April 1996

Vol. 20 No. 4

NASA Tech Briefs

The Design/Engineering Technology Digest

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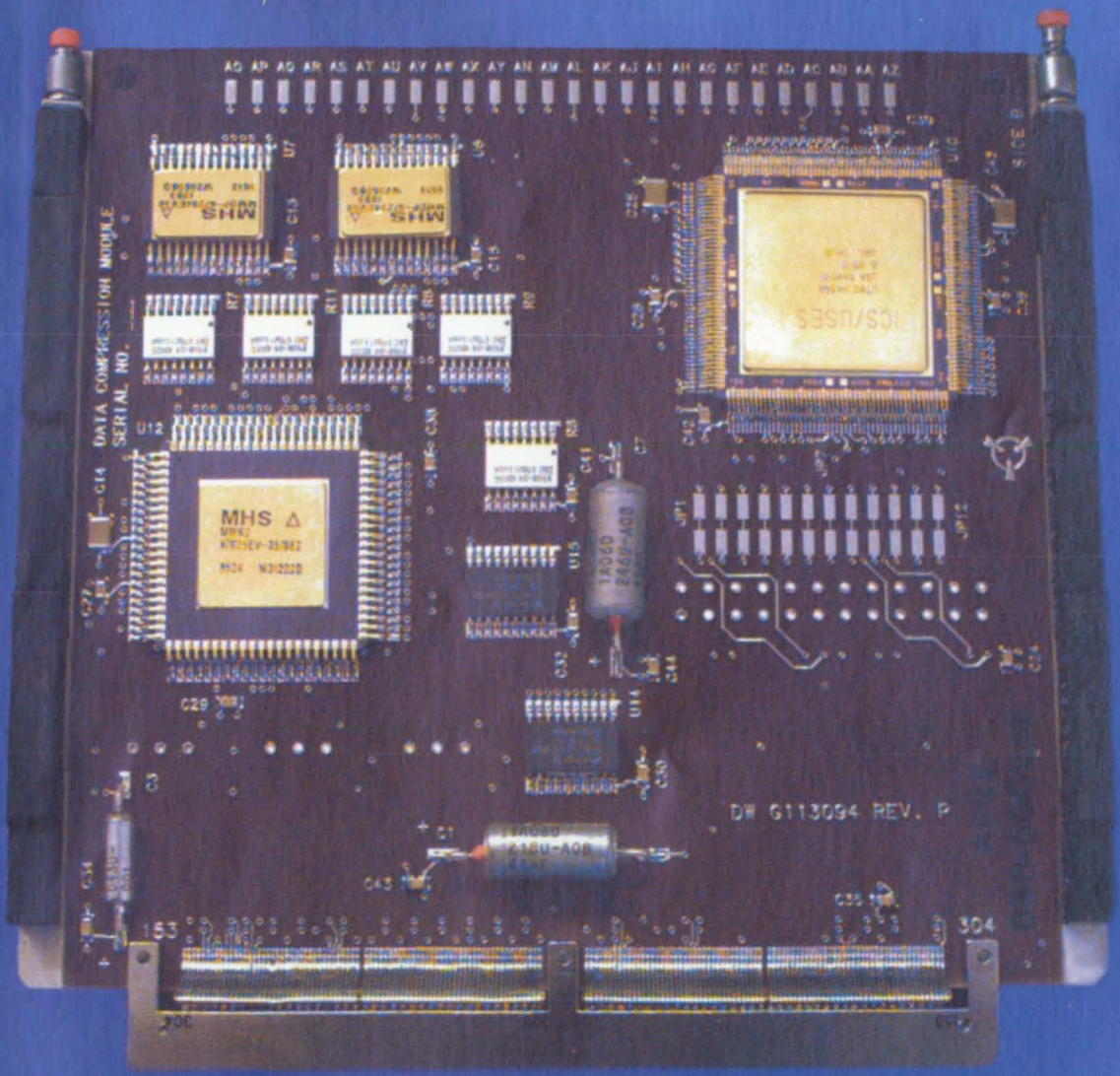

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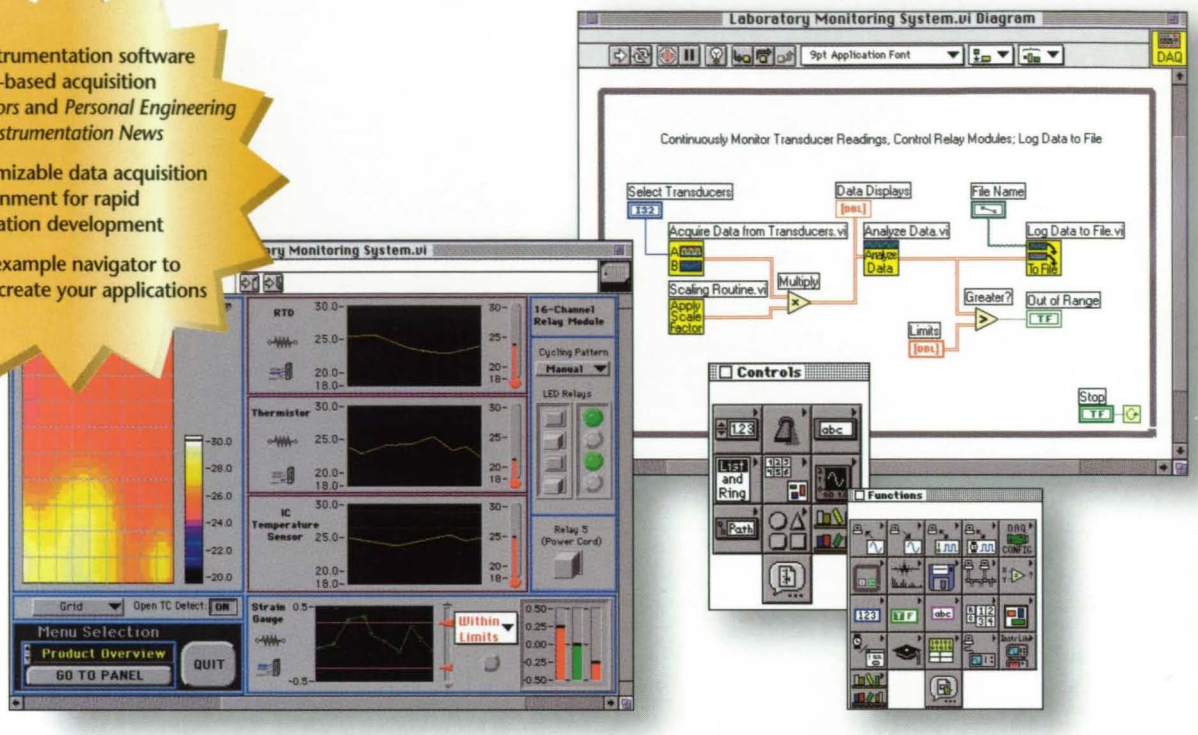

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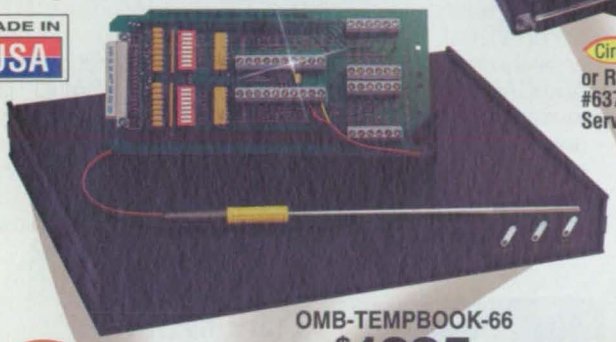

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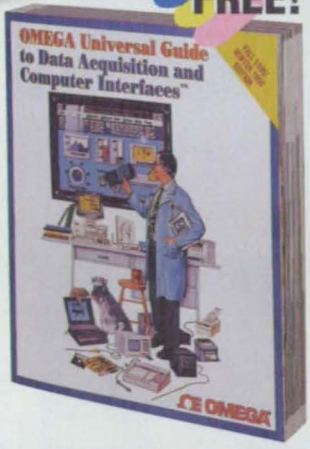

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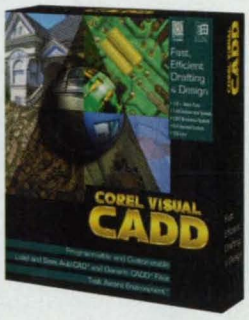

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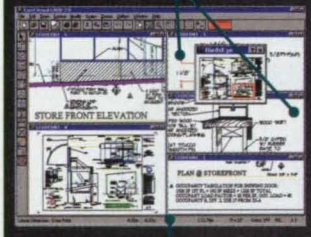
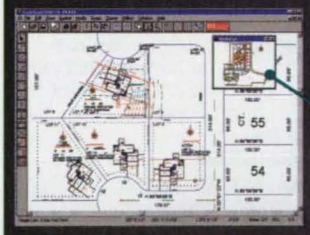


Multiple Dimension Types - Select from ordinate, datum, linear, angular and radial options. Plus, associative dimensions for automatic adjustment of dimension lines.



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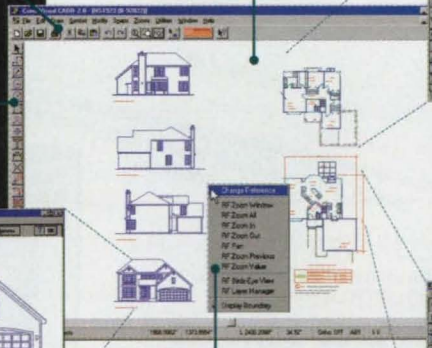

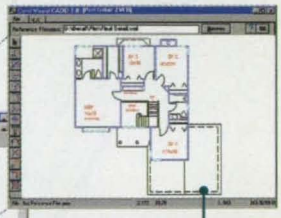

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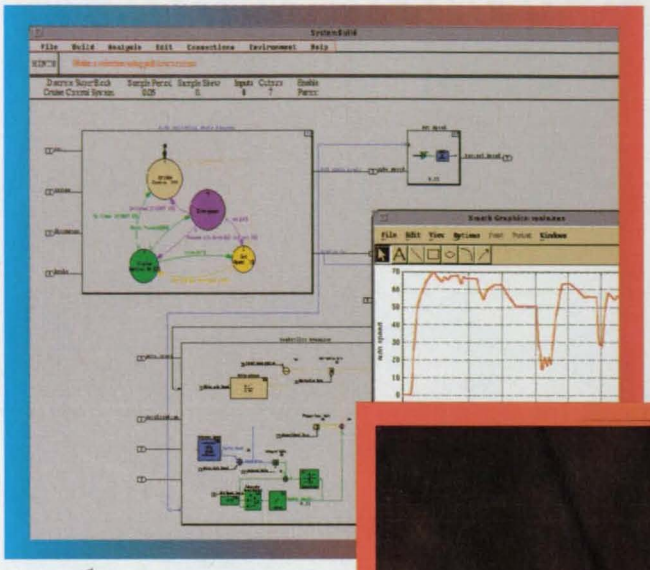

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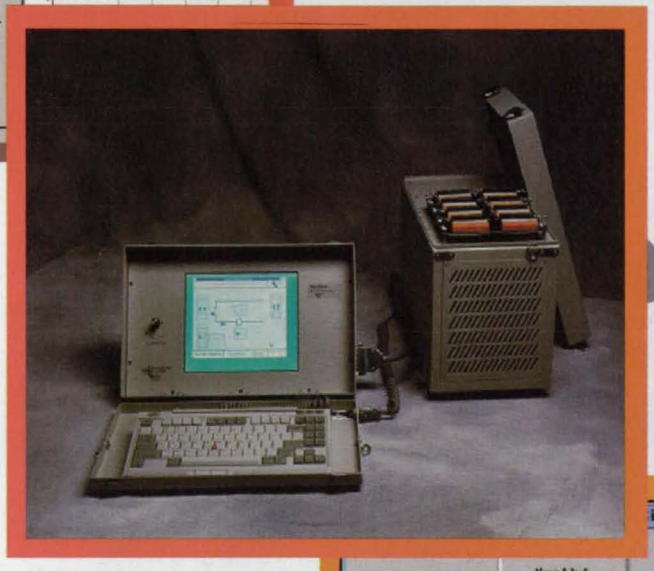

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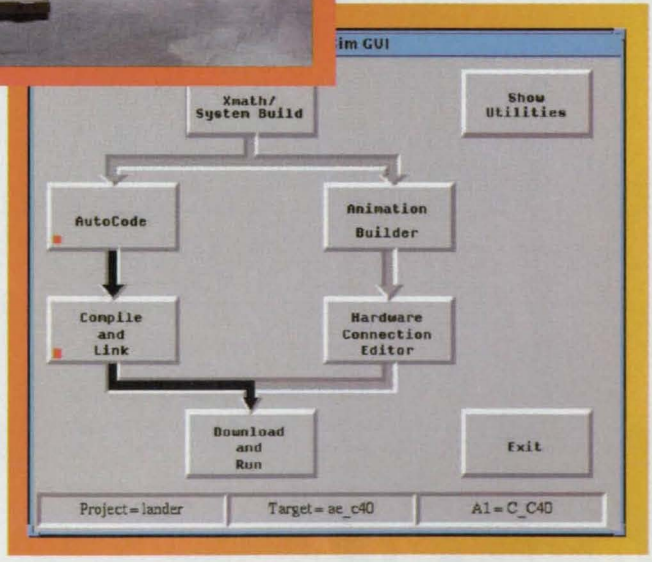

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TECHNICAL SECTION

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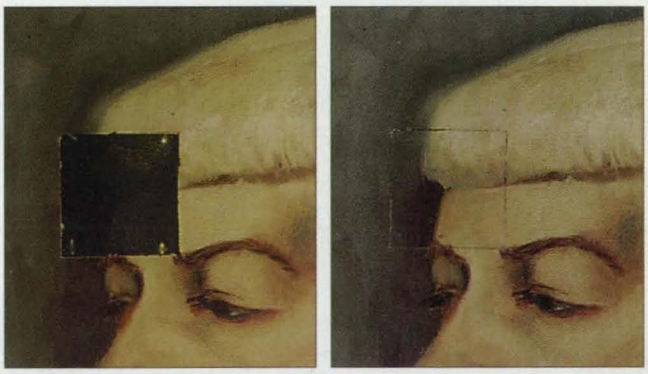

Soot deposited on paintings during a building fire can be very difficult to remove without damaging the underlying surface. A relatively nondestructive plasma process developed at Lewis Research Center generates monatomic oxygen, which removes organic coatings like soot or yellowed and cracked varnish without attacking the oxide-based pigments in the paint layers. Shown are a smoke-exposed section set back into a painting (left) and the same smoke-exposed section after exposure to atomic oxygen. The underlying paint layers remain undisturbed. For more information, see the Tech Brief on page 61.

Photo courtesy of Lewis Research Center

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On the cover:

The NASA Government Invention of the Year was awarded to Dr. Pen-Shu Yeh of Goddard Space Flight Center for her method of coding low entropy data, which provides enhanced data compression without loss of information during decompression. The "lossless" data compression method has wide-ranging applications for information storage and retrieval in virtually any industry. For more information on the winners and finalists, see page 20.

Photo courtesy of Goddard Space Flight Center

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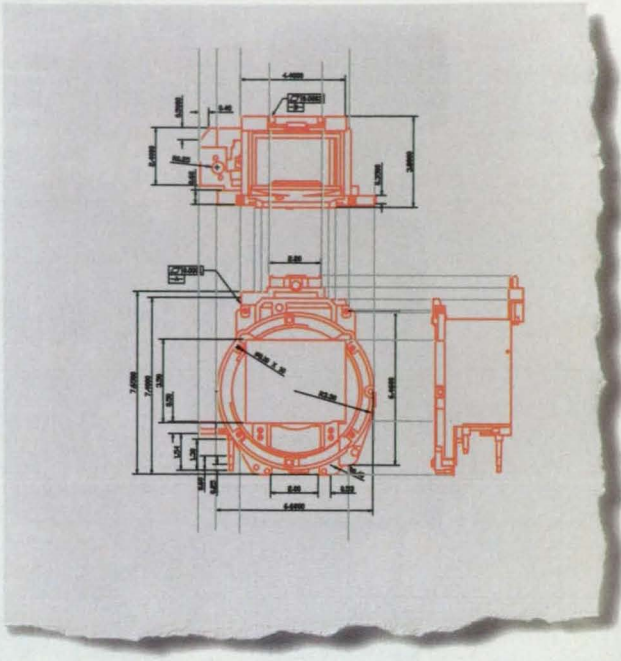

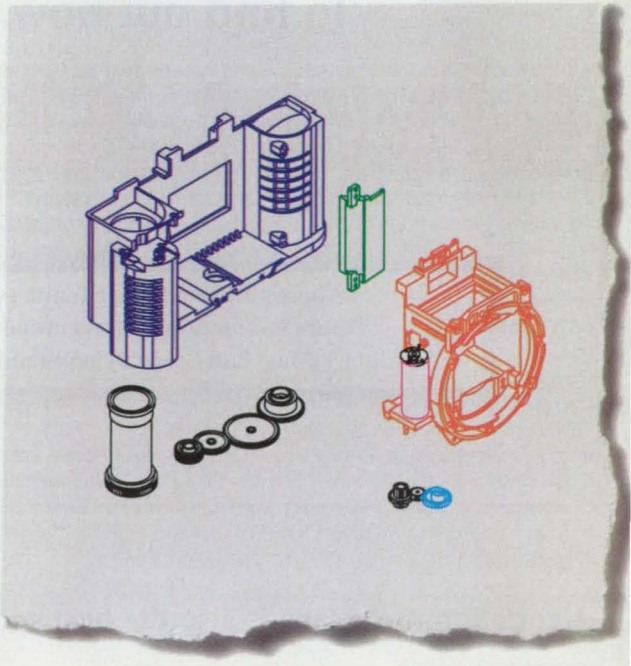

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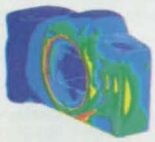

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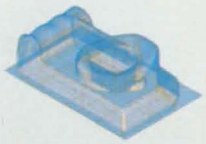

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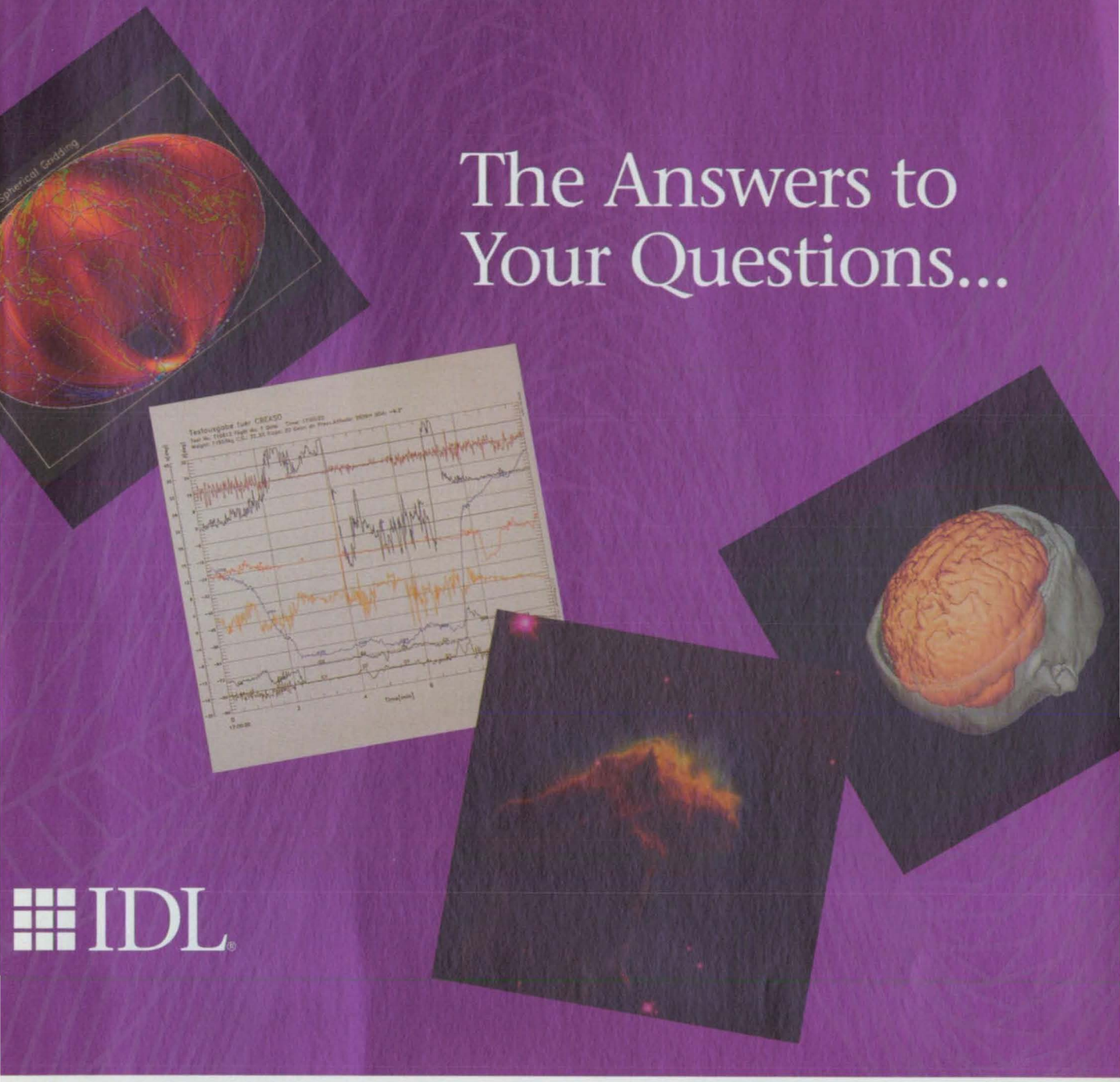

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SPAIN Estudio Atlas 34 45 298 080 • **TAIWAN** Concentrate Corporation 886 2 883 7752 • **UK** Floating Point Systems UK Ltd. 44 1734 776333

For More Information Write In No. 597

NASA Commercial Technology Team

NASA's R&D efforts produce a robust supply of promising technologies with applications in many industries. A key mechanism in identifying commercial applications for this technology is NASA's national network of commercial technology organizations. The network includes ten NASA field centers, six Regional Technology Transfer Centers (RTTCs), the National Technology Transfer Center (NTTC), business support organizations, and a full tie-in with the Federal Laboratory Consortium (FLC). We encourage all businesses with technical needs to contact the appropriate organizations for more information. For those who have access to the Internet, general information can be accessed with Mosaic software on the NASA Commercial Technology Home Page at URL: http://nctn.oact.hq.nasa.gov. Instructions regarding how to acquire the free Mosaic software can be obtained by sending an e-mail request to: innovation@oact.hq.nasa.gov.

NASA's Technology Sources

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

Ames Research Center
Selected technological strengths: Fluid Dynamics; Life Sciences; Earth and Atmospheric Sciences; Information, Communications, and Intelligent Systems; Human Factors.
Syed Shariq
(415) 604-0753
syed_shariq@qmgate.arc.nasa.gov

Dryden Flight Research Center
Selected technological strengths: Aerodynamics; Aeronautics Flight Testing; Aeropropulsion; Flight Systems; Thermal Testing; Integrated Systems Test and Validation.
Lee Duke
(805) 258-3119
duke@louie.dfrf.nasa.gov

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

Jet Propulsion Laboratory
Selected technological strengths: Near/Deep-Space Mission Engineering; Microspacecraft; Space Communications; Information Systems; Remote Sensing; Robotics.
Wayne Schober
(818) 354-2240
wayne.r.schober@jpl.nasa.gov

Johnson Space Center
Selected technological strengths: Artificial Intelligence and Human Computer Interface; Life Sciences; Human Space Flight Operations; Avionics; Sensors; Communications.
Hank Davis
(713) 483-0474
hdavis@gp101.jsc.-nasa.gov

Kennedy Space Center
Selected technological strengths: Emissions and Contamination Monitoring; Sensors; Corrosion Protection; Bio-Sciences.
Bill Sheehan
(407) 867-2544
billsheehan@ksc.nasa.gov

Langley Research Center
Selected technological strengths: Aerodynamics; Flight Systems; Materials; Structures; Sensors; Measurements; Information Sciences.
Dr. Joseph S. Heyman
(804) 864-6005
j.s.heyman@larc.nasa.gov

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

Marshall Space Flight Center
Selected technological strengths: Materials; Manufacturing; Nondestructive Evaluation; Biotechnology; Space Propulsion; Controls and Dynamics; Structures; Microgravity Processing.
Harry Craft
(800) USA-NASA
susan.van.ark@msfc.nasa.gov

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

NASA-Sponsored Commercial Technology Organizations

These organizations were established to provide rapid access to NASA and other federal R&D and foster collaboration between public and private sector organizations. They also can direct you to the appropriate point of contact within the Federal Laboratory Consortium.

Lee Rivers
National Technology Transfer Center
(800) 678-6882

Robert Stark
Far-West Technology Transfer Center
University of Southern California
(800) 642-2872 or
(213) 743-2353

Dr. William Gasko
Center for Technology Commercialization
(800) 472-6785 or
(508) 870-0042

J. Ronald Thornton
Southern Technology Applications Center
University of Florida
(800) 472-6785 or
(904) 462-3913

Gary Sera
Mid-Continent Technology Transfer Center
Texas A&M University
(800) 472-6785 or
(409) 845-8762

Lani S. Hummel
Mid-Atlantic Technology Applications Center
University of Pittsburgh
(800) 472-6785 or
(412) 648-7000

Chris Coburn
Great Lakes Industrial Technology Center
Battelle Memorial Institute
(800) 472-6785 or
(216) 734-0094

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

NASA Program Offices

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

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

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

Philip Hodge
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phodge@osfms1.hq.nasa.gov

Gerald Johnson
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Bill Smith
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wsmith@sm.ms.ossa.hq.nasa.gov

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Office of Mission to Planet Earth (Code Y)
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gpaules@mtpe.hq.nasa.gov

NASA's Business Facilitators

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

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

Jill Fabricant
Johnson Technology Commercialization Center
Houston, TX
(713) 335-1200

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

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

If you are interested in information, applications, and services relating to satellite and aerial data for Earth resources, contact: Dr. Stan Morain, **Earth Analysis Center,** (505) 277-3622. For software developed with NASA funding, contact **NASA's Computer Software Management and Information Center (COSMIC)** at phone: (706) 542-3265; Fax: (706) 542-4807; E-mail: http://www.cosmic.uga.edu or service@cosmic.uga.edu. If you have questions...**NASA's Center for AeroSpace Information** can answer questions about NASA's Commercial Technology Network and its services and documents. Use the Feedback Card in this issue or call (410) 859-5300, ext. 245.

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For More Information Write In No. 552

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:

Ultrahigh-Purity Dimensionally Stable INVAR 36

(U.S. Patent No. 5,476,633)

Inventors: Witold M. Sokolowski, Marc S. Lane, Cheng H. Hsieh, and Timothy P. O'Donnell, Jet Propulsion Laboratory

Ultrahigh-purity INVAR 36 is produced by powder metallurgy from very pure starting materials without introducing impurities in processing, ensuring a material with low thermal expansion and good temporal stability. When compared to conventional Invar 36, the new material exhibits better fatigue properties. INVAR 36 meets the strict requirements for dimensional stability, machinability, and mechanical strength needed for support structures in instruments having optical components focused on distant objects. On space flights, for example, INVAR 36 can be used for metering rods in camera athermalizing systems. It also has more practical applications since it is easy to fabricate and has low coefficients of thermal expansion over a range of temperatures.

For More Information Write In No. 732

Control System for Prosthetic Devices

(U.S. Patent No. 5,480,454)

Inventor: Richard J. Bozeman, Jr., Johnson Space Center

Typically, a prosthesis provides relief to those disabled by the absence or defect of a body part. The control of a drive mechanism in association with a prosthesis calls for highly complicated processing. Unfortunately, prior control devices have been disproportionally large in size for the number of modes of motion the artificial limb is expected to produce. The new control system for prosthetic devices comprises a transducer for receiving movement from a body part and generating a sensing signal associated with that movement. The invention facilitates easy adaptation by children or adults and the electronic control package is small in comparison to prior devices. The control device is mounted easily in the prosthesis and does not require the user to wear additional containers or carriers.

For More Information Write In No. 733

Cascaded VLSI Neural Network Architecture for On-Line Learning

(U.S. Patent No. 5,479,579)

Inventors: Tuan A. Duong, Taher Daud, and Anilkumar P. Thakoor, Jet Propulsion Laboratory

High-speed, analog, fully parallel and asynchronous building blocks are cascaded for larger sizes and enhanced resolution. A hardware-compatible algorithm permits hardware-in-the-loop learning despite limited weight resolution. A computation-intensive feature classification application has been demonstrated with this flexible hardware and new algorithm at high speed. The building-block approach to the construction of fully parallel neural networks allows implementation of networks of various sizes and architectures using only a small set of custom VLSI chip designs. These building block chips can be embedded as application-specific coprocessors for solving real-world problems at extremely high data rates.

For More Information Write In No. 734

Augmented Thermal Bus

(U.S. Patent No. 5,483,800)

Inventor: Dean S. Schrage, Lewis Research Center

The invention involves a thermal bus for dissipating heat by using a number of individually controlled thermo-electric heat pumps, each of which controls a region on a source. All pumps are controlled by a model-based controller. This new bus is an augmentation of a conventional single-phase thermal bus with an interstitial thermo-electric heat pump, which is a solid-state direct energy conversion device. Since the pump has no moving parts, it is structurally and thermally robust, making it suitable for temperature cooling in a hostile environment. The augmented thermal bus also provides a high level of isothermality in a heat source or baseplate, and upgrades the waste heat produced by the system, reducing the surface area required for a radiator.

For More Information Write In No. 735

Remote Monitor Alarm System

(U.S. Patent No. 5,485,142)

Inventors: Robert A. Stute, F. Houston Galloway, Pedro J. Medelius, Robert W. Swindle, and Tracy A. Bierman, Kennedy Space Center

Large communication systems often employ remote terminal equipment whose operational condition must be monitored at a central location. It is imperative, therefore, that operational problems with the remote equipment be located and communicated quickly. The invention is a remote monitor alarm system in which power supply and alarm conditions of communication terminal equipment installed at remote sites are monitored and detected by a number of remote terminal units, which communicate the conditions to a central monitoring unit. The central monitoring unit, which consists of a video display, hard disk memory, line printer, and audio alarm, is located where technical personnel can observe the alarm and other conditions received by the remote terminal units, allowing quick action when operational problems occur.

For More Information Write In No. 736

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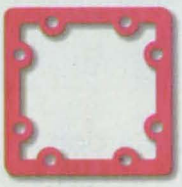

Gasket Manufacturing

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Engraving Wood

Marking Microprocessors

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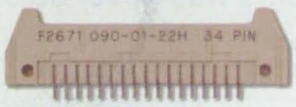

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For More Information Write In No. 520

New Product Ideas

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

Ultrastable Multigigahertz Photonic Oscillator

An ultrastable oscillator is being developed as a source of microwave and millimeter-wave signals. The oscillators would be generated photonically, then converted to electronic form. (See page 34.)

Photonic Diagnostic Technique for Thin Photoactive Films

This method involves simultaneous measurements of both electrical and optical photoresponse of a film under test sandwiched between two electrodes as in a capacitor. This technique could play a vital role in facilitating the manufacturing of high-density ferroelectric memories. (See page 49.)

Celsian Glass-Ceramic Matrix Composites

These composites feature strength, toughness, low relative permitivity, and low absorption of electromagnetic waves over a wide temperature range. The material is to be used in low dielectric applications, such as radomes. (See page 24.)

Wideband, High-Input-Impedance Buffer Amplifier

An improved amplifier offers a high input impedance to a signal source. Its input impedance remains high, relatively constant, and essentially resistive over a wide range of frequencies. This characteristic is essential for minimizing signal distortion in certain applications. (See page 38.)

Pyrolytic Carbon as a Lubricant in Hot Ceramic Bearings

Pyrolytic carbon may prove useful as a solid lubricant in ceramic bearings in advanced gas-turbine engines, where high temperatures would destroy liquid lubricants. Ethylene gas would be made to flow past the bearings and would be pyrolized to replenish the carbon lubricant particles. (See page 60.)

NASA Landing Systems Research Aircraft

A Convair 990 airplane has been modified to incorporate a tire-and-landing-gear test facility. The system can dynamically simulate vertical-load profiles, sideslip angles, and wheel braking on real runways. (See page 67.)

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SCOPE HINT 1

An Easy Way to Isolate the Cause of Noise Problems.

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

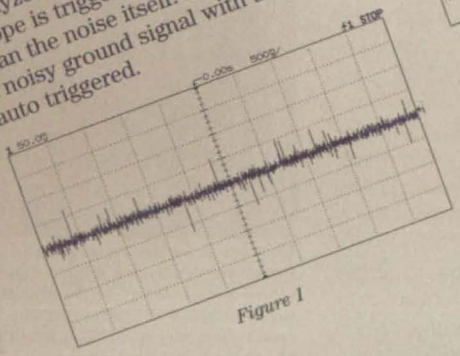


Figure 1

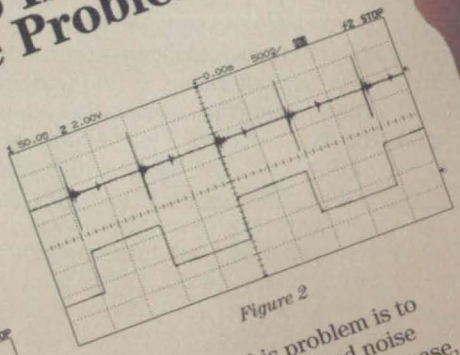
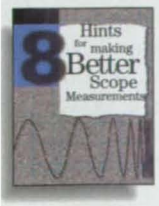


Figure 2

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

Making scope measurements isn't always easy. That's why we're sharing some of our favorite hints for making better measurements — no matter what kind of scope you're using.

What else you'll find inside our free booklet:



- Hint 2: Poor Man's TDR.
- Hint 3: Probing Sanity Check.
- Hint 4: Troubleshooting Infrequent Events.
- Hint 5: How to Prevent Your Scope from Aliasing.
- Hint 6: Analyze Harmonic Distortion Using FFT.
- Hint 7: Use Holdoff to Stabilize Complex Digital Waveforms.
- Hint 8: Capture Fast, Low-Duty-Cycle Pulses Using Peak Detect.

You've seen a sample, now send for all eight scope hints by mailing in the attached reply card. Or call **1-800-452-4844, Ext. 1148.** It may be the best free advice you'll ever get.

There is a better way.

For More Information Write In No. 533

NASA Invention of the Year

The NASA Invention of the Year competition consists of a Government Invention of the Year and a Commercial Invention of the Year. For 1995, a commercial winner was not selected. Instead, an invention was chosen as NASA's nominee for the Intellectual Property Owners 1995 National Inventor of the Year Award.

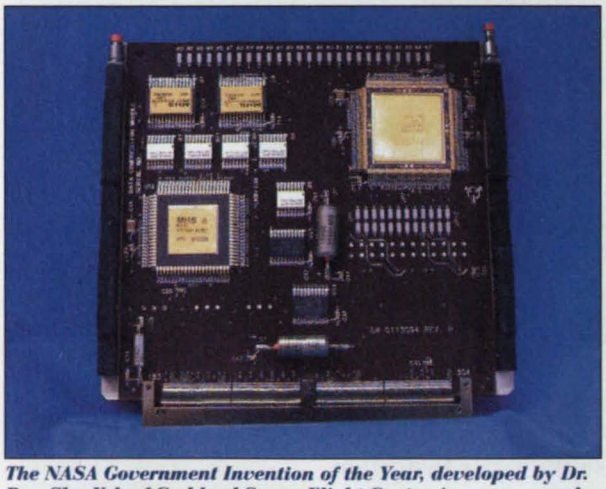
The NASA 1995 Government Invention of the Year was awarded to Dr. Pen-Shu Yeh of Goddard Space Flight Center for her Method of Coding Low Entropy Data. The Engines-Only Flight Control System invented by Frank W. Burcham, Joseph L. Conley, Charles G. Fullerton, Glenn B. Gilyard, and James F. Stewart of Dryden Flight Research Center was chosen as NASA's nominee to the National Inventor of the Year competition.

NASA's Government Invention of the Year

Method for Coding Low Entropy Data

Dr. Pen-Shu Yeh

Goddard Space Flight Center



The NASA Government Invention of the Year, developed by Dr. Pen-Shu Yeh of Goddard Space Flight Center, is a source coder that provides enhanced data compression without any loss of information during decompression.

Information sources such as imaging and voice data are often digitized, processed, modulated for transmission, and stored on mass media. Data compression allows more information to be stored in a finite space or transmitted in real time. However, when data is decompressed, valuable information may be lost. Dr. Yeh developed a computer program that provides enhanced data compression without any loss of information during decompression. This method for efficient coding and decoding of signal sources having a low information rate results in "lossless" data compression.

Lossless source coding preserves data accuracy while removing redundancy in the data source. After the decoding process, the original data can be reconstructed from the compressed data by restoring the removed redundancy. The coding method uses an algorithm which can be implemented in simple logic and does not require an intermediate buffer or Huffman code books. It also works with data of intermittent zero-valued symbols. The reconstructed data will be the exact duplicate of the original information source, which is essential when data integrity cannot be compromised.

The lossless source coder consists of two separate functional parts: a preprocessor and the adaptive entropy coder, which calculates uniquely decipherable, variable-length codewords corresponding to each block of samples input from the preprocessor.

The patented program is used extensively throughout NASA and government, and was first used and flown on the Mars Observer. When used on space missions such as the Hubble Space Telescope and the Submillimeter Wave Astronomy Satellite, the program will allow two to three times more data to be stored on and transmitted from the spacecraft.

The College of Radiology, Phillips Medical, Kodak Medical, and Picker International—all members of the National Electrical Manufacturers Association (NEMA)—are evaluating the program for use in disk storage for digital medicine, such as digital radiography, ultrasound, and magnetic resonance imaging (MRI) and CT (CAT) scans. NEMA also has recommended the invention be made a worldwide standard for data compression.

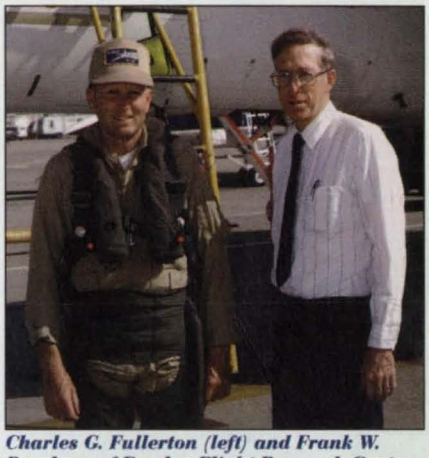
The Department of Defense, Sandia National Laboratories, and the US Air Force have purchased chips that incorporate the invention. Other applications include sensor data, computer images, seismic data, implantable medical devices, and pacemaker data storage and transmission.

NASA's National Inventor of the Year Nominee

Engines-Only Flight Control System

Frank W. Burcham, Joseph L. Conley, Charles G. Fullerton, Glenn B. Gilyard, and James F. Stewart

Dryden Flight Research Center



Charles G. Fullerton (left) and Frank W. Burcham of Dryden Flight Research Center stand beside the F-15 jet that was landed in April 1993 using the propulsion-controlled aircraft (PCA) engines-only flight control system they invented.

Flight control systems in today's military and commercial aircraft are highly reliable, thanks to multiple control surfaces, hydraulics, sensors, control computers, and control cables. However, occasional flight control failures do occur, at which times another form of flight control is necessary. While conventional backup control systems are installed on many airplanes, they are vulnerable to damage that renders the flight control system useless, resulting in loss of the aircraft, and loss of life.

The flightpath of some multiple-engine aircraft can be controlled somewhat by manual adjustment of the throttle controls. For example, aircraft have flown by manually adjusting the throttle controls after complete hydraulic failure. However, this does not provide sufficient control to land the aircraft, since the change in response to manual throttle control adjustment is too slow.

One type of conventional backup con-

trol system uses auxiliary engines to control the flightpath of an airplane. The auxiliary engines are arranged to supply thrust in various directions in order to correct emergency conditions while in flight. These auxiliary engines are provided in addition to the main engines. The system is expensive and involves modification of the aircraft.

Following the crashes of several commercial aircraft due to hydraulic failure—most notably the crash of a United Airlines DC-10 in Sioux City, IA, in 1989—the Dryden team began developing a backup system for controlling the flightpath of multiple-engine airplanes using the main engines. The system uses a standard autopilot control already present in the cockpit, with new programming in the aircraft's flight control computer.

The system incorporates an input device—comprising a control stick, thumbwheel, or instrument landing system receiver—for generating a control command indicative of a desired flightpath; a feedback sensor; and a control device for changing the output power of at least one of the main drive engines on each side of the airplane in response to the control command and the feedback signal. For example, for pitch control, the program increases thrust to climb; thrust is decreased to descend. The autopilot increases the left engine thrust while decreasing right engine thrust in order to turn right.

On August 29, 1995, one of the inventors, Gordon Fullerton, landed a McDonnell-Douglas MD-11 transport aircraft at Dryden using only engine power for control. Using a similar system, he previously had landed a NASA F-15 research aircraft in April, 1993.

The patented system could save thousands of lives by enabling a pilot to not only perform a survivable crash-landing, but to actually perform a normal landing without the use of standard flight controls.

Finalists

Phenylethynyl Terminated Imide Oligomers

Paul M. Hergenrother, Robert G. Bryant, Brian J. Jensen, and Steven J. Havens
Langley Research Center

Four phenylethynyl terminated imide oligomers were developed for NASA's High Speed Research Program specifically for potential use as structural resins on high-speed civil transports (HSCTs). To build an economically viable HSCT, approximately 50% of the structural weight must be composites. The high-performance organic polymeric materials invented by the Langley team have a unique combination of properties.

The cured polymers display excellent property retention over a wide range of temperatures. The low-molecular-weight imide oligomers have melt viscosities that allow excellent compression moldability and the phenylethynyl groups cure at elevated temperatures without volatile evolution. Adhesive panels, composites, films, and moldings made from the polymers exhibited excellent mechanical performance and high chemical and thermal stability.

Imitec, a Schenectady, NY-based company, licensed the rights to manufacture the phenylethynyl terminated imide oligomers and moldings, and produced hundreds of pounds of the resin during 1995. Licensing is pending to manufacture the polymers, as well as prepregs, composites, and moldings made from them. The US Navy, Xerox, IBM, and General Electric have expressed interest in evaluating the materials for use in the microelectronic/electronic area.

Rotating Unbalanced-Mass Device

Dr. Michael E. Polites and Dean C. Alhorn
Marshall Space Flight Center

Marshall researchers Dr. Michael E. Polites (right) and Dean C. Alhorn perform a full-scale laboratory experiment for testing rotating unbalanced-mass (RUM) devices for scanning gimbaled payloads and free-flying spacecraft.

In space exploration, x-ray and gamma-ray instruments and telescopes often require line-of-sight scanning that cannot be accomplished optically or electronically. This is also true of some sensors, telescopes, and electronic devices on the space shuttle, the space station, and on free-flying spacecraft. The most common method for achieving various scan patterns is to gimbal the scanning device, suspending the gimbals so that they can be activated to generate a scan pattern.

The Marshall duo invented a new approach to scanning space-based and balloon-borne gimbaled payloads, free-flying spacecraft, and ground-based gimbaled payloads. The basic system uses a pair of rotating unbalanced-mass (RUM) devices, mounted on the payload or spacecraft, to generate the basic scan motion, and an auxiliary control system (ACS) which keeps the scan centered on the target and produces a complementary motion for raster scanning. Simply, a RUM device is a mass on a lever arm that rotates at a constant angular velocity. The masses rotate about parallel axes in parallel planes, but 180° out of phase with each other. This causes the instrument to scan back and forth in a pattern which may be a straight line, a circle, or a raster, depending on the number and positioning of the RUMs.

RUMs have potential applications in defense, industry, and medicine including dithering gun barrels in military fire control systems; spraying water for fighting forest fires; spraying liquid fertilizers in open fields; and scanning medical devices with considerably less power.

Rotorcraft Blade-Vortex Interaction Controller

Fredric H. Schmitz
Ames Research Center

Noise is one of the prime inhibitors of extensive commercialization of rotorcraft. For a helicopter in flight, blade-vortex-interaction (BVI) noise—also referred to as "blade slap"—originates in the short-duration, high-amplitude aerodynamic forces that occur when rotor-blade tip vortices pass in close proximity to the same or different rotor blades at later times near the rear and sides of the rotor disk. Reducing BVI noise can be achieved by maximizing the flow through the plane of the rotor so that each following blade encounters as little as possible of the airflow disturbance generated by the preceding blade(s).

Mr. Schmitz's invention introduces an auxiliary force in the fore-aft direction to reorient the rotorcraft's rotor tip-path-plane angle. The changing angle increases the inflow through the rotor disk, lessening the likelihood of BVI noise. A rotorcraft would be equipped with two airfoils that would extend out sideways from the fuselage and rotated about their common horizontal axis. During forward, level flight, the airfoils would be oriented in a

horizontal plane, acting as small wings augmenting lift. The airfoils would be turned into a vertical plane to generate drag, making it necessary to tilt the main lifting rotor more to oppose the drag.

The device can be applied to most rotorcraft, including helicopters.

Ion Exchange Polymers and Method for Making

Warren H. Philipp and Kenneth W. Street, Jr.
Lewis Research Center

Dumping production waste products containing toxic metal ions—such as lead, mercury, and copper—into streams, rivers, lakes, or sewers unfortunately used to be a common practice. The Lewis team has developed an alternative means for removing heavy metal ions from water or aqueous solutions that is based on the fact that ion exchange materials positioned in polluted water attract heavy metal ions.

The invention incorporates an ion exchange polymer comprised of an alkali metal or alkaline earth metal salt of a poly(carboxylic acid) in a poly(vinyl alcohol) matrix. The mixture may be cast as a film or extruded as a fiber or granules. The material is then subjected to an alkaline aqueous solution of an alkali metal salt or alkaline earth metal salt. The ion exchange materials can be cleansed of the heavy metal ions by various methods such as acid treatment and then reused.

Previously, contaminated water was pumped into a holding tank and precipitating agents and flocculating chemicals were added. The resultant sludge was removed by settling or filtering, and buried in a landfill. The polymers developed by Lewis researchers may allow the removal of the heavy metal ions without transferring water between sites.

Lewis has received six proposals for licensing. The proposed uses include purification of maple syrup and other aqueous foods, kits for testing safety of drinking water, cleaning of drinking water, and pollution prevention.

Constant Current Loop Impedance Measuring System That Is Immune To The Effects of Parasitic Impedances

Karl F. Anderson
Dryden Flight Research Center

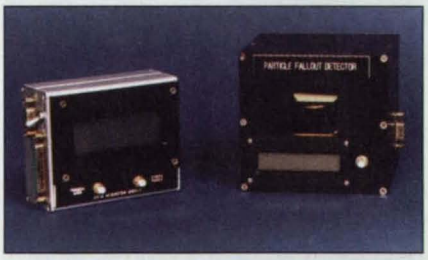
Measurements taken during scientific experiments must be as accurate as possible. When measuring a characteristic of an environment, it is common to dispose in the environment a resistor whose resistance varies in proportion with the characteristic being measured. This type of resistor is commonly used as part of a Wheatstone bridge system—a two-branched voltage diverter network usually consisting of three fixed resistors and a variable resistor. The problem with using a Wheatstone bridge is the existence of parasitic resistances, which are due to the connecting wires or additional components which couple the resistors together.

The inventor has designed a system for accurately measuring the characteristic of an environment so that the measurements are unaffected by parasitic voltages caused by parasitic resistances in the system. The invention provides a constant current loop measuring system that provides linear output, high sensitivity more than twice that of a Wheatstone bridge, and a bandwidth that extends to DC.

The current loop circuit technique enables fewer and smaller lead wires to serve multi-gauge sensors such as strain gauge rosettes. Applications for the system include highway structures, nuclear reactors, medical measurements, and product quality.

Particle Fallout/Activity Sensor

Curtis M. Ihlefeld, Robert C. Youngquist, John S. Moerk, and Kenneth A. Rose III
Kennedy Space Center



This battery-operated monitor developed by Kennedy Space Center researchers uses commercial off-the-shelf components to provide real-time, continuous monitoring of particle fallout in sensitive environments.

Detecting and measuring particle fallout—such as dust and fibers onto sensitive payload components—is part of the payload processing procedure at Kennedy Space Center. The previous method of indicating the amount and type of particle contamination was performed with witness plates placed at selected locations around the payload components and left for a period of time to collect particle fallout. However, this approach allows potentially destructive contamination to accumulate over an extended time period. The inventors developed a method of providing real-time, continuous monitoring of particle fallout in cleanroom and processing facilities.

The battery-operated system was designed using commercially available components and consists of two parts: a sensor module and a data acquisition module. The sensor module is made of black delrin with an opening in the top through which dust can fall and settle onto a test mirror. An infrared LED with a limiting aperture illuminates a portion of the mirror. The light is reflected when no dust or scratches are present. Light is scattered when it encounters particles or scratches.

The patented invention was used during certification of Kennedy's Space Station Processing Facility last year, and has been made available for licensing. Commercial potential for the system exists in the aerospace, pharmaceutical, semiconductor manufacturing, and other industries requiring very low particulate fallout conditions.

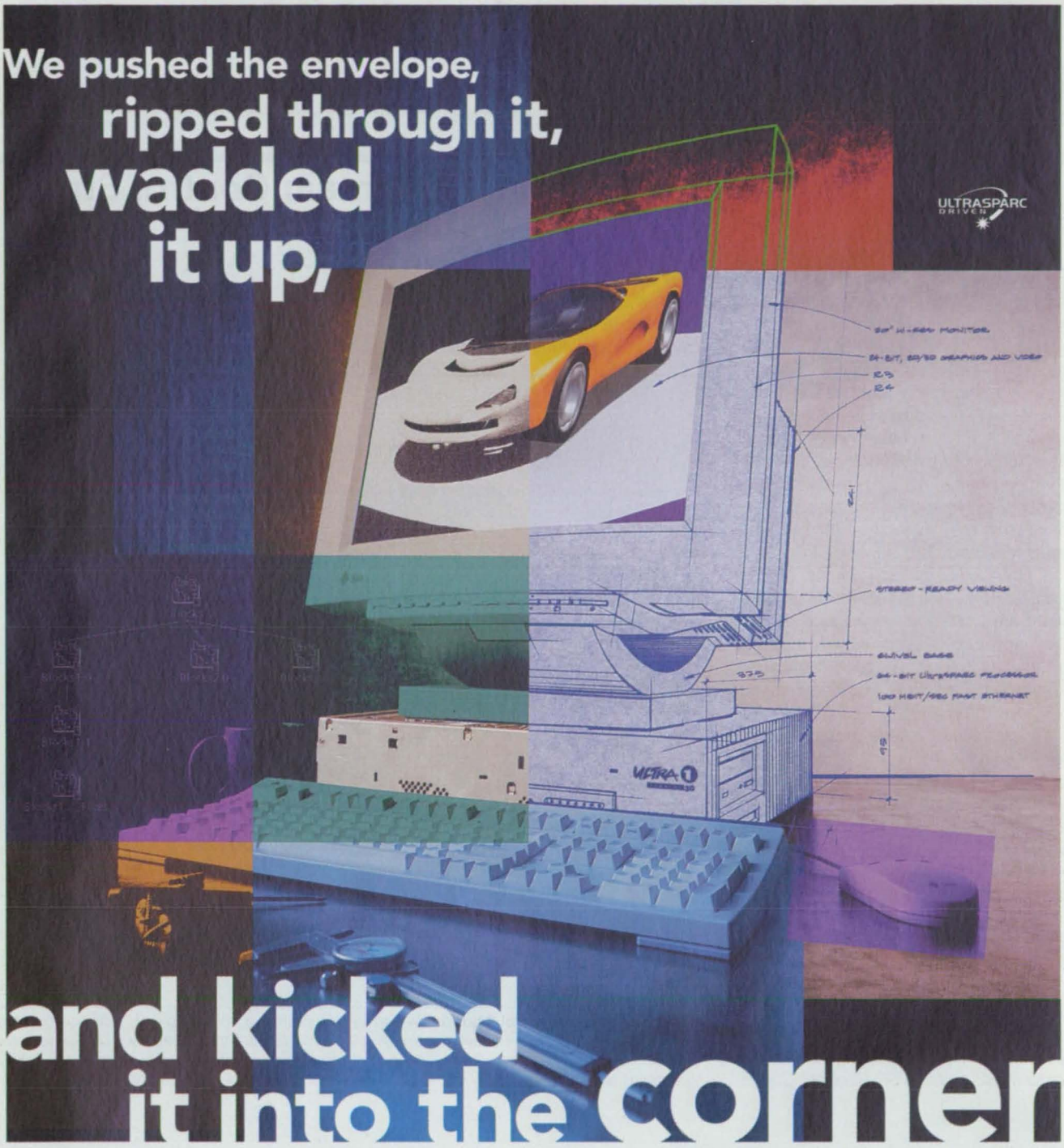
Methods for Using Liquid Crystal Coatings to Measure Surface Shear Stress Magnitude and Determine Shear Direction

Dr. Daniel C. Reda
Ames Research Center

In fluid mechanics and aerodynamic research, valuable information can be obtained from visualizing both the outer flow and surface shear stress patterns over solid bodies immersed in fluid streams. Dr. Reda and the Ames team developed a method for determining shear direction in which a beam of white light is directed onto the surface of a liquid crystal coating (LCC), which disperses it from the surface in a spectrum having bands of different colors in a fixed spatial sequence. The magnitude of color change scales directly with shear stress magnitude.

In order to test the methodology, the inventors devised an image-based system incorporating two opposing-view, synchronized color video cameras: one with an oblique, downstream-facing view of the test surface, and the other with an oblique, upstream-facing view. Full-surface color images of LCC response to a 3D turbulent wall jet flowing over a planar surface were acquired. The results are believed to be the first full-surface shear stress vector data sets.

For more information on the technologies described in this article, contact the NASA field center that sponsored the research (see page 14).



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Intraply Hybrid Composites Would Contain Control Strips

Sensors and actuators would be distributed throughout "smart" structures.

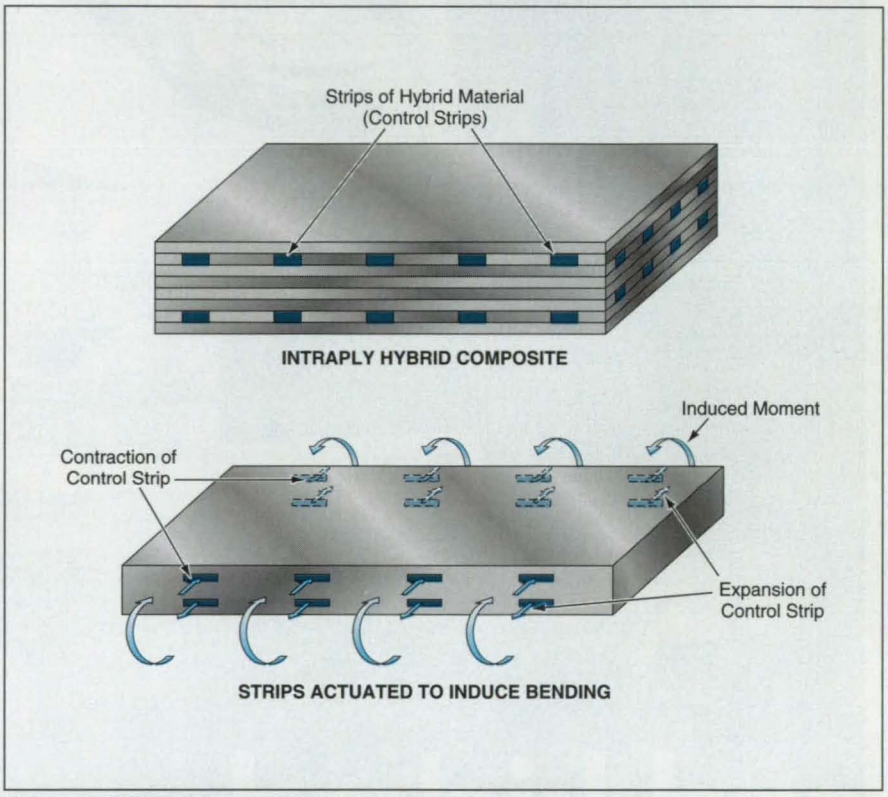
Lewis Research Center, Cleveland, Ohio

"Smart" structural components with sensors and/or actuators distributed throughout their volumes would be made of intraply hybrid composite materials, according to a proposal. At present, "smart" composite structural components typically contain monolithic surface-bonded or embedded piezoceramic wafers, which limit the strengths of the composites. Moreover, the piezoceramic wafers are vulnerable to cracking under concentrated stresses in operation and under curing pressure during manufacture. As a result, these components are limited to small-scale deflections and low stresses. The proposed intraply hybrid composite structural components are intended to overcome these limitations.

An intraply composite material would be similar to an ordinary matrix/fiber laminated composite, except that some of the plies, called "control plies," would consist of strips of the ordinary composite material interspersed with strips of a hybrid composite material (see figure). The hybrid composite material would contain sensor and/or actuator fibers (e.g., piezoelectric fibers) mixed with the ordinary composite fibers.

This work was done by Christos C. Chamis of **Lewis Research Center** *and Chi-Yu Shiao of Sverdrup Technology, Inc. For further information,* ***write in 62*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Lewis Research Center; (216) 433-2320. Refer to LEW-15877.



Strips of Hybrid Control Material would be interspersed with strips of ordinary (passive) composite material in some layers, providing a distributed control capability. For example, the near and far edges of the plate could be bent upward by commanding bottom control strips to expand and simultaneously commanding the upper control strips to contract.

Celsian Glass-Ceramic Matrix Composites

These materials are strong and tough, exhibit low dielectric properties, and endure high temperatures.

Lewis Research Center, Cleveland, Ohio

Glass-ceramic matrix reinforced fiber composite materials have been developed for use in low dielectric applications, such as radomes. The glass-ceramic matrix material in a composite of this type is barium strontium alumina silicate $xBaO{\cdot}(1–x)SrO{\cdot}Al_2O_3{\cdot}2SiO_2$ [$0 \le x \le 1$], which exists as a monoclinic celsian phase. The fibers that reinforce the matrix are made of a silicon nitride-based ceramic. These composite materials offer strength, toughness (see figure), low relative permittivity, and low absorption of electromagnetic waves over a wide temperature range.

The matrix and fibers are thermally compatible with each other in the sense that the coefficient of thermal expansion of the fibers (about 3 × 10–6/°C) nearly matches that of the matrix (about 2.5 × 10^{-6}/°C). Before incorporation into a composite, the fibers are coated with a thin (≈1 μm thick) layer of one or more ceramic material(s) that exhibit low relative permittivity, are thermally stable, resist oxidation, and serve as a weak interfacial layer between the matrix and

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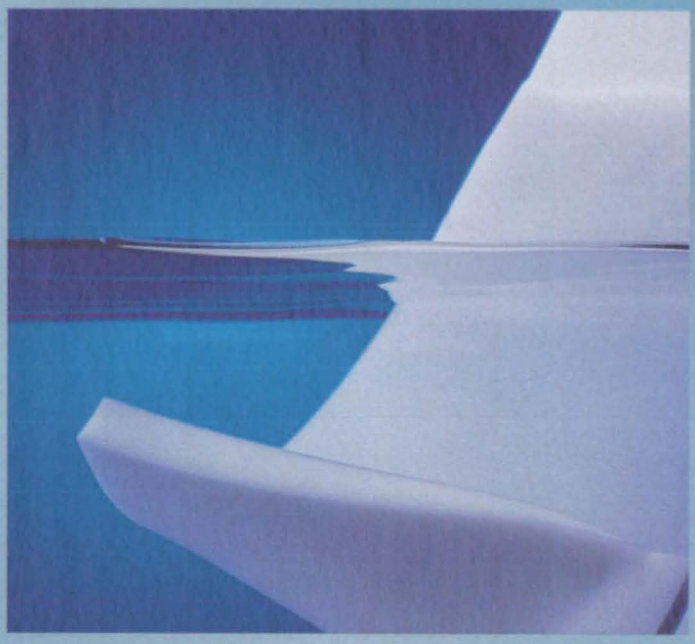

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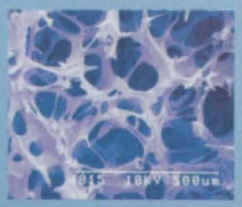

PVA versatility—custom-specified shapes, colors, porosities and hardness levels can be produced to your requirements. Powders can be impregnated into PVA or secondary operations executed to alter or enhance performance. It's also chemically resistant. A wide range of sizes can be manufactured in sheet, block, tube/roller and custom forms.

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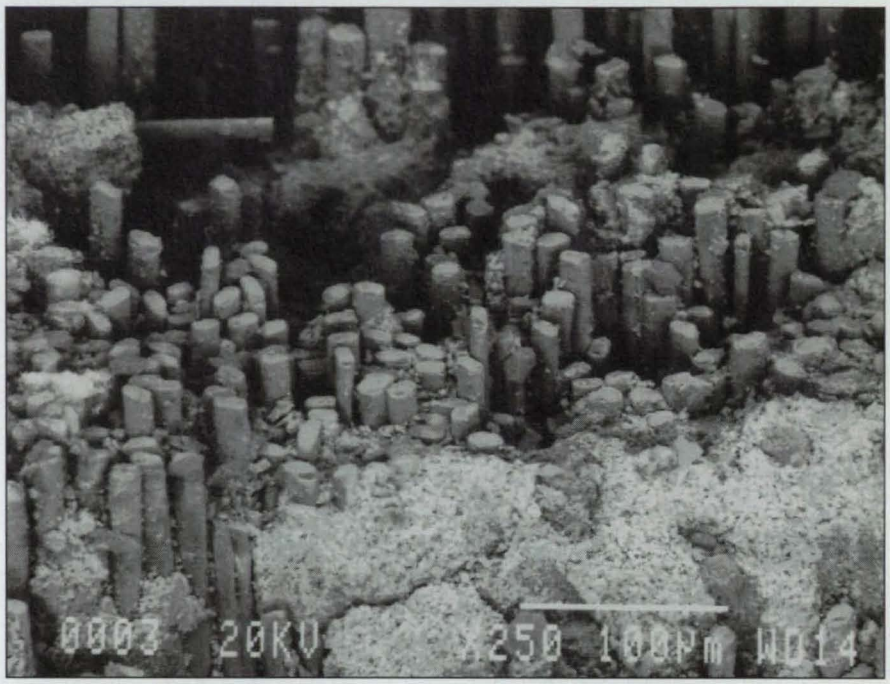
the fibers to impart toughness to the composite. A suitable interfacial layer can comprise a sublayer of Si_3N_4 over a sublayer of BN or some other combination of materials that offer properties required in a specific application.

A composite of this type can be fabricated, for example, as a two-dimensional laminate as follows: A matrix-material slurry is prepared by ball-milling barium strontium alumina silicate glass powder along with a fugitive organic binder, a plasticizer, a deflocculant, and a surfactant. If $x > 0.85$ in the desired composition, then 10 to 20 weight percent of fine monoclinic celsian seeds can be added to the slurry. Tows of the coated fibers are passed through the slurry, then wound on a takeup drum to allow the slurry to dry. The sheets are then cut, stacked, and warm pressed to make a "green" laminated composite.

The organic materials are burned out and the composite is consolidated further by hot pressing it under vacuum at a suitable temperature between 1,200 and 1,400 °C. For example, the specimen shown in the figure was cut from a composite that was pressed at 1,400 °C for two hours at a pressure of 3.5 kpsi (24 MPa). During hot pressing, the glassy matrix converts into monoclinic celsian glass-ceramic.

This work was done by Narottam P. Bansal and James A. DiCarlo of **Lewis Research Center**. *For further information,* ***write in 85*** *on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Lewis Research Center; (216) 433-2320. Refer to LEW-15714.



This **Scanning Electron Micrograph** shows a fracture surface of a specimen of glass-ceramic matrix composite material. Note that fibers have been pulled out: this is characteristic of a tough composite.

Rigid-Rod Polyimides

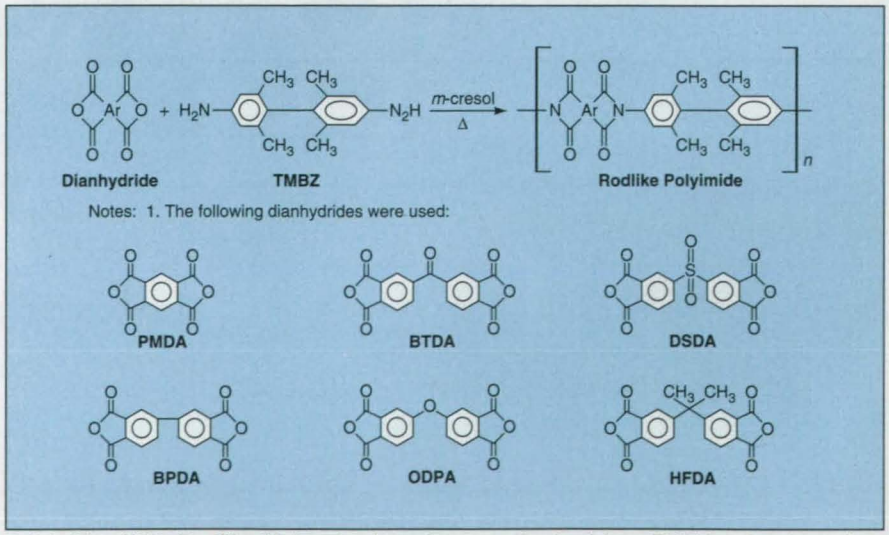
These polymers can be used to make colorless fibers and transparent films.

Lewis Research Center, Cleveland, Ohio

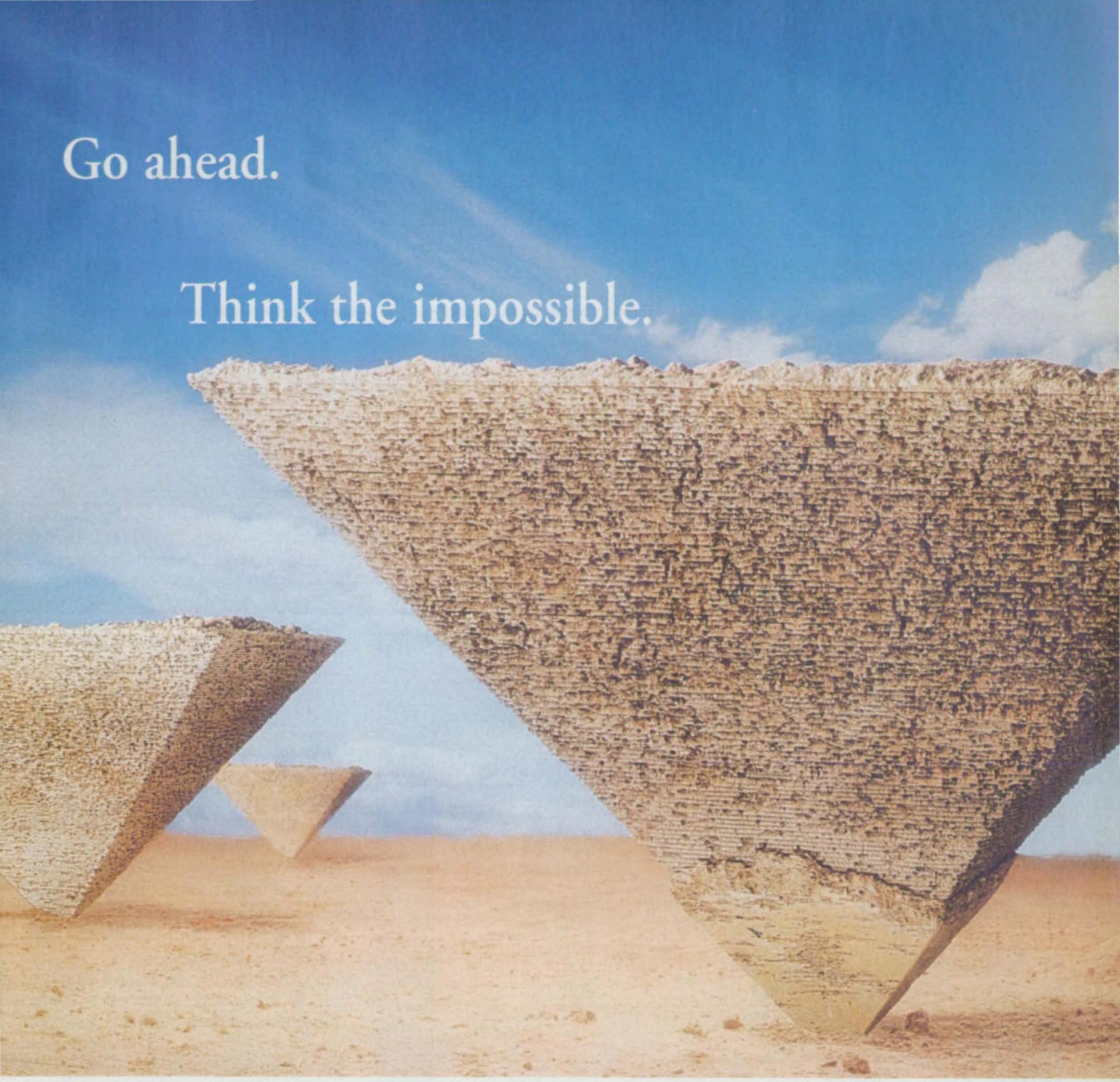
Experimental polyimides that are relatively rigid have been synthesized in an effort to exploit some of the advantages of rodlike polymers, while alleviating their disadvantages. Rodlike polymers are known for their interesting thermotropic or lyotropic liquid crystalline behaviors, and for outstanding performance as high-strength fibers. However, rigid-rod polymers are often insoluble in common organic solvents, which makes them difficult to process.

The rigid-rod polyimides were made from 2,2′,6,6′-tetramethylbenzidine (TMBZ) and various aromatic dianhydrides. The polymerization was accomplished by reacting TMBZ with an aromatic dianhydride in boiling metacresol for 3 – 4 hours (see figure). The polymers were precipitated from 95 ethanol with a fast air stirrer to form colorless polyimide fibers, which were dried for 24 h at 125 °C. These polyimides can also be cast into transparent films for optical and electronic application.

X-ray crystal structure of TMBZ revealed that the two phenyl rings on the TMBZ molecule were twisted out of a coplanar conformation (dihedral angle = 79.3°). This noncoplanar conformation may be a factor contributing to the enhanced solubility and processability of these rigid-rod polyimides.



Polyimides With Rodlike Molecules have been synthesized from TMBZ and various dianhydrides.



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These rodlike polyimides exhibited high glass-transition temperatures which ranged from 306 to 390 °C. They also displayed a 5 percent weight loss at temperatures varying from 485 to 525 °C by thermogravimetric analysis under nitrogen, which is indicative of excellent thermal stability.

A dry-jet wet spinning process is currently under investigation to produce high-strength fibers from these rigid-rod polyimides.

This work was done by Kathy C. Chuang of **Lewis Research Center**, *James D. Kinder of the National Research Council, and Diana L. Hull and Wiley J. Youngs of the University of Akron. No further documentation is available.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Lewis Research Center; (216) 433-2320. Refer to LEW-15991.

Al_2O_3/SiO_2 Coats on Polyimide-Matrix/Carbon-Fiber Composites

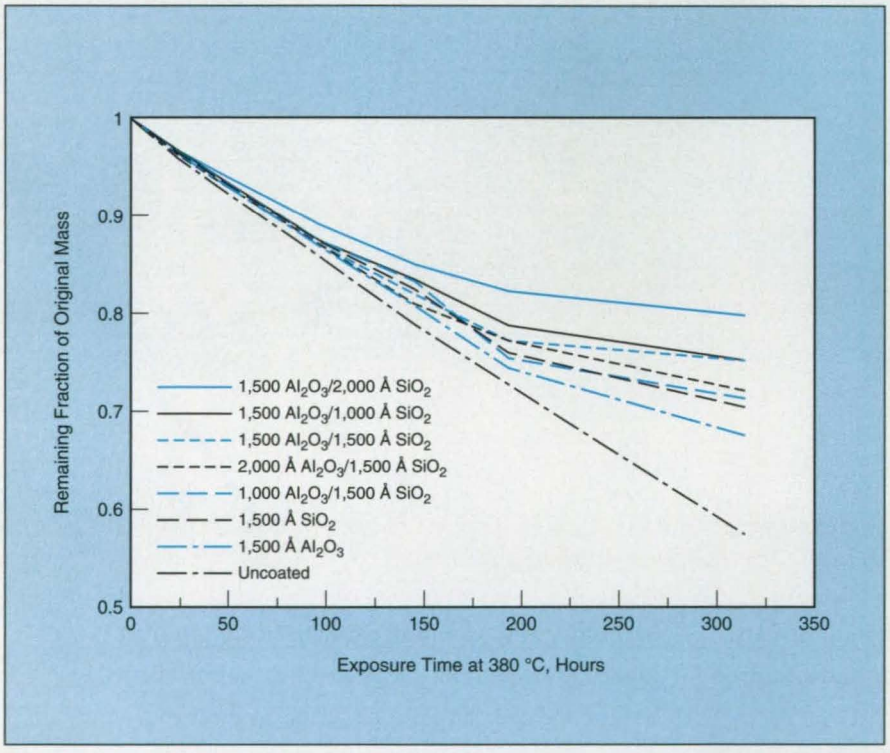
These coats increase thermooxidative stability.

Lewis Research Center, Cleveland, Ohio

Experiments have shown that thin surface coats of silicon dioxide on thin undercoats of aluminum oxide can retard the thermooxidative degradation of polyimide-matrix/carbon-fiber composite materials. These experiments represent an extension and convergence of two previous lines of research on protecting substrates against thermooxidative degradation: One of these efforts involved coating a neat polyimide with aluminum oxide; the other effort involved coating solar cells with both oxides.

In regard to the latter effort, the motivation for trying this two-oxide-layer coating system was threefold. First, the Al_2O_3 layer was found to promote adhesion to a graphite/epoxy composite substrate. Second, the Al_2O_3 was known to resist the penetration of oxygen more strongly than SiO_2 does, while SiO_2 was thought to provide better resistance to moisture. Third, the use of two dissimilar but compatible materials aids in covering pinhole defects: the likelihood that an overlayer will cover pinholes in an underlayer is greatly enhanced when the two layers are of different materials.

In experiments to test the feasibility of the present two-oxide-layer concept, films of Al_2O_3 and SiO_2 in various thickness were formed, by plasma-enhanced vapor deposition, on substrates made of two different polyimide-matrix/carbon-fiber composites. In one of the composites, the polyimide was PMR-15; in the other composite, it was PMR-30. In all cases except one in which aluminum oxide was not used, the underlayers were aluminum oxide and the overlayers were silicon dioxide. Aluminum tri-isopropoxide was used as the source gas for depositions of Al_2O_3; tetraethoxysilane was used as the source gas for deposition of SiO_2. Each of these gases contains sufficient oxygen to enable the formation of the respective stoichiometric material (Al_2O_3 or SiO_2) by pyrolytic and plasma-induced decomposition, without the need to supply additional oxygen.



Resistance to Thermooxidative Degradation of coated specimens was measured in terms of fraction of mass retained during exposure at 380 °C. The greatest retention of mass occurred in the specimen coated with 1,500 Å of Al_2O_3 and 2,000 Å of SiO_2.

To quantify the protective capabilities of the oxide layers, the coated substrates were heated to a temperature of 380 °C and their masses were measured as functions of time. The slowest losses of mass (the greatest resistance to thermooxidative degradation) were observed in specimens on which the alumina underlayers were 1,500 Å thick. Of these, a specimen on which the silicon dioxide overlayer was 2,000 Å thick exhibited the slowest loss of mass (see figure).

This work was done by Larry M. Miller and Daniel A. Gulino of Ohio University for **Lewis Research Center**. *No further documentation is available.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Lewis Research Center; (216) 433-2320. Refer to LEW-15993.

(continued on page 32)

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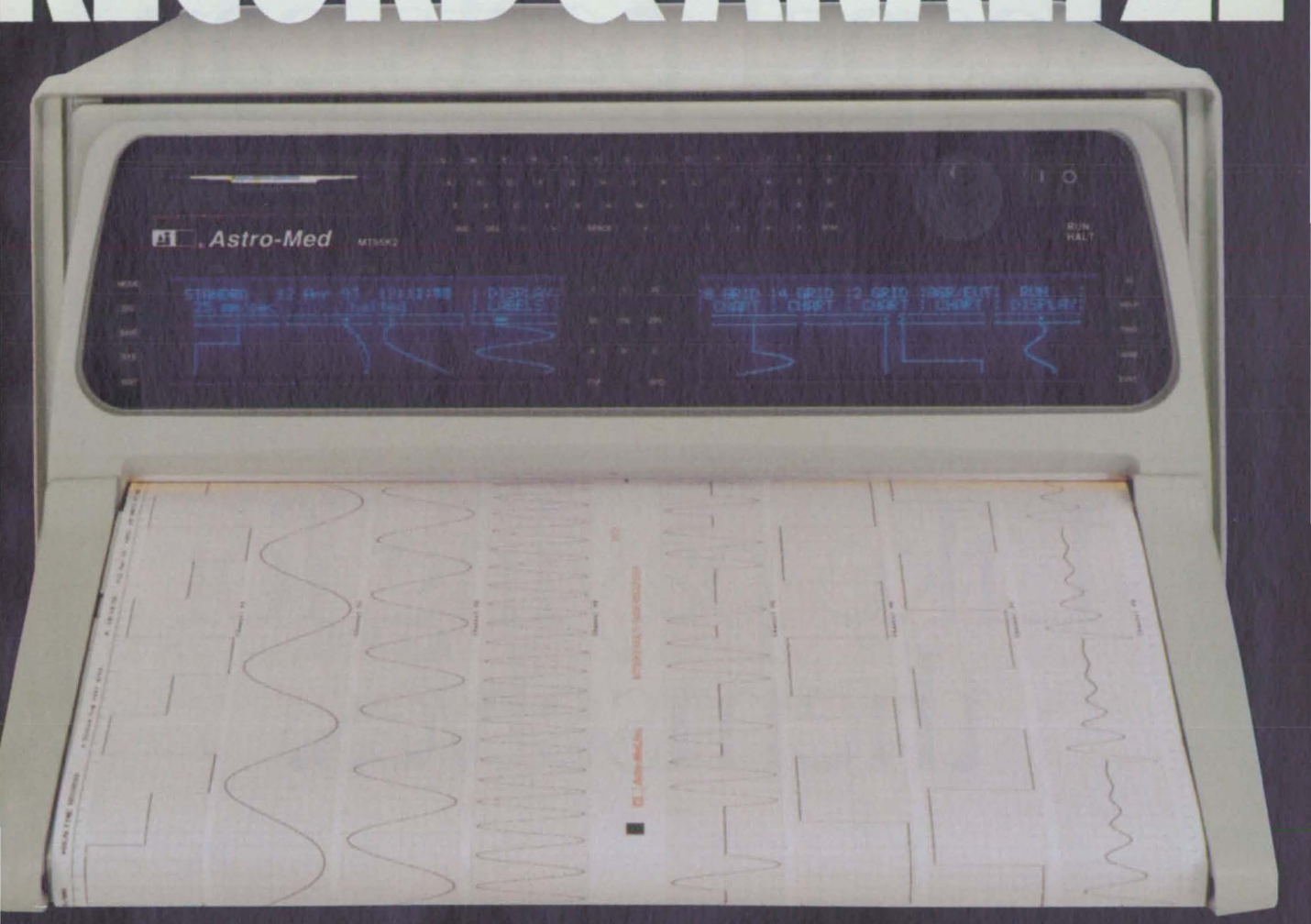

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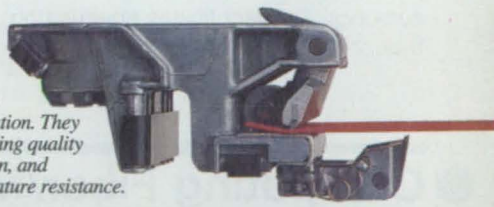

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(continued from page 28)

Zone Directional Solidification of NiAl Composites

Interfacial shear strengths are increased.

Lewis Research Center, Cleveland, Ohio

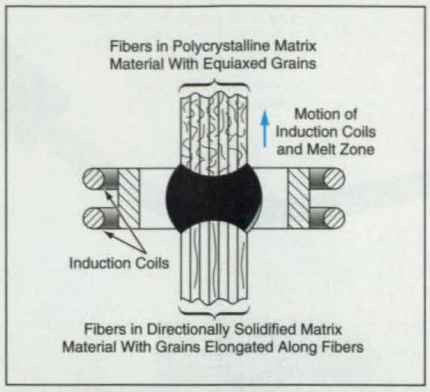
Zone directional solidification has been investigated for use in toughening nickel aluminide matrices in NiAl-matrix/Al_2O_3(sapphire)-fiber composite materials. Toughening is needed because the nickel aluminide matrices investigated previously have exhibited minimal ductility and toughness at low to intermediate temperatures, whereas greater ductility and toughness would be required in practical uses of these composites.

One of the processes for making nickel aluminide-matrix/sapphire-fiber composite materials is the powder/cloth process. This process begins with the preparation of mats of NiAl powder and organic binders, plus mats of sapphire fibers and another binder. The NiAl mats are stacked alternately with the fiber mats, then the stack is diffusion-bonded by application of high pressure and temperature. In another process, fiber mats are directly coated with NiAl by arc or plasma spaying, and then diffusion bonding is performed. In yet another process, the NiAl matrix is formed around the sapphire fibers by vacuum casting.

All three processes yield polycrystalline NiAl matrices, whereas the classes of NiAl-based material that show most promise for achievement of low-temperature ductility and toughness are (1) microalloyed single-crystal NiAl; (2) dual-phase microstructures, wherein the brittle ß phase is surrounded by a thin ductile layer of another phase; and (3) directionally solidified eutectics. This fact invites speculation that zone directional solidification might be a suitable technique for reprocessing nickel aluminide-matrix/sapphire-fiber composites to toughen the NiAl matrices (see figure).

In preparation for experiments to test this proposition, nickel aluminide-matrix/sapphire-fiber composite specimens with 12 volume percent fibers, cross sections of 0.25 by 0.4 cm, and lengths of several cm were made by the powder-cloth process. Some specimens were also made by the vacuum-casting process. In each experiment, a specimen was zone directionally solidified: The specimen was heated locally to create a melt zone 0.6 to 0.8 cm long, that was moved along the specimen at the optimal melt-zone temperature.

The shear strengths of the fiber/matrix interfaces in the specimens were measured by fiber-pushout tests. The load-vs.-displacement response in each test was correlated with the interfacial fracture behavior by interrupting the pushout at various stages and examining the front and back faces of the specimen by scanning electron microscopy. These measurements showed that specimens made by the powder/cloth process and then zone directionally solidified had interfacial shear strengths greater than those of specimens made by the powder/cloth process alone. Even greater interfacial shear strength was observed in specimens made by vacuum casting followed by zone directional solidification. It has been conjectured that gaseous microporosities in the powder/cloth + zone directionally solidified specimens exert a weakening effect and that the greater strength of the vacuum cast + directionally solidified specimens can be attributed to absence of gaseous microporosities in these specimens. Thus, it appears that vacuum casting and zone directional solidification should be investigated further to optimize mechanical properties of nickel aluminide-matrix/sapphire-fiber composites.



Zone Directional Solidification shows promise as a technique for toughening NiAl matrices of NiAl-matrix/Al_2O_3-fiber composites.

This work was done by Randy R. Bowman of **Lewis Research Center,** *Surendra N. Tewari of Cleveland State University, and Rajesh Tiwari and Rajiv Asthana of the National Research Council. No further documentation is available.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Lewis Research Center; (216) 433-2320. Refer to LEW-16009.

Computing Fiber/Matrix Interfacial Effects in SiC/RBSN

An application of the boundary-element method is described.

Lewis Research Center, Cleveland, Ohio

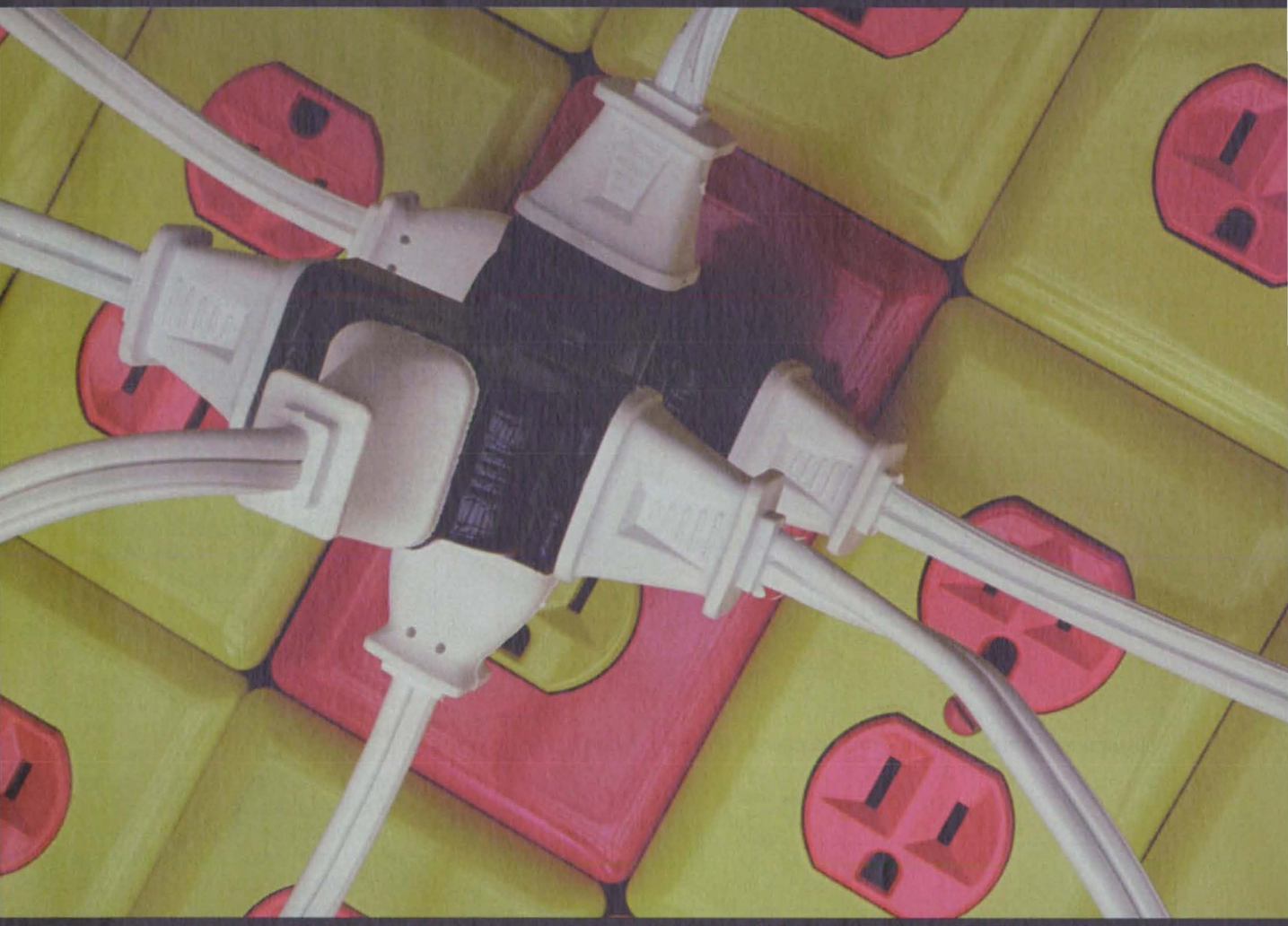
A computational study was conducted to demonstrate the use of the boundary-element method in analyzing the effects of the fiber/matrix interface on the elastic and thermal behaviors of representative laminated composite materials. The boundary-element method is a numerical-simulation method that has been used previously to analyze the elastic and thermal behaviors of laminated composite materials with perfect bonding at the micromechanical scale. In this study, the boundary-element method was implemented by the Boundary Element Solution Technology — Composite Modeling System (BEST-CMS) computer program. The composite materials in this study comprised 30 volume percent of silicon carbide fibers in reaction-bonded silicon nitride (RBSN) matrices. BEST-CMS was used to compute the effective tensile moduli and Poisson's ratios and effective directional thermal conductivities. The computed values of these physical properties were found to approach experimental values when appropriate interface conditions are considered.

This work was done by Robert K. Goldberg and Dale A. Hopkins of **Lewis Research Center.** *No further documentation is available.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Lewis Research Center; (216) 433-2320. Refer to LEW-16012.

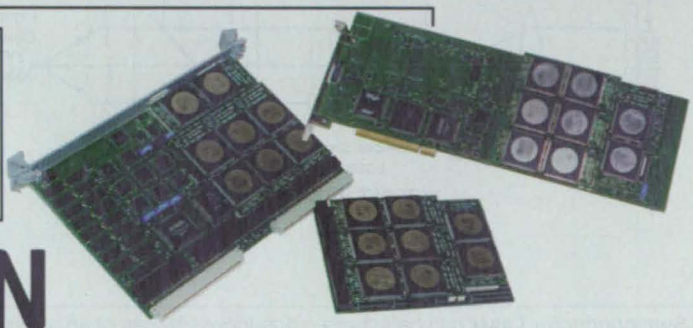
Alacron's FT-SHARC

Architecture PREVENTS Bus Overloading



Parallel Data Paths MAXIMIZE SHARC Processor Performance

The **Alacron FT-SHARC** architecture buffers each SHARC processor with dedicated dual-ported RAM, while data flow is managed by an i960 RISC controller. Processors run continuously at peak capacity, achieving sustained throughput of nearly 1 gigaFLOPS.



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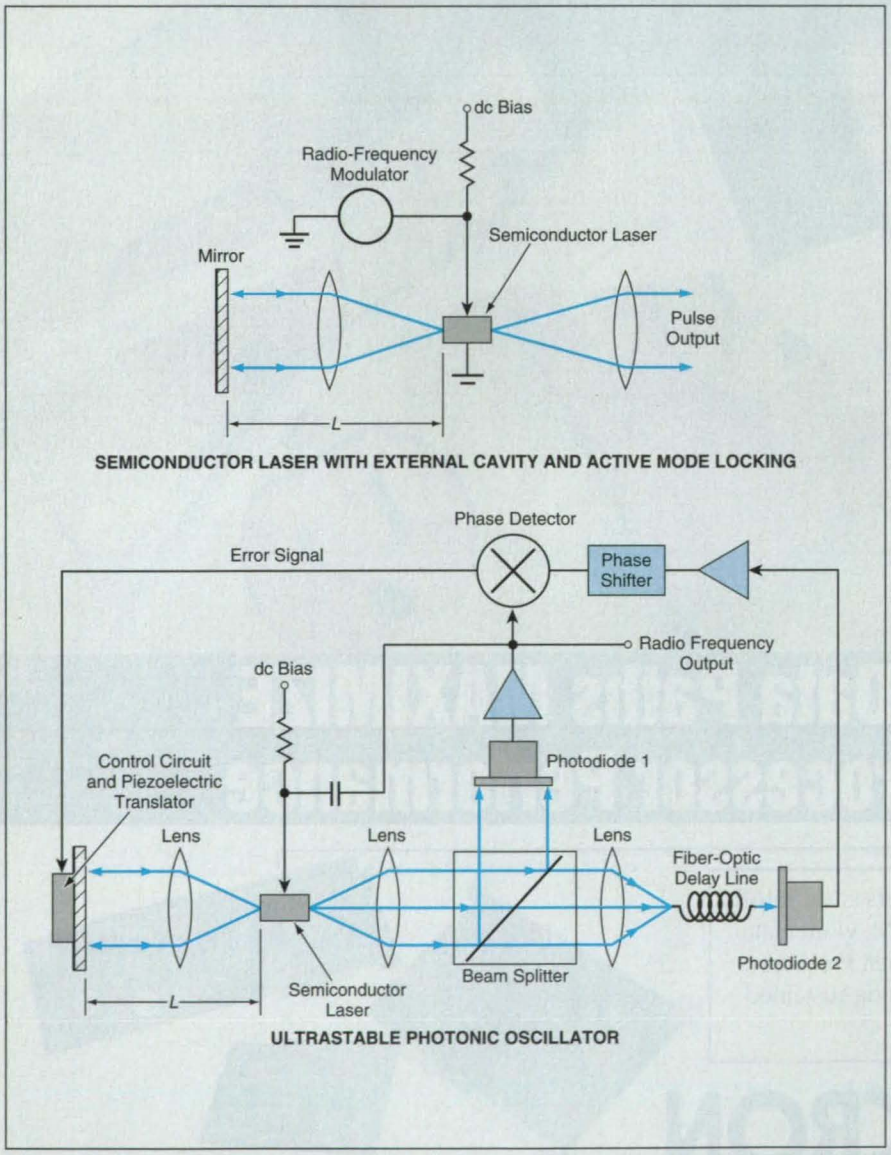
Ultrastable Multigigahertz Photonic Oscillator

Oscillations are generated photonically, then converted to electronic form.

NASA's Jet Propulsion Laboratory, Pasadena, California

A novel photonic oscillator is being developed to serve as an ultrastable source of microwave and millimeter-wave signals. In this system, the oscillations would be generated photonically, then converted to electronic form. The system would include a self-mode-locked semiconductor laser that would produce a stream of pulses, which would be detected and fed back to the laser as input. The system would also include a fiber-optic-delay-line discriminator, which would detect fluctuations of the self-mode-locking frequency and generate an error signal that would be used in a negative-feedback loop to stabilize the pulse-repetition frequency.



A **Semiconductor Laser** can be actively mode-locked by use of an externally supplied modulating signal. Alternatively, it could be self-mode-locked by use of its own output pulses, in which case it would act as a photonic (more precisely, photonic/electronic) oscillator and frequency multiplier.

The principle of operation of the system is based on that of the actively mode-locked external-cavity semiconductor laser shown in the top part of the figure. The difference F_{CAV}, between the frequencies of successive longitudinal waveguide modes of the laser is given by $F_{CAV} = c/2L$, where c is the speed of light and L is the length of the laser cavity. Typically, F_{CAV} of an isolated semiconductor laser is of the order of several hundred gigahertz, but it can be lowered into the microwave range by putting an antireflection coat on one of the laser facets and using an external mirror as a laser facet positioned to increase L to the desired value.

When the laser gain is modulated at a frequency of F_{CAV} by application of a sinusoidal or otherwise shaped drive signal, the laser modes become strongly coupled and phase-locked: this is what is meant by "active mode locking." The output in the case of active mode locking is a train of optical pulses that are ultrashort (typically 1 to 10 ps in duration). By detecting these pulses with a fast photodiode, one obtains an electrical signal that contains the fundamental mode-locking frequency and many harmonics that typically extend well beyond 100 GHz. Thus, a mode-locked semiconductor laser can be used as a microwave and millimeter-wave oscillator and frequency multiplier. Furthermore, one can take advantage of its optical output to use a fiber-optic-delay-line stabilization scheme.

The developmental system, illustrated in the lower part of the figure, would include a mode-locked semiconductor laser like the one discussed above. However, an external electrical drive signal would not be used: Instead, part of the laser output would be fed to a photodetector, and part of the pulsed electrical output of the photodetector would be fed back to the laser as mode-locking modulation. Thus, the system would internally generate a mode-locking signal; that is, its output would be self-mode-locked.

For stabilization, part of the laser output would be fed through a fiber-optic

delay line and a phase shifter to a second photodetector. The output of the second photodetector and part of the output of the first photodetector would be fed to a phase detector, which would put out an error signal indicative of the difference between the phases of the electrical photodetector outputs—a measure of the fluctuation in phase during the delay period. The error signal would be used as a feedback control signal for a piezoelectric translation stage to adjust the position of the mirror to stabilize the phase and frequency of the electrical output.

This work was done by Ronald T. Logan, Jr., of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 41*** *on the TSP Request Card. NPO-19190*

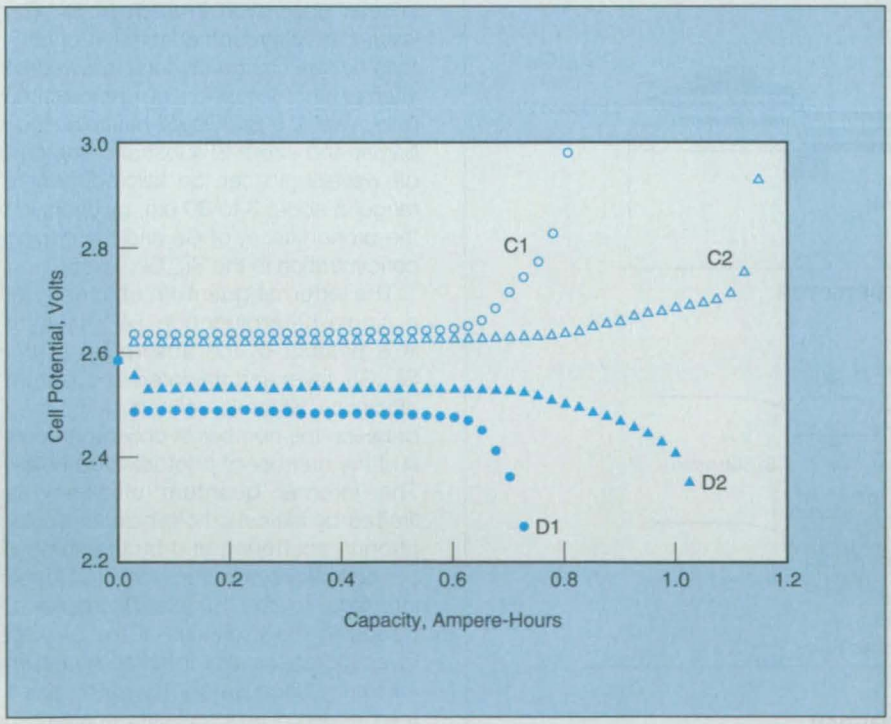
Thin, Large-Area Positive Electrodes in $Na/NiCl_2$ Cells

Greater power densities should be achievable, without compromising on energy densities.

NASA's Jet Propulsion Laboratory, Pasadena, California

Thin, larger-area, noncylindrical positive electrodes have been investigated for use in place of smaller-area, cylindrical positive electrodes now used in $Na/NiCl_2$ high-temperature rechargeable electrochemical cells and batteries. The proposed electrodes should help to increase overall power densities of the cells and batteries.

An $Na/NiCl_2$ cell comprises a molten sodium anode (the negative electrode), a separator made of ß″ alumina (a solid electrolyte for Na^+ ions), a molten sodium tetracholoroaluminate electrolyte, and an $NiCl_2$ cathode (the positive electrode). In a cylindrical configuration, polarization losses at the cathode limit the achievable power density. The optimum thickness of an $NiCl_2$ electrode has been estimated to be 4 mm; at greater thickness, diffusional loss sets in, while at lesser thickness, overall energy density decreases. Between these constraints, it may be difficult to



These **Charge and Discharge Curves** were measured on an $Na/NiCl_2$ cell with a spiral-wound $Na/NiCl_2$ sheet electrode fabricated with a binder of EPDM prior to sintering. C1 denotes the first charge at a current of 75 mA, D1 the first discharge at 75 mA, C2 the second charge at 50 mA, and D2 the second discharge at 75 mA. With optimization of design, it should be possible to achieve high efficiencies at rates of charge and discharge much greater than these.

achieve reasonable energy density in an $Na/NiCl_2$ cell. The thin, large-area, noncylindrical $NiCl_2$ electrodes were conceived in an effort to overcome these limitations; that is, to achieve higher power densities with no compromise on energy densities.

An $NiCl_2$ electrode of this type is first fabricated as a flat sheet. In preparation, $NiCl_2$ powder is mixed with an organic binder and a suitable solvent; for example, ethylene propylene diene monomer (EPDM) dissolved in cyclohexane or polytetrafluoroethylene (PTFE) emulsified in a suitable solvent. The solid/liquid mixture is brushed, rolled, or spread with a doctor's blade onto an expanded nickel screen. The coated screen is sintered, causing the binder to decompose and vaporize.

The resulting $NiCl_2$ electrode sheet is then wound into a spiral or folded into a corrugated shape and placed inside a ß″ alumina separator tube. The sodium negative electrode surrounds the ß″ alumina tube in this configuration. Alternatively, (especially in the spiral-wound case) the $NiCl_2$ electrode can be placed on the outside of the tube and the sodium on the inside.

The ratio between geometric surface area and charge capacity of $NiCl_2$ electrodes of this type is about 85 cm^2/Ah, as compared to 25 cm^2/Ah for older cylindrical $NiCl_2$ electrodes. These electrodes exhibit conversion efficiencies as high as 98 percent, as illustrated by the data plotted in the figure. The ohmic and diffusional components of polarization loss at these electrodes are significantly less than those of cylindrical $NiCl_2$ electrodes. Accordingly, these electrodes are expected to be capable of greater rates of charge and discharge.

This work was done by Ratnakumar Bugga, Alan Attia, and Gerald Halpert of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 3*** *on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Resident Office–JPL; (818) 354-5179. Refer to NPO-19178.

Infrared Detectors Containing Stacked $Si_{1-x}Ge_x/Si$ Layers

Relatively strong photoresponses are observed at wavelengths of 2 to 20 μm.

NASA's Jet Propulsion Laboratory, Pasadena, California

Long-wavelength-infrared detectors containing multiple layers of high-quality crystalline p^+ $Si_{1-x}Ge_x$ alternating with layers of Si are undergoing development. Each such detector comprises a stack of $Si_{1-x}Ge_x/Si$ heterojunction internal photoemission (HIP) photodetectors. In comparison with older HIP detectors containing single $Si_{1-x}Ge_x/Si$ heterojunctions, the developmental detectors feature greater quantum efficiencies and thus stronger photoresponses.

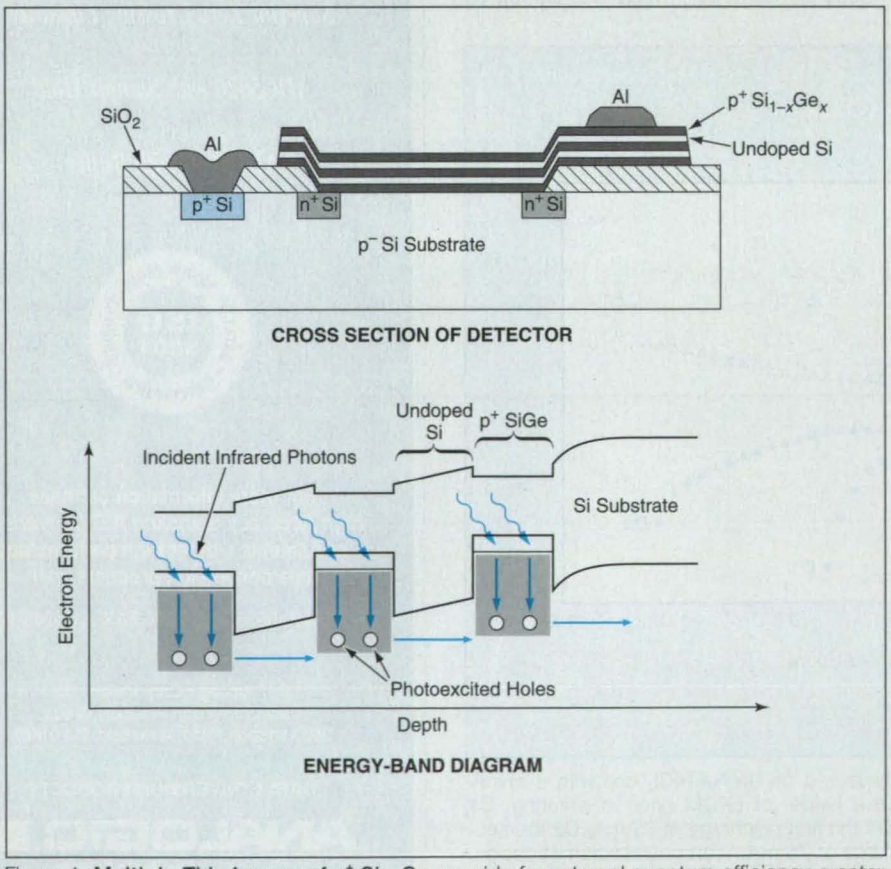


Figure 1. **Multiple Thin Layers of p^+ $Si_{1-x}Ge_x$** provide for external quantum efficiency greater than that of a similar photodetector containing a single, thicker layer of $Si_{1-x}Ge_x$.

The detection mechanism involves infrared absorption in each p^+ $Si_{1-x}Ge_x$ layer, mainly through absorption of photons by free charge carriers, followed by internal photoemission of photoexcited holes over the $Si_{1-x}Ge_x/Si$ heterojunction barrier and into a Si substrate. The cutoff wavelength can be tailored, over a range of about 3 to 30 μm, by changing the proportion, x, of Ge and the doping concentration in the $Si_{1-x}Ge_x$ layer.

The external quantum efficiency of a single-heterojunction HIP detector is a product of the absorption in the $Si_{1-x}Ge_x$ layer and the internal quantum efficiency, which is defined as the ratio between the number of collected holes and the number of photoexcited holes. The internal quantum efficiency is limited by inelastic hole/hole and hole/phonon scattering and by the number of holes redirected from the $Si_{1-x}Ge_x$/air interface to the $Si_{1-x}Ge_x/Si$ interface. Reducing the thickness of the $Si_{1-x}Ge_x$ layer increases the internal quantum efficiency because photoexcited holes then undergo less inelastic scattering. However, reducing the thickness of the $Si_{1-x}Ge_x$ layer also reduces the number of photons absorbed. Thus, the optimal thickness of the $Si_{1-x}Ge_x$ layer is a com-

promise between absorption and internal quantum efficiency.

In the present multiple-layer detectors, high internal quantum efficiency is achieved, without loss of absorption of photons, by incorporating thin multiple absorbing $Si_{1-x}Ge_x$ layers stacked between Si barriers (see Figure 1). By virtue of its thinness, each individual $Si_{1-x}Ge_x$ layer has high internal quantum efficiency. The absorption from each $Si_{1-x}Ge_x$ layer contributes to the total absorption. Furthermore, an electric field is applied across the stack, toward the Si substrate, so that photoexcited holes initially traveling in the opposite direction are redirected toward the Si substrate: this further increases the internal quantum efficiency.

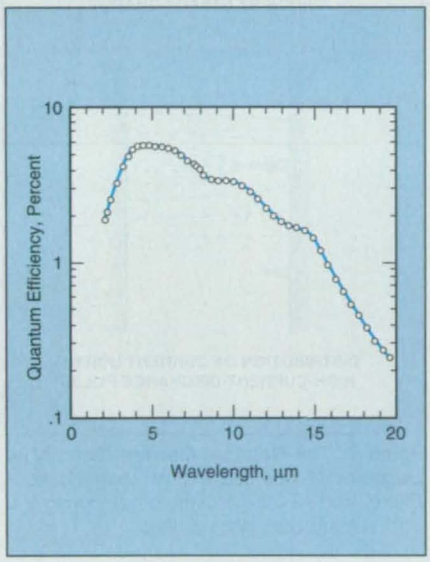


Figure 2. The **Quantum Efficiency** of a prototype $Si_{0.7}Ge_{0.3}$/Si detector containing three layers of $Si_{0.7}Ge_{0.3}$ was measured at a temperature of 30 K and a bias of -0.5 V (positive to the top-side $Si_{0.7}Ge_{0.3}$).

Prototype $Si_{0.7}Ge_{0.3}$/Si detectors containing three layers of $Si_{0.7}Ge_{0.3}$ were fabricated by low-temperature molecular-beam epitaxy, with boron doping of the $Si_{0.7}Ge_{0.3}$ to a concentration of about 4×10^{20} atoms/cm^3. The doped $Si_{0.7}Ge_{0.3}$ layers were ≤50 Å thick; the undoped Si layers were ≈300 Å thick. Figure 2 shows the photoresponse spectrum of one of these detectors in terms of external quantum efficiency.

This work was done by Jin S. Park, True-Lon Lin, Eric Jones, Hector Del Castillo, and Sarath Gunapala of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 37*** *on the TSP Request Card.*
NPO-19311

Suppressing the Growth of Dendrites in Secondary Li Cells

High-current intermittent discharge pulses would be superimposed on charging currents.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed technique for suppressing the growth of lithium dendrites in rechargeable lithium electrochemical power cells involves the periodic interruption of steady charging current with short, high-current discharge pulses (see Figure 1). This technique should be applicable to lithium cells of several different types, including Li/TiS_2, $Li/NbSe_3$, Li/CoO_2, Li/MoS_2, Li/VO_x, and Li/MnO_2.

These cells are candidates for use in spacecraft, military, communications, automotive, and other applications in which high-energy-density rechargeable batteries are needed. However, the practical use of these cells has been inhibited by the danger and the limitations on charge/discharge cycle lives that arise in connection with the growth of dendrites during charge/discharge cycles. Because of uncontrollable factors that include surface inhomogeneities, impurities, and the low overpotential for electrodeposition of lithium, dendrites grow outward from anodes, eventually reaching across to cathodes and thereby short-circuiting the affected cells.

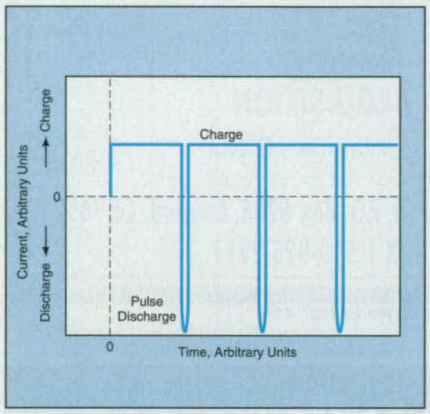


Figure 1. **Short, High-Current Discharge Pulses** would periodically interrupt the steady charging current.

As shown in Figure 2, the distribution of electrical current in a cell is uneven, the current density being greater at the tips of dendrites than on the relatively flat surrounding anode surface. The proposed technique would exploit this characteristic: The higher current density at the tips of the dendrites would cause the dendrites to be stripped out much faster if a constant-current charge were interrupted by high-current discharge pulses. The growth of dendrites during charge would thus be suppressed by intermittent dissolution.

This work was done by Evan D. Davies, David E. Perrone, and David H. Shen of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 40*** *on the TSP Request Card. NPO-19328*

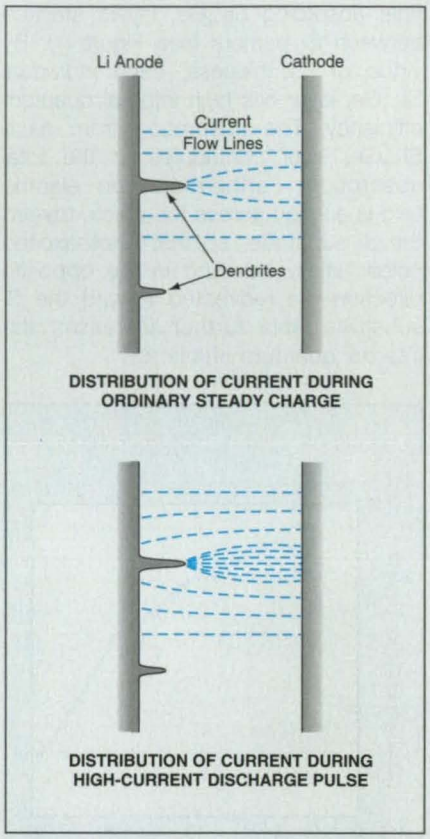


Figure 2. The **Relative Current Density Is Larger** at the tips of dendrites than it is elsewhere, and would be even larger during the high-current discharge pulses.

Wideband, High-Input-Impedance Buffer Amplifier

Input impedance is essentially resistive over a wide range of frequencies.

Goddard Space Flight Center, Greenbelt, Maryland

The figure illustrates an improved buffer amplifier that offers a high input impedance to a signal source. This buffer amplifier differs from older buffer amplifiers in that its input impedance remains high, relatively constant, and essentially resistive over a wide range of frequencies: An input-impedance-versus-frequency characteristic like this one is essential for minimizing distortion of a signal that includes components distributed over a wide frequency range and that originates in a sensor or other source that has variable impedance.

Operational amplifier 1 is connected in a voltage-follower configuration and driven by a source voltage v_{in} through source impedance R_S. Capacitor C_1 is drawn, for convenience of analysis, as though it represented a separate external capacitor, but actually it represents the interelectrode capacitance of operational amplifier 1. This capacitance in this configuration gives rise to a well-known single-pole gain-versus-frequency response that includes an input impedance characterized by negative conductance at frequencies above the frequency (the "–3-dB" frequency) at which the gain has decreased to $2^{-1/2}$ × the gain at zero frequency.

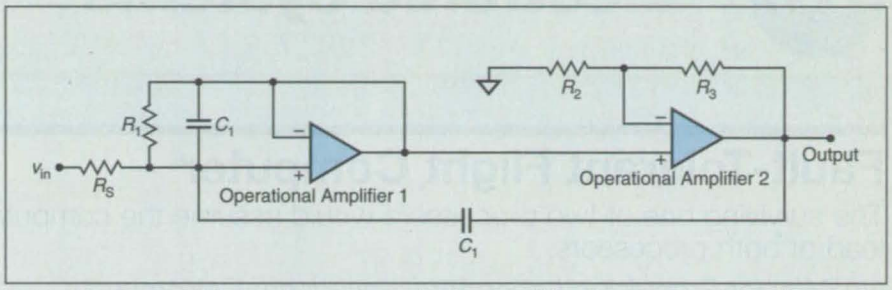
Resistance R_1 connected between the inverting- and noninverting-input terminals is chosen equal to the reciprocal of [C_1 × the gain-bandwidth product of the gain-vs.-frequency response]; this causes the net input conductance at high frequencies to be zero. Thus, at high frequencies, the net input impedance is a pure capacitive reactance attributable to C_1, plus a very high input resistance.

This input capacitive reactance is then eliminated by the following arrangement: The output of operational amplifier 1 is fed to the noninverting input terminal of operational amplifier 2. The output of operational amplifier 2 is fed back, via capacitor C_2, to the noninverting-input terminal of operational ampli-

fier 1. When operational amplifier 2 is combined with suitably chosen values of C_2 and of resistances R_2 and R_3, the resulting combination exhibits an input impedance equal to the negative of the capacitive reactance of C_1. Consequently, the net input reactance is zero and the input impedance presented to the signal source consists solely of a very high resistance.

This work was done by Leonard Kleinberg of **Goddard Space Flight Center.** *For further information,* ***write in 25*** *on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Goddard Space Flight Center; (301) 286-7351. Refer to GSC-13571.



In this **Wideband, High-Input-Impedance Buffer-Amplifier Circuit**, the values of R_1, C_2, R_2, and R_3 are chosen (in conjunction with given interelectrode capacitances and gain-bandwidth characteristics of the operational amplifiers) to obtain zero net effective input capacitance, with consequent high input impedance and a flat gain-vs.-frequency response, over a wide range of frequencies.

Lower-Thermal-Conductivity Tapes for Tape Automated Bonding

These tapes are better for electronic circuits that operate with substantial temperature gradients.

NASA's Jet Propulsion Laboratory, Pasadena, California

Foils of manganin (87 percent copper, 13 percent manganese) can be substituted for the copper foils that ordinarily serve as the electrical conductors on the tapes used in tape automated bonding (TAB) in electronic circuits. This modification makes it possible to apply TAB technology to circuits in which substantial gradients of temperature exist under design operating conditions.

With appropriate surface treatment, a manganin foil can be bonded to a polyimide tape with an acrylic adhesive. After lamination, the conductive pattern of interconnections for the specific circuit is etched in the foil. This TAB processing involves the same photomasking and etching techniques as are used with copper conductors.

The reason for using manganin is that its thermal conductivity is low relative to that of copper. Low-thermal-conductivity electrical interconnections are needed to minimize the spurious transfer of heat from warmer components to colder components. Examples of colder components include cooled infrared photodetectors and superconducting devices; the corresponding warmer components are the associated signal-processing and switching circuits.

Heretofore, low-thermal-conductivity electrical interconnections have been made, variously, by manual wiring or interconnection with low-thermal-conductivity flexible cables. Both of these conventional techniques are more labor-intensive than is TAB, and neither can provide interconnection density as great as that afforded by TAB. Other advantages of TAB technology include high reliability, automated assembly, and automated testing.

This work was done by Erick T. Young and Michael J. Scutero of the University of Arizona for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 53*** *on the TSP Request Card. NPO-19449*

Fault-Tolerant Flight Computer

The surviving one of two processors would assume the computational load of both processors.

NASA's Jet Propulsion Laboratory, Pasadena, California

The figure schematically illustrates a general design concept for an adaptive, fault-tolerant flight computer. Originally intended for application to a flight computer of a spacecraft on a scientific mission to Pluto, the concept should also be applicable to other computing systems that are required to tolerate faults and in which partial loss of processing speed or functionality is an acceptable price to pay for continued operation in the event of faults.

In the absence of a fault, the computer would operate almost as though it were two separate computers, with processor 1 attending only to inputs and outputs exchanged with equipment system 1 and processor 2 similarly attending only to inputs and outputs exchanged with equipment system 2. [In the original spacecraft application, equipment system 1 would comprise the power, telecommunication, and other engineering subsystems of the spacecraft, while equipment system 2 would comprise the scientific instruments and supporting equipment.]

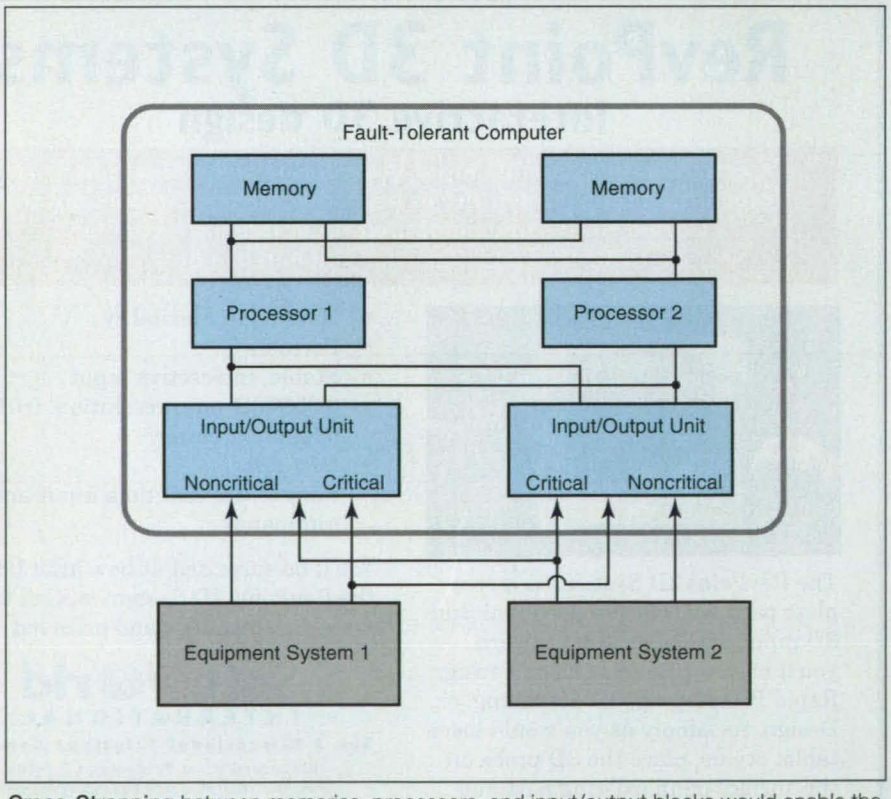
Upon detection of a fault in either processor, the surviving processor would assume the responsibility for both equipment systems. This would be possible because of cross-strapping between the processors, memories, and input/output units. During normal operation, each processor would have access to its own memory. As soon as a fault was detected in one of the processors, the surviving processor would be given access to the memory of the failed processor. The fault-recovery software of the surviving processor would immediately retrieve the information about the process states and data structures from the memory of the failed processor and would incorporate this information into its own control structure. The surviving processor could continue to use both memories as long as they remained free of faults. The failed processor would also be blocked from access to its own memory.

In the absence of any faults, all of the inputs and outputs of equipment system 1 or 2 would be routed only to processor 1 or 2, respectively. Upon detection of a failure in one processor, all inputs and outputs would be routed to the surviving processor, and the failed processor would be blocked from access to the input/output blocks.

If a major failure occurred in one of the memories, its processor would have to relocate or reestablish all of its control information and engineering or scientific data in the surviving memory. To simplify the process, each memory could include a portion reserved to accommodate the data from the failed memory. However, inevitably, some data would be lost unless a large area in each memory were reserved for recovery from failure of the other memory.

It is important to note that the input and output blocks would be only partly fault-tolerant in that only the critical inputs and outputs would be duplicated; the noncritical ones would not be duplicated. This reduction in fault tolerance would enable a reduction in the mass, power, and connectivity of the input/output blocks. Thus, if one of the input/output blocks failed, all of the critical inputs and outputs would still be routed to the processor(s), but the noncritical inputs and outputs of the equipment system connected to the failed input/output block would be lost.

This work was done by Savio Chau of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 1*** *on the TSP Request Card.*
NPO-19675



Cross-Strapping between memories, processors, and input/output blocks would enable the computer to recover from a fault in one of these units and thus continue to operate, albeit at reduced functionality.

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Improved Closed-Loop Carrier-Phase Synchronization in BPSK

A scheme motivated by the maximum-likelihood approach appears to offer advantages over other well-known schemes.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed scheme for synchronization with the phase of a received carrier signal modulated by binary phase-shift keying (BPSK) in the presence of additive white Gaussian noise (AWGN) has been selected from among several candidate schemes as one that theoretically offers the possibility of improved performance. This and the other candidate schemes that were studied theoretically follow a likelihood-function approach to the estimation of the carrier phase, as explained below. This approach involves, among other things, utilization of the power in the data-modulation sidebands to improve the carrier-phase-tracking performance over that obtainable by using the carrier signal alone.

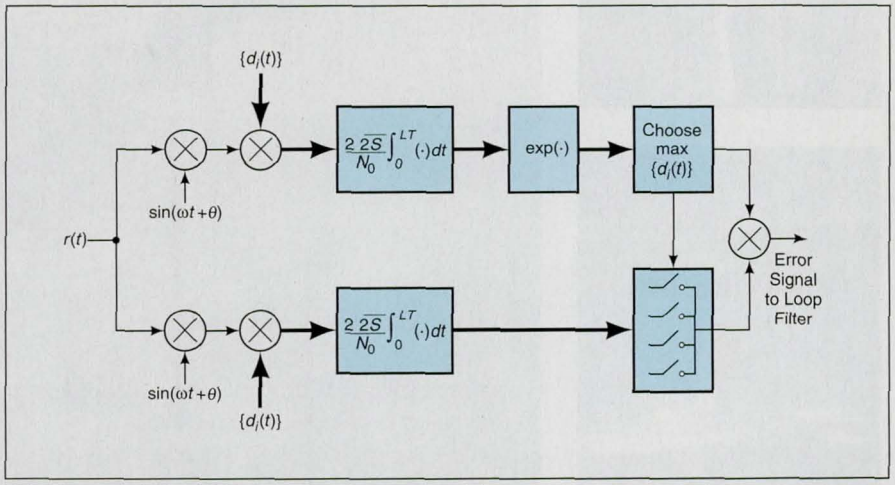
In a likelihood-function approach to the estimation of the carrier phase (θ), the optimum estimate is deemed to be that assumed value of θ that maximizes a conditional probability density function $q(\theta)$. At this optimum point, $dq(\theta)/d\theta = 0$; near this point, $dq(\theta)/d\theta$ provides an indication of the difference between the assumed value of q and the optimum value. Thus, $dq(\theta)/d\theta$ or a monotonic function of this derivative could be used as an error feedback signal in a closed-loop estimation scheme.

More specifically, the proposed scheme (see figure) follows a maximum-likelihood approach in which the computation of $q(\theta)$ involves consideration of all possible binary data sequences that could have been received during an observation time of L symbol periods and the selection of the sequence that yields the best match to the noise-corrupted received signal received during that time. The received signal is represented by $r(t) = (2S)^{1/2}d(t)\sin(\omega t+\theta) + n(t)$, where S is the received power, t is time, $d(t) = \pm 1$ is the binary data signal of symbol period T, ω is the carrier angular frequency, and $n(t)$ is the AWGN with single-sided power spectral density N. The conditional probability-density function in the proposed scheme is

$$q_{\hat{i}}(\theta) = \exp\left\{\max_{\{d_i(t)\}}\left[\frac{2\sqrt{2S}}{N}\times \int_0^{LT} r(t)d_{\hat{i}}(t)\sin(\omega t+\theta)dt\right]\right\}$$

where $\{di(t)\}$ denotes the ith data sequence, which is one of 2^L equally likely data sequences and $\hat{i}$ denotes that particular value of i for which $\{di(t)\}$ maximizes the right side of the equation. The error signal is then given by

$$dq_{\hat{i}}(\theta)/d\theta = [q_i(\theta)]\exp\left\{\max_{\{d_i(t)\}}\left[\frac{2\sqrt{2S}}{N}\times \int_0^{LT} r(t)d_{\hat{i}}(t)\sin(\omega t+\theta)dt\right]\right\}$$



This **Proposed Signal-Processing System** would generate an error signal proportional to the derivative of a conditional probability density function with respect to estimated carrier phase. This signal would serve as a feedback signal in a carrier-phase-tracking loop.

Theoretical calculations have shown that when properly optimized, this scheme could potentially exhibit mean-square-phase-error performance superior to that of other maximum-likelihood schemes and average-likelihood schemes.

This work was done by Marvin K. Simon, Haiping Tsou, and Sami M. Hinedi of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 16*** *on the TSP Request Card. NPO-19377*

Fiber-Optic Link for Transmission of a Reference Frequency

The design emphasizes maintenance of stable frequency despite changes in temperature.

NASA's Jet Propulsion Laboratory, Pasadena, California

The figure schematically illustrates a fiber-optic link for transmission of a highly stable 100-MHz reference-frequency signal to a receiver at a distance of about 700 m from the source of the signal. In the original application for which this fiber-optic link was designed, the source of the signal is a hydrogen maser in a controlled environment in a signal-processing facility, and the receiver is located on an outdoor antenna of the Deep Space Network, where the ambient temperature varies widely. Similar fiber-optic links could be used to transmit stable reference-frequency signals in other applications in which variations in temperature could otherwise potentially cause variations in signal-propagation

times and thereby cause undesired variations in frequency.

The use of a fiber-optic link to transmit a radio signal as modulation on an optical carrier signal is not new. For example, this concept was described previously in "Diplex Fiber-Optic Link for Frequency and Time Signals" (NPO-18180), *NASA Tech Briefs*, Vol. 15, No. 6 (June, 1991), page 39 and "Improved Microwave Fiber-Optic Link" (NPO-19007), *Laser Tech Briefs*, Vol. 3, No. 1 (February, 1995), page 19. What is new in the present application is the specific design, in which the emphasis is on ensuring stability of the radio frequency delivered at the output end of the optical fiber and, more particularly, minimizing the effect of variations in ambient temperature on the delivered radio frequency.

At the transmitter, the 100-MHz reference signal is used to modulate the intensity of a temperature-controlled, single-mode, distributed-feedback laser diode operating at a wavelength of 1,310 nm. Before entering the optical fiber, the output laser beam passes through two optical isolators, which are installed to prevent back reflections from degrading the laser performance. Slant-polished fiber-optic connectors at the transmitter and receiver also help to reduce reflections. Typically, the optical loss between the transmitter and receiver is less than 1 dB, and the signal arrives at the receiver with ample intensity margin.

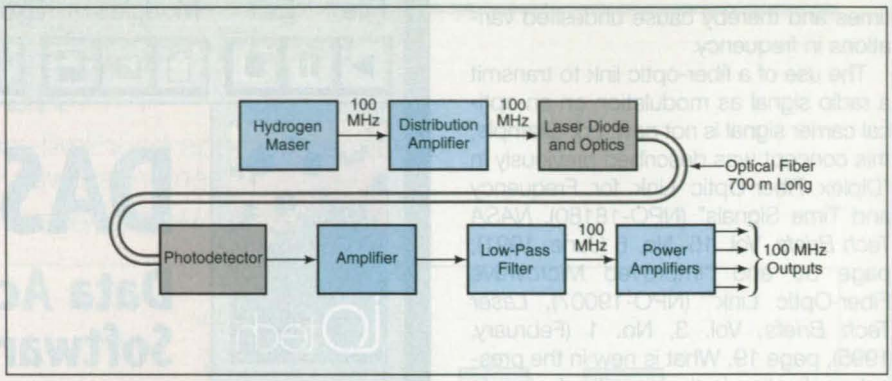
The optical fiber is a commercial fiber that has been specially treated to reduce the temperature coefficient of signal-propagation delay to $< 10^{-6}$/°C at temperatures up to 35 °C. As much of the optical fiber as possible is buried in the ground at a depth of 1.5 m, where seasonal, but not diurnal variations in temperature are observed. Only about 70 m of the fiber at the receiver end is exposed to the full variation of ambient temperature.

In the receiver, the optical signal is attenuated to prevent overdriving a photodetector, which converts the intensity modulation of the laser light back into a 100-MHz electrical signal. The radio signal is then processed through a low-noise amplifier, followed by a low-pass filter that mitigates the effects of nonlinear responses of the laser diode and photodetector. The signal is then distributed to local equipment via low-noise radio-frequency power amplifiers that provide 100 dB of isolation between output ports.

The receiver circuitry is housed in a shielded box to prevent stray electromagnetic fields at radio and lower frequencies from corrupting the 100-MHz signal. Variations in the temperature of

the receiver are reduced to 1/50 the variations in ambient temperature by a temperature-control apparatus that comprises a Peltier device, temperature sensor, and temperature-control circuit. The Allan deviation of the delivered radio frequency (a measure of its relative instability), as computed from measurements of frequency for observation times of the order of thousands of seconds, was found to be about 2×10^{-16}.

This work was done by Malcolm D. Calhoun and Paul F. Kuhnle of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 76*** *on the TSP Request Card. NPO-19083*



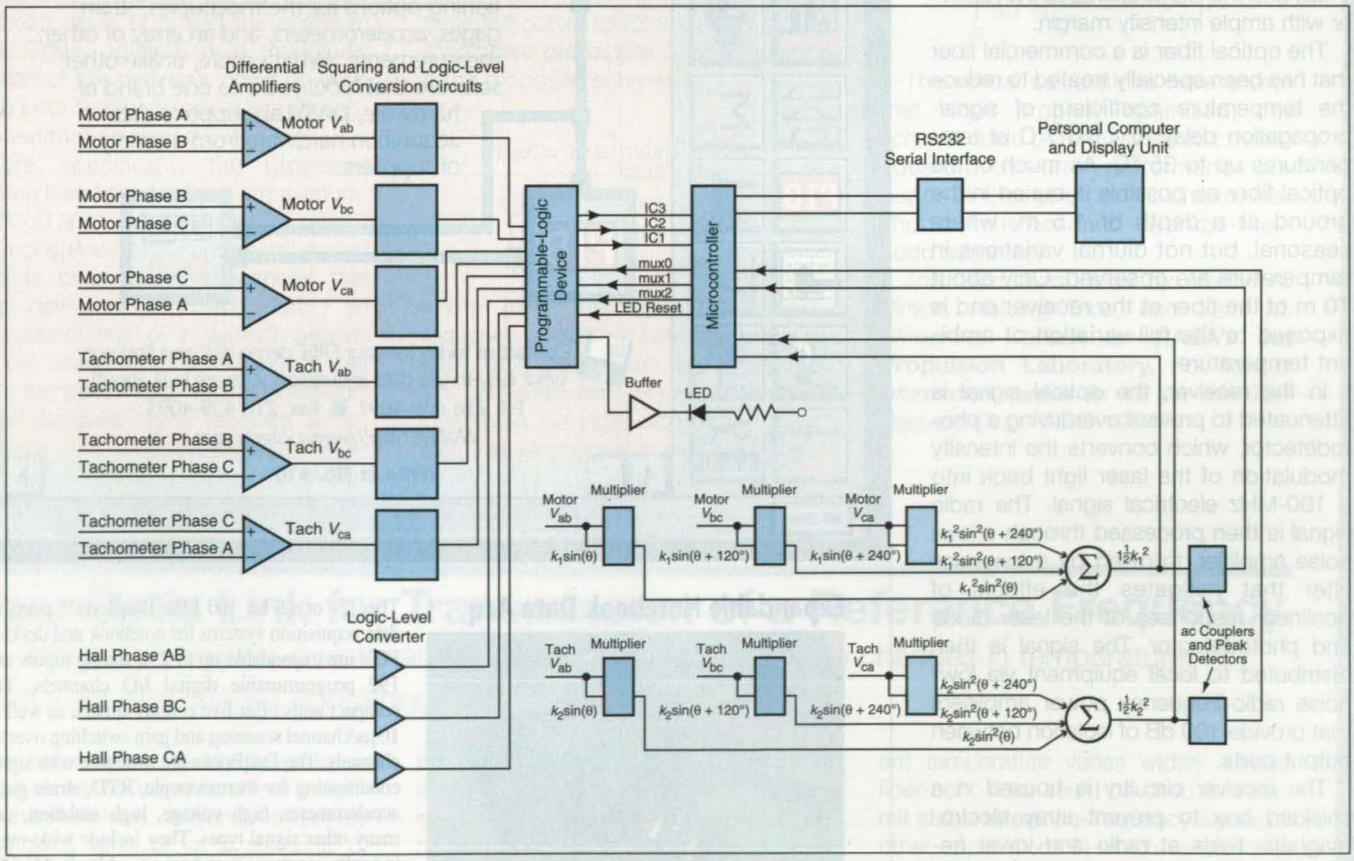
A **Fiber-Optic Link** 700 m long delivers a 100-MHz reference-frequency signal via amplitude modulation of an optical signal. Temperature control is used in the transmitter and receiver, and the optical fiber has a low temperature coefficient of delay.

System for Characterizing Three-Phase Brushless dc Motors

Tedious measurement and calculation procedures are automated.

Marshall Space Flight Center, Alabama

A system of electronic hardware and software has been developed to automate the measurements and calculations that are needed to characterize the electromechanical performances of three-phase brushless dc motors, the associated shaft-angle sensors needed for commutation, and the associated brushless tachometers. The system quickly takes measurements on all three phases of a motor, tachometer, and shaft-angle sensor simultaneously and processes the measurements into performance data. Previously, it was necessary to take measurements on one phase or pole at a time and to perform calculations based on those measurements in a tedious and time-consuming manual procedure that yielded results of doubtful accuracy. Because it automates and accelerates the motor-testing



This **System Extracts Data** on the performance of a motor from measurements of the voltages between the phase terminals of the motor, the tachometer, and the shaft-angle sensor (comprising Hall-effect devices).

process and provides more accurate performance data, this system is a prototype of systems that could also be useful in the development and testing of motors with not only three phases but also two phases and four or more phases.

The hardware portion of the system (see figure) includes a microcontroller and an RS-232 interface from the microcontroller to a personal computer. The personal computer is used to display options and issue commands to the microcontroller, make calculations on the data received from the microcontroller, and display the results.

In the normal mode of operation, an auxiliary motor is used to turn the motor under test at a suitable speed within the signal-processing capability of the microcontroller. Differential amplifiers sense the voltages between the terminals of the phases of the motor, tachometer, and shaft-angle sensor. These voltages are denoted V_{ab}, V_{bc}, and V_{ca}, where the subscripts denote phases a, b, and c. In this example, the shaft-angle sensor comprises three Hall-effect devices.

The outputs of the differential amplifiers are conditioned by squaring and level-conversion circuits to obtain signals that are compatible with transistor-transistor logic (TTL) circuitry and that exhibit level transitions between their logic levels at times that correspond to the zero crossings of the corresponding sensed voltages. These signals are fed to one set of input terminals of a programmable-logic device, while command-logic signals called "mux0," "mux1," and "mux2" are fed from the microcontroller to another set of input terminals.

The programmable-logic device puts out three logic signals called "IC1," "IC2," and "IC3," which constitute a combination of some of the TTL zero-crossing signals described in the preceding paragraph. Depending on the logic states of the "mux" commands, the combination is one of the following:

- motor V_{ab}, motor V_{bc}, and motor V_{ca};
- tachometer V_{ab}, tachometer V_{bc}, and tachometer V_{ca};
- Hall V_{ab}, Hall V_{bc}, and Hall V_{ca};
- motor V_{ab}, tachometer V_{ab}, and Hall V_{ab};
- motor V_{bc}, tachometer V_{bc}, and Hall V_{bc}; or
- motor V_{ca}, tachometer V_{ca}, and Hall V_{ca}.

Thus, by use of the microcontroller, one can select any of these combinations for further processing to determine the relative timing of the various motor, tachometer, and Hall voltages.

Another output of the programmable-logic device causes a light-emitting diode (LED) to be latched on whenever unallowable Hall-effect-device state occurs and lasts for more than about a nanosecond. An unallowable state is defined as one in which the logic states of the outputs of all three Hall-effect devices are simultaneously high or simultaneously low.

The system includes a subsystem in which each of the three motor voltages and three tachometer voltages [the back-electromotive force (EMF) signals] are squared, and these squared voltages are summed. This is done to take advantage of the trigonometric identity $k^2\{[\sin(\theta)]^2 + [\sin(\theta + 120°)]^2 + [\sin(\theta + 240°)]^2\} = (3/2)k^2$, where θ is a phase angle that, in this case, represents the instantaneous shaft angle, and k, in this case, is the amplitude of the back-EMF. Thus, at least theoretically, the sum of the squared voltages equals a constant value of $(3/2)k^2$ (provided that the motor speed is constant). The value of k obtained from this process can be used in calculating the back-EMF and torque constants of the motor.

Any ac ripple in the sum of the squared voltages about a theoretical steady value of $(3/2)k^2$ can indicate an imperfection in the motor or drive circuitry; for example, that the amplitudes of the three motor voltages are unequal, that the three voltages are not phased 120° apart, or that

at least one of these voltages is not truly sinusoidal. Accordingly, the outputs of the summing circuits are fed to ac couplers followed by peak detectors for measurement of the ac ripple.

This work was done by David E. Howard and Dennis A. Smith of **Marshall Space Flight Center.** *For further information,* ***write in 91*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center; (205) 544-0021. Refer to MFS-31029.

Rollback Hardware for Time Warp Multiprocessor Systems

This hardware helps to realize the speedup potential of parallel processing.

NASA's Jet Propulsion Laboratory, Pasadena, California

A Rollback Chip (RBC) module is a computer circuit board that contains special-purpose memory circuits for use in a multiprocessor computer system. The RBC modules are designed to help realize the speedup potential of parallel processing for simulation of discrete events by use of the Time Warp operating system developed at NASA's Jet Propulsion Laboratory.

The Time Warp algorithms accelerate object-oriented simulation of discrete events by providing a synchronization protocol for multiprocessor computer systems. Time Warp divides a simulation into multiple objects running on separate nodes that schedule events for each other. Events are scheduled for particular virtual times, and these events must be executed in the correct order. Time Warp is optimistic, and always runs each event at the earliest virtual time on each of its parallel nodes. If an event (message) from one node arrives in the simulated past at another node, Time Warp rolls back the object in question to the appropriate time to correctly simulate a new version of the event. In order to make it possible to roll the state of an object back to a previous virtual time, it is necessary to save copies of previous states of the object (as represented by collections of variables attributed to the object at various times).

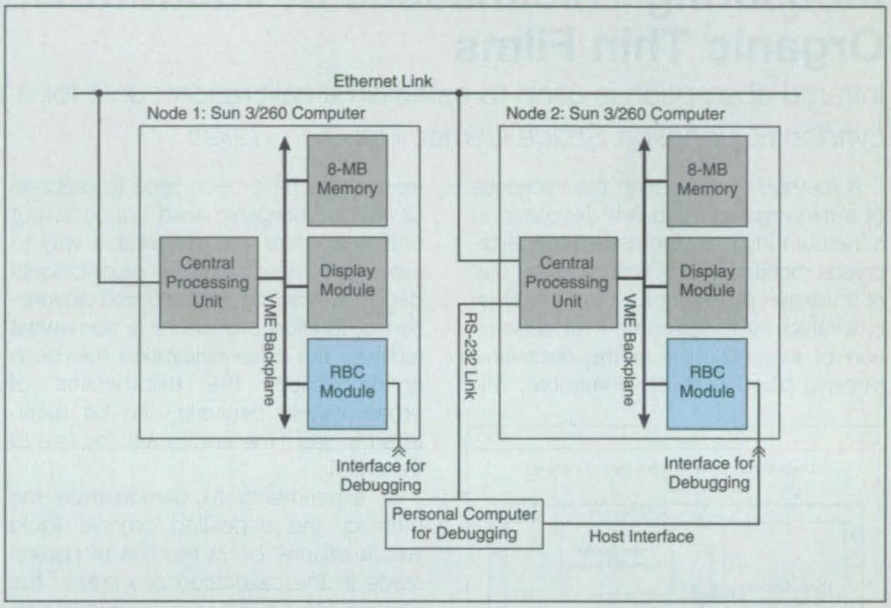
The synchronization, communication, and state-saving overhead needed for rollback and recovery can be so large as to negate the speedup theoretically afforded by parallel processing. To relieve a multiprocessor system of much of this overhead, an RBC module is installed in each processor. From the perspective of a simulation object or process, an RBC looks like an ordinary state memory, except that it keeps copies of each variable for multiple (as many as 64) preceding increments of time. Control circuitry in the RBC determines which copy of the state is made visible to the simulation; only one is made visible, on the basis of information provided by Time Warp. Because the state memory of each node now resides on its RBC rather than being part of the

main local memory of the node, this effectively frees the local memory for tasks other than state saving. Furthermore, the RBC memory is expandable; this will facilitate incremental upgrading of the multiprocessor system to enable it to simulate events of greater complexity.

Each RBC module includes a 1-megabyte-by-64-bit "most-recent-version" tracking memory array for maintenance of previous state variables, a 64-bit-wide, circular-queue priority encoder and masking algorithm implemented in four complex programmable logic devices (CPLDs), and a reduced-instruction-set computer (RISC) processor for execution, in the background, of advances and rollbacks. The RBC modules built thus far were configured as standard VersaModule Eurocard (VME) modules; some were integrated with VME backplanes of Sun 3/260 computers (see figure), and one was connected to the Sbus backplane of a Sun 4 SPARC IPX computer via a VME backplane and VME-to-Sbus translator.

Timing tests were conducted to determine the effects of the RBCs on the performances of single- and multiple-processor Time Warp systems containing Sun 3/260 processors. The tests involved three different discrete-event simulations. The results of the tests showed that the RBC modules can relieve the processors of virtually all of the overhead associated with state copying in Time Warp and thereby provide substantial performance benefits for applications in which state-copying times would otherwise constitute a large fraction of elapsed simulation times.

This work was done by Michael J. Robb and Calvin A. Buzzell of Integrated Parallel Technology, Inc., for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 100*** *on the TSP Request Card. NPO-30014*



An **RBC Module** is installed on the backplane of each processing node, along with memory modules, a display module, and other circuitry.

Measuring Thicknesses of Vacuum-Deposited Organic Thin Films

Infrared absorption is used to establish a calibration curve for a quartz-crystal monitor.

Lyndon B. Johnson Space Center, Houston, Texas

A method of measuring the thickness of a thin organic liquid film deposited in a vacuum involves the use of a quartz-crystal monitor (QCM) calibrated by use of a witness plate that has, in turn, been calibrated by measurement of absorption of infrared light in the deposited material (see Figure 1). Heretofore, witness plates have been used to calibrate QCMs for inorganic solid deposits, but until now there was no reliable way to calibrate witness plates for organic liquid deposits. The present infrared-absorption calibration procedure is somewhat tedious, but once calibration has been accomplished, the thicknesses of organic liquid deposits can be monitored in real time and *in situ* by use of the QCM.

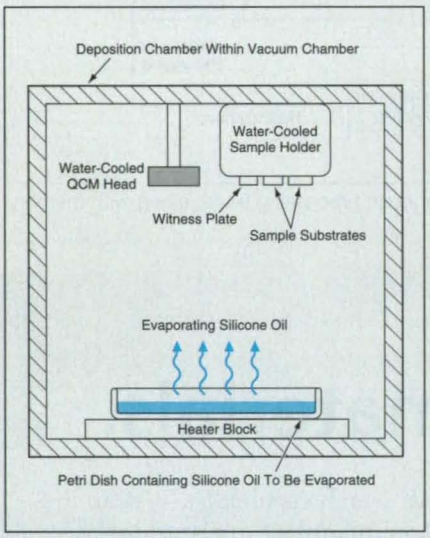


Figure 1. A **Witness Plate Is Mounted Near a QCM**. The thickness of the deposit on the QCM is measured by infrared absorption and used to calibrate the thickness reading of the QCM.

In experiments to demonstrate the method, the deposited organic liquid was a silicone oil. In the first of several steps in the calibration procedure, the silicone oil was mixed in various known concentrations with carbon tetrachloride. These liquids were chosen because they are miscible and because the infrared-absorption spectrum of the silicone oil is clearly distinguishable from the infrared-absorption spectrum of carbon tetrachloride (CCl_4).

Each of these liquid mixtures was placed in a KBr cell and the infrared-absorption spectrum of the cell and liquid mixture was measured by use of a Fourier-transform infrared (FTIR) spectrophotometer. To provide for computational elimination of the effects of absorption in the cell walls and the CCl_4, a background reading was taken on a cell containing CCl_4 only. Then by use of Beer's law, the thickness of a layer of pure silicone oil that would exhibit the same infrared absorbance was calculated from the known concentration of the silicone oil and the known length of the optical path through the cell. The resulting plot of thickness vs. absorbance served as the first of two calibration curves (see Figure 2).

In the next step of the calibration procedure, the witness plate, which is made of KBr, was analyzed by use of the FTIR spectrophotometer to obtain a background absorbance reading in the absence of any deposit. Then the witness plate was mounted in the deposition vacuum chamber near the QCM, the chamber was evacuated, and deposition was performed. This was done several times to obtain deposits of different thicknesses. Each time, the thickness of the liquid deposit on the witness plate was computed from its infrared absorbance, by use of the first calibration curve, and this computed thickness was plotted versus the QCM reading to obtain the second calibration curve. Thereafter, infrared-absorbance readings from the witness plate alone could be used to compute the thickness of the deposited

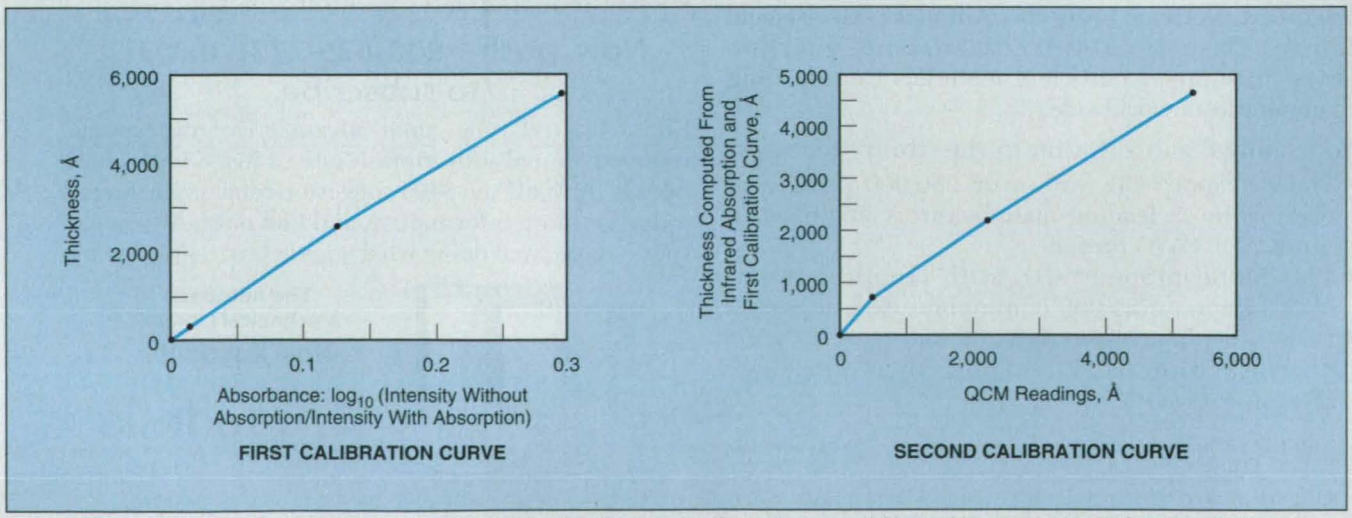


Figure 2. **Two Calibration Curves** are developed; the first for the witness plate, the second (derived by use of the first) for the QCM.

liquid by use of the second calibration curve. Of course, the validity of the calibration procedure also depends on the validity of the assumption that the thicknesses of the deposits on the QCM, the witness plate, and any other sample substrates of interest are all the same.

This work was done by Carey E. David of McDonnell Douglas Corp. for **Johnson Space Center**. *For further information,* ***write in 44*** *on the TSP Request Card. MSC-22324*

Photonic Diagnostic Technique for Thin Photoactive Films

Structural, electrical, and optical characteristics can be measured noninvasively, at high resolution.

NASA's Jet Propulsion Laboratory, Pasadena, California

A photonic diagnostic technique is being developed for use in noninvasive, rapid evaluation of thin paraelectric/ferroelectric films. The method would prove useful in basic research, on-line monitoring for quality control at any stage of fabrication, and development of novel optoelectronic systems. The method (see figure) involves simultaneous measurements of both the electrical and optical photoresponses of the film under test sandwiched between two electrodes as in a capacitor. In the case of a film-and-electrode structure on an opaque (e.g., silicon or gallium arsenide) substrate, the measured photoresponse is the photocurrent/photovoltage and photoreflectance. In the case of a film on a transparent (e.g., quartz or sapphire) substrate, the phototransmittance and the photoreflectance are both measured, in addition to the photovoltage/current. A high-resolution beam-scanning feature provides a map of the measured aspects of the microstructure of the noninvasively probed area of the film, with potential for achieving spatial resolution approaching 100 nm.

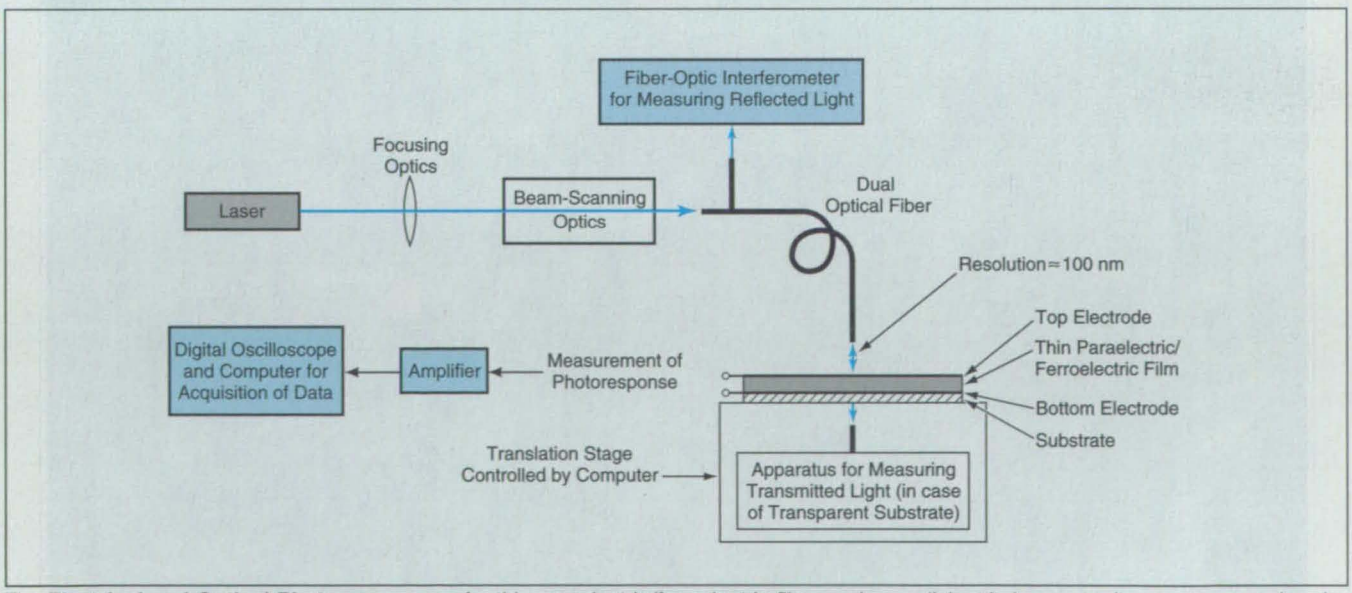
Paraelectric/ferroelectric films could be utilized to make a variety of electronic and optical devices, including microcapacitors, ultra-large-scale integrated dynamic random-access memories, nonvolatile memories, and optical memories. Typically, these films are made of multicomponent crystalline materials (e.g., perovskite titanate). Because imperfections in crystalline structures can exert profound effects on the electrical and optical properties of such films, methods of determining microstructures and associated electrical and optical properties is needed to enable further progress in understanding these films and realizing their full potential in novel electronic and optical devices.

The present method has the potential to satisfy part of that need. In particular, photoresponse mapping can provide data for correlation of microstructure at the grain and grain-boundary level with such performance parameters as leakage, time-dependent dielectric breakdown, and breakdown voltage.

This technique offers a unique, noninvasive, sensitive high-speed measure of the fatigue and retention behavior in ferroelectric nonvolatile memories. In particular, this technique could be used to predict imprint-prone memory cells, and to study time evolution of defects in the ferroelectric memories during their processing. This technique could play a vital role in enabling high-density ferroelectric memory manufacturing.

One potential application may lie in the use of photoresponse for nondestructive readout of polarization memory states in high-density, high-speed memory devices. In another application, an extension of the basic concept of this method may make it possible to develop a specially tailored ferrocapacitor to act as a programmable detector, wherein the remanent polarization could be used to modulate the photoresponse. Large arrays of such detectors could be useful in optoelectronic processing, computing, and communication.

This work was done by Sarita Thakoor of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 17*** *on the TSP Request Card. NPO-19393*



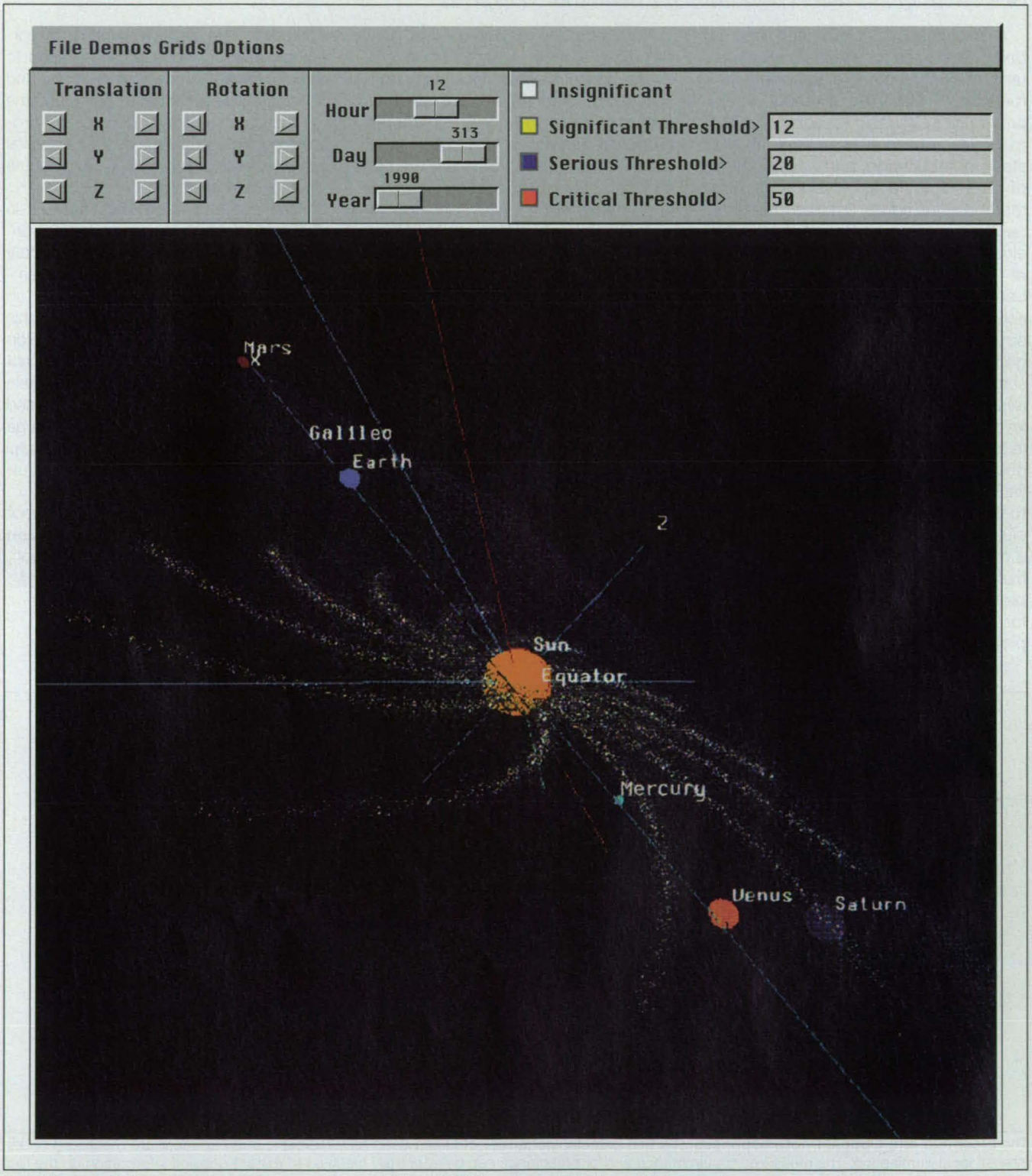
The **Electrical and Optical Photoresponses** of a thin paraelectric/ferroelectric film used as a dielectric in a capacitor are measured under intense local illumination. The measured transmittance and/or reflectance can be spectrally resolved to extract detailed information on the film material.

Predicting Arrival of Protons Emitted in Solar Flares

Action can be taken to protect electrical and electronic systems.

NASA's Jet Propulsion Laboratory, Pasadena, California

The Visual Utility for the Localization of Corona Accelerated Nuclei (VULCAN) computer program provides both advance warnings and insight for post-event analyses of the effects of solar flares. Using measurements of the peak fluxes, times of detection, flare location, solar wind velocities, and x-ray emissions from the Sun, as electronically sent by NOAA (National Oceanographic and Atmospheric Administration), VULCAN predicts the resulting intensities of proton fluxes at various user-chosen points (spacecraft or planets) of the solar system. It also



Spiral Proton Trajectories in the mathematical model in VULCAN are essentially lines of the interplanetary magnetic field.

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predicts the times of onset of the fluxes of protons and the peak values of these fluxes. In so doing, VULCAN provides warnings to the operators of electronic and electrical systems that can be affected by the proton fluxes. Such systems include Earth-station/spacecraft communication systems, aviation communication systems operating in polar regions, and some electric-power-distribution systems.

VULCAN implements a mathematical model of proton trajectories and fluxes based on two principles:

- Certain solar electromagnetic emissions of varying intensity are indicative of proton fluxes.
- Protons are transported from the Sun nondiffusively in the inner heliosphere, along spiral trajectories that can be described by strict mathematical relationships. [As used here, "inner heliosphere" means the space from Mercury out to Mars. (Even though the theory as proposed by Smart/Shea at the Air Force Geophysical Laboratory only treats points within the inner heliosphere near the plane of ecliptic, VULCAN computes fluxes and displays trajectories outside this region for experimental purposes.)]

VULCAN provides a graphical user interface that includes several window displays (see figure). When a flare is detected, a small icon is changed (with beeping) to alert the user to the event, and the flux and trajectory computations are performed.

This work was done by John N. Spagnuolo, Jr., Ursula M. Schwuttke, Cecilia S. Han, and Felipe Hervias of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 98*** *on the TSP Request Card. NPO-19263*

Multicolor Holography With Phase Shifting

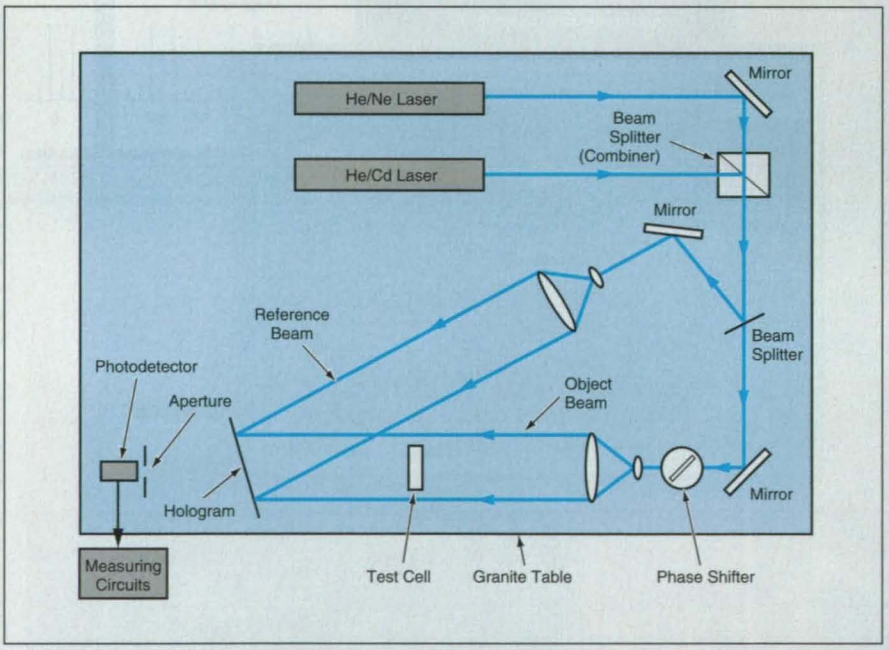
Measurements can yield data on multiple phenomena that affect refraction.

Marshall Space Flight Center, Alabama

Multicolor holography is one of a number of optical techniques that are being developed for use in nonintrusive measurement of flow phenomena that affect indices of refraction. Two phenomena of particular interest in this regard are the gradients of temperature and concentration in the liquid in a crystal-growth apparatus. Single-color holographic interferometry provides data on spatial variations of the index of refraction in a fluid, but the effects of temperature and concentration are combined, and it would be necessary to acquire ancillary temperature data (e.g., from intrusive thermocouple probes) to separate the temperature and concentration effects. However, two-color holography provides the two sets of data needed to solve the equations for the effects of temperature and concentration. The concept can be extended to holography at three or more wavelengths to measure three or more phenomena associated with significant variations in the index of refraction.

The figure is a schematic diagram of a prototype apparatus constructed to test feasibility of a two-color holographic interferometric scheme in which data for reconstructing the holographic wavefront are obtained with the help of a phase-shifting technique. The hologram is recorded initially when the fluid in the test cell is in a standard or known condition (e.g., a homogeneous solution containing a known concentration of solute at a known temperature). The hologram is developed and put back into the position in which it was recorded. Thereafter, interference between the light diffracted by the hologram and the light refracted by the test cell is related to changes of temperature and/or concentration in the test cell.

The interference fringes — the variations in the intensity of illumination across a suitably defined observation surface — contain information on the wavefront phase distribution, from which the spatial variations of the index of refraction can be computationally reconstructed. In this case, the intensity pattern is measured by a photodetector that is scanned across the observation surface. This scan is repeated at several different settings of the phase shifter in the object beam. Then by solving the simultaneous equations for the measured intensities at the various phase settings at each measurement position, one can obtain the desired phase distribution. Experiments on the prototype apparatus showed that it is possible to resolve the phase distribution to better than 1/200 fringe.



In this **Two-Color Holographic Interferometric Apparatus**, the holographic phase distribution or wavefront is reconstructed from photodetector scans at several different settings of the phase shifter.

This work was done by Chandra S. Vikram of the University of Alabama for **Marshall Space Flight Center.** *For further information,* ***write in 6*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center; (205) 544-0021. Refer to MFS-27316.

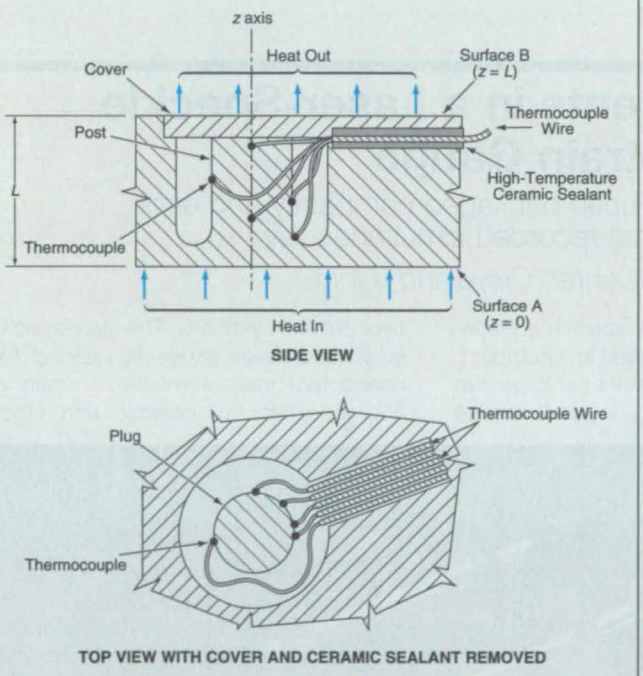
Dual-Active-Surface Miniature Plug-Type Heat-Flux Gauges

The gauges are incorporated integrally into heat-transfer walls.

Lewis Research Center, Cleveland, Ohio

Improved miniature plug-type heat-flux gauges have been developed for determining fluxes of heat through the surfaces on both sides of heat-transfer walls. The walls could be those of heat exchangers, engine housings, furnaces, chemical reactors, or any of a variety of other structures in which the fluxes of heat are important quantities that one seeks to measure.

Of other types of heat-flux gauges, some are restricted to measuring fluxes of heat across single surfaces and some are restricted to measuring either transient or steady fluxes (but not both). Also, some introduce substantial thermal-conduction discontinuities that perturb wall temperature fields appreciably and thus contribute large errors to the measurements. The present improved gauges yield data on both transient and steady



This **Miniature Plug-Type Heat-Flux Gauge** yields measurement data from which one can compute steady or transient fluxes of heat through surfaces A and B.

fluxes, and they are incorporated integrally into the heat-transfer walls in such a way as to minimize perturbations of wall temperature fields.

As shown in the figure, a gauge of this type includes a cylindrical plug that is formed as an integral part of the heat-transfer wall: a cylindrical layer of wall material extending part way through the thickness of the wall is removed by electrical-discharge machining, so that the plug is what is left in the middle. A recess for a cover is also machined into the wall on the side from which the plug is machined.

Thermocouples are welded to the plug at several positions along the plug to provide multiple temperature measurements

for computing the thickness-wise gradient of temperature as a function of position through the thickness. A cover made of the same material as that of the wall is welded or brazed in place in the recess, taking care to ensure intimate thermal contact between the cover and the back surface of the plug. The thermocouple leads are brought out through a groove machined into the wall under the cover.

Assuming that the gradient of temperature is predominantly through the thickness (no substantial thermal gradient along either surface), the equation for the heat balance in the gauge is $dq_A/dt = dq_S/dt + dq_B/dt$, where t is time, dq_A/dt is the flux of heat into the gauge through surface A, q_S is the heat per unit area stored in the gauge, and dq_B/dt is the flux of heat out of the gauge through surface B.

The rate of change of stored heat per unit area (the second term in the equation above) can be calculated from the experimental values of temperature as functions of position and time by the equation

$$dq_S / dt = \int_0^L (\rho C \partial T / \partial t)\, dz$$

where ρ is the mass density of the plug material, C is the mass-specific heat of the material, and T is the temperature at time t and depth z. The flux of heat out of the gauge through surface B can be calculated from $dq_B/dt = -k\partial T/\partial z$ at $z = L$. Using the measurement temperature values, these equations can be solved together numerically to obtain the fluxes of heat through surfaces A and B.

This work was done by Curt H. Liebert and John Koch, Jr., of **Lewis Research Center.** *For further information,* ***write in 82*** *on the TSP Request Card.*

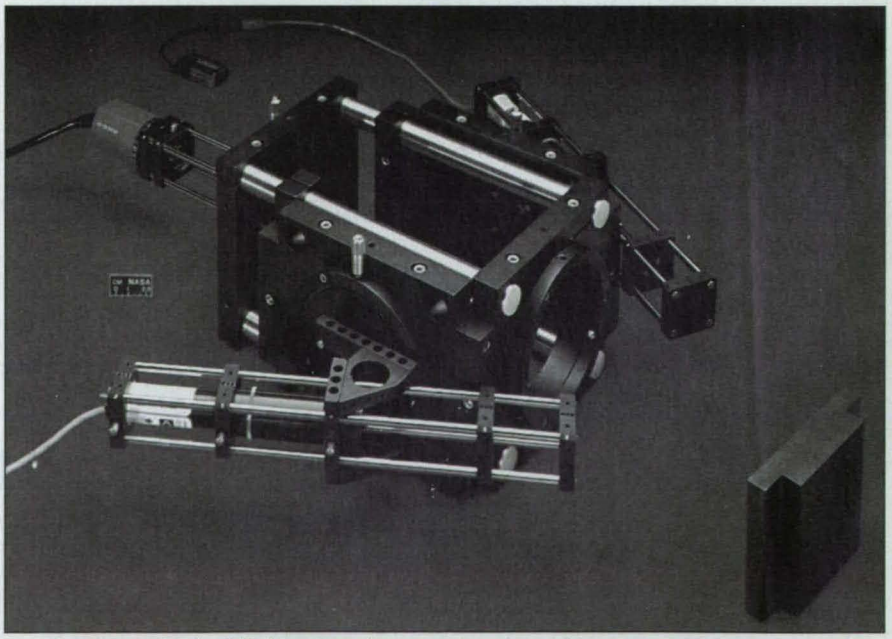
This invention has been patented by NASA (U.S. Patent No. 5,314,247). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Lewis Research Center; (216) 433-2320. Refer to LEW-15643.

Improvements in a Laser-Speckle Surface-Strain Gauge

The optics have been packaged compactly and error correction data are recorded simultaneously.

Lewis Research Center, Cleveland, Ohio

Advances in a laser-speckle surface-strain gauge have resulted in a compact, easy-to-use measurement package that exhibits improvements in performance over previous versions. The laser-speckle surface-strain gauge is needed for noncontact measurements of strain in hot specimens of ceramic and other



The **Compact Optical Subsystem** incorporates several improvements over the optical subsystems of previous versions of the laser-speckle surface-strain gauge: faster acquisition of data, faster response to transients, reduced size and weight, lower cost, and less complexity.

refractory materials. The operation of the laser-speckle surface-strain gauge is based on Ichirou Yamaguchi's theory of deducing strains from shifts in speckle patterns of two laser beams reflected from a specimen: The principle of operation was described previously in two articles in *NASA Tech Briefs*, Vol. 17, No. 4 (April, 1993): "Laser System Measures Two-Dimensional Strain" (LEW-15046), page 22; and "Two-Dimensional Laser-Speckle Surface-Strain Gauge" (LEW-15337), page 25.

A brief review of the principle of operation will help to explain the advantages of the current version of the laser-speckle surface-strain gauge. Laser-speckle patterns, generated by the spatially coherent illumination of a rough specimen surface, shift when the surface is strained or when the specimen undergoes rigid-body motion. The speckle patterns are recorded on a two-dimensional array of charge-coupled devices (CCDs) before and after shifting, and cross-correlations of a single video line are calculated to determine the amount of shift between them. Errors contributed by rigid-body motions are canceled by taking differences between shifts of speckle patterns generated by two laser beams incident on the specimen from equal but opposite angles; only the strain components of the shifts remain after the subtraction.

The current version of the laser-speckle surface-strain gauge includes an improved, compact optical subsystem (see figure) in which the illumination to form the speckle patterns is provided by two small, visible-wavelength laser diodes. The optical design enables the simultaneous recording of the two speckle patterns on a single two-dimensional CCD array. This greatly decreases the sensitivity of the measurement to rigid-body motion and makes it possible to determine surface strains accurately from measurements of speckle patterns that move faster and over longer distances because of faster dynamic loading of the specimen.

The current version also includes a high-performance digital image-data processor plugged into a bus on a desktop computer. The computer synchronizes the acquisition of image and load data, and the processor computes the strains from the speckle-image data, at a repetition rate of about 5 Hz. The overall system is fully automated under control of the computer and can be operated remotely.

This work was done by Christian T. Lant of Sverdrup Technology, Inc., for **Lewis Research Center.** *For further information,* ***write in 94*** *on the TSP Request Card. LEW-15914*

Improvements in Vapor-Detecting Electrochemical Cells

John F. Kennedy Space Center, Florida

Improvements have been made to extend the lifetimes of electrochemical cells used at Kennedy Space Center to detect monomethyl hydrazine vapors. Degradation and failures of the cells have been attributed to several causes, including leakage of the electrolyte (a 28-percent potassium hydroxide solution), buildup of potassium carbonate on membranes in the cells, and deterioration of the membranes. The buildup of potassium carbonate appears to be caused by chemical reaction of atmospheric CO_2 with the electrolyte. Deterioration of the membrane is linked to pressure fluctuations caused by on/off cycles of a detector pump. The fragile membrane tends to tear under the com-

bined influences of the deposits and pump oscillations. The addition of a filter or damper volume between the cell and the pump was found to reduce pressure fluctuations at the cell. The substitution of cesium hydroxide for potassium hydroxide in the electrolyte was found to at least double the life of a typical cell. Also, because the cesium carbonate resulting from the CO_2/air-electrolyte interaction is more soluble than potassium carbonate is, the potential for deposition of carbonate is reduced.

This work was done by Dale E. Lueck of **Kennedy Space Center**; *Barry J. Meneghelli and Nilgun A. Leavitt of I-NET; Susan L. Rose-Pehrsson of the U. S. Naval Research Laboratory; and Karen P. Brenner of Geo-Centers, Inc. For further information,* ***write in 26*** *on the TSP Request Card. KSC-11706*

Telescope With a Two-Color Camera and Two Imaging Spectrometers

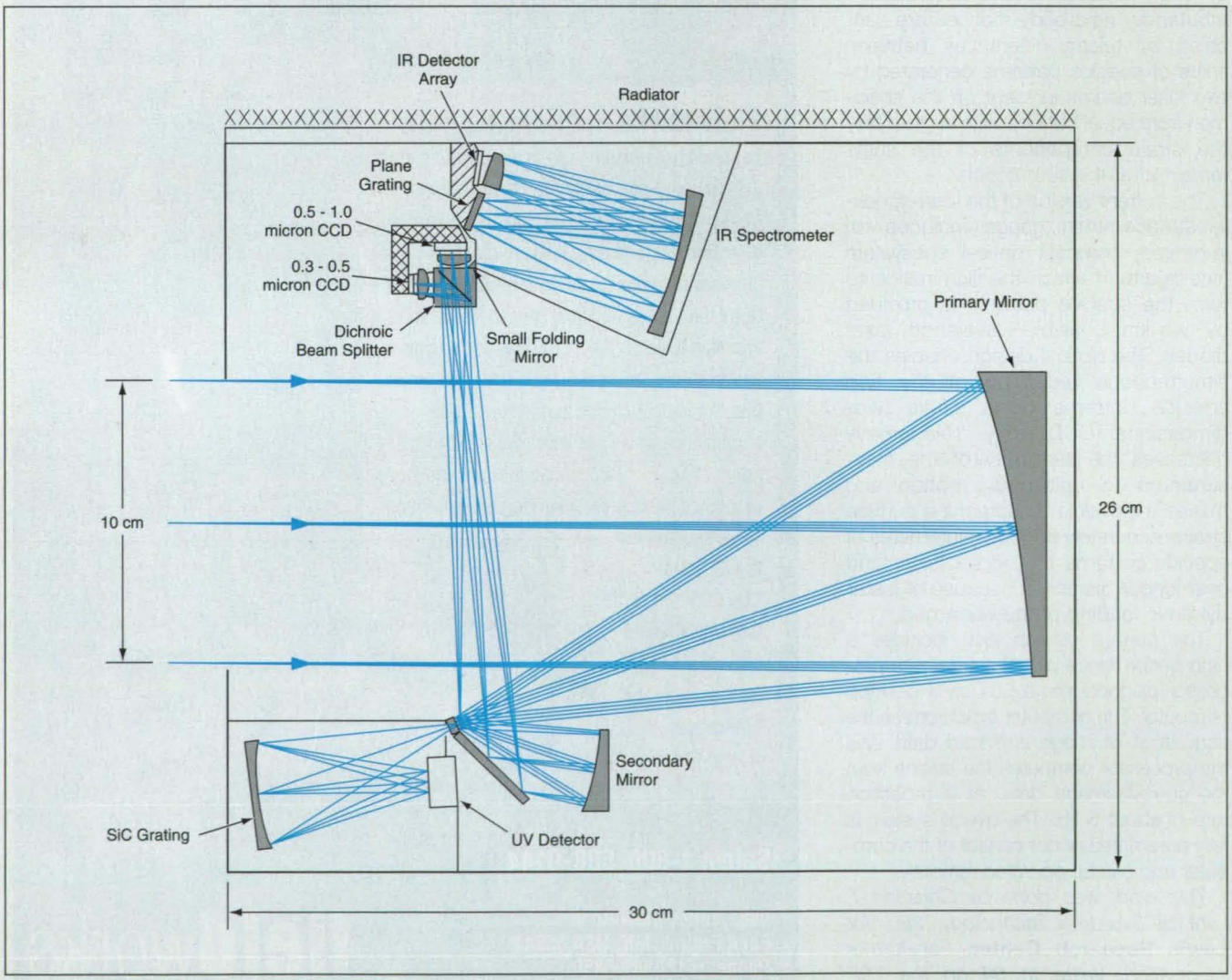
Multiple instruments share common foreoptics in a compact, lightweight package.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed remote-sensing optical instrument system includes two charge-coupled-device (CCD) video cameras sensitive to different colors of light; a line-imaging infrared spectrometer; and a line-imaging ultraviolet spectrometer; all sharing common telescope foreoptics. Principal advantages of this system are compactness and light weight. Previously, such an assembly of instruments would have been considerably larger and heavier because each instrument would have been designed as a separate unit with its own telescope.

The upper part of the figure shows the basic optical configuration with ray traces. As shown in the lower part of the figure, the fields of the two cameras occupy the same position in the field of view, while the slits of the two line-imaging spectrometers occupy positions adjacent to, and on opposite sides of, the camera fields.

The primary and secondary telescope mirrors are off-axis sections of rotationally symmetric aspheres made from aluminum by diamond turning with postpol-



Four Optoelectronic Instruments are integrated into a compact, lightweight package in which they share common telescope foreoptics.

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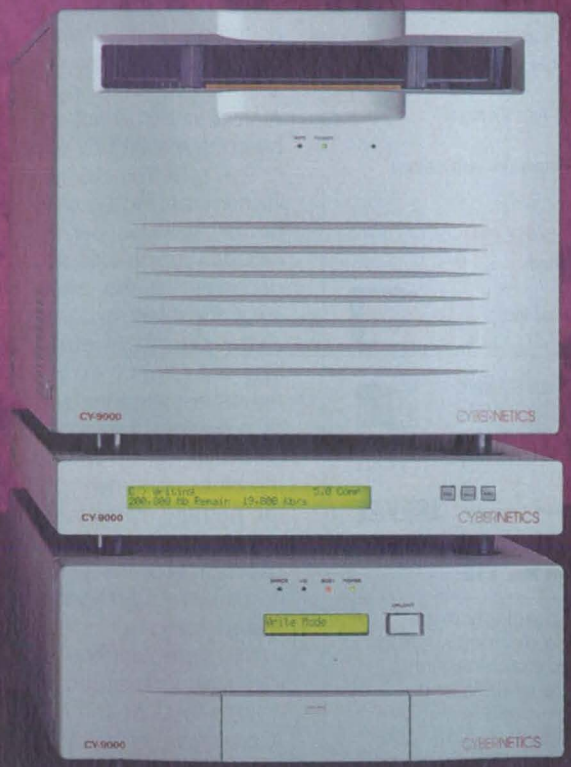

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ishing. Before reaching the secondary mirror, the light from the primary mirror is focused onto a small folding mirror, which splits the field of view into two parts: the folding mirror is sized and positioned so as to (1) allow the light bound for the line-imaging ultraviolet spectrometer to pass by and enter the slit of this spectrometer and (2) reflect, toward the secondary telescope mirror, the light bound for the cameras and the line-imaging infrared spectrometer.

The secondary mirror focuses this light across the telescope to the cameras and the cooled subassembly containing the line-imaging infrared spectrometer. The light passes through a cubic dichroic beam splitter, which divides the light into shorter- and longer-wavelength beams. The shorter-wavelength beam passes through a field-flattening lens and is focused onto the CCD in one camera. The longer-wavelength beam passes through another field-flattening lens and is focused onto the other CCD. A small mirror attached to the dichroic cube brings the off-axis beam to the slit of the infrared spectrometer.

This spectrometer is related to spectrometers of the Czerny-Turner type, with a short focal length. It utilizes a plane grating of 100 grooves per millimeter and a focusing mirror. It also includes an off-axis segment of a spherical lens, which compensates for the extreme field curvature occasioned by the small-focal-length design.

The placement of the line-imaging ultraviolet spectrometer near the primary focus instead of at the secondary focus with the other instruments helps to solve the major design problem of providing sufficient ultraviolet transmittance. The loss of ultraviolet light is limited by sharing only the primary mirror with the other instruments in the system. To limit this reflection loss, the primary mirror is coated with platinum.

The entrance slit of the line-imaging ultraviolet imaging spectrometer lies slightly off-axis from the focus of the primary mirror and adjacent to the fold mirror. The aberration-corrected holographic toroidal grating in this spectrometer has a nominal groove frequency of 1,200 grooves per millimeter and is coated with silicon carbide to maximize its reflectance. This grating focuses the light onto a microchannel detector array. A prototype of this instrument has been made out of silicon carbide and tested.

This work was done by Michael P. Chrisp of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 35*** *on the TSP Request Card. NPO-19188*

Using BEEM To Probe Strains in Semiconductors

Spatial resolutions at the nanometer level can be achieved.

NASA's Jet Propulsion Laboratory, Pasadena, California

Ballistic-electron-emission microscopy (BEEM) has been found to be useful in determining strains in semiconductors under some conditions. More specifically, BEEM is a variant of scanning tunneling microscopy and is sensitive to the electronic structure of the probed material. In the present approach, BEEM is used to obtain data on those aspects of variations in electronic structures that are related to variations in strains. Then by use of mathematical modeling of relationships between electronic structures and strains, the variations in strains are deduced from the BEEM data.

The strains that one seeks to examine in this way are those induced by mismatches of crystalline lattices between adjacent layers of different semiconductor materials in semiconductor heterostructures. The strains involve distortions of the lattices, and these distortions modify the electron-energy-band structures of the materials. Knowledge of strains is therefore useful for correct mathematical modeling of the electronic behaviors of semiconductor devices. Because of its relatively high spatial resolution (of the order of a nanometer in a plane parallel to the planes of the semiconductor layers), BEEM is superior to other techniques for acquisition of strain-related data at the required microscopic level.

In this use of BEEM, measurements are performed in a nitrogen-purged glove-box at room temperature and at 77 K. Electrons are injected, by quantum-mechanical tunneling, into a metal layer on the specimen to be probed. By varying the tip-sample voltage, energies of electrons injected into the specimen can be controlled, and a spectroscopy of transport can be performed.

This approach has been applied to $Ag/Si_{1-x}Ge_x/Si$ and $Au/Si_{1-x}Ge_x/Si$ specimens, in which electron-conduction bands are split because of strains. In the analysis of BEEM data from such specimens, one uses the dependency of conduction-band splitting on the Ge alloy fraction, x. Numerical methods are used to model variations of strain induced by surface roughness, and a finite-element mathematical model is used to represent the effects of elasticity. Derived strains in a layer are then used to calculate conduction-band positions and splittings.

This work was done by L. Douglas Bell, Autumn M. Milliken, Stephen J. Manion, and William J. Kaiser of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 32*** *on the TSP Request Card. NPO-19608*

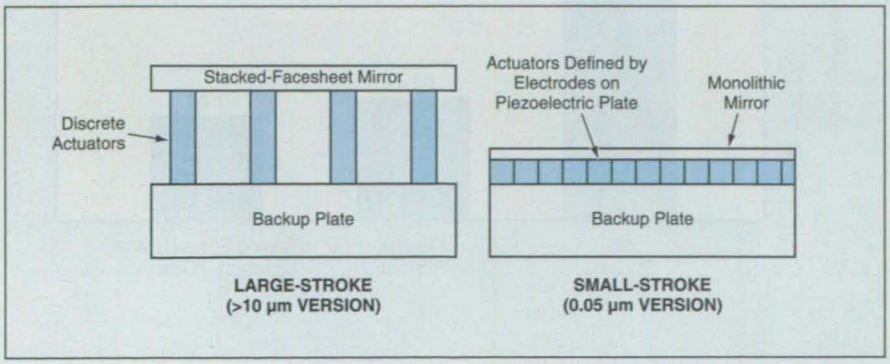
Adaptive Optics for Imaging Bright Objects Next to Dim Ones

Corrections would be made for scattering from imperfections in the imaging optics.

NASA's Jet Propulsion Laboratory, Pasadena, California

Adaptive optics would be used in imaging optical systems, according to a proposal, to enhance high-dynamic-range images (images of bright objects next to dim objects). The adaptive optics would be designed to alter wavefronts to correct for the effects of scattering of light from small bumps on the imaging optics. The original intended application of this concept would be in an advanced camera to be installed on the Hubble Space Telescope for imaging of such phenomena as large planets near stars other than the Sun. The concept is also applicable to other high-quality telescopes and cameras.

In an optical system that is not diffraction-limited, the scattering of light from the bumps on the imaging optics (the sizes of the bumps are 10 to 30 nm in the original application) is the source of the fundamental limitation on high-dynamic-range imaging. In the image plane, the scattered light appears to diffuse out of the image of the bright object into the adjacent area, where it can overwhelm the image of the nearby dim object that one seeks to view simultane-



An **Array of Piezoelectric Actuators** would support a mirror and deform the mirror as commanded. Optionally, as shown at the right, the array of actuators could be defined by an array of electrodes on a unitary plate of piezoelectric ceramic.

ously. Accordingly, the proposal for enhancing the image is based on a strategy of redistributing the scattered light and, more specifically, diverting as much of it as possible away from the small region of the image that contains the bright and dim objects of interest.

"Adaptive optics" (also called "active optics") in this context denotes a deformable mirror supported by a suitably large number, *N*, of piezoelectric actuators (see figure). By applying a suitable voltage to each actuator, one could deform the mirror surface slightly and thereby alter the wavefronts of light reflected from the mirror. In the proposed method, a control system would produce actuator voltages computed to alter the wavefronts of the light focused into the image to correct as much as possible for the effects of scattering on the light propagating toward the small image region of interest.

The computation would be performed according to the dark-hole algorithm, which exploits the facts that (1) each pixel in the image plane represents one component of a Fourier transform of the pupil wavefront of the imaging optical system and (2) by use of a deformable mirror, spatial frequencies within the Nyquist limit can be set to arbitrary values. In the proposed method, the dark-hole algorithm would compute mirror deformations to be effected by *N* actuators to set the intensity of scattered light to zero in *N* adjacent pixels.

This work was done by Michael Shao, Jeffrey W. Yu, and Fabien Malbet of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 89*** *on the TSP Request Card.*
NPO-19244

Pyrolytic Carbon as a Lubricant in Hot Ceramic Bearings

The carbon would be replenished by a flow of ethylene.

Lewis Research Center, Cleveland, Ohio

Pyrolytic carbon may prove useful as a solid lubricant in ceramic bearings in advanced gas-turbine engines, where high temperatures would destroy liquid lubricants. Ethylene gas would be made to flow past the bearings and would be pyrolized to replenish the carbon lubricant particles.

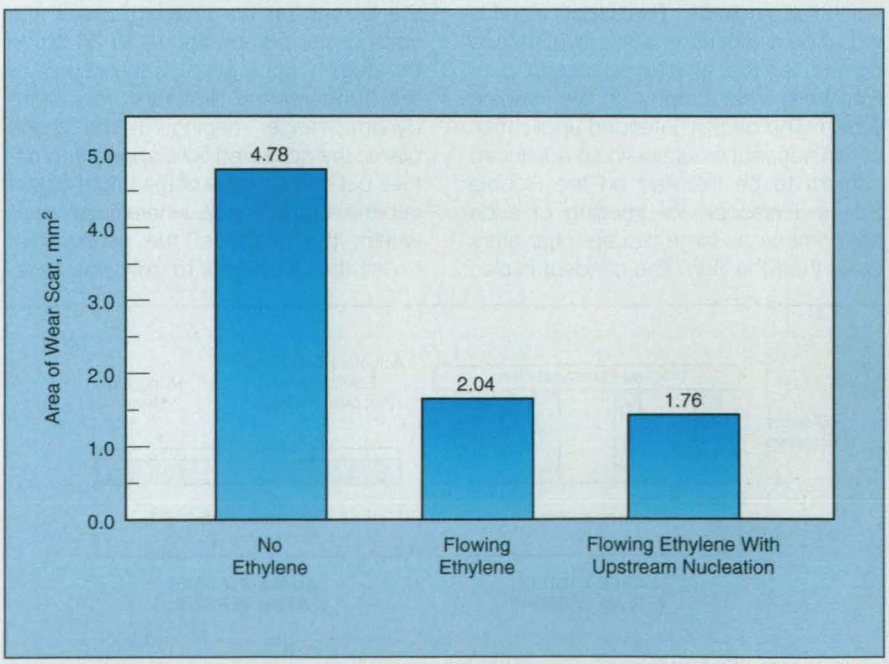
The underlying chemical and physical principles are probably related to those of a technique, studied during the 1950s, that involved flash photolysis of hydrocarbons. In that technique, hydrocarbons were heated rapidly to "flash temperatures," then cooled in friction contacts.

The concept is based partly on the observation that pyrolysis of hydrocarbons to solid carbon occurs in two stages — nucleation followed by growth of particles — and the rates in the two stages are different. The nature of the nuclei is still unknown; it has been conjectured that they could be (a) C_2, CH^+, and/or C_2H_2 in the gas phase, and/or (b) a particular form of solid carbon deposited on the surfaces to be lubricated. Both the nucleation and growth stages depend on temperature and the gradient of temperature. Moreover, the nucleation stage is likely to be influenced by surface catalysis.

In a lubrication system according to this concept, the ethylene gas would flow past a heated catalytic surface before reaching the somewhat cooler bearing surfaces. Thus, most of the nucleation would be made to take place upstream of the bearing, and the lubricating carbon particles would grow on the bearing surfaces. The friction on the bearing surfaces would provide the thermal flash necessary for growth of particles from the nuclei already present in the flowing gas.

The feasibility of this concept has been demonstrated in several experiments, including sliding-contact tests in a pin-on-disk tribometer and both sliding- and rolling-contact tests in a modified four-ball tribometer. Tests were conducted both with and without flowing ethylene, at contact-surface temperatures of about 500 °C. Of the tests in which ethylene was used, some did and some did not involve prenucleation by heating the flowing gas about 30 cm upstream with a nichrome wire heated electrically to a temperature of 800 °C. For example, the results of four-ball sliding tests (see figure) clearly show a reduction of wear in the presence of flowing ethylene and a further reduction of wear effected by upstream nucleation.

This work was done by J. L. Lauer of Rensselaer Polytechnic Institute and L. C. Davis of Allison Engine Co. for **Lewis Research Center.** *For further information,* ***write in 69*** *on the TSP Request Card. LEW-16190*



Sizes of Wear Scars were measured after sliding-contact tests in a modified four-ball tribometer. The tests were conducted at a contact-surface temperature of 575 °C, contact pressure of 2.66 GPa, and speed of 7.8 cm/s for 5 min.

Atomic Oxygen Removes Varnish and Lacquer From Old Paintings

The underlying paint layers are not damaged.

Lewis Research Center, Cleveland, Ohio

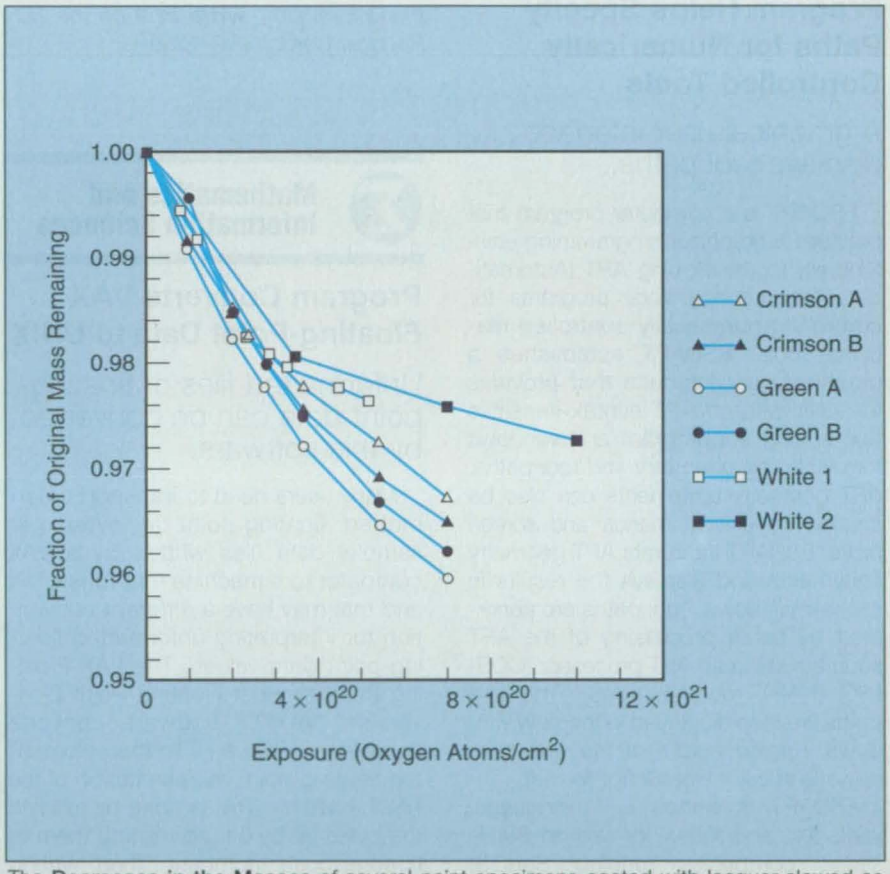
A dry and relatively nondestructive plasma process has been found to be effective in removing protective coats of varnish and/or lacquer from old paintings. Because these protective coats become yellow and cracked as they age, they are often removed and replaced during efforts to restore old paintings. Heretofore, varnish or lacquer coats have been removed by a variety of techniques that involve solvents (which may damage or alter the pigment layers) and, sometimes, mechanical contact (which can disturb or remove pigments).

The plasma process is one that generates monatomic oxygen, which reacts with varnish, lacquer, polyurethane, acrylic, and other organic coating materials; the reactions produce mostly carbon monoxide and water vapor, which are simply pumped away by the vacuum system in which the plasma is generated. The monatomic oxygen does not attack oxide-based pigments in underlying paint layers, and brush-stroke marks remain undisturbed.

If allowed to reach the underlying paint, the atomic oxygen does slightly attack the vehicle (binder) at the surface of the paint, causing a microscopic texturing of the surface and consequently a more matte appearance. However, this visible effect can be reversed almost completely by recoating with new varnish or lacquer. The process can also be used on a painting that contains organic-based pigments if the exposure is carefully timed so that it can be stopped just as the last of the protective coat is removed and before the paint is attacked.

A commercial radio-frequency plasma apparatus was used to demonstrate the process. Samples of paint on glass slides and coupons from a painting on fiberboard were placed in the vacuum chamber of the plasma apparatus. The chamber was partly evacuated, leaving air at a pressure of 100 millitorr (13 Pa) to form the plasma. At intervals, the exposure to the plasma was interrupted and the samples removed for weighing (to determine losses of mass) and for measurements of light from the surface to determine changes in reflectance. The rates of loss of mass were found to decrease slightly once the varnish or lacquer coats had been removed (see figure), indicating that reaction with the monatomic oxygen in the plasma slowed when the oxide-based pigments in the paint were reached. These pigments helped to shield the underlying vehicle materials.

This work was done by Sharon K. Rutledge and Bruce A. Banks of **Lewis Research Center** *and Michael Cales of Cleveland State University. For further information,* ***write in 97*** *on the TSP Request Card.*



The **Decreases in the Masses** of several paint specimens coated with lacquer slowed as the lacquer was consumed and the plasma containing monatomic oxygen reached the underlying paint.

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Lewis Research Center; (216) 433-2320. Refer to LEW-16031.

Computer Programs

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Manufacturing/ Fabrication

Program Helps Specify Paths for Numerically Controlled Tools

A graphical user interface displays tool paths.

ESDAPT is a computer program that provides a graphical programming environment for developing APT (Automatically Programmed Tool) programs for controlling numerically controlled machine tools. ESDAPT establishes a graphical user interface that provides the user with an APT syntax-sensitive text-editing subprogram and windows for displaying geometry and tool paths. APT geometry statements can also be created by use of menus and screen picks. ESDAPT interprets APT geometry statements and displays the results in its view windows. Tool paths are generated by batch processing of the APT source code in an APT processor (COSMIC P-APT recommended). The tool paths are then displayed in the view windows. Printed output of the view windows is in color PostScript format.

ESDAPT is written in C language, yacc, lex, and XView for use on Sun4-series computers running SunOS. ESDAPT requires 4MB of disk space, 7MB of random-access memory, and release 4 of version 11 of MIT's X Window System, or version 3 of OpenWindows for execution. Program documentation in PostScript format and an executable code for version 3 of OpenWin-dows are provided on the distribution medium. The standard medium for distribution of ESDAPT is a 0.25-in. (6.35-mm) streaming-magnetic-tape cartridge (Sun QIC-24) in UNIX tar format. This program was developed in 1992.

This program was written by Timothy Premack and James Poland, Jr., of **Goddard Space Flight Center.** *For further information,* ***write in 9*** *on the TSP Request Card. GSC-13590*

Mathematics and Information Sciences

Program Converts VAX Floating-Point Data to UNIX

Unformatted files of floating-point data can be converted by this software.

Many users need to transport unformatted floating-point (4 bytes per sample) data files written by a VAX computer to a machine that runs UNIX and that may have a different convention for interpreting unformatted floating-point data values. The VAX Floating Point to Host Floating Point Conversion (VAXFC) software converts these non-ASCII files to the unformatted floating-point representation of the UNIX machine. This is done by reading the bytes bit by bit, converting them to floating-point numbers, then writing the results to another file.

VAXFC is useful when data files created by a VAX computer must be used on other machines. For instance, NASA/JPL AIRSAR synthetic-aperture-radar synoptic data are processed on a VAX computer, but many times users wish to analyze the data on such computers as DEC Alpha, SUN, HP, SGI, or others. This requires that the data be converted to the floating-point format of several different types of computers.

The VAXFC software was written with generality in mind. A data file is allowed to have a header of any length (header values are not converted, so if it is an ASCII header, it will be preserved). A data file is also allowed to have header bytes of any length at the beginning of each line (must be a constant length for each line).

VAXFC was originally written to convert AIRSAR synoptic data from VAX floating-point format to UNIX floating-point format. These files have three lines of ASCII header information (15,360 bytes), followed by 5,088 lines of data, each data line being 5,120 bytes (1,280 floating-point numbers), with no prefix header at the beginning of each line. Therefore, these values are the default values. However, any unformatted floating-point data file can be converted by this software.

VAXFC is written in C language for use on UNIX systems. This program was developed on a DEC Alpha computer running OSF/1 and was designed to be UNIX-independent. VAXFC has been successfully compiled on a Sun4 computer running SunOS 4.1.3, a DEC Alpha AXP 4000/610 computer running OSF/I v2.0, an SGI Indigo 2 computer under IRIX 5.2, and a DECstation 5000 computer running ULTRIX v4.3a. The standard distribution medium for VAXFC is one 3.5-in. (8.89-cm), 1.44MB diskette in UNIX tar format. Electronic versions of the documentation in PostScript, ASCII text, and Microsoft Word v6.0 for Windows are included on the distribution medium. VAXFC was released in 1994 and is a copyrighted work with all copyright vested in NASA.

This program was written by Marcos Alves, Bruce Chapman, and Eugene Chu of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 57*** *on the TSP Request Card. NPO-19464*

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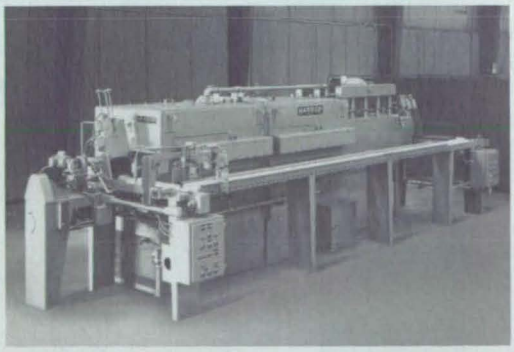

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Improved Estimation of Vibrations in Engines and Pumps

Changes in a scaling formula yield better correlations with empirical data.

Marshall Space Flight Center, Alabama

A method of estimating the vibrational loads upon, and the vibrational power dissipated in, rocket engines, pumps, turbomachines, and similar flow-through-type machinery is derived from an older vibration-scaling concept of estimating the vibrations of components of a rocket engine in the design stage, without complicated mathematical modeling and calculations. These methods involve scaling vibrations via global variables like mass-flow rates and exit velocities of engine exhausts.

The present method is called the "Improved Composite Loads Spectra-Component Scaling Criteria" ("Improved CLS-CSC") method. According to this method, the root-mean square vibrational acceleration (G_{rms}) of a pump, engine, or other machine or component is proportional to a quantity known as the component-specific power (P_s) which is approximately the kinetic energy of the fluid flowing through the component per unit mass of the fluid per unit mass of the component. Thus, the level of vibration $G_{rms\ (new)}$ of a machine that has not yet been built or tested can be estimated from the measured level of vibration $G_{rms\ (old)}$ of a similar machine that has been built and tested and from the component-specific powers $P_{s\ (old)}$ and $P_{s\ (new)}$ of the old and new machines:

$$\frac{G^2_{rms\ (new)}}{G^2_{rms\ (old)}} = \frac{P_{s(new)}}{P_{s(old)}} \quad \text{or}$$

$$G^2_{rms\ (new)} = \frac{P_{s(new)}}{P_{s(old)}} G^2_{rms\ (old)}$$

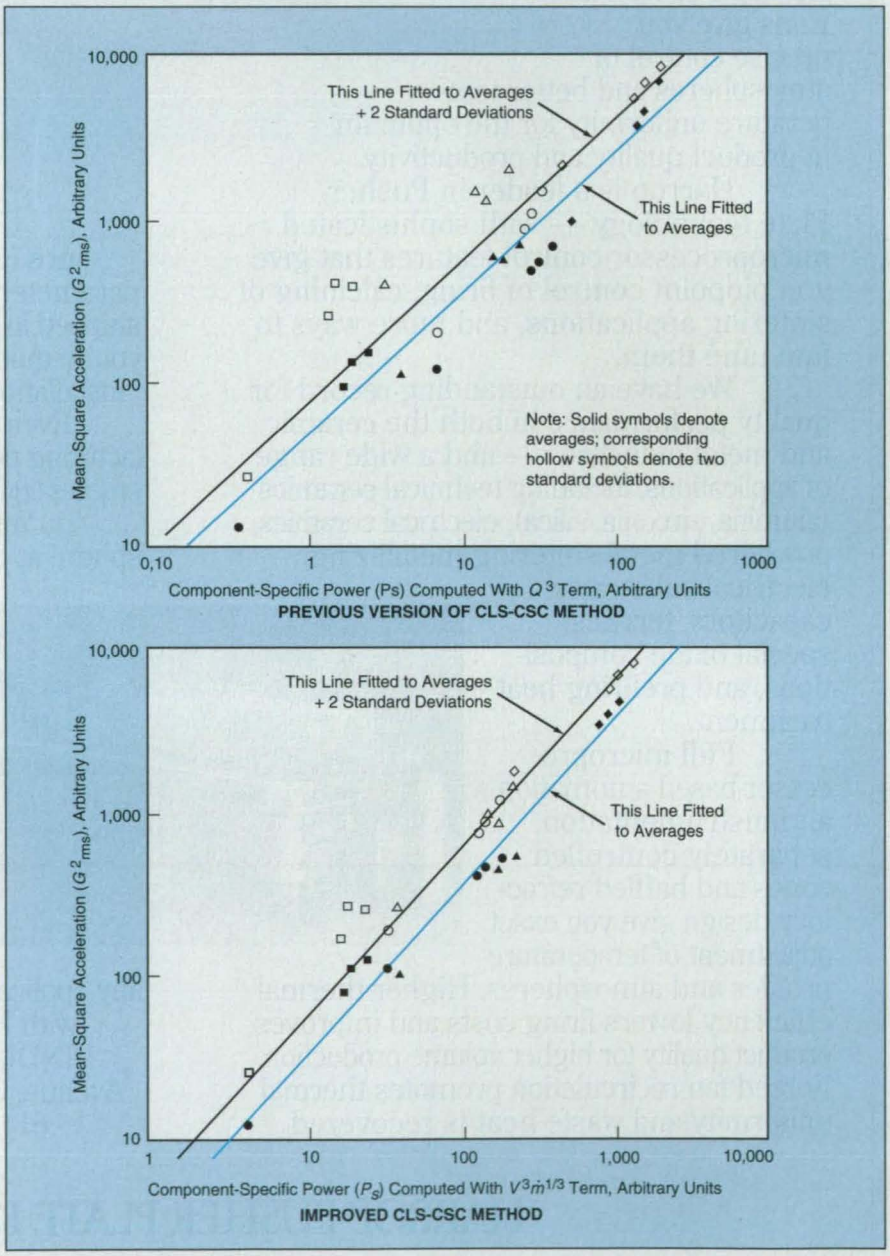
The component-specific power for use in the above equations is given by

$$P_s = \frac{K_f V^3 \dot{m}^{1/3}}{m_p}$$

where V is the speed of the fluid at the outlet of the machine, $\dot{m}$ is the discharge mass flow rate of the machine, m_p is the mass of the machine, and K_f is a factor that depends on the geometry of the flow path in the machine. In the case of a turbopump, K_f is given by

$$K_f = \frac{1}{x_f} \int_0^{x_f} \frac{1}{L(x)} \left[\frac{1}{A(x)} \right]^3 dx$$

where x_f is the total axial length of the flow path through the pump, $A(x)$ is the cross-sectional area of the flow path at axial position x, and $L(x)$ is the clearance between the turbopump impeller and the



The **Improved CLS-CSC Method** results in closer alignment of data points with a straight line like that predicted by the approximate scaling law. The various data-point symbols represent measured vibrations and computed component-specific powers pertaining to various turbopumps in the space shuttle.

turbopump housing at axial position x.

One difference between this improved CLS-CSC method and previous versions of the CLS-CSC method lies in the formula for P_s: In the previous version, P_s was given by

$$P_s = \frac{K_f Q^3}{m_p}$$

where Q is the volumetric rate of flow through the machine. Another difference lies in the incorporation of more vibration measurements from known machines [$G_{rms\ (old)}$] into a data base for prediction of $G_{rms\ (new)}$ plus better filtering of the data base to correct for spurious effects of instrumentation and other machinery.

The improved CLS-CSC method results in better correlations of the measured vibrations and component-specific powers of different machines (see figure).

This work was done by David C. Chow of Rockwell International Corp. for **Marshall Space Flight Center.** *For further information,* ***write in 56*** *on the TSP Request Card. MFS-29958*

Improved Mechanical Seals for Tubes

Lyndon B. Johnson Space Center, Houston, TX

Improved tube-to-fitting seals can be made by application of soft metal pieces to either the ends of tubes or to the interior of the fittings. The soft metal can be silver, gold, platinum, tin, or other easily malleable metal selected to be inert with the fluid of use. The metal can be plated, evaporated, or sputter-deposited. The coat of soft metal is thin, so no changes are required in the design or tolerances of standard fittings. In one trial application, a 0.1-mil (0.0025-mm) layer of tin was plated over a nickel-coated stainless-steel tube and fitted to a titanium swage fitting. The leak rate was less than 10^{-9} and was maintained during thermal cycling under high pressure, a reduction from a 10^{-5} leak rate without the soft metal seal. The technique is suitable for hydraulic or other fluid systems in which leakage from mechanically joined sections of tubes can occur. A patent is being issued and commercial licensing discussions are in progress.

This work was done by Henry W. Babel, Raymond H. Anderson, Phillip L. Fuson, Colin D. Chickles, and Cherie A. Jones of McDonnell Douglas for **Johnson Space Center.** *For further information,* ***write in 50*** *on the TSP Request Card.*

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

McDonnell Douglas
John P. Scholl
Counsel, Intellectual Property
3855 Lakewood Blvd.
Long Beach, CA 90846

Refer to MSC-22477, volume and number of this NASA Tech Briefs *issue, and the page number.*

Improved Aircraft Inlet Total-Pressure Distortion Rakes

An innovative design simplifies installation and reduces cost.

Dryden Flight Research Center, Edwards, California

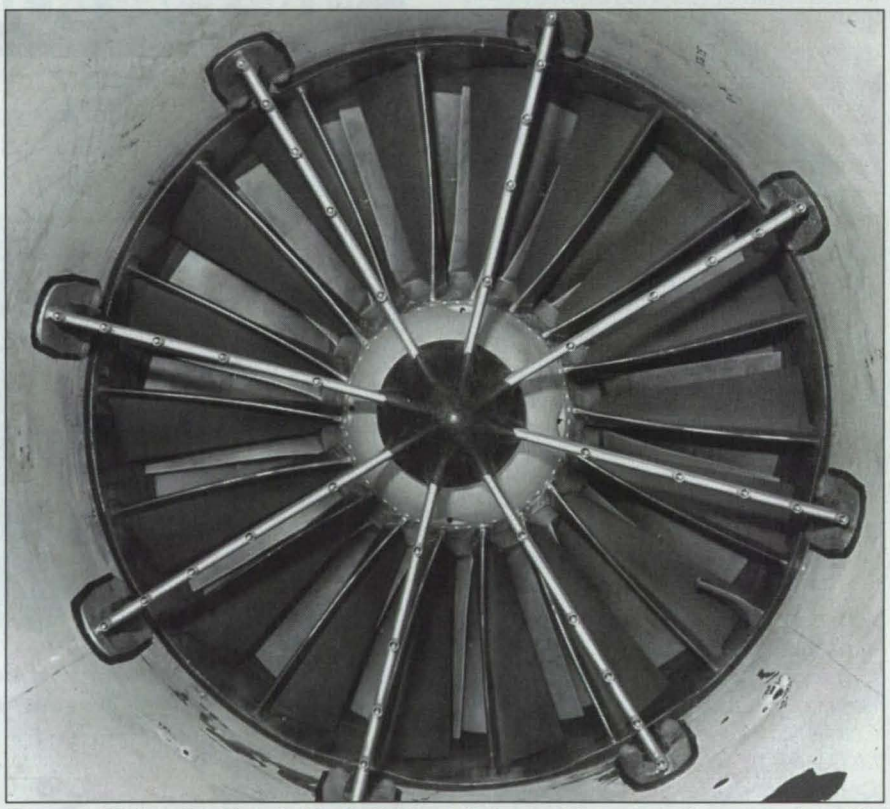
Researchers at Dryden Flight Research Center have developed an innovative rake of pressure transducers for measuring the distortion of the total pressure at the inlet of a jet engine. The rake features a one-piece wagon-wheel design (see figure), which reduces cost and installation time relative to those of traditional designs. One prototype and two flight-worthy rakes were successfully designed, developed, built, and qualified for flight for less than $500,000 (1995). Installation of one of these rakes in an F/A-18 aircraft, including necessary modifications of the aircraft, was accomplished in only three days. Design features included light weight, high strength, low structural resonance, low flow blockage, and ease of removal and replacement of transducers. The entire rake assembly weighs about 15 lb (6.8 kg).

The design, development, and installation of an inlet total-pressure-distortion rake in an aircraft is expensive and time-consuming. Heretofore, the cost of developing such a rake has typically ranged from 1 to 1.5 million dollars (1995). Previously, inlet-rake systems featured, variously, eight-legged duct-wall cantilevered designs or inlet guide-vane leading-edge designs. These designs have commonly required extensive modifications to aircraft or engines. Development of a rake of cantilevered design can be particularly expensive because it is necessary to design and test each rake leg individually; it is also particularly time-consuming because it entails relatively extensive structural modifications of aircraft, plus flight-qualification testing. The time required for modification and installation ranges from 1 to 6 months.

The present innovative rake includes a streamlined hub and eight aerodynamically shaped rake legs (corresponding to the spokes of the wagon wheel). The inlet duct of the aircraft corresponds to the rim of the wagon wheel. The rake is self-supported with no physical contact with the engine; the load-bearing structure of the rake is a welded nickel-alloy unit that joins the rake bodies and the hub into a single piece that is supported by integral foot pads and bolted to the inlet duct flange.

Each of the eight rake legs contains five pressure probes located on the centroids of five equal portions of the flow area. The hub contains an isolated metal vibration-damping ring potted in a polyurethane central body. The polyurethane elastomer is bonded to the metal. With this design, the hub dissipates vibrational energy more effectively than would an all-metal hub.

The same polyurethane material used to damp vibrations is also used to form the streamlined shape of the hub and the trailing edges of the rake bodies. Some of the vibrational energy is dissipated within the rake legs as the flexing and twisting motions of the open-backed metal sheets of rakes put the polyurethane elastomer in shear. The leading edges of the rake bodies are made by forming sheet metal into the leading edge and sides of an airfoil shape. The sheet metal is left open at the trailing edge to enable installation of the sensor and lead-out tubes.



Pressure Probes Are Mounted in Radial Legs that resemble spokes of a wagon wheel. The assembly is bolted to the inlet duct flange of an aircraft directly in front of the engine.

The construction of the rake assembly as a single piece results in a structure that is redundant in the sense that it enables each rake leg to share part of the load on the structure through the hub and transfer it to the airframe duct as shear loads to the bolts in the duct flange. The configuration in which the rake bodies are bolted to the inlet duct flange enables the inlet duct flange to support the rake without inducing any bending load in the sheet-metal wall of the duct.

Each of the 40 pressure probes in the rake includes a dual-measurement port (dual in the sense that it serves for both low- and high-frequency pressure mea-

surements). The high-frequency pressure transducer of each probe is mounted at the port.

One significant advantage of this rake design is its adaptability to inlets of other aircraft. The rake can be scaled to smaller and larger inlets with minimal qualification requirements. The current rake system can withstand flight at a speed up to mach 1.7. A follow-on development program will extend this capability to mach 2.5.

This work was done by Ronald J. Ray of **Dryden Flight Research Center** *and Andrew J. Yuhas of PRC, Inc. For further information,* ***write in 23*** *on the TSP Request Card. DRC-95-07*

NASA Landing Systems Research Aircraft

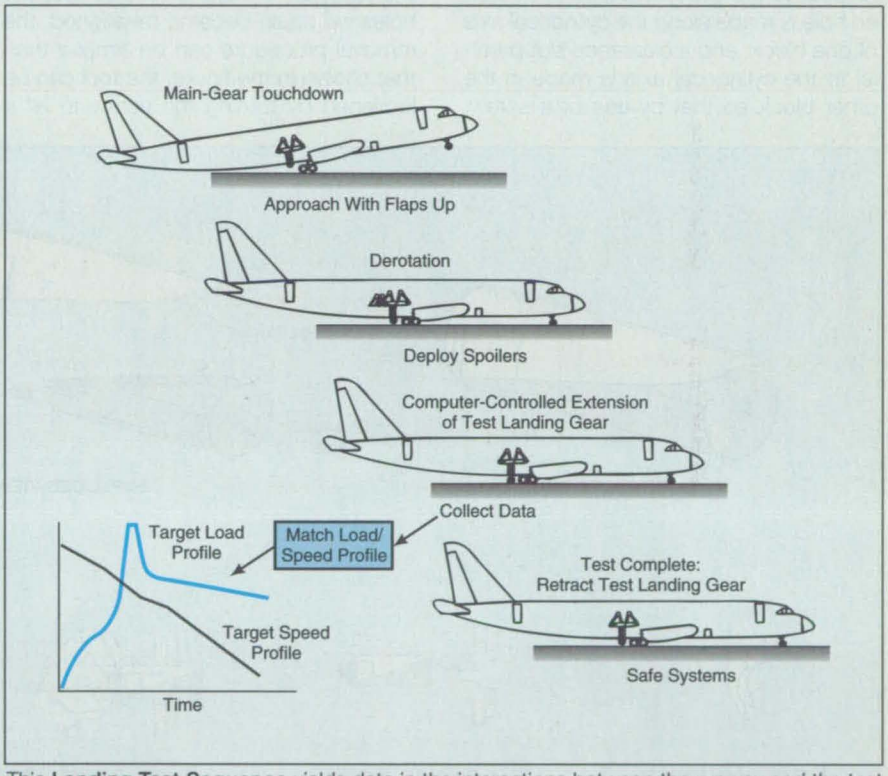
This airplane is instrumented to measure loads, velocities, and slip angles between tires and runways.

Dryden Flight Research Center, Edwards, California

The NASA Landing Systems Research Aircraft (LSRA) is a Convair 990 airplane that has been modified to incorporate a tire-and-landing-gear test facility containing a test fixture. This fixture is powered by hydraulic actuators for vertical load and steering. Researchers at the Dryden Flight Research Center are using the LSRA as a unique addition to complement existing aircraft dynamic tire-testing facilities. The system can simulate tire vertical-load profiles up to 250,000 lb (1.1 MN), sideslip angles to 15°, and wheel braking on real runways. Onboard computers control the preprogrammed test profiles through feedback and record loads along three axes, plus the slip angle and the condition of the tire under test. To date, the LSRA has provided tire force and wear data for the space shuttle orbiter tire on three different runways and at east- and west-coast landing sites.

The figure shows a typical landing test sequence, beginning with the final approach of the aircraft. After touchdown and derotation, the pilot calls for initiation of the test and uses spoilers, thrust reversers, and brakes to follow the pilot speed advisory. The test landing gear is extended and controlled to match the preprogrammed test profiles of vertical load, slip angle, and braking on the test tire. Upon completion of the test, the test landing gear is automatically retracted. If a problem occurs during the test, either the computer or a hardware fault-detection system commands retraction of the test landing gear.

The LSRA has capability for onboard collection of data or telemetry. The data rates range from 25 to 200 Hz. The test instrumentation includes load cells for three axes. The accuracies of the measured loads on the space shuttle orbiter tire are ±3000 lb (±1.3 × 10^4 N) vertical, ±500 lb (±2.2 × 10^3 N) sideways, and ±300 lb (±1.3 × 10^3 N) drag. The LSRA is also equipped with video cameras that can provide five different views of the tire fixture. These cameras enable real-time monitoring of tests as well as postflight analysis by use of images recorded on video tape synchronized with the other test data. High-speed film photographs of tests are also available.



This **Landing Test Sequence** yields data in the interactions between the runway and the test landing gear.

The LSRA has been used in approximately 150 test operations at Edwards Air Force Base in Edwards, California, and at Kennedy Space Center in Florida. During these operations, all preparation of flight-test profiles, reduction of data, and analyses were performed at the test sites.

The LSRA effort has provided significant data to the Space Shuttle Program. Tests on dry-lake-bed runways at Edwards Air Force Base were used to redefine the tire-drag mathematical model used in simulations and planning of flights of the space shuttle orbiter. A 20-knot (10-m/s) crosswind capability was demonstrated for landings of the space shuttle orbiter on the concrete runway of Edwards Air Force Base, and LSRA testing helped define the effects of ply steer and wheel tilt on the tire-force mathematical model for the space shuttle orbiter. The most significant contribution of the LSRA to the Space Shuttle Orbiter Program is that of tire-wear data, which helped to define the need to resurface the runway at the landing facility at Kennedy Space Center.

This work was done by John F. Carter of **Dryden Flight Research Center** *and Christopher J. Nagy of PRC, Inc. For further information,* ***write in 11*** *on the TSP Request Card. DRC-95-31*

Hole-Aligning Tool

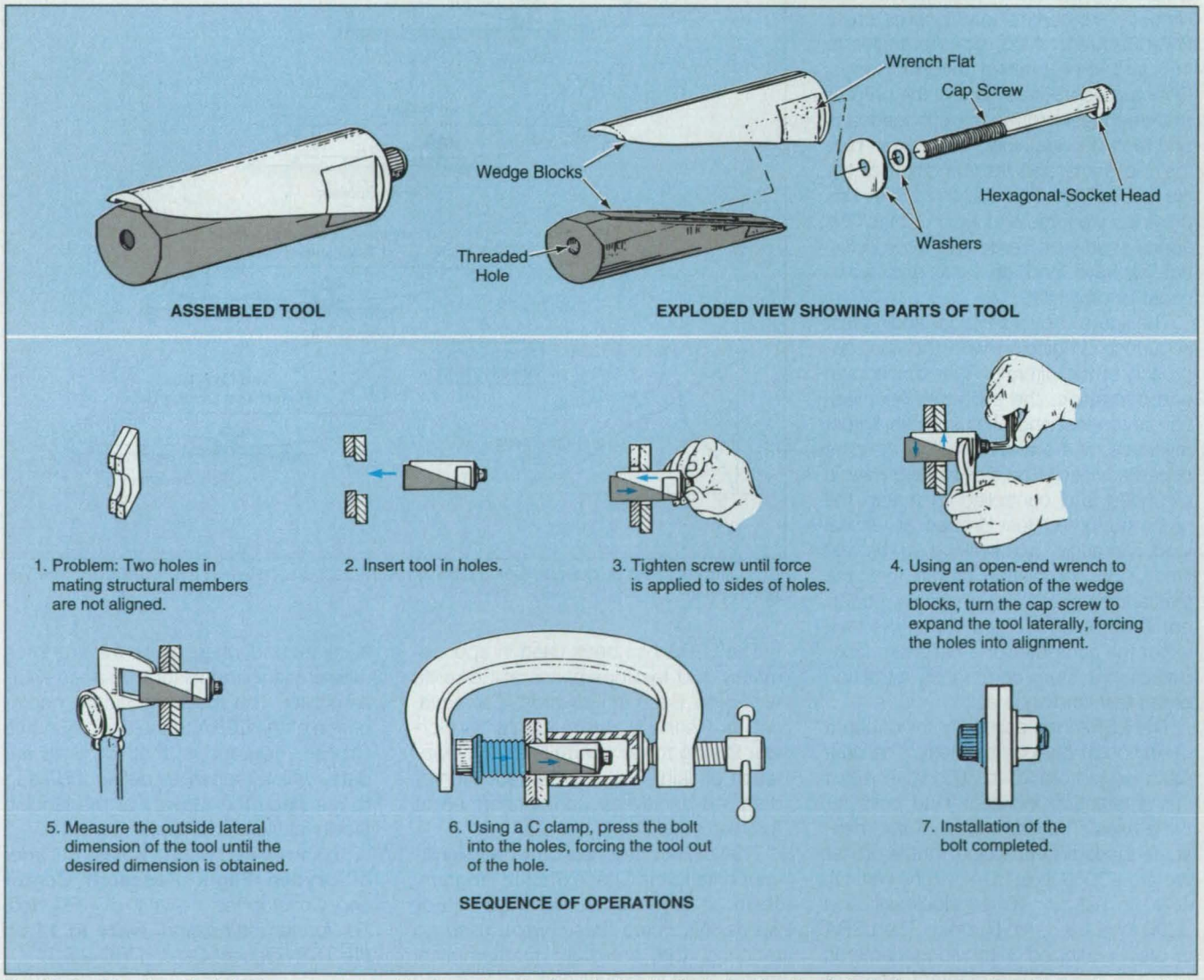
Holes can be aligned without exerting forces perpendicular to the planes of the holes.

Lyndon B. Johnson Space Center, Houston, Texas

A tool has been designed for use in aligning holes in plates or other structural members that are to be joined by a bolt through the holes. The tool, shown in the upper part of the figure, includes two wedge blocks approximately equivalent to two parts of a cylinder that has been split along a plane slanted with respect to the cylindrical axis. A threaded hole is made along the cylindrical axis of one block, and a clearance slot parallel to the cylindrical axis is made in the other block so that by use of a screw, the two blocks can be driven on each other along the slanted surface to expand the tool laterally against the edges of the holes.

The lower part of the figure illustrates the use of the tool to align holes in two structural members, followed by the use of a C-clamp to insert a bolt and force the tool out. If there is no risk that the holes will again become misaligned, the removal procedure can be simpler than that shown in the figure; the tool can be loosened by turning the screw to let it contract laterally, then simply pulled or pushed out of the holes. To prevent elongation of the holes, the tool should be made of a material softer than that of the structural members to be joined.

This work was done by Frank A. Collins, Frank Saude, and Martin J. Sep of Rockwell International Corp. for **Johnson Space Center.** *For further information,* ***write in 24*** *on the TSP Request Card. MSC-22411*



The Hole-Aligning Tool features a screw-driven-wedge design similar to (but simpler than) that of some automotive exhaust-pipe-expanding tools.

Copper Gas Diffusers for Purging Line-Focus Laser Welds

These diffusers are not damaged by reflected laser energy.

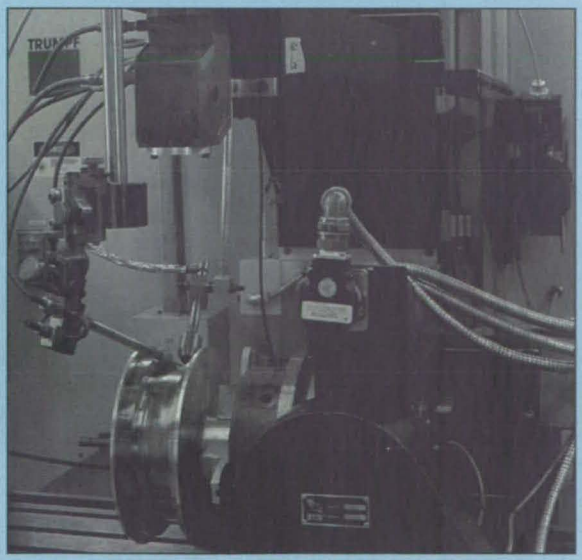
Marshall Space Flight Center, Alabama

Modified flow diffusers have been built for inert-gas purging of welds made with 5-kW CO_2 lasers operating with line-focus optics in a conduction mode instead of with point-focus optics in the customary keyhole mode. The modified diffusers are needed because the reflection of laser energy from the workpiece in the line-focus mode is so strong that it destroys the original diffusers designed for the point-focus mode.

Each of the modified diffusers (see figure) is made of fine-mesh copper screen (the flow-diffusing element) contained in a copper jacket, with a coarse-mesh copper screen across the outlet. The coarse-mesh outlet screen protects the fine-mesh internal diffusing screen. The copper jacket and screens function together as a heat sink that dissipates the reflected laser energy.

This work was done by Steve L. Fonteyne, Timothy J. Hosking, and D. Mark Shelley of Rockwell International Corp. for **Marshall Space Flight Center.** *For further information,* ***write in 72*** *on the TSP Request Card. MFS-30051*

COPPER DIFFUSERS FOR USE WITH LINE-FOCUS OPTICS



COPPER DIFFUSER IN USE DURING LASER WELDING

Flow Diffusers made of copper components brazed together are robust enough to withstand strong reflections of line-focused laser energy.

Data-Base Software for Tracking Technological Developments

This system performs routine functions automatically and serves multiple users.

John F. Kennedy Space Center, Florida

The Technology Tracking System (TechTracS) computer program has been developed for use in storing and retrieving information on technology and related patent information developed under the auspices of NASA Headquarters and NASA's field centers. The contents of the TechTracS data base include multiple scanned still images and quick-time movies as well as text. TechTracS includes word-processing, report-editing, chart-and-graph-editing, and search-editing subprograms. Extensive keyword searching capabilities enable the rapid location of technologies, innovators, and companies.

One of the major subprograms in TechTracS is an automatic agent that runs in the background, on the workstation. The automatic agent coordinates print jobs for multiple users and automatically executes routine jobs like printing forms and form letters. Using rule-based logic, the automatic agent monitors user activity and automatically triggers appropriate tasks when specified events occur. For example, when a database document has been released for publication, the system generates letters to authors notifying them of that approval. Tasks can also be triggered at specific dates, or after specified time intervals. Thus, for example, a user can select the number of days to wait before sending an automatically generated letter. The automatic agent also performs automatic maintenance of the data base and can schedule tasks for later execution.

Service provided for users of the system include automatically sending notification of new technology items to interested users by electronic mail and automatic responses to electronic-mail inquiries on the statuses of new-technology reports. Field offices can automatically transmit additions and updates to the database via the Internet.

This work was done by James A. Aliberti of **Kennedy Space Center** *and Simon Wright and Steve K. Monteith of Research Triangle Institute. For further information,* ***write in 4*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Kennedy Space Center; (407) 867-2544. Refer to KSC-11820

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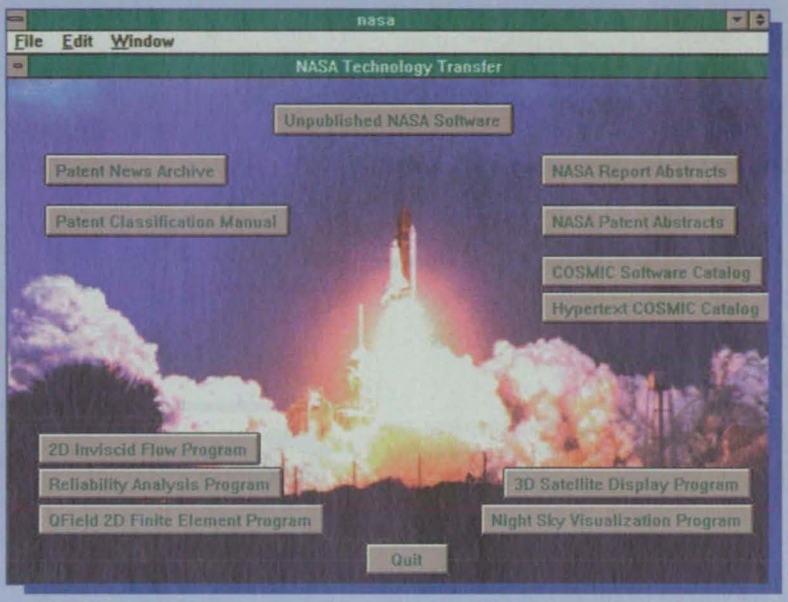

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Books & Reports

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

Physical Sciences

Nucleation Pathways for Freezing of Two Grades of Zirconium

A report discusses the classical nucleation theory of freezing and describes an experimental study of the nucleation mechanisms that predominate during freezing of spherical specimens of initially molten zirconium levitated electrostatically in a vacuum. In the experiments, the levitated specimens were repeatedly melted by radiative heating from a xenon arc lamp, then allowed to cool radiatively to induce freezing. The temperatures of the specimens were measured by use of a single-color (wavelength of 659 nm) silicon pyrometer.

This work was done by Won-Kyu Rhim and Aaron Rulison of Caltech and Robert Bayuzick, William Hofmeister, and Craig Morton of Vanderbilt University for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Containerless Liquid to Solid Nucleation Pathways in Two Representative Grades of Commercially Available Zirconium,"* ***write in 21*** *on the TSP Request Card. NPO-19727*

Hybrid Electric Thruster for Spacecraft

A report describes a proposed hybrid electric spacecraft thruster that would combine the best features of the resistojet and the arcjet, both of which are proven spacecraft thrusters. In the resistojet, a propellant gas is heated by an electrically heated filament; in the arcjet, the propellant gas is heated by an intense arc in the gas. The resistojet offers greater power efficiency, while the arcjet offers the capability of heating to greater temperature. An advantage of the hybrid design may accrue from having the arc pass through the throat of the thruster nozzle: the arc may help keep the throat open, counteracting a tendency of the resistojet nozzle throat to become clogged by condensation of metal vapor.

This work was done by Thomas J. Pivirotto of Caltech for **NASA's Jet Propulsion Laboratory.** *To obtain a copy of the report, "Hybrid Electric Thruster,"* ***write in 10*** *on the TSP Request Card. NPO-19526*

Machinery/Automation

More About Cutting Tool for Shaving Weld Beads

A report describes the modification and testing of the proposed tool discussed in "Cutting Tool for Shaving Weld Beads" (MFS-30056), *NASA Tech Briefs*, Vol. 19, No. 8 (August, 1995), page 68. To recapitulate, the tool would be a modified version of a commercial pneumatically driven rotary cutting tool that can remove such hard metals as nickel alloys, titanium, and stainless steels. The report describes the implementation of the modifications and the testing of the resulting tool.

This work was done by Peter A. Oelgoetz and William M. Davis of Rockwell International Corp. for **Marshall Space Flight Center.** *To obtain a copy of the report, "SSME Nozzle Jacket Weld Bead Reinforcement Removal Implementation Project Final Report,"* ***write in 27*** *on the TSP Request Card. MFS-30084*

Electronic Systems

More About the Video Event Trigger

A report presents additional information about the system described in "Video Event Trigger" (LEW-15076), *Laser Tech Briefs*, Vol. 2, No. 4 (Fall 1994), page 31. To recapitulate: the video event trigger is a digital electronic system that processes video-image data to generate a trigger signal when the image shows a significant change, such as motion, or the appearance, disappearance, change in color, change in brightness, or dilation of an object. Potential uses include monitoring of hallways, parking lots, and other areas during hours when they are supposed to be unoccupied, looking for fires, tracking airplanes or other moving objects, identification of missing or defective parts on production lines, and video recording of automobile crash tests.

This work was done by Glenn L. Williams of **Lewis Research Center**. *To obtain a copy of the report, "VLSI-Based Video Event Triggering for Image Data Compression,"* ***write in 46*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Lewis Research Center; (216) 433-2320. Refer to LEW-16203.

Electronic Components and Circuits

Compiled Data on Single-Event Effects Caused by Heavy Ions

A report presents test data on the susceptibility of a new set of digital integrated circuits and other semiconductor products to single-event effects (soft errors and latchups) caused by heavy ions incident at high energies. The report summarizes observations from JPL and many laboratories in North America and Europe. The data can be used to develop generalizations for protecting electronic equipment from single-event effects. In some cases, tested parts can be selected as candidates for use in specific applications.

This work was done by Donald K. Nichols, James R. Coss, and Harvey R. Schwartz of Caltech for **NASA's Jet Propulsion Laboratory.** *To obtain a copy of the report, "Trends in Device SEE Susceptibility From Heavy Ions,"* ***write in 74*** *on the TSP Request Card. NPO-19718*

(continued on page 80)

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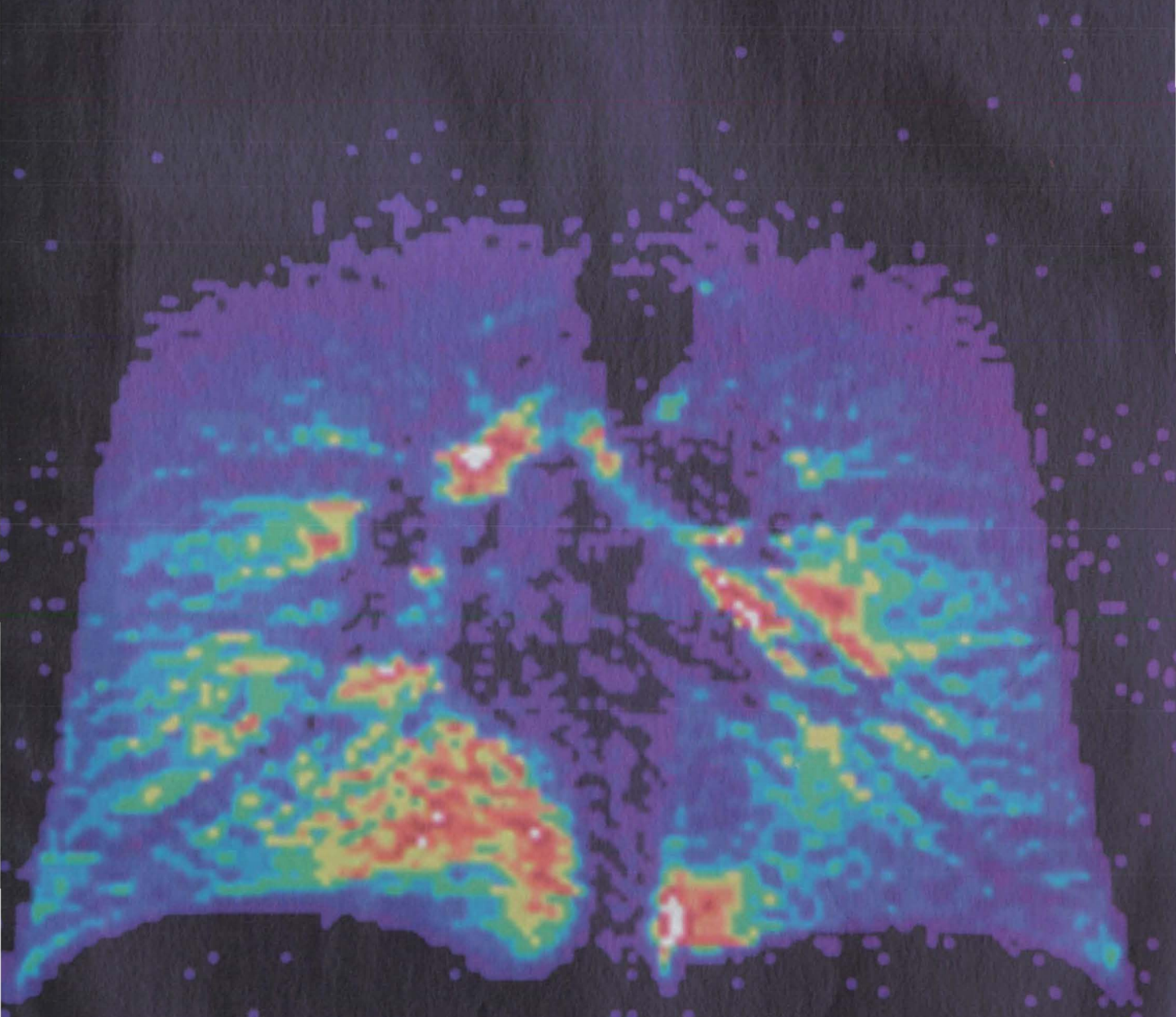

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DEPARTMENTS

On the cover:

The image is among the first high-resolution pictures of a human lung recently acquired using a new gas-based magnetic resonance imaging (MRI) procedure. Physicists at Princeton University and scientists with Duke University's Center for In Vivo Microscopy employed an experimental laser-polarized gas MRI method to obtain the images, which could be key to detection of emphysema, asthma, pulmonary embolisms, and other lung diseases that have been difficult or impossible to diagnose with conventional proton MRI. High-power diode lasers from Opto Power Corporation were used in the creation of a gas inhalant that makes the lungs "visible" to the technique. *Photo courtesy Opto Power Corp.*

NEWS BRIEFS

Notes from Industry and the Laboratories

The Beckman Laser Institute (Irvine, CA) received renewals of two programs sponsored by the National Institutes of Health (NIH), making more than $2.2 million in new funding available over four years for some of Beckman's most promising research and clinical studies.

The Laser Microbeam and Medical Program (LAMMP), now in its sixteenth year as an NIH-designated Biotechnology Resource, got fresh backing from the federal health agency. As a national user facility, LAMMP fosters the development of new instrumentation for biomedical applications and promotes collaboration among the academic, corporate, medical, and federal sectors. Currently LAMMP sponsors research, service, and training projects in laser microsurgery, optical trapping, and other fields. The program's new initiatives in tissue interaction and optical diagnostics were endorsed by the NIH review as having "high technical merit."

NIH also renewed support for Beckman's long-standing study of photodynamic therapy (PDT) for malignant tumors. PDT involves the intravenous or topical administration of photosensitizing compounds to malignancies. They react with light of an appropriate wavelength to generate highly reactive oxygen molecules that destroy tissues in which the sensitizers concentrate. Since they "localize" only in diseased tissues, healthy tissues are not affected.

Recently Beckman invited journalists to the Animal Operating Room to observe experimental surgery to remove a cancerous tumor from the ear of a Santa Catalina Island kit fox, an endangered species. Dr. George M. Peavy, the Institute's Veterinary Director, and Dr. Mike Wyatt of the Catalina Conservancy removed the bulk of the tumor, which had resisted conventional surgery, with a carbon dioxide laser. Then they used a small diode laser developed jointly by the Institute and Lawrence Livermore National Laboratory to activate the photosensitive dye that had been injected into the kit fox the evening before.

After surgery, the fox went to Dr. Wyatt's clinic for recovery. "She has made tremendous progress," Dr. Peavy says, "and has been returned to her habitat on Santa Catalina Island."

A collaboration between NASA's Marshall Space Flight Center, the Center for X-Ray Optics of the State University of New York (SUNY) in Albany, and X-Ray Optical Systems Inc. of Albany has produced an instrument capable of generating the most intense x-rays known to the commercial world.

The key to the development is a new type of lens called "capillary optics." It consists of tens of thousands to hundreds of thousands of tiny channels in a glass matrix, through which x-rays are guided by total external reflection. According to Walter Gibson, professor of physics at SUNY, this affords a means of controlling the direction of x-rays and concentrating them, something not possible before.

Researchers at the SUNY center and X-Ray Optical Systems have been working on the technical development since late 1990. One of the university team interested Marshall scientists in the theoretical and experimental evaluation of the technology for use in protein crystallography, and NASA provided funding. The resulting instrument, operated for the first time late last year, determines the atomic structure of proteins that are the targets for drug design. (See "NASA News Briefs," *NASA Tech Briefs*, March 1996, page 18.)

David Gibson, president of X-Ray Optical Systems, the lens fabricator, says that early applications for a commercial instrument are likely to be in materials analysis, for x-ray diffraction and fluorescence, and in neutron control for neutron depth profiling and similar techniques. "In the longer term," he says, "we can expect them to be useful in soft-tissue imaging such as mammography and angiography. Eventually they could find their way into industry for point-source x-ray lithography and into basic science measurements such as x-ray telescopes."

The Department of Defense has made a grant of up to $3.2 million to the Center for Optics Manufacturing (COM) at the University of Rochester (NY) as part of a $6.8-million effort to automate the fabrication of aspherical lenses. The Center aims to develop computerized equipment, another in its series of Opticam machines, that will reduce the cost of fashioning aspheres, one of the most expensive optical components to manufacture.

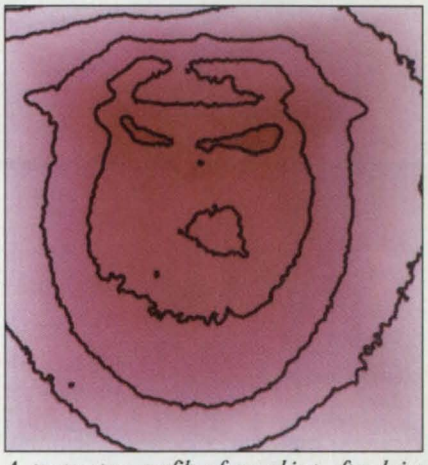
Funding also comes from several industrial partners who are devoting time and laboratory resources to the project. They include Eastman Kodak, CNC Systems, and Sinclair Optics, all of the Rochester area; Apeiron of Minneapolis; Lockheed Martin of Orlando; Moore Tool Co. of Bridgeport, CT; and Texas Instruments of Dallas. DOD support comes through the Advanced Research Project Agency's Technology Reinvestment Program.

COM aims to have a prototype of the asphere machine, the Opticam AM, by next year. Fabrication capabilities would include IR materials such as silicon, germanium, and sapphire, visible glasses, and ceramics. The machine will probably sell for $150,000-$300,00, like the automated machine for producing spheres, the Opticam SX, that has been delivered to several companies.

Among other COM projects, the Optical Micro SX for spherical micro-optics, delivered by CNC Systems late last year, is undergoing acceptance testing and, according to Michele Richard, COM program manager, "doing really well." Also in testing are the Opticam MRF for magneto-rheological finishing of optical surfaces, and the Opticam PM for prisms.

Work going on at Los Alamos National Laboratory in New Mexico aims to predict how explosives inside a nuclear weapon might behave if projectiles such as bullets fired by terrorists were to penetrate it. High-speed photographs of the shock waves generated could provide scientists with the information needed to make computer models of what might ensue.

The researchers used a frequency-doubled Nd:YAG laser, a high-speed camera, and a specially designed gas gun to measure the deformation wave produced by a blunt penetrator of a block of high explosives. Light from the laser forms a speckle pattern on the block. The camera recorded distortions of the pattern, showing how the shock wave travelled when a small brass projectile from the gun detonated the explosives. In addition, infrared photography showed how heat travelled through the material after impact.



A temperature profile of an object after being struck by a projectile shows how heat is distributed: near the point of impact, close to the two irregularly oblong areas just above the photo's center, the object is hottest, and it is cooler as the distance from the point of impact increases.

The experiments offered a preliminary solution to the classic problem in mechanics known as the Prandtl Punch Problem. Two theories on the shape of the deformation wave produced by a blunt penetrator have long vied for scientists' allegiance. One is that a single wave moves from the center of the penetration, diffusing force and heat in a three-dimensional arc. The second hypothesizes that two distinct waves travel side-by-side away from the impact point, with sharp peaks resembling cones, rather than an arc. The Los Alamos data seems to confirm the first theory.

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Switched-Polarization Birefringent Optical Delay Lines

Polarization would be switched in segments to adjust the overall delay.

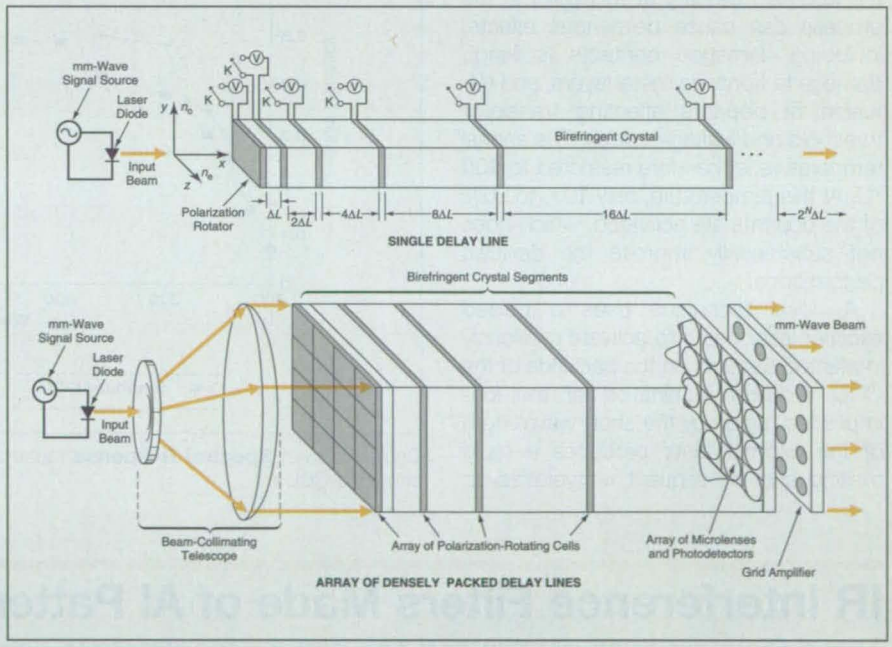
NASA's Jet Propulsion Laboratory, Pasadena, California

Controllable birefringent optical delay lines are proposed for use in photonically controlling the phases of the signals in the radiating elements of phased-array antennas. Electronic circuits developed previously for this purpose tend to be lossy and relatively bulky, and they do not offer delay resolution fine enough to enable high-angular-resolution steering of beams radiated or received by arrays that contain large numbers of elements. The proposed optical delay lines would feature low optical insertion losses and could be made very compact, enabling high packing densities where multiple delay channels were needed. They would also provide the requisite delay resolution: the time delay in a line of the proposed type would be adjustable, in discrete increments of the order of 0.1 ps with continuous tuning between the discrete increments, over a total delay-adjustment range of the order of 1 ns. Furthermore, two or more delay lines could be cascaded to increase the delay-adjustment range.

The upper part of the figure schematically illustrates one of several design concepts according to the proposal. A delay line of total length L would be divided into M segments along the axis of the beam of light to be delayed (the x axis in this example). The lengths of the segments increase successively by a factor of 2, with the smallest segment of length ΔL. Each segment would contain a birefringent electro-optical crystal cut along its principal axes and oriented so that the perpendicular y and z axes would be the axes of the polarization eigenstates of the crystal; light polarized along the y axis would propagate along the x axis with an index of refraction of n_o (the "ordinary" index of refraction), while light polarized along the z axis would propagate along the x axis with an index of refraction of n_e (the "extraordinary" index of refraction).

A controllable polarization rotator would be placed at the input end of each segment. Provided that the input beam was initially linearly polarized, the polarization rotator for each segment could be used to select y or z polarization, so that the propagation delay in that segment would be proportional to n_o or n_e, respectively. Thus, the overall delay in the line could be adjusted in discrete increments by changing the numbers of segments with y or z polarization, the discrete increment being $|n_e - n_o|\Delta L/c$ and the total delay-adjustment range being $|n_e - n_o|L/c$, where c is the speed of light. Electrodes would be attached to each crystal so that a voltage could be applied to vary the index of refraction via the electro-optical effect and thereby achieve fine tuning of the delay.

The lower part of the figure illustrates an example of integration of multiple delay lines into a single compact unit. By using crystals with larger cross sections and subdividing each polarization rotator into a rectangular array of polarization-rotating cells, one could obtain a two-dimensional array of adjustable-delay outputs, as shown in the lower part of the figure. In this case, it would be necessary to use a collimating telescope to expand the input beam to cover the input end of the array, plus an array of microlenses to focus the optical outputs onto a corresponding array of photodetectors.



The **Delay in Each Segment of Length ΔL Could Be Switched** by using the polarization rotator at the input end of that segment to select either y or z polarization.

This work was done by Xiaotian Steve Yao of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 52*** *on the TSP Request Card.*

NPO-19412

Laser Technique to Fabricate Improved Backside-Illuminated CCDs

The new fabrication method improves the spectral-response and dark current characteristics of the imaging devices.

Naval Command, Control and Ocean Surveillance Center (NCCOSC), RDT&E Division (NRaD), San Diego, California

To obtain broad spectral response and improved imaging capabilities, backside-illuminated charge-coupled devices (CCDs) require a high concentration of dopants peaked at the back surface to avoid charge trapping due to the formation of the native silicon oxide. Fabricators use ion implantation to incorporate dopants into the back surface in an attempt to avoid the charge trapping. Only a small fraction of the implanted dopant atoms, however, reside in locations in the crystal that are electrically active. Therefore, thermal energy must be provided to permit the migration of dopant atoms into active sites.

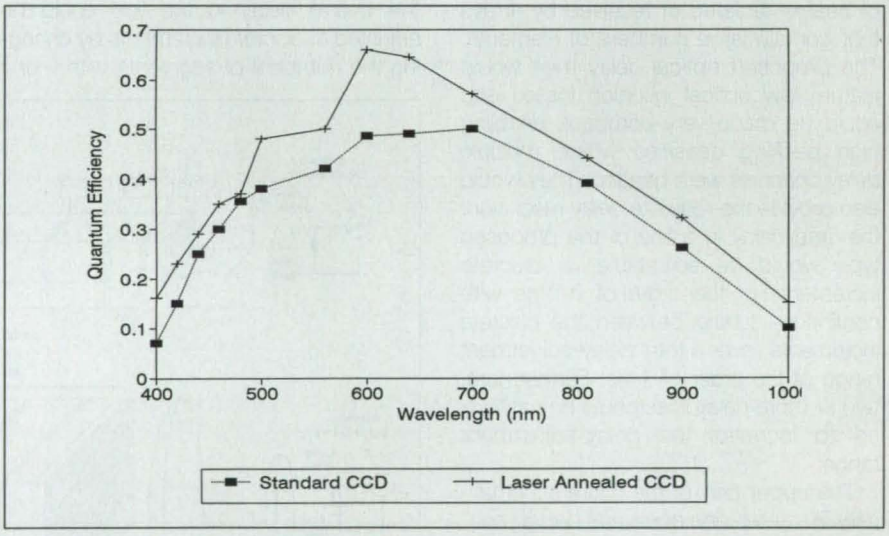
The obstacle that must be overcome by fabricators when this approach is relied on is that the backside doping process (and heating) occurs after all frontside device fabrication, because of the mechanical fragility of these thinned CCDs. A large temperature elevation of the frontside circuitry at this point in the process can cause deleterious effects, including damaged contacts (spiking), damage to frontside metal layers, and diffusion of dopants affecting transistor threshold and leakage values. The anneal temperature is therefore restricted to 400 °C. At this temperature, only 10% to 20% of the dopants are activated, which does not substantially improve the device's performance.

A novel technique uses a pulsed excimer laser beam to activate previously implanted dopants on the backside of the CCD. Uniform illumination of the ion-implanted region by the short wavelength of the excimer laser produces a rapid melting and subsequent recrystallization of the backside of the CCD, which simultaneously activates the dopant and anneals out implant damage. This improves the dark-current response, and repairs defective pixels by annealing crystalline defects caused by the ion implantation process. In addition, this improves spectral response (see figure) by removing the charge trapping at the back surface.

This process heats a very thin layer of the material to high temperatures on a nanosecond time scale while the bulk of the delicate CCD substrate remains at low temperature. Excimer laser processing of backside-illuminated CCDs enables salvage and utilization of otherwise nonfunctional components by bringing their dark-current response to within an acceptable range. This process is particularly useful for solid-state imaging detectors used in commercial, scientific, and government applications requiring a wide spectral response and low-light-level detection.

A variation of this laser process eliminates the ion implantation step altogether, and extracts dopants from a surrounding gaseous ambient and incorporates the dopants directly into the CCD to produce the same performance improvements.

This work was done by Dr. Stephen D. Russell and colleagues at the **Naval Command, Control and Ocean Surveillance Center, RDT&E Division.** *Inquiries concerning rights for the commercial use of this invention should be addressed to Commanding Officer, Attn: Technology Transfer Liaison, NCCOSC RDTE DIV 0143, 53560 Hull St., San Diego, CA 92152 5001; (619) 553-2101.*



Comparison of **Spectral Response** (quantum efficiency) of standard (lower line) and laser-annealed CCDs.

IR Interference Filters Made of Al Patterns on Si Substrates

These filters are relatively thin and can better accommodate convergent infrared beams.

NASA's Jet Propulsion Laboratory, Pasadena, California

Infrared (IR) interference filters with pass bands centered at a wavelength of about 70 μm have been made in the form of aluminum patterns 1,000 Å thick on both sides of silicon substrates 12 to 15 μm thick. The substrates, in turn, are mounted on silicon frames 0.2 mm thick. These filters are prototypes of a class of miniature band-pass infrared filters that are small enough to be bonded to, and cooled with, infrared detectors.

Previously, some infrared band-pass interference filters were made of metal meshes stretched taut for suspension without dielectric spacers and were typically a few centimeters thick. The present filters are not only much thinner but are also less sensitive to the angles of incidence of infrared beams because the relatively high index of refraction of silicon causes the portions of the beams within the substrates to propagate more nearly perpendicularly to the surfaces. Thus, the band-pass characteristics of the present filters are less

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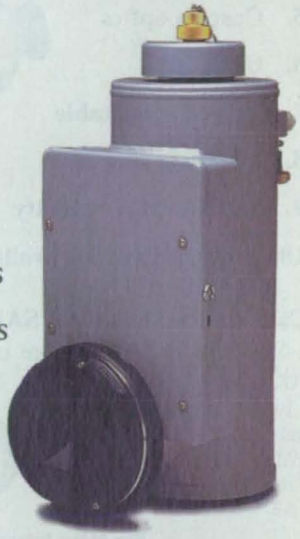

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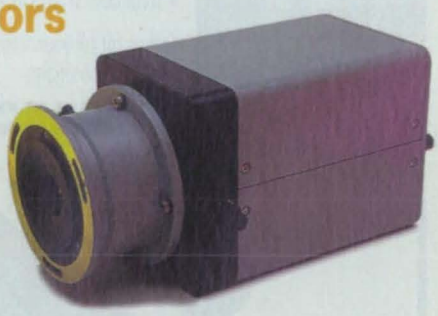

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affected by angles of incidence and therefore show less variation across convergent infrared beams.

In designing a filter of this type, the shapes and dimensions of the metal patterns are chosen in conjunction with the thickness of the substrate to select transmission and reflection resonances that, taken together, yield the desired band-pass characteristic. The choice is guided partly by approximate mathematical models of the behavior of electromagnetic waves in and near the filter; the choice is then refined by experimental trial and error. In the case of the prototype filters, the metal patterns on the faces of each substrate are square arrays of crosses (see Figure 1).

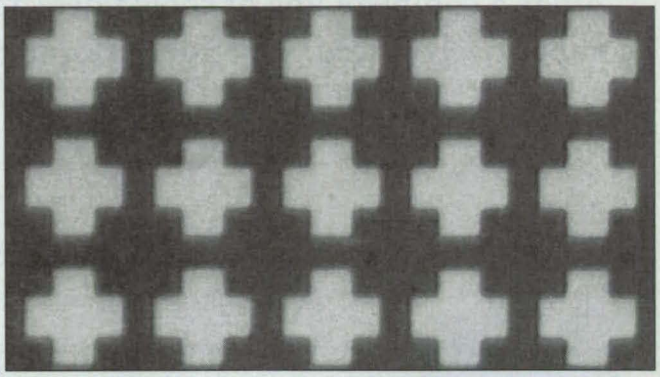


Figure 1. **Aluminum Crosses in Periodic Square Arrays** on both faces of a silicon substrate form a resonant structure. The transmission resonance of this structure is combined with the frequency dependence of reflectance of the crosses to obtain the desired band-pass characteristic of the overall filter.

In preparation for fabrication of the prototype filters, aluminum was thermally evaporated on the faces of silicon substrates. The aluminum-coated faces were coated with photoresist, then the patterns were written on the photoresist coats by electron-beam lithography. The photoresist was developed, then used as an etch mask; the portions of the aluminum coats not covered by the remaining photoresist were etched away by use of phosphoric acid. Then the photoresist was removed and the resulting pattern-covered substrates were mounted on the frames.

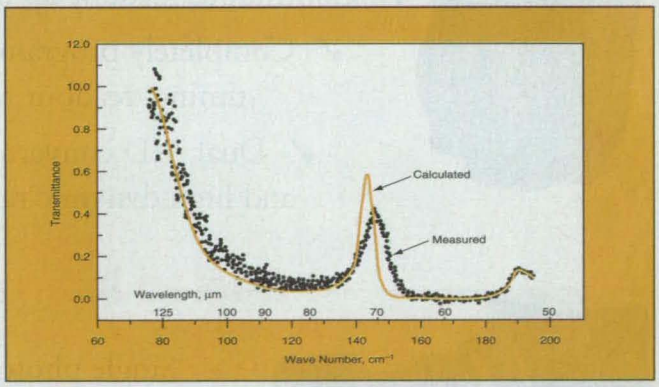


Figure 2. The **Spectral Transmittance** of the filter of Figure 1, as both calculated theoretically and measured, exhibits a band-pass characteristic in the vicinity of a wavelength of 70µm.

Figure 2 shows measured and calculated band-pass characteristics of a prototype filter of Figure 1. The calculation takes account of a nonuniformity (estimated standard deviation 2 percent) in the thickness of the substrate. Note that the filter provides out-of-band rejection over a rather limited wave-number interval. The out-of-band rejection could be improved by combining this filter with a wide-band-pass filter made of a single metal layer with cross-shaped holes.

This work was done by Alexander Ksendzov, Robert Fathauer, Paul M. Maker, and Richard Muller of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 20*** *on the TSP Request Card. NPO-19462*

Generating Stereoscopic Television Images With One Camera

This technique is amenable to zooming in on small areas within broad scenes.

Lyndon B. Johnson Space Center, Houston, Texas

A straightforward technique for generating stereoscopic television images involves the use of a single television camera that is translated laterally between the left- and right-eye positions. The camera acquires one of the images (which could be the left- or right-eye image), and the video signal from this image is delayed while the camera is translated to the position where it acquires the other image. The length of the delay is chosen so that both images can be displayed simultaneously or as nearly simultaneously as necessary to obtain the stereoscopic effect.

Unlike in traditional two-camera stereoscopy, there is no problem of registration of images from two different cameras and no need to match fields of view or to adjust two sets of camera electrical parameters to match brightnesses, contrasts, and/or colors. Because the use of only one camera automatically ensures registration of images, it is a simple matter to zoom in on selected areas in the stereoscopic images, without the complexity of adjusting two cameras and lenses.

In addition, the baseline separation between the two image-acquisition positions (the effective interpupillary separation) can be varied continuously to vary the stereoscopic image disparity and thereby obtain such special effects as exaggerated perception of depth. This adjustability is an important advantage in remote viewing (e.g., from an aircraft) because the optimum baseline separation depends on many variables, the altitude, and the field of view. In this respect, the emergence of single-video-camera stereoscopy is especially timely in that variable-delay devices for video signals are becoming increasingly practical, easier to adjust, and more reliable. Frame synchronizers that provide single frames of delay can be cascaded to provide longer delays. The ability to vary the delay makes it possible to adjust the baseline separation and thus the stereoscopic image disparity as needed for the scene in view.

This technique can also be used with film motion-picture cameras by exposing the film as the camera moves sideways. To generate two channels of stereoscopic information, the film imagery can then be recorded on video tape, then processed as though it were generated with a video camera. Alternately, two film projection prints can be produced and viewed with one print delayed by a finite amount to generate stereoscopic imagery.

Potential applications for single-video-camera stereoscopy include three-dimensional viewing of geological features and meteorological events from spacecraft and aircraft, inspection of workpieces moving along conveyor belts, and aiding ground and water search-and-rescue operations. The technique could also be used to generate and display imagery for public education and general information, and possibly for medical purposes.

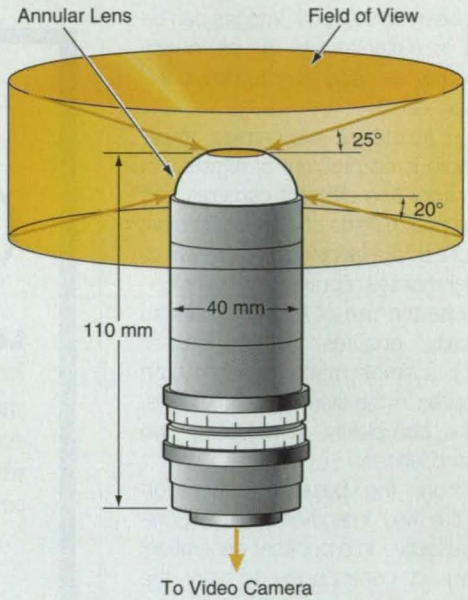
This work was done by Paul P. Coan of **Johnson Space Center**. *For further information,* ***write in 88*** *on the TSP Request Card. MSC-22586*

Video System for Inspecting Walls of Cavities

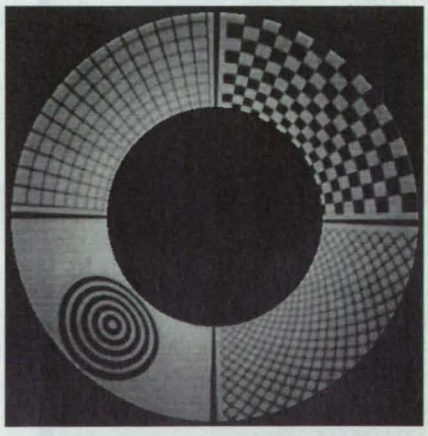
It is not necessary to rotate the probe to obtain a panoramic image.

Marshall Space Flight Center, Alabama

An endoscopic video-imaging system generates a panoramic image of part of the wall of a cavity surrounding the tip of a probe that is inserted in the cavity. The system can be used, for example, to inspect the inner surface of a tube, passage, or manifold located deep within an engine or other complex structure.



ANNULAR LENS AND FIELD OF VIEW



ANNULAR IMAGE OF TEST PATTERN

The **Panoramic Annular Lens** is 38 mm in diameter and operates in conjunction with a transfer lens of 25-mm focal length and a stop of *f*/1.4. These lenses project the cylindrical scene onto an annulus.

The probe includes an annular lens, a transfer lens, and a video camera. The annular lens is located at the probe tip, with the plane of the lens perpendicular to the cylindrical axis of the probe. It is not necessary to rotate the probe tip to obtain the

panoramic view because the field of view of the combination of lenses consists of an apparent cylindrical region that completely surrounds the probe tip circumferentially and that extends from 20° back to 25° ahead of the plane of the lens (see figure). For practical purposes, the depth of field extends from the surface of the annular lens to infinite distance. The combination of the annular lens and transfer lens projects the scene from the cylindrical field of view onto an annulus in the image plane of the video camera. In the flat annular image, radius corresponds to axial position and azimuth corresponds to circumferential position on the wall.

If simple inspection without measurement is required, a device called a "cylindrical light ring" can be mounted on the probe to illuminate the scene. Light from an incandescent lamp is delivered to the cylindrical light ring via an optical waveguide.

A different illumination device can be used when it is required to measure the distance of the wall of the cavity from the cylindrical axis of the probe: This device includes a laser diode and a rotating mirror that projects a ring of light onto the wall of the cavity. The apparent radial position of a point on this ring as a function of angular position in the annular image is related in a known way to the distance that one seeks to measure. For purposes of both measurement and enhancement of appearance for ordinary viewing, the annular video image is digitized and processed in a desktop computer. Processing can include approximate linearization of the mapping between points in the cylindrical field of view and points in the annular image, so as to minimize distortion of features that one seeks to examine.

This work was done by John A. Gilbert of the University of Alabama in Huntsville and Donald R. Matthys of Marquette University for **Marshall Space Flight Center**. *For further information,* ***write in 77*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [205-544-0021]. Refer to MFS-26247.

Laser-Beam-Absorption Chemical-Species Monitor

Marshall Space Flight Center, Alabama

An apparatus measures the concentration of a chemical species in a fluid medium (e.g., a gaseous industrial process stream). The apparatus directs a laser beam through the medium, and measures the intensity of the beam after passage through the medium. The relative amount of beam power absorbed in the medium is indicative of the concentration of a chemical species; the laser wavelength is chosen to be one at which the species of interest absorbs.

This work was done by Michael Gersh, Neil Goldstein, Jamine Lee, Fritz Bien, and Steven Richtsmeier of Spectral Sciences, Inc., for **Marshall Space Flight Center**. *For further information,* ***write in 33*** *on the TSP Request Card.*

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 Spectral Sciences, Inc., 99 South Bedford Street #7, Burlington, MA 01803-5169. Refer to MFS-26351.

Ladderlike Switched-Path Optical Delay Lines

These delay lines would be relatively simple, compact, easy to fabricate, and inexpensive.

NASA's Jet Propulsion Laboratory, Pasadena, California

Switched-path adjustable optical delay lines with ladderlike configurations are proposed for use in photonically controlling the phases of radio signals in the radiating elements of phased-array antennas and in adaptive filtering of signals.

A delay line of this type (see Figure 1) would be a stack of delay blocks, each block containing a polarization rotator and two polarization beam splitters. Optionally, each delay block would also contain lenses to overcome diffraction; these would be positive lenses with focal lengths chosen equal to half the distance between the lenses. The lenses could be of any suitable type; graded-index-of-refraction cylindrical lenses are shown in the figure. Optionally, each block would also contain two polarizers to suppress spurious polarization components. The polarization rotators would likely be of the liquid-crystal type, though magneto-optical or electro-optical polarization rotators could be used instead.

Each block would operate in either of two states called "reflecting" and "passing." To obtain the reflecting state, the switch K of the block would be set open. This would cause the polarization of the incoming light (the light traveling upward in the figure) to be rotated by 90°, so that the beam would be reflected by the two polarization beam splitters and thereby redirected toward the output port (downward in the figure). After the reflected beam passed through the polarization rotator a second time on its way out of the block, its polarization would be restored to that of the incoming beam. Closure of switch K would put the block in the passing state, in which polarization of the beam would remain unchanged after passage through the polarization rotator, allowing the incoming beam to pass through to the next block.

Suppose that all the delay blocks below the ith block in a stack were in the passing state, while the ith block was in the reflecting state. Then an incoming beam would travel up through the stack to the ith block, then back down through the stack toward the output port. The time delay Δt of a signal propagating on the beam would be given by $\Delta t = \Delta t_{min} + 2(i-1)nh/c$, where $\Delta t = \Delta t_{min}$ is the minimum delay in the bottom block, n is the effective index of refraction of the block material, h is the height of the block, and c is the speed of light. The smallest discrete increment, δt, of adjustable delay would be that obtained by moving the turnaround location one block up or down the stack; that is, $\delta t = 2nh/c$. Typically, δt would be of the order of 10 ps, while delay adjustment ranges (which would depend on the number of blocks in the stack) would be of the order of 10 ns.

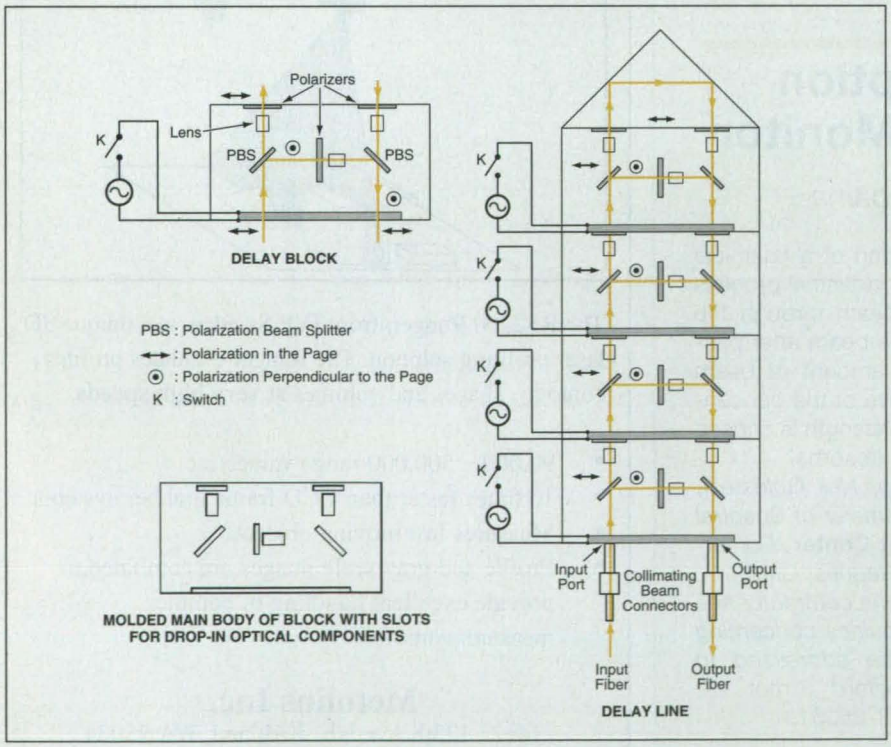


Figure 1. **Switchable Delay Blocks Would Be Stacked** like building blocks to form incrementally adjustable delay lines.

For the sake of low cost in mass production, the main body of each block could be injection-molded of glass or poly(methyl methacrylate). The injection mold could be shaped to provide slots for the polarization beam splitters, polarizers, polarization rotators, and lenses. In assembling a block, one would simply drop the polarization rotators, polarization beam splitters, polarizers, and lenses into their assigned slots, then fix these components in the slots by use of an epoxy with an index of refraction matched to that of the main body of the block. To reduce the number of blocks, the heights of the blocks can be increased successively by a factor of 2, similar to the crystal arrangement described in the article "Switched-Polarization Birefringent Optical Delay Lines" (NPO-19412) on page 3a of this section.

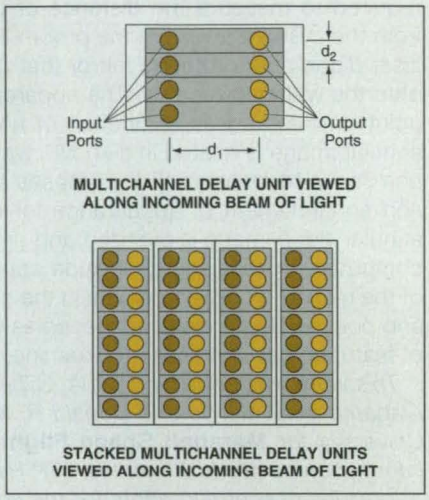


Figure 2. **Delay Lines Would Also Be Stacked** to form high-density multiple-channel delay systems.

As shown in Figure 2, many identical delay lines like that of Figure 1 could be stacked together to obtain a high packing density. Because the distance d_1 between the input and output ports of a delay line does not affect δt, this distance can be made very small for the sake of compactness, the minimum allowable value of this distance being the width of the light beam plus a small allowance for misalignment. The minimum allowable value of distance d_2 would also have to be chosen to accommodate the width of the beam.

This work was done by Xiaotian Steve Yao of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 43*** *on the TSP Request Card. NPO-19413*

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For More Information Write In No. 390

IMPROVE ANY FUZZY PROBLEM WITH APART!

• World's leading stray light program! • Improve your signal-to-noise ratio (SNR) in any optical system. • Optimize your contrast/detection on any ground- or space-based system. • Specify your surface quality and BRDF from a full coating library. • Calculate ghost, glints, and particle problems before they happen. Breault Research Organization Inc., 6400 East Grant Rd., Ste. 350, Tucson, AZ 85715; Tel: (800) 882-5085 or (520) 721-0500; FAX: (520) 721-9630.

Breault Research Organization Inc.

For More Information Write In No. 391

1995/6 LIGHTSTAR LASER DIODE INSTRUMENTATION PRODUCTS

LightStar laser diode control products combine low noise and high stability, all at a price you can afford. Formerly Seastar instruments, LightStar is now manufactured by ILX Lightwave Corp., in keeping with our commitment to laser diode instrumentation. ILX Lightwave Corp., 31950 East Frontage Rd., PO Box 6310, Bozeman, MT 59771; (406) 586-1244; Fax: (406) 586-9405.

ILX Lightwave

For More Information Write In No. 392

VIBRATION ISOLATION SYSTEMS

TMC's new 48-page, 4-color product catalog describes its complete line of vibration isolation systems, including optical and laboratory tables, table-top and floor platforms, and suspension systems. Illustrations feature technical insights, performance charts, specifications, R&D and manufacturing data. An applications guide and custom capabilities are also included. Send for the Industry Standard. Tel: 800-542-9725; Fax: 508-531-8682.

Technical Manufacturing Corp.

For More Information Write In No. 393

CD-ROM HOLDS BEST OF NASA TECHNOLOGY

JB Data announces *The NASA Technology CD-ROM*, containing 800 previously unpublished NASA software programs, abstracts of 90,000 NASA technical reports, front pages and claims to more than 2800 NASA patents, and more. Source code listings for expert systems, CAD/CAM, aerospace analysis, robotics, and materials analysis programs. **Special Bonus:** 5700 *NASA Tech Briefs* published over 8 years; NASA's CLIPS expert system, a $350 value if purchased separately. Runs on Windows. Price for a limited time: $195. JB Data, 317 Madison Ave., New York, NY 10017; (212) 490-3999; Fax: (212) 986-7864; E-mail: pp000531@interramp.com

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For More Information Write In No. 394

POLISHING EQUIPMENT FOR SMALL LENSES

Larsen Equipment Design's RP-601 radial arm "Bridge Technology" and substantially reduced size offer the same or better performance as larger, more cumbersome polishers, while offering the efficiencies associated with size and superior control functions. For microlenses call Larsen Equipment Design, 1117 NW 52nd St., Seattle, WA 98107; (206) 789-5121; FAX (206) 789-7756.

Larsen Equipment Design

For More Information Write In No. 395

Wafer-Scale Charge-Coupled Device Imager

The array is a back-illuminated frame-transfer readout of 1960 X 2560 pixels.

Headquarters, Electronic Systems Center, Hanscom Air Force Base, Massachusetts

A charge-coupled device (CCD) imager, developed by the Electronic Systems Center (ESC) in conjunction with Lincoln Laboratory, Massachusetts Institute of Technology, provides high resolution and large-format images at high framing rates. The CCD imager will be used to enhance the deep-space surveillance capabilities of the Air Force Electro-Optical Space Telescope Systems. The imager has potential commercial applications for use not only in astronomical telescope systems, but also in wide-area security surveillance systems, high-resolution visual inspection systems, and medical imaging systems.

The CCD chip occupies an entire 100-mm silicon wafer and comprises a 1960-X-2560 array of pixels with a pixel size of 24 X 24 microns. The actual focal-plane imaging area is 61.4 X 47 mm. A complete frame-store and transfer technique is used to support high image-framing rates. The integration period of the next frame can begin immediately after the frame store, completely eliminating the wait time for data-read transfer.

The frame store requires 19 ms, while the maximum frame rate is 3 frames per second, using 8 data ports, each having variable data-transfer rates up to 2 MHz. Table 1 provides the significant performance characteristics of the CCD.

Table 1

CCD Performance Specification

- Solar Quantum Efficiency >0.65
- Quantum Efficiency Variation <2% RMS
- Dark Current @ -40 °C <60 e/pixel/second
- Dark Current Variation <10% RMS
- Charge Transfer Inefficiency <1.0 X 10^{-5} @ 1620 e, -40 °C, 2 MHz
- Full Well Capacity >75,000 e/pixel

The basic structure of the three-phase CCD uses three gate levels. The gates are formed by depositing thin films of polycrystalline silicon, delineating the gate pattern using photolithographic techniques, and oxidizing the polysilicon. The SiO_2, or polyoxide, over each gate serves to isolate the three gate levels from each other electrically. The device is thinned to allow back illumination, which provides very high uniform quantum efficiency, together with 100% fill factor, avoiding losses due to absorption in the gate structure, which would occur with front illumination.

Testing performed on the prototype wafers included a basic shorts/open test (checks for gate-gate shorts, gate substrate shorts, and open circuits, etc.), and low-temperature wafer probe tests (checks for bright pixels, dark pixels, dark current, output circuit gain, output charge-to-voltage conversion, and charge-transfer inefficiency using soft x-rays as a signal source).

The device is mounted with epoxy on a molybdenum plate. A circular printed circuit board with the center cut out to fit over the CCD is wire-bonded to gold-plated traces along the inner edge of the PCB. These traces carry the signals and video outputs to three multipin connectors at the edge of the card. Electrostatic-discharge protection circuits are resident in the package. In order to provide a flat focal plane, a package flatness of ±10 microns is required over the

Table 2

Package Features

- All lines are ESD protected
- Video outputs buffered through low noise follower
- Decoupling capacitors on sensitive DC lines
- 10-layer PCB with separate digital and analog ground planes
- Molybdenum cold plate
- Standard multipin connectors.

entire chip. Table 2 highlights the package features.

This work was done by Lincoln Laboratory, Massachusetts Institute of Technology, for **Headquarters Electronic Systems Center, Hanscom Air Force Base**, *Massachusetts. Inquiries concerning rights for commercial use should be addressed to Lt. Mara McNeill, Electronic Systems Center/XRR; (617) 271-4513.*

Optical Process-Control Sensors for Metallurgical Processes

An accurate new measure of mineral concentrations offers several advantages over current sensor technology.

US Bureau of Mines, Salt Lake City Research Center, Salt Lake City, Utah (now closed)

Former Bureau of Mines researchers developed an optical sensor that uses color to measure mineral content in mineral-purification processes. The sensor is primarily designed for controlling froth flotation, one of the most common mineral processing operations.

Froth flotation uses reagents to attach minerals selectively to the surface of air bubbles, forming a froth containing the concentrated mineral. The froth is then skimmed to separate the desired minerals from the residue. Experienced plant operators routinely estimate how well the flotation is performing by visually checking the color and consistency of the froth in flotation cells. Video technology is now beginning to match or exceed this capacity of the human eye to distinguish color changes. The optical sensor can determine the color and mineral concentration in a flotation froth or slurry in seconds.

For a quantitative measure of flotation performance, mill operators have relied on analyses using x-rays. Optical sensors can provide composition data much faster than x-ray sensors and do not require shielding against hazardous radiation. Optical sensors are also more compact and less expensive than x-ray instruments.

One of the most important advantages of the optical sensor is that it can measure mineral concentrations in the complex mixture of air, water, and mineral that makes up a flotation froth as the mineral separation process occurs. X-ray analyzers measure concentration in slurries only after the flotation is finished. As a result of the fact that flotation performance can only be measured after the fact, process control is difficult.

Other process variables such as the texture of a flotation froth or particle size can also be measured using analysis of video images collected by the sensor. Optical sensors may also be easily multiplexed via fiber optics or multiple cameras to monitor a number of individual process steps simultaneously.

The team demonstrated that the instrument can measure copper (Cu) and molybdenum (Mo) concentrations in the laboratory and in a commercial flotation plant. The optical sensor measures Cu and Mo concentrations in flotation froths with an accuracy of +/ 2%. Also demonstrated is the ability of the sensor to control reagent addition in a flotation process to optimize mineral recovery.

The sensor has also been successfully used to measure the concentration of coal-resin flotation products using fluorescent light emitted from resin exposed to UV light. Other applications of the optical sensor in mineral processing are limited only by the requirement that some optical quality such as color must be characteristic of the property that needs to be measured. Commercial testing of the instrument is in progress.

Improvements in the control of mineral processing operations can provide several valuable benefits in addition to improved mineral recoveries. Reagent usage, energy consumption, and pollution can all be reduced by more efficiently producing needed mineral products.

This sensor was developed by John M. Oestreich, William K. Tolley, and John Cocanour III at the **US Bureau of Mines Salt Lake City Research Center.** *The Bureau of Mines is now closed. A patent application has been filed on the method of using the optical sensor to measure properties like concentration.*

Pending Department of Interior release of rights to commercialize the technology, inquiries concerning further information, commercial use, or demonstration should be addressed to William K. Tolley, 3192 S. 1940 East, Salt Lake City, UT 84106; (801) 485 2405.

NEW LITERATURE

Coordinate Measuring Machines

A new brochure describes a wide range of coordinate measuring machines (CMMs) offered by the Industrial Measuring Technology Division of Carl Zeiss Inc., Minneapolis, MN. Zeiss designs its CMMs to meet many application requirements and provide solutions for inspecting large and small parts in controlled environments and on the factory floor. The brochure includes details on Zeiss' scanning technology, which enables measurement of form, position, and dimension on a single CMM.

For More Information Write In No. 812

Photonics Components and System-Level Products

Aimed at engineers and scientists engaged in photonics R&D and manufacturing, the 160-page standalone photonics product catalog from Newport Corp., Irvine, CA, features both components and systems. Included are Newport's laser diode instrumentation line, consisting of drivers, temperature controllers, and mounts; benchtop and handheld optical meters and optical spectrum analyzers; detectors; and fiber optics, including new tunable and fixed fiber optic filters, and fiber optic isolators. The catalog showcases about 20 new optical fibers.

For More Information Write In No. 813

Metals and Materials for Lasers & Optronics

Almost 4000 items are listed in the 1995-6 Catalog of Metals and Materials for Research and Industry from Goodfellow Corp., Doylestown, PA. Also included are technical specifications and comparative data. The 560-page catalog features pure metals, alloys, polymers, ceramics, composites, and honeycombs, available in small quantities and ready for 48-hour delivery.

For More Information Write In No. 814

Communications Fiber Optic Components

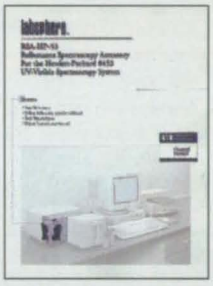
Lasertron, Burlington, MA, offers a 12-page 1996/97 Short Form Catalog of its lines of fiber optic components for communication and instrumentation systems. Sections include lasers, light-emitting diodes, PINFET receivers, PIN detectors and receivers, transmitters and instruments, and package specifications. The catalog features specifications, technical drawings, and photographs.

For More Information Write In No. 815

New Products for Spectral Analysis

New Products for 1996 is a 20-page catalog supplement from EG&G Ortec, Oak Ridge, TN. It contains 17 new products, including DSPEC™, a totally digital gamma-ray spectroscopy system; PINS neutron-activation chemical assay system for field evaluation of containers holding munitions or hazardous chemicals; the Picosecond Time Analyzer, a multiple-stop time spectrometer with 1-ps precision for LIDAR, time-of-flight mass spectrometry, or fluorescence lifetime measurement; and the IGLET-X™ germanium detector with 135 eV resolution for x-rays of energy less than 0.5 keV.

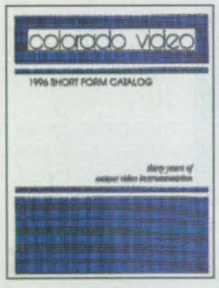
For More Information Write In No. 816



Reflectance Spectroscopy Accessory

A 4-page brochure from Labsphere Inc., North Sutton, NH, describes the RSA-HP-53 reflectance spectroscopy accessory for the Hewlett-Packard 8453 spectrophotometer. It has operational features and specifications for the integrating-sphere-based accessory; measurement capabilities and typical applications round out the brochure's information.

For More Information Write In No. 817



Specialized Video Instruments

The 1996 12-page Short Form Catalog from Colorado Video, Boulder, CO, outlines the company's line of instruments for the positioning, measurement, and analysis of video images. Included are a family of video memories, as well as signal analyzers, measuring equipment, image modifiers, and still-picture transmission systems. The systems are designed for use in research, industrial inspection, and communications.

For More Information Write In No. 818

Two-Stage Vacuum Isolation Valve

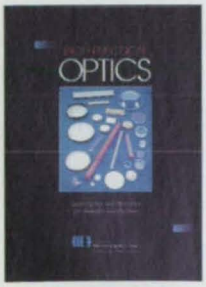
HPS, Boulder, CO, a division of MKS Instruments Inc., has revised and expanded its brochure describing the VacuComp™ Two-Stage Valve, a vacuum isolation valve used to slow system evacuation. The booklet has specifications and descriptive tables on the five-model line, along with technical drawings and information on spare and replacement parts.

For More Information Write In No. 819

CCD Cameras with Many Options

A 128-page full-color catalog of High-Performance Digital CCD Cameras from Princeton Instruments, Trenton, NJ, outlines the company's line, with applications from microscopy to astronomy. The cooled slow-scan imaging CCD cameras have spectral response from x-ray to the near infrared. The catalog has specifications for the more than 30 CCD chips offered in the cameras, and application notes to help in selecting from the line.

For More Information Write In No. 823



Precision Optical Products and Fabrication

Meller Optics, Providence, RI, offers a four-page brochure detailing its precision laser optics and photonics for medical, industrial, and defense applications and its fabrication capabilities. Included are sapphire windows, substrates, lenses, and prisms; laser optics; and IR detector, sensor and filter optics. Built around the five-axis Opticam™ SX machining center for fabricating sapphire missile radomes, capabilities relating to materials, configurations, dimensions, and testing and support services are listed.

For More Information Write In No. 821

Flexibility for Fiber-to-Fiber Connections

The specification sheet "Specialty Fiber Accessories" from 3M, West Haven, CT, describes the new Fiber Terminator, a reusable connect/disconnect device for joining two single-mode or large-core multimode fibers. The company calls the Fiber Terminator the first termination device for fibers with core sizes larger than 200 µm, whose patented design eliminates the need for special tooling fixtures, extra hardware, or adhesives. The sheet's four pages contain product data and operating instructions.

For More Information Write In No. 822

Precision Ruled Optical Slits

A capabilities statement from Deerfield Optics, Framingham, MA, gives details of apertures, substrates, coatings, and applications of available ruled slits. All variations of linear patterns, single or multiple, can be ruled on metals, glass, quartz, or ceramics. Also available are ruled Foucault knife-edges.

For More Information Write In No. 820

LED Transillumination Panels

An eight-page product guide 87-2 from Lumex Opto/Components, Palatine, IL, describes a new family of light-emitting-diode transillumination panels. Electronic and mechanical specifications are included for four panel types: chips-on-board, edge-lit, post-lit, and edge-lit LEDs-on-board assemblies.

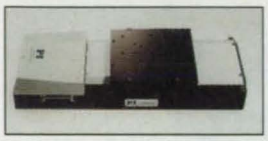
For More Information Write In No. 824

NEW PRODUCTS

30-W Diode Laser

Opto Power Corp., Tucson, AZ, adds the OPC-B030-FCTS to its line of microprocessor-controlled diode laser units. It delivers up to 30 W of constant output power via an optical fiber at manufacturer-preset user-selectable wavelengths between 795-980 nm. Measuring 16 × 16 × 8 in., the unit has four modes of operation—continuous-wave, single-shot, multishot, and burst—which can be set on the control panel. The panel also controls pulsewidth (200 µs-CW), repetition rate (up to 1 kHz), output power, and pulse count. The unit has a transient-protected power supply, active thermoelectric cooling, and an RS-232 interface for external computer control.

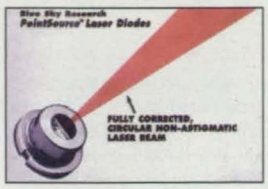
For More Information Write In No. 800



Linear Stage with 0.1-Micrometer Resolution

Polytec PI, Auburn, MA, adds the M-515 linear stage to its M-500 family of micropositioners. Available with 300, 200, and 100-mm travel, the M-515 has a solid forged aluminum base and 100-kg (220-lb.) load capacity. Its resolution is 0.1 micrometer, and it can reach a maximum velocity of 100 mm/s. It is available with either stepper or DC motors, and an optional integrated Heidenhain linear encoder to enhance accuracy and repeatability.

For More Information Write In No. 801



Laser Diode with Nonastigmatic Output

The PointSource™ laser diode from Blue Sky Research, San Jose, CA, has a circularized nonastigmatic diffraction-limited output beam. The company calls it a cost-effective alternative to the intrinsically elliptical and astigmatic beams of other laser diodes. Integrated into the hermetically sealed package is the company's µLENS™ Virtual Point Source microlens. The device is available with a variety of output powers and visible and near-IR wavelengths, and in small or large quantities.

For More Information Write In No. 802

Sealed DC-Excited Carbon Dioxide Lasers

Available with either 12 or 30 W output power, the Geolase™ series of sealed DC-excited CO_2 lasers from Merchantek Electro-Optics, Carlsbad, CA, have continuous-wave output and "super-pulsing" up to 2 kHz. The company says these features enable deep penetration and small spot sizes for ablating materials; the beam can be defocused for welding and other surface treatment. The lightweight single-mode lasers consist of the head, a board-level or turnkey power supply, optional pulsing control module, water-cooling system, and beam delivery optics.

For More Information Write In No. 803

Excimer and Nd:YAG Focusing Lenses

The excimer and Nd:YAG focusing lenses from OptoSigma Corp., Santa Ana, CA, are air-spaced multielement lenses optimized for axial focusing or collimation of laser light. The fused silica excimer lenses have a wavelength transmission range of 180-400 nm, and the Nd:YAG lenses, which provide minimum spot size at 1064 nm, are chromatically corrected so that a HeNe beam will be in focus at the same point. A selection of diameters and focal lengths is offered from stock.

For More Information Write In No. 804

PC-Card Enhancements for IR Camera

FLIR Systems Inc., Portland, OR, announces several enhancements for its Prism DS infrared imaging camera, all loadable in the field via a PC card. They include support for 40-Mbyte PC cards capable of storing 260 high-resolution images; an isotherm function, enabling multipoint temperature measurement of an object even as it moves around the field of view; atmospheric attenuation to compensate for severe ambient conditions; and electronic zoom.

For More Information Write In No. 805

Three-Rod Design in Nd:YAG Laser

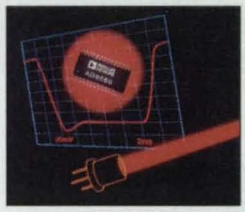
Continuum, Santa Clara, CA, says that the Powerlite Plus Q-switched Nd:YAG laser has the highest energy per pulse of any commercially available laser of its type. A new entry in the Powerlite 9000 series, the 10-Hz Plus produces more than 3 J at 1064 nm and 1.5 J at 532 nm. The company says the simple 3-rod design allows the laser to operate at low pump levels, minimizing thermal loading and maintaining beam quality at 532, 355, and 266 nm. A single-longitudinal-mode seeding option is available.

For More Information Write In No. 806

Mounted Corner Cube Prisms

Corner cube prisms from Edmund Scientific, Barrington, NJ, designed to reflect any ray entering the prism face back upon itself regardless of the prism's orientation, are mounted in an aluminum body and held in place with RTV potting cement. They are easily set up via two ¼-20 tapped holes, and each prism has been silvered to decrease polarization effects and increase field of view.

For More Information Write In No. 807



Laser Diode Driver with Current Sourcing

The AD9660 integrated laser diode driver from Analog Devices Inc., Norwood, MA, designed for magneto-optical disk drives and optically driven printers and copiers, serves as a switched current source. It can switch between read (bias) and write power levels at rates up to 200 MHz. Dual analog feedback loops and output drivers produce independently calibrated read and write currents up to 90 mA and 60 mA, respectively, at 3 V. The AD9660 has a sourcing current output, eliminating the need for an external drive transistor.

For More Information Write In No. 808

4-Megapixel CCD Camera for Computed Tomography

Photometrics Ltd., Tucson, AZ, offers a 12-bit cooled camera with a 2032-x-2044 CCD array of 9-µm-square pixels. Photometrics says the PXL 4200 is ideal for applications requiring high spatial resolution such as computed tomography (CT), large-format microscopy, film digitization, and color scanning. It has software-selectable readout speeds of 0.5, 1.0, or 2.0 MHz: at the last, an entire array can be read out in 2.6 s, and with 2-x-2 binning at less than 1.5 s, particularly useful for CT where many images are required for a single 3D reconstruction.

For More Information Write In No. 809

X-Y Micropositioners for Manual Fine-Tuning

For the one-time adjustments typical when setting up lasers, mirrors, and related optical instruments, Charles Supper Co., Natick, MA, offers X-Y Micro-Slide Assemblies. The aluminum sledges with hardened stainless-steel drive screws are adjustable and fully lockable in both planes using a 6-spline drive key. Three sizes are offered, from 0.500-in. square with 0.125-in. X-Y travel to 1.490-in. OD with 0.750-in. travel. Options include Z-axis attachments. Prices start at $175.

For More Information Write In No. 810

Pockels Cells in Various Configurations

The Series 1000 high-speed Pockels cells from Lasermetrics, Saddle Brook, NJ, are fabricated from highly deuterated (98%) KD*P crystals. For laser Q-switching, pulse chopping, seeding, gating, and modulation, they come in a variety of configurations and housings to match applications. The series encompasses capacitive, strip-line, and 50-ohm impedance designs. Switching speeds as fast as 40 ps and apertures as large as 50 mm are standard. Prices range from $1750 for a typical 10-mm aperture Q-switch (Model 1059) to $16,500 for a 50-mm device (Model 1092) used in large systems.

For More Information Write In No. 811

RUSSIA'S SECRET TECHNOLOGIES REVEALED

With the Cold War over and Iron Curtain "lifted," Russia is making available a treasure of previously-classified technologies and products developed for space, military, and other major R&D programs in the former Soviet Union.

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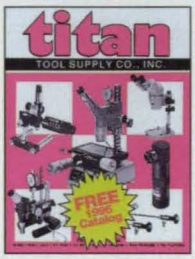
National Instruments

For More Information Write In No. 300

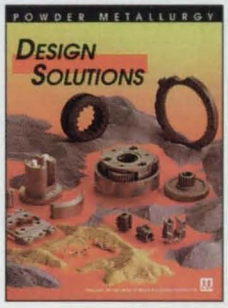


OPTICS FOR METROLOGY

New 1996 Catalog contains 120 pages of information and prices on toolmaker's microscopes, stereo microscopes, alignment microscopes, monocular zoom microscopes, micro-telescopes, pocket microscopes, borescopes, micro video lenses, and fiber optic and miniature illumination systems. Also described are centering microscopes, optical cutting tool geometry analyzers, X-Y tables, and micro-finishing equipment. Titan Tool Supply Co., Inc.; Tel: 716-873-9907; Fax: 716-873-9998.

Titan Tool Supply Co., Inc.

For More Information Write In No. 301



THE POWDER METALLURGY DESIGN SOLUTIONS BROCHURE

This 20-page illustrated brochure, published by the industry's trade association, is yours for the asking. It presents cost-effective design solutions and new ways to handle parts fabrication. Metal Powder Industries Federation, 105 College Road East, Princeton, NJ 08540; Tel: 609-452-7700; Fax: 609-987-8523.

Metal Powder Industries Federation

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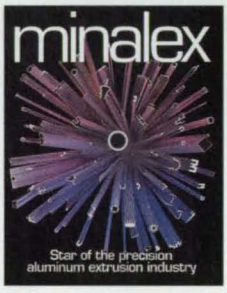

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Minalex

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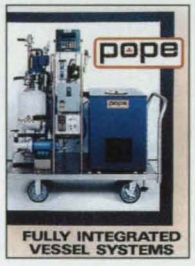

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Pope Scientific, Inc.

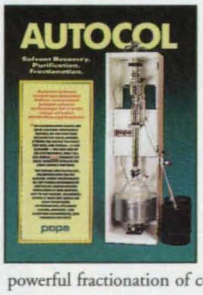
For More Information Write In No. 304

STEP & SERVO MOTOR SYSTEMS & CONTROLS

Compumotor's new 408-page catalog covers motion control products. The Engineering Reference section covers motors, drive & feedback technologies with illustrated examples, how-to section and terminology. Second section covers Brushless Servo motors, amplifiers, controls and support software. Third section features Microstepping, Ministepping, & Linear Step Motor systems, indexers & encoders. Parker Hannifin Corporation, Compumotor Division; Tel: 800-358-9070; Fax: 800-328-8087.

Parker Hannifin Corporation, Compumotor Division

For More Information Write In No. 305

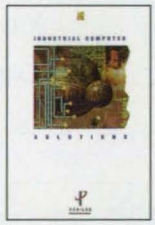


AUTOMATED DISTILLATION SYSTEM

Autocol is an automated, packed column still with many cost-saving applications for solvent recovery, concentration of wastes, and small scale batch production. With 15 theoretical plates for powerful fractionation of components, Autocol can automatically purify and recover individual solvents from complex mixtures. Send for new color brochure or call 414-251-9300.

Pope Scientific, Inc.

For More Information Write In No. 306

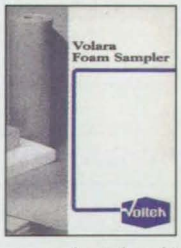


MULTI-PLATFORM INDUSTRIAL COMPUTERS INCLUDE PCI ALTERNATIVES

Pro-Log's new catalog provides a complete selection of rugged industrial computer platforms—all backed by a five-year warranty. Pro-Log offers Pentium-based PCI/ISA computers for high performance data acquisition and telecommunications; **and now CompactPCI**, Pentium-based computers (PCI in Eurocard format) for rugged applications that need real-time performance. In addition, Pro-Log offers the STD bus and ISA bus. Pro-Log Corporation, 12 Upper Ragsdale Drive, Monterey, CA 93940; Tel: 800-655-7006; Fax: 408-646-3517.

Pro-Log Corporation

For More Information Write In No. 307



POLYOLEFIN FOAMS SAMPLE KIT

Samples of Volara®, a fine-celled, irradiation crosslinked polyolefin foam, are available from Voltek. Volara combines a smooth, consistent surface quality and gauge control with superior mechanical, cushioning, insulating, chemical resistance, and moisture resistance characteristics to make it suitable for a wide range of applications. It is available in sheets or continuous rolls in a variety of densities, thicknesses, and colors. Voltek, 100 Shepard St., Lawrence, MA 01843; Tel: 800-225-0668; Fax: 508-685-9861.

Voltek

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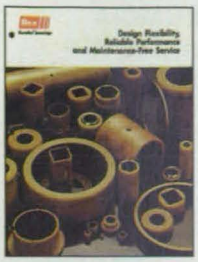


DURALON® COMPOSITE BEARINGS

Duralon® PFTE Composite bearings are used in mechanical linkages that pivot, have linear motion or travel at slow speeds, high loads, and in full rotation. Let us help you achieve a maintenance free mechanism by replacing linear ball bushings, powder metal and molded plastic bearings. Rexnord Corporation, 2324 Curtiss Street, Downers Grove, IL 60515; Tel: 800-591-0886; Fax: 708-969-8752.

Rexnord Corporation

For More Information Write In No. 309

COMPUTER CONTROLLED VALVES

This brochure describes APP's line of remote and computer controlled on-off, metering and servo valves, pressure generators, automated pressure and flow control systems, pressure gauge calibration systems, and capability for custom configurations. Pressure range: high vacuum to 60,000 PSI. Tel: 607-257-5544 or 800-APP-VALV; Fax: 607-257-5639; Address: 83 Brown Rd., Ithaca, NY 14850; E-mail: info@pmiapp.com; URL: http:\\www.pmiapp.com.

Advanced Pressure Products

For More Information Write In No. 310

GET A GRIP... ON TEST AND VERIFICATION!

New CodeTEST tools from Applied Microsystems provide unit, integration and system testing, comprehensive software performance analysis, coverage analysis, and trace and memory allocation analysis, with non-sampled measurements, across your entire program. Know how your code performs, how much code your test exercises, and if memory allocation works as planned. Call for your free brochure and annotated screen-shot package—1-800-895-0831.

Applied Microsystems Corporation

For More Information Write In No. 311

CD-ROM CATALOG—WORKBENCHES AND SYSTEMS

This interactive multi-media presentation covers Teclab's workbenches and laboratory systems furniture. Designed for Windows™, the CD-ROM presentation features hundreds of benches. *Meeting the Challenge*, Teclab's introductory video, highlights unique features and benefits of a Teclab bench. Select what you want by clicking on the icons that interest you. Teclab, Kalamazoo Technical Furniture, 6450 Valley Industrial Drive, Kalamazoo, MI 49009; Tel: 800-832-5227; Fax: 616-372-6116.

Teclab

For More Information Write In No. 312

COMPUTER CONTROLLED AUTOMATED PRESSURE REGULATOR

The pressure regulator is designed to provide accurate control of gas pressures and complement APP's line of automated valves and pressure control systems. Controlled by a 0-2V, 0-5V, 0-10V, or a 4-20mA signal from a computer or a digital input. This regulator is designed for laboratory, pilot plant, and process control applications. Available in pressure ranges from 10-30,000 PSI. Tel: 607-257-5544 or 800-APP-VALV; Fax: 607-257-5639; Address: 83 Brown Rd., Ithaca, NY 14850; E-mail: info@pmiapp.com; URL: http:\\www.pmiapp.com.

Advanced Pressure Products

For More Information Write In No. 313

AUTOMATED PRESSURE GAUGE CALIBRATION SYSTEM

The Automated Pressure Gauge Calibration is designed to test the linearity, hysteresis, and repeatability of pressure gauges and can calibrate up to 40 slave gauges in one calibration process. This highly accurate system is available in pressure ranges from vacuum to 60,000 PSI. The calibration process and report generation are easily controlled through Windows-based software. Tel: 607-257-5544 or 800-APP-VALV; Fax: 607-257-5639; Address: 83 Brown Rd., Ithaca, NY 14850; E-mail: info@pmiapp.com; URL: http:\\www.pmiapp.com.

Advanced Pressure Products

For More Information Write In No. 314

ALGOR PROVIDES "4-WAY" INFO ON THE WORLD WIDE WEB

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

Algor, Inc.

For More Information Write In No. 315

BOOK WITH DISK DELIVERS REAL-WORLD FEA INSTRUCTION

A comprehensive FEA reference/textbook that offers a unique blend of theory & real-world engineering examples. Dr. Constantine Spyrakos, well-known finite element stress & vibration analysis expert, has created a reference for all mechanical engineers from designers to "gurus." Richly illustrated hardcover book includes every example problem on a disk. Subjects include: FEA basics, element types, modeling, types of analysis & the interpretation of results. Tel: 1-800-482-5467; URL: http://www.algor.com/apd.htm; E-mail: apd@algor.com.

APD

For More Information Write In No. 316

NEW KIND OF MULTIMEDIA VIDEO TEACHES FEA LESSONS

Finite Element Analysis in Action! is a new kind of instructional video for engineers. Available on VHS tape or interactive, multimedia CD-ROM, the video packs a lot of information into a short running time of only 26 minutes. Live lab experiments and FEA analysis are conducted to show how to better use any FEA software. Demonstrates specific modeling and analysis techniques. Tel: 1-800-482-5467; URL: http://www.algor.com/apd.htm; E-mail: apd@algor.com.

APD

For More Information Write In No. 317

ELECTRO-MAGNETIC DESIGN SOFTWARE

The legendary Vector Fields suite of software, including the TOSCA, ELEKTRA and OPERA packages, combines classical finite element techniques with user friendly interactive graphics for high accuracy 2D and 3D simulation and design of all types of electromagnetic equipment.

Vector Fields Inc.
1700 North Farnsworth Avenue
Aurora, IL 60505
Tel: 708-851-1734 Fax: 708-851-2106

For More Information Write In No. 318

MECHANICAL COMPONENTS

PIC Design's new Catalog 43 is bigger than ever–288 pages, including new Modular Framing Elements, Linear Motion Systems & Positioning Tables, and expanded lines of Lead Screws & Nuts, Belts & Pulleys, Ball Slides, Shoulder Screws, Bearings, Shafting, Couplings and much more, all in inch and metric dimensions. PO Box 1004, Middlebury, CT 06762. Tel: 800-243-6125; Fax: 203-758-8271; E-Mail: info@pic-design.com.

PIC Design

For More Information Write In No. 319

PRESSURE TRANSDUCERS/TRANSMITTERS

Taber pressure transducers/transmitters are outlined in a new brochure. They are available in low and high models in a variety of pressure ranges. Differential transducers provide high differential overload pressure and high line pressure capability. Oceanographic transducers are completely submersible, highly accurate pressure sensors. For more information contact: John Pinder. Tel: 800-333-5300.

Taber Industries

For More Information Write In No. 320

Scientific WorkPlace is a complete word processing system designed specifically for preparing technical documents, especially those containing mathematics. SWP is a software program designed for writers in many technical fields including: mathematics, physics, engineering, and computer science. Call TCI at 800-874-2383 or visit our Web Site: http://www.tcisoft.com/tcisoft.html.

TCI Software Research

For More Information Write In No. 321

METAL BELTS AND DRIVE TAPES

This general product brochure describes the various attributes that make metal belts and drive tapes an exceptional and exciting option for design engineers. Manufactured by Belt Technologies for 25 years, this unique family of products has helped design engineers overcome challenging application requirements in the electronics, aerospace, biomedical, optical and packaging industries. Belt Technologies, Inc., PO Box 468, Agawam, MA 01001; Tel: 413-786-9922; Fax: 413-789-2786.

Belt Technologies, Inc.

For More Information Write In No. 322

1996 PCMCIA PRODUCTS CATALOG

The new PCMCIA-PC CARD standard has brought many new devices such as Video Capture, 16-bit Stereo, CD-ROM, Wireless Communication and PC Card Camera Cards. ENVOY DATA has just released its new catalog with these new products plus many other products like: Memory, I/O (serial, parallel, SCSI, A/D, etc.), along with Industrial Card and Drives, Multimedia, Industrial, and Engineering tools for PCMCIA applications. ENVOY DATA Corporation, 953 E. Juanita Ave., #A, Mesa, AZ 85204; Tel: 602-892-0954; Fax: 602-892-0029.

ENVOY DATA Corporation

For More Information Write In No. 323

FREE LAMP CATALOG

PSC LAMPS, Inc. is one of America's fastest growing sources of replacement specialty lamps for A/V, Photographic, Stage, Studio, Video, Television, Micrographic, and Graphic Arts equipment, plus Medical & Electronic instruments. Customer satisfaction is key to our continuing success. We offer the best brands including Osram Sylvania, GE, Philips, Ushio, and Wiko at the right price, no minimum order & two-day delivery at no extra cost! For a free catalog, call 800-772-5267; Fax: 800-257-0760. PSC LAMPS, Inc., 1 Fishers Rd., Pittsford, NY 14534-9511; E-mail: http://www.roccplex.com/psclamps

PSC LAMPS, Inc.

For More Information Write In No. 324

POSITIONING/ MOTION CONTROL CATALOG

NEW, detailed 160 page catalog covers NEAT's expanding line of precision positioning and motion control components and systems. Featured are single axis, X-Y, multi-axis, rotary, high vacuum, air bearing, and microscope stages. NEAT also provides a complementary line of stepping and servometer drives and controls. NEAT specializes in providing modified, custom, and turnkey SOLUTIONS to a wide range of positioning and motion control applications. Please contact our Sales Engineers at 800-227-1066, or send E-mail to neat@tiac.net for more information.

New England Affiliated Technologies

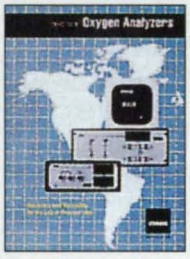
For More Information Write In No. 325

LIGHT MEASUREMENT CATALOG

International Light offers their latest version full-line catalog describing light measurement instrumentation, applications, and basic concepts of Radiometry/Photometry. Many new products are introduced covering a wide range of UV-VIS-IR applications. All technical details such as spectral and spatial responses, measurement ranges, and descriptions have been either updated, enlarged, or expanded in scope. International Light, Inc., 17 Graf Rd., Newburyport, MA 01950-4092; (508) 465-5983; Fax (508) 462-0759; E-mail: ilsales@intllight.com; Internet: http://www.intl-light.com/

International Light

For More Information Write In No. 326



OXYGEN ANALYZERS

A full-color brochure introduces a complete line of oxygen analyzers for the laboratory or process line. They are ideally suited for monitoring the oxygen levels in all types of gas streams. Trace oxygen levels from ppb to 100% are accurately determined by these ruggedly constructed instruments. No periodic maintenance or special operator skills are required. Intrinsically-safe and battery-operated models are also available.

Illinois Instruments Inc.

For More Information Write In No. 327

TIME AND FREQUENCY PRODUCTS

TrueTime's Precision Time and Frequency Products catalog features GPS-Synchronized Clocks in rackmount, portable, and board-level configurations. Included are illustrations and product specs for Synchronized Clocks, Time Code Products, Board Level Products and Remote Displays. TrueTime products fit a variety of time and frequency applications. TrueTime, Inc., 2835 Duke Court, Santa Rosa, CA 95407; Tel: 707-528-1230; Fax: 707-527-6640; E-mail: truetime@nbn.com.

TrueTime, Inc.

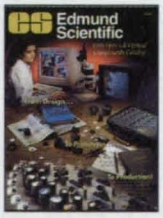
For More Information Write In No. 328

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 Manufacturing Co. Inc.

For More Information Write In No. 329



NEW! OPTICS & OPTICAL COMPONENTS CATALOG

Edmund Scientific's free 224-page color technical reference catalog features one of the largest selections of precision off-the-shelf optics and optical instruments. Our unique line of off-the-shelf optical components can take you from design, to prototype, to final production. We provide technical design and production solutions with our extensive inventory of precision optics and optical components. Over 8,000 hard-to-find items, including magnifiers, magnets, microscopes, telescopes, and "machine vision" products. Tel: 609-573-6259; Fax: 609-573-6233.

Edmund Scientific Co.
Dept. 16B1, N954

For More Information Write In No. 330

"HANDS-ON" ADVANCED COMPOSITE WORKSHOPS SINCE 1983

The brochure describes 14 different "hands-on" workshops in advanced composite materials technology, including fabrication, repair, manufacturing, tooling, print reading, adhesive bonding, ultrasonic inspection of composites, resin transfer molding, and engineering. Emphasis is placed on glass, carbon and aramid fiber materials and processes, utilizing vacuum bagging and oven and autoclave curing. Three workshops are Canadian D.O.T. approved. REFRESHER WORKSHOPS OFFERED. Call toll-free: 1-800-638-8441; Fax: 702-827-6599. Abaris Training Resources, Inc., 5401 Longley Lane, Suite 49, Reno, NV 89511.

Abaris Training Resources, Inc.

For More Information Write In No. 331

VORTEX TUBES

Data sheet describes how EXAIR Vortex Tubes produce up to 10,000 Btu/hr. with no moving parts. Tubes convert an ordinary supply of compressed air into two streams: one hot and one cold. Temperatures are adjustable from -50° to +250°F. Bulletin highlights advantages for a variety of industrial cooling applications. EXAIR Corporation, 1250 Century Circle North, Cincinnati, OH 45246; Tel: 800-903-9247; Fax: 513-671-3363; E-mail: techelp@exair.com.

EXAIR Corporation

For More Information Write In No. 332

AIR KNIFE FOR BLOWOFF

The EXAIR-Knife reduces air consumption and noise levels on a wide range of blowoff applications. Using a small amount of compressed air as a power source, the air knife pulls in large volumes of surrounding air to produce a high flow, high velocity curtain of air for blowoff. Compressed air flow is amplified 30:1. Six sizes up to 36" in length are available. Applications include: blowing liquid, chips, and contamination from parts and conveyors; cooling hot parts; and air screening. EXAIR Corporation, 1250 Century Circle North, Cincinnati, OH 45246; Tel: 800-903-9247; Fax: 513-671-3363; E-mail: techelp@exair.com.

EXAIR Corporation

For More Information Write In No. 333

APP ANALYTICAL SERVICES

Advanced Pressure Products offers a complete line of pressure and flow control related services including:

- Pressure gauge calibration
- Flow meter calibration
- Isostatic pressure testing
- Burst testing
- Compression testing
- Fatigue testing
- Leak testing
- Cyclic pressure testing

Tel: 607-257-5544 or 800-APP-VALV; Fax: 607-257-5639; Address: 83 Brown Rd., Ithaca, NY 14850; E-mail: info@pmiapp.com; URL: http:\\www.pmiapp.com.

Advanced Pressure Products

For More Information Write In No. 334

POSITION CONTROLLED VALVES

The Advanced Pressure Products Remote Position Controlled Valve provides a very cost-effective remote controller for metering valves. The valve is controlled by a single analog or digital signal (0-5V, 0-10V, or 4-20mA) which determines the desired position of the valve. The controller moves the valve to match this target position. Automatic limit protection is provided. Control can be provided from a simple remote potentiometer, analog voltage, milliamp output, or via a computer interface. Tel: 607-257-5544 or 800-APP-VALV; Fax: 607-257-5639; Address: 83 Brown Rd., Ithaca, NY 14850; E-mail: info@pmiapp.com; URL: http:\\www.pmiapp.com.

Advanced Pressure Products

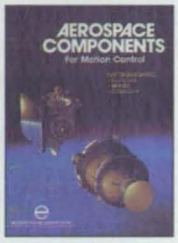
For More Information Write In No. 335

FIRESTONE AIR SPRINGS

Your motion control solution! Firestone Industrial Product Company's Airstroke® actuators and Airmount® isolators blow traditional cylinders and isolators away. The bellows-shaped air springs defy the traditional way of thinking about cylinders and isolators. They are durable, self-aligning, compact and cost-effective. Firestone Industrial Products Company, Carmel, IN; Tel: 800-888-0650; E-mail: firestone@industry.net.

Firestone Industrial Products Company

For More Information Write In No. 336



6-page color brochure of Aerospace Components for Motion Control. Brochure features photos, features, specs and applications on electromagnetic clutches, brakes and solenoids. Products are Mil-spec'd for aerospace and military applications as well as for commercial and business aircraft.

Electroid Company

For More Information Write In No. 337

AUTOMATED PRESSURE CONTROL SYSTEM

The Automated Pressure Control System is a Windows-based system designed to allow easy computer control of high pressure generation and control up to 60,000 PSI for continuous pressurization situations. Pressure ramps can be programmed for complete hands-off operation by providing the software with a list of desired pressures and holding times. Tel: 607-257-5544 or 800-APP-VALV; Fax: 607-257-5639; Address: 83 Brown Rd., Ithaca, NY 14850; E-mail: info@pmiapp.com; URL: http:\\www.pmiapp.com.

Advanced Pressure Products

For More Information Write In No. 338

INSTRUMENT CATALOG 1996

Metric sells, rents and buys the latest in refurbished electronic test and measurement instruments from Hewlett Packard, Tektronix, Fluke, Keithley, etc. All products are tested in our lab to insure compliance to original manufacturers' specifications and are traceable to N.I.S.T. Six-month warranty on most models, five-day free trial, complete with accessories and manuals. BIG SAVINGS 20% to 60% off list. For free catalog call Metric; Tel: 800-432-3424; Fax: 415-341-8874.

Metric Equipment Sales, Inc.

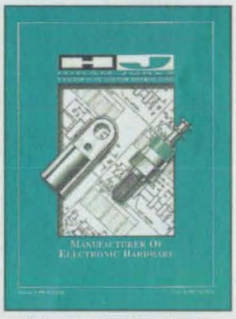
For More Information Write In No. 339

FIBEROPTIC TESTER

Automatically measure the surfaces of a variety of fiber components including connector end faces, ferrules, APCs, PCs, fibers, etc. In seconds, obtain non-contact, three-dimensional measurements and industry-standard statistics of roughness, apex offset, apex angle, protrusion/undercut, radius of curvature, and more. For more information, contact WYKO at: 800-FON-WYKO; E-mail: sales@wyko.com.

WYKO

For More Information Write In No. 340



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 stand-offs 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.

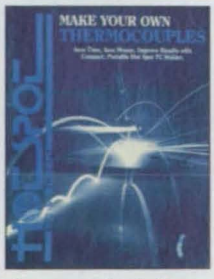
For More Information Write In No. 341

NEW CATALOG OF OVENS & FURNACES

Expanded, 4-color capabilities section, fully illustrated, plus specifications for over 250 standard ovens and furnaces to 2700°F, as well as custom-designed heat processing systems. Includes: laboratory, bench, cabinet, truck, walk-in and conveyor ovens; cleanroom and pharmaceutical ovens; laboratory and industrial furnaces and environmental test chambers. For baking, drying, pre-heating, annealing, stress relieving, curing, sterilizing, depyrogenation and heat treating. The Grieve Corporation, 500 Hart Rd., Round Lake, IL 60073-9989; 847-546-8225; Fax: 847-546-9210.

The Grieve Corporation

For More Information Write In No. 342



THERMO-COUPLES, MAKE YOUR OWN

The HOTSPOT allows thermocouple wire to be formed into freestanding 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: 609-662-7272; Fax: 609-662-7862.

DCC Corp.

For More Information Write In No. 343

LOCATE HIGH-TECH RESEARCHERS & RESEARCH CENTERS

Synergistic Technologies, Inc. (STI) publishes valuable information on researchers and research centers in the high-tech areas of semiconductors, advanced materials, electronics, optoelectronics, environmental management and biotechnology. Comprehensive information on each researcher or research center allows you to quickly locate new technologies, identify early-stage research and reach laboratory decision-makers. Synergistic Technologies, Inc.; http://www.netscan.com/sti; Tel: 800-972-8501; Fax: 919-941-8399.

Synergistic Technologies, Inc.

For More Information Write In No. 344

Apec high-heat polycarbonate, known for its unique combination of high heat resistance, toughness, transparency, color stability and flowability, is described in a new 16-page color brochure issued by the Polymers Division of Bayer Corporation, Pittsburgh, PA. The brochure shows typical applications for this material, and provides information on flame retardance, chemical and stress crack resistance, solubility and processing methods. Bayer Corp., Polymers Division, 100 Bayer Road, Pittsburgh, PA 15205-9741; Tel: 412-777-2000.

Bayer Corp., Polymers Division

For More Information Write In No. 345

TECHNICAL FIBRE PRODUCTS MATERIAL ADVANTAGE

TFP is an Advanced Fiber Nonwoven Manufacturer that produces veils varying from 0.2-8.0 oz/yd^2 from virtually any fiber type. Examples are Carbon, Aramid, Quartz, Silcon Carbide, Metal-coated and Glass. TFP's accurate fiber blending technology can result in a hybrid, provide a specific resistivity level or utilize a thermoplastic fibre for molding. TFP also produces Intumescent mat for fire protection. Tel: 914-355-4190; Fax: 914-355-4192.

Technical Fibre Products Limited

For More Information Write In No. 346

The Capattery is a high-reliability double layer capacitor used as a standby power source in memory back-up and bridge-power applications. It has virtually unlimited cycle life and over 20x the capacitance density of conventional capacitors. With a Permselective valve, patented by Evans, 33 Eastern Ave., East Providence, RI 02914-2107, Tel: 401-434-5600; Fax: 401-434-6908.

Evans

For More Information Write In No. 347

MERCURY ROTATING ELECTRICAL CONNECTORS

Mercury-wetted contacts are covered in brochure. They are superior to conventional slip rings and feature sealed, ball bearing construction. Durable, compact, low-cost connectors offer reliability, extremely low electrical noise, and less than 1 milliohm resistance. Ideal for computers, instrumentation, thermocouples, cable reels, strain gauges, packaging equipment, robotics, turntables, testing, and control devices. Mercotac Inc., 6195 Corte del Cedro #100, Carlsbad, CA 92009.

Mercotac Inc.

For More Information Write In No. 348

RUGGED MINIATURE SWITCH

The new Series 70 is an environmentally rugged line of lighted and unlighted switches. Ready for wet, dusty or oily duty, the Series 70 is ideal for a variety of control and instrumentation requirements. Available with DPDT Momentary or Alternate switch actions. Mounts on 0.700" centers with 0.880" behind the panel space. Lighted pushbuttons use T-1 LED or Incandescent MFB lamps for a wide variety of display types, colors, and lighting styles. StacoSwitch, Inc., Costa Mesa, CA 92626. Tel: 714-549-3041; Fax: 714-549-0930.

StacoSwitch, Inc.

For More Information Write In No. 349

Find out how Datum Inc. Network Time Servers and Board Level Timing Modules can be used to synchronize your network and workstations to Global Positioning System, GPS, satellites and IRIG Time Code. TCP/IP and Novell Netware™ networks can be synchronized to within 1-10 milliseconds. VME, VXI, PC, SUN SBus™, QBus™ workstations can be synchronized to within 1 microsecond. Tel: 800-348-0648 or 408-578-4161; Fax: 408-578-4165.

Datum Inc. — Bancomm Division

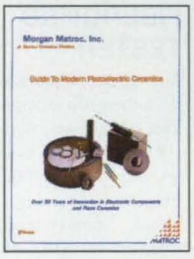
For More Information Write In No. 350

LUMITEX... CREATORS OF WOVEN LIGHT

This eight-page color catalog describes new low-power, long-life light sources for use in portable and hand-held applications. Also included are new woven panel construction options for use in high-volume, price sensi-tive backing areas. Ideal for LCD backlighting, machine vision, and switch, keypad, and control panel applications. Lumitex, Inc., 8443 Dow Circle, Strongsville, OH 44136. Tel: 800-969-5483; Fax: 216-243-8402.

Lumitex, Inc.

For More Information Write In No. 351



PIEZOELECTRIC CERAMICS

A 28-page brochure is a design guide for piezoelectric ceramics in a variety of shapes and sizes. Piezo-electric and electromechanical properties for various PZT materials (lead zirconate titanate) are included, and various types of piezoceramic configurations, including stacks and bimorphs® are described. Tel: 216-232-8600; Fax: 216-232-8731.

Morgan Matroc Inc.

For More Information Write In No. 352

WINDOWS-BASED CAM SYSTEM WITH SURFACE MODELING

SURFCAM integrates mechanical design, surface modeling, and powerful 2,3,4, and 5 axis machining. Compatible with all other CAD/CAM systems, solid models are imported and machined. Easy to learn, SURFCAM runs under Microsoft® Windows™, Windows 95 and Windows NT. Call 800-SURFWARE (800-787-3927).

Surfware Incorporated

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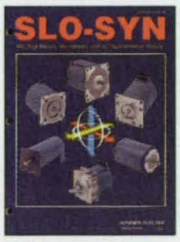


DC STEP & AC SYNCHRONOUS MOTORS

SLO-SYN® DC Step Motors, Gearmotors and AC Synchronous Motors Catalog ACDC593 has a DC step section that describes motors with 1.8° full, 0.9° half and 0.0144° microstep capability and operate to 20,000 steps/sec. Holding torques to 5330 oz-in. AC Synchronous section includes 72 rpm 3-phase types, 200 rpm types and gearmotors with torque capability to 26 ft-lbs and ratios from 3:1 to 125:1. Selection guide incorporated. Superior Electric, 383 Middle St., Bristol, CT 06010; Tel: 800-787-3532.

Superior Electric

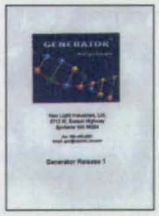
For More Information Write In No. 354

AIR MOVERS

Air Amplifiers convey, vent, exhaust, cool, dry and clean—with no moving parts. Using a small amount of compressed air as a power source, Air Amplifiers move large volumes of surrounding air to produce high velocity outlet flows. Air amplifiers are compact, durable, portable, and maintenance free. Applications include small parts conveying; venting fumes, cleaning, drying, or cooling parts. EXAIR Corporation, 1250 Century Circle North, Cincinnati, OH 45246; Tel: 800-903-9247; Fax: 513-671-3363; E-mail: techelp@exair.com

EXAIR Corporation

For More Information Write In No. 355



GENETIC ALGORITHM FOR EXCEL SPREADSHEETS

Optimize ANYTHING that can be modeled on an Excel spreadsheet—electronic circuits, chemical systems, control functions, schedules, distribution plans, stock portfolios, mechanical designs, curve fitting, and more. Originally developed for NASA, this software is now available to private industry. Runs on PC-compatibles under Windows; requires Excel. Price $375. For detailed information and a free demo version, see www.iea.com/~nli or contact us at 509-456-8321; Fax: 509-456-8351; E-mail: stevem@comtch.iea.com.

New Light Industries, Ltd.
9713 W. Sunset Highway, Spokane, WA 99204

For More Information Write In No. 356

NEW MINIATURE BALL SCREWS

New MRB96 catalog features super smooth BS&A miniature rolled ball screws with sizes from 4 mm to 14 mm diameter. These stocked screws have leads from 1 mm to 20 mm for high resolution to high speed applications. Miniature screw lead error is less than .002"/foot and backlash is less than .001". BS&A can quickly machine ends and provide end bearings from stock. Contact: Greg Traeger, Sales Manager, Ball Screws & Actuators Co., Inc., 800-882-8857.

Ball Screws & Actuators Co., Inc.

For More Information Write In No. 357

APP SERVO VALVE CONTROLLERS

The Advanced Pressure Products Servo Valve Controllers use a single or a pair of microprocessor controlled metering valves which allow computer control of the flow into and out of the system to maintain pressure, flow, or other variables. Single valve servo systems are also available. Tel: 607-257-5544 or 800-APP-VALV; Fax: 607-257-5639; Address: 83 Brown Rd., Ithaca, NY 14850; E-mail: info@pmiapp.com; URL: http:\\www.pmiapp.com.

Advanced Pressure Products

For More Information Write In No. 358

BURST PRESSURE TEST SYSTEM

Advanced Pressure Products has just developed a fully automated, precise, computer operated and controlled Burst Pressure Test System. The system is designed to determine the exact pressure at which materials burst or fail. Applications include determining: burst-pressure of disks, tubes, and hoses; crushing-point of materials; crimp or vent failure of battery casings, etc. Tel: 607-257-5544 or 800-APP-VALV; Fax: 607-257-5639; Address: 83 Brown Rd., Ithaca, NY 14850; E-mail: info@pmiapp.com; URL: http:\\www.pmiapp.com.

Advanced Pressure Products

For More Information Write In No. 359

FREE CATALOG OF TOOLING COMPONENTS

New reference catalog of over 20,000 items offers a full range of tooling components and equipment. Items include clamps, handwheels, handles, knobs, spring & ball plungers, latches, leveling pads, set-up accessories, locating devices, springs, thread inserts, and metric items. All items are in stock for same-day shipment with no minimum order requirement. Reid Tool Supply Company, 2265 Black Creek Rd., Muskegon, MI 49444; Tel: 800-253-0421; Fax: 800-438-1145.

Reid Tool Supply Company

For More Information Write In No. 360

WINDOWS-BASED ENVELOPE SURFACE AREA ANALYZER

The Windows-Based Envelope Surface Area Analyzer (WESA) offers a simple, quick, and reliable method for obtaining the envelope surface area of a powder by using the flow permeametry technique. WESA uses accurate, state-of-the-art flow control and is controlled by Windows-based software which can handle all low level commands and provide user interface and dialog boxes when needed. Tel: 607-257-5544 or 800-APP-VALV; Fax: 607-257-5639; Address: 83 Brown Rd., Ithaca, NY 14850; E-mail: info@pmiapp.com; URL: http:\\www.pmiapp.com.

Porous Materials Inc.

For More Information Write In No. 361

CAPILLARY FLOW POROMETER

PMI's Capillary Flow Porometer provides fully automated through-pore measurement, bubble point, gas and liquid permeability, average pore diameter, and pore size distribution. The Capillary Flow Porometer tests small samples of various geometries as well as complete parts for pores ranging from 0.03 to 500 microns using inlet pressure as high as 200 PSI. Windows-based software handles all control, measurement, data collection and reduction, and report generation. Tel: 607-257-5544 or 800-APP-VALV; Fax: 607-257-5639; Address: 83 Brown Rd., Ithaca, NY 14850; E-mail: info@pmiapp.com; URL: http:\\www.pmiapp.com.

Porous Materials Inc.

For More Information Write In No. 362

TELEDYNE WAH CHANG: FIRST IN REACTIVE & REFRACTORY METAL SOLUTIONS

Teledyne Wah Chang is the world's largest producer of hafnium, pure niobium, and vanadium, and is also one of the world's largest producers of titanium and zirconium, available in various degrees of purity or in specialty alloys. Visit our Internet site at http://www.twca.com or call 541-967-6977.

Teledyne Wah Chang

For More Information Write In No. 363

PNEUMATIC COMPONENTS CATALOG

New 95A edition includes many new and updated products, including the NEW ISONIC 2 & 3-way solenoid valves, NFPA interchangeable cylinders, index table, flow controls, plastic fittings, binary valves, and slide/lockout devices. Special reference section answers common pneumatic design questions such as choosing the right valve to control a cylinder. Mead Fluid Dynamics, Inc., 4114 N. Knox Ave., Chicago, IL 60641; Tel: 312-685-6800; Fax: 312-685-7002; http://www.industry.net/mead.

Mead Fluid Dynamics, Inc.

For More Information Write In No. 364

EXTRUDED SEALS, GASKETS & WEATHER STRIPPING

The six-page, four-color brochure features Lauren Manufacturing's polymer extrusion and molding capabilities including pressure-sensitive adhesive applications, and secondary fabrication services. Also featured are sections on typical extruded profiles, elastomeric properties, and a physical and chemical properties comparison guide. Lauren Manufacturing, 2228 Reiser Ave., SE, New Philadelphia, OH 44663; Tel: 800-683-0676 or 330-339-3373; Fax: 330-339-7166.

Lauren Manufacturing

For More Information Write In No. 365

COMPOSITE BEARING MATERIALS

Orkot Inc. offers three full-color brochures featuring the complete line of composite bearing materials covering a wide range of bearing applications in the marine, hydroelectric and industrial industries. These materials offer unique mechanical and physical properties that make it an ideal bearing material. Orkot is self-lubricating and manufactured in tubes, sheet and finished product. Complete specs and prices are available for all products. Orkot Incorporated, 2535 Prairie Rd., Eugene, OR 97402; Tel: 541-688-5529; Fax: 541-688-2079.

Orkot Incorporated

For More Information Write In No. 366

GIGABIT NETWORK!

Introducing **FibreXpress™**, SYSTRAN Corp.'s new line of Fibre Channel adapter cards and switches. FibreXpress provides a way to connect computers at speeds of up to 1.0625 Gb/sec. Call 800-252-5601 for this FREE Catalog!

SYSTRAN Corp.

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CONTROL THE WORLD WITH VISSIM/FUZZY-TECH

VisSim/fuzzyTECH works seamlessly with VisSim™ to create an ideal environment for fuzzy control development and simulation. Additional VisSim add-ons include C code generation, communication design, real-time I/O, neural networking, constrained optimization, and frequency domain analysis. VisSim is used for 6-DOF guidance, anti-lock braking, servo and drive motor control, web processes, winders, gas turbines, and data communications.

Visual Solutions, Inc.
487 Groton Road
Westford, MA 01886
Tel: 508-392-0100 Fax: 508-692-3102

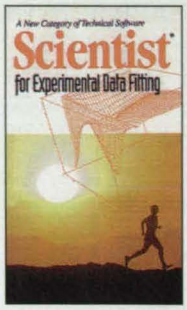
For More Information Write In No. 368

Apollo 11 Commemorative Sweatshirt

Striking full-color illustration on quality white shirt recaptures the spirit and excitement of the Apollo moon landing. Available in adult sizes–S,M,L,XL $19.95 each plus $5.00 shipping/handling.

(NY residents add sales tax.)

Mail with payment to: Associated Business Publications, 317 Madison Avenue, Ste 921, New York, NY 10017. For credit card orders call (212) 490-3999.



MICROMATH® SCIENTIFIC SOFTWARE

MicroMath's software products include applications for curve fitting (including differential equations and Laplace transforms), pharmacokinetic data analysis, and solution chemical equilibrium problems. A full-featured trial version of SCIENTIST for Windows, a general data-fitting package, is available on our Web site at http://www.micromath.com.

MicroMath

For More Information Write In No. 369

REMOTE VIEWING INSTRUMENTS

Inspecting inaccessible areas or hostile environments is easy with ITI's 1800+ rigid & flexible instruments, specially built to suit aviation & aerospace needs. Custom work a specialty. Instrument Technology, Inc. - The Leader in Remote Viewing, PO Box 381, Westfield, MA 01086; Tel: 413-562-3606; Fax: 413-568-9809; E-mail: iti@scopes.com; http://www.scopes.com.

Instrument Technology, Inc.

For More Information Write In No. 370

VACUUM VALVES

VAT's 225-page catalog contains detailed information and drawings on the widest available selection of gate, angle, all-metal, slit, fast-closing, throttle, and pressure control valves. Using innovative sealing technology, they are ideal for pump isolation, load-locks, beam lines, or other vacuum applications. VAT Inc., 500 W. Cummings Park, Woburn, MA 01801; Tel: 617-935-1446 or 800-935-1446; Fax: 617-935-3940.

VAT Inc.

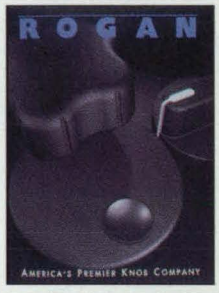
For More Information Write In No. 371

NEW SIGMASTAT 2.0 FOR WINDOWS 95, NT & 3.1

It's like having a professional consultant at your fingertips. Award-winning SigmaStat, designed specifically for researchers, is the only software that guides you through your entire statistical analysis. SigmaStat's unique Advisor Wizard suggests what test to run and then runs it. SigmaStat offers a range of statistical procedures, automatically checks if data fits underlying assumptions, and handles messy data. SigmaStat 2.0 takes full advantage of 32-bit performance, multitasking and the new Windows 95 interface. Jandel Scientific Software, 2591 Kerner Blvd., San Rafael, CA 94901; Tel: 800-4-JANDEL (800-452-6335); Fax: 415-453-7769; E-mail: sales@jandel.com; Internet: http://www.jandel.com. (ANTSS046)

Jandel Scientific Software

For More Information Write In No. 372



NEW ROGAN KNOB CATALOG

The complete lineup of Rogan clamping and control knobs and dials is featured in this comprehensive, 46-page, illustrated catalog. Included is Rogan's expanded selection of soft-to-the-touch Pure Touch™ knobs. To obtain a free copy, contact Rogan Corporation; Tel: 800-423-1543.

Rogan Corporation

For More Information Write In No. 373

(continued from page 72)

Materials

Water-Based Electroplating Maskant Is Safer

A report proposes the use of the commercial water-based electroplating maskant Tolber 0-18 as a nontoxic alternative to the commercial organic-solvent-based electroplating maskant Turco 531-A. The solvent-based maskant contains 71.1 percent perchloroethylene, which is a suspected carcinogen. In comparison with a previously qualified water-based maskant and with 11 other water-based maskants that were also evaluated as candidates to replace the solvent-based maskant, Tolber 0-18 was found to be equal or superior in key properties, including suitability for application by brushing, effectiveness of sealing, and durability. In addition, this water-based maskant was found to exert no adverse effect on the environment or on the health of workers, and was found to enable users to comply with local and federal antipollution laws. The use of this maskant could prove beneficial in most, if not all, electroplating applications that involve brush application of maskants to areas that are not to be electroplated.

This work was done by Garry M. Pickett of Rockwell International Corp. for **Marshall Space Flight Center.** *To obtain a copy of the report, "Tolber 0-18 Maskant Replacement for SSME,"* ***write in 99*** *on the TSP Request Card.*
MFS-30088

Mechanics

Computed Flow About the Integrated Space Shuttle, Revisited

A report discusses numerical simulations of the flow of air about the integrated space shuttle (the complete space shuttle assembly including the orbiter, the solid rocket boosters, and the external tank) in ascent. This is an updated version of the report described in "Computed Flow About the Integrated Space Shuttle," (ARC-12685), *NASA Tech Briefs*, Vol. 15, No. 10 (October 1991), page 80. The goal of these and related studies is to improve the understanding of, and the ability to predict, how the integrated space shuttle will perform during both nominal and aborted ascent under various conditions. The emphasis in the computations was upon the prediction of pressure loads, and the effects of viscosity were included with this emphasis in mind.

This work was done by P. G. Buning, S. Obayashi, and J. L. Steger of **Ames Research Center**; *I. T. Chiu of Iowa State University; F. W. Martin, Jr., of Johnson Space Center; and R. L. Meakin, Y. M. Rizk, and M. Yarrow of Sterling Software. To obtain a copy of the report, "Flowfield Simulation of the Space Shuttle Vehicle in Ascent,"* ***write in 12*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Ames Research Center; (415) 604-5104. Refer to ARC-13163.

New on Disk

Mechanical Dynamics, Ann Arbor, MI, has introduced a Windows NT version of ADAMS **mechanical system simulation software.** The virtual prototyping software simulates the behavior of mechanical systems and analyzes multiple design variations until an optimal design is achieved. Applications include biomechanics, medical equipment, aircraft and aerospace, and industrial machinery.

For More Information Write In No. 720

T.C. Fonts version 4.0 **AutoCAD fonts software** from Technical Software, Cleveland, OH, contains 6028 hand-lettered, low-resolution, and calligraphy fonts for AutoCAD users who create tables and charts for engineering or technical drawings. International characters and special symbols also are included. The Windows program costs $148.

For More Information Write In No. 721

Ansoft Corp., Pittsburgh, PA, has announced EMSS **electromechanical simulation software**, which allows analysis of an electromechanical system, including the electromagnetic device and electronic drive controller. The program combines finite element analysis, mechanical dynamics, and electronic circuit equations. A perpetual license costs $19,900; the workstation price is $24,900.

For More Information Write In No. 722

WinSoft Corp., Santa Ana, CA, offers PowerLib™ for Windows **mathematical formula reference software**, which provides more than 2000 formulas, equations, diagrams, charts, and tables for use in analysis, reports, and programming. Algebra, geometry, trigonometry, probability, hyperbolic functions, and other topics are covered. A chemical periodic table also is included.

For More Information Write In No. 727

Insight II Version 300 **molecular simulation software** from Molecular Simulations Inc., San Diego, CA, contains tools for researchers working with polymer structure and properties, catalytic processes, and electronic materials. Enhanced features include quantum mechanics utilities and a navigational tool for the calculation of polymer miscibility.

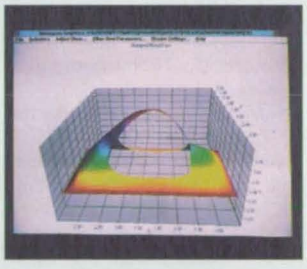
For More Information Write In No. 723

Structural Research & Analysis Corp., Los Angeles, CA, has released COSMOS/M Designer II **design software**, which contains a MicroStation™ Modeler-based modeling and visualization system for MSC/NASTRAN® users. It imports and exports solids data in SAT file format and vector formats for use with other CAD programs.

For More Information Write In No. 724

Gridgen Version 11 **grid generation software** from Pointwise, Bedford, TX, prepares quadrilateral and hexahedral meshes for use with computational fluid dynamics and other numerical analysis software. The program includes geometry modeling, grid generation, and direct interfaces for many analysis software packages and is available for Silicon Graphics and Hewlett-Packard workstations.

For More Information Write In No. 726



Macsyma, Arlington, MA, offers PDEase® **finite element analysis software**, which solves nonlinear static, dynamic, and eigenvalue problems. The program contains more than 80 solved demonstrations involving heat transfer, solid mechanics, reaction/ diffusion, fluid mechanics, electromagnetics, and quantum mechanics.

For More Information Write In No. 725

TriSpectives™ and TriSpectives Professional **3D design software** from 3D/Eye, Ithaca, NY, provides 3D modeling, illustration, and animation with application to graphics and product design. A Windows interface is compatible with Microsoft Office, Windows 95, and ACIS-based solid modeling programs. TriSpectives costs $300; TriSpectives Professional, with additional design capabilities, costs $500.

For More Information Write In No. 728

New on the Market

Product of the Month

TEN, East Providence, RI, has introduced an **online information service for engineers**, which allows them to view catalogs and specs; run selection software and CD-ROMs; view and download CAD files; send E-mail to any TEN subscriber; access specialized databases; find answers to questions; view new products and company news; run software updates and demos; place or browse classified ads; and upload or download shareware. Required equipment includes a 386 or higher microprocessor and at least 640KB of RAM, DOS 3.3 or higher, a mouse, a modem, and TEN's Rlink free interim communications software. The service is provided free via direct access through May 31; a flat monthly fee will be charged thereafter. At press time, the service was expected to be available on the Internet.

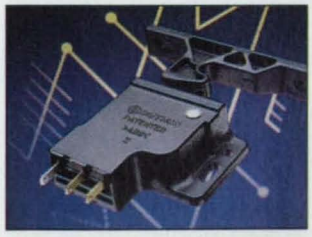
For More Information Write In No. 700

Immersion Corp., San Jose, CA, has introduced the Microscribe-3DL **3D digitizer**, which allows physical objects of any shape, size, and material to be turned into 3D data sets for CAD, 3D-graphics, animation, or scientific applications. The user traces over the contours of a physical object with the stylus and captures 3D as points, lines, polygons, or nurbs. It is compatible with PCs, Macintosh, or SGI workstations and provides a 66" spherical workspace.

For More Information Write In No. 708

Ultralube™ permanent **dry film lubricant** from Diversified Drilube, Tulsa, OK, features 1/2-micron thickness and acts as a mold release for computer, molding, aircraft, and cutting applications. It is effective from -212°C to +538°C, and will not chip, peel, or crack. It is nontoxic, inert, and has a friction coefficient of 0.030.

For More Information Write In No. 704

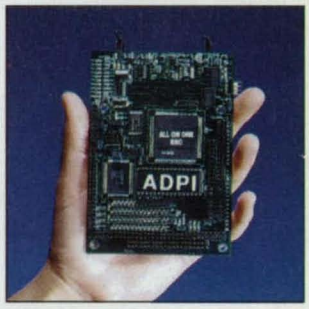


The Grabber™ Catch **latch assembly** from Southco, Concordville, PA, includes the catch and an integral microswitch which opens and closes the switch contacts as a panel door opens and closes. The plastic assembly can operate an indicator light or form part of a non-safety-related logic circuit.

For More Information Write In No. 706

Uni-Form™ **epoxy resins** from Multi-Seals, Manchester, CT, environmentally seal electronic, automotive, and fiber-optic components. The one-part resins are available in a range of shapes and sizes and are solid at room temperature. They melt and cure when heated, forming a seal to resist dust, moisture, oil, solvents, conformal coatings, and other contaminants.

For More Information Write In No. 702



The Little Guy All On One™ IBM-compatible **single-board computer** from Analog & Digital Peripherals, Troy, OH, combines all functions necessary for data acquisition, program loading, and data transfer on a 3.5" x 4.9" board. It includes a PC-104 connector, two PCMCIA slots, two serial ports, an IDE/2 device, a bidirectional parallel port, an SCSI port for up to seven devices, a floppy disk controller for two drives, on-board power control, keyboard interface, LCD and CRT interface, and a speaker connector.

For More Information Write In No. 705

The PD/CD-ROM Library from Panasonic Communications and Systems Co., Secaucus, NJ, consists of three multi-drive **disk autochangers**, which store, access, and archive 50, 100, and 200 quad-speed CDs and/or rewritable PD disks. They provide near-online access to shared data for multiple computer users from a common data repository. The 50- and 100-disk models store up to 33.4 Gb of data and up to 66.8 Gb of data, respectively.

For More Information Write In No. 710

New on the Market

Falcon Systems, Server Development Div., Sacramento, CA, has introduced the FastfilePro™ dedicated **file servers** for fast file access to networked UNIX environments. Features include a 100 MHz Pentium processor, up to four PCI RAID processors, and a PCI bus that runs at 132 Mb per second. It incorporates the AerREAL real-time operating system and links with Sun, Silicon Graphics, IBM, Hewlett-Packard, and Digital Equipment systems.

For More Information Write In No. 703

Flame-resistant polymers for electronic, aerospace, and automotive component protection are offered by Tra-Con, Medford, MA. The casting, bonding, and potting polymers include ablative or sacrificial capabilities for extreme conditions, flexible formulas for stress-sensitive castings, lightweight systems, and rigid structural products.

For More Information Write In No. 707

VersaLogic Corp., Eugene, OR, offers the VL-186-2 DOS-based **CPU board** for the STD 32 bus, and provides up to 1 Mb of RAM, Flash, or EPROM memory. PC-compatible COM and LPT ports are included, as well as an on-board floppy and IDE interfaces. The 4.5" x 6.5" board can operate at temperatures from 0° C to 65° C; extended-temperature models operate from -25° C to +85° C.

For More Information Write In No. 709

Evans Co., East Providence, RI, offers a **hybrid capacitor** for pulse power, filtering, and communications applications requiring capacitances to 1F and working voltages to 450V. It features an RuO_2 electrochemical cathode and a tantalum anode that combine for high energy density.

For More Information Write In No. 701

The 100-MHz TDS 340, the 200-MHz TDS 360, and the 400-MHz TDS 380 **digital oscilloscopes** from Tektronix, Beaverton, OR, offer more bandwidth and higher sampling rates than previous models, store set-ups and waveforms, and perform 21 different automatic measurements. A DOS-compatible floppy disk drive built into the 360 and 380 models stores and downloads reference waveforms and setups, and imports/exports waveform values into application programs.

For More Information Write In No. 711

WinSystems, Arlington, TX, offers the PCM-518 analog subsystem, a **data acquisition card** which acquires sensor data for any PC/104-based system. It is designed for temperature and low-level signal measurements, and supports thermocouples, RTDs, strain and pressure gauges, resistors, thermistors, and voltage inputs. The unit supports eight, individually programmable differential sensor channels with 16-bit resolution.

For More Information Write In No. 712

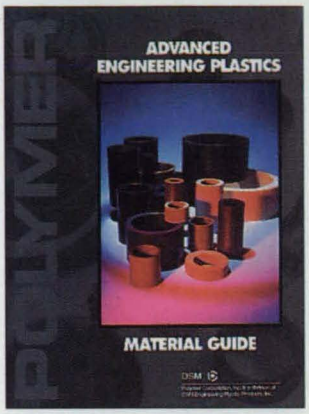
The ABMR-1000 **linear electromechanical actuator** from Kollmorgen Motion Technologies Group, Inland Motor, Radford, VA, consists of a ball screw output shaft with a ball nut that attaches to the valve mechanism. A Goldline brushless DC motor with rare-earth magnets, resolver, and explosion-proof housing are included. The actuator supports a continuous load of 400 lbs. and a maximum statis load of 600 lbs.

For More Information Write In No. 713

StressTel Corp., Scotts Valley, CA, has introduced the T-Mike EL **ultrasonic thickness measurement gauge**, which provides a choice of sequential or grid format and preloaded software. Features include a visual alarm LED indicator, B-Scan for graphical representation of measured material, a measuring range from 0.025" to 19.999", a bi-directional RS-232 serial interface, and built-in memory to store more than 40,000 readings.

For More Information Write In No. 714

New Literature



A 16-page brochure from DSM Engineering Plastic Products, Reading, PA, describes **engineering plastics** for design engineers who require temperature- and chemical-resistant thermoplastic parts. Twenty-nine different extruded, compression, and injection molded products are featured.

For More Information Write In No. 741

A line of **power products** is described in a 16-page catalog from Astrodyne, Taunton, MA. More than 250 modular products, including AC/DC switches, miniature open frame switches, high-power density DC/DC converters, and desktop external power adapters are featured with specifications and mechanical dimensions.

For More Information Write In No. 748

PaintFree™ Petra® **resin**, a PET thermoplastic polyester for injection molding, is described in a brochure from AlliedSignal Engineering Plastics, Morristown, NJ. Available in a variety of colors, the resins eliminate sanding and paint application on plastic parts.

For More Information Write In No. 751

Laboratory and field analysis products are described in a 1996 catalog from Orion Research, Boston, MA. Included are electrodes, conductivity meters, water quality measurement systems, and electrochemistry systems.

For More Information Write In No. 742

A selection guide of **accelerometers** is available from Sensotec, Columbus, OH. The six-page guide features piezoelectric, shock-resistant, strain gauge, and crash test accelerometer models, as well as pressure and torque transducers, amplifiers, and instrumentation.

For More Information Write In No. 744

The Brad Harrison® line of **connector products** is described in a 148-page designer's guide from Daniel Wood-head Co., Northbrook, IL. The catalog contains sections on Multi-Port interconnection systems, molded connectors, control connectors, safety plugs, and dual round connectors.

For More Information Write In No. 753

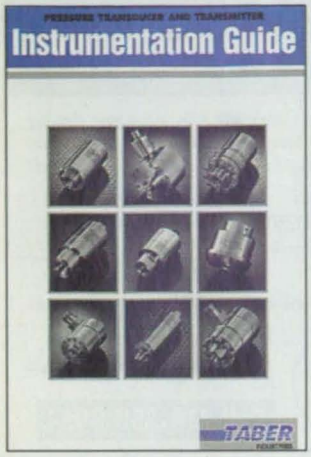
Whatman LabSales, Hillsboro, OR, has released a 300-page catalog of **laboratory instrumentation**, including research equipment, lab supplies and instruments, pH meters, electrodes, conductivity equipment, and safety products.

For More Information Write In No. 743

Avantek **RF and microwave components** are featured in a brochure from PSElect, a division of Penstock, Sunnyvale, CA. IF/RF cascadable modules, thin-film amplifiers, voltage-controlled limiters, detectors, and IF/RF attenuators are described.

For More Information Write In No. 746

New Literature



Taber Industries, North Tonawanda, NY, has released an instrumentation guide of **pressure transducers and transmitters** for special-purpose pressure instruments. The guide features photographs, specifications, and application information.

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The Plasmadize® group of **composite coatings** from General Magnaplate, Linden, NJ, is featured in a four-page brochure. Composed of layers of metallic and/or ceramic particles infused with polymers, the coatings are used to prevent corrosion on new or worn metal or aluminum surfaces.

For More Information Write In No. 749

Bishop Wisecarver Corp., Pittsburg, CA, offers a 28-page catalog describing the Hepco heavy-duty **linear slide system** for precision machine tool applications. Technical specifications, dimensional diagrams, and application examples are included.

For More Information Write In No. 750

A four-page brochure of **thermoplastic products** from Westlake Plastics, Lenni, PA, includes rod, heavy gauge and thin gauge sheet, film, and tubing made from fluoropolymer and elastomer thermoplastics. ASTM, military, and federal specifications are provided, as well as material grades and resin names.

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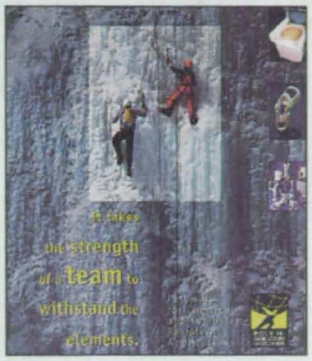

Poly Hi Solidur, Fort Wayne, IN, has released a 10-page brochure describing **chemical- and corrosion-resistant polymers** available in a variety of sizes, colors, and modifications. Operating temperatures and physical properties of Proteus™ polypropylenes and other polymers are included.

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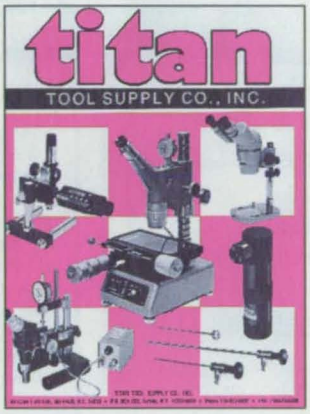

Titan Tool Supply Co., Buffalo, NY, offers a 1996 catalog of **optical instruments**, including metrology and viewing instruments. Also featured are general inspection tools, micro finishing equipment, video viewing systems, and a new line of borescopes.

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Bull Electric, Arlington Heights, IL, offers a six-page brochure describing **DC electric motors**. Available from 7.5 hp to 900 hp, the motors feature laminated frames and a choice of enclosures.

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Product of the Month

KP-D50

Hitachi scores with the KP-D50, a DSP color camera providing enhanced performance for image processing applications. The unit is fully RS232 controllable and features 768x494 pixels on a 1/2-inch Interline Transfer CCD. White suppression, black stretch, contour compensation and 2H enhancement provide the highest quality pictures under adverse conditions. The KP-D50 has NTSC, Y/C and RGB outputs as well as external sync capability. With 470 line resolution and 50db S/N ratio, this camera is a winner!

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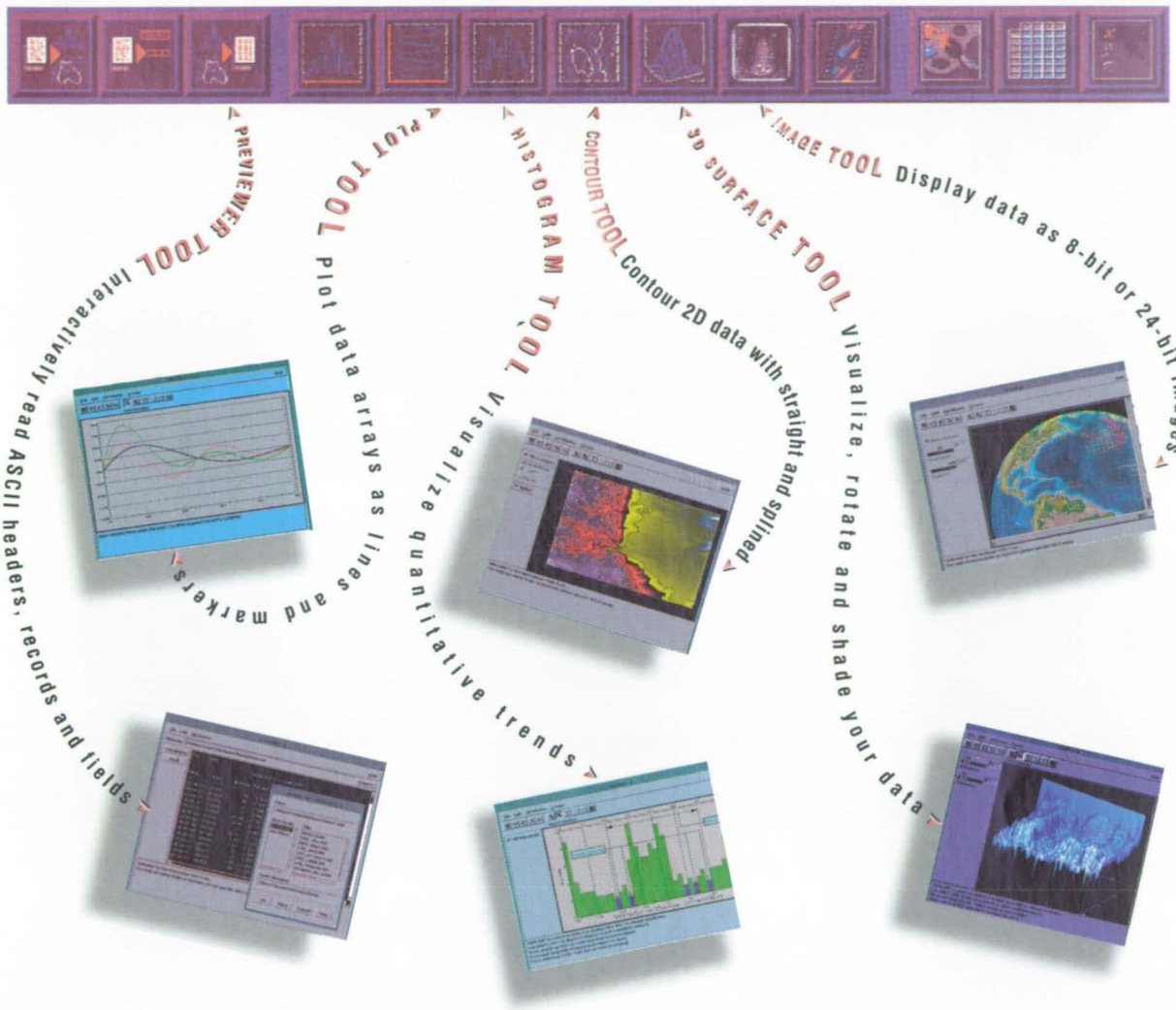

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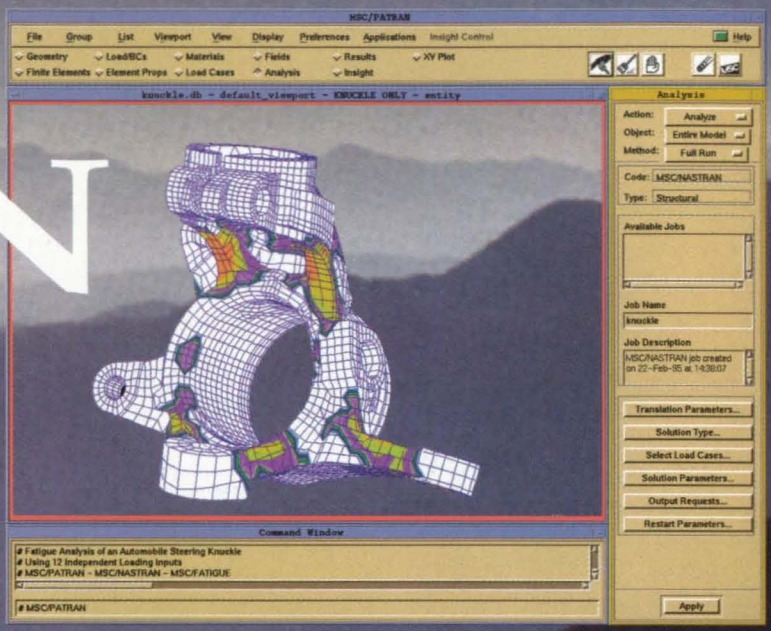

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