation tool will be less costly and will take less time to design, as it can be fully tested on a desktop computer before cutting any hardware. Current spacesuits take

ten years to design, test, and certify, and cost millions of dollars. Bruins plans to cut both time and cost in half.

Bruins also hopes to track and evaluate respiratory, heart, and other body functions through the new spacesuits. He will then be able to see when, for example, a muscle would fatigue in various gravitational fields. Ultimately, one will be able to scan humans, turn them into 3D virtual humans, place them into a 3D virtual spacesuit scanned from an existing suit, and move that virtual human to see where the suit is insufficient and uncomfortable. From that information, they will be able to design a better suit — a virtual spacesuit (V-Suit) based on virtual and rapid prototyping. Today, Bruins and Rice already have completed the upper and lower extremities and the back, and are at work on the thorax, abdomen, and pelvis.



Current vehicle crash simulations use avatars that realistically obey the laws of physics, but lack human physiologic features and pre-crash reactions that S3 models can incorporate.

Limitless Potential

Uses of S3 Project technology are not limited to space travel. Rice said he soon will have models for all parts of the body except the head and neck, for which his group is awaiting funding, and described the available technology as an "interactive model for NASA applications and commercialization." The simulated human can conform to any shape or size, strength or limitation, and attribute of health or disease. This highly realistic and customizable VR human model can be used wherever there are human-in-the-loop issues of human factors engineering; that is, wherever a human is in an environment.

Dynoverse Corp., of Houston (www.dynoverse.com), the commercial counterpart of the Institute of Somatic Sciences, is actively seeking licensees and joint developers in several application areas. In the automotive industry, there is potential for an intelligent crash dummy. Within a virtual reality environment, not only will it be able to experience an accident, but it will even have anticipatory reactions to it. S3 technology will be useful in defense and aerospace, not only for the next-generation spacesuit, but also for pilot pressure suits, crash simulations, and tactical training scenarios that require accurate human modeling.

Dynoverse plans a library of virtual environments to assist presentation by attorneys of complex functions, structural, and traumatic changes to the body resulting from circumstances in civil and criminal litigation. In the medical arena, virtual patients, injuries, disease-states, and cadavers are possibilities to aid in education. Instead of dissecting cadavers, medical students will be able to perform surgery on virtual humans whom they not only can see, but also feel. The interactive 3D human also will be able to simulate disease and trauma.

In addition to medical education, it will be useful in developing therapeutic plans for patients in need of physical rehabilitation, and for medical research in which virtual simulations may replace the use of experimental animals. S3 Project technology will even be useful in general education and entertainment — the virtual reality experience can provide creative and informative explorations of the inner workings of the human body in immersive settings, IMAX films, museum exhibits, and diverse entertainment formats. The virtual human can be fully integrated into virtual environments and can actively interface with virtual products.

The possibilities for use are numerous, according to Rice. Wherever a person is interacting in an environment, he sees an application for this technology.

For more information, contact Anthony Bruins at: 281-483-7071; e-mail: anthony.c.bruins1@jsc.nasa.gov; or Dr. Robert Rice at: 281-364-6028; www.somaticsciences.org.

What's on the Drawing Board

Few Americans are aware that when Congress created NASA, it required that the space agency share its developing technology with American business, industry, and academia. The *Inspection* event, where Robert Rice and Anthony Bruins met and planned their collaboration on the Somatic Sciences Simulation Project, is an event geared to do just that.

This year, the fifth *Inspection* event, *Inspection2000*, will be held November 1-3 at NASA's Johnson Space Center in Houston, where NASA will once again share developing technologies, (including the S3 Project), expertise, and state-of-the-art facilities with American professionals. Though the Johnson Space Center is NASA's lead center for human space flight, today their technologies have commercial applications in many American industries, from biotechnology and medicine, to communications and manufacturing.

Inspection2000 is an opportunity for professionals in industry, government, and academia to inspect NASA-developed technologies and processes, learn about patented technologies available for licensing, find out how to partner with NASA, discuss technical issues with JSC experts, and observe JSC's unique facilities up close. For more information or to register, visit: **http://inspection.jsc.nasa.gov**.

Adaptive Camouflage

Sensor-and-display systems would create illusions of transparency.

NASA's Jet Propulsion Laboratory, Pasadena, California

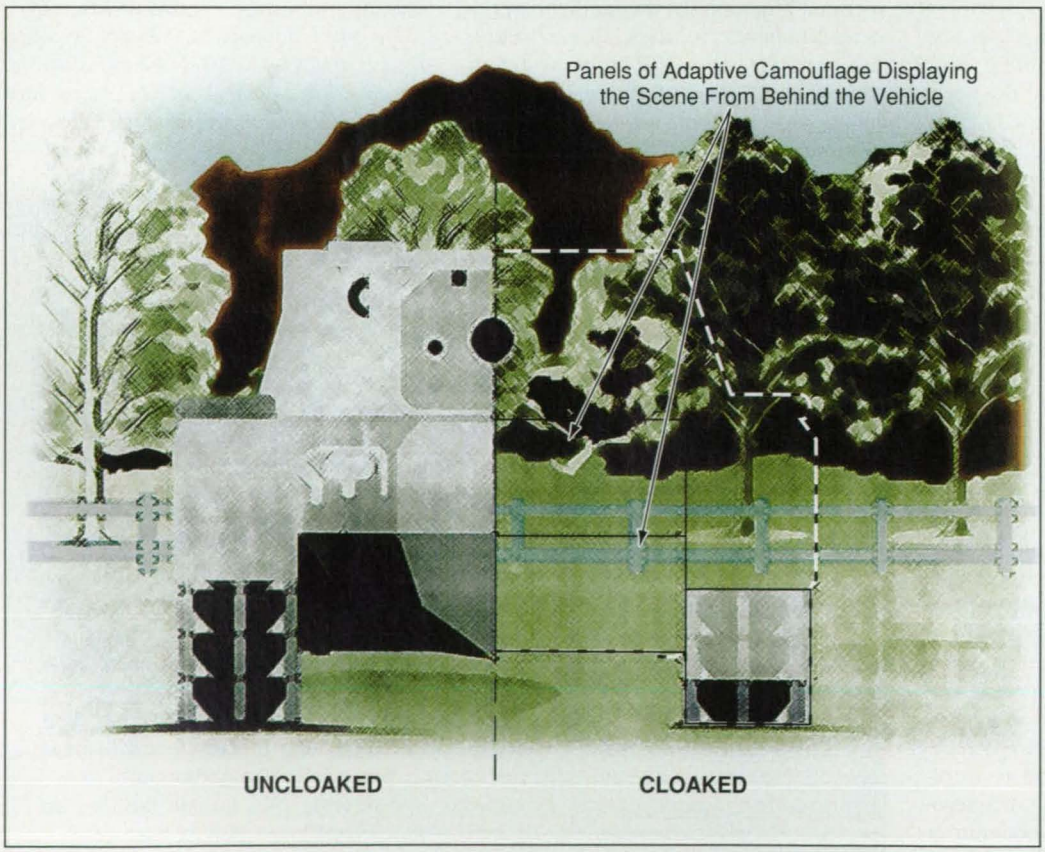
Lightweight optoelectronic systems built around advanced image sensors and display panels have been proposed for making selected objects appear nearly transparent and thus effectively invisible. These systems are denoted "adaptive camouflage" because unlike traditional camouflage, they would generate displays that would change in response to changing scenes and lighting conditions.

The basic overall function of an adaptive camouflage system would be to project, on the near side of an object, the scene from the far side of the object. Although adaptive camouflage was conceived for use in battlefield settings (see figure), there are also potential commercial uses — for example, as an electronic "window" that would display a nearby outdoor scene in an office that lacks a real window, or as a home security system in place of a door peephole.

A typical adaptive camouflage system would likely include a network of flexible electronic flat-panel display units arrayed in the form of a blanket that would cover all observable surfaces of an object that one seeks to cloak. Each display panel would contain an active-pixel sensor (APS) [or possibly another advanced image sensor] that would look outward from the panel through an aperture that would occupy only a small fraction of the area of the panel. The blanket would also contain a wiring harness that would include a cross-connected fiber-optic network, through which the image from each APS would be transferred to a complementary display panel on the opposite side of the cloaked object.

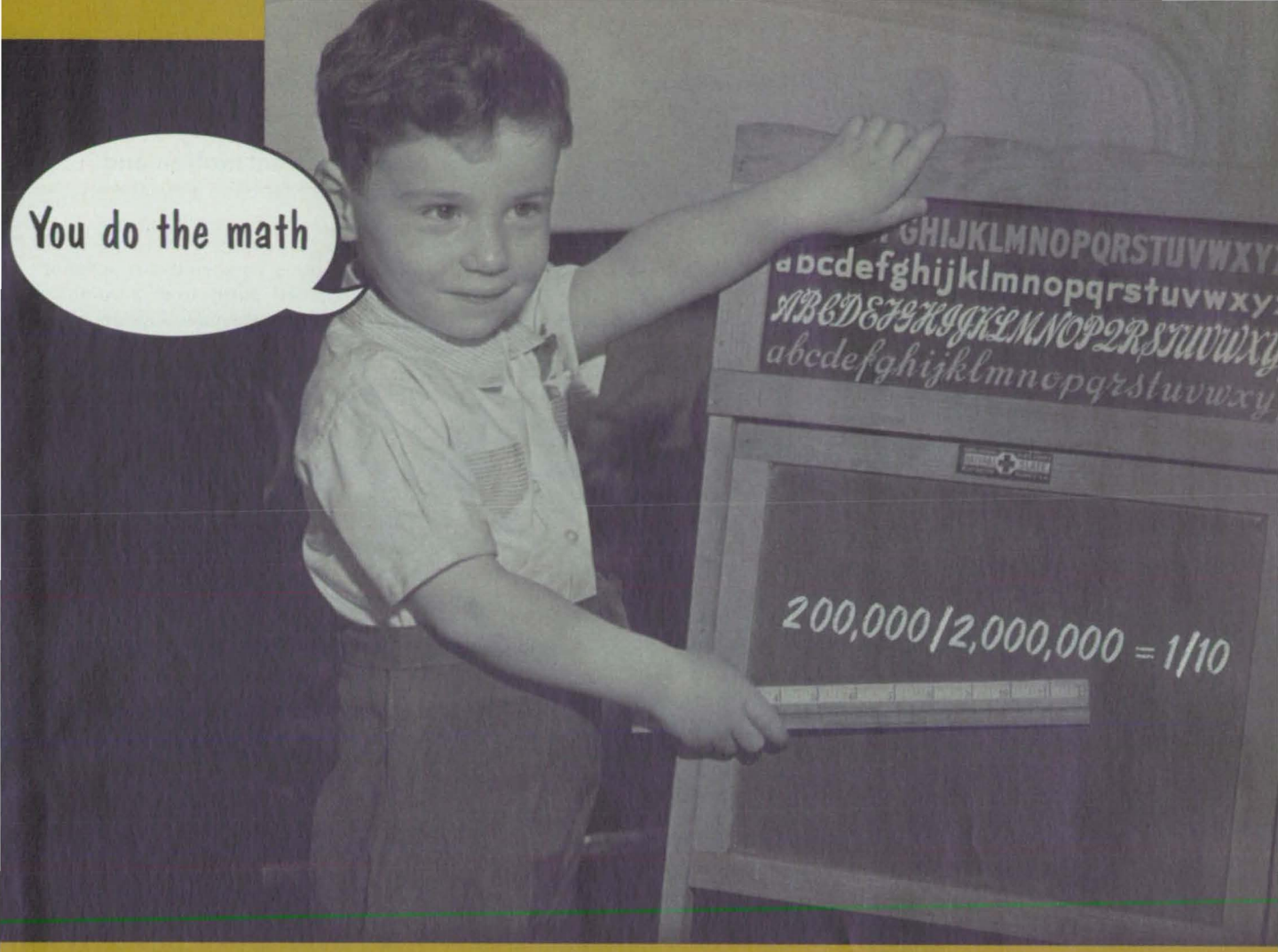
The positions and orientations of all the image sensors would be slaved to the position and orientation of one image sensor that would be designated a master imager. The orientations would be determined by a levelling instrument sensed by the master imager. A central controller connected to an external light meter would automatically adjust the brightness levels of all the display panels to make them conform to the to ambient lighting conditions. The underside of the cloaked object would be illuminated artificially so that the display from the top of the cloaked object would show the ground as though in ambient light; if this were not done, then an obvious shadow-induced discontinuity would be seen by an observer looking down from above.

The display panels could be sized and configured so that a common inventory of such panels could be used to cloak a variety of objects, without need to modify the objects. Sizes and weights of representative adaptive camouflage systems and subsystems have been estimated: The volume of a typical image sensor would be less than about 1 in.^{3} (≈16 cm^3). A system to completely cloak an object 10 m long by 3 m high by 5 m wide would weigh less than about 100 lb (≈45 kg). If the object to be cloaked were a vehicle, then the adaptive camouflage system could readily be operated on power provided by the vehicle electrical system, without adversely affecting the operation of the vehicle.



The **Scene From Behind an Object** would be displayed on panels on the front of the object. The effect of cloaking is illustrated in this simulated image of an armored vehicle with adaptive camouflage on one side only.

This work was done by Philip Moynihan of Caltech and Maurice Langevin of Tracer Round Associates, Ltd., for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Systems category.*
NPO-20706



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For More Information Circle No. 554

Moving Chair for Virtual Reality

The chair provides a combination of synthetic motion and support in a minimally stressful posture.

Lyndon B. Johnson Space Center, Houston, Texas

An apparatus called a "personal motion platform" (PMP) is undergoing development for use in adding the sensations of motion to computer-controlled simulated environments of the type now popularly known as virtual reality. The PMP was conceived originally for training an astronaut to interact with surrounding objects in a simulated zero-gravitation environment; it also has obvious potential for use in a variety of applications in biomedical research, education, and entertainment.

The PMP (see figure) includes a chair that supports the occupant in a modified version of the neutral body posture of zero gravitation. The chair is supported by a three-degree-of-freedom system of linear electric-motor actuators. A computer commands the actuators to produce the desired synthetic motions, which are reminiscent of computer-controlled motions of aircraft cockpit flight simulators. The PMP is also equipped with hand-operated controls.

The motion commands for actuators are computed partly from a combination of (1) a mathematical model of the synthetic environment, (2) the kinematics of the chair, and (3) position feedback. In addition, to enhance the interaction between the user and the synthetic environment, motion commands can be derived from simulated collisions with objects and from the hand-operated controls. As in the case of flight simulators, the computed motions are adaptively filtered to retain as much as possible of acceleration frequency components needed for realistic sensations of motion while limiting overall excursions to avoid hard stops at the limits of the actuators.

This work was done by Brian Park of Flogiston Corp. for **Johnson Space Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Machinery/Automation category.*

MSC-22623

The **Reclining Chair Pitches, Rolls, and Heaves** as it holds the occupant in a minimal-stress posture intermediate between the neutral body posture of zero gravitation and a normal posture of relaxation on a flat, level surface. Linear electric motors at the base of the chair drive the motion.

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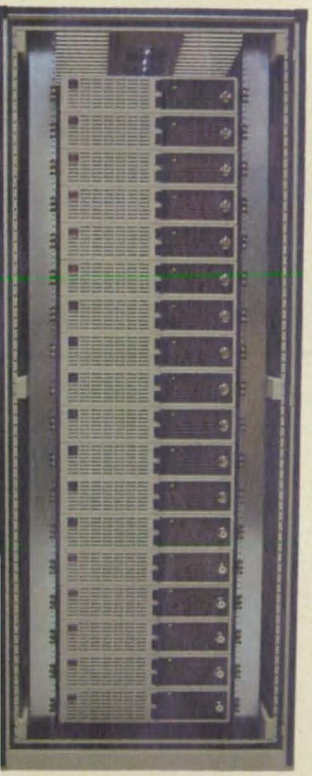

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For More Information Circle No. 568

Program for Viewing Remotely Generated Summary Data

NASA's Jet Propulsion Laboratory, Pasadena, California

The Beacon Visualization (BeaVis) computer program provides a ground-based computing environment for displaying, tracking, storing, and maneuvering through telemetric data streams that contain summaries of engineering data generated aboard a spacecraft. BeaVis can also serve as a general-purpose software tool for monitoring data of other specific types. In the original spacecraft-to-ground application, BeaVis enables the user to scroll through a graphical depiction of telemetry downlinks to select desired data. Summary data are represented graphically, with hypertext links to strip charts of sensor channels represented by summary data packets. BeaVis also generates time-line and tabular displays. A time line depicts when, during a spacecraft mission, summary downlinks and beacon tone detections have occurred. The tabular and strip-chart displays are available through hypertext links from the time-line display. BeaVis also provides graphical user interface elements that show such specific summary data components as changes in mission activities, snapshot telemetry, episode data, and user summary data. The program also includes a software tool for creating tables of parameters that are uploaded to a spacecraft.

This work was done by E. J. Wyatt, Robert Sherwood, and Tim Fogarty of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Information Sciences category.*

This software is available for commercial licensing. Please contact Don Hart of the California Institute of Technology at (818) 393-3425. Refer to NPO-20665.

Numerical Speed of Sound

This concept is applicable to flows at all speeds.

John H. Glenn Research Center, Cleveland, Ohio

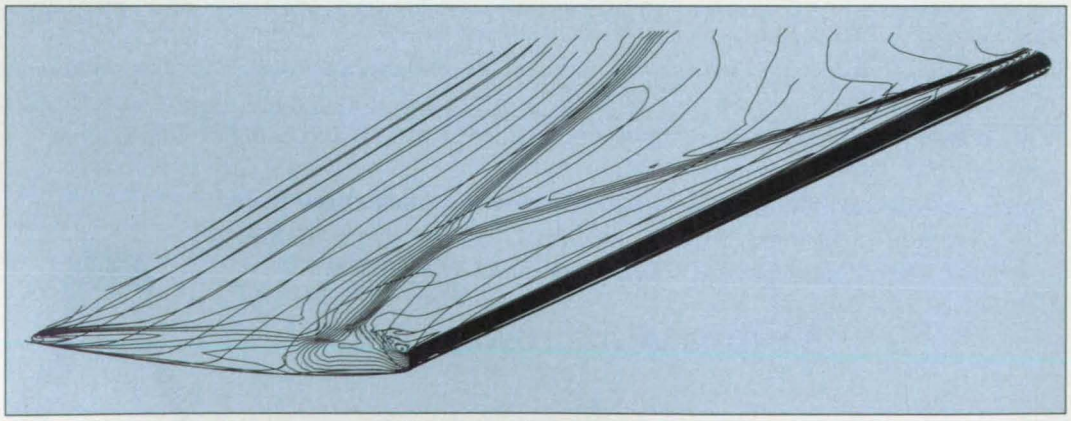
The numerical speed of sound is a variable that is used in the numerical solution of flows from low to high speeds. The numerical speed of sound is an effective speed of sound associated with Mach numbers used in the numerical splitting of a flow into upwind and downwind mass-flux components that are defined on the faces of cells of a computational grid into which a flow volume is divided. Depending on the details of a given flow problem and the algorithm chosen to solve it, the numerical speed of sound may or may not equal the physical speed of sound.

The numerical speed of sound has been found to be very useful in constructing upwind numerical-solution schemes to satisfy certain criteria. [As used in this special context, "upwind" (as distinguished from "central" or "downwind") refers to a manner of approximating spatial derivatives of flow quantities by taking differences between discretized flow quantities at locations biased toward the upwind side with respect the location of immediate interest.] An especially notable criterion is the capability for exact capturing of contact and shock discontinuities in one-dimensional flows. The concept of the numerical speed of sound can also be extended to apply to the computation of low-speed (in effect, incompressible) flows. In such an application, a scaling factor that varies with speed is introduced. As a result, the numerical dissipation decreases with the flow speed and, as a further consequence, the rate of convergence of iterative computations toward the solution is increased. The accuracy of the solution is also increased.

In a study, the numerical speed of sound was incorporated into some numerical-solution schemes based on a method called advection-upstream-splitting method (AUSM). It can also be incorporated in other upwind schemes, including one known as Roe flux splitting, wherein an averaged speed of sound, among several other averaged variables, is automatically required. Other numerical-solution schemes can also be made to capture shocks exactly.

This work was done by Meng-Sing Liou of **Glenn Research Center** *and Jack R. Edwards of North Carolina State University. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Information Sciences category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-17011.



Pressure Contours on a Wing were computed by using a scheme called "AUSM+," augmented with the numerical speed of sound, to solve the Navier-Stokes equations numerically. The wing is of the M6 type of the Office National d'Etudes et de Recherches Aérospatiales (ONERA). The flow conditions for this computation were a free-stream speed of mach 0.84, a Reynolds number of 18.2×10^6, and an angle of attack of 3°. The computed pressure contours are in good agreement with available experimental data, especially in capturing two shocks that manifest themselves in the λ-shaped pattern of closely spaced curves.

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For More Information Circle No. 527

SensAble Technologies, Cambridge, MA, offers the PHANTOM™ Desktop **force feedback system** with 3-D Touch™ that connects to a computer via an extended parallel port. The force feedback system senses motion in six degrees of freedom, providing a realistic sense of 3D touch for design applications. Users can feel the point of the stylus in all axes and track its orientation (pitch, roll, and yaw).

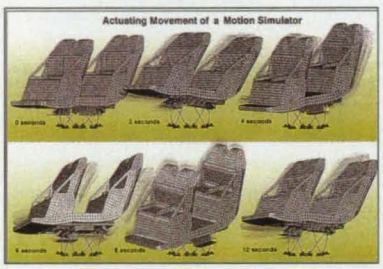
The system's 3-D Touch technology allows users to directly interact with digital objects and data using the sense of touch. Engineers can navigate and evaluate complex 3D data with continuous two-way interaction. The PHANTOM system incorporates GHOST® middleware as the "touch" engine, allowing users to feel physical properties such as location, mass, friction, and stiffness.

For More Information Circle No. 731

The Muse Software Development Environment 2000 **visualization/simulation software** from Muse Technologies, Albuquerque, NM, features new speech recognition and voice command capabilities, as well as HP-UX compatibility. Designed for the automotive, manufacturing, aerospace, and medical imaging industries, the software allows users to view complex data sets, either on desktop computers or in immersive environments.

The software also features multiscreen display, and collaboration via the Internet or local-area network. It uses Microsoft's SAPI interface for speech recognition and synthesis on the Windows NT platform. The new version enables users to incorporate sound, including speech recognition and synthesis, while operating in visualized environments.

For More Information Circle No. 732



Algor, Pittsburgh, PA, offers **actuator element technology** enabling engineers to realistically simulate computer-controlled movement with their proprietary Mechanical Event Simulation (MES) software. The technology reduces the need for physical prototyping and automatically determines the motion, flexing, and resulting stresses of a part or assembly at each instant of an event.

In using the actuator elements, engineers can specify contraction and extension values over time to drive motion between the connected parts. Multiple actuator elements can be used in a system to replicate asymmetric motion. Several actuators working in unison can simulate hydraulic and pneumatic cylinders and electric solenoids that function symmetrically.

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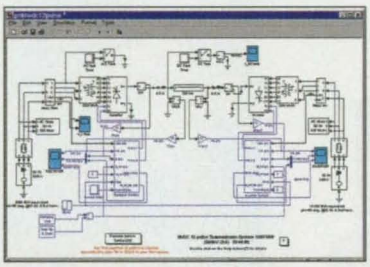
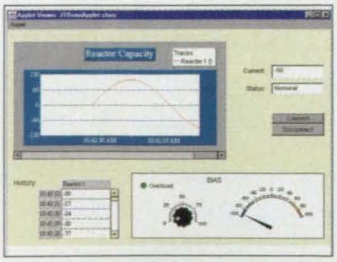


The Power System Blockset 2.0 from The MathWorks, Natick, MA, is a **simulation add-on** that allows control system engineers and designers to create and simulate graphical models in a design environment. The toolkit enables users to run multi-domain simulations of electrical power components in the development of self-contained power systems.

The blockset utilizes variable step integrators and event location techniques. It enables users to efficiently model the generation, transmission, and distribution of electrical power with its associated control systems. The program features a library of pre-assembled block models for power system networks, power electronics, and control and measurement.

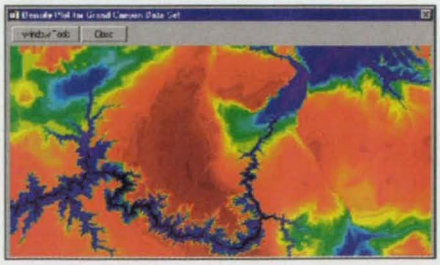
For More Information Circle No. 734



Real Time Integration, Kirkland, WA, has introduced the NetAcquire™ Java Toolkit, with integrated JavaBeans support, for creating Java test and measurement applications and Java **virtual instrumentation** front-panels. JavaBeans are pre-engineered Java components that can be graphically configured without programming. The toolkit includes JavaBeans components for graphing, text, and lamp displays; disk logging; scaling; real-time network communication; and data distribution.

The components allow the creation of real-time data display screens and instrument front-panels. The client/server network model also allows time-critical buffering and control code to run on the NetAcquire server hardware. Server-side data processing avoids forcing time-critical functions to run on the client computer's Java interpreter. The toolkit aids in building enterprise-wide distributed test and measurement systems, and Internet-compatible systems.

For More Information Circle No. 735



Research Systems, Boulder, CO, has introduced RiverTools Service Pack, an extension to the RiverTools digital terrain and river network **visualization and analysis software**. The service pack adds new file formats, and enables the software to import data from almost any digital elevation model. Additional features include new display tools, and enhancements to the flow grid extraction algorithm that enable users to process and visualize data faster.

The RiverTools program includes graphical capabilities such as shaded relief, density plots, contour plots, surface plots, and river network maps. Forty color palettes are available for enhancing imagery. The software and the service pack are available for Windows, Macintosh, and UNIX workstations.

For More Information Circle No. 730

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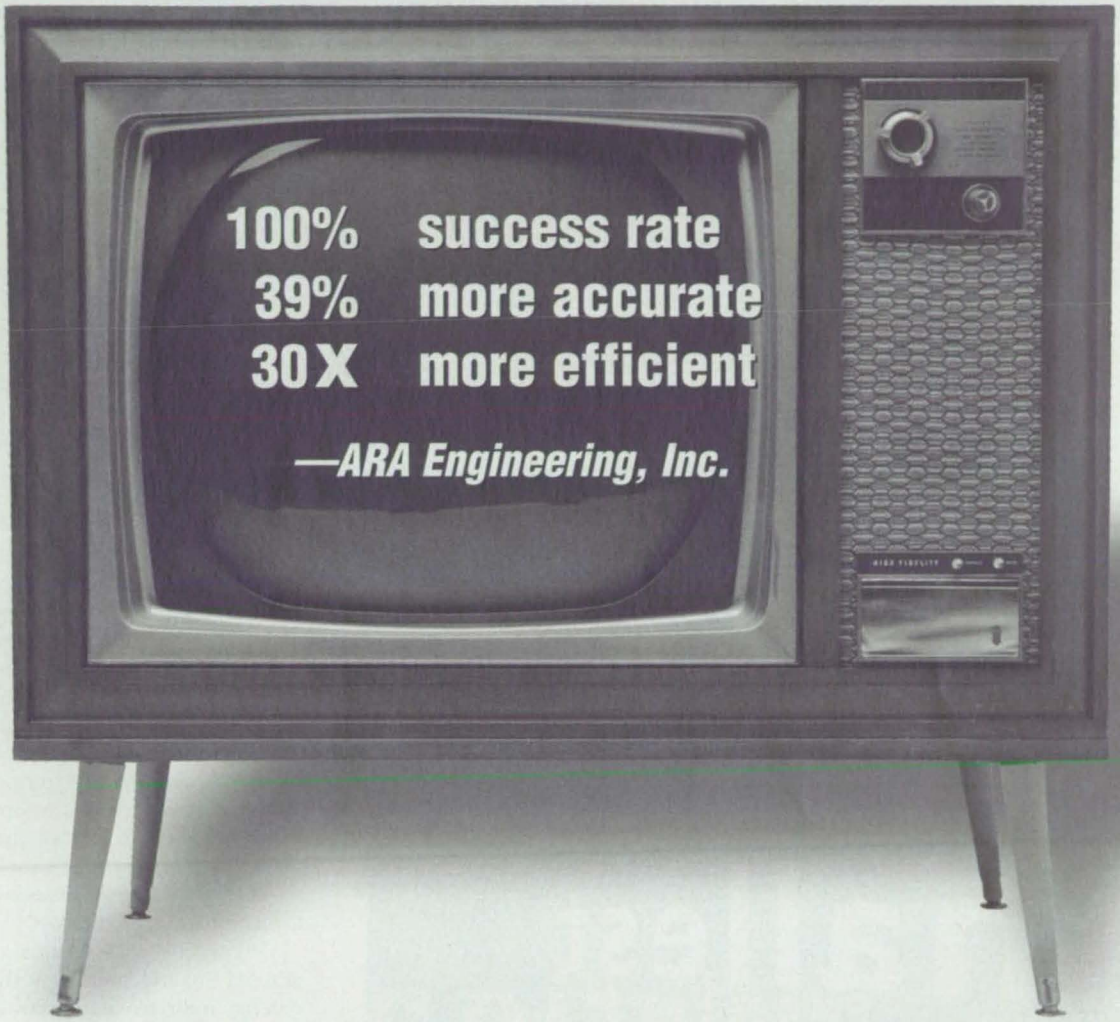

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Locally Connected Neural Networks for Pattern Recognition

Patterns could be recognized even if rotated and/or translated.

NASA's Jet Propulsion Laboratory, Pasadena, California

Neural networks of a proposed type would be formed with computational units called "neuromorphs" attached in a locally connected array. These neural networks would achieve pattern recognition invariant under rotation and translation by exploiting a combination of network symmetry and biologically inspired image-information-processing concepts. The architecture of these networks can be implemented in software; it is also suitable for implementation in hardware in the form of single-chip integrated circuits that would function in parallel-processing modes and thus be capable of fast recognition of patterns.

A typical previously developed image-recognition system effects a process that includes a feature-extraction subprocess followed by a classification subprocess: First, the system extracts features relevant to the kinds of objects that it seeks to classify. These features tend to fall into three classes: global, local, and relational. These feature vectors are then put into a classifier that has been trained or structured to differentiate the feature vectors into different pattern groups.

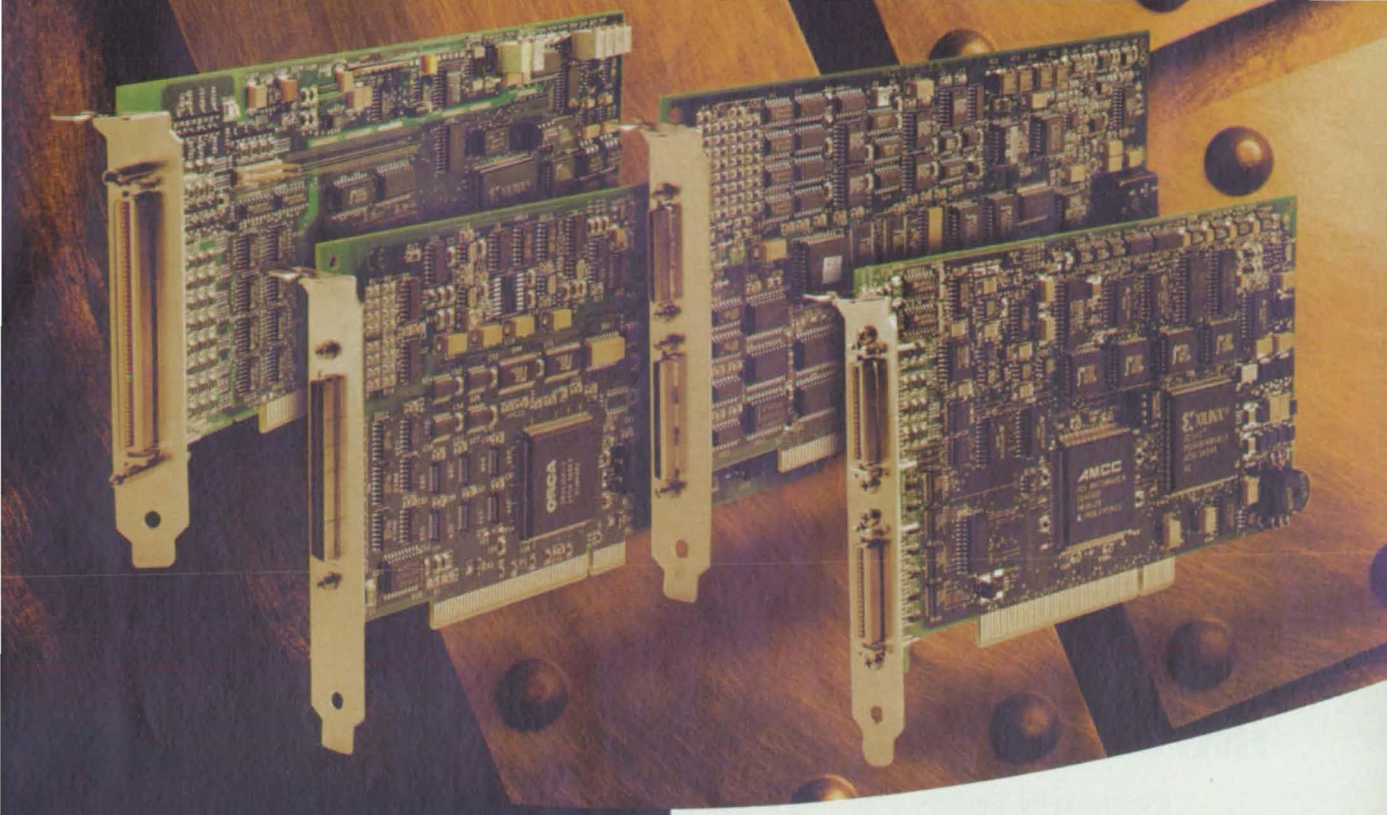
A neural network of the proposed type would produce feature vectors that would be global, local, and relational, all at the same time. Consequently, for some applications, single feature vectors would be all that would be needed for classification; moreover, inasmuch as features would be easily differentiable, adequate back-end classifier subsystems could be made less complex than those of previously developed pattern-recognition systems. The proposed neural networks could be made quite compact and suitable for analog array processing systems in which neuromorphs would be incorporated directly into the electronic circuitry of image-detecting arrays of photodetectors. Eventually, efforts to integrate this type of neural pattern-recognition circuitry with image-sensing circuitry should lead to the development of single chips that would perform image-acquisition and pattern-recognition functions analogous to visual preprocessing in eye/brain systems.

The concept of a locally connected network of neuromorphs evolved from previous research on the use of pulse-coupled neural networks for fast, invariant automatic target recognition. More specifically, the proposed network architecture is derived from, but is more efficient than, the architecture of an experimental pattern-recognition neural network based on a biomorphic neuron model that includes both the spiking behavior at the axon hillock and the synapto-dendritic processing of a biological neuron. The proposed neural networks would process information in a manner similar to that of the pulse-coupled neural networks, but could be implemented more easily and could process information at higher rates.

The results of computational simulations of the architecture of the proposed systems indicate an ability to perform translation- and rotation-invariant pattern recognition. Analog integrated circuits for use as building blocks (neuromorphs) of locally connected neural networks of the proposed type were designed and tested in other computational simulations, and the results of these simulations indicate that in comparison with previously developed pattern-recognition systems, the proposed system could achieve faster convergence, could operate with lower power consumption, and could be fabricated with greater integration density.

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

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, NASA Resident Office–JPL; (818) 354-5179. Refer to NPO-20633.



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Cross-Correlated Trellis-Coded Quadrature Modulation

There is more flexibility for optimization than there is in older related modulation techniques.

NASA's Jet Propulsion Laboratory, Pasadena, California

Cross-correlated trellis-coded quadrature modulation (XTCQM) has been proposed as a generic scheme with specific embodiments that potentially offer superior alternatives to other highly power- and bandwidth-efficient phase-shift-keying (PSK) modulation schemes. Examples of such schemes include Gaussian minimum-shift keying (GMSK), staggered quadrature offset raised cosine (SQORC), Feher's patented quadrature PSK (FQPSK), and pulse-shaped offset quadrature PSK (OQPSK).

Previously developed trellis-coded-modulation (TCM) techniques combine (1) the bandwidth efficiency of such conventional multilevel-modulation techniques as multiple-phase-shift keying (MPSK) and quadrature amplitude modulation (QAM) with (2) the power efficiency of error-correction coding into (3) unified modulation schemes that, through suitable mappings, simultaneously exploit the desirable properties of (1) and (2). While the previously developed TCM techniques afford the bandwidth efficiency inherent in multilevel modulation, less attention was given, in the development of those techniques, to achieving high levels of spectral containment as quantified, for example, by keeping out-of-band power levels low to minimize adjacent-channel interference.

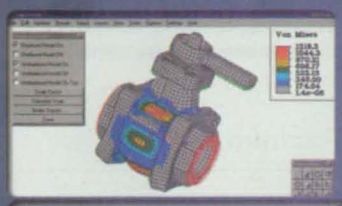
Considering only quadrature modulations, the innovative aspect of the development of XTCQM lies in a focus on the spectral occupancy of the transmitted signal, along with careful attention to a desirable constant-envelope property and to the power efficiency of the demodulation/decoding operation at the receiver. The more-generic nature of XTCQM (as compared with FQPSK and other schemes) affords considerably more flexibility for trading off between power and spectral efficiencies.

In XTCQM, a cross-correlation and a suitable waveform mapping are introduced into the in-phase (I) and quadrature (Q) baseband signals transmitted on quadrature carriers, in such a way as to provide a high level of spectral efficiency while also maintaining high power efficiency and a constant or pseudo-constant envelope. XTCQM would be implemented by use of such standard, currently available subsystems as an offset-QPSK modulator and a receiver containing such items as matched filters, and a Viterbi decoder. The transmitter portion of a conceptual XTCQM communication system has been shown, in a computational simulation, to perform as predicted by theory. At the time of reporting the information for this article, the software for computational simulation of the performance of the receiver portion of the system was in an early stage of development.

This work was done by Marvin K. Simon and Tsun-Yee Yan of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Systems category.*

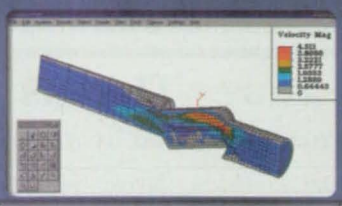
NPO-20532

12 Reasons Why Algor Should Be Your FEA Partner

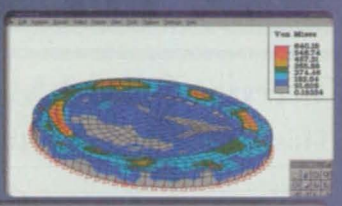


Linear Static Stress - Algor's linear static stress product enables you to capture complex assemblies, such as this valve assembly, from a CAD solid modeler and run a finite element analysis using fast solver technology. Typical loadings are pressure, acceleration, temperature, force and prescribed displacements.

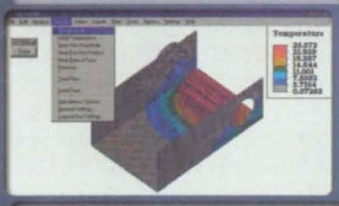
Steady Fluid Flow - Prescribed velocities and pressures provide the loading for this 3-D steady fluid flow analysis of a pipe with a gate valve. Algor's multiple load curves allow for easy data entry for adding loading such as gravity.



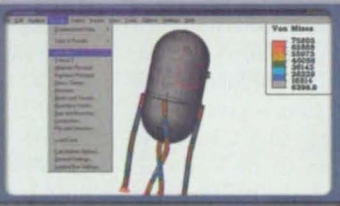
Unsteady Fluid Flow - Unsteady fluid flow of this ball valve system was analyzed using a 3-D CAD solid model. Algor's unique processor solves for velocities and pressures throughout the dynamic event, using a specialized meshing algorithm for high velocity gradients.



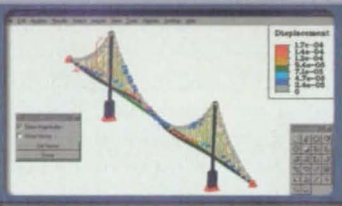
DDAM - Algor's Dynamic Design Analysis Method enables you to analyze the shock response at the mountings of shipboard equipment such as watertight doors, masts, propulsion shafts, rudders, exhaust uptakes and portholes, as shown above.



Transient Heat Transfer - The dynamic effects of a transient heat transfer analysis were needed for the time-dependent temperature loading of this heat sink assembly. Algor's multiple load curves for various loading conditions allow for the simulation of the thermal event.

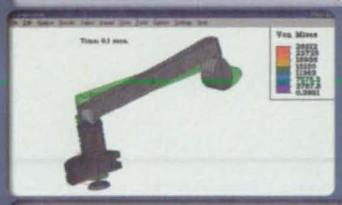


Nonlinear Static Stress - Algor's nonlinear product helps to accurately predict large deformation and large strains caused by static loading. As seen by this water tank, buckling of a structure is one type of failure that can be exposed.

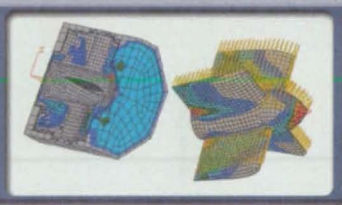


Linear Dynamic Stress- A modal analysis is one of the linear dynamic stress analyses performed on this suspension bridge. Failure can occur when the loading frequency is at the structure's resonant frequency. Algor's linear dynamic analyses accurately predict these frequencies and dynamic effects.

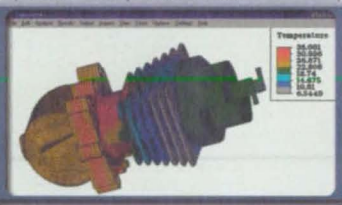
Mechanical Event Simulation (MES) with Nonlinear Material Models - Algor's MES extends full dynamic analysis capabilities to large strain/deformation analyses of nonlinear materials, as shown by this landing gear assembly. Kinematic elements can be used for quicker processing.



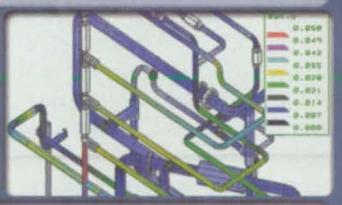
Mechanical Event Simulation (MES) with Linear Material Models - Algor's MES with linear material models allows you to represent a dynamic analysis while solving for kinematics, deflections and stresses of the structure. Analyses using large CAD assemblies, such as this rocker arm assembly model, can be expedited by using kinematic elements.



Multiphysics - Algor's multiphysics products enable you to combine multiple analysis types into one event. Resultant forces from flow around this turbine were calculated and then projected onto the object for a structural analysis. Other multiphysics capabilities include combining heat transfer with fluid flow, heat transfer with static/transient stress and heat transfer with fluid flow and stress.



Steady-State Heat Transfer - Algor's steady-state thermal processor helps predict temperature distribution due to thermal loading. Loading such as convection, radiation, conduction, applied temperatures and surface heat fluxes can be added to an analysis for fast, accurate results. In the case of this engine casing, both conduction and convection were part of the analysis of this 3-D solid model.



Piping Design and Analysis - Algor's piping design and analysis product enables you to calculate the deflections and stresses of this plant piping system and then compare the results with ASME/ANSI code allowables. Loadings can include: dead weight, thermal differences, pressure, wind loads, earthquake loads, time history of forces/displacements, response spectrum, natural frequencies and pitch and roll.

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Thrust Stand Measures Thrusts of <1 Pound

This device measures thrusts produced by miniature cold-gas thrusters in vacuum and air.

Lyndon B. Johnson Space Center, Houston, Texas

The development of miniature, cold-gas thrusters for on-orbit propulsion of such small devices as remotely piloted cameras and for inclusion in astronaut propulsion backpacks gave rise to a need to measure thrusts ranging from 0.04 to 0.8 lb (0.2 to 3.6 N). In addition, there was a need to measure thrust in a vacuum environment as well as in air at a pressure of 1 atmosphere (0.1 MPa), and over a wide range of propellant inlet pressures. The primary obstacle to be overcome for such measurements was to solve the problem of delivering the cold-gas propellant (compressed nitrogen gas) to the thruster without affecting thrust measurements, particularly those below 1/4 lb (1 N).

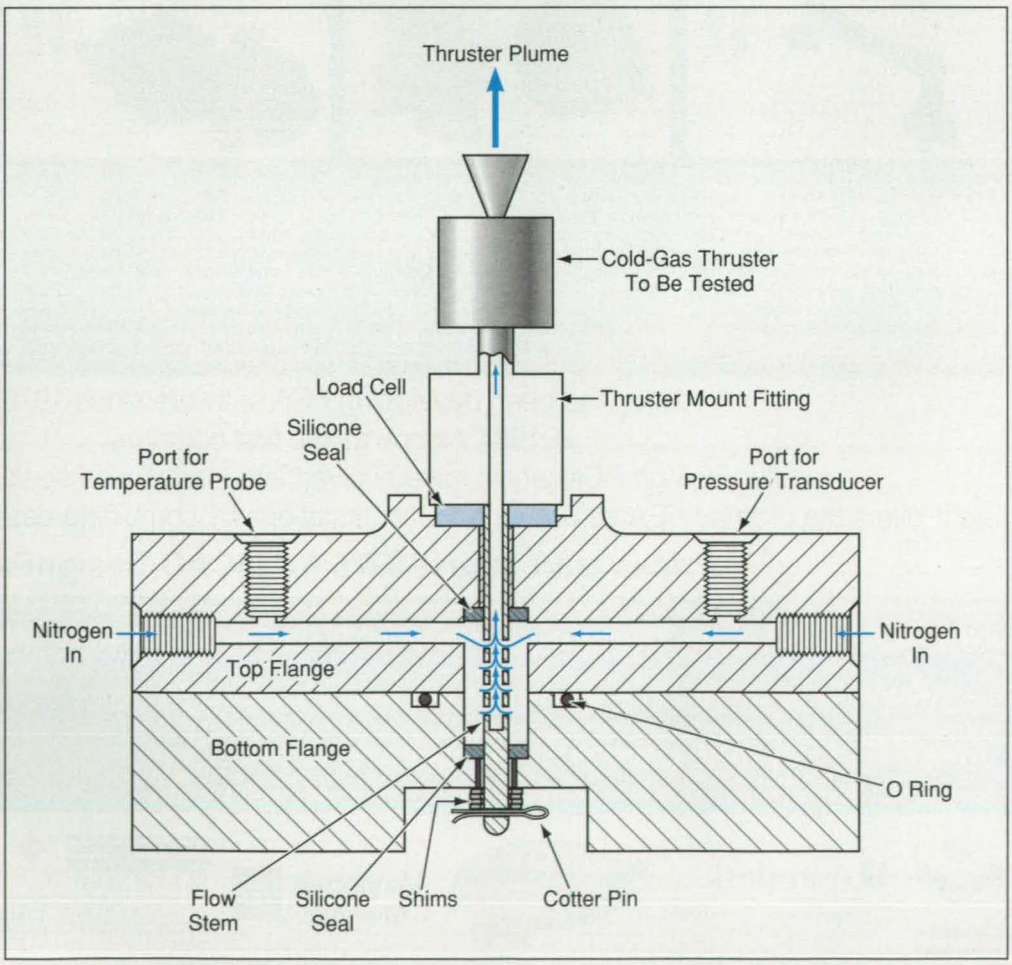
Methods for measuring larger thrusts include the use of flexible tubes or rotating fluid couplings to deliver propellants. However, in the present low-thrust application, the forces applied by flexible tubes to thrust sensors would be large with respect to the thrust being measured. In addition, the forces generated by flexible tubes vary with changes in propellant pressures and apply off-axis loads to the thrust sensors. The internal frictional forces in rotating fluid couplings, and the variations of these forces with pressure, would also be too great with respect to the low thrusts to be measured.

The figure is a cross section of a thrust stand designed for measuring small thrusts in vacuum or in air at atmospheric pressure. A readily available doughnut-configuration load cell is used as the thrust sensor. The doughnut configuration was chosen because its central hole makes it possible to make the propellant-flow path coaxial with both the thruster and the load cell. The load cell is equipped with a vent port so that the pressure of air in its internal cavity always equalizes with the pressure of the surrounding air, to prevent undue pressure-related shifts in load-cell output.

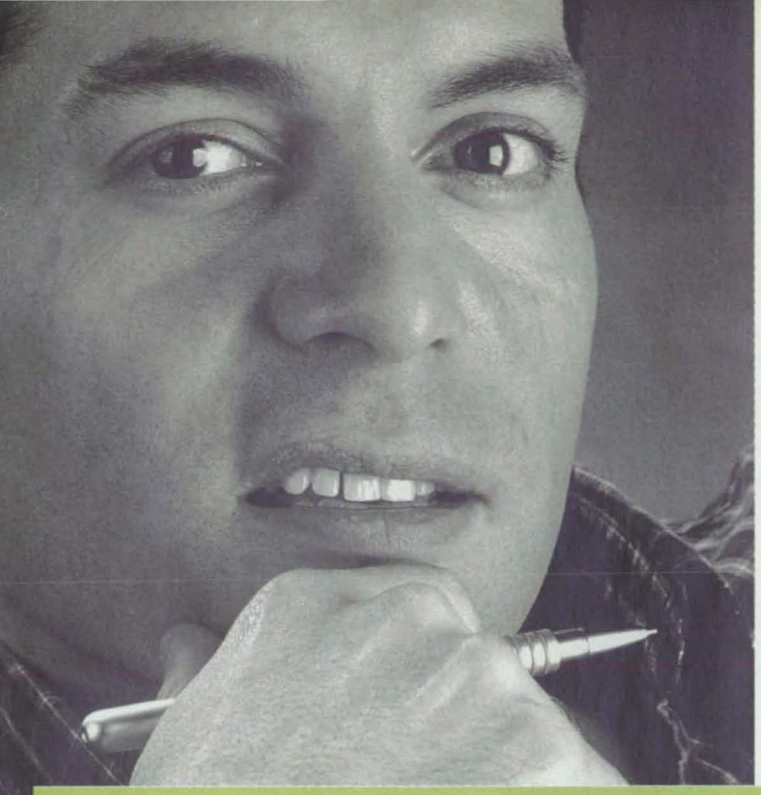
A flange assembly and flow stem are included to provide for delivery of propellant coaxially through the load cell to the thruster. The flow stem is also part of a thruster-mount fitting, which transfers thrust from the thruster to the load cell. The coaxial arrangement of the thruster, load cell, and flow stem eliminates all off-axis loads.

The flow stem was designed to protrude through both the top and bottom flanges so that propellant pressure is axially balanced on the stem in opposing directions. This was done to negate the force on the load cell produced by the static pressure and by variation of the static pressure of the propellant. In practice, this design feature proved successful, balancing 98.7 percent of the force [7.8 out of 7.9 lb (34.7 out of 35.1 N)] at a propellant pressure of 258 psi (1.78 MPa).

One focus of design efforts was the problem of how to best seal the gap between the flow stem and the flanges to prevent the escape of nitrogen, while allowing for consistent reactions from the load cell for a given thrust. Initially, the flange passageways incorporated internal O-ring grooves, with the O-ring sealing against the flow stem in the top



This **Thrust Stand** has been calibrated to yield accurate measurements of thrusts from 0.02 to 0.61 lb (0.09 to 2.7 N). This view is a simplified cross section; some details are omitted.



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and bottom flange. Since full deflection of the load cell was <0.001 in. (<0.025 mm), the seals could be regarded as parts of a static configuration in which the O rings served as flexures to a tiny extent. In practice, however, the O rings tended to shift in their grooves with variations in propellant pressure, thus yielding inconsistent readings from the load cell.

To provide an alternate method of sealing between the flow stem and flanges to eliminate shifting of the seals, O rings were replaced with a silicone sealant. It was reasoned that once the sealant became cured, the adhesion of the sealant to the flow stem and flanges would ensure a fixed geometry, without the slippage between dissimilar surfaces that had occurred in the use of the O rings. Like the O rings, the new silicone seals would flex microscopically, but they would not slip along the flow stem or shift in their grooves as the O rings did. A pourable silicone sealant with proper viscosity in the uncured state and proper shear strength in the cured state was selected. An assembly method and tools were devised to support pouring and curing of the silicone seals during assembly of the thrust stand. During testing of the silicone seals, no leakage was observed at pressures up to 270 psi (1.86 MPa).

Additional features of the thrust stand include the following:

- A shoulder on the thruster mount fitting holds preload weights that are needed to optimize the sensitivity of the load cell.
- A raised wall on the top flange protects the load cell, which is delicate.
- Leakage relief paths from the silicone seals prevent unwanted pressurization in the event of a leak.
- Ports for temperature and pressure sensors are included.
- A cotter pin and shims retain the flow stem in the flange assembly. Shim stack height is set as needed to carry any inadvertent loads applied to the bottom of the flow stem during handling and installation, thus protecting the silicone seals from damage.

Calibration of the thrust stand began with pressurizing it to one of the pressures desired for testing thrusters. Next, calibrated brass weights were placed on the thruster nozzle, and the electrical output of the load cell was recorded. After calibrations were completed, the thruster was fired several times, then calibration was repeated.

During a test program, the thrust stand was calibrated in thrust ranges of 0.02 to 0.16 lb (0.09 to 0.71 N) and 0.39 to 0.61 lb (1.7 to 2.7 N). The error in the measurements was ±5 percent of indication in the low range and ±3 percent of indication in the higher range. This combination of ranges and accuracies amounts to an exceptionally wide useful overall range for a thrust-measurement system. The thrust measurements obtained in thruster firings were found to be equally or more repeatable (that is, characterized by error bands of equal or smaller width), in comparison with the thrust measurements obtained during calibration.

Further changes in the design of the thrust stand have been proposed to increase its capability for future use. Mounting the load cell under the bottom flange in a holding fixture would make it possible to replace the load cell easily with a load cell of a different measurement range. Thrust would still be transferred to the load cell coaxially, but it would be transferred from the bottom tip of the flow stem, through a thermal-isolation fitting, to the load cell. Not only would the replacement of the load cell be much simpler; in addition, this configuration would thermally isolate the load cell from the thruster and propellant, thus providing

for temperature conditioning of the thruster and propellant beyond the range allowable for the load cell. This configuration would also make it possible to use a larger diameter flow stem to accommodate thrusters with higher flow rates.

In this application, time constraints dictated the purchase of a best available, off-the-shelf load cell that had a normal measurement range of up to 2 lb (8.9 N). The use of the load cell for a wide range of measurements is what made it necessary to perform both a low-range calibration and a separate high-range calibration to ensure accuracy. Time permitting, future versions of the thrust stand would incorporate lower-range load cells for the lowest of thrust measurements.

This work was done by Mark L. Villemarette of* **Johnson Space Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Test and Measurement category.*

MSC-22861

**Presently of Oceaneering Space Systems.*

Software for Designing Model Rockets for Base-Heating Tests

This program eliminates a week or more of manual calculations for each configuration.

Marshall Space Flight Center, Alabama

The Impulse Combustion Excel (ICE) computer program was developed to facilitate and accelerate the design and analysis of subscale rocket engines for use in base-heating tests. Such tests are performed on the ground to obtain data for estimating the heating effects of hot exhaust plumes on the aft regions of full-scale rockets during ascent. The computer program is so named because typically, a base-heating test involves impulse combustion — short-duration (of the order of 100 ms long) hot firing using flight propellants. Heretofore, the design of the subscale engines and base-heating tests has been a difficult, time-consuming, iterative process. ICE can be expected to reduce the testing times and costs and to yield improved designs. ICE can be used to design models to be tested in both wind tunnels and vacuum tanks.

ICE is a spreadsheet code that provides all of the parametric data used in the geometric design, heating analysis, and system analysis for many propulsion systems. The power of ICE lies in the capability to change only one or all input variables to adjust a design. ICE can also be used as an educational tool for learning the effects of various parameters on an entire design.

ICE eliminates a week or more of manual calculations for each model configuration. The program incorporates engineering relations that have been used previously but, until now, have been found in several reports and documents and never gathered into one consistent form or location. In addition, ICE incorporates an expanded set of features including (1) a procedure for determining the loss of energy resulting from internal transfer of heat to cold metal surfaces, (2) a methodology for sizing a combustion chamber and associated ports of one or more engine(s), (3) a valve-selection sheet, and a (4) historical design data base.

The spreadsheet contains the following pages: (1) input, (2) Venturi sizing, (3) charge-tube and buffer-gas-tube lengths, (4) system start time, (5) injector design, (6) combustor design, (7) combustor/nozzle heating, (8) surface heating, (9) valve pressure drop, and (10) historical design data. When the input page is filled out, ICE automatically generates the specifications necessary for computer-aided design (CAD) of a model. The CAD numerical model can be translated into an image of a solid model for electronic display and visual inspection; alternatively or in addition, a material model can be grown from the numerical model by use of stereolithography.

This work was done by Carl D. Engel of Qualis Corp. for **Marshall Space Flight Center.** *For additional information, please contact the company at (256) 533-9282.*

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

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Refer to MFS-31402, volume and number of this NASA Tech Briefs *issue, and the page number.*

Software for Analysis of Contamination of the ISS

Lyndon B. Johnson Space Center, Houston, Texas

The NASAN computer program can perform detailed analyses of molecular column density and molecular deposition on and around such complex space structures as the International Space Station (ISS). Contamination from both point sources (e.g., thrusters and vents) and diffuse sources (e.g., reflected plumes or outgassing of materials) can be analyzed. NASAN has been used to perform the assessments reported in the ISS incremental-design-review documents.

NASAN consists of several interactive tools (subroutines) that are linked together into a single, modular computer program that takes advantage of common program elements, which include manipulation of geometric models and plotting of results of computations. The central program components are designed to be easily expandable to perform additional analyses.

NASAN includes ray-tracing subroutines that are efficient means for calculating surface shadowing within the various program application modules. A variety of mathematical models of plumes can be easily called from the application modules. Two of these plume models calculate surface view factors, as needed, so that contamination calculations can proceed efficiently.

Because geometric models with as many as 25,000 surfaces can be analyzed, the fidelity achievable by use of NASAN is greater than that achievable with software developed previously for the same purpose. The modular structure of NASAN, along with a high degree of portability, makes it possible to perform contamination calculations on a much wider variety of computer platforms than was previously possible. Considerable time is saved over prior software of this type by use of NASPLT, which is a plotting subroutine within NASAN: this is because results of contamination calculations can be plotted from within the same subprograms that perform the calculations.

Another module of NASAN is CDPLT, which is a unique software tool for calculating and displaying the molecular column density around a spacecraft. This module has enabled the completion of numerous column-density calculations that, previously, could not be attempted.

Yet another module, FIRJET, models a surface plume and enables quick calculation of direct-flux molecular deposition onto a geometric model that has easily reorientable surfaces. The surface-source-plume model has enabled the analysis of more outgassing sources and model configurations than were previously possible.

The program is operational on several UNIX platforms, and some ray-tracing calculations can be performed in parallel on computers that include multiple processors. A simple, interactive user interface enables quick, interactive calculations, and facilitates setup for longer batch calculations. The contamination analyses performed by use of NASAN are helping to make possible the ISS design and verification activities to proceed on schedule. NASAN is also a powerful means for more detailed assessments of the local environments around specific payloads.

This program was written by Charles Lynn Hakes, Rose T. Rodriguez, Doug Warrington, and Eleazar Rios of Lockheed Martin for **Johnson Space Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Software category.*

MSC-22963

CVD of Diamond Using Magnetoplasmadynamic Sources

Rates of deposition are expected to exceed those from other sources.

NASA's Jet Propulsion Laboratory, Pasadena, California

A program of research and development is addressing the feasibility of using magnetoplasmadynamic (MPD) sources in the chemical vapor deposition (CVD) of synthetic diamond films. Because of its unique combination of thermal, electronic, mechanical, and chemical properties, diamond has potential for use as a coating material in numerous engineering and scientific applications.

A large amount of research has been directed toward understanding and developing CVD process (including plasma-assisted CVD process) for the synthesis of diamond and diamondlike materials. The plasma-assisted CVD processes include some that involve dc-arcjet sources; the development of these processes has benefitted from extensive prior research on dc-arcjet thrusters for spacecraft. Rates of deposition that have been achieved by use of dc-arcjet sources have exceeded those achieved by use of other gas-activation sources.

The success of the dc-arcjet approach has led to speculation on the utility of other thruster-type plasma sources for CVD of diamond. There is a large body of data from previous research on the performance and plume characteristics of electric propulsion devices; these data are available to support continuing efforts to understand the reaction kinetics and growth chemistry of diamond. One logical extension of the prior research would be an assessment of electric thrusters, other than dc-arcjet thrusters, for their potential to increase rates of deposition even further. MPD thrusters are among those that could be considered.

Regarded as thrusters, MPD sources have been found to perform with low efficiency at power levels below a hundred kilowatts. However, some characteristics of the discharges and plumes from MPD sources indicate that these sources might be well suited to synthesis and deposition of diamond at rates higher and over areas larger than those achievable by use of dc-arcjet sources; the characteristics of particular relevance in this regard are higher levels of dissociation and ionization of gas in the cores of the

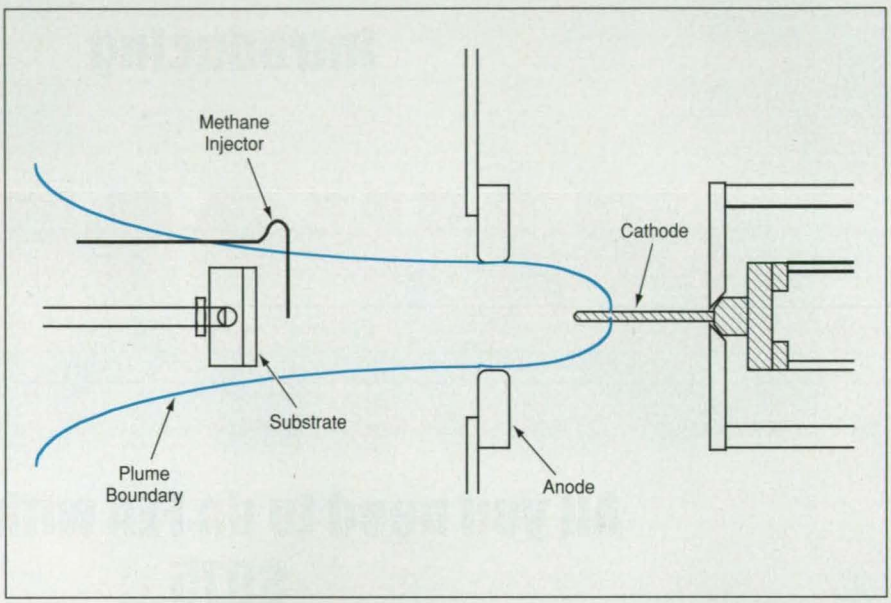

Figure1. **The Cathode Test Facility** at NASA's Jet Propulsion Laboratory includes a vacuum chamber and associated equipment previously used to investigate the behavior of high-current, thermionic cathodes for high-powered electromagnetic thrusters. This schematic shows the arrangement of substrate and methane injector to the accelerator electrodes.

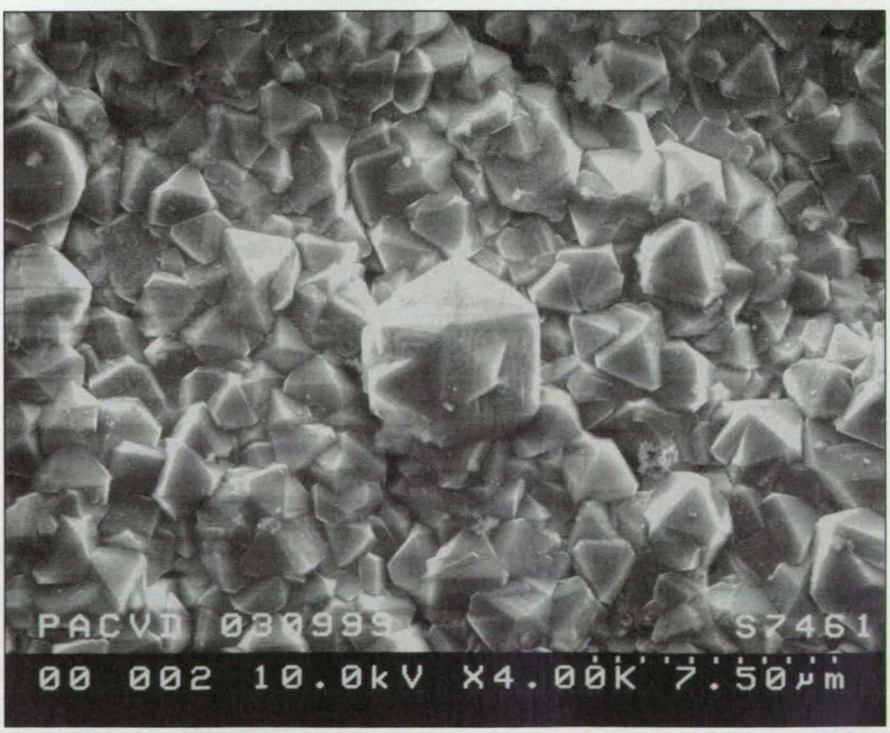

Figure 2. **Scanning Electron Microscope Image** (magnification 4,000×) of diamond film is shown (approximately 2.5 µm thick) grown over 180-minute test at low power (<20 kW) using a mixture of 1.5 percent methane to hydrogen by volume.

plasma plumes, higher jet velocities, and the scaleability to higher power levels.

The experimental part of this research is being performed in a segmented stainless-steel vacuum chamber (see Figure 1). An argon-hydrogen discharge operating at a power level in the range of 10 to 20 kW is being used to demonstrate feasibility and explore the effects of substrate biasing. Methane serves as a carbon precursor for deposition of diamond and is injected just downstream of the anode plane through a molybdenum tube. Farther downstream, a water-cooled copper mount supports a removable molybdenum disk that serves as a substrate for deposition of diamond (see Figure 2). Windows would provide access for optical diagnosis at several locations. A monochromator will be used for all emission spectroscopy in the plume, and an optical pyrometer and thermocouples are used to measure the temperature of the substrate.

The research includes a combination of experimental and computational analyses of the MPD-assisted CVD process, designed to assess the feasibility of the process and to compare it with dc-arcjet-assisted CVD processes. Topics would include the following:

- Parametric sensitivity (effects of discharge power, gas mixture, substrate biasing, and background pressure on substrate temperature, film quality, area of deposition, and rate of deposition);
- Properties of the plasma plume (e.g., mean gas velocity, pressure, and temperature);
- The degree of pyrolysis of methane (assessed by means of spectroscopy of visible emission lines of C, H, and CH), in comparison with corresponding published information for arcjets;
- Gas-phase and surface chemistry (modeled computationally with the help of experimental and published data).

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

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

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Refer to NPO-20668, volume and number of this NASA Tech Briefs *issue, and the page number.*

Oxygen Batteries Based on a Solid Polymer Electrolyte

Oxygen gas is used as the electroactive cathode material.

Lyndon B. Johnson Space Center, Houston, Texas

Scientists have developed a derivative of the lithium-ion cell that could prove useful in spaceflight and commercial applications in which it is planned to use oxygen batteries based on solid polymer electrolytes. This derivative cell, which contains a solid polymer electrolyte and an oxygen gas cathode, is designed for and operates best in an oxygen-rich atmosphere. (Inasmuch as the derivative cell as designed cannot store oxygen, the gas must be obtained from the environment.) Because the demand for portable electronic devices for scientific, educational, and even entertainment uses is constantly increasing, the need for rechargeable batteries as alternative means to power these devices is also increasing. Batteries based on the present derivative cell could be one such alternative means.

A unique feature of the polymer-electrolyte-based lithium cell is the way in which it utilizes (1) oxygen as an electroactive cathode (positive electrode) and (2) lithium — or another electroactive metal (e.g., magnesium, sodium, calcium, aluminum, or zinc) — as an anode (negative electrode). To implement this utilization scheme, the scientists sandwiched a lithium-ion-conductive solid polymer electrolyte film between a lithium anode and a composite carbon electrode that serves as the cathode current collector on which electroactive oxygen is reduced when the battery discharges to generate electric current. The simple design objective for these scientists was to devise a novel, solid-polymer-electrolyte-based lithium battery that could be used in spaceflight and industry.

The cathode current collector is, more specifically, made of a high-surface-area carbon (e.g., carbon black or graphite powder). In operation of the derivative cell, oxygen is reduced on the cathode collector. If lithium is the anode material, then the open-circuit potential of the cell is about 2.9 V, while the potential under load ranges between 2 and 2.9 V, depending on the load current. The theoretical specific energy of the cell is 5,200 Wh/kg — a value that makes the cell design useful, except in a vacuum, where it would be necessary to provide a self-contained supply of oxygen.

The design of the derivative cell can satisfy requirements of government and industry for rechargeable batteries that utilize oxygen gas cathodes. Because the design is experimental, anticipated cost savings cannot be surmised; however, the design holds promise and could provide another answer to the burgeoning need in the commercial marketplace and the U. S. space program for alternative forms of rechargeable batteries.

This work was done by Zhiping Jiang and Kuzhikalail Abraham of EIC Laboratories, Inc., for **Johnson Space Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Materials category.*

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

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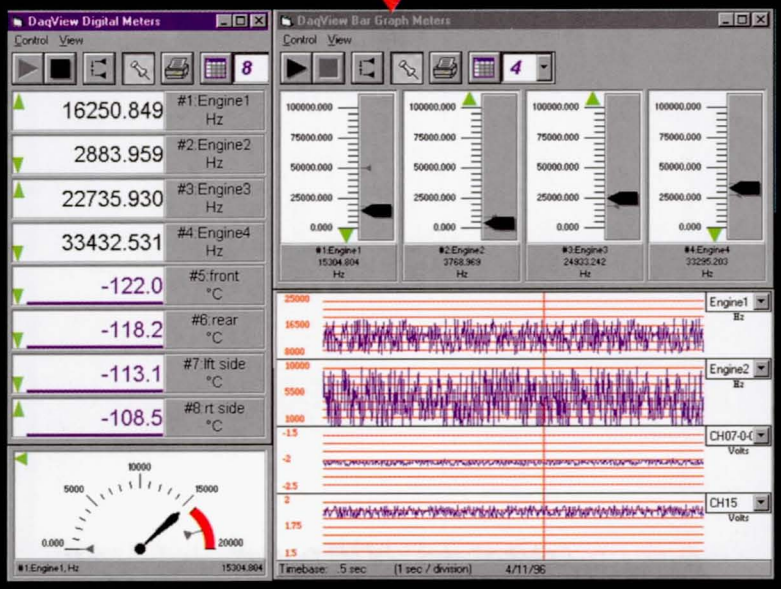

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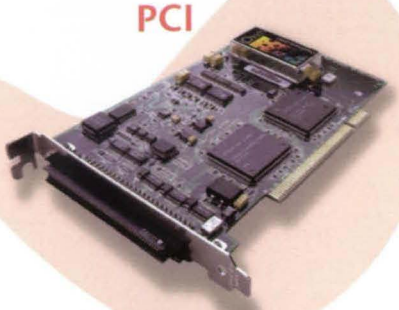

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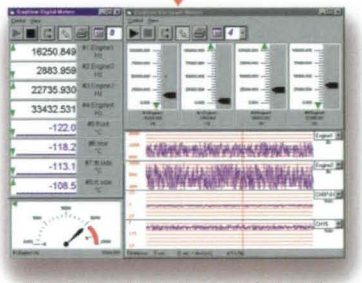

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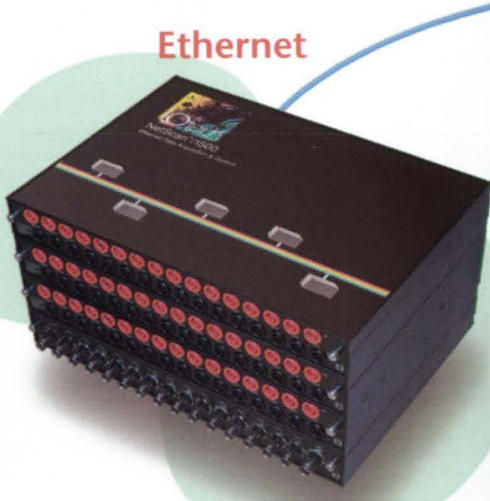

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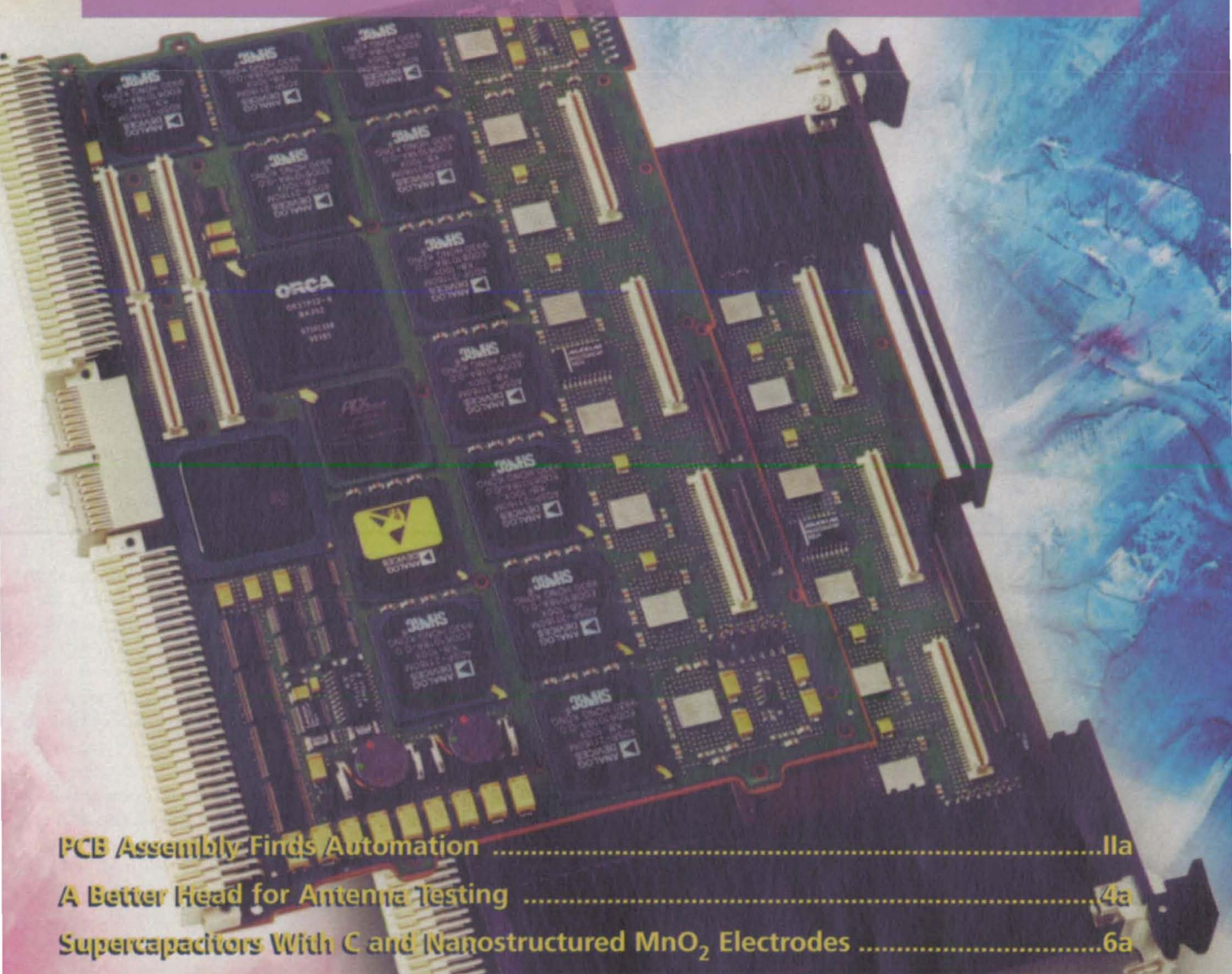

Cover photo courtesy Radstone Technology Inc.

PCB Assembly Finds Automation

Automated optical inspection is boosting defect detection and circuit-board yields.

CR Technology's XRV inspection system is the world's first to combine both x-ray and vision technologies.

In recent years, yield improvement and rework systems have emerged as an area of significant interest to printed circuit board (PCB) manufacturers, largely motivated by the fact that an immense volume of process and test data is generated by a typical PCB manufacturer during his test operations. This volume continues to grow as automated inspection instrumentation improves. With the advent of improved defect or failure analysis tools, the accuracy of the data is also improving. Rapid identification, collection, analysis, and rework are both advantageous and desirable, for they reduce the response time and cost caused by an upset or excursion. As a result, manufacturing engineers and quality-control personnel are constantly challenged by the need to rapidly collect and analyze any new data and to use it to improve manufacturing yield rates.

One of the primary tools used by PCB and electronics contractors is automated optical inspection (AOI). When the efficiency and repeatability of AOI systems are compared to that of human inspectors, we can understand the appeal of the automatic system. For example, a typical PCB assembly line at an electronics contract manufacturer employs between two and four inspectors for an inspection and rework operation.

In contrast, an AOI system requires only one operator to select the programs, detect defects, and perform rework on failed PCBs. This reduces the per-shift requirement for labor to a significant degree. But before a manufacturer makes an investment in automation, he should conduct a realistic evaluation of all the factors that influence yield improvement and return on investment.

Overcoming Limitations

AOI systems were first introduced to the PCB assembly industry in the early 1980s. Designed to replace human inspectors in seeking visible defects such as missing parts, placement, and similar errors, these first systems were expensive, slow, and difficult to use. Recently, however, thanks to improvements in PC computing power, software, and imaging technology, a new generation of AOI systems has overcome many of these limitations. The systems can be utilized in various modes at several points in the assembly line. In a typical surface-mount technology scenario, inspection is performed after parts placement, reflow, and/or final assembly. The types of defects found by an AOI system include missing parts, incorrect components, polarization errors, placement errors, and solder defects. All defect information is identified and reported for rework.

There are limitations, however. Although AOI systems do an excellent job on optical inspection of the board's surface, they can only analyze visible features. With ball grid arrays (BGAs), micro-BGAs, chip-scale packages (CSPs), flip chips, and other hidden-connection devices, manufacturers have to opt for x-ray systems to analyze the critical solder joints of these new-generation packages. Also, double-sided PCBs must be flipped over for proper inspection of both sides.

Today, AOI systems are typically used to complement in-circuit test (ICT) methods. This type of usage covers an inspection spectrum wider than either process could do alone. In addition, increasing numbers of engineers in mid- to high-volume manufacturing environments employ AOI post-reflow as an SMT process inspection tool. The AOI system provides engineering analysis data that can be used to perform a variety of analytical tasks, such as component sourcing, product traceability, higher test yields, high mean time before failure (MTBF), fewer escapes to the field, and better process control. In addition, trend analysis is a time-tested method of monitoring for changes in a manufacturing line, both good and bad. If a desirable trend is found, the AOI system can assist the user in pinpointing the change(s) that resulted in the improvement. Alternatively, if an undesirable trend is found, the AOI system can assist the user in determining what went wrong.

As with any return-on-investment calculation, the investment in automation should reduce the cost per function and improve the yield that is currently being realized. A major improvement, obviously, is a reduction in labor. According to research conducted by Teradyne, it has been estimated that trained human inspectors account for about 50 percent of the detectable visible defects on circuit boards. The low percentage of effectiveness can be laid to several factors,

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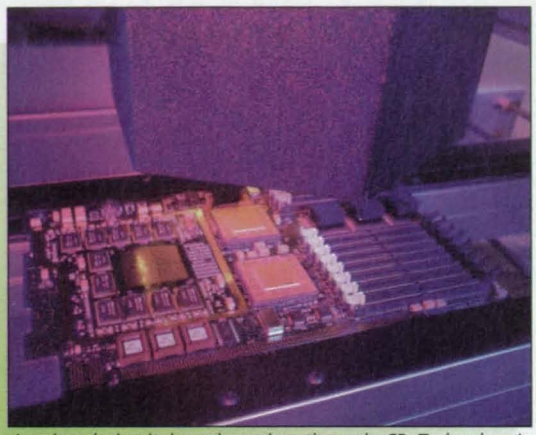


A printed circuit board passing through CR Technology's RTI-6500 vision inspection system.

primarily the repetitive and demanding nature of the work, which makes concentration hard to maintain. The monotony also results in a high staff turnover with consequent costs in hiring and training. Inspection may also be influenced by such indeterminate factors as the attention span of the particular inspector, the specific day (inspectors may be less effective on Friday afternoon than on Monday morning), and time of day (inspectors may be less effective on any afternoon than they are mornings). AOI, on the other hand, is able to deliver high defect coverage consistently and repeatably—as high as 99 percent—with virtually no escapes to the next production stage.

Rework Data Server

The development of CR Technology's rework data server (RDS) is expected to increase the effectiveness of AOI systems dramatically. With the RDS, defect data gathered by the inspection systems are channeled via open database connectivity (ODBC) to be stored centrally on a server. This advanced web-based software tool then generates a series of web pages that guide repair technicians through the rework processes of their defective PCBs. Computers anywhere on the LAN will be able to view the defect data using a web browser such as the Internet Explorer.

The RDS presents defect and yield information in four main pages, including board statistics, master table, defect map, and defect classification. Defect information is dynamically listed in table format, while defect location is indicated graphically on a user-friendly map. After performing the rework, the technician can instantly log in the date, time, and reworker's name. In addition, the system presents defect statistics of PCBs for multiple assembly lines. Because it is web-based, the RDS is able to present data across the company's Intranet, or users may choose to have the data available on the Internet for an audience anywhere in the world.

The uneven performance of human inspectors was the primary driver for SMS Manufacturing Technologies Inc., a contract electronic manufacturer in San Diego. "We introduced AOI systems on our SMT assembly lines because there were simply too many defects getting through," said Allan Stein, director of manufacturing. "We even find AOI effective on double-sided boards. We look at one side, then flip the board and check the other side," he added. "Now, by using both AOI and human inspectors, we've improved our quality and our yield."

The higher yield because of the improved AOI coverage means fewer PCBs to diagnose, repair, and retest. In some manufacturing operations, this improvement in yield has been so dramatic that the manufacturer has eliminated ICT altogether, with a consequent saving in labor, capital, and floor space.

As mentioned previously, many visible defects are not detectable by either ICT or functional board tests (FBTs). Although many of these defects can be detected by human inspectors and AOI, operators typically miss half of the defects. The result is that the defects that pass through inspection and tests can cause problems at a later stage:

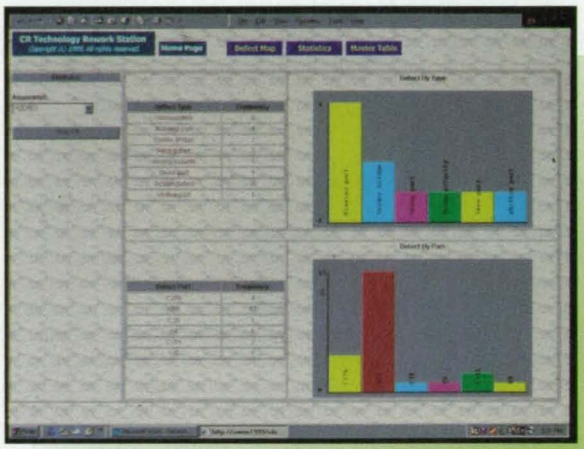
- intermittent failure during FBT;
- failure or intermittent failure at system integration;
- customer dissatisfaction; and
- PCBs dead on arrival with warranty returns.

AOI reduces the incidence of these failures, which should help manufacturers meet their customer requirement for increased product quality. For example, a dimensional aberration of a single part could conceivably shut down an assembly line until the problem was discovered and rectified. AOI should eliminate this type of problem.

Increasing product quality increases product yield, ensuring that one of the key elements sustaining long-run costs remains low. An important yield improvement and failure analysis tool is visual/electrical correlation. The ability to correlate visual defects observed during processing with electrical test failures can be a powerful tool for reducing failure analysis time and increasing failure analysis efficiency, i.e., increasing yield.

Real-Time Monitoring

Real-time monitoring is another aspect of improving product yield. Not only will it alert the line manager as soon as a process upset occurs, but it can rectify catastrophic occurrences, such as selection of the incorrect placement program. Data can be collected, product quality analyzed, and repair procedures initiated at critical steps in the manufacturing process. Finding problems quickly can prevent the manufacture of large numbers of defective boards, as many, perhaps, as several hundred or even thousands.



The new RDS system allows for PCB repair through the Internet.

Long-term process improvement is a concept that requires input from as many sources as possible. AOI, where defect data is automatically collected, maintained, and monitored, is an ideal starting point for improving both product quality and yield. A well-managed yield improvement system is the cost-effective means of achieving and maintaining high yields in circuit-board production.

For additional information, contact Don Miller, the author of this article, at CR Technology, 125 B Columbia, Aliso Viejo, CA 92656; (949) 448-0443; fax: (949) 448-0445; e-mail: sales@crtechnology.com. Please visit CR Technology at www.crtechnology.com.

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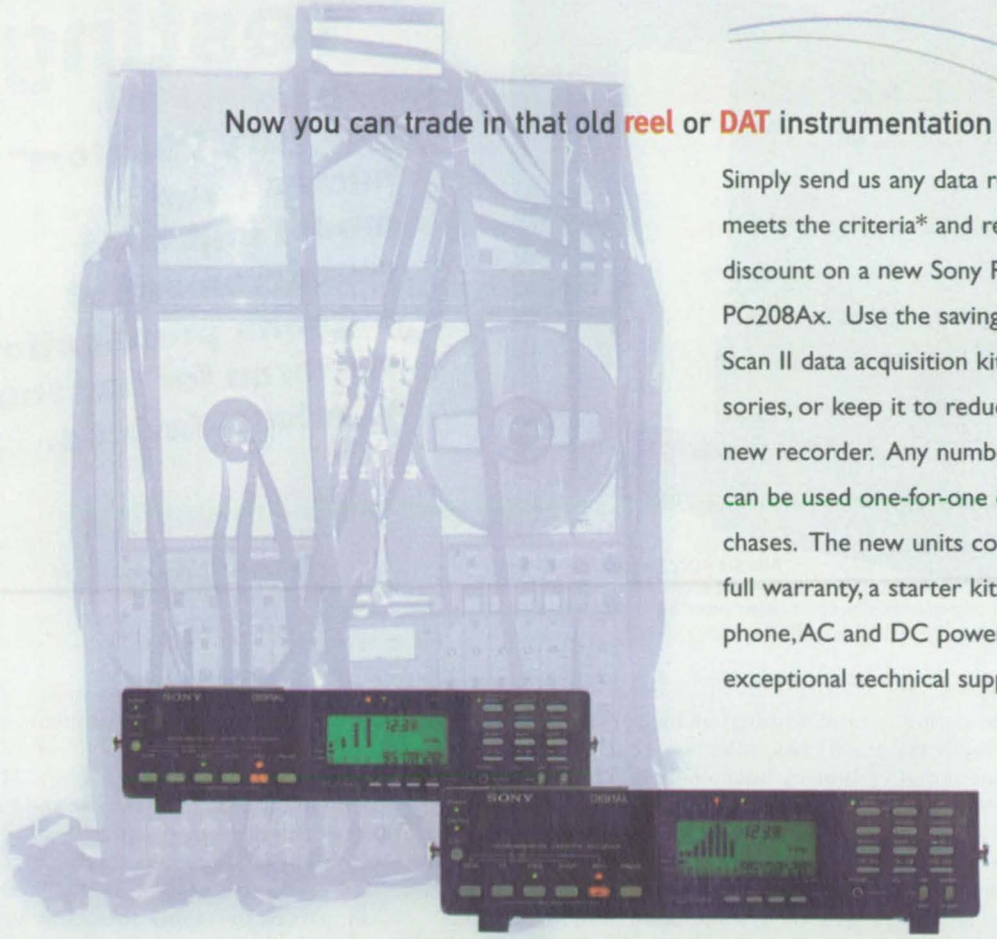

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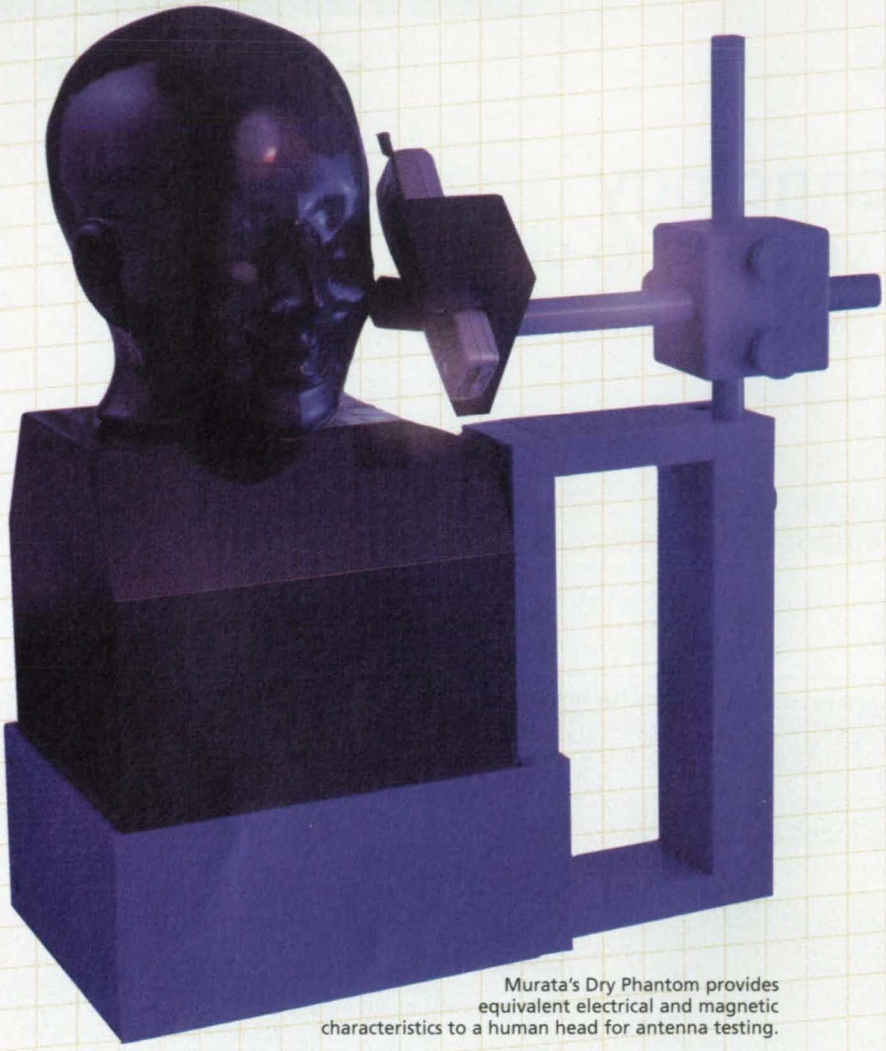

Murata's Dry Phantom provides equivalent electrical and magnetic characteristics to a human head for antenna testing.

A Better Head for Antenna Testing

The "Dry Phantom" human head model improves measurement of antenna propagation patterns for handheld wireless devices.

With wireless communication, especially cellular systems, steadily on the rise, the demand for equipment that is both miniaturized and offers better performance increases. One of the most important characteristics that must be measured is antenna propagation in certain stable conditions. Murata Electronics, a wholly owned subsidiary of Murata Manufacturing Co., of Japan, is meeting this need with a unique and innovative piece of microwave test equipment. Called the "Dry Phantom," the device mimics the reflection, absorption, and dissipation of electromagnetic waves characteristic of the human head, part of the upper torso, and part of the arm.

Antenna propagation patterns need to be evaluated as closely as possible to the way humans actually experience them. But measuring them with real human beings introduces too many unstable factors into the results. Temperature, humidity, the time of day, and seasonal changes make the electrical and magnetic conditions of the human body change. Because of these factors the measurements have long been made using a "phantom" head.

Previous microwave and RF phantom technology utilized liquids, such as sol-gels or a solution of sodium chloride and water, to obtain conditions closely matched to the human head. But whereas these traditional methods were relatively inexpensive and proven, they required constant maintenance, were subject to infection by fungi or bacteria, and did not provide a consistently stable reference point for the engineering measurements.

Murata, in conjunction with NTT of Japan, took a different and innovative approach to the problem: they developed a new design utilizing a combination of complex dielectric materials of ceramic powder, polymer, and carbon powders. These materials, combined in a carefully molded head formation, provide a very stable test environment for comparison and improvement of cell-phone antenna designs. The "Dry Phantom" has relative dielectric and loss tangent characteristics that are very similar to those of the human body.

The complete system includes the head, part of the upper torso and arm, set stand, positioning pin, adjustable arm, and carrying case. Whereas older and less exact test phantoms that provide only the head model cost in the vicinity of $20,000, the "Dry Phantom" costs $33,000. But the added stability and ideal "human" characteristics should be worth the cost to universities, government test agencies, and major corporations that research, qualify, and design for today's most advanced wireless markets.

For more information contact Scott Klettke, design engineer at Murata Electronics, 2200 Lake Park Drive, Smyrna, GA 30080-7604; (814) 237-1431, ext. 3980; e-mail: sklettke@murata.com.

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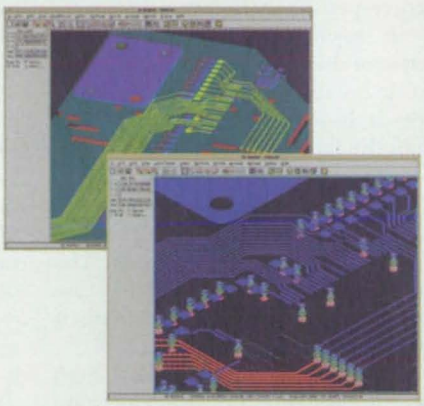

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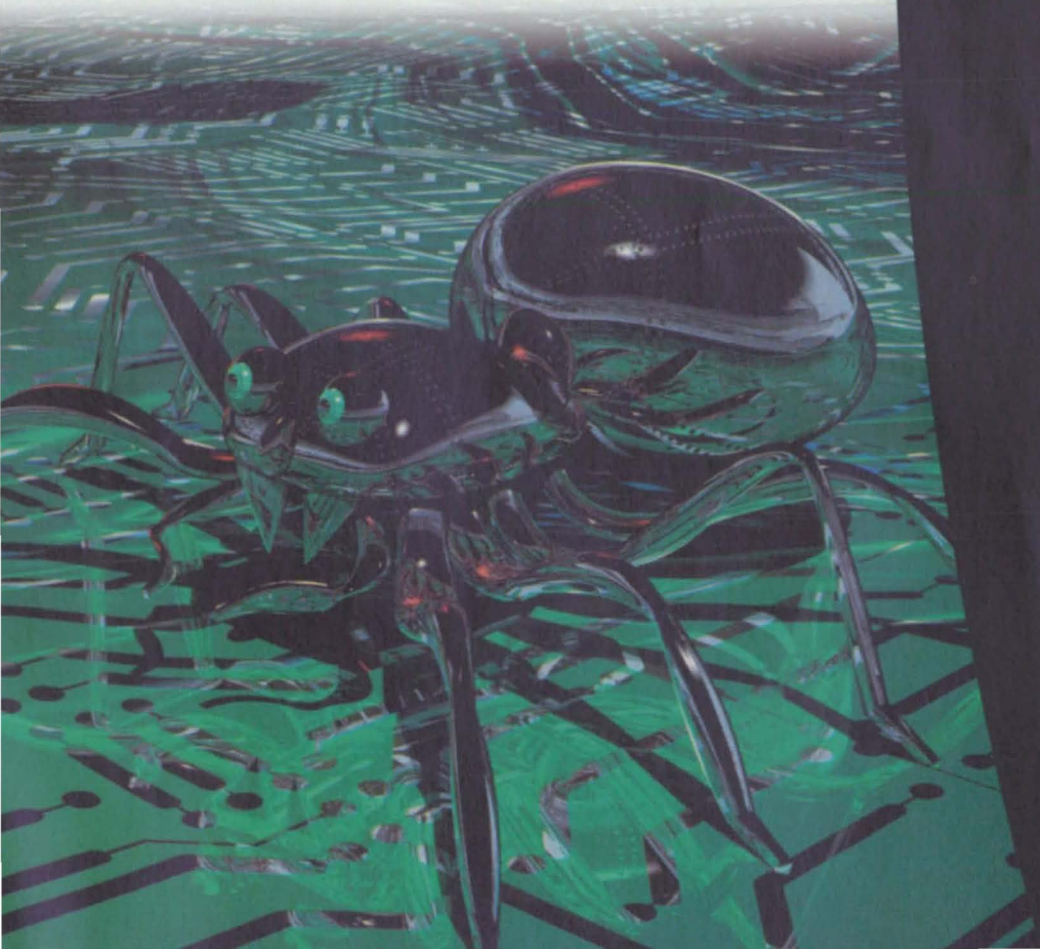

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John H. Glenn Research Center, Cleveland, Ohio

A class of developmental asymmetric electrochemical capacitors is based on (1) nonpolarizing positive electrodes made of nanostructured γ-MnO_2, (2) aqueous electrolytes, and (3) polarizing negative electrodes made of activated carbon. Like other state-of-the-art electrochemical capacitors, these can store several hundred times as much energy per unit weight or volume as can traditional electrolytic capacitors. In comparison with other, symmetric state-of-the-art electrochemical capacitors, these asymmetric electrochemical capacitors are expected to be capable of higher energy densities. In addition, by virtue of the high surface areas of the nanostructured γ-MnO_2 electrodes, these capacitors are expected to be capable of high power densities. These capacitors could be particularly useful as load-leveling devices in conjunction with batteries, or as replacements for batteries, in portable electronic devices that rely on short-term intermittent or pulsed high power.

The energy densities of asymmetric electrochemical capacitors can be made to exceed those of symmetric electrochemical capacitors for several reasons:

- The two electrodes of an electrochemical capacitor, having capacitances C_1 and C_2, are electrically connected in series. One of the electrodes is made of a material with a specific charge capacity and thus a capacitance greater than that of the other electrode. The capacitance of the series combination [given by $C_T = C_1C_2/(C_1+C_2)$] is almost equal to the smallest of C_1 or C_2. In contrast, the capacitance of a symmetric electrochemical capacitor is only about half that of either electrode.
- Because the specific charge capacity of one electrode material greatly exceeds that of the other electrode material, the mass and volume of one electrode can be made smaller than that of the other electrode. The decrease in volume translates to an increase in the energy density of the overall capacitor.
- Unlike a symmetric electrochemical capacitor, an asymmetric electrochemical capacitor with an aqueous electrolyte can reliably operate at voltages above 1.22 V without evolution of gas, whereas commercially available symmetric aqueous electrochemical capacitors are limited to about 0.9 V. Inasmuch as energy density is proportional to voltage squared, the energy density of an asymmetric capacitor can be correspondingly higher.

In an asymmetric electrochemical capacitor of the present type, the positive electrode is expected to act as pseudocapacitor: it is expected to store charge through the faradaic reaction

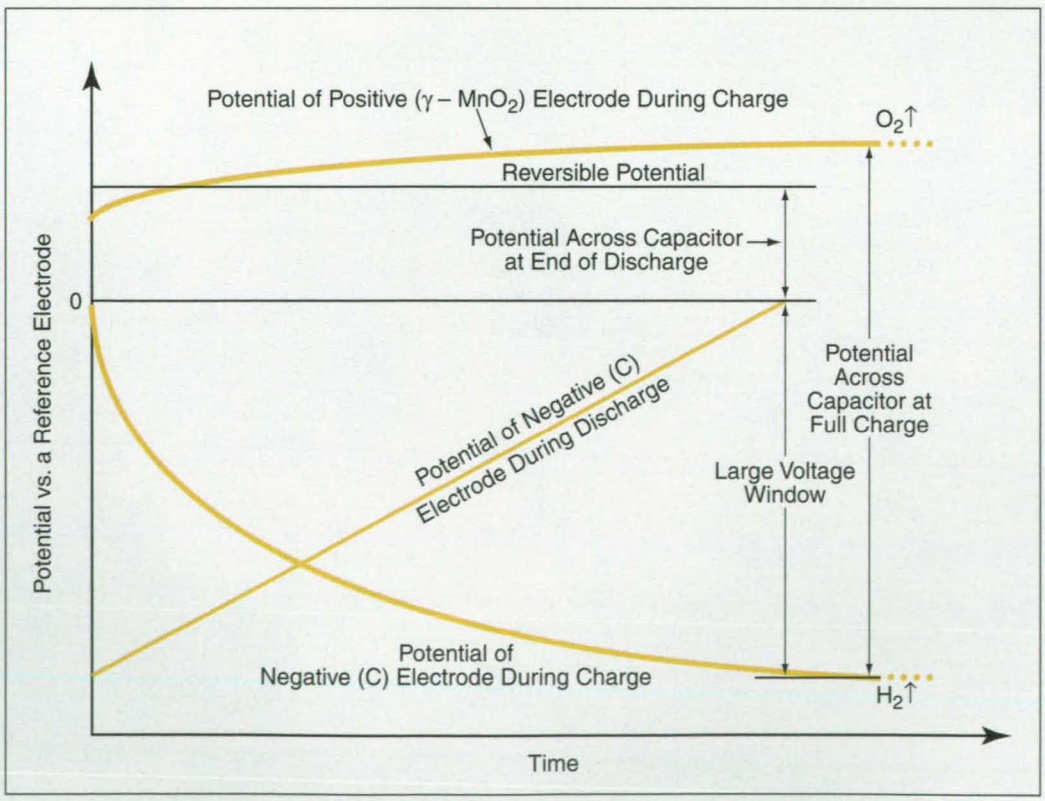
$$\gamma\text{-}MnO_2 + H_2O + e^- \leftrightarrow \alpha\text{-}MnOOH + OH^-$$

with a reversible potential of 1.23 V versus a standard hydrogen electrode. The negative electrode is expected to store charge at the electrode/electrolyte interface (double-layer capacitance).

To make it possible to obtain high energy density, the positive electrode must exhibit a low degree of polarization; that is, the potential of the positive electrode must change little from its reversible potential during the passage of current. In addition, nonfaradaic processes must be minimized and faradaic processes must occur at high reaction rates across the surface of the positive electrode. On the other hand, the negative electrode should be highly polarizable and, under ideal conditions, should develop a large window of potential change during charge and discharge. The figure qualitatively depicts the expected changes in potential at each electrode during charge and discharge.

This work was done by David E. Reisner and T. Danny Xiao of US Nanocorp, Inc.; John R. Miller of JME, Inc.; and Stephen M. Lipka of Florida Atlantic University for **Glenn Research Center.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Systems category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16930.



A **Large Voltage Window** is expected to arise through polarization at the negative electrode as a capacitor of the present type is charged. The potential window is limited by the onset of the evolution of hydrogen and oxygen at the electrodes. The potential of the metal oxide electrode remains essentially unchanged during both charge and discharge.

Heterodyne Doppler Lidar Using Pseudonoise Code

This low-power, compact unit will be suited to a variety of meteorological uses.

NASA's Jet Propulsion Lab zry, Pasadena, California

A low-power, miniature Doppler lidar instrument is being developed for use in measuring opacity (from dust) and wind profiles in the Martian atmosphere. The instrument could also be used on Earth to measure turbulence in the atmospheric boundary layer, for assessments of urban and regional air quality, and perhaps for studying aircraft wing-tip vortices. The instrument is being designed to measure wind velocity component along its line of sight with a precision of 1 m/s and to perform ranging at distances from 3 km to a maximum of 10 km (or less, depending on the concentration of airborne dust).

There are other Doppler lidar systems that produce range-gated measurements of opacity and wind velocities, but those systems are unacceptably large and power-hungry for the intended application. The other systems contain, variously, gas or solid-state lasers operating in pulse mode. The heart of the transmitter in the present developmental instrument is a diode laser, which is chosen for compactness and because the electrical efficiencies of diode lasers are generally greater than those of gas and solid-state lasers. On the other hand, diode lasers are not suitable for pulsed operation at the peak power levels and pulse-repetition frequencies needed for range gating in the intended application; therefore, in the present instrument, range gating is achieved by use of a pseudonoise code.

The instrument will be highly electrically efficient. The diode laser in the transmitter will operate with a conversion efficiency approaching 40 percent. The design of the instrument will incorporate recent developments in high-speed, low-power receiver electronics.

The transmitting diode laser will be modulated with the pseudonoise code — a prescribed pseudorandom sequence of "on" and "off" states — with each "on" or "off" state lasting 1 to 2 μs. The receiver will perform heterodyne detection; it will include a beam splitter, which will enable the use of a local-oscillator diode laser modulated and frequency-shifted (to measure the Doppler effect) separately from the transmitting diode laser. The entire transmitter/local-oscillator package will be compatible with fiber optics.

For the original Mars-wind-profiling application, the desired transmitter power is about 200 mW. The spectral width of the transmitted light must be no more than about 1 MHz. At present, these requirements can be satisfied by use of a diode laser master oscillator and a fiber laser amplifier, and compact diode-laser devices that satisfy these requirements are expected to be developed during the next few years.

The receiver will include a unique, high-speed, low-noise photomixer with a matched amplifier and a high-speed, low-power, 12-bit analog-to-digital converter followed by circuitry that computes fast Fourier transforms and circuitry that processes power spectra.

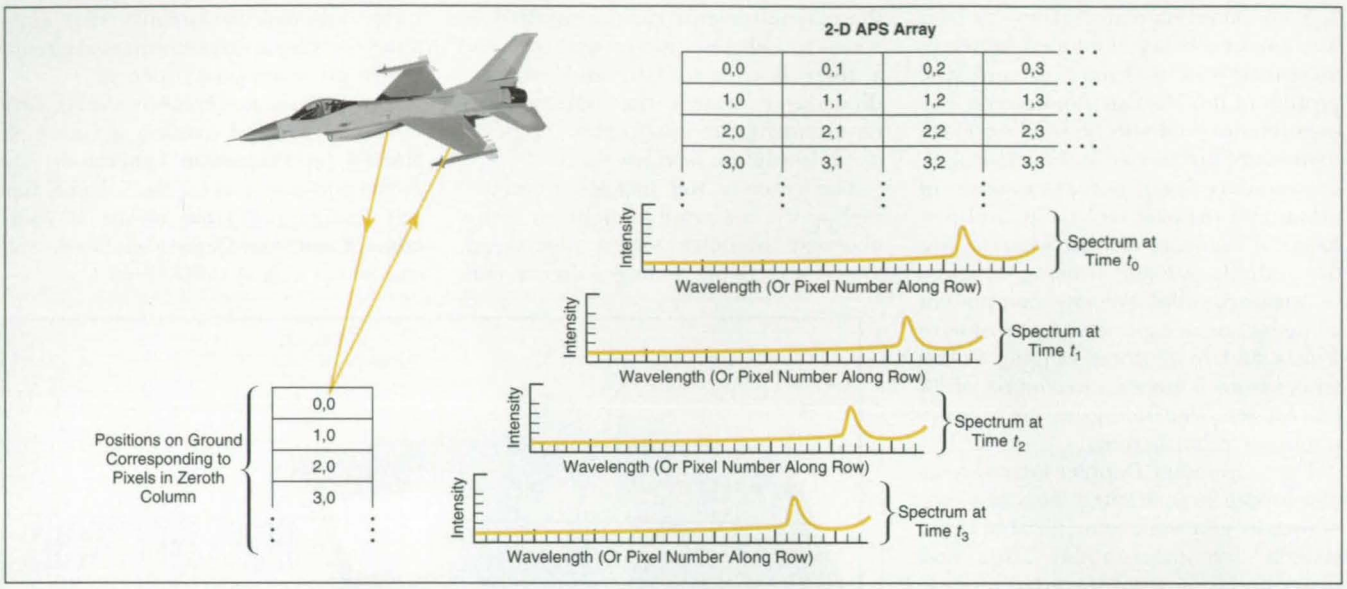
This work was done by Robert Menzies, Greg Cardell, and Hamid Hemmati of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Systems category. NPO-20466*

Two-Dimensional Active-Pixel Spectral Lidar

Targets would be probed using spatially, temporally, and spectrally resolved optical signals.

NASA's Jet Propulsion Laboratory, Pasadena, California

etb TEST AND MEASUREMENT



Light Returning from the Target Would Be Spectrally Dispersed — in this case, along the zeroth row of an APS array. Hence, by processing the readouts from the pixels in this row at different times, one could obtain a time-resolved spectrum of the target.

Two-dimensional active-pixel-spectral lidar (TAPSL) is a proposed remote-sensing technique for obtaining spatially, spectrally, and temporally resolved information about terrain or other targets. Operating aboard an airborne or spaceborne platform above the Earth or a remote planet, a TAPSL system would be used to gather data on geological, biological, and chemical phenomena that manifest themselves through characteristic optical emission spectra.

A TAPSL system would include a single-frequency laser that would illuminate a target. The light returning from the target would include an elastically scattered component (the spectral component at the original laser frequency) that could be used for ranging as in conventional lidar. The return would also include inelastically scattered (Raman-shifted and fluorescent) spectral components that would be characteristic of the target material in response to excitation by the laser.

The light returning from the target would be detected by a rectangular array of active-pixel sensors (APSs) that would be sensitive to visible and near-infrared light. The APS would operate in conjunction with miniaturized electronic control, readout, and pixel-data-processing circuits. Before impinging on the APS array, the light would pass through a diffraction grating oriented to disperse the light along the rows of pixels. Consequently, the frequency or wavelength of the light received by each pixel could be identified from the position of the pixel along its row (see figure). Optionally, the system could be operated without the laser to obtain the reflected-sunlight spectrum and/or the thermal spectrum of the target.

As described thus far, the system would derive information about the relative position of the target in the manner of conventional lidar. However, if a lens were used to image the target scene onto the APS, then the position of each pixel along a column could be used to obtain spatial resolution along the corresponding axis on the target; this approach could be useful if the laser beam did not provide sufficient resolution, or if it were desired to scan the terrain in "push-broom" fashion. Alternatively, it might be possible to vary the time gate of each pixel with position along each column to obtain additional resolution for ranging or spectral analysis.

This work was done by Quiesup Kim of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Systems category. NPO-20737.*

Improved Temperature-Compensating Microwave Attenuators

These passive devices feature constant impedances and tailorable temperature coefficients of attenuation.

etb COMPONENTS

John H. Glenn Research Center, Cleveland, Ohio

Improved passive temperature-compensating attenuators have been developed for use in processing radio signals at frequencies up to about 18 GHz. In general, temperature-compensating circuits and devices are needed to minimize (preferably, to eliminate) undesired temperature dependences of the overall gains of amplifiers, filters, and other microwave-signal-processing circuits. The role of a temperature-compensating attenuator is to provide a temperature-dependent amount of power dissipation complementary to the temperature-dependent gain or dissipation of other devices in the circuit, such that the overall gain or attenuation of the circuit varies minimally (preferably, not at all) with temperature.

Active temperature-compensating attenuators that include temperature sensors, transistors, and other circuit elements are known; unfortunately, these active attenuators often exhibit nonlinear responses, giving rise to distortion of signals (intermodulation distortion and harmonics). In some applications (e.g., some microwave-signal-processing applications), it is possible to use passive temperature-compensating attenuators, which are preferable to active attenuators in that the passive devices are more reliable and smaller, and their responses to signals are more nearly linear (they do not introduce intermodulation distortion or harmonics).

The improved passive temperature-compensating attenuators were developed because users expressed a need for degrees of temperature compensation greater than those afforded by previously available passive temperature-compensating attenuators. Ideally, in a typical application, a temperature-compensating attenuator intended for use in a specified temperature range would function with no loss (no attenuation) at the highest temperature in the range and with maximum loss at the lowest temperature in the range. While none of the improved attenuators performs in this ideal manner, it is notable that they can be made to present constant input and output impedances, and their temperature coefficients of attenuation (TCAs) are tailorable. Both units with positive and units with negative TCAs have been fabricated.

The improved passive temperature-compensating attenuators are all variants of the same basic device: Each such attenuator comprises a network of thick-film thermistors (similar to thick-film chip resistors) deposited on an alumina substrate. The thermistors are made of materials that have been formulated specifically for this use and that exhibit temperature coefficients of resistance (TCRs) considerably greater than those of previously commercially available materials. The parameters of the thermistors are selected to obtain the desired temperature-dependent amounts of attenuation while maintaining constant input and output impedances.

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

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16927.

Atmospheric Electron X-Ray Spectrometer

Specimen surfaces can be analyzed quickly, at high spatial resolution.

NASA's Jet Propulsion Laboratory, Pasadena, California

The Atmospheric Electron X-ray Spectrometer (AEXS) is being developed for performing rapid, nondestructive *in situ* analyses of the elemental composition of surfaces. The capability of the AEXS to operate in air and to be brought to a surface to be analyzed makes it unnecessary to bring a specimen to a laboratory and prepare the specimen for analysis.

The AEXS belongs to a class of miniature instruments that perform *in situ* elemental composition analysis by the excitation and analysis of x-ray fluorescence from specimens. Prior techniques include excitation of the x-ray fluorescence by α particles and x rays, both of which entail larger target areas and longer spectrum acquisition times than the electron beam based excitation used in the AEXS. The AEXS is predicted to be able to analyze samples at high spatial resolution determined by its controllable electron-beam spot size. The spectrum acquisition time of the AEXS is expected to be less than a minute. The short spectrum acquisition time results in less energy consumption and makes the AEXS suitable for incorporation into manufacturing, inspection, and quality control processes.

The figure schematically depicts a laboratory prototype of a portable AEXS instrument. Electrons are generated, accelerated, and focused by a commercially available electron gun within an evacuated enclosure. The vacuum is isolated from the ambient atmosphere by an electron-transparent membrane. The membrane is microfabricated from low-atomic-number materials such as silicon nitride, boron nitride, or diamond. Active pumping of the electron column against leaks and diffusion of air through the membrane can be achieved by an ion pump.

The electron beam passes through the membrane and travels a short distance to the specimen surface. The electrons impinge on the surface, exciting x rays at wavelengths characteristic of surface elements. The x rays are detected by a thermoelectrically cooled silicon positive/intrinsic/negative (PIN) photodiode. The signal from the PIN photodiode is fed into a signal-conditioning amplifier and a multichannel analyzer. The output of the multichannel analyzer is an x-ray spectrum that can be analyzed to determine the elemental composition of the surface.

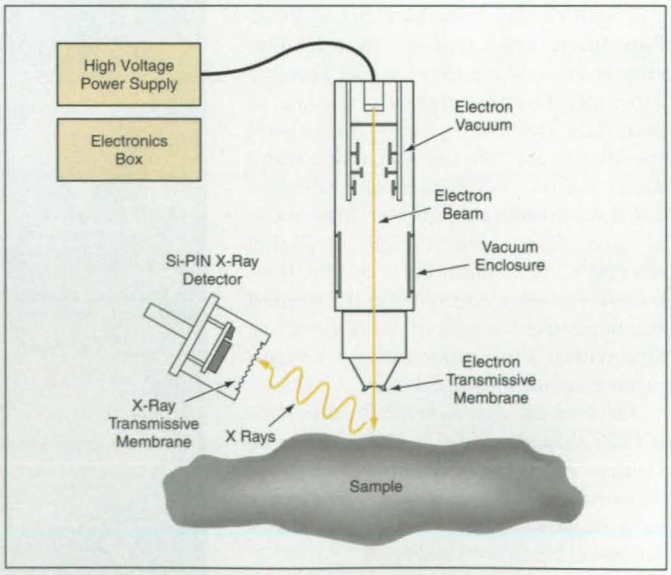
The instrument is designed to be powered by a battery. The high voltage (30 kV) for the electron gun is generated by a miniature voltage multiplier circuit. Instrument control electronics are required to operate the electron gun, ion pump, x-ray detector, and analyzer. The spectrum from the multichannel analyzer is routed through a serial interface to a computer.

This work was done by Jason Feldman, Thomas George, and Jaroslava Wilcox of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free online at www.nasatech.com*** *under the Physical Sciences category.*

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

Technology Reporting Office
JPL
Mail Stop 122-116
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-2240

Refer to NPO-20463, volume and number of this NASA Tech Briefs *issue, and the page number.*



An **Atmospheric Electron X-Ray Spectrometer** shown in this schematic is designed to be a portable instrument that can be brought to a specimen surface. After operation of about a minute, it can give information on the elemental composition of the specimen surface. The dimensions of the instrument in its final form are expected to be about 4 by 8 by 14 in. (about 10 by 20 by 36 cm).

etb COMMUNICATIONS

Microstrip Patch Rectenna With High Output Voltage

Output voltage is maximized by use of dual polarization and series dc connections.

NASA's Jet Propulsion Laboratory, Pasadena, California

A prototype dual-polarization microstrip patch rectenna dimensioned for an operating frequency of 8.51 GHz has been built to demonstrate a design concept for obtaining maximum output voltage from a rectenna of a given size. This rectenna contains nine square microstrip patch antenna elements in a square array. The antenna can utilize incident radiation with polarization components parallel to either or both sides of the square because the circuitry under each patch includes two independent rectifiers — one for each polarization component. The dc output terminals of the two rectifiers under each patch are connected in series, and the series rectifier pairs of all patches are connected in series. Consequently, the maximum output voltage (obtainable in the special case of circularly polarized incident radiation) can be 18 times that generated by a single-rectifier, single-polarization patch element.

Each microstrip patch antenna element is supported over a ground plane by a layer of lightweight foam with a low (1.07) permittivity. Microstrip feed circuitry, rectifier diodes, and dc conductors that collect the output power are located below the ground plane. Microwave energy is coupled from the antenna elements to the feed circuitry through apertures or coupling slots. Except for this aperture coupling, the antenna and the microstrip feed circuitry are divorced from each other.

The placement of the feed and rectifier circuitry below the ground plane makes it possible to isolate the rectifier circuitry from direct exposure to the incident microwave energy and thus prevents spurious coupling of microwave energy onto the dc conductors. The ground plane also prevents the direct reradiation of the harmonics that are generated by the diodes as unavoidable byproducts of rectification. A microstrip line filter is used to prevent radiation back through the aperture feed. Yet another advantage of mounting the rectifier circuitry below the ground plane is that the ground plane serves as an effective thermal sink for the diodes. The ground plane is not a single conductive

plane but, rather, an array of dc-isolated, capacitively-coupled islands registered with the overlying antenna patches. The capacitive coupling is effected by a thin layer of copper-coated polyimide. The dc isolation of the ground-plane islands in conjunction with the orthogonality of the layout makes it possible to use these islands as parts of the series-connected dc output circuitry.

In tests at an optimized load resistance of 5.4 kΩ, the rectenna was found to function with an overall energy-conversion efficiency exceeding 52 percent over a large range of incident power densities, with a peak of 53 percent at a power density of 38.8 mW/cm^2. The results of the tests also showed that a target output potential of 50 Vdc can be achieved at a power density of 25.2 mW/cm^2.

This work was done by Larry Epp and Abdur Khan of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Systems category.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to Technology Reporting Office, JPL, Mail Stop 122-116, 4800 Oak Grove Drive, Pasadena, CA 91109, (818) 354-2240.

Refer to NPO-20641, volume and number of this NASA Tech Briefs *issue, and the page number.*

Acoustic Navigation Aid for Autonomous Miners

etb SENSORS

Sensor registers the distance from adjacent parallel tunnels.

Army Research Laboratory, Adelphi, Maryland

Miners today use externally powered machines designed to be used by a single operator, the autonomous miner. Many companies offer computer-operated mining equipment that can be used for both high wall and underground applications. Programmable logic controls with ring laser gyroscopes and inclinometers are utilized to enable miners to follow prescribed paths in a coal seam with accuracy. Because of this technology, miners may be positioned in nonhazardous locations as they steer the mining equipment.

After a single tunnel has been dug through the coal seam, however, the operator needs to dig another tunnel parallel to the first while maintaining a certain wall thickness to support the mine. Although sophisticated electronic equipment aids miners, they may nonetheless creep edgewise. This can lead to the coal walls becoming too thin and ultimately collapsing.

An acoustic system was developed at the Army Research Laboratory (ARL) to improve the navigational abilities of autonomous mini systems by allowing the miner to sustain a prescribed sidewall thickness while excavating adjacent to other tunnels. Better control of the structural stability of the mine site can be maintained and more coal can be mined. The technology also allows coal to be distinguished from other elements such as rock, clay, and water so that the miner is more efficient.

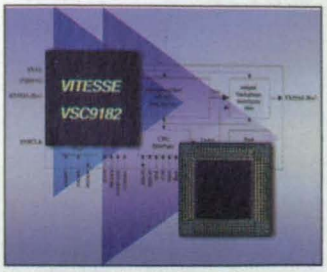
ARL's technology is essentially a sensor that will enhance state-of-the-art mining equipment. It easily can be incorporated into existing systems. The technology will equip miners with a sound navigation and ranging, or sonar-like, system comprising one or more acoustic transducers for sending and receiving acoustic signals, and a processor that is used to determine the wall thickness as the miner digs coal. The sonar head, a ceramic transducer, and some associated electronics are placed on a retractable isolation arm so that they may be quickly positioned against the coal wall for operation. A short pulse of sound is projected into the coal sidewall in a narrow beam by placing a vibrating transducer solidly against the wall. The length of time it takes the sound to bounce back indicates the thickness of the coal wall. If the sound is returned too quickly, the miner is too close to the next tunnel.

If, for example, the interior wall of another tunnel is approximately five feet away, the sound will be strongly reflected because of the large impedance mismatch of sound propagation through air and coal. The sound waves will arrive back at the transducer in approximately 0.67 millisecond, and the transducer will now be reversed from the transit mode to the receiving mode. Feedback from ARL's sensor ties into the computer controls of existing mining equipment to help miners steer in the appropriate direction.

This work was done at the **Army Research Laboratory**. *For more information, please contact Ms. Norma Cammarata, ARL's Technology Transfer Officer, at 2800 Powder Mill Rd., AMSRL-CS-TT, Adelphi, MD 20783-1197; (301) 394-2952; fax: (301) 394-5818; e-mail: normac@arl.mil.*

NEW PRODUCTS

PRODUCT OF THE MONTH



Multiplexer and Demultiplexer Chipset

Vitesse Semiconductor Corp., Camarillo, CA, releases the VSC8173 16:1 multiplexer and VSC8174 1:16 demultiplexer featuring a 10 Gbs/s chipset. The company says they have the lowest power dissipation available today, minimizing heatsink, airflow, and power supply requirements. Vitesse recommends the chipset for telecommunication, dense wavelength multiplexing (DWDM), undersea transmission and test equipment. The VSC8173 model integrates a clock output that can be used to verify jitter performance during operation, ensuring SONET compliance. The companion chip, the VSC8174 demultiplexer, incorporates the clock and data recovery functions. Both models operate on the standard SONET line rates of 9.953 and 10.66 Gbs/s, allowing the use of forward error correction in the data transmission without changing devices or boards.

For More Information Circle No. 751

Low-Voltage Universal Bus Transceiver

Fairchild Semiconductor International's Interface and Logic Group, South Portland, ME, has added the 74LVTH16500 to its low-voltage transceiver portfolio. The device is an 18-bit universal bus transceiver with tri-state outputs, and can be used for driving applications such as backplanes, memory arrays, telecom switches and networking applications. The company says that this addition gives engineers an easy socket replacement when transitioning from 5-V advanced BiCMOS technology to 3-V systems. It also offers designers high speed (3.7 nanoseconds max at 3.3-V V_{cc}) and input and output interface capability to 5-V V_{cc} systems.

For More Information Circle No. 752

Digital I/O Module

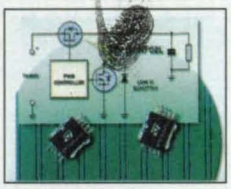
Wadsy Anafaze, St. Louis, MO, releases a digital I/O module, the PPC-2040, as an accessory to the PPC-2000, a programmable, multi-loop proportional integral derivative controller enhanced with hardware and firmware features. The 2040 card allows users to individually configure each of the 32 I/O points as either an input or an output. It also enables users to achieve control over difficult processes, to interface temperature readings to chart recorders, and/or to control set points from external devices. Up to two inputs can read high-speed pulse signals, allowing users to adjust the I/O balance of the module to meet the requirements of each application.

For More Information Circle No.753

Pneumatic Fixture

A pneumatic loaded board fixture from Everett Charles Technologies, Pomona, CA, has been added to its Test Fixture product line. The pneumatic fixture is being initially offered for use on HP3070 testers. The company says that the pneumatic cylinders provide low maintenance and reliable performance for high-volume manufacturing environments. Features include adjustable cylinder actuation for control and smooth actuation, allowing fine pitch test and flexibility for dual stage and stabbing requirements.

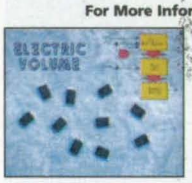
For More Information Circle No. 754



Second Generation STripFET™ devices

STMicroelectronics, Lexington, MA, introduces the NF series, its second generation of STripFET™ devices, to complement its NE series. According to the company, the new devices offer lower on-resistance values and reduced gate charge to be achieved at highly competitive cost, making them suitable for use in motherboards, mobile phones, laptop energy management systems, UPS and DC motor controls. The NF series initially comprises over 70 devices housed in a variety of through-hole and surface mount packages.

For More Information Circle No.755



Switching Regulators

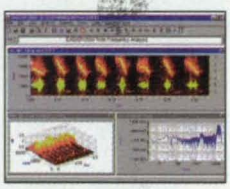
Seiko Instruments, Torrance, CA, introduces the S-8330 series, the first family of switching regulators, which can be adjusted with an 8-bit digital signal from a microprocessor or other control unit. Seiko believes this feature makes the series fitting as a bias generator for dot-matrix liquid crystal display graphics, power supplies for portable equipment such as pagers, handheld calculators, remote controllers, and constant voltage power supplies for cameras, video equipment and communications equipment. The series delivers digitally controlled output voltages from 8 to 30 V over a wide range of input voltages from 9 down to 2 V.

For More Information Circle No. 756

Data Acquisition Systems

UDAS™ universal serial bus (USB) data acquisition systems from Intelligent Instrumentation, Tucson, AZ, provide an alternative to plug-in PC data acquisition boards. UDAS models utilize the USB, which offers hot-swappable and true plug-and-play configuration and operation. USB I/O systems can be utilized for automated test and measurement, data logging, temperature measurement, laboratory automation, portable data acquisition, production test, electronics test, and research and development. The systems can be configured for 16-single-ended/8-differential 12-bit analog input channels.

For More Information Circle No.757



Engineering Spreadsheet

The DADiSP/2000 engineering spreadsheet from DSP Development Corp., Newton, MA, contains an updated graphical user interface, connectivity support with ActiveX, real-time analysis and plotting capability, and a sizable increase in the library of more than 1,000 mathematical, engineering and scientific functions. The company says that DADiSP/2000 provides users with a more familiar and productive analysis environment by tightly integrating standard buttons, property sheets, tabbed dialog boxes, quick menus, and enhanced custom menus.

For More Information Circle No. 758

Secure Digital Memory Card Connectors

AVX Corporation, Myrtle Beach, SC, releases a family of secure digital memory card connectors that offer integral card detect and write protect. Designated the 5638 Series, the connectors feature a nine-contact configuration with SMT tails located within the connector body to save PCB real estate. The connectors offer a current rating of 0.5 A per pin and rated voltage of 5 V with dielectric withstanding voltage of 500 V rms/min. All parts are surface-mountable and compatible with automated assembly equipment. The series includes low profile and narrow width options, with optional card eject features.

For More Information Circle No. 759

Synchronous Clock Module

Raltron Electronics Corp., Miami, FL, introduces the Stratum-3 synchronous clock module for clock-network synchronization and wireless communication systems. Raltron says that the Model SY-0001 Stratum-3 clock module is a semicustom subsystem that offloads costly design engineering tasks and offers a turnkey solution to many complex challenges of communication systems design. The SY-0001 module features its own Stratum-3 oven-controlled crystal oscillator, two independent inputs of any reference frequency from 8 kHz to 77.76 MHz, and a digital signal processor phase-locked loop with bandwidth of 0.1 Hz that eliminates jitter in any incoming signal.

For More Information Circle No. 760

Digital Signal Processor

Radstone Technology, Montvale, NJ, introduces the VANTEGRA-2 digital signal processor (DSP) series, its latest generation of the VERSA-module Eurocard (VME) DSP board family based on the 600 megaflops ADSP-21160 SHARC® DSP from Analog Devices. With 12 ADSP-21160 DSPs in a single VME slot, the VANTEGRA-2 provides 7.2 gigaflops and is designed for multi-DSP applications such as radar, sonar and image processing. The VANTEGRA-2 link port architecture is optimized for efficient parallel processing and, via interboard link port connections, enables a system comprising multiple VANTEGRA-2s to provide extensive processing power.

For More Information Circle No. 761

Gap Welding Preforms

Ribbon RF connections could be made with greater consistency.

Goddard Space Flight Center, Greenbelt, Maryland

Small, temporary, disposable inserts, called "gap welding preforms," have been proposed for use in attaching electrically conductive ribbons to radio-frequency (RF) electronic circuits. As explained below, the use of gap welding preforms would help to ensure consistency of the ribbon connections and would reduce the time necessary for making the connections.

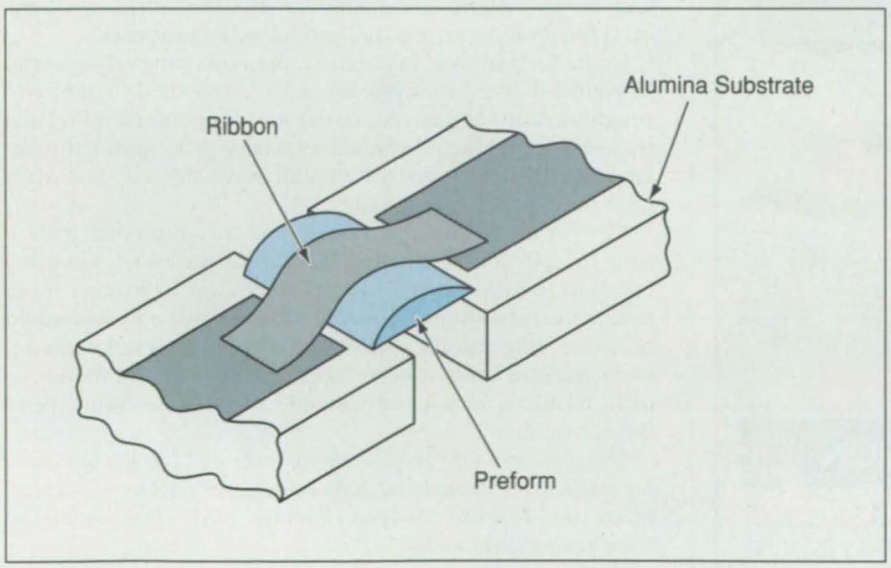
In the situation that inspired the proposal, gold ribbons 0.025 in. (0.64 mm) wide and 0.001 in. (0.025 mm) thick must be formed and attached to RF circuitry under a microscope up to 0.6 in. (15 mm) deep into RF housings. A ribbon must be manually held in place and formed to the required strain-relief arch between connection points by use of tweezers and other small tools, according to the best judgement of a technician. The ribbon is attached by use of a gap welding machine that includes small probes for placing welds. The technician's view of the ribbon through the microscope can be limited, especially inasmuch as side viewing is usually not possible. Sometimes, this difficult forming-and-attachment procedure inadvertently results in excessive strain-relief arch, which can degrade the RF signal and thus make it necessary to rework the connection.

A gap welding preform would be made of a material that could hold a predetermined shape and could be easily removed after use without causing any deterioration of the welded ribbon or the surrounding material. For example, a gap welding preform could be made of a thickened acrylic compound similar to that used for conformal coating of circuit boards. Thickeners and solidifiers could be mixed into the material to facilitate extrusion into various predetermined shapes. A gap welding preform for a given application would be shaped so that a ribbon laid on it during a forming-and-attachment procedure would end up shaped in the strain-relief arch required for that application.

The steps in the use of a gap welding preform would be the following:

1. The preform would be cut to a length greater than the width of the ribbon to be attached.
2. The preform would be placed between the connection points in the circuit path.
3. The ribbon would be formed over the preform (see figure) and one end of the ribbon would be welded in place.
4. The ribbon would be examined to determine whether it was in the desired shape and, if not, would be reformed as necessary.
5. The ribbon would be welded in place at the end not previously welded.
6. The preform would be dissolved by a suitable solvent (e.g., alcohol) and the ribbon connection would be inspected. The use of dissolution (instead of another method) to remove the preform would eliminate the risk of tearing the welded ribbon, reduce the time needed to remove the preform, and reduce the time needed for inspection.

This work was done by Richard F. Davis and Mark A. Hillyer of Hughes Electronics Corp. for **Goddard Space Flight Center.**
GSC-14103



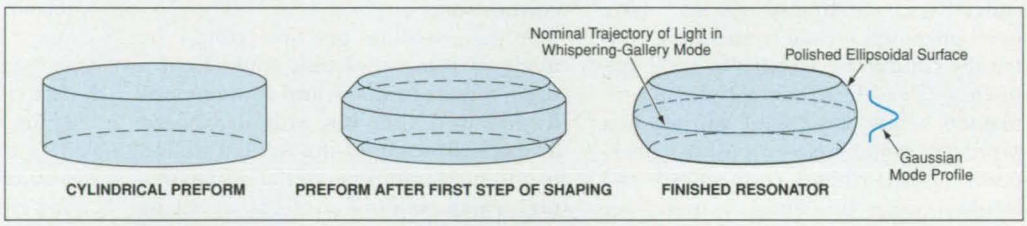
The **Preform Is Placed in the Gap** between contact points to which the ends of the ribbon are to be welded. The ribbon is shaped to the desired strain-relief arch by bending it on the preform.

Microfabricated High-Q Optical Resonators for Microphotonics

Ultra-high-Q microcavities would be mass-produced and integrated by techniques adapted from microelectronics.

NASA's Jet Propulsion Laboratory, Pasadena, California

Submillimeter-sized, transparent, solid, truncated spheres and ellipsoids for use as optical resonators in integrated microphotonic devices would be made by microfabrication techniques like those used in the electronic industry to make integrated circuits, according to a proposal. Such resonators, heretofore denoted generally as "microspheres," have been described in several recent articles in *NASA Tech Briefs*. In a microsphere, resonance is achieved through glancing-incidence total internal reflection in one or more "whispering-gallery" modes, in which the light propagates in equatorial planes near the surface, with an integer number of wavelengths along a nominal closed circumferential trajectory. If the surface of the resonator is sufficiently smooth and a sufficiently close approximation of a sphere or ellipsoid, then in principle, the resonance quality factor (Q) is limited only by attenuation in the resonator material; for a microsphere made of fused silica, this translates to a potential to obtain $Q \geq 10^{10}$.



An **Ellipsoidal Optical Resonator** would be fabricated by micromachining, starting from a preform of fused silica or other highly-transparent material.

Heretofore, microspheres have been fabricated manually, in small numbers, for use in laboratory experiments. The proposal regarding adaptation of microfabrication techniques is prompted by a desire to obtain mass-producibility of such resonators with reproducibility of design, plus a capability for integration of the resonators with other photonic devices.

A typical fabrication sequence according to the proposal (see figure) would begin with preparation of a circular cylindrical disk preform of the resonator material, with a diameter between 100 and 200 μm and an axial thickness of 20 to 40 μm. Chamfers would be introduced at the top and bottom edges, and the resulting edges would be chamfered further, so that the original cylindrical surface would be made to evolve toward an ellipsoid. This shaping would be accomplished in a sequence of steps that could include a combination of thermal and mechanical treatments. Alternatively, shaping could involve wet and/or dry etching, ion milling, laser-assisted etching, chemical-assisted ion-beam etching, and/or other processes.

In the final steps of fabrication, the remaining edges would be rounded and the ellipsoidal surface smoothed to minimize roughness and thereby reduce the scattering loss of light. Final treatment could include radiative heating to fire-polish the surface to reduce the surface roughness to the subnanometer level (in effect, the molecular level).

The finished resonator would have an ellipsoidal surface near the plane of symmetry. Because of the nearly Gaussian falloff of the whispering-gallery modes away from their localization near the symmetry plane, the truncated ellipsoid would be electromagnetically indistinguishable from a full ellipsoid. Consequently, flat border surfaces could be used for mounting or heat-sinking without adverse effect on the performance of the optical cavity.

This work was done by Vladimir Iltchenko and Chi Wu of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category.*

NPO-20604

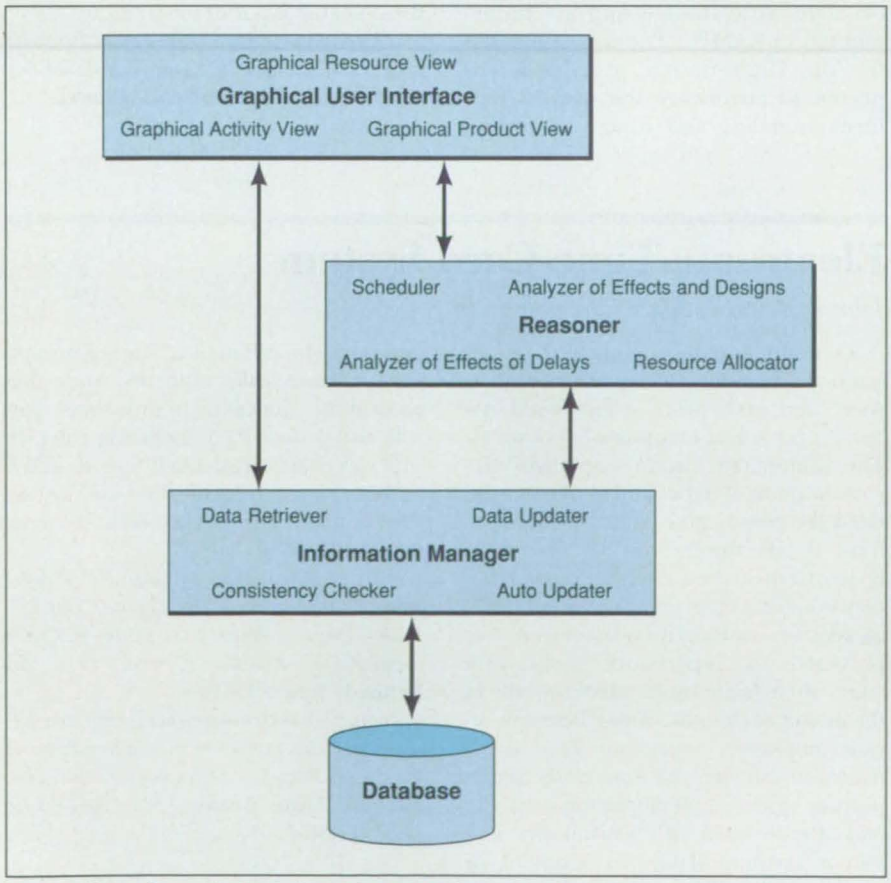
Knowledge-Based Software for Generating and Changing Plans

Effects of changes in requirements and resources are automatically taken into account.

Lyndon B. Johnson Space Center, Houston, Texas

A methodology of computer-aided planning has been developed to (1) accelerate the generation of plans for activities within complex systems of personnel and equipment; (2) increase the quality of the plans thus generated; and (3) decrease the difficulty of predicting and responding to the effects of changes in plans, requirements, resources, and/or other constraints. Originally intended for application to planning of missions of the space shuttle and other spacecraft, the methodology could also be applied to strategic business planning, management of projects, general scheduling, and planning of manufacturing processes and systems.

The three principal components of the methodology are (1) an ontology of mission planning; (2) knowledge-based algorithms and conceptual (including mathematical) models for the analysis of plans; and (3) the Knowledge Aided Mission Planning System (KAMPS) computer program, which embodies the ontology, algorithms, and models. The KAMPS software implements a structured method for planning and re-planning. The KAMPS planning method involves (1) a template-based approach to the generation of plans; (2) representation, from alternate perspectives, of knowledge about plans, application of plans, and maintenance of plans; and (3) qualitative and quantitative analysis



The **KAMPS Software** is divided into four modules, each of which performs a different set of functions.

of plans for prediction of the effects of changes.

The ontology and an associated theoretical framework were developed to enable detailed characterization of the world for the purpose of performing mission planning in this domain. The ontology and framework provide a conceptual foundation for knowledge-based creation, maintenance, and analysis of plans. The development of the ontology included the characterization of the key entities involved in the mission-planning process, and of the relationships and constraints that govern the behavior of those entities. This development effort resulted in a characterization of the ontology and the production of information models and process models for the mission-planning domain.

KAMPS provides means for capturing the information that pertains to the flight-design process, reasoning with this information to assist in developing plans, and to assist in the analysis of the effects of plans and of changes. KAMPS is based on a very clear and succinct modeling paradigm in which all of the information is managed in three views: product-centered, activity centered, and resource-centered. The concepts that occur in each of these views and the relationships among the various concepts were studied and are implemented in KAMPS. The use of KAMPS for the flight-design process is expected to encourage the user to perform modeling and design according to the best practice and research conventions, which have been incorporated into KAMPS.

KAMPS incorporates a rich library of qualitative and quantitative conceptual models for predicting the effects of changes. Temporal effects are included in quantitative predictions; effects on values, processes, inputs, and outputs are included in qualitative predictions.

KAMPS facilitates modeling of products and activities at multiple levels of abstraction. KAMPS also supports planning and reasoning at multiple levels: For example, upper managers can use KAMPS to do planning at a relatively abstract level, whereas middle managers can use KAMPS to perform planning at a more detailed level.

Once experience with KAMPS results in the accumulation of sufficient pertinent information about flights and templates, it should be possible to use KAMPS as means to provide detailed information on the flight-design process that is detailed, standardized, and more complete than the information in the flight-design handbook used heretofore for training. In comparison with the handbook, KAMPS presents relevant information in ways that are more interactive, modular, and graphical. Thus, KAMPS can serve as both a means to document the NASA flight-design process and as a tool for training.

This work was done by Benjamin Perakath and Blinn Thomas of Knowledge Based Systems, Inc., for **Johnson Space Center.**
MSC-22830

Electronic Time-Card System

John F. Kennedy Space Center, Florida

A computer-based automated system has been developed to replace a cumbersome and error-prone paper-based system for recording employees' work times. The automated system minimizes the consumption of paper and eliminates the need for weekly pick-up and delivery of time sheets throughout the Kennedy Space Center. The computer-based system simplifies daily entry of times by employees, who select jobs worked from lists provided by supervisors. Employees "sign" their "time cards" electronically at the end of each week. Supervisors can review employees' electronic time cards daily and can sign the time cards of employees under their supervision at the end of each week, all electronically. The system accommodates reassignment of employees to different departments or supervisors, as well as replacement of supervisors who call in sick. The system software automatically enforces rules that control the processing of time-sheet, payroll, and project data, including rules on who can charge how much time to which account. The electronic-time-card system was compiled using Visual Basic incorporating SQL server.

This work was done by James W. Thorpe, James P. Williams, Larry D. Jewell, Doris L. Bailey, Debra S. Blum, and Shirley R. Curry formerly of EG&G Florida, Inc., for **Kennedy Space Center.**

Inquiries concerning rights for the commercial use of this invention should be addressed to Lew Parish, Technology Counselor, Kennedy Space Center, (321) 867-6373. Refer to KSC-12051.

Improved Unidirectional Cell-Stretching Device

Cells can be stretched controllably, without removing them from a culture medium.

Lyndon B. Johnson Space Center, Houston, Texas

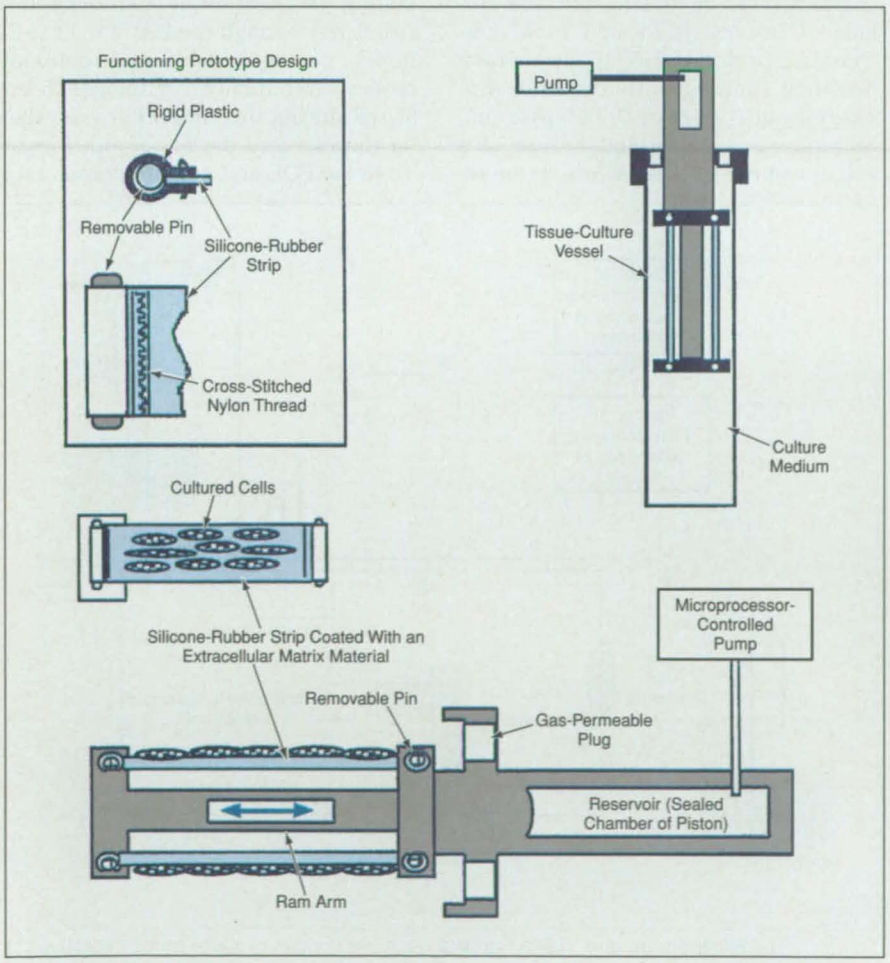
An improved stretching device has been developed for use in research on the effects of unidirectional loading on human and animal cells. The device is capable of applying or removing a load (a controlled amount of stretch) on command to mimic the loading or unloading experienced by skeletal muscles and other tissues of interest.

This device is designed to overcome the deficiencies of three cell-stretching devices that were commercially available at the time of reporting the information for this article. In the present device as in the commercial devices, a cell culture is grown on a coated sheet of silicone rubber that is immersed in a culture medium and the sheet is stretched to apply the desired load. One of the commercial devices can apply the load only in discrete steps and must be removed from the culture medium to change to a different load step. The other two commercial devices contain circular silicone membranes that are deformed in such ways that the resulting stretches include radial components and are thus not the desired unidirectional stretches. The present device need not be removed from the culture medium and produces a continuously adjustable, truly unidirectional stretch.

The silicone rubber sheets in the present device are in the form of rectangular strips coated with an extracellular matrix compound (i.e., collagen Type I). The strips are arranged parallel to each other with their long axes laid out along the axis of a round cylindrical ram (see figure). By use of removable pins, the ends of the strips are attached to the ends of the ram at equal circumferential intervals. This design makes it possible to grow cells on the strips in standard tissue culture plates to the required cell density or differentiation state before placing the strip in the cell stretcher. This design also offers the advantage of ease of removal of the cells for examination at the end of the stretching procedure.

The ram assembly with the strips attached is inserted in a tissue-culture vessel that contains a culture medium. The stretching actuator in the ram is a sealed-chamber piston. Stretching along the cylindrical axis is effected by injection of a sterile fluid into the sealed chamber by use of a pump controlled by a microprocessor. (The pump is situated outside the culture vessel.) Reversal of the injection flow results in a decrease in the amount of stretch. The rate of stretching or unstretching is controlled by controlling the rate of flow.

According to a proposed alternative design of this device, the ram would be advanced by a screw drive actuated by a microprocessor-controlled stepping motor. According to another proposed alternative design, the cell stretcher would be built into a tissue-culture vessel that would include a heater, a temperature sensor, ports for exchange and/or sampling of the culture medium, a port for infusion of gas, a pressure sensor, gas sensors, and optical ports for observation of cells during the loading procedure.



This **Unidirectional Cell Stretcher** incorporates several improvements over commercially available cell stretchers.

This work was done by Daniel L. Feeback of **Johnson Space Center** *and Mark S. F. Clarke of the National Research Council. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Bio-Medical category.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center, (281) 483-0837. Refer to MSC-22834.

Apparatus Measures Attachment or Detachment of Biofilm

Efficacy of a biocide can be assessed quantitatively.

Lyndon B. Johnson Space Center, Houston, Texas

Figure 1 schematically illustrates a laboratory apparatus that provides quantitative information on the density and on the rate of increase (or decrease) of density at which bacteria attach themselves to solid surfaces in a potable-water-supply system. These biofilms are potentially pathogenic and/or phytotoxic and can adversely affect processing of the water under some circumstances. The apparatus was devised to assess the abilities of biocide chemicals in water to suppress the biofilms in potable-water subsystems within closed life-support systems of spacecraft, but may also be adaptable to similar investigations of biofilms in terrestrial water supplies.

The apparatus implements a recently developed method of automated image analysis for continuous, real-time monitoring of attachment of microbes to (or detachment of microbes from) a surface of interest that is immersed in water containing the microbes and chemical(s) to be investigated. The surface of interest is located in a flow-chamber/optical-cell (FOC), which is a modified fungal-growth chamber with interior dimensions of 30 by 5 by 2 mm. Monitoring is performed by use of a video camera mounted on a microscope that is focussed on the surface of interest.

Water is recirculated through the FOC at a rate of 9.8 mL/min by a high-speed micropump. The pump produces a pulsating flow; the pulses are damped by a device of 1-mL volume upstream of the FOC. The influent and effluent tubes are positioned to achieve turbulent flow in the middle of the FOC, where the monitored surface is located.

The video images of the monitored surface are preprocessed into binary images. Then a frame grabber grabs two successive images and stores an average of them on an optical disk. The averaged image is processed to extract information on the number and total area of objects (attached bacteria) in the field of view. This process can be repeated at intervals, yielding cell counts that can be plotted as a function of time, to determine rates of attachment and/or detachment.

In a typical experiment, water containing a suspension of microbes is first circulated through the FOC for 18 to 24 hours, during which time some microbes attach themselves. Images are analyzed during this time to acquire data on the rate and density of attachment. Then the FOC and its recirculation loop

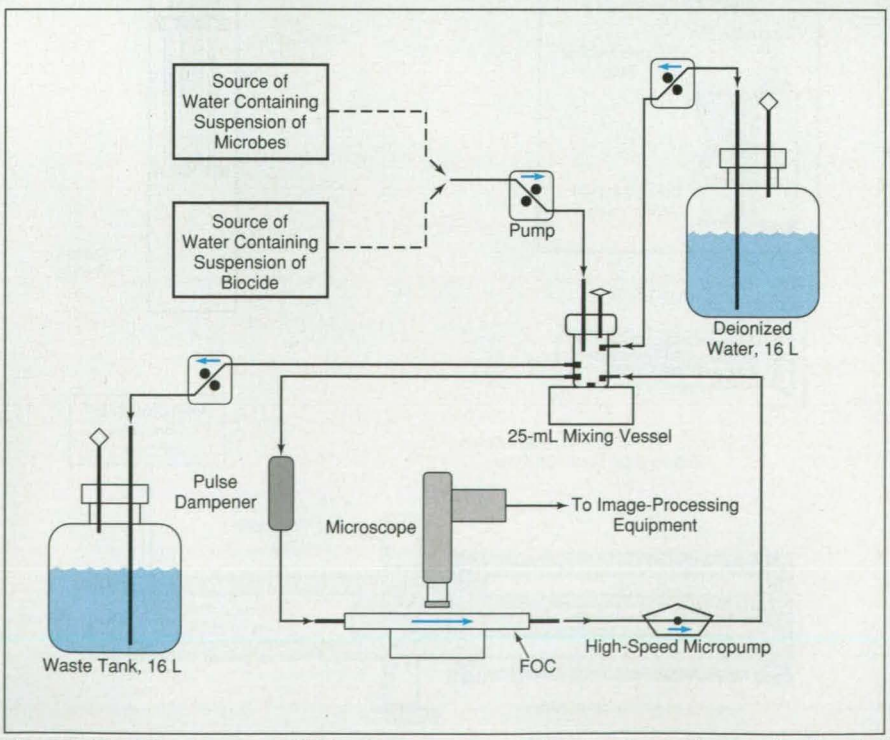
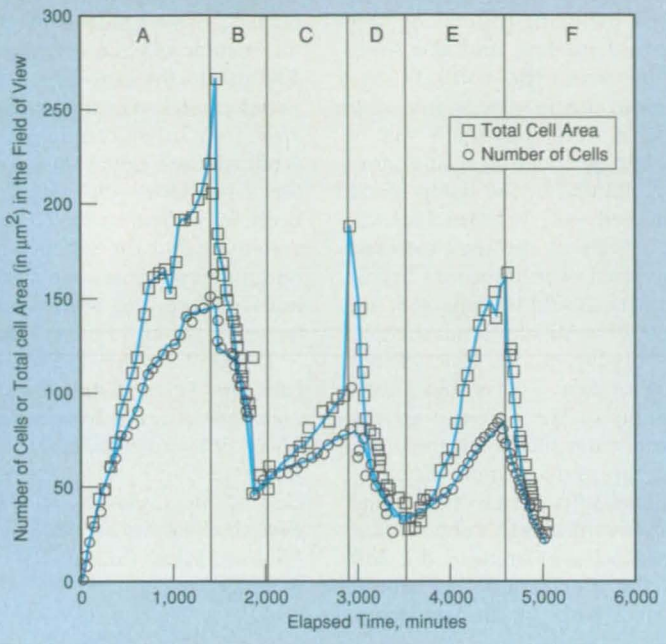


Figure 1. The **Microscope and Video Camera** generate images of water-borne microbes that have attached themselves to a solid surface. The images are digitized and processed to yield cell counts as a function of time.



Plot	Phase of Experiment
A	Adhesion
B	Treatment With 12 ppm of Chlorine
C	Adhesion
D	Treatment With 24 ppm of Chlorine
E	Adhesion
F	Treatment With 48 ppm of Chlorine

Figure 2. These **Plots of Cell Counts Versus Time** were obtained in an experiment in which the microbes were *Pseudomonas cepacia*.

with the high-speed micropump are isolated from the source of the cell suspension and washed with 300 mL of deionized water. Next, water containing the biocide to be tested is pumped into the FOC and recirculated through the FOC for 5 to 6 hours, during which time more images are analyzed and data collected. This is followed by another wash cycle, which is followed by another cycle of recirculation of the cell suspension and analysis of images, to measure the rate and degree of attachment on the surface of interest after the treatment with the biocide (see figure). Images are acquired at a frequency of at least once an hour, to measure the rate of attachment, and at least once every 20 minutes, to evaluate the effect of the biocide on the size of microbes and on the rate of detachment.

This work was done by Duane. L. Pierson of **Johnson Space Center** *and David W. Koenig and Saroj K. Mishra of KRUG Life Sciences, Inc. For further information, access the Technical Support Package (TSP)* ***free online at www.nasatech.com*** *under the Bio-Medical category.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center, (281) 483-0837. Refer to MSC-22679.

Software To Detect Malfunctions in Anesthesia Equipment

Response times in critical situations can be reduced.

Lyndon B. Johnson Space Center, Houston, Texas

To reduce response times and save lives in operating rooms, community trauma centers, and remote combat care facilities, a team of scientists working on behalf of Lyndon B. Johnson Space Center (JSC) has developed an artificial-intelligence alarm-management software system that detects malfunctions in esophageal intubation and anesthesia machines. This system uses CLIPS [the C-Language Integrated Production System] knowledge-based rules derived from real-time data supplied by a sheep model. Although this system is one of several current alarm-management software systems, it is vastly superior to the commercial software systems designed to perform the same or similar functions.

Commercial software systems of this type monitor faults that occur above or below preset thresholds. Threshold settings may vary, but the monitors are unable to detect faults "intelligently." They are, in effect, hampered by preset values and can mistake threshold issues for life-endangering malfunctions. Because of this possibility of error, an alarm must always be treated as a serious matter, whether or not there is a malfunction. In an operating room, when an alarm warns of a possible malfunction, the surgical procedure can be disrupted. Without intelligent software already in place, surgical team members must verify that a malfunction has indeed occurred, or will occur, thus increasing both their own response time and the risk to the patient. A change is needed.

An artificial-intelligence software system that can detect and define faults accurately while it monitors patients on esophageal intubation and anesthesia machines would decrease response times and reduce risks to patients. CLIPS, the artificial-intelligence software designed at JSC, is a decision-support tool that can effect this change because CLIPS can be taught to determine the parameters of machines.

Basically, an artificial neural network implemented in software in a computer mimics the thought processes of the human brain. CLIPS follows pathways of reasoning, very like human thought processes, to eliminate possibilities. To support CLIPS, data are needed to design a program unique to the esophageal-intubation and anesthesia-machine environment; it is from these data that intelligent software can learn. The task for the team of scientists was to gather these data. For them, gathering data was an integral part of the development of the needed artificial-intelligence software system. The scientists selected a sheep model from which to elicit real-time data; from this model, the team compiled clinical annotations to validate their software system — all without risk to human patients.

Other artificially intelligent systems fail to provide similar annotations. For

example, one prototype simulator that enables users to control and monitor an anesthesia delivery system resembles the JSC software. However, because all of its data and faults are simulated, it lacks the validation of real-time data. In short, no animal-model testing was done for this prototype. Thus, the major limitation of this and other currently available systems is the impossibility of validating them in environments in which they can be used without interfering with normal routines or endangering patients. Yet the user-interface design is critical, and artificial-intelligence software can learn from the results of animal-model testing.

During the team effort, advances in artificial-intelligence software were applied to develop an expert system that could provide, to medical personnel, decision support on the condition of the patient and the anesthesia machine. The rules of the knowledge-based domain were defined by data extracted from various sources, including supporting literature, medical experts, and the sheep model. The prototype software that emerged from this process is still in an early stage of development; it will be tested further by users in a laboratory. The data generated by the sheep model will be analyzed and, if the analysis warrants, the design of the user interface will be modified. The inventors believe that more data should be collected, and hope to test 20 to 30 additional sheep to refine the quality of the expert-system rules being written. This would enable the validation of the software in real time to determine sensitivity and specificity in recognizing alarm conditions.

CLIPS-based software can detect malfunctions in esophageal intubation and anesthesia machines because the software uses the sheep model to provide real-time data from which knowledge-based rules are built. Because the reported malfunctions will be genuine, this system will reduce response times. The use of the real-time data from the sheep model sets this software system apart from other, commercially available artificial-intelligence software systems of this type. Once the sheep model has been fully demonstrated, the scientists anticipate that the system will be tested on human patients — in a way that does not interfere with patient care and adheres to standard medical practices.

This work was done by Todd T. Schlegel of **Johnson Space Center** *and Karin C. Loftin of KRUG Life Sciences, Inc.; Travis A. Moebes of Science Applications International; Jurine Adolf of Lockheed Martin; Donald J. Deyo of the University of Texas Medical Branch; and Jeffrey M. Feldman of the Albert Einstein Medical Center.*
MSC-22675

Device for Testing Susceptibility of Bacteria to Antibiotics

Tests can be performed safely, easily, and quickly.

Lyndon B. Johnson Space Center, Houston, Texas

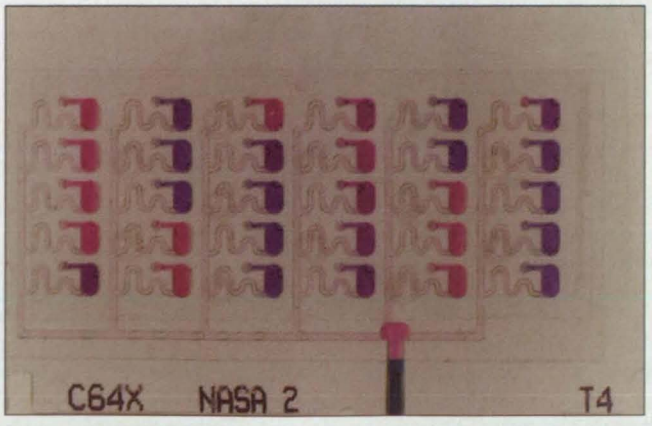
A compact, lightweight, device makes it possible to assess the effects of antibiotics on bacteria. The device safely contains the antibiotic/bacteria mixtures, and its operation involves minimal ancillary equipment and minimal expense of time and effort by technicians. Originally designed for use aboard spacecraft, the device could also be mass-produced for use on Earth in isolated, remote environments and in situations in which automated instrumentation is inaccessible.

Testing to assess the effectiveness of antibiotics has been made necessary by the emergence of resistance to antibiotics in several common bacterial pathogens. Such testing is routinely performed in clinical laboratories by traditional manual and automated methods. An important measure of antibiotic effectiveness in laboratory testing is the highest dilution (minimum concentration) at which the drug under test inhibits the growth of bacteria; this concentration is known as the minimal inhibitory concentration (MIC). Using the present device, one can determine the MIC of an antibiotic with respect to the bacteria of interest, without the complex fluid-handling procedures and without the relatively bulky, expensive, power-consuming equipment of traditional laboratory testing.

The device is a modified version of a commercial test card that provides visual indications of MIC values. The card is credit-card-sized, weighs less than 15 grams, and contains 30 small reaction wells. The reaction wells are filled with dehydrated antibiotic substrates mixed with the antibiotics at various levels of dilution. The modification consists of the addition of Alamar Blue (a redox indicator) to the mixture in the reaction wells. This redox indicator serves as a visual indicator of the growth of bacteria in the wells. Resistance of microbes to the antibiotic in a given well is manifested by a distinctive bright pink color in the wells, whereas susceptibility of the microbes to the antibiotic is indicated by a blue color in that well.

To initiate a test, a technician inoculates the wells with a suspension of microbes that has been prepared from a 24-hour culture of the species of interest. The inoculated device is placed in a Ziploc (or equivalent) edge-sealing plastic bag and incubated at a temperature of 35° C for 18 to 24 hours. After incubation, the device (see figure) is inspected and the colors in the wells are recorded.

In the original space-flight application, two devices are inoculated and bagged in a terrestrial laboratory. One device is transported under refrigeration at 4° C, then incubated in the low-gravity test environment; another device that serves as a control is similarly refrigerated and incubated on Earth.



The **Reaction Wells of This Device** exhibit colors that were developed in a test of antibiotic substrates with *Staphylococcus aureus*.

This work was done by Duane L. Pierson of **Johnson Space Center**, *Joyce A. Skweres and Saroj K. Mishra of KRUG Life Sciences, and James H. Jorgensen of UT-Health Science. For further information, access the Technical Support Package (TSP)* ***free online at www.nasatech.com*** *under the Bio-Medical category.*
MSC-22658

OMEGA Engineering, Stamford, CT, offers the PX790 Series sanitary voltage output **pressure transducer**, which utilizes thin-film technology and precision machining and electropolishing to meet 3A standards. The transducer can be used for pharmaceutical and biotech applications. It features a stainless steel diaphragm, diffused silicone sensor gage, and utilizes a NEMA 4X enclosure.

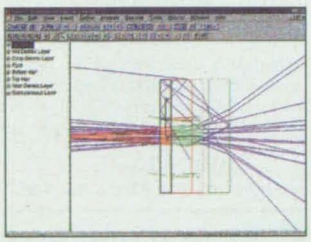
The unit has 800% range burst pressure, 200% range proof pressure, and 100M-cycle durability. Its output is 1 to 5 Vdc unregulated, and it features an operating temperature range of -20 to 180° F. Units in the series feature ranges from vacuum to 1000 psi.

For More Information Circle No. 737

Solar Light, Philadelphia, PA, has introduced the PMA 2200 **radiometer/photometer** with a range of NIST-traceable, high-sensitivity detectors. The systems are suitable for a wide range of laboratory and radiometry applications. With UV-B detectors, the radiometers are used for measuring biologically effective radiation in skin testing, phototherapy, materials testing, and environmental monitoring. With UV-C (254nm) detectors, the radiometer has application wherever germicidal lamps are used, such as in cleanrooms, hospitals, and laboratories.

The unit's front-panel keypad enables setting of zero, span, and user-specified parameters. A two-line, anti-glare LCD displays values and units. Other features include a dynamic range of 6.5 digits, a sampling rate of 3 times/sec, over 30 interchangeable detectors, and RS-232 output for data capture, analysis, and archiving.

For More Information Circle No. 738



TracePro® 2.1 opto-mechanical **3D solid modeling software** from Lambda Research Corp., Littleton, MA, is designed for industries such as biomedical and pharmaceutical. The software includes modeling of thin-film stacks, gradient index materials, and temperature dependence of material and surface properties. New features designed for medical-instrument developers include the modeling of bulk scattering in biological tissue, along with the addition of a database of bulk scatter in human tissue.

The temperature feature allows users to define the index of refraction and surface properties versus temperature, and calculate the thermal dependence for the analysis of systems in the medical industry. Enhanced thermal emission modeling allows calculation of radiative heat transfer for infrared systems and modeling of blackbody and incandescent sources.

For More Information Circle No. 739

The GP-KS462 Super Micro **color camera module** from Panasonic Industrial/Medical Group, Secaucus, NJ, is used in medical applications where size and performance are critical criteria. The unit measures 5.6 x 5.6 x 5.4 mm and weighs 1 gram. The 0.25" color CCD produces 480 lines of color resolution with a signal-to-noise ratio of 50 dB. The micro camera head is 6.7 mm in diameter and 30.3 mm in length.

The camera head can be separated from the circuit board module over distances of 10 mm. Incorporating external electrode pads facilitates cable connection to the camera control unit up to 10 m from the camera. Other features include RGB digital signal processing (DSP), auto white balance, auto gain control, backlight level, and an EVR serial interface.

For More Information Circle No. 740

Hoffer Flow Control, Elizabeth City, NC, offers the Nova-flow **flow computer**, which is configurable as a rate indicator/totalizer, batch controller, or mass-flow computer through the use of a system architecture. The flow computer has eight expansion slots to accommodate electronic modules, which provide I/O and communication options. As a mass-flow computer, the system can be used with gases and cryogenic liquids requiring temperature, pressure, and compressibility compensation.

Configuration of the basic unit and the module are implemented using Windows-based software, which is included with the unit. The unit may be configured to support mass flow and will accommodate inputs from RTDs, temperature transmitters, pressure transducers, and densitometers. The basic unit includes eight additional lines of digital I/O that are configured via software.

For More Information Circle No. 741

The AxioCam **digital microscope camera** from Carl Zeiss, Thornwood, NY, provides high resolution (6.7 x 6.7 µm pixel size) in areas such as pathology, cell research, genetics, neuroscience, materials analysis, and quality assurance. The camera allows users of light microscopes to document microscopic and macroscopic exams with digital images. Features include image digitization and storage in 14 bits; no mechanical shutters, filter wheels, or fans; and color correction optimally matched to the color temperatures of the light sources used with the microscope.

The camera can be connected to a PC running on a standard Windows operating system, via high-speed fiber-optic cables, at a speed of 200 Mbit/sec. The camera's integration time goes from 1 ms to 40s. The resolution of the image size can be set in a range from 1300 x 1030 pixels, to 3900 pixels, and therefore matched to the relevant tasks. This permits loss-free images at full microscope resolution.

For More Information Circle No. 742

DATA ACQUISITION PRODUCT GUIDE

National Instruments' Data Acquisition Product Guide outlines an extensive line of PC-based tools available for measurement and automation applications, including hardware and software for analog, digital, and timing I/O, signal conditioning and connectivity, image acquisition, motion control, and computer-based instruments. National Instruments; Tel: (800) 327-9894 (U.S. and Canada), (512) 794-0100; Fax: (512) 683-9300; e-mail: info@ni.com; www.ni.com/info/daq

National Instruments

For More Information Circle No. 600

INSTRUPEDIA™

Instrupedia, the interactive encyclopedia of instrumentation, is a source of abundant information useful for building PC-based measurement and automation applications. This free CD includes the entire National Instruments product catalog, evaluation software, application notes, customer solutions, the searchable Knowledge Base, and more. Compatible with Windows 2000/NT/9x/3.1 and Mac OS systems, Instrupedia also provides links directly to the National Instruments Web site. National Instruments; Tel: (800) 443-3488 (U.S. and Canada), (512) 794-0100; Fax: (512) 683-9300; e-mail: info@ni.com; www.ni.com/info/instrupedia

National Instruments

For More Information Circle No. 601

INDUCTOSYN® POSITION TRANSDUCERS

Our 16-page Engineering Guide describes how to select and use Inductosyn® position transducers for applications in extreme aerospace and industrial-manufacturing environments. Rotary Inductosyn® transducers provide absolute and incremental position information, accurate to ±0.5 arc second or better, with resolution to 26 bits. Linear Inductosyn® transducers are accurate to ±µ40 inches or better, with sub-µinch resolution. Farrand Controls, a division of Ruhle Companies, Inc.; Tel: 914-761-2600; Fax: 914-761-0405; e-mail: sales@ruhle.com; www.ruhle.com

Farrand Controls

For More Information Circle No. 602

INTEGRATE CAD AND ALGOR MES FOR BETTER DESIGNS

Algor's InCAD products capture exact part or assembly geometry, like this housing component, for dynamic stress analysis with Mechanical Event Simulation for linear or nonlinear material models. InCAD products work with CADKEY, Mechanical Desktop, Pro/ENGINEER, Solid Edge, and SolidWorks. Address: 150 Beta Dr., Pittsburgh, PA 15238; Phone: +1 (412) 967-2700; E-mail: info@algor.com; or Fax: +1 (412) 967-2781; www.algor.com, www.feaincad.com

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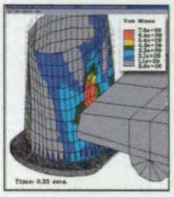
For More Information Circle No. 603



ALGOR'S ACCUPAK/VE SOFTWARE REPLICATES REAL-WORLD EVENTS

In this impact simulation, Algor's Accupak/VE Mechanical Event Simulation software and kinematic element technology replicates physical behavior by determining the motion, flexing and resulting stresses of a CAD part or assembly in a "virtual laboratory." Add thermal, fluid or electrostatic effects to Accupak/VE analyses with linear and nonlinear materials to simulate multiple physical phenomena. Address: 150 Beta Dr., Pittsburgh, PA 15238; Phone: +1 (412) 967-2700; E-mail: info@algor.com; or Fax: +1 (412) 967-2781; www.algor.com

Algor, Inc.

For More Information Circle No. 604

TUESDAY @ TEN: INTERNET TV DISTANCE DEMOS SHOW WHAT'S NEW

Join Algor every Tuesday at 10 a.m. Eastern Time at www.eTechLearning.com to learn about Algor's Finite Element Analysis and full Mechanical Event Simulation software and its InCAD products for doing FEA within CAD. Viewers can phone or e-mail questions to be answered by Algor engineers during these free, public Webcasts. Replays are available on demand. Phone: +1 (412) 967-2700; E-mail: info@algor.com; or Fax: +1 (412) 967-2781; www.eTechLearning.com, www.algor.com

Algor, Inc.

For More Information Circle No. 605

METRIC AIR SPRING MANUAL FROM FIRESTONE

Firestone Industrial Products has revised its *Metric Engineering Manual and Design Guide* for Airmount® isolators and Airstroke® actuators. The manual provides complete spring specifications in metric dimensions, including height, force, and static data. Airstroke actuators are a low-cost equivalent to conventional pneumatic and hydraulic cylinders; Airmount isolators feature a compact installed height and unsurpassed isolation capability. Firestone Industrial Products Co., 12650 Hamilton Crossing Blvd., Carmel, IN 46032; www.firestoneindustrial.com

Firestone Industrial Products Co.

For More Information Circle No. 606

VACUUM PUMP VIBRATION ISOLATORS

The NEC vibration isolators effectively remove turbo-molecular and cryo-pump vibrations. Two models are available in elastomer and air-isolated versions. They are UHV compatible, have short insertion lengths, and high conductance. A wide variety of flanges are available. National Electrostatics Corp., 7540 Graber Rd., Box 620310, Middleton, WI 53562-0310; Tel: 608-831-7600; Fax: 608-256-4103; e-mail: nec@pelletron.com; www.pelletron.com;

National Electrostatics Corp.

For More Information Circle No. 607

NEW EDITION OF PUMP STANDARDS

Learn how to apply and order pumps most effectively. The greatly expanded, 1000-page ANSI/2000 edition helps you understand pump definitions, nomenclature, installation, operation, and test procedures. It has been completely updated, replacing all previous editions, and is "required reading" for pump users, contractors, and engineers. The new HI Supplier Finder service lets you find 100 pump manufacturers, six different ways, online at www.pumps.org. Hydraulic Institute, 9 Sylvan Way, Parsippany, NJ 07054. Tel: 973-267-7772

Hydraulic Institute

For More Information Circle No. 608

DEVICE DATA INTO WINDOWS APPLICATIONS

WinWedge instantly inputs serial (RS232-RS485) or TCP/IP data into any Windows application: Excel, Access, MMIs, etc. Collect data from and control gauges, micrometers, balances, meters, bar-code scanners, measuring instruments ... any device. Easily perform graphing and analysis of your instrument data in any program. TalTech, 2027 Wallace St., Philadelphia, PA 19130; Tel: 800-722-6004, 215-763-7900; Fax: 215-763-9711; www.taltech.com

TalTech

For More Information Circle No. 609

CUSTOM ELECTROFORMS

Rugged, precision, lightweight electroforms can be used at cryogenic temperatures or up to 1000° F. Diameters can range from 0.030 to 8 inches. Wall thicknesses from 0.0003 to 0.025 inches can be supplied. They can be made an integral unit with a bellows to produce a "dynamic" component. Servometer Corp., 501 Little Falls Rd., Cedar Grove, NJ 07009-1291; Tel: 201-785-4630; Fax: 800-785-0756 (U.S.); Fax: 201-785-0756 (outside U.S.); www.servometer.com

Servometer Corp.

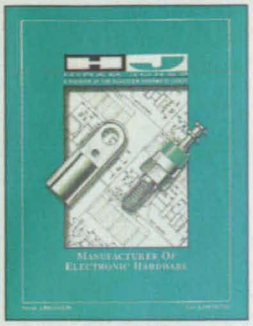
For More Information Circle No. 610

100,000 PROCESS MEASUREMENT AND CONTROL PRODUCTS

More than 100,000 process measurement and control products can now be ordered directly via OMEGA Engineering Inc.'s new online store at www.omega.com. Most items are in stock for overnight delivery. Products include thermocouple and RTD probes; instruments for temperature measurement and control; pressure transducers and load cells; plus a full line of data acquisition products. OMEGA Engineering Inc.; One Omega Dr., P.O. Box 4047; Stamford, CT 06907-0047; Tel: 800-826-6342; Fax: 203-359-7700; e-mail: info@omega.com; www.omega.com

OMEGA Engineering Inc.

For More Information Circle No. 611



Hiram Jones Electronics, Inc./A Division of the Seastrom Hardware Group manufactures a complete line of standard miniature and subminiature terminals including: insulated test jacks, assembled standoffs and press-type terminals. All standard catalog items are available for immediate pricing and delivery. Call today for your free 27-page catalog: 800-634-2356.

Hiram Jones Electronics, Inc.

For More Information Circle No. 612

WAVE/COMPRESSION SPRING CATALOG

The new 2000 edition catalog, #WS-2000, contains thousands of stock-size wave springs (hundreds of new sizes added), design formulas, a materials guide, and typical applications. This 40-page engineering and parts manual describes the advantages of wave springs and helps engineers solve problems. All springs are not equal! Smalley springs, available from 3/8" to 84" in diameter, fit in tight radial and axial applications. Work heights can be reduced by 50% using a wave spring. Smalley engineers are available for free assistance. Smalley Steel Ring Co., 385 Gilman Ave., Wheeling, IL 60090; Tel: 847-537-7600; Fax: 847-537-7698; e-mail: info@smalley.com; www.smalley.com

Smalley Steel Ring Co.

For More Information Circle No. 613

REMOTE VIEWING INSTRUMENTS

ITI, the leader in remote viewing, offers more than 2,000 standard RVI's for inspecting engines, air frames, or components in inaccessible areas. Products include new Camera Dedicated Borescopes and patented PROTECHT™ Fiberscopes and Videoscopes. Custom and OEM scopes are a specialty. All component parts carry a one-year warranty from date of purchase. Instrument Technology, Inc., PO Box 381, 33 Airport Rd., Westfield, MA 01086-0381; Tel: 413-562-3606; Fax: 413-568-9809; e-mail: iti@scopes.com; www.scopes.com

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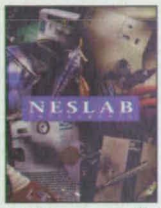
For More Information Circle No. 614

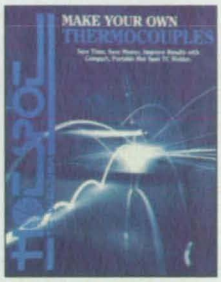


CHILLERS/COOLERS CATALOG

NESLAB's newest product catalog features industrial chillers and liquid coolers. It includes features, specifications, and customizing options available, including refrigeration, controller, pump, fluid, heater, and electrical specs. NESLAB offers a range of cooling solutions for applications such as industrial lasers, EDM, plastics, plating, packaging, chilled rolls, and welding. There is a NESLAB solution to fit each constant-temperature application. NESLAB Instruments, PO Box 1178, Portsmouth, NH 03802-1178; (603) 430-2271; fax (603) 430-8411; E-mail: neslab@neslabinstruments.com; www.neslabinc.com.

NESLAB Instruments

For More Information Circle No. 615



THERMOCOUPLES, MAKE YOUR OWN

The HOTSPOT allows thermocouple wire to be formed into free-standing junctions, or welded to metal surfaces. It provides a simple means of fabricating thermocouples "when needed and where needed." Brochure and specification sheet available. Address: 7300 North Crescent Blvd., Pennsauken, NJ 08110. Tel: 856-662-7272; Fax: 856-662-7862; http://www.thomasregister.com/dcc

DCC Corp.

For More Information Circle No. 616

STORCASE ENCLOSURES

Have you heard the news? Kingston Technology Storage Products Division, the 12-year manufacturer of the original Data Express and other RAID-ready storage enclosures, has officially become StorCase Technology, Inc. This new storage-dedicated sister company of Kingston Technology will maintain the same quality products, service, and support. Contact StorCase today to request new literature, which includes information on their latest InfoStation backplane design chassis. Tel: 714-438-1850; e-mail: info@storcase.com; www.storcase.com

StorCase Technology, Inc.

For More Information Circle No. 617

THE SOURCE FOR ELECTRONIC & MECHANICAL HARDWARE

Seastrom takes pride in offering one of the widest selections of standard electronic and assembly hardware available from stock. Seastrom's 66-A Catalog provides a complete source for over 45,000 products. For a free 550-page catalog, call 800-634-2356.

Seastrom Mfg Co. Inc.

For More Information Circle No. 618

SMALL PARTS CATALOG NO. 20 QUALITY COMPONENTS, MATERIALS, AND TOOLS

This catalog is packed with products for engineering design, research and development, prototypes and modeling, and industrial assembly. Thousands of items are in stock, including miniature fasteners, specialty components, fluid and motion control devices, select materials, and precision tools. SMALL PARTS, INC., 13980 NW 58th Court, Miami Lakes, FL, 33014, Attn: Free Catalog - Dept. 200F; Tel: 800-220-4242; Fax: 800-423-9009; www.smallparts.com

Small Parts, Inc.

For More Information Circle No. 626 or visit www.nasatech.com/626

FREE 2000 QUATECH PRODUCT CATALOG & CD

Quatech's 2000 catalog details our extensive line of quality communication, data acquisition, and signal conditioning products for USB, PCMCIA, PCI, and ISA. New for 2000 are the FreedomUSB Series of multi-port USB serial adapters and USB hubs. Available in print or as an interactive CD linked to our secure online ordering system, the catalog provides product overviews, photos, and complete technical specifications. Call 1-800-553-1170 for your free copy or visit *www.quatech.com.*

Quatech, Inc.

For More Information Circle No. 620

POWER LINE FILTERING & SURGE-SUPPRESSION SYSTEMS

Control Concepts offers a broad range of power-line filters and state-of-the-art surge suppression to meet all of your power-quality needs. Our products make it easy and cost-effective to safeguard any electronic equipment from malfunction, downtime, or failure. Send for a free brochure and our handy informational guide to Surge Suppression and Filtering, or call us toll-free at: 877-523-7185. Control Concepts Corp., P.O. Box 7429, Endicott, NY 13761-7921; Tel: 607-724-2484; Fax: toll-free 800-233-1074; e-mail: cconcepts@control-concepts.com; www.control-concepts.com

Control Concepts

For More Information Circle No. 621

MERCURY SLIP RINGS

Bulletin describes rotating electrical connectors that combine mercury with compatible metals for stable, noise-free connections. Conductors are immersed in separate pools of mercury. Shielding protects the mercury and electrodes. The corrosion-resistant connectors have ball bearing construction to minimize seal wear and are suited for sensitive circuits with milliamp signals. Up to 8 channels are available with electrical capacities to 30 A at 240 VAC. Mercotac, Inc., 6195 Corte del Cedro, #100, Carlsbad, CA 92009; Tel: 760-431-7723; Fax: 760-431-0905; www.mercotac.com

Mercotac, Inc.

For More Information Circle No. 622

New on the MARKET

Purge Cabinet Coolers

Exair Corp., Cincinnati, OH, offers a series of non-hazardous purge cabinet coolers designed to keep dirt, smoke, and water out of electrical enclosures while purging them with clean, 20° F air. The coolers use a vortex tube to convert an ordinary supply of compressed air into cold air without the use of refrigerants or environmentally harmful CFCs. Under normal conditions, this system passes 1 SCFM of air through the cabinet cooler to maintain a slight, positive pressure inside the electrical enclosure. When the thermostat detects a high temperature, it energizes the solenoid to pass line pressure to the cabinet cooler, producing full cooling capacity. **Circle No. 700**

Mechanical Fastener

Frank Roth Co., Stratford, CT has introduced the UNI-KEY™ fastener, which can be applied to a wide variety of construction materials common to knockdown furniture, electrical connectors, architectural structures, and diverse industries. It allows less stringent keyway toleranancing and provides axial and torsional clamping force once it is grouped together with other UNI-KEYs. The fastener keys shaft-mounted objects, eliminates hubs and set screws, and is accessible axially from the ends. **Circle No. 701**

GPIB Controllers

National Instruments, Austin, TX, has released the GPIB-ENET/100 Ethernet-to-GPIB controller and the PCI-8212 combination GPIB and Ethernet interface for PCI. Both offer high-speed interfaces for connecting, sharing, or controlling GPIB instruments on Ethernet networks, and are designed for engineers who want to use Ethernet and GPIB in the same test and measurement system. The GPIB-ENET/100 high-speed interface controls GPIB instruments across Ethernet networks. Users can access remote test equipment from anywhere in the world via TCP/IP protocols on 10BaseT and 100BaseT networks. The PCI-8212 interface combines a GPIB controller and a standard Ethernet controller in a single PCI board. The GPIB controller chip is capable of transfer rates of up to 8 Mbytes/s. **Circle No. 702**

Temperature Calibrator

Fluke Corp., Everett, WA, has introduced the Fluke 724 temperature calibrator designed for process instrument technicians. The calibrator's measure and source functions can test and calibrate almost any temperature instrument. It can simultaneously view input and output data on a dual display. The calibrator powers transmitters during testing using loop power supply with simultaneous mA measurement. It also measures, sources/simulates RTDs, thermocouples, volts, and ohms to test and calibrate temperature sensors and transmitters. **Circle No. 703**

Handheld Computer

The CEL industrial-grade handheld computer from Two Technologies, Horsham, PA, runs the Microsoft® Windows CE® operating system. The CEL offers a sunlight-readable display with optional touchscreen technology, a variety of interface capabilities, and rugged construction for industrial commercial use. The computer features a 192 x 128 pixel LCD and an optional electroluminescent backlight. One serial port is standard, with a choice of RS-232/422/485 or CMOS/TTL protocols. Applications include field data acquisition, inventory management, warehouse control, and field inspection. **Circle No. 704**

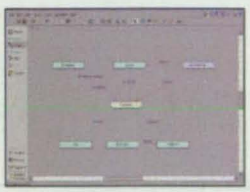
New on DISK

Engineering Spreadsheet

DSP Development Corp., Newton, MA, has announced DADiSP/2000 engineering spreadsheet software. Features and enhancements include an updated graphical user interface and an expanded library of over 1,000 mathematical, engineering, and scientific functions. The product features ActiveX support and real-time support, and offers a command debugger for its SPL programming language to reduce development time and improve the quality of SPL routines. New functions offer improvements in signal processing, data manipulations, statistics, and graphing. **Circle No. 711**

DSP System Design

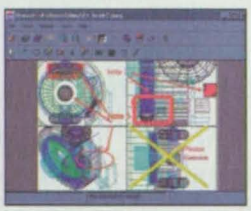
Version 4.5 of the SystemView system-level design tool for DPS and communications applications is available from Elanix, Westlake Village, CA. This release links SystemView with TI Code and Composer Studio for C5x/C6x software development and test, and a partnership with Xpedion Design Systems has linked the two companies' system and RF/Microwave design software. Version 4.5 features enhanced libraries that provide new models for communications applications. System designers can simulate communications systems without developing custom functions, and DSP and RF designers can simulate and test their subsystems within the context of the overall system design. **Circle No. 715**



Problem-Solving Software

Invention Machine Corp., Boston, MA, has released a new version of its TechOptimizer tool for research and design engineers. It is fueled by a technical knowledge base, known as the Effects Module, which contains more than 7,500 scientific and engineering effects and examples in all areas of engineering, physics, and chemistry. Features include more than 100 enhancements, enabling users to analyze, postulate, and solve engineering product and process problems. **Circle No. 716**

Web-Based Viewing



Brava! 2.2 Java-based drawing and document software for web-delivered viewing and collaborative commerce is available from Informative Graphics Corp., Phoenix, AZ. It allows users to publish drawings and images in native file formats for viewing, and to exchange ideas by overlaying markups without requiring the same hardware platform, native software application, or browser. Brava! 2.2 introduces the first of a series of related server-based products: Brava! Thumbnail Bean, Brava! Explorer, and a Brava! MPS Print Server. It also offers improved markup handling and file location management, including auto preload for viewing all markups when a drawing or image is accessed. **Circle No. 714**

Hybrid Modeling

CADKEY Corp., Marlborough, MA, has released CADKEY Parametrics, an optional modeling technique designed for users of feature-based modeling and/or constraint-based sketching tools. Available for Windows 95/98/NT/2000, the module allows users to convert existing or imported wireframe data into sketches and automatically constrain them. Full access is provided to values used in each solid model's creation and interactions between sets of features and parts. Sketching tools offer enhancements to 2D drawing and can be used to enhance 2D drafting as profiles for modeling. **Circle No. 778**

New LITERATURE

Tubing Pumps

The OEM Group of Barnant Co., Barrington, IL, offers a 16-page brochure describing applications for its Masterflex peristaltic tubing pump products in agriculture, medical, and manufacturing. The brochure describes representative samples of Masterflex tubing pumps, fixed and variable speed designs, with specifications and related industries. Single and multi-channel designs are available in a wide range of pumping capacities. **Circle No. 720**

Temperature Sensors

Minco Products, Minneapolis, MN, has released a six-page document on how to specify temperature sensors in hazardous areas. "Application Aid #19" explains the North American and European classification systems, and includes drawings to show the components of an explosion-proof temperature sensor and an intrinsically safe installation; tables to summarize various classifications, definitions, and to compare protection methods; and charts that show models suitable for various hazardous conditions. Included is a list of often-used acronyms for agencies, ratings, and standards. **Circle No. 721**

EMC Test Solutions

Schaffner EMC, Edison, NJ, offers a 152-page catalog featuring integrated EMC instrumentation systems and services, including EMC test solutions for industrial, commercial, telecom, and automotive industries. Individual sections address the growth of electronics in vehicle management and equipment, the assembly of a complete RF conducted and radiated test system, and the design of systems to verify individual test setups and facilities. **Circle No. 723**

Metals and Materials

A 24-page brochure from Goodfellow Corp., Berwyn, PA, provides an overview of the company's metals and materials, as well as a wide range of technical services. Also featured are pure metals, alloys, polymers, ceramics, compounds, intermetallics, and composites. **Circle No. 722**

Document-Management Software

Océ Engineering Systems, Chicago IL, offers an eight-page brochure on Océ Engineering Exec software for automating printing activities. Features include scalable modules and open architecture, a concept that combines precise print-management and document-distribution capabilities with optional advanced printroom features. The software controls, stores, and manages engineering documents, and can be used with most brands of wide-format copiers and printers. **Circle No. 725**

Power Transmission Products

A 12-page brochure featuring power transmission products is offered by KEBCO, St. Paul, MN. Included are open-loop frequency inverters, closed-loop vector and servo drives, a variety of geared motors, and a selection of brakes. **Circle No. 726**

Motion Control

Oriental Motor, Valencia, CA, offers a catalog describing Vexta® Alpha Step motion-control products, including motors, planetary gearheads, brakes, and drivers. The catalog explains gear types, discusses precautions, motor dimensions, driver functions, and input/output signals. **Circle No. 727**

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SGI Federal, an SGI Company	www.sgifederal.com	532	13
Small Parts, Inc.	www.smallparts.com	626	59
Smalley Steel Ring Co.	www.smalley.com	613	59
Sony Precision Technology America, Inc.	www.sonypt.com	591	3a
Sorensen	www.sorensen.com	590	1a
Specialty Coating Systems, Speedline Technologies	www.scscookson.com	454	11a
SPIE	www.spie.org/pe		13a
StereoGraphics Corporation	www.stereographics.com/democd/	412	47
StorCase Technology, A Kingston Technology Company	www.storcase.com	526, 617	9, 59
Stress Engineering Services	www.straindaq.com	425	61
Synrad, Inc.	**www.synrad.com**	**401**	**8**
TalTech	www.taltech.com	609	58
TestMart	**www.testmart.com**	**570**	**41**
TSI Incorporated, Flowmeter Division	http://flowmeters.tsi.com	403	14
Voltek	www.voltek.com	426	61

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This Month in

Rapid Product Development online

The web publication for *NASA Tech Briefs* readers

*NASA Tech Briefs' all-digital publication, Rapid Product Development Online (**www.rapidproducts.net**), helps engineers develop better products faster by providing immediate 24-hour access to the latest information on CAD, FEA, modeling, mold-making, reverse engineering, and rapid prototyping tools and techniques. This month's RPD Online includes:*

Online Engineering Resource Reduces Design Time for Airframe Surface Features

For many years, engineers at Cessna Aircraft Co. found it worth the half-hour drive to the company's central library facility to access the volumes of design methods and data published by Engineering Sciences Data Unit (ESDU) of London, UK. Now ESDU's full collection of engineering documents is available on the Internet, allowing engineers to access the data without leaving their workstations. This online resource — which includes more than 230 volumes of validated design and analysis data and methods — has helped Cessna's engineers reduce the time required to design many airframe surface features by up to 50 percent.
www.rapidproducts.net/AUG00/airframe.html

FDM Saves $2 Million in Automotive Tooling Costs

Aggressive use of rapid prototyping and rapid tooling saved Toyota more than $2 million in designing the 2000 Avalon. Fused deposition modeling (FDM) cut over $200,000 (US) in tooling costs by eliminating the prototype tooling for the right-hand side-mirror housing. The company saved another $300,000 in tooling cost for the four door-handle tools, which were created from FDM masters rather than by CNC machining. The savings Toyota achieved on the door handle and mirrors alone more than paid for the Stratasys FDM8000 machine used to produce the prototypes.

www.rapidproducts.net/AUG00/fdm.html

Intuitive Solid Modeler Speeds Rapid Prototyping of Rubber-Metal Suspension Mount

Vellum Solids — a CAD program from Ashlar, Austin, TX — has enabled product engineers in Cooper-Standard Automotive's NVH Control Systems Division to create concept drawings and a rapid prototype of a rubber-metal suspension mount in half the time that the legacy CAD systems would have required. The intuitive nature of the modeler allowed the project to be completed quickly by simplifying the creation of radii, tangent lines, and other complex geometric entities.
www.rapidproducts.net/AUG00/modeler.html

New Product Highlights

Featured products include the PC version of Mikron Quick Code from DP Technology Corp., Camarillo, CA, and the Mikron Technology Group. This G-code editor has dialog boxes that guide the machinist through the manual G & M coding programming process and an automatic speeds and feeds database and calculator. Moldflow Corporation, Lexington, MA, has introduced C-MOLD 2000.7™. This latest version of the software delivers Fusion and Underfill (flip-chip) capabilities for advanced C-MOLD products. In addition, C-MOLD 2000's user interface, design optimization, and polymer-melt analysis have been enhanced.
www.rapidproducts.net/AUG00/products800.htm

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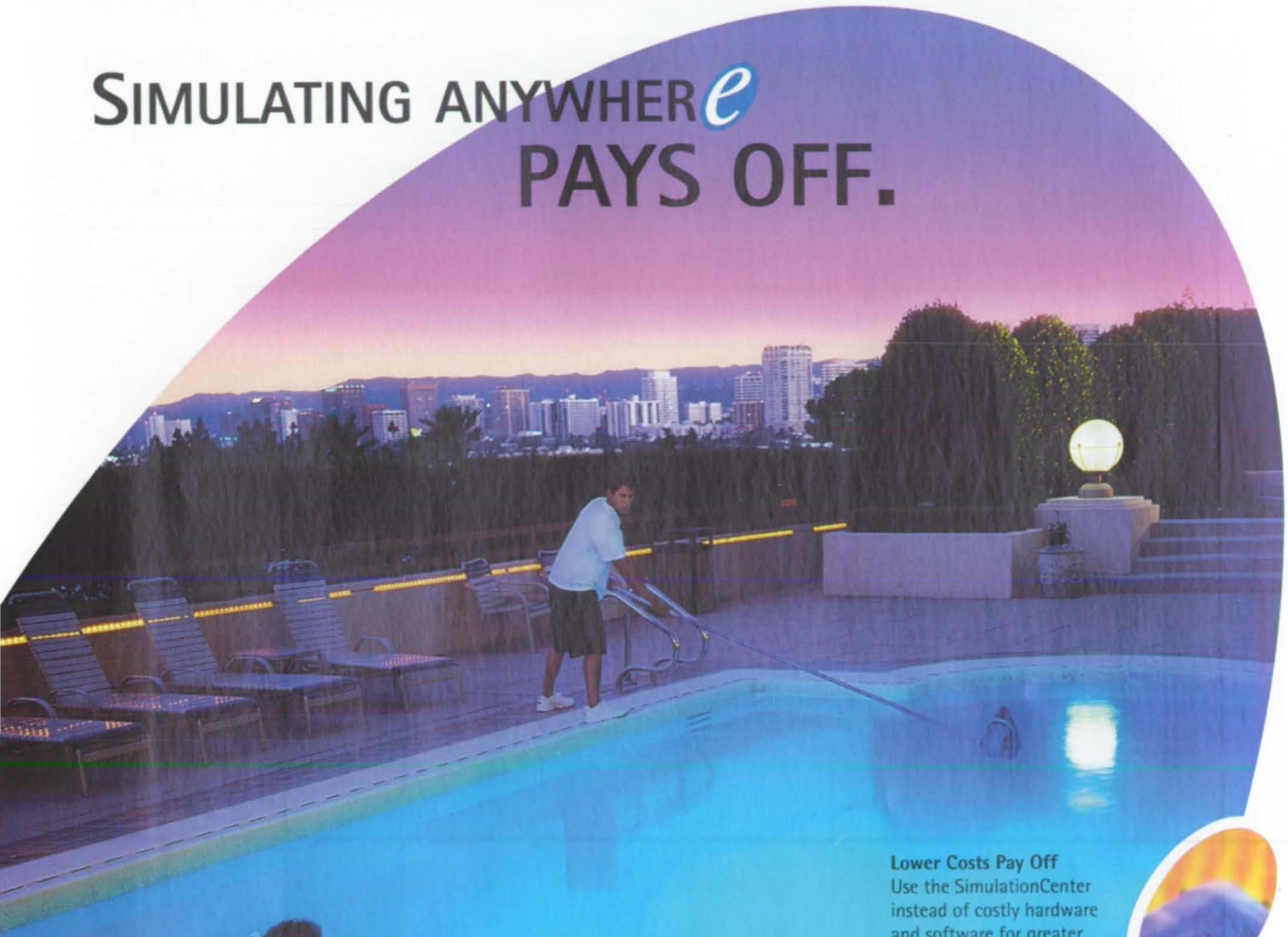

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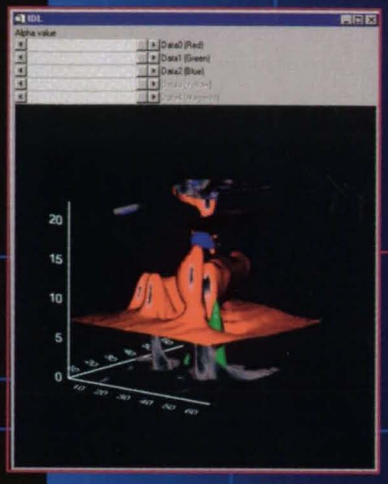
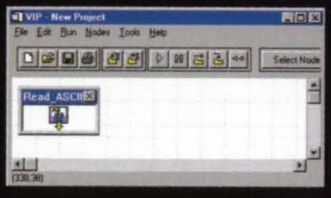
VIP™ – Go with the Flow

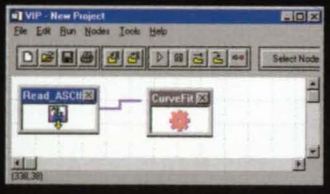
VIP,™ *the Visual IDL® Programming environment,* is a powerful, easy-to-use data flow modeling environment for data analysis and visualization. Create, modify and run sophisticated programs without writing a single line of code. VIP nodes are reusable program objects – share them with your colleagues.



It's as easy as 1,2,3!

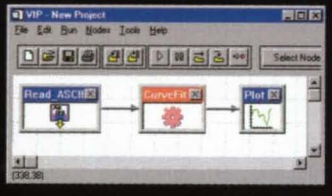
1 Select your nodes and drag them to the workspace

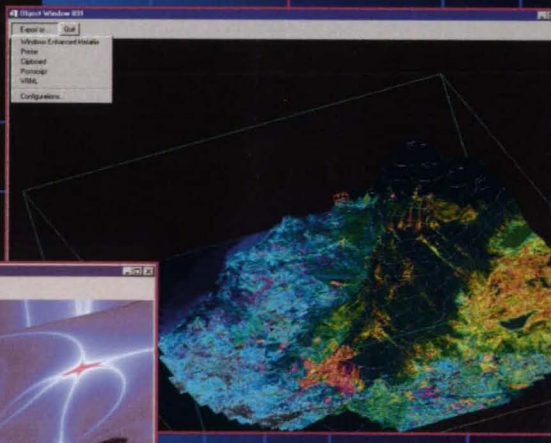




Connect them with the click of a mouse 2

3 Click "run" and watch your program spring to life!





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