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February 1995 Vol. 19 No. 2

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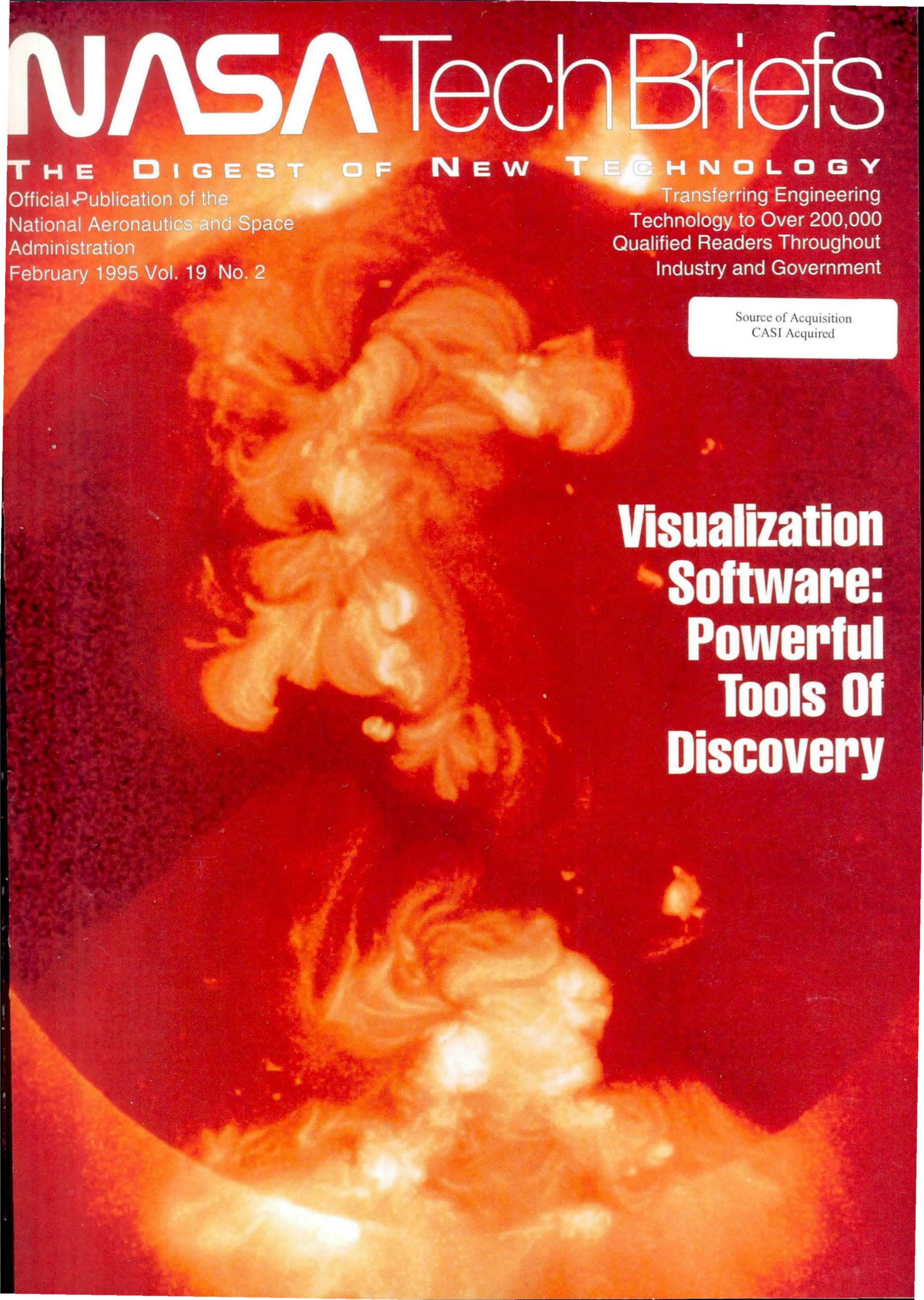

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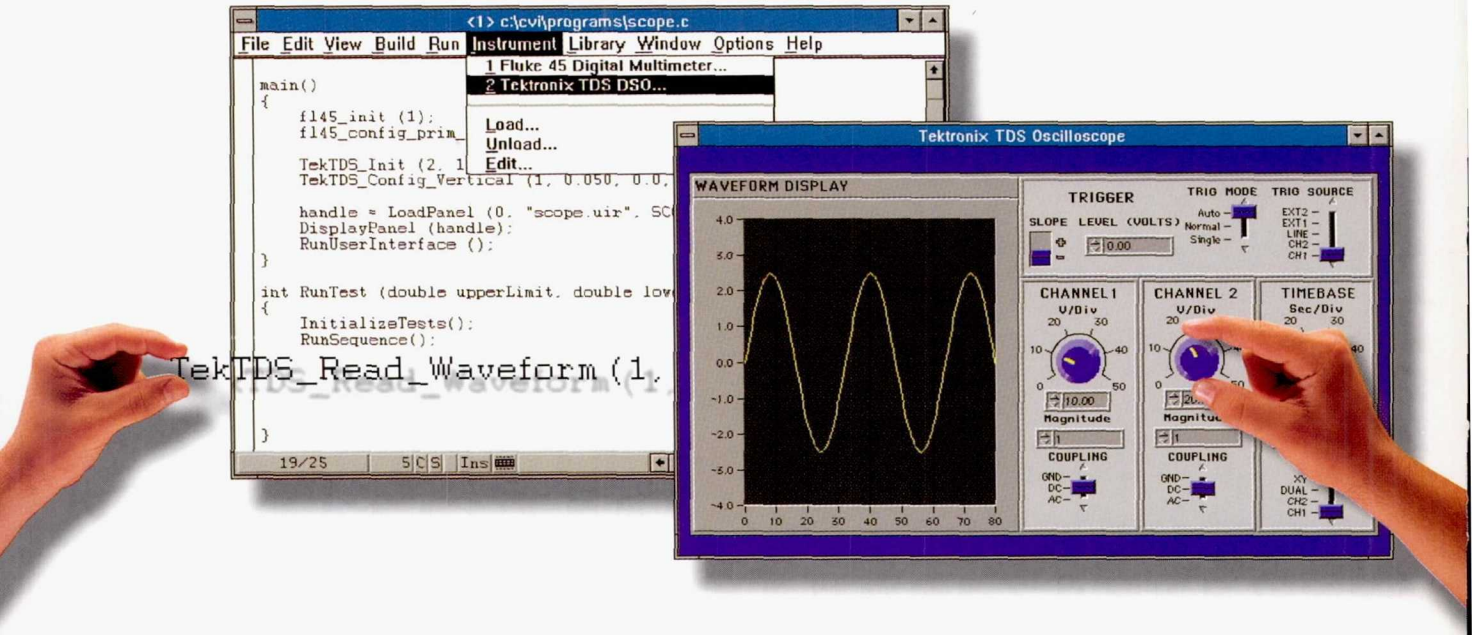

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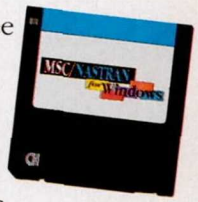

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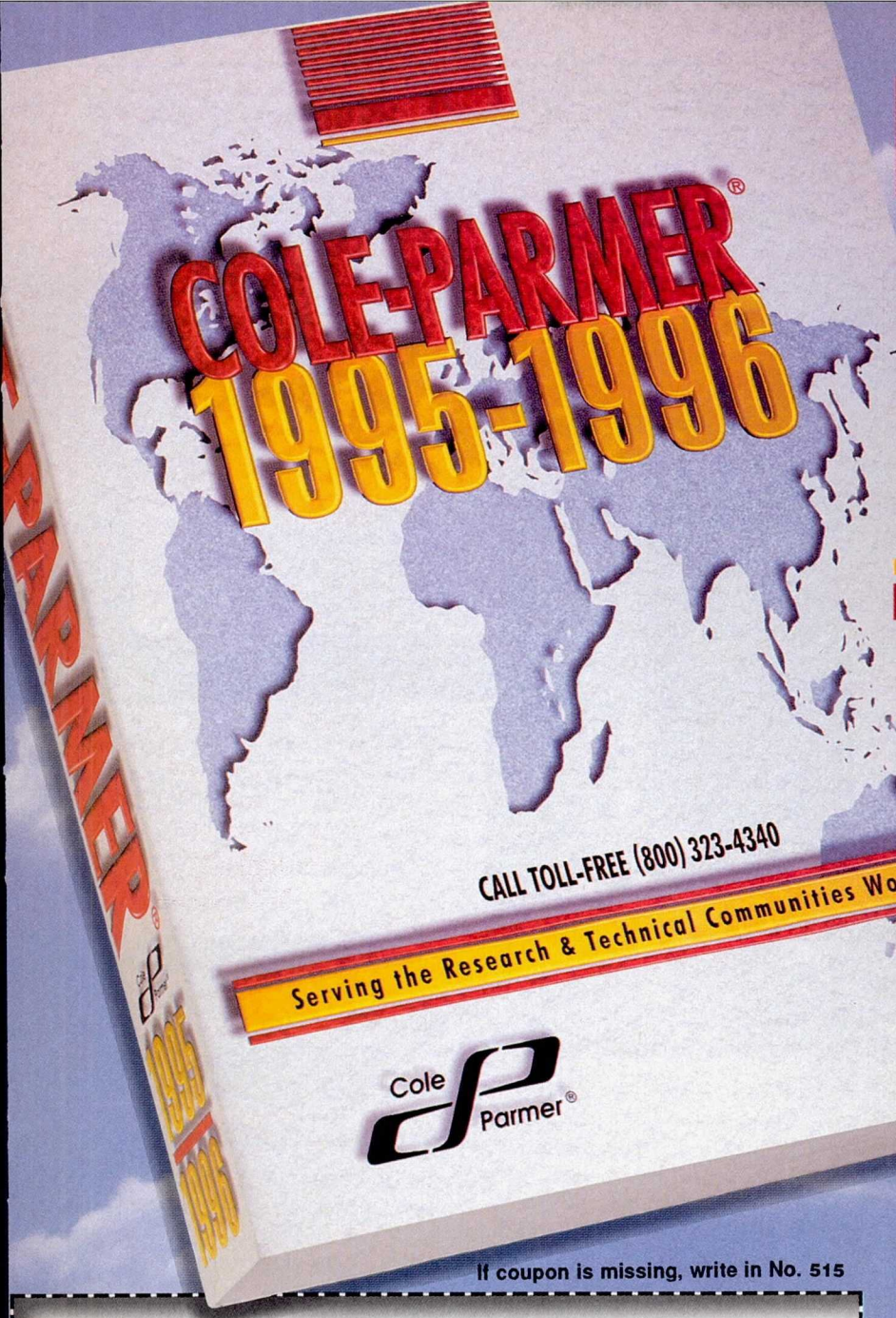

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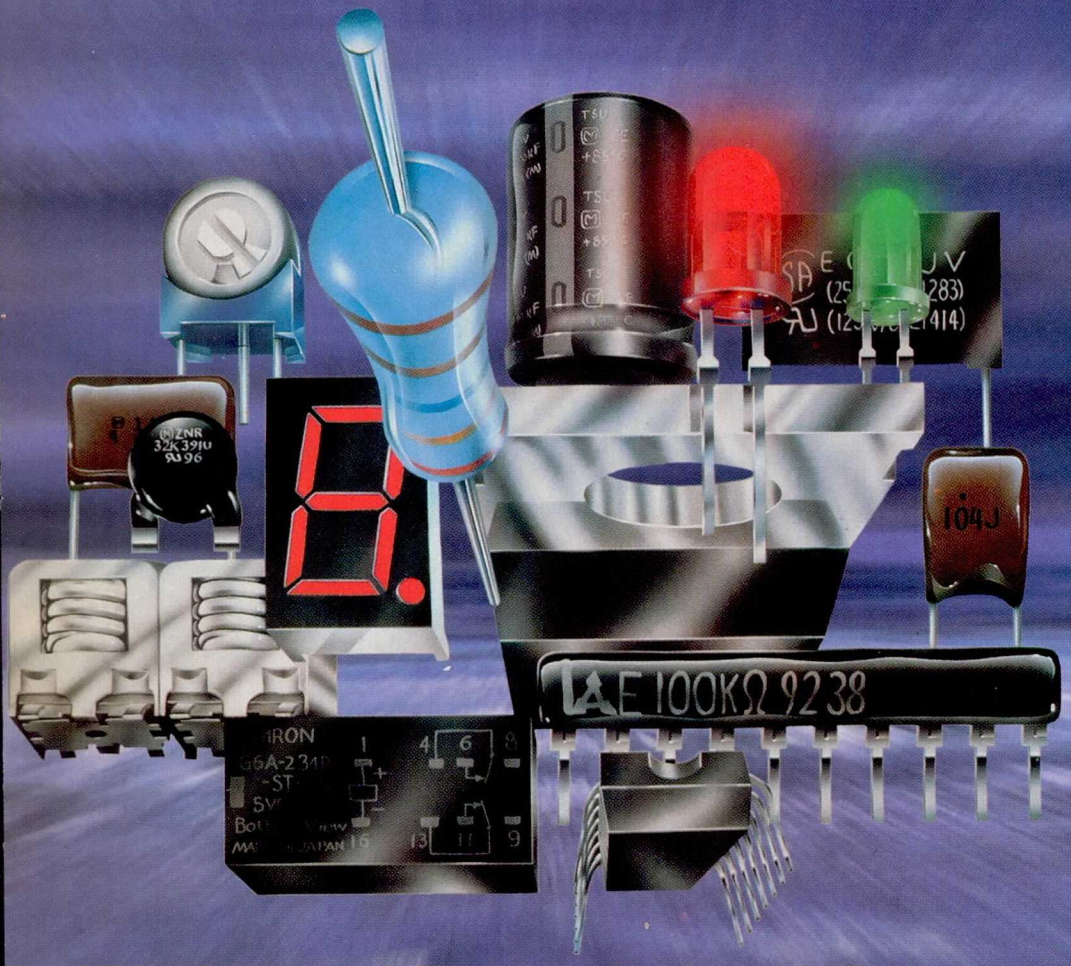

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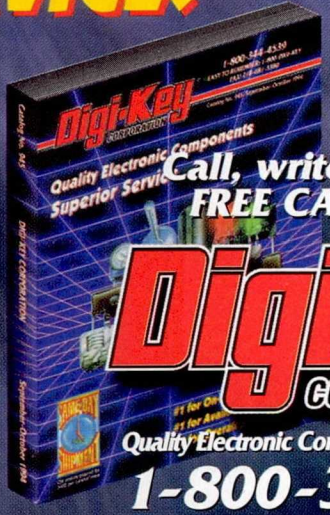

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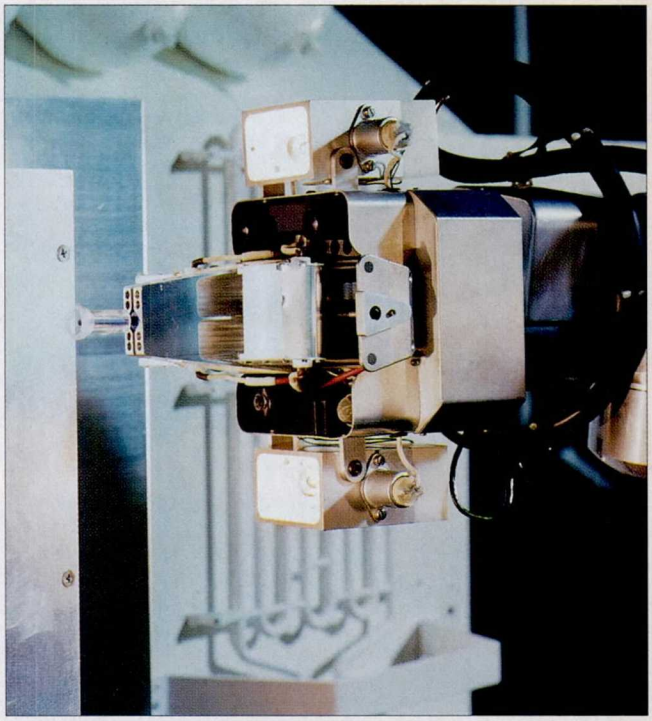

Researchers at Jet Propulsion Laboratory have developed the Integrated Sensor End-Effector (ISEE) to enable complete and repeatable inspection of the space station by a robotic arm. The ISEE has two cameras and illuminators for visual inspection and a set of other sensors to detect temperature, gases/vapors, eddy currents, proximity, and force. The tech brief on page 68 describes a method for computing robotic motions using data from the ISEE.

Photo courtesy Jet Propulsion Laboratory

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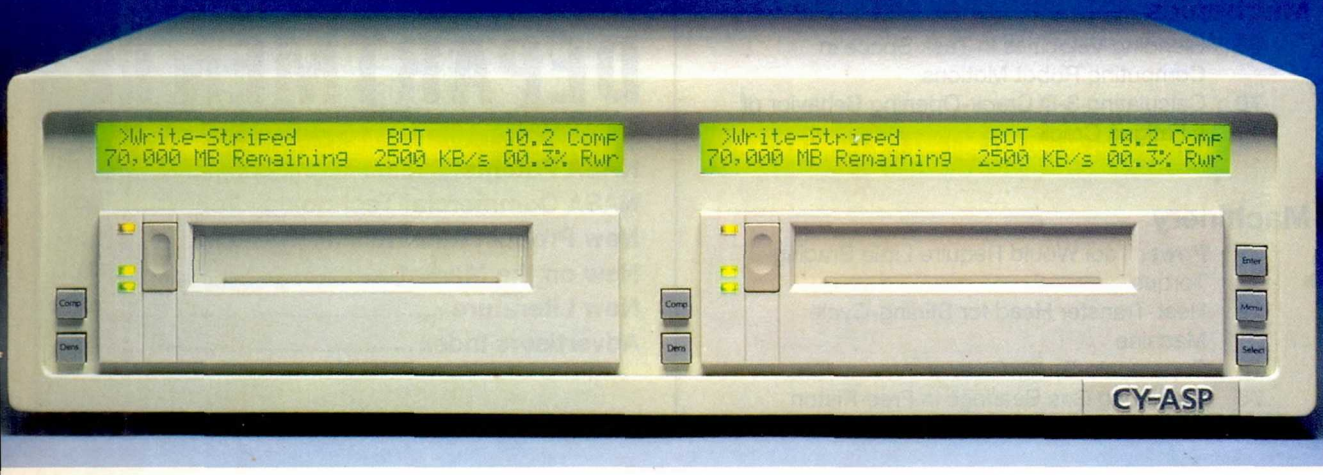

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Contents *(continued)*

DEPARTMENTS

On the cover:

Japan's Yohkoh satellite carried a combination soft x-ray telescope/CCD camera, built by Lockheed's Solar and Astrophyics Laboratory, that captured the sun in the x-ray wavelength region. This image illustrates how the million-degree plasma surrounding the sun is confined into loops by the solar magnetic field. Processing of the image was performed using Interactive Data Language, a scientific computing environment from Research Systems Inc. that integrates mathematical, statistical, 2D plotting, 3D graphics, mapping, and image processing functions. Turn to Mission Accomplished on page 16.

Photo courtesy Research Systems, Inc.

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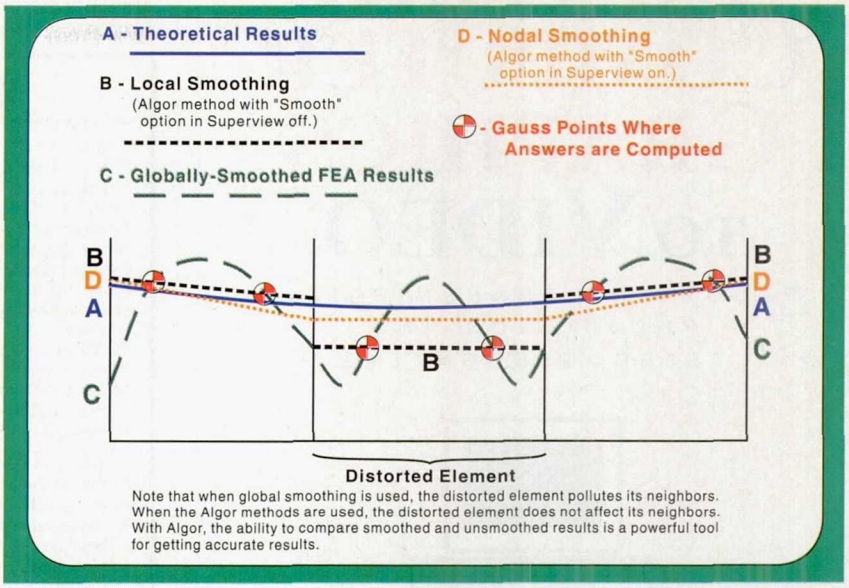
From Algor:

Straight Talk about Accurate Results

Algor Prevents Error "Pollution"



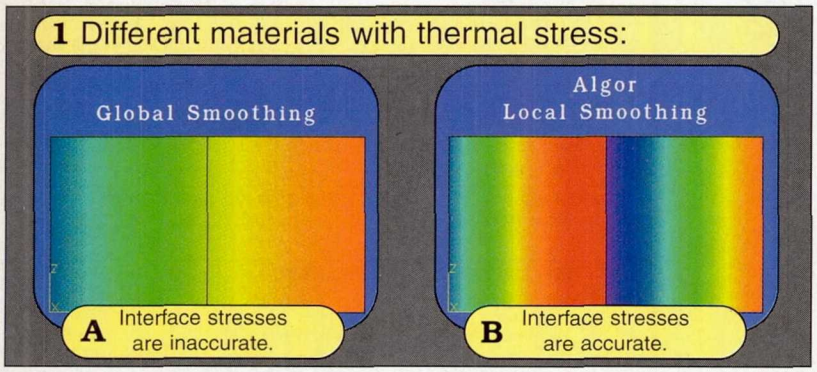
The results from any FEA program are most accurate at interior locations inside each element called Gauss points. The Gauss points are usually located roughly halfway between the middle and corners of an element. However, the highest stress usually occurs at nodes on the outside of a model, away from the Gauss points of adjoining elements. An issue every FEA program faces is how to compute the best results at the nodes, where the action is.

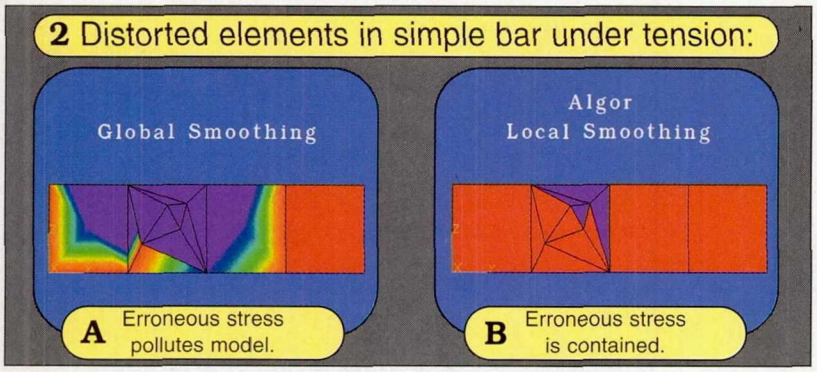
Algor uses a special technique called "local smoothing" to compute the stress at each node. Within each element the stresses are extrapolated from the Gauss points to the nodes. At each node, every element touching that node has a different computed stress value. This is known as "stress to nodes." When desired, stress values at nodes are averaged to provide better accuracy and nicer contouring. Other programs use "global smoothing" which "smears" the stresses over several elements, or even the entire model and consequently pollutes the analysis with errors from the distorted mesh.

Here's how:

1 When different materials are joined together, the stress picture really is different from one element to the next. Smearing the results with global smoothing masks these differences. Local smoothing the Algor way preserves these real stress differences. For example, if two materials are joined together and subjected to a thermal change, the transverse stresses are needed to design the joint. With local smoothing, the tensile/compressive stresses at the interface are clearly visible (Figure 1B). With global smoothing, these tensile/compressive stresses are averaged to near zero (Figure 1A).

2 If a distorted element is in the model, Algor's local smoothing isolates its inaccurate results, eliminating the "pollution" of surrounding elements. Global smoothing used by other FEA programs spreads this pollution around, decreasing the overall accuracy (see Figure 2).





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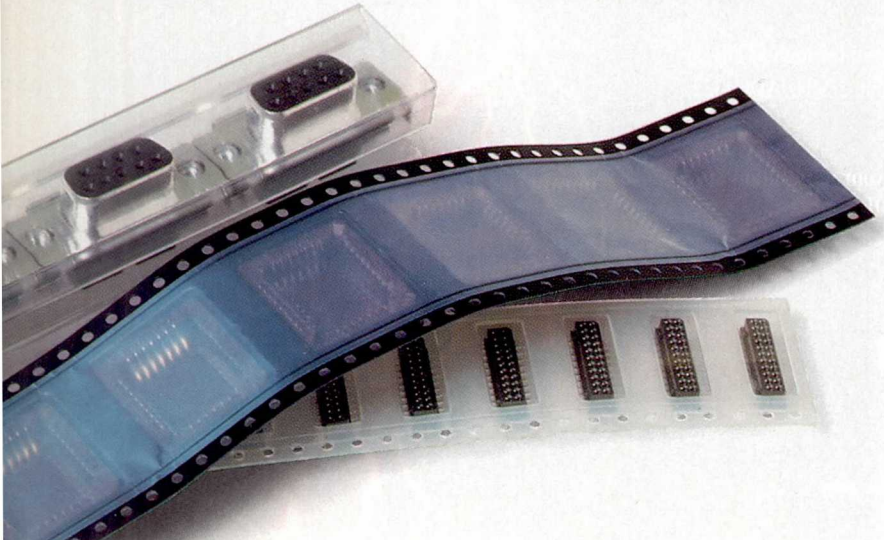


NASA PATENTS

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

Plasma Arc Welding Torch Having Means for "Vortexing" Plasma Gas Exiting the Welding Torch

(US Patent No. 5,362,938)

Inventors: **William McGee** and **Daniel Rybicki**, Marshall Space Flight Center

A swirl ring, or vortexing device, in the body of a welding torch creates a vortexing action in the plasma gas, which concentrates the arc into a denser and more narrow energy column. This vortexing permits a more narrow weld bead and heat-affected zone and also helps maintain arc symmetry, thereby reducing asymmetrical weld bed shapes and related defects.

For More Information Write In No. 743

Method and Apparatus for Detection and Control of Prelasing in a Q-Switched Laser

(US Patent No. 5,355,383)

Inventor: **George E. Lockard**, Langley Research Center

In a Q-switched pulsed laser, the Q-switch sometimes fails to hold off completely the laser cavity's lasing action, resulting in premature leaks of light from the cavity, or "prelasing." Mr. Lockard's apparatus generates an electrical signal when it detects light at a point beyond both the Q-switch and partially transparent endplate of a laser resonator cavity. When the signal exceeds an established threshold value indicative of prelasing, laser operation is terminated.

For More Information Write In No. 745

Airplane Takeoff and Landing Performance Monitoring System

(US Patent No. 5,353,022)

Inventors: **David B. Middletown, Raghavachari Srivatsan,** and **Lee H. Person**, Langley Research Center

Data on runway ambient condition, flap setting, and airplane loading characteristics allow a novel airplane monitoring system to generate an acceleration history and predict performance during takeoff and landing. The system compares these predictions with measurements taken as the airplane actually moves down the runway and depicts the results in real-time on both a head-up and head-down display. An improved estimate of the runway coefficient of rolling friction can be derived by comparing measured with predicted performance.

For More Information Write In No. 741

Acceleration Recorder and Playback Module

(US Patent No. 5,359,896)

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

Vibrational analysis of machinery can help prevent extensive repairs and catastrophic failures, yet the necessary accelerator recording and analysis systems have been both bulky and expensive. Mr. Bozeman's relatively lightweight and low-cost solid-state analog module obviates the need for digitizing equipment because analog signals are stored directly into memory cells rather than being digitized before storage.

For More Information Write In No. 742

Parachute Having Improved Vent Line Stacking

(US Patent No. 5,360,187)

Inventor: **John E. Hengel**, Marshall Space Flight Center

When conventional vented parachutes are carrying a load, the adjacent vent lines extend from the vent band at such an angle that tension tends to tear the vent band. Mr. Hengel's design has a central vent opening with vent lines extending across the opening and the ends of the lines secured to a vent band extending around the opening's periphery. Each vent line lies on a diameter of the opening with the centers of the lines forming a stack in its center. Vent lines that are adjacent on the vent band are separated in the stack by no more than one vent line.

For More Information Write In No. 740

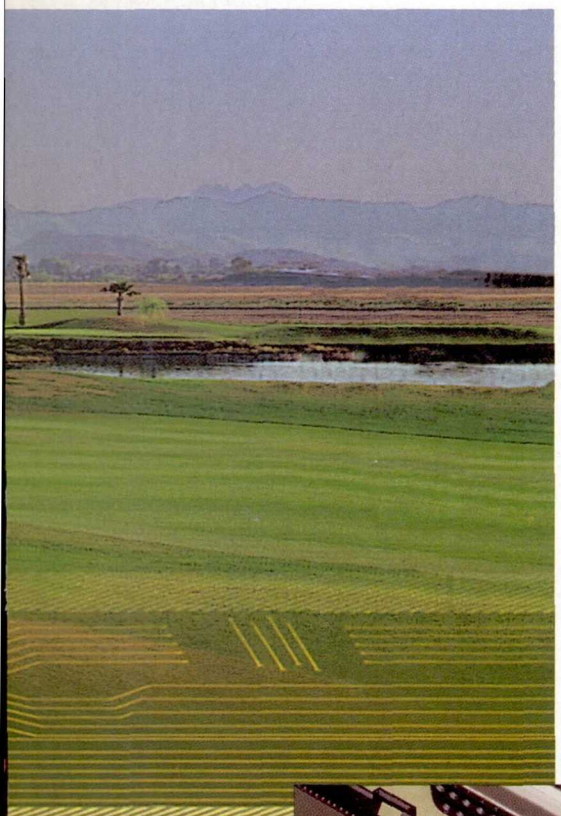
Thin Composite Solid Electrolyte Film for Lithium Batteries

(US Patent No. 5,360,686)

Inventors: **Emmanuel Peled, Ganesan Nagasubramanian, Gerald Halpert,** and **Alan I. Attia**, Jet Propulsion Laboratory

Because of their high energy density, long active life, and low self-discharge, lithium batteries are under consideration for various space, communication, and automotive applications. However, current polymer electrolyte/lithium batteries exhibit low mechanical strength, especially above 100 °C. A new thin composite solid electrolyte (CSE) film comprises small reinforcing alumina (Al_2O_3) particles in a binder rein such as polyethylene oxide that are coated with a compatible lithium salt such as lithium iodide. The CSE exhibits a Li^+ transport number close to one and an interfacial Li/CSE resistance ten-fold lower than the polymer electrolytes.

For More Information Write In No. 744



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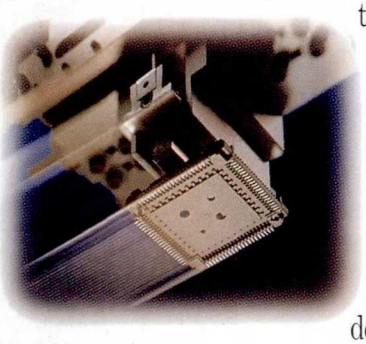

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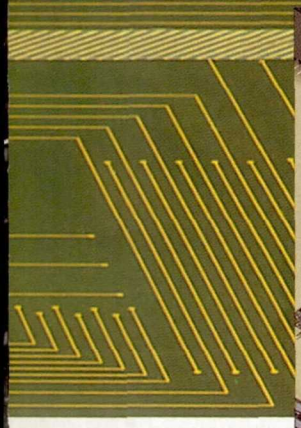

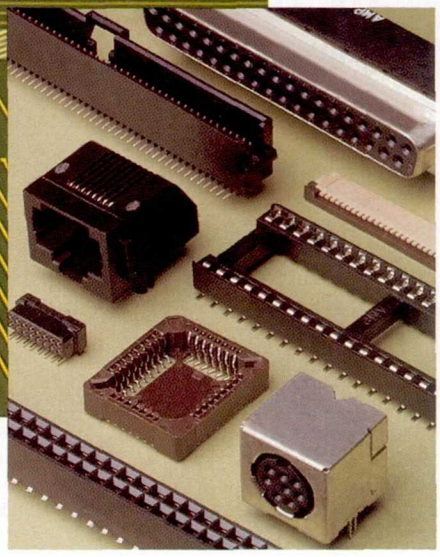

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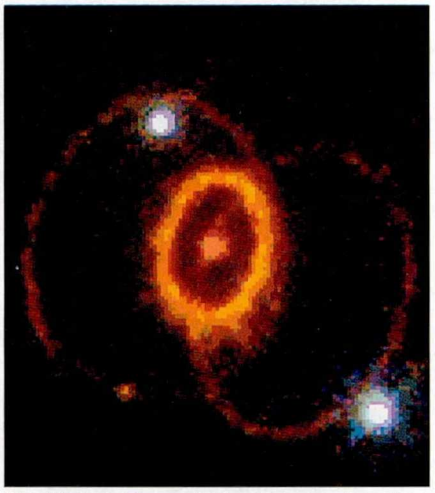
For More Information Write In No. 511

Mission Accomplished

To cut programming time on visual translation of data from days or weeks to just hours, a scientist or engineer can turn to Interactive Data Language (IDL) from Research Systems, Inc. (RSI). Instead of laborious programming in C or FORTRAN, the IDL user has in one package the tools necessary to tailor the translation to the particular kind of data.

The system provides a wide array of mathematical and statistical, 2D plotting, surface plotting, 3D graphics, mapping, and image processing functions and combines them all in complex manipulative operations. Thus a single command may be equal to a page of C-language code. For example, a researcher may have data on atmospheric temperature according to millibars of height at various points in the globe. With just a few functions, IDL can plot the data on a three-dimensional map and add color for temperature variations.

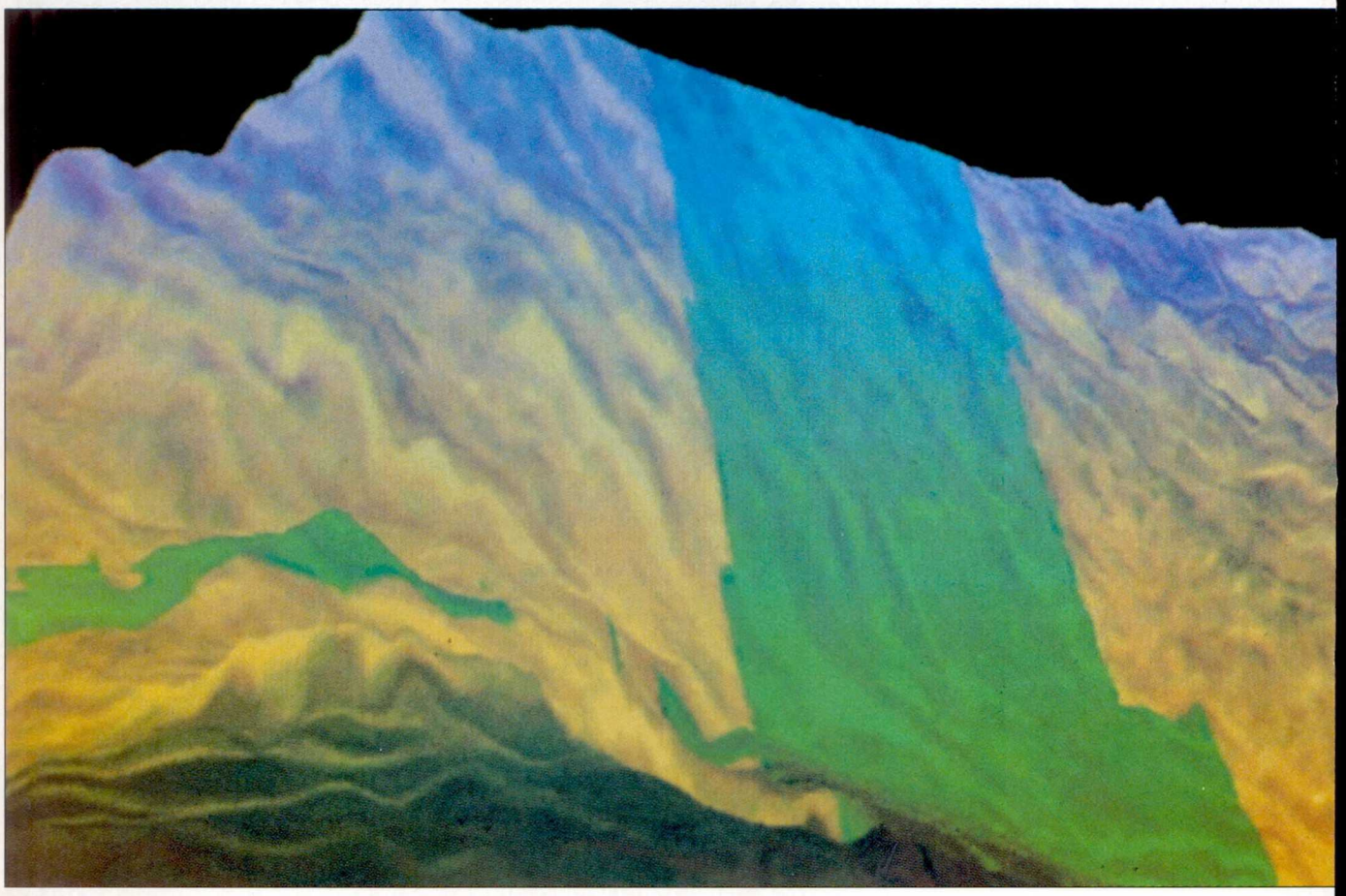
IDL also offers a way to check for flaws in the data. In the atmospheric plot, the map may reveal irregularities in the patterns—perhaps sudden unlikely shifts in atmospheric temperature in certain regions—due to data acquisition errors. The user then clicks the mouse on the flawed area of the map to make the program switch to the data set and corrects the data. Instantly, the map reflects the correction.



The Hubble Space Telescope captured three rings of glowing gas encircling the site of supernova 1987A, a star that exploded in February 1987. The image was taken in visible light with the Wide Field Planetary Camera 2 and deblurred using IDL.

Image courtesy Dr. Christopher Brown, John Krist, ESA/STScI, and NASA

Capable of more than data analysis and imaging, IDL is a complete "scientific computing environment," said Jim Wilson, RSI director of communications. "Before [RSI President] David Stern came up with IDL, there wasn't one package people could turn to" for computational work such as mathematics, 3D plotting, and image processing. Instead, scientists had to deal with separate software packages for functions such as plotting or mapping. Although other systems besides IDL have since combined several such packages into



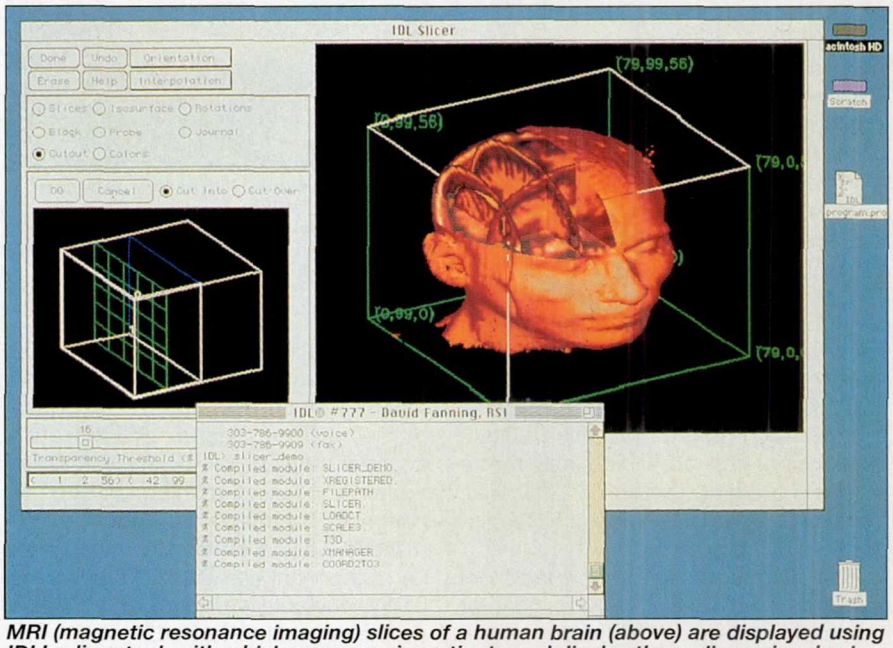
one, IDL remains the only one that, according to Wilson, can run on networks with all kinds of hardware—UNIX, VMS, Macintosh, PC, Convex.

Applications of IDL range from astronomy to zoology but concentrate mainly in those with heavy image processing requirements, such as astrophysics, oceanography, geology, and meteorology. According to Wilson, two of the largest customers are NASA's Goddard Space Flight Center and Jet Propulsion Laboratory (JPL). Recent significant projects using IDL include deblurring images transmitted from the Hubble Space Telescope with the help of a Convex supercomputer. In 1992, NASA's Dr. Sally Heap, one of IDL's first users, employed the software to image the hottest star on record. Researchers in the Cosmic Background Explorer (COBE) and Shoemaker-Levy comet/Jupiter impact projects have employed IDL as have JPL scientists mapping Venus via the Magellan spacecraft.

"IDL saves us lots of development time—it has a built-in user interface and image processing tools," said Jim Firestone, software developer for NASA Goddard's SeaWIFS (Sea-viewing Wide Field-of-view Sensor) ocean imaging project. Using IDL, his group has written an ocean-color program—SeaWIFS Data Analysis System—that it is planning to distribute through Goddard's Distributed Active Archive Center.

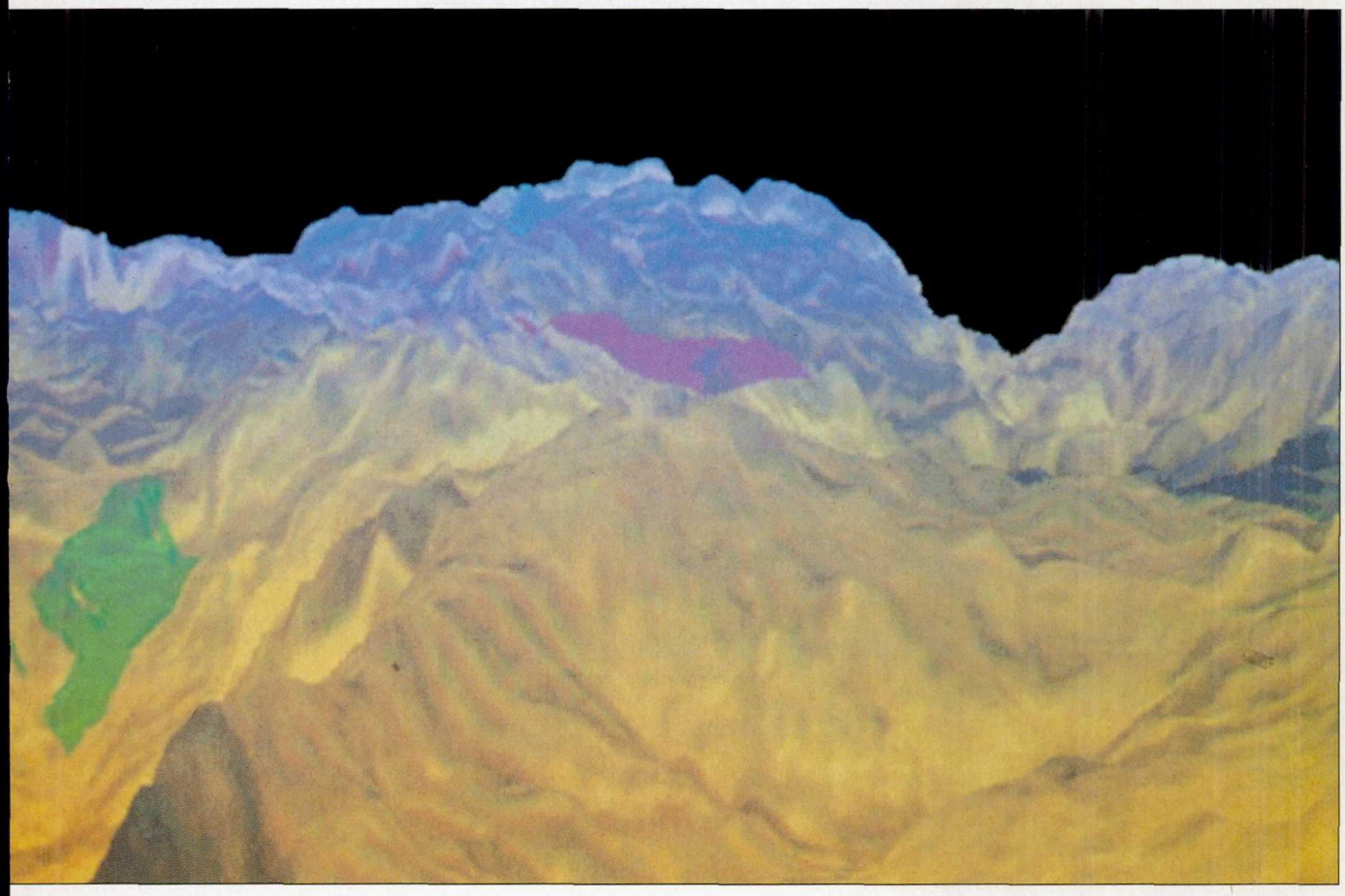
Researchers at Goddard and other NASA facilities have played a pivotal role in IDL's evolution. When Firestone's group needed a hierarchical data format (HDF), which incorporates descriptions with data, RSI added the feature to an IDL update. RSI worked with Goddard's Mark Schoeberl on adding mapping features to IDL for the Earth Observer Satellite, and with Goddard's Horace Mitchell on developing a port so IDL can operate on Convex supercomputers.

Such "synergism," as Schoeberl described it, between RSI and NASA has a precedent in NASA's and IDL's long history together. Straight out of school,



MRI (magnetic resonance imaging) slices of a human brain (above) are displayed using IDL's slicer tool, with which users can investigate and display three-dimensional volumes of data. A digital elevation model in IDL (below) of Maxwell Mountain on Venus pictures the highest known mountain in the solar system. The data was collected by NASA's Magellan satellite.

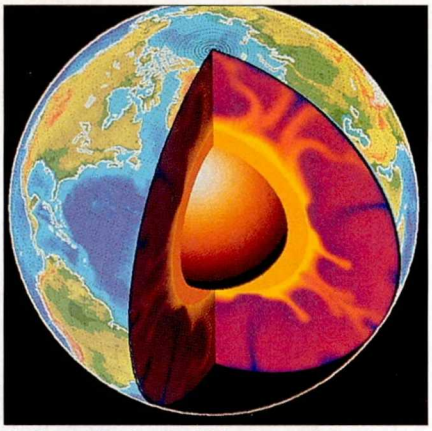
Photos courtesy RSI



David Stern began working at University of Colorado's Laboratory for Atmospheric and Space Physics (LASP) in 1969, on a project writing software to process spectral data for NASA's Mariners 7 and 9. After Mariner, he continued programming for the Orbiting Solar Observatory from 1973 to 1975. The software grew steadily more sophisticated, so that as computers changed, the system became a language. According to Stern, the first system did not look like IDL but did put real spectral data on the screen. In 1977, Stern quit LASP to form RSI, and IDL's first version was ready for sale by 1979.

An application of IDL outside the physical sciences that has shown considerable potential is magnetic resonance imaging (MRI) of the human body for medical diagnostics or physiological research. IDL's slicer tool lets researchers display and investigate three-dimensional sections of internal organs, such as the brain. To facilitate anatomical research, RSI has made available a digital library of 7,800 axial, coronal, and sagittal photographic cross-sections of a human male.

RSI offers another IDL specialty tool for Earth scientists—the Environment for Visualizing Images (ENVI). A program developed by RSI and Boulder's Better Solutions Consultants and written in IDL, ENVI is designed to analyze and visualize remote sensing data from air- or spaceborne, ground-based, or laboratory spectral measurements. Besides traditional processing techniques such as contrast enhancements, color transformations, vegetation indexes, and principal component analysis, ENVI has some unique characteristics, including the ability to read data files directly off the disk without conversion to another format.



A 3D rendering by IDL of two data sets illustrates Earth surface elevation data as well as simulated convection data of the planet's mantle showing the magma flow that drives continental movement.

Photo courtesy of RSI

The unlimited file capacity allows the program to process hyperspectral data. For processing such data, ENVI allows importation of multiple spectral libraries to help determine what kind of mineral or rock is represented. One set of researchers is using such analysis to determine how different contaminants appear spectrally in various soil and vegetation environments.

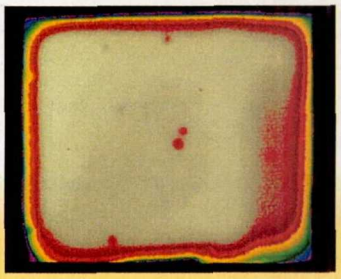
With an eye toward the future, RSI also is looking into incorporating "end-user callability" into IDL, Wilson said. "What's happening in the software world is that [scientific] applications don't talk to one another," he said, resulting in a new trend toward "piecing modules together to produce new applications much more quickly." RSI is seeking to make it possible for a user to call up any application within IDL or an IDL application within another program. For example, the user may want to call up IDL's plotting capabilities within FORTRAN but not the rest of the language. RSI will be testing this callability within the next several months.

For more information about the technology described in this article, contact: Research Systems, Inc., 2995 Wilderness Place, Suite 203, Boulder CO 80301; Tel: 303-786-9900; Fax: 303-786-9909.

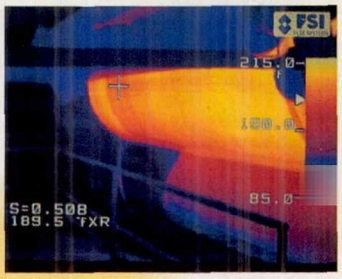
Engine development

Measure casting temperatures

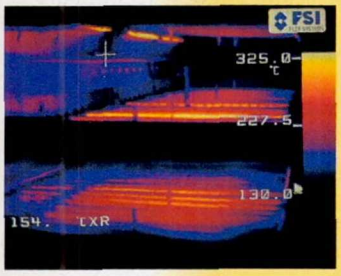
Defects in composite materials



Moisture content in paper



Monitor soldering processes



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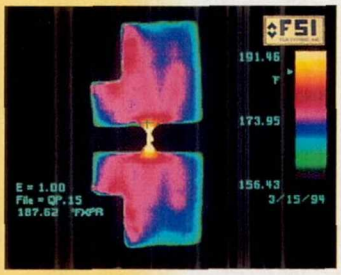
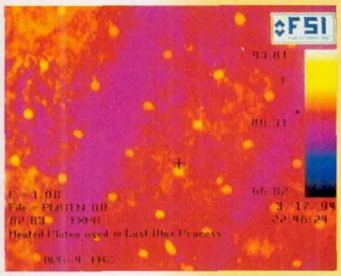
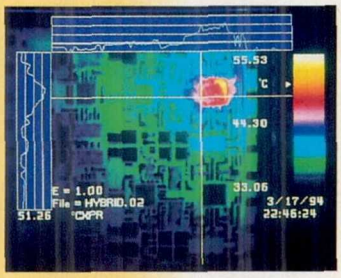
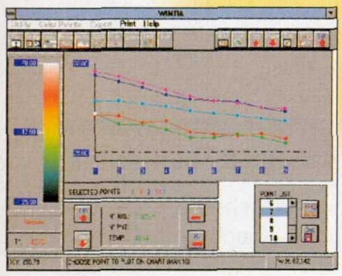




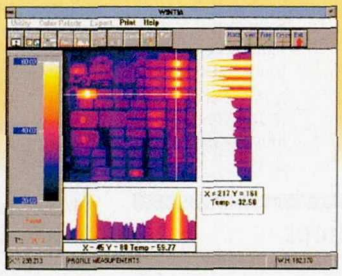
Evaluate wax injection presses



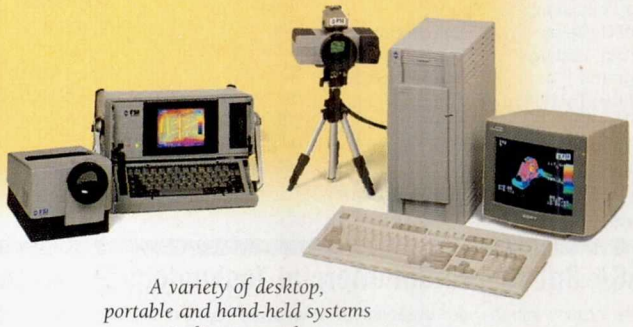
Hybrid circuit failure analysis



Analyze trend data



Post-processing thermal analysis



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Walter Kim
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Harry Craft
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harry.craft@msfc.nasa.gov

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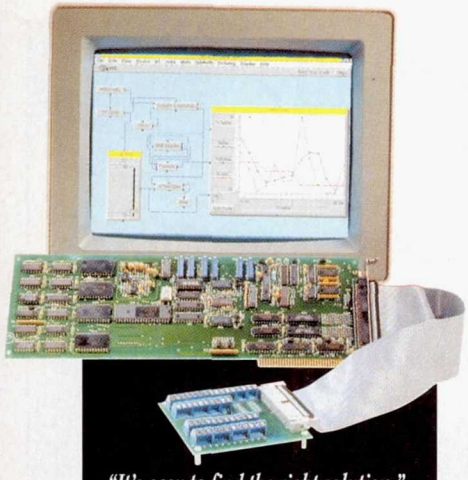

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New Product Ideas

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 in 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 20).

Instruments Sniff Organic Surface Contaminants

Portable instruments are being developed to detect both nonvolatile and volatile surface contaminants. These instruments will be easy to use and will eliminate the need for messy liquid solvents, witness plates, and cutting of specimens from the surfaces to be inspected.
(See page 51.)

Rechargeable Magnesium Power Cells

These cells present a safer alternative to high-energy-density cells that use lithium or sodium anodes. The latter are vulnerable to catastrophic failures that release hot toxic fumes and can cause fires.
(See page 38.)

Intercalated-Graphite-Fiber Composites

Composite materials that contain 50 percent bromine-intercalated graphite fibers have promising properties. A fourfold increase in conductivity opens up potential applications in electrical grounding planes and in shields against electromagnetic interference.
(See page 59.)

Polyimides Made From 3,5-Diaminobenzotrifluoride

Compared with other polyimides, these fluorinated polyimides have greater solubility in polar solvents, less color, and lower dielectric constants. Potential applications are in aerospace and electronic industries as free-standing films, coatings, and moldings.
(See page 56.)

Wireless Headset Communication System

A new system consists of a base station, four radio/antenna modules, and as many as 16 remote units with headsets. Digital modulation is used on a spread spectrum to avoid interference among the units.
(See page 44.)

Power MOSFETs Formed in Silicon Carbide

The advantages over conventional MOSFETs include lower "on"-state resistance at the same rated voltages, operating temperatures as high as 650 °C, and higher thermal conductivity. Holding promise to be more resistant to ionizing radiation, these MOSFETs may offer advantages in switching applications in nuclear facilities.
(See page 30.)

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Photo: Courtesy of Honeywell Military Avionics

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Special Focus: Test Tools

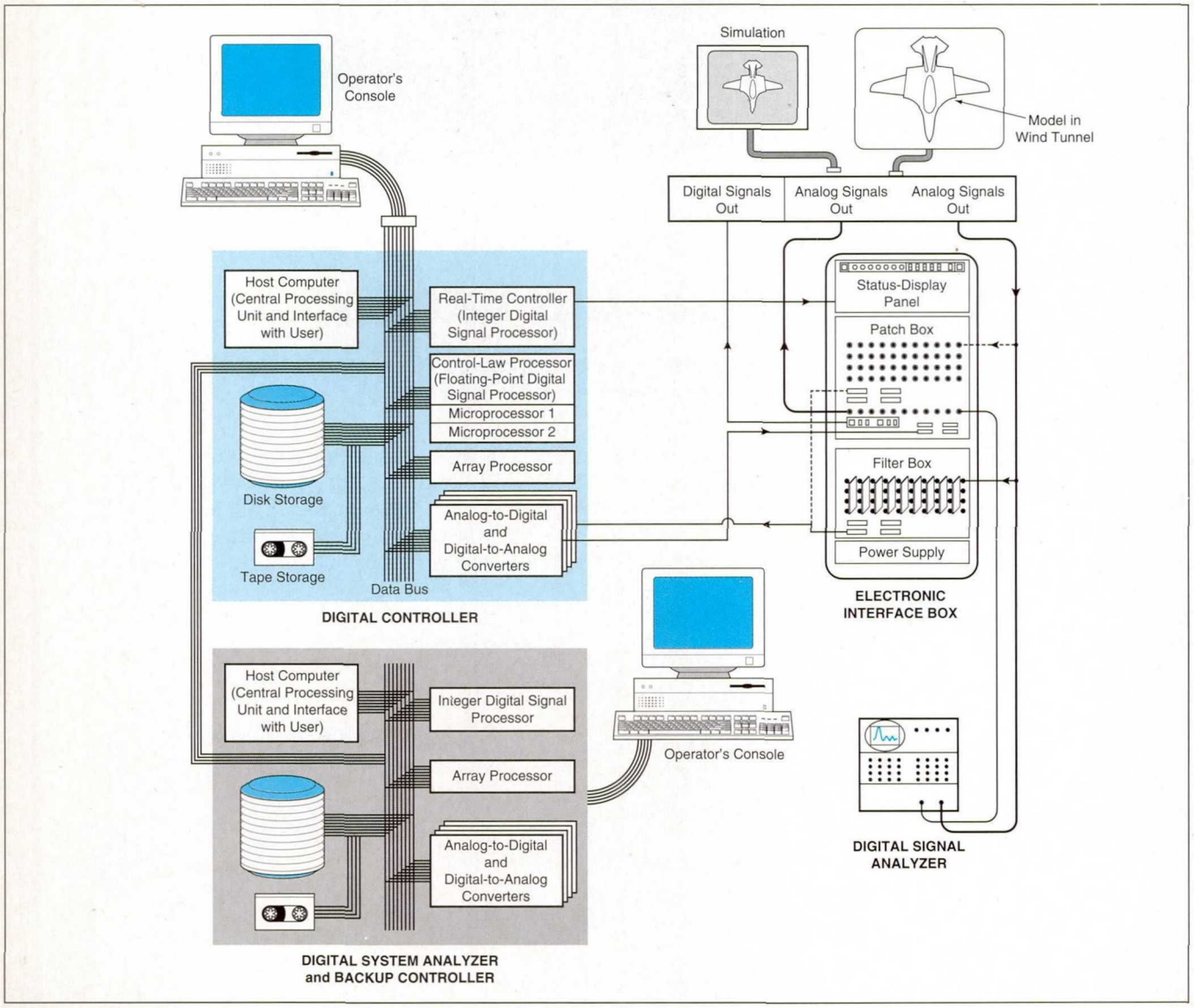
Digital Control System for Wind-Tunnel Model

Multiple functions are performed by multiple coordinated processors for real-time control.

Langley Research Center, Hampton, Virginia

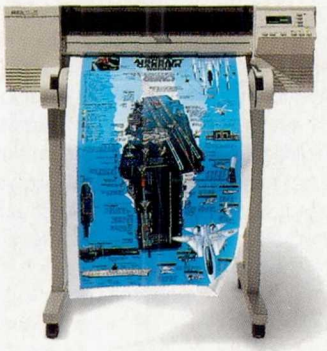
A multiple input, multiple-output, multiple-function digital control system has been developed for a wind-tunnel model of an advanced fighter airplane with actively controlled flexible wings. This control system interacts with sensors and actuators in the model, implementing a feedback control scheme that provides simultaneously for suppression of flutter, control of roll angle, roll-rate tracking during maximized roll maneuvers, and alleviation of loads during roll maneuvers.

The major subsystem of the digital control system is indicated by the box labeled "Digital Controller" in the figure. The digital controller includes a host computer (central processing unit) that serves as an interface with the user. The host computer is linked to several special-purpose processors via a data bus. One of the special-purpose processors is the real-time controller, which is an integer-arithmetic processor that operates at regulated speeds up to 200 Hz (in terms of time from sensor input to actuator-command output). This special-purpose processor synchronizes the operation of the other special-purpose processors and provides the user interface between the host computer and the real-time system. It also coordinates the acquisition, transfer, and storage of data for real-time operation and for analysis of performance and estimation of parameters of the dynamics of the model and control system in nearly real time. The



The **Digital Control System** provides flexibility in selection of control laws, sensors, and actuators, plus some redundancy to accommodate failures in some of its subsystems.

The Unplodder.



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main reason for using the real-time controller (rather than the host computer) to synchronize and coordinate is that the host computer is too slow to effect real-time control: the operating-system software limits the speed of the host computer to about 60 Hz.

One of the other special-purpose processors is a floating-point digital signal processor containing two microprocessors that perform all the control-law computations. A third special processor is an array processor that performs floating-point calculations of flutter-suppression control laws in case the floating-point digital signal processor fails. The controller also includes circuits that perform all the necessary conversions between the digital forms of signals in the controller and the analog forms of signals in the sensors and actuators in the model. A second computer similar to the host computer is used to analyze the performance of the system in nearly real time and to estimate the parameters of the open- and closed loop dynamics of the model and control system.

The design of the system provides flexibility in (1) the number, form, and functionality of control laws and (2) the selection of sensors and actuators used. In a demonstration, the system proved successful in suppressing flutter during various roll maneuvers. In particular, it provided active suppression of flutter in maneuvers that involved dynamic pressures up to 25 percent above the maximum allowable in open-loop control, both in cases in which the model was free to roll and in cases in which it was not free to roll.

This work was done by Sherwood T. Hoadley of **Langley Research Center** *and Sandra McGraw of Lockheed Engineering & Sciences Co. For further information,* ***write in 286*** *on the TSP Request Card.*
LAR-14778

Phase-Locked Loop for Measurement of Small and Large Delays

Phase shifts from 0° to >360° can be measured to within 0.112°.

Langley Research Center, Hampton, Virginia

An electronic signal-generating and processing subsystem of an ultrasonic inspection or measurement system consists mainly of a variable-and-fixed-frequency, pulsed phase-locked loop (VFFPPLL) that measures phase shifts from 0° to more than 360° with an accuracy of 0.112°. The VFFPPLL sends a toneburst to an ultrasonic transducer, which transmits the toneburst as a pulse of ultrasound into a specimen or acoustic-coupling medium. When the toneburst ends, the VFFPPLL and transducer go into a receiving mode: the echoes of the toneburst are received by the transducer, then amplified, then either (1) sampled directly or (2) mixed with a reference signal, then filtered, then sampled. The phase shift is then computed by comparing the phase of the sampled echo signal with that of the original toneburst. This phase shift is a measure of the ultrasonic-signal-propagation delay; it can be used, for example, to determine strain in a bolt or to track an irregular surface of a specimen that is being inspected ultrasonically.

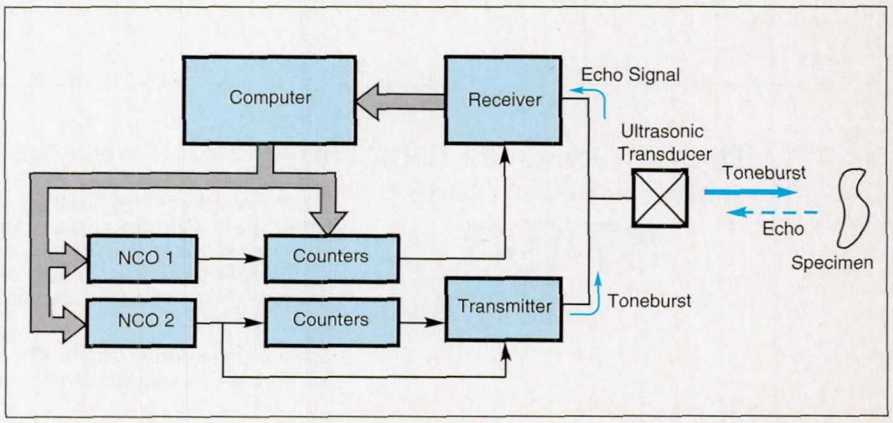
The VFFPPLL (see figure) includes a personal computer that performs the control and digital signal-processing functions. Two numerically controlled oscillators (NCO1 and NCO2) driven by a common 50-MHz master clock generate tones at a common fixed or variable frequency ordered by the computer. The signal from NCO1 is the clock signal that governs sampling of the echo signal in the receivers; the signal from NCO2 is the tone that is gated to generate the toneburst in the transmitter. NCO1 and NCO2 operate at independently programmable phases.

Each box labeled "counters" in the figure denotes a 15-bit independently programmable divide-by-N counter and an 8-bit independently programmable downcounter triggered by the divide-by-N counter. The difference between the echo-signal-sampling time and the time of transmission of the toneburst is governed by the relative phases of the NCO1 and NCO2 signals that drive the divide-by-N counters, and equals the relative delay between the output pulses of the two pairs of counters. Acting via the 8-bit downcounters, the computer controls the durations of these pulses, thereby controlling the durations of the transmitted toneburst and the receiving pulse.

The receiving pulse can be used to drive a sample-and-hold circuit or to gate the input to an analog correlator. The output of the sample-and-hold circuit or analog correlator is fed to an analog-to-digital converter (ADC). The computer is programmed to accomplish phase lock by varying the frequency of the tone or the relative phases of the NCOs in such a way as to force the output of the ADC to zero. When phase lock is reached, the measured delay equals the difference between the phases (or the sum of incremental relative phase advances) of the NCOs divided by the angular frequency of the tone. The computer enables the use of sophisticated signal-processing and signal-recognition methods that enhance (in comparison with completely analog circuitry) the ability to find and hold phase lock.

This work was done by Mark Froggatt of **Langley Research Center**. *For further information,* ***write in 288*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Langley Research Center [see page 20]. Refer to LAR-14840.



The **VFFPPLL Measures the Phase Shifts** between a transmitted ultrasonic toneburst and its echo, thereby measuring the ultrasonic-propagation delay.

Improved Portable Ultrasonic Leak Detectors

The primary advantage is greater sensitivity.

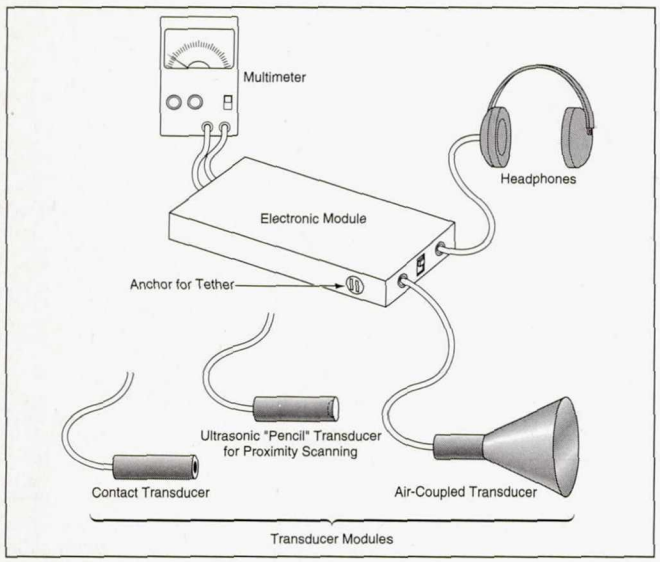
John F. Kennedy Space Center, Florida

Improved portable ultrasonic leak-detecting instruments have been designed to overcome some of the limitations of commercial instruments of this type. In the original application that motivated this development, a combination of high background noise in the testing environment and low sensitivity of the commercial leak detectors resulted in a tedious leak-detection process and marginal leak-detection performance. As compared with the commercial instruments, the improved leak detectors perform significantly better and are smaller and more rugged.

Ultrasonic leak detectors respond to jetlike leaks (leaks in which the flows are not laminar). The turbulence in a jetlike leak is accompanied by variations of pressure in the ultrasonic frequency range. Thus, an ultrasonic receiver with enough sensitivity and enough discrimination against background noise can be used to detect a small jetlike leak from a convenient distance.

The new instrument (see figure) includes an electronic module that processes the sig-nal received from an ultrasonic-transducer module and feeds output to a set of headphones and/or to a multimeter. The ultrasonic-transducer module is connected to the electronic module via a cable that can be unplugged to connect another such module. Each ultrasonic-transducer module contains a commercial ultrasonic transducer of 40-kHz center frequency; this transducer features slightly more sensitivity and about half the noise of another 40-kHz commercial ultrasonic transducer that had been used in the commercial ultrasonic leak-detecting instrument that was replaced by the present instrument. The output of the ultrasonic transducer is preamplified before being transmitted through the cable to the electronic module.

Three interchangeable ultrasonic-transducer modules are supplied with each instrument. One of these modules is equipped with an ultrasound-collecting horn for use in scanning to detect leaks from a distance; the horn provides a directional sensitivity pattern with sensitivity multiplied by a factor of about 6 in the forward direction. Another module is similar except that it does not include the horn; this module is used for scanning close to a suspected leak, where the proximity of the leak more than offsets the loss of sensitivity occasioned by the lack of the horn. The third module is designed to be pressed against the leaking vessel; this module includes a rugged stainless-steel shell.



The Improved Portable Ultrasonic Leak Detector features three interchangeable ultrasonic-transducer modules, each suited for operation in a unique noncontact or contact mode.

In the electronic module, the preamplified output of the ultrasonic transducer is buffered, amplified further, then mixed with a 36-kHz signal from a local oscillator to shift the received ultrasonic signal to an audible frequency. The output of the mixer is low-pass filtered and amplified, yielding an audio signal containing frequencies of 2 to 6 kHz. The audio signal is sent to two optional output branches: in one branch, it is amplified for the headphones; in the other branch, it is amplified and half-wave rectified to provide a dc signal, proportional to the measured ultrasound, for the multimeter.

In practice, reading the multimeter appears to provide a slightly more sensitive indication of ultrasound than does listening via the headphones. The instrument is powered by two 9V batteries, which are contained in the electronic module. Tests have shown that the instrument can operate continually for more than 24 h on a pair of batteries. The estimated cost of a mass-produced commercial version of the improved ultrasonic leak detector with the horn transducer module should be less than $500 (based on prices of components in 1994). In contrast, the commercial ultrasonic leak detector that was replaced by this instrument costs more than $3,500.

This work was done by Robert C. Youngquist, John S. Moerk, William D. Haskell, Robert B. Cox, Jimmy D. Polk, James P. Strobel, and Frank Luaces of I-NET for **Kennedy Space Center**. *For further information,* ***write in 25*** *on the TSP Request Card.*

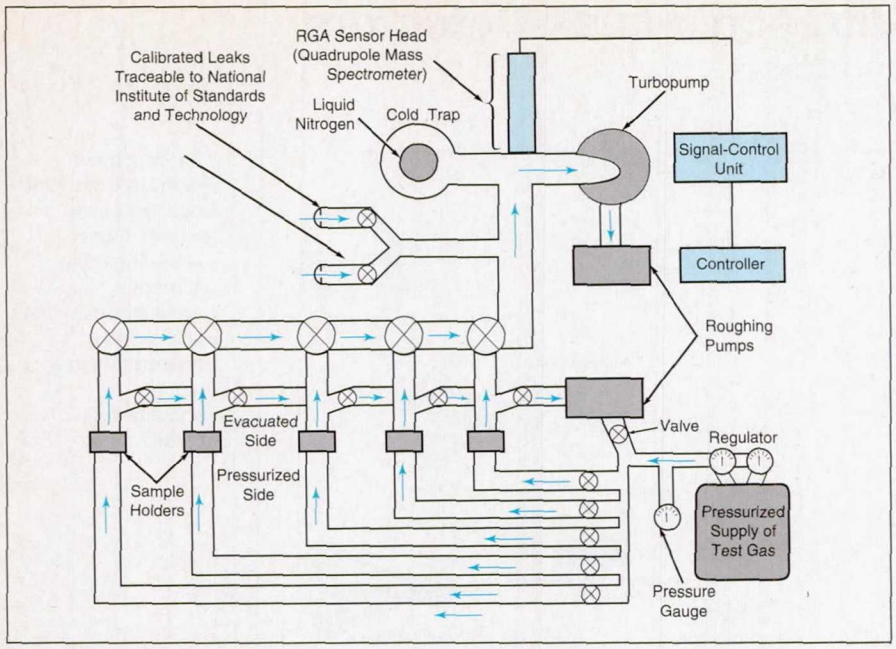
Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Kennedy Space Center [see page 20]. Refer to KSC-11751.

Apparatus Measures Permeation of Gases Through Coupons

Permeability can be measured at a wide range of temperatures and pressures.

Lyndon B. Johnson Space Center, Houston, Texas

The apparatus shown schematically in the figure measures the permeation of any of a variety of commercially available pure or mixed gases through polymeric or other material coupons of various thicknesses at pressures ranging from 1 to 1,000 psia (about 7 kPa to 7 MPa) and temperatures ranging from −195 to +150 °C. The apparatus includes a residual-gas-analyzer (RGA) sensor head (a quadrupole mass spectrometer) and associated circuitry, and a vacuum system. The apparatus also includes a manifold with valves, through which the gas of interest can be allowed to permeate through the test coupon before traveling downstream to the evacuated RGA sensor head. The temperature of the test coupon



This **Laboratory Apparatus Measures Permeation of Gases** through test coupons, providing data that are relatively precise and reproducible in comparison with permeability data obtained by older manometric and volumetric apparatuses.

is monitored by a thermocouple and can be maintained at a specified value above ambient by use of an electrical heating mantle or below ambient by use of a bath of ethylene glycol, water, and dry ice.

In a test, coupons are exposed continuously to the high vacuum on the downstream side and pressurized with the test gas on the upstream side. Standardized calibrated leaks containing the test gas are located on the downstream side. The gas that permeates through a given test coupon or calibrated leak is detected by the RGA sensor head, and the amount of each constituent molecular species in the gas is read directly on the digital readout of the RGA, which monitors atomic mass units from 1 to 200 on six separate channels and gives area counts for each atomic mass unit selected. This feature enables the monitoring of as many as six separate gases simultaneously, plus observation of any changes in the quantities of gases as they pass by the sensor head.

At the beginning of a test, a background reading (RB) for the test gas is taken first on the closed vacuum system (no permeation, no calibrated leak). The valve leading to the test coupon is then opened, and the test gas at the desired pressure is applied to the coupon until equilibrium is established (typically, reaching equilibrium takes from 2 hours to 2 days, depending on the gas used). Once equilibrium is established, a reading (RE) of the amount of gas permeating through the coupon is taken. The valve to the test coupon is then closed, the valve to a calibrated leak is opened, and after an hour, an equilibrium reading (RL) that corresponds to the calibrated rate of leakage (L) is taken.

The rate of permeation (P) can then be calculated from

$$P = \left(\frac{R_E - R_B}{R_L - R_B}\right) L$$

Then a permeation-rate constant (Kp) can be calculated from the rate of permeation, the thickness (T), the test pressure (C), and area (A) of the test coupon by Kp = PT / CA.

This work was done by Steven J. Adam, Jim T. Morrow, and Carey E. David of McDonnell Douglas Corp. for **Johnson Space Center**. *For further information,* ***write in 191*** *on the TSP Request Card.*
MSC-22051

Phase-Insensitive Ultrasonic Testing System

This system reveals disbonds at rough interfaces.

Langley Research Center, Hampton, Virginia

An ultrasonic testing system is being developed for use in revealing hidden disbonds at rough, inaccessible interfaces between layers of material. A rough surface or surfaces can introduce artifacts of two types into reflected ultrasonic signals. One type comprises severe artifacts of phase cancellation at the face of a typical phase-sensitive transducer used in conventional ultrasonics. The other type comprises artifacts caused by reflection of part or all of an ultrasonic beam away from a transducer. These artifacts can impair the detection of defects at interfaces. If an interface between two layers is rough and uneven, then it is difficult to detect disbonds between the layers by use of the pulse/echo technique.

If the excursions of a surface from flatness are of the order of a quarter of an ultrasonic wavelength or larger over lateral dimensions of the order of the width of the ultrasonic beam, then the ultrasonic signal can be severely compromised. Such is the case for the configuration of the bondline inhibitor, liner, and fuel at the ends of the segments of the solid rocket motor of the space shuttle. Here, the liner-to-fuel bondline is very rough with respect to the ultrasonic wavelength. The development of the present ultrasonic system and the phase-insensitive-array technique on which it is based was motivated by the need to detect disbonds under conditions like these.

The system includes an array of small (maximum dimension about a wavelength or less) piezoelectric transducers, the receiving outputs of which are electronically processed individually and combined in such a way as to make the system phase-insensitive, thereby overcoming the limitations imposed by the phase-sensitivity of conventional ultrasonic transducers. An array is technically feasible and offers the further advantage that the signals applied to elements of the array during transmision can be phase-controlled to focus the transmitted acoustic energy. A simple way to suppress the reflection-type artifacts is to use a receiving transducer that has a large area: by subtending a larger angle with respect to the apparent source of the signal in question, the receiving transducer receives more incident energy.

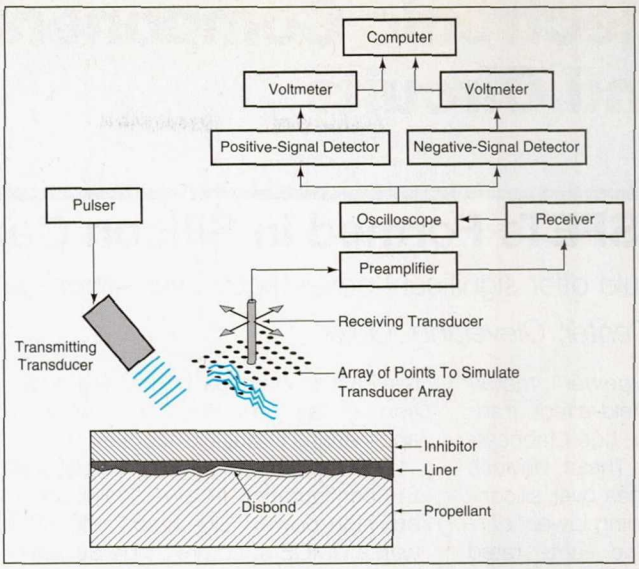
Thus, artifacts of both types could be suppressed by a phase-insensitive array of piezoelectric transducers that subtends a large angle. The array could then be used in a pulse mode like that of a conventional pulse/echo transducer during transmission, but during reception it

would be phase-insensitive and less sensitive to reflection-type artifacts.

To demonstrate this ultrasonic-testing concept, a prototype apparatus was constructed, using a standard ultrasonic transducer as a transmitter and a small, pointlike piezoelectric transducer as a receiver. The receiver was translated, in steps of 0.5 cm, to each of 49 locations of a 7-by-7 array on the surface of a specimen to simulate the operation of a 7-by-7 transducer array. The signals reflected from the rough interface were received, detected, recorded, and subsequently added in a phase-insensitive manner. The results were then compared with those obtained by use of a conventional pulse/echo system.

The figure illustrates the prototype apparatus. The transmitter was a 1-MHz transducer with a diameter of 1 in. (2.54 cm) and a focal length of about 4 in. (about 10 cm). (This transducer was also used in the comparative pulse/echo scan.) The receiver was a 1-MHz planar transducer with a diameter of 0.031 in. (about 0.08 cm). The transmitter was driven by a square-wave pulser, which was tuned to provide relatively sharp pulses measured at the receiver.

The signal was tuned with respect to the echo from the inhibitor-to-liner interface to account for severe attenuation in the thick inhibitor layer. Because the thickness of the inhibitor remained very nearly uniform across the ultrasonic beam, the roughness of the inhibitor did not pose a significant problem, and made it convenient to tune in this way. The transmitter and receiver were set at opposing angles of about 15° from normal and operated in a pitch/catch mode: in this configuration, the echoes could be detected in a manner similar to that of a pulse/echo system. That part of the received signal that emanated from the liner-to-propellant bondline was gated out, and the heights of signal peaks were measured. Comparison of the results showed that the conventional (pulse/echo) system was sensitive to only 42 percent of disbonds, while the prototype (phase-insensitive array) system was sensitive to 79 percent of disbonds.



One Pointlike Receiver was translated to 49 locations in a 7-by-7 array to record signals from which a phase-insensitive image could be constructed.

This work was done by Eric I. Madaras of **Langley Research Center**. *For further information,* ***write in 213*** *on the TSP Request Card.*
LAR-13980

Power MOSFETs Formed in Silicon Carbide

These devices could offer significant advantages over silicon-based devices.

Lewis Research Center, Cleveland, Ohio

High-performance power metal/oxide/semiconductor field-effect transistors (MOSFETs) have been fabricated in silicon carbide. These devices offer potential advantages over silicon-based MOSFETs, including lower "on"-state resistances at the same rated voltages, the ability to operate at higher temperatures (as high as 650 °C for some demonstration units), and higher thermal conductivity (with consequent ability to dissipate more power). SiC devices may also prove to be more resistant to damage by ionizing radiation — an advantage for switching applications in nuclear facilities.

The top part of Figure 1 illustrates the configuration of a vertically-oriented high-power SiC-based MOSFET with a UMOS structure made by use of trench-etching techniques and epitaxial growth to define the channel region. In the case of this n-channel device, an n^+ substrate is used for the drain contact. An n^- epitaxial layer of thickness and doping level required for the intended drain voltage of the FET is grown on the substrate. This n^- layer acts as the drain-drift region of the device.

A p-doped epitaxial layer is then grown, with a doping level and thickness chosen to prevent full depletion of the p layer when the intended drain voltage is applied to the p^+/n^- junction. The source wells can be formed either by implantation of n^+ ions into the p layer or by growing an n^+ epilayer on top of the p layer. In the latter case, it would be preferable to etch all the way through the central part of the n^+ layer so that the p layer makes contact with the source contact, as shown in the lower part of Figure 1. By thus short-circuiting the source and the p-doped channel layer together, one mutes the parasitic n/p/n bipolar transistor that is inherent in the structure.

The gate is formed by subsequently etching a trench through the n^+ well, p layer, and into the n^- drain-drift region. The gate oxide is then formed on the sides and bottom of the trench, and the gate contact is patterned onto the gate oxide. Thus, the inversion layer forms under the oxide on the side walls of the trench, between the n^+ source and the n^- drain, when a positive potential is applied to the gate contact. The etched sides of the trench can be sloped as in

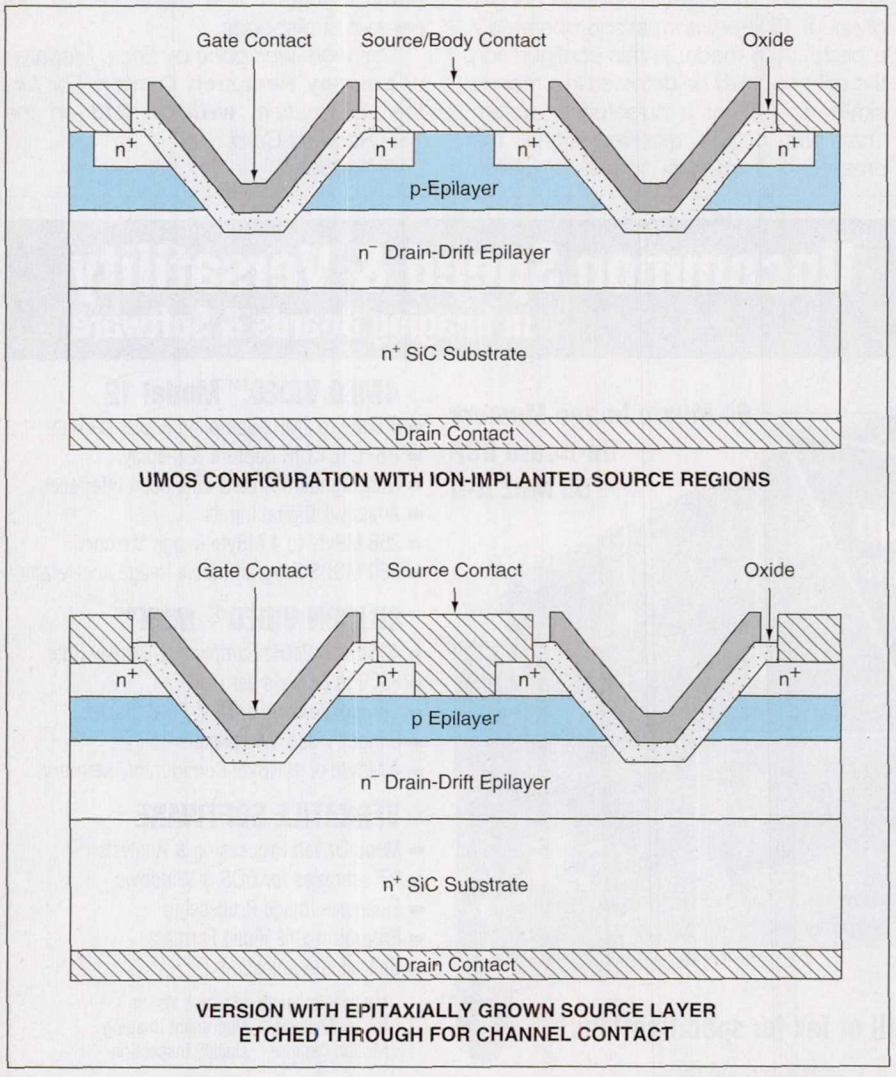


Figure 1. **Power MOSFETs Can Be Formed in SiC** in several alternative configurations. These are n-channel configurations.

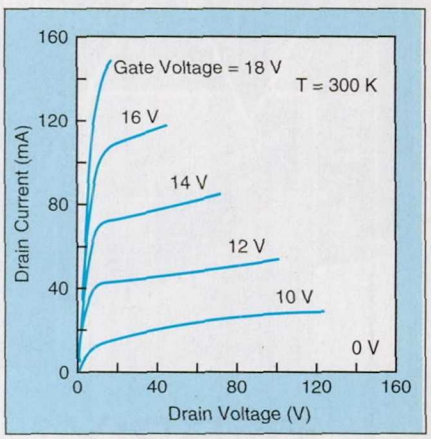


Figure 2. These **Curves Show the Electrical Characteristics** of a 150-V 4h-SiC vertical UMOS MOSFET. The area of this MOSFET is 6.7×10^{-4} cm^2.

Burt Rutan Makes Vellum Fly

Two years after the Voyager completed its record-shattering around-the-world flight, you could still find its designer, Burt Rutan, working at a drafting table with pencil and paper.

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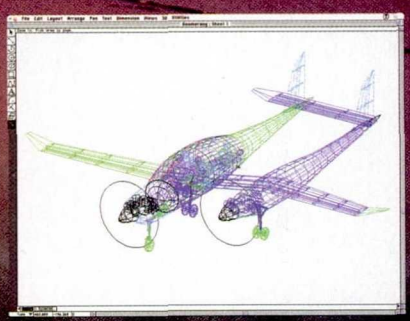

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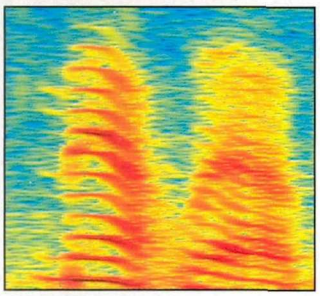
MATLAB simplifies analysis and algorithm development with integrated modeling, design, and visualization tools. This spectrogram shows how a speech signal varies with time and frequency.



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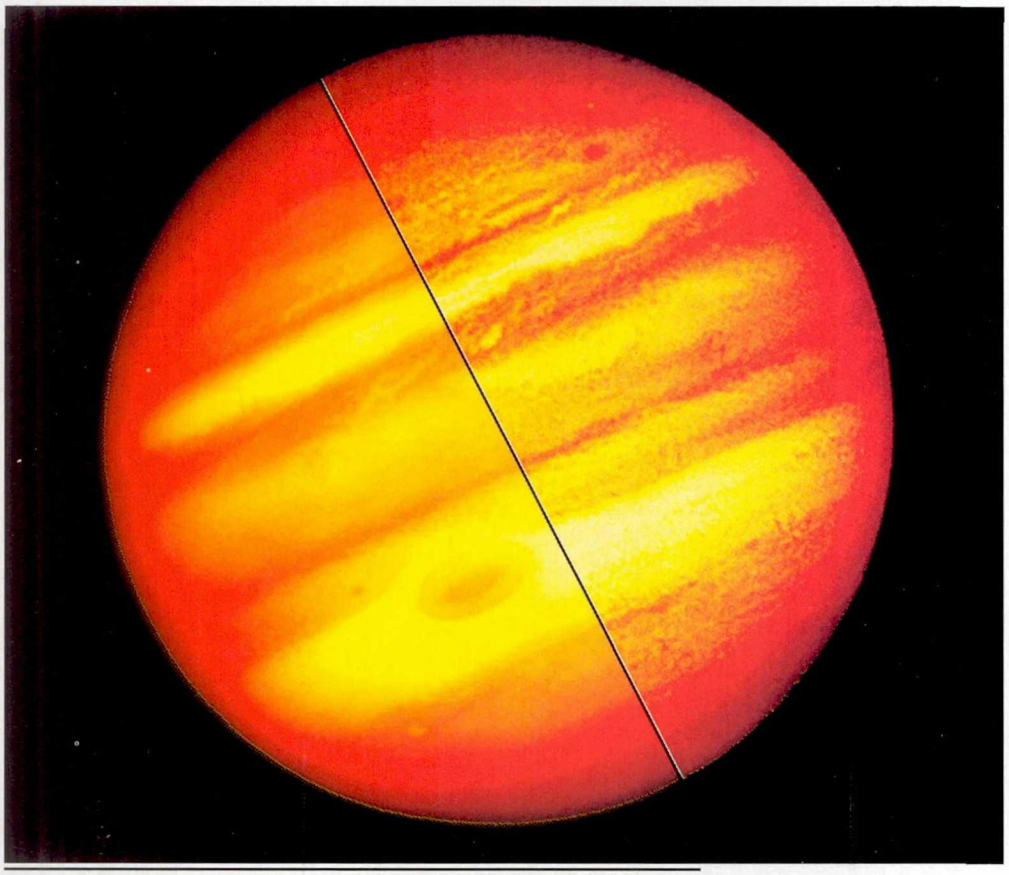

This blurred image of Jupiter (left side), produced by the Hubble Space Telescope before its repair, was corrected with the MATLAB Image Processing Toolbox and MATLAB's numeric processing power using an iterative restoration technique (right side). Data courtesy of Dr. S. J. Reeves, Auburn University.

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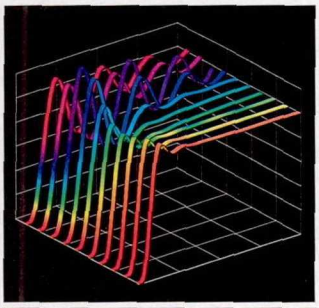

The Nonlinear Control Design Toolbox automates control design. From a poorly tuned initial response (rear), it automatically optimizes controller parameters in a series of steps.

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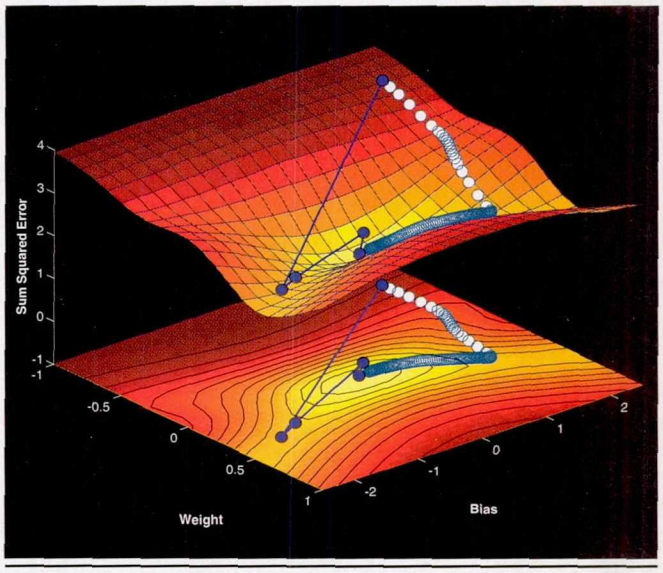

MATLAB graphics enhance understanding of system behavior. This neural network plot compares training rates for backpropagation (white, 108 steps) and the fast Levenberg-Marquardt algorithm (blue, 5 steps).

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the figure, or vertical. Initial results have been achieved with these structures. The current-voltage characteristics of a small area SiC-UMOS MOSFET are shown in Figure 2. This device blocked 150 V and could achieve a drain current of 67 mA (100 A/cm^2) at a drain voltage of 3.3 V; This corresponds to a specific on-resistance of 33 mW-cm^2.

This work was done by John W. Palmour of Cree Research, Inc., for **Lewis Research Center.** *For further information,* ***write in 273*** *on the TSP Request Card.*

Title to this invention, covered by U.S. Patent No. 5,264,713 has been waived under the provisions of the National Aeronautics and Space Act {42 U.S.C. 2457 (f)}. Inquiries concerning licenses for its commercial development should be addressed to

Cree Research, Inc.
2810 Meridian Parkway
Durham, NC 27713

Refer to LEW-15350, volume and number of this NASA Tech Briefs issue, and the page number.

Flexible Multiplexed Surface Temperature Sensor

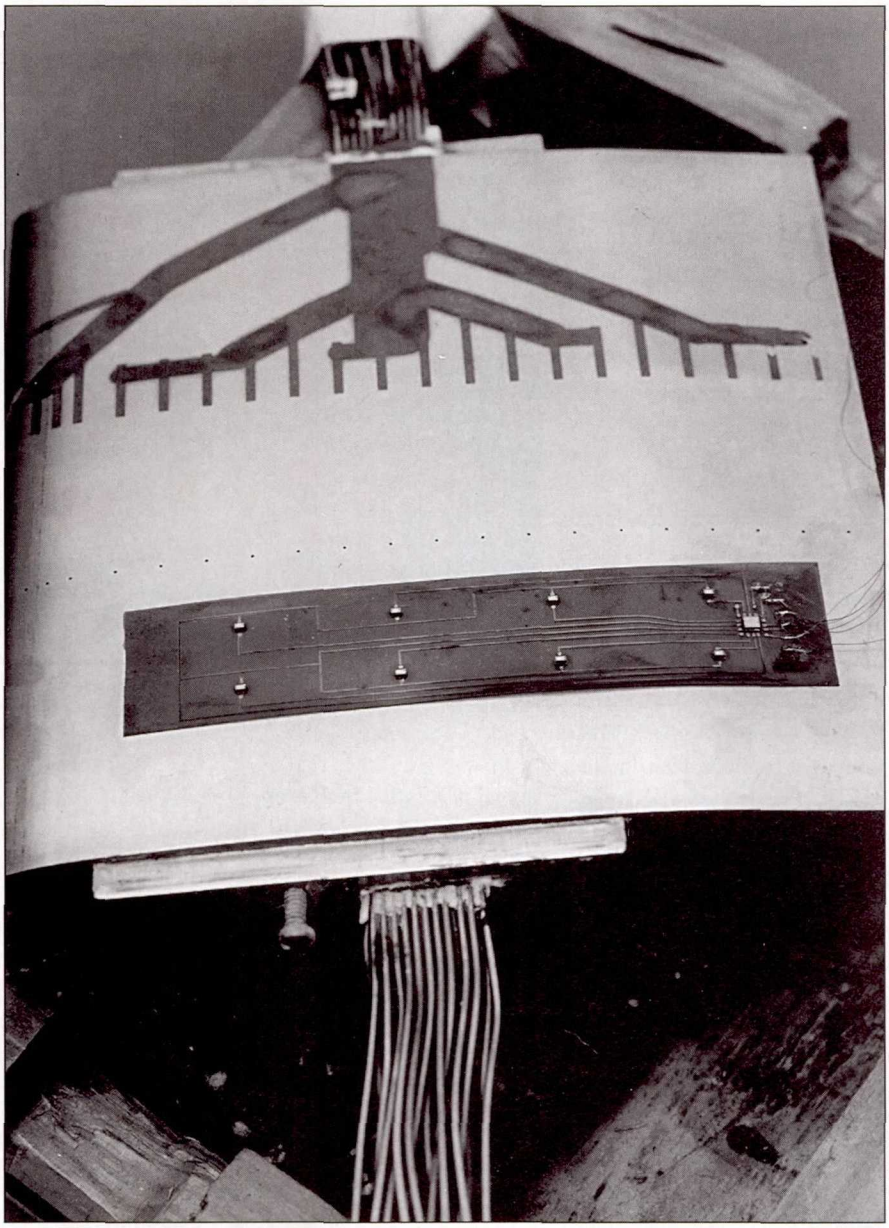
Multiplexing enables rapid scanning of temperatures on aerodynamic surfaces.

Langley Research Center, Hampton, Virginia

The figure illustrates a surface temperature sensor or, more precisely, a unitary array of sensors that measure temperatures at points distributed over a designated area on a surface. The array should prove useful in measuring the surface temperatures of aerodynamic models and thermally controlled objects. The measurement of surface temperatures is important for designers and researchers. Heretofore, most approaches to the measurement of surface temperatures have involved the attachment of many single sensors to the surfaces of interest. The unitary array of sensors represents a novel approach.

The unitary array measures 1 by 4 in. (about 2.5 by 10 cm). It is made of a combination of integrated-circuit microchips and film circuitry. The circuitry consists of gold conductors etched on flexible polyimide film 0.002 in. (≈0.05 mm) thick. Eight AD590 temperature-sensing integrated-circuit microchips are mounted on the film: Eight sensor channels were selected to demonstrate the concept, but in principle, larger arrays (128, 512, or more temperature-sensing chips) could be constructed. The temperature-sensing chips can be scanned (that is to say, polled) at speeds approaching 10 kHz by use of a CD4051B analog multiplexing chip. The operating range of the sensor is –40 °C to 120 °C with a digital output that varies linearly with temperature at a rate of 1 μA/°C.

The flexibility of the array enables it to conform to curved surfaces. The multiplexer eliminates the need for numerous monitoring cables. Control of the acquisition and recording of data is effected by connecting the array to microcomputers via suitable interface circuitry.



The **Prototype Array of Eight Sensors** with a multiplexer is installed on a test airfoil to measure surface temperatures.

This work was done by Kamran Daryabeigi and L. A. Dillon-Townes of **Langley Research Center** *and Preston B. Johnson and Robert L. Ash of Old Dominion University. For further information,* **write in 24** *on the TSP Request Card.*

LAR-14003

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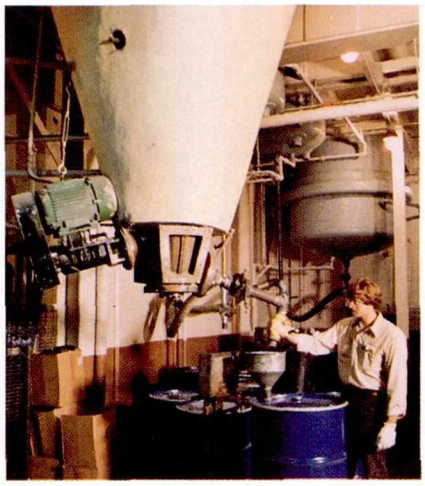

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Measuring Work Functions of "Dirty" Surfaces With a Vibrating Capacitive Probe

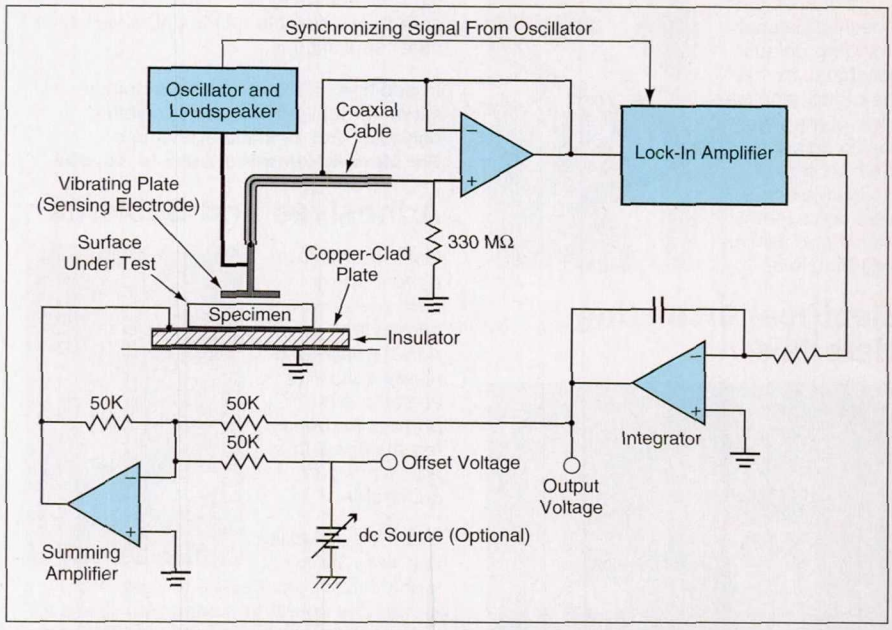
Variations in work functions are associated with variations in microstructure and with contamination.

Langley Research Center, Hampton, Virginia

An apparatus measures the work function (f) of the possibly contaminated surface of a specimen of metal or other electrically conductive material. The apparatus is designed for use in conjunction with improved photoelectric and other techniques for measuring surface contamination; heretofore, the interpretation of photoelectric measurements has been complicated by the fact that both the intensity of photoemission of electrons (which is affected by f) and f itself can vary, not only with surface contamination, but also with the microstructure of the material to be inspected.

The apparatus, which is an application of the "Kelvin Probe" concept, measures the work function of the specimen in terms of the contact potential between (the difference between the work functions of) the specimen and a flat-plate probe that is made of a metal of known work function and is known to be clean. Despite the name "contact potential," the probe is not placed in direct contact with the specimen. Instead, the contact potential is measured with the associated circuitry shown in Figure 1.

The specimen is placed on a copper-clad surface that is mounted on an electrically insulating platform and maintained at a controllable dc bias voltage. The probe is positioned near and parallel to the surface of the specimen (see figure) and is vibrated, at a frequency of about 100 Hz, by use of a modified loudspeaker. The vibration gives rise to an oscillation between the flat-plate probe and the specimen, thereby generating an alternating voltage proportional to V, which equals the specimen/probe contact potential plus or minus, variously, the known bias voltage and the known contact potentials of intervening circuitry. This alternating voltage is buffered by a high-input-impedance operational amplifier and sent to a lock-in amplifier synchronized with the signal that drives the loudspeaker.



This **Apparatus Measures the Work Function** of the specimen indirectly, by vibrating capacitive measurement of contact potential. The work function of the specimen is affected by microstructure and by contamination.

The output of the lock-in amplifier is proportional to V. This output is fed to an integrator, the output of which is fed to one of the two input terminals of a summing amplifier to control the bias applied to the specimen. When the bias is such that V is zero, the output of the lock-in amplifier is zero and the output of the integrator stabilizes. At that point, the applied voltage is a measure of the contact potential between the specimen and the flat plate probe. An offset voltage can be fed to the other input terminal of the summing amplifier to test the circuit.

This work was done by William T. Yost of **Langley Research Center.** *No further documentation is available.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Langley Research Center [see page 20]. Refer to LAR-14671.

Rechargeable Magnesium Power Cells

A moderate reduction in energy density would buy an increase in safety.

Lyndon B. Johnson Space Center, Houston, Texas

Rechargeable power cells based on magnesium anodes are being developed as safer alternatives to high-energy-density cells like those based on lithium and sodium anodes. Partly because of the low melting temperatures of lithium and sodium (179 °C and 98 °C, respectively) and partly because of the peculiarities of their electrochemistries, lithium- and sodium-based cells are both highly susceptible to catastrophic failures that release hot, toxic fumes and can cause fires.

Although the energy densities of magnesium cells are likely to be somewhat smaller than those of lithium cells, magnesium offers important advantages: the melting temperature of magnesium is higher (651 °C), and magnesium compounds tend to exhibit low toxicity. Thus at the cost of some reduction in energy density, magnesium-based cells would be safer in that they would be much less susceptible to catastrophic meltdown

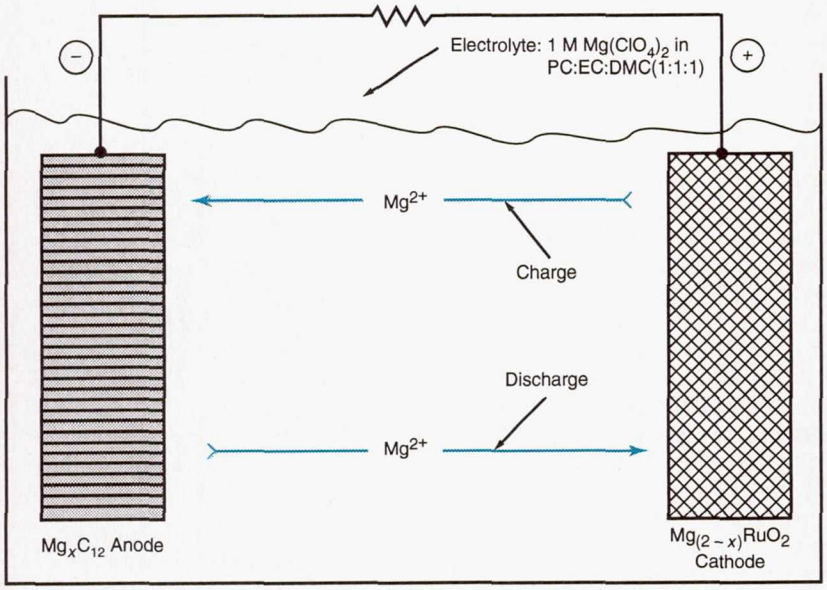
followed by flames and venting of toxic fumes. Other advantages of magnesium include ease of handling, machining, and disposal, and relatively low cost of about $4.50/kg (1992 prices).

Magnesium cells containing an aqueous electrolyte have been used in military applications, but they are not rechargeable because of side reactions between the anodes and the electrolyte. Research on the feasibility of rechargeable magnesium cells has focused on two principal questions: (1) How do magnesium anodes behave in charge/discharge cycles in nonaqueous electrolytes? and (2) Are there high-voltage transition-metal oxide cathode materials into which Mg^{2+} can be inserted (similarly to the reversible insertion of Li^+ in CoO_2 and NiO_2)? The search has led to a prototype cell (see figure) composed of the following:

- An anode of magnesiated graphite ($Mg_x C_{12}$);
- An electrolyte consisting of 1 M $Mg(ClO_4)_2$ dissolved in a mixture of equal volumes of propylene carbonate (PC), ethylene carbonate (EC), and dimethyl carbonate (DMC);
- A ruthenium oxide cathode, which can participate in the 4-electron redox reaction $2\ Mg + RuO_2 \rightleftharpoons Mg_2RuO_2$.

The estimated practical energy density of a cell of this type constructed with typical hardware is 100 to 115 Wh/kg, which exceeds that of a typical nickel/cadmium cell (45 Wh/kg) or a nickel/metal hydride cell (75 Wh/kg). Preliminary experiments at 10 to 15 percent depth of discharge showed that cells of this type could be charged and discharged hundreds of times, albeit with some loss of capacity during the early cycles.

This work was done by Victor R. Koch, Chenniah Nanjundiah, and Michael Orsini of Covalent Associates, Inc., for **Johnson Space Center.** *For further information,* ***write in 23*** *on the TSP Request Card.*
MSC-22293



The **Prototype Rechargeable Magnesium Cell** *operates according to a "rocking-chair" principle: Mg^{2+} ions from the electrolyte become alternately intercalated into the graphite anode (during charge) or the ruthenium oxide anode (during discharge).*

Layout of Antennas and Cables in a Large Array

Total land area and the total length of cables are minimized.

NASA's Jet Propulsion Laboratory, Pasadena, California

A layout has been devised to minimize the total land area occupied by a large phased array of antennas and to minimize the total length of cables in the array. In the original intended application, the array would be an expanded version of the array of paraboloidal-dish microwave communication antennas of the Deep Space Network. The layout may also be advantageous for other phased arrays of antennas and antenna elements, including notably printed-

circuit microwave antenna arrays.

In the original application, the minimum distance, L_{min}, between antennas is dictated by the requirement that an antenna not shadow an adjacent antenna down to a prescribed low angle of the line of sight above the horizon; in other applications like those mentioned above, L_{min} would typically be governed by mechanical or electromagnetic requirements. In either case, it is well known from mathematics and solid-state physics that the packing is densest (the total land area is minimized) when the antennas are arranged in a regular hexagonal pattern in which each antenna lies at the center of a regular hexagon circumscribed about a circle of diameter L_{min} and the hexagons are contiguous. The land area assigned to each antenna is $(3^{1/2}/2)L_{min}^2$ — the area of a circumscribed hexagon.

For maximum flexibility of operation, it is required that the array be divisible and subdivisible into smaller interlocking arrays that can be operated independently or in combinations. The hexagonal close packing must be maintained in any division or subdivision. It is required that each signal cable from each antenna be routed to a signal-processing facility at the center of the array. It is required to minimize the number of varieties of cables used throughout the array. No cable is allowed to cross another cable: In the original application, this prohibition is dictated by the requirement that cables be buried and by the consequent need to prevent snagging of previously buried cables by a cable plow. In other applications, (printed-circuit microwave antennas, for example), noncrossing of transmission lines could be dictated by the need to avoid the complexity and cost of multilayer circuitry.

The layout that satisfies these requirements while minimizing the total land area and the total length of cable is based on a fractal object known as the Gosper snowflake, which is formed from a recursive tiling of hexagons (see Figure 1). Starting with a single hexagon, the first-order Gosper snowflake is created by a first-order transformation in which each side of the hexagon is broken into segments of equal length, such that the original area of the hexagon is preserved. This first-order transformation is equivalent to grouping together of seven hexagons. The second-order Gosper snowflake is created in a second-order transformation, in which seven first-order Gosper snowflakes are grouped together. Similarly, and in general, a Gosper snowflake of order N+1 is created by grouping together seven Gosper snowflakes of order N.

The basic element of the minimum-length cabling scheme is a star that connects the six outer elements of the first-order Gosper snowflake to the central element. At the central element, the seven cables from the individual elements are spliced to a larger trunk cable. A similar structure of trunk cables connects the six outer first-order Gosper snowflakes to the center of the second-order Gosper snowflake to which they belong. In the same manner, larger trunk cables connect the six outer second-order Gosper snowflakes to the center of the third-order Gosper snowflake to which they belong. This scheme can be carried to higher orders. However, at orders ≥4, the trunk cables that connect the third-order Gosper snowflakes to the center must be made crooked in some places to prevent crossing of cables.

This work was done by Ronald T. Logan, Jr., of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 34*** *on the TSP Request Card.*

NPO-19264

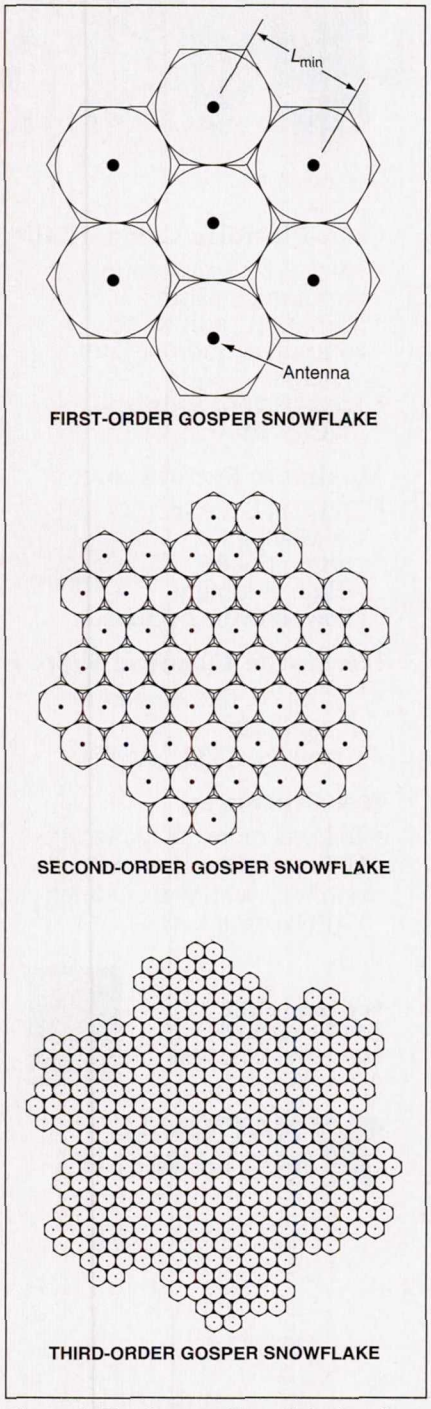


Figure 1. The **Gosper Snowflake** is a fractal object in which arrays and subarrays of various orders can be formed in a regular hexagonal tiling.

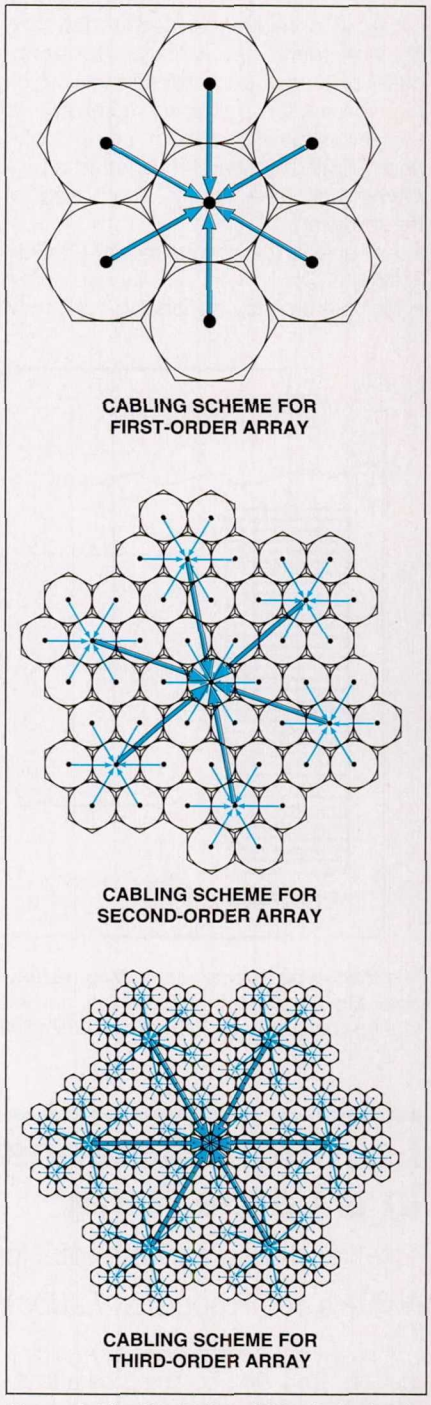


Figure 2. The **Six-Pointed Star** is the basic element of the noncrossing, minimum-total-length cabling scheme for antennas in a Gosper snowflake array.

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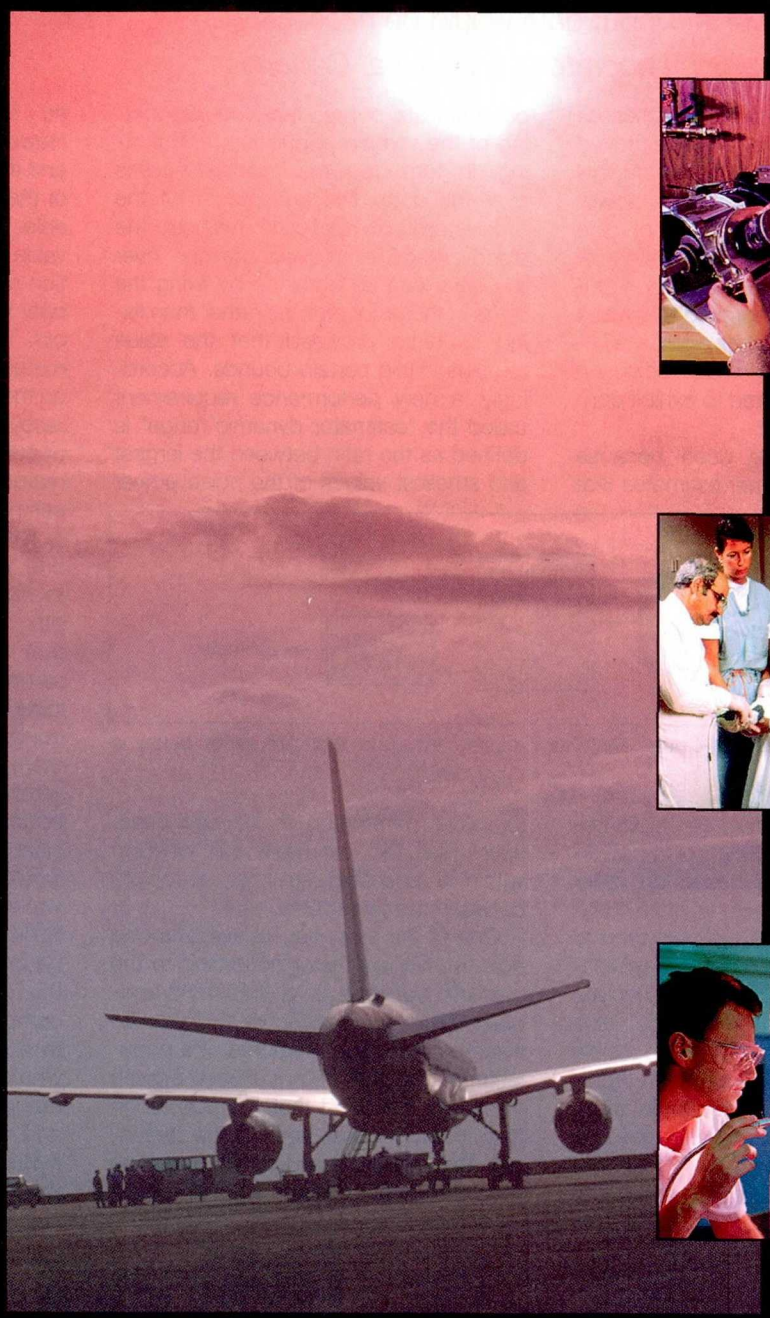

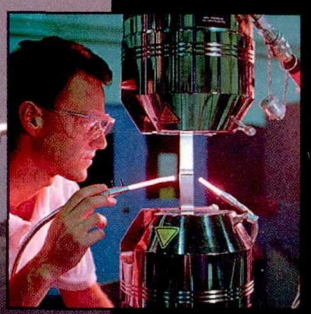

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NASA

Improved Noise-Power Estimators Based on Order Statistics

Only one pass over the input data would be necessary.

NASA's Jet Propulsion Laboratory, Pasadena, California

A technique based on order statistics would enable the design of improved noise-power estimators. In the original intended application, the noise-power estimators would be part of the microwave-signal-processing system of the Search for Extraterrestrial Intelligence project. The improved technique is also applicable to other signal-detection systems and to image-detection systems that are required to exhibit constant false-alarm rates.

Order statistics are used because they provide noise-power estimates that are relatively insensitive to radio-frequency interference. Older noise-power-estimating techniques based on order statistics generally require multiple passes over the input data and thus tend to be too inefficient for real-time applications. The present technique involves limiting the dynamic range of the value to be estimated; this makes it possible to achieve the performance of an order-statistical estimator with simple algorithms and equipment and with only one pass over the input data.

In general, the computation of an order statistic of fixed rank requires sorting of the sample population, and sorting, in turn, requires multiple passes over the data. The advantages of the order-statistical approach (without the disadvantage of multiple passes over the data) can be obtained by fixing the value of the order statistic rather than fixing its rank, provided that the value remains within certain bounds. Accordingly, a new performance requirement called the "estimator dynamic range" is defined as the ratio between the largest and smallest values of the noise power (or other parameter) to be estimated, such that the estimator will perform within a specified error at all points between the two values.

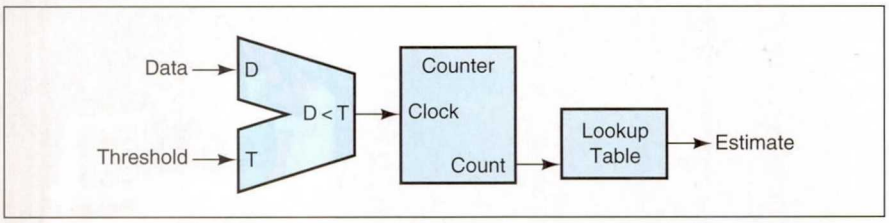


Figure 1. A **Threshold-and-Count Estimator** counts the data that are at or below a threshold value.

One of the essential subsystems of a noise-power estimator according to the present concept is a threshold-and-count estimator (See Figure 1). This subsystem counts the members of a population of data that do not exceed a given threshold. Provided that the population is sufficiently dense around the threshold, the threshold-and-count operation is equivalent to choosing an order statistic for the noise-power estimate. However, the value of the order statistic and the threshold are fixed, and the rank of the order statistic is the random variable. The result is an estimate of the value of the cumulative distribution function at the threshold; that is, the probability that a datum lies below the threshold. The noise power can then be estimated from a lookup table, interpolating on the cumulative distribution function to recover the mean noise power of the population. A threshold-and-count estimator can be designed for a specified estimator dynamic range.

The top part of Figure 2 illustrates one noise-power estimator according to this concept: It would contain multiple threshold-and-count estimators that would operate in parallel on the same input data. The estimator dynamic ranges of these units would be made contiguous in the effort to ensure that there would always be one operating within its estimator dynamic range. The bottom part of Figure 2 shows an efficient single-pass hybrid estimator that would combine a threshold-and-count implementation with a histogram-based implementation: This estimator would be only slightly more complicated than the other one and considerably less complicated than a histogram-based true order-statistical estimator, yet would provide much greater dynamic range than is possible in a threshold-and-count-only implementation. The hybrid estimator would require only one threshold. It would produce an order

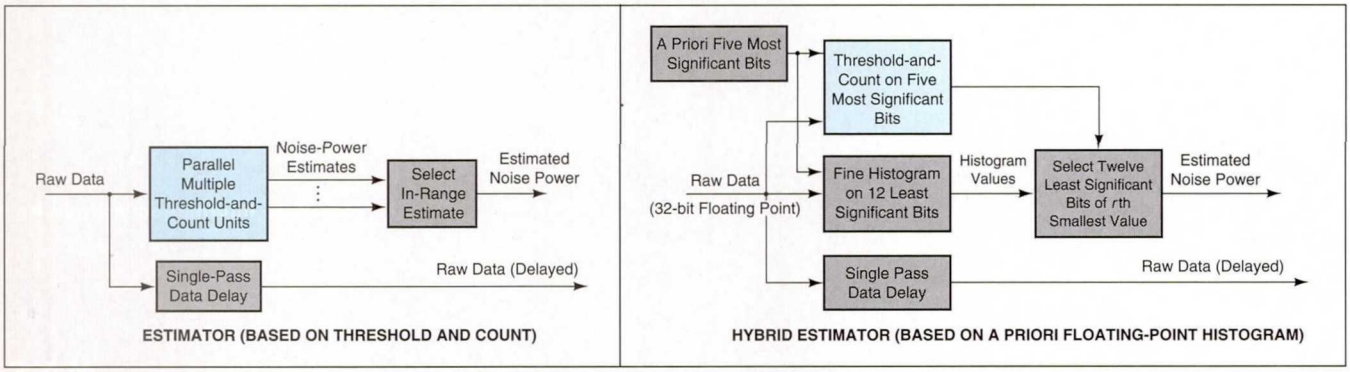
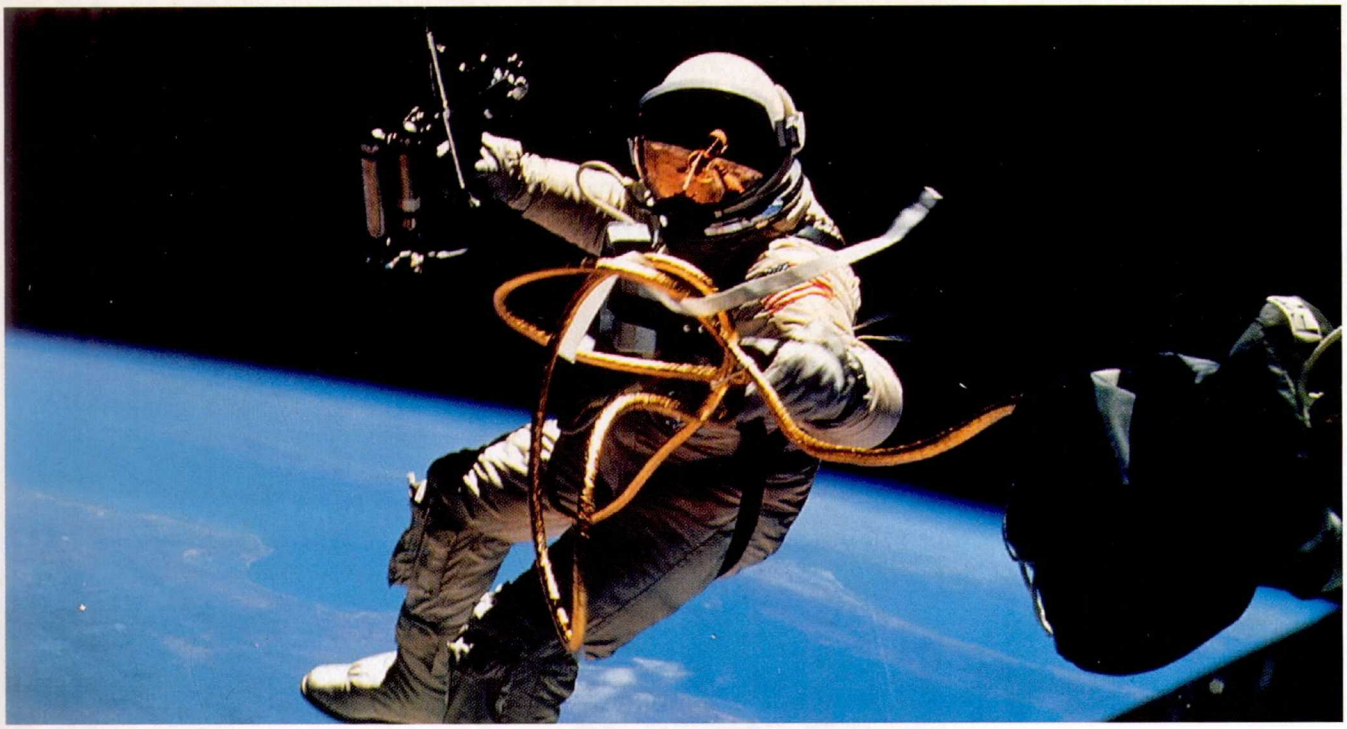


Figure 2. These **Proposed Noise-Power Estimators** are based on the order-statistical concepts described in the text.



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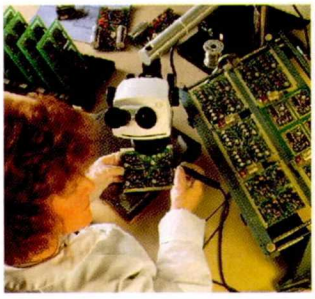

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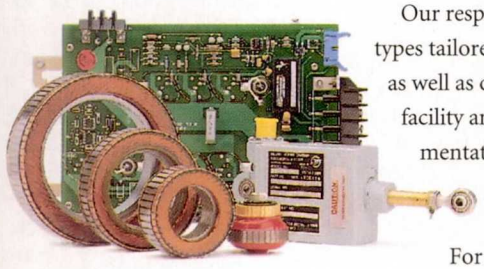

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statistic of desired rank, provided that the desired order statistic was within its dynamic range.

This work was done by George A. Zimmerman of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 157*** *on the TSP Request Card.*
NPO-19213

Wireless Headset Communication System

This system combines features of pagers, walkie-talkies, and cordless telephones.

John F. Kennedy Space Center, Florida

A wireless headset communication system uses digital modulation on a spread spectrum to avoid interference among units. The system consists of a base station, 4 radio/antenna modules, and as many as 16 remote units with headsets (see figure). The base station serves as network controller, an audio-mixing network, and an interface to such outside services as computers, telephone networks, and other base stations.

The remote units are battery-powered and weigh 18 oz (about 0.5 kg) each. The radio-frequency output power of each remote unit is 100 mW. A remote unit functions as a full telephone user interface via a keypad on the front cover. The user can set up conference calls, private calls, and ordinary telephone calls via simple keystroke sequences.

The radio/antenna modules communicate with the remote units via radio links in the frequency band from 902 to 928 MHz. The base station sends queries to the remote units sequentially; each headset is assigned a unique time slice in a time-division-multiplex protocol. A query is a data packet that contains a packet header, an address, some control information, and audio-signal data. A remote unit generates sound in the headset earphones according to the audio data. The packet contains enough data to produce the proper sounds until the next packet arrives. When a remote unit receives a query, the headset sends a response packet. Like a query packet, it contains a header, an address, control information, and audio data. The base station updates control settings according to the control information.

The radio/antenna modules can be as far as 1,000 ft (about 300 m) away from the base station. A remote unit can operate as far as about 500 ft (about 150 m) away from a radio/antenna module. Developed for use at Kennedy Space Center, the system could also be useful in industrial maintenance, emergency operations, construction, and airport operations. Also, its digital capabilities could be exploited; for example, by adding bar-code readers for use in taking inventories.

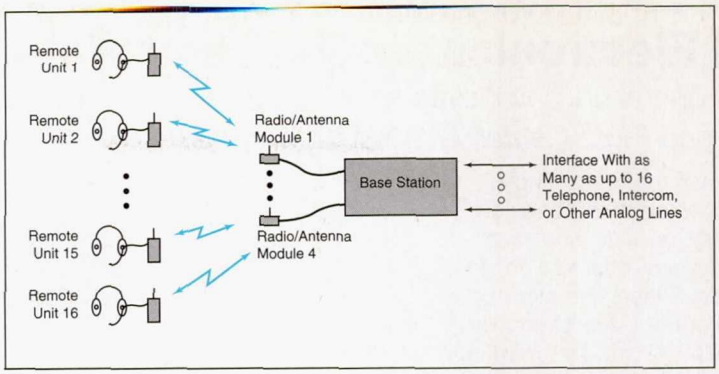
This work was done by Wilfred K. Lau, Richard Swanson, and Kurt K. Christensen of Telenexus, Inc., for **Kennedy Space Center.** *For further information,* ***write in 162*** *on the TSP*

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

Wilfred K. Lau
1410 Summit Ave. Suite 1
Plano, TX 75074

Refer to KSC-11650, volume and number of this NASA Tech Briefs issue, and the page number.



Workers Communicate With Each Other and with the outside world through portable headset units and a base station. Voice quality is good, with minimal echo.

High-Density Digital Data Storage System

This system stores 5 GB of digital data from a variety of sources.

Langley Research Center, Hampton, Virginia

A high-density digital data storage system is designed for cost-effective storage of large amounts of information acquired during experiments. (In the original application, the information consists of acoustic-measurement data.) The system can accept up to 20 channels of 16-bit digital data (see Figure 1) with overall transfer rates of 500 kilobytes per second. The data are recorded on 8-mm magnetic tape in cartridges, each capable of holding up to five gigabytes of data. Each cartridge is mounted on one of two tape drives. The operator can choose to use either or both of the drives. One drive can be used for primary storage of data while the other can be used to make a duplicate record of the data. Alternatively, the other drive can serve as a backup data-storage drive when the primary one fails.

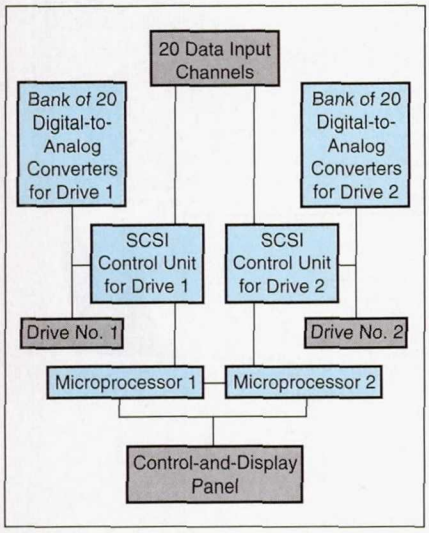


Figure 1. The **High-Density Digital Data Storage System** accepts data in as many as 20 channels of data, and records the data on one or two 8-mm tapes.

The system includes data-input circuits, two microprocessors that operate the data-input circuits, small-computer-systems-interface (SCSI) tape-drive control units, and a control-and-display panel. An analog output for each channel is used to monitor the data signals sent to the tape drive(s) during recording or retrieved from the tape drive(s) during playback; two banks of digital-to-analog conversion circuits provide these analog outputs to the control-and-display panel. The system automatically searches for data on each tape that is loaded and enables front-panel controls either for a blank tape or a tape on which data are already recorded.

The operator can set the system to record data received on any number of input channels from 1 to 20. Incoming 16-bit serial data for each channel are fed to its data-input circuit (see Figure 2). In this circuit, the format of the data signal is converted from serial to parallel under the control of bit-clock and word-clock signals. Data in parallel format are then fed, in 8-bit units, to two first-in/first-out (FIFO) buffers that provide 2,048 samples of interim storage to compensate for any mismatch between the speed of input of data and the speed of recording of data on the tape. Address-logic circuitry provides addresses for encoding all 20 channels of input data onto a single tape channel and decodes the addresses to separate the data into their respective channels during playback.

This work was done by Kenneth D. Wright and David L. Gray of **Langley Research Center.** *For further information,* ***write in 200*** *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, Langley Research Center [see page 20]. Refer to LAR-14651.

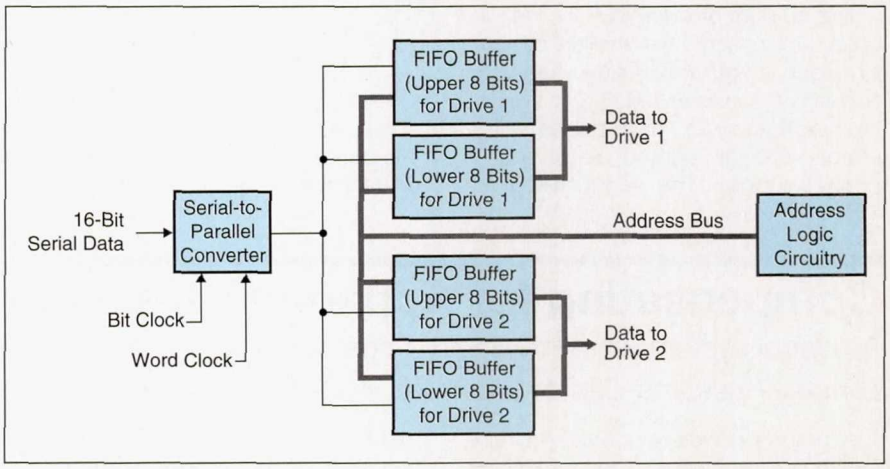


Figure 2. The **Data-Input Circuit** associated with each of two tape drives performs serial-to-parallel conversion of incoming data and addresses and formats the data for recording.

Control Electronics for Reaction Wheel

Bidirectional operation is achieved with a single-polarity main power supply.

Goddard Space Flight Center, Greenbelt, Maryland

The figure shows the major functional blocks of electronic circuitry that controls a two-phase ac induction motor with a reaction wheel attached to its shaft. The reaction wheel can store up to 0.8 ft·lb·s (about 1.1 J·s) of angular momentum at 250 r/min. The control circuitry is designed to supply pulse-width-modulated square drive waveforms, at 50 V peak to peak, to the two motor windings, 90° out of phase with each other, at an excitation frequency of 800 Hz.

The control circuitry operates partly in response to a digital magnitude-and-direction torque command generated by an external control subsystem and partly in response to tachometric feedback in the form of two once-per-revolution sinusoids with amplitudes proportional to speed. Operation can be in either of two modes called "normal" and "safehold." In the normal mode, the drive pulses are timed so that, on the average over one or a few cycles, the motor applies the commanded torque. In the safehold mode, the pulses are timed to keep the motor running at a set speed in one direction.

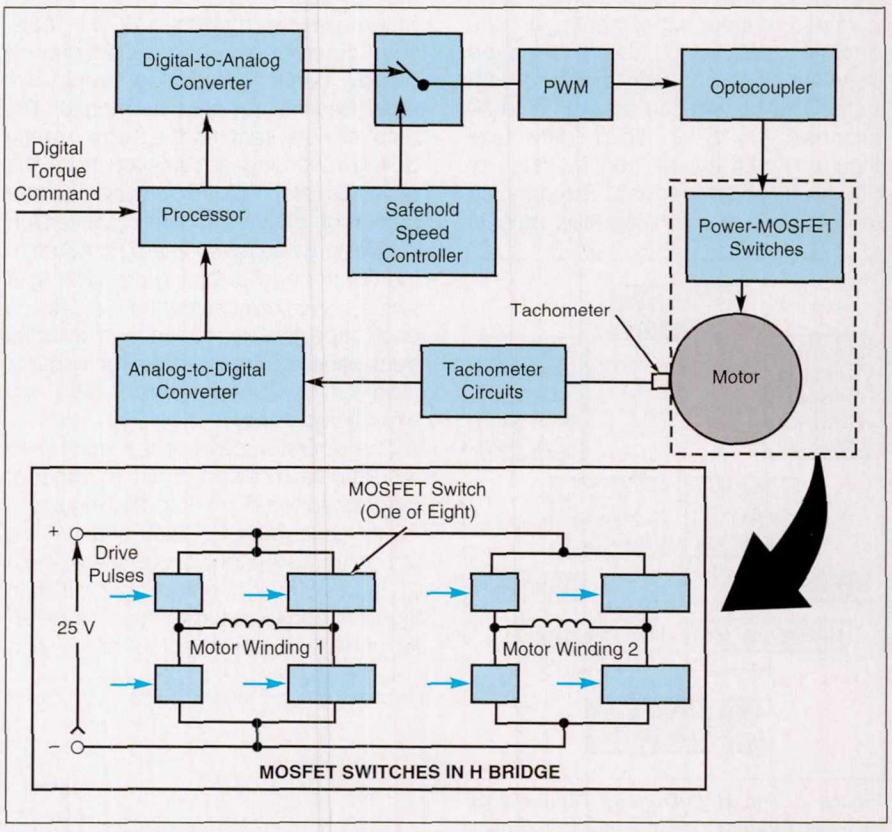
The control circuitry includes a pulse-width modulator (PWM) and a processor that computes a setting for the PWM on the basis of the actual speed and the most recently commanded torque. In the normal mode, torque commands are processed at a rate of 2 Hz. The digital output of the processor is converted to PWM-driving analog error signals. The PWM generates a four-phase, 800-Hz sequence of pulses. The durations of the pulses are controlled by the analog error signals via ramp-waveform voltage-to-time converter circuits.

The outputs of the PWM are fed, via optocouplers and other ancillary circuits, to eight metal oxide/semiconductor field-effect transistor (MOSFET) switches, which apply the drive pulses to the motor windings from a single +25-V power supply. The eight MOSFET switches are arranged in two four-switch H bridges — one H bridge for each motor winding. Each H bridge provides the required 50-V peak-to-peak square waveforms in the following way: During the first part of an 800-Hz cycle, one pair of MOSFET switches in the bridge is turned on to connect one side of the winding to +25 V and the other side to 0 V. During the second part of the cycle, the other pair of MOSFET switches is turned on to apply 25 V in opposite polarity. During intervals when all the MOSFET switches in a bridge are turned off, diodes direct flyback energy from the motor windings to the power supply.

The control circuitry enters the safehold mode whenever an externally generated watchdog pulse has not been received within the past 5 seconds. In the safehold mode, the motor-drive pulses are applied or not applied in simple on/off fashion, depending on whether the speed is above or below a set value as indicated by comparison of the amplitude of the tachometer output with a set dc level: When the speed rises above the preset value, the motor drive is turned off and remains off until friction decelerates the motor and wheel below the preset speed.

This work was done by Keith Chamberlin of **Goddard Space Flight Center**. *For further information,* ***write in 269*** *on the TSP Request Card.*

GSC-13593



The **Control Circuitry** generates pulse-width-modulated 800-Hz waveforms to drive a two-phase ac motor and reaction wheel.

Compensating for Apparent Strain at High Temperature

A control system would maintain a compensation strain gauge at the same temperature.

Langley Research Center, Hampton, Virginia

A proposed high-temperature strain-gauge system would include a subsystem that would compensate for apparent strain. There are many prior techniques for compensating for apparent strain, and each is more or less effective, depending on the specific application. The technique embodied in the proposed system is relatively complicated, but in return it offers the potential advantage of adaptability to a wide range of measurement conditions.

Hydrogen-Detection Apparatus

The concentration of hydrogen can be monitored continuously.

Stennis Space Center, Mississippi

An apparatus continuously monitors the concentration of hydrogen, at a level ranging from a few parts per million to several percent, in a mixture of gases. Such a mixture could occur, for example, in a vessel that has been used to store or transport hydrogen and that has nominally been purged of hydrogen in preparation for maintenance or repair. The apparatus can be used to alert technicians to potentially explosive concentrations of residual hydrogen. In contrast, the older technique of collecting gas samples and taking them to an analytical laboratory for determination of the concentrations of hydrogen in them is time consuming and expensive and provides delayed measurements that are applicable only to the sampling instants.

In the apparatus (see Figure 1), the stream of gas to be sampled first passes through an oxygen-removing membrane, then toward a catalytic methanator. A feed stream of carbon dioxide gas is mixed with the sampled gas, and the resulting mixture is fed to the catalytic methanator. The catalyst in the methanator promotes the reaction between the hydrogen (if any) from the sample stream and the carbon dioxide from the feed stream. Downstream of the catalytic methanator, the concentration of methane is measured (and thus the relative concentration of hydrogen in the sampled gas is inferred) by use of a fixed-filter infrared detector.

The catalyst is designed for high methanation activity and minimal retention of product gases to achieve rapid response (see Figure 2). In fabricating a prototype of the catalyst, 0.65 weight percent ruthenium (as ruthenium chloride) was applied to low-specific-surface-area (0.4-m^2/g), 30-mesh-size alumina supporting particles with a pore size of 5.5 μm. About 1 g of the particulate catalytic material thus prepared was packed into a tube of 0.25-in. (6.35-mm) diameter. The resultant catalyst provides for a low metal support area with large pores and a high rate of conversion of CO_2 to CH_4.

The oxygen-removing membrane at the input end of the apparatus is necessary to provide an inert environment to the catalyst. The CO_2 feed stream and sample gas stream pass through mass-flow controllers, which provides a 1:1 mixing ratio. The catalytic methanator is heated to a temperature of 380 °C. The stream that leaves the catalytic methanator contains methane, oxygen, excess carbon dioxide, and other inert gas from the sampled atmosphere. The infrared detector that probes this stream is optimized for the detection of methane at a wavelength of 3.4 μm. It is simple and fast, providing high sensitivity and linear response.

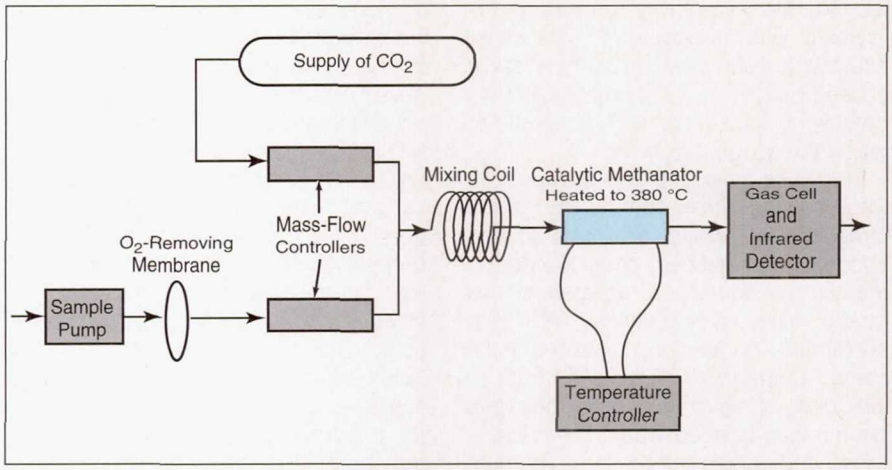


Figure 1. This **Hydrogen-Detection Apparatus** continuously measures the concentration of hydrogen in the sampled atmosphere.

This work was done by H. Richard Ross and Chris M. Bourgeois of Sverdrup Technology, Inc., for **Stennis Space Center.** *For further information,* ***write in 284*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Stennis Space Center [see page 20]. Refer to SSC-00021.

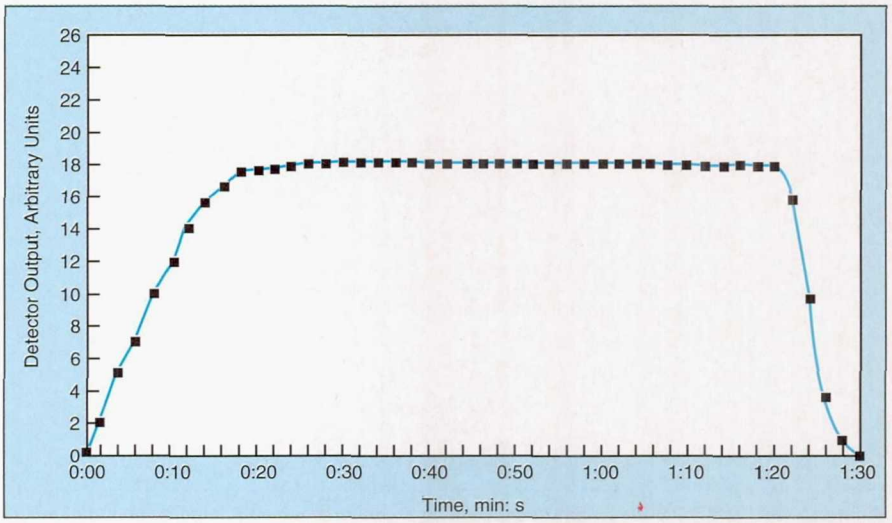


Figure 2. The **Rapid Response** of the apparatus is evident in this graph. The sample gas was introduced at time 0:00 and shut off at time 1:20.

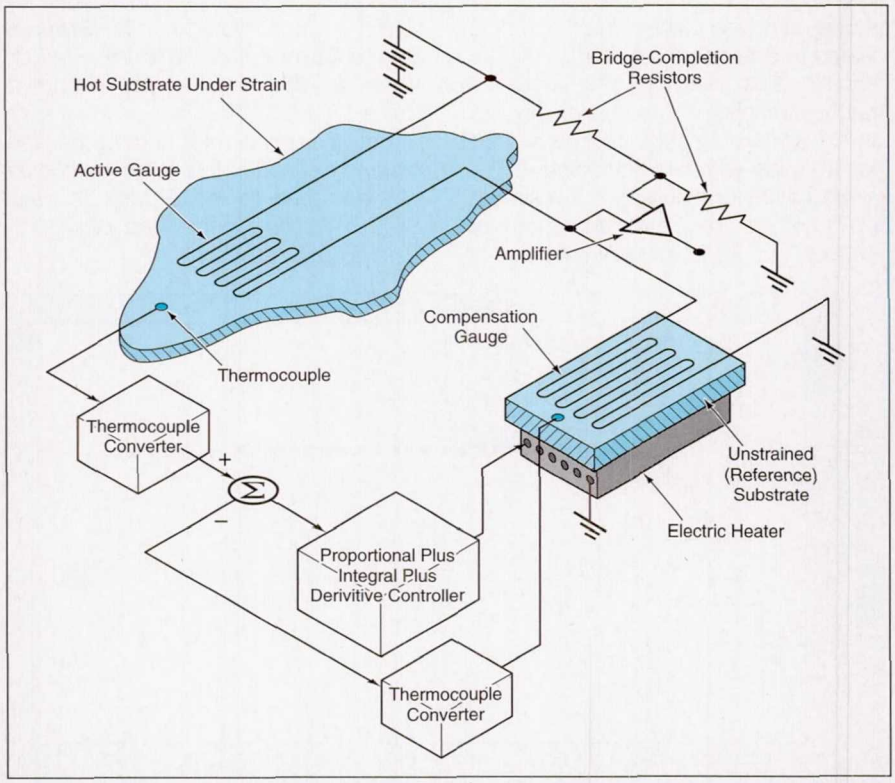
In particular, the system should be able to cope with the nonrepeatable, nonlinear nature of the apparent-strain problem in complicated materials like matrix/fiber composites at high temperatures, at which apparent strains can greatly exceed real mechanical strains by orders of magnitude.

Apparent strain is a spurious temperature-dependent component of the strain-gauge reading, caused by two additive effects that occur in the strain-gauge installation. One effect is the variation of the electrical resistivity of the gauge material with temperature. The other effect is an apparent mechanical strain caused by differential thermal expansion between the gauge and the substrate to which the gauge is bonded.

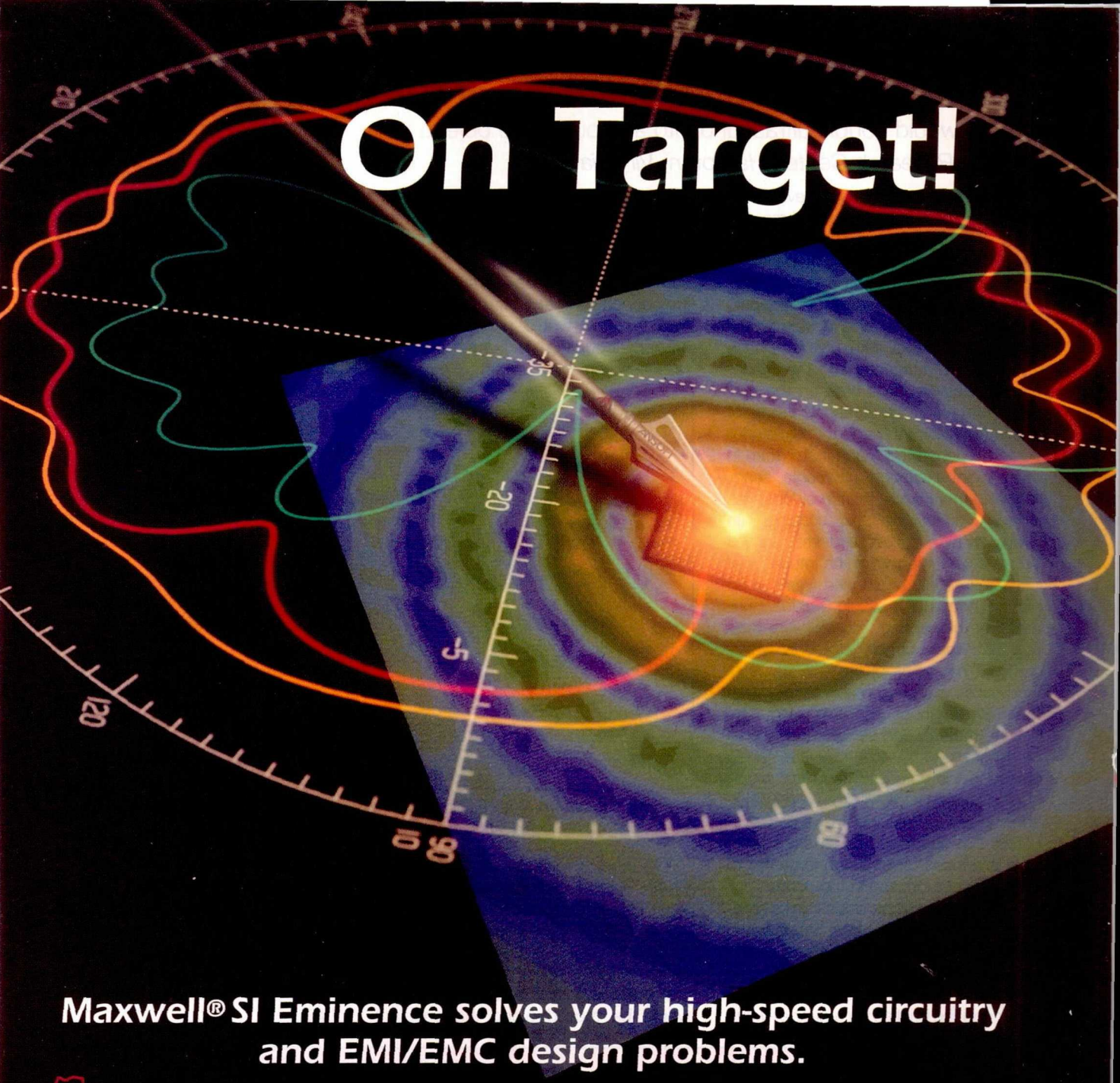
The most desirable way to eliminate the apparent-strain component of the strain-gauge reading would be to use two matched gauges, each bonded in the same orientation on a separate substrate of the same material, with both substrates and gauges maintained at the same temperature. The substrate to which one of the strain gauges (the active gauge) was bonded would be the substrate undergoing the strain to be measured. The other substrate would remain unstrained, and the strain gauge bonded to this substrate would serve as a compensation gauge. Inasmuch as both gauges would be exposed to identical temperature and material environments, both would be subject to the same apparent strain. Thus, the gauge readings could be subtracted electrically in the Wheatstone bridge to obtain the true mechanical-strain component of the output of the active gauge.

Heretofore, it has been nearly impossible to implement this compensation scheme in practice because of various difficulties involved in keeping both gauges at the desired temperature under the required apparent-strain conditions. The proposed system would overcome the difficulties. The system (see figure) would include a thermocouple attached to the strained substrate, as close as possible to the active gauge. The compensation gauge and its substrate would be similarly instrumented with a thermocouple. The compensation gauge and substrate would be attached to a controllable electric heater. The Wheatstone-bridge-completion resistors would be housed in a signal-conditioning-and-power-supply electronic unit. A proportional plus integral plus derivative controller would continually adjust the power supplied to the heater, striving to keep the thermocouple outputs (and thus the temperatures of the substrates and strain gauges) equal.

This work was done by Harlan K. Holmes of **Langley Research Center**. *For further information,* ***write in 216*** *on the TSP Request Card.*
LAR-14726



A **Feedback Control Subsystem** implementing a proportional plus integral plus derivative control algorithm would maintain the temperature of the compensation gauge equal to that of the active gauge.



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More Information Write In No. 638

Device for Ultrasonic Scanning of Curved Object

Bristles would couple ultrasound into and out of the object.

Langley Research Center, Hampton, Virginia

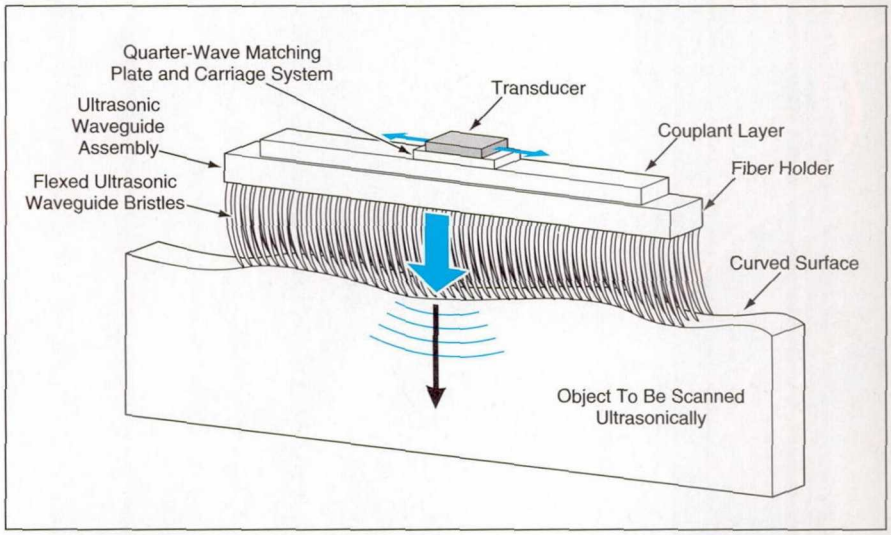
The ultrasonic brush is a device that has been proposed to overcome the major difficulties that are now encountered in ultrasonic scanning of the interior of an object that has a curved surface. Unlike other scanning ultrasonic devices now in use, this device would insonify the object with uniform-phase wavefronts propagating into the interior from a relatively large area on the surface. As a result, an ultrasonic image of subsurface flaws throughout the interior could be generated much faster than in older point-excitation ultrasonic scanning and more easily than in older large-area-excitation ultrasonic scanning (in which surface curves and irregularities interfere with imaging of the interior).

The ultrasonic brush (see figure) is so named because it would include hundreds of thin, springy, coated wire bristles that would act as ultrasonic waveguides. The radius of the wire cores of the bristles would be much smaller than the wavelength of the ultrasound. The coating material and its thickness would be chosen to concentrate the sonic energy in the core and keep the waveguides isolated sonically from each other, analogously the manner in which transparent thin fiber-optic cores are coated with low-index-of-refraction material to keep the light focused in the cores.

The wires would protrude from a holder, and the free ends of the fibers would be pressed against the surface of the object to be scanned. Ultrasound would be coupled between an ultrasonic transducer and the bristles via a quarter-wave matching plate and a couplant layer on the fiber holder. Where possible, the bristles would be made of materials such that the bristles would have the same or nearly the same acoustic impedance as that of the object to be scanned: this would provide for more efficient coupling and less spurious reflection from the surface.

The bristles would all be of the same length, so that sound generated by the transducer would arrive simultaneously at the ends of all the bristles, insonifying the object with a uniform, coherent beam propagating in from the surface. The transducer and quarter-wave plate would be moved along the couplant layer and holder to effect a B scan. In addition, the brush could be reoriented to scan in a different direction and thereby acquire data from which a three-dimensional image of subsurface flaws could be reconstructed.

This work was done by Eric Irvine Madaras of **Langley Research Center.** *No further documentation is available.*



Springy Bristles *would act as ultrasonic waveguides, coupling ultrasound into and out of an object through its curved surface.*

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, Langley Research Center [see page 20]. Refer to LAR-14621.

Instruments Sniff Organic Surface Contaminants

Contaminants react with activated gas molecules, forming excited molecules that emit characteristic light.

John F. Kennedy Space Center, Florida

Portable instruments that detect both nonvolatile and volatile organic surface contaminants (principally, hydrocarbons) in real time are being developed. These instruments are easy to use: they operate under ordinary ambient atmospheric conditions, without need to use messy liquid solvents or to install and remove witness plates, and without need to cut specimens from the surfaces to be inspected. The principle of detection involves sweeping a pure, activated gas across the surface spot to be inspected, then monitoring light emitted at wavelengths characteristic of the excited molecules that are formed by chemical reactions between the activated gas and the contaminants.

The gas can be activated by a dc discharge, radio-frequency induction, microwave radiation, laser beam, hot filaments, or any other suitable means that excites some of the gas molecules. The preferred gas is nitrogen, the active species of which include single atoms of nitrogen and metastable, high-energy nitrogen molecules. One of the products formed in chemical reactions between organic materials and the active nitrogen species is excited cyanogen (CN), which emits light at a characteristic wavelength of about 385 nm.

The figure shows, schematically, one version of an instrument of this type. Here, the nitrogen gas is supplied as a regulated flow from a Dewar flask of boiling liquid nitrogen: it is advantageous to do this because at the temperature of liquid nitrogen, the vapor pressures of the hydrocarbon contaminants in commercially supplied nitrogen are much lower than the vapor pressure of the nitrogen, so that the nitrogen gas supplied is highly pure, as needed to prevent spurious contaminant readings.

The nitrogen gas is fed into a wand that is positioned on the surface spot to be inspected. The wand is essentially a specially designed gas-distributor head that directs the flow across the inspected surface. Spacer feet keep the wand at a fixed distance off the surface, thereby helping to ensure repeatability of readings. The slight positive pressure of the outflow of the nitrogen gas pushes ambient air out of the space between the wand and the inspected surface, so that the instrument does not read spurious atmospheric contaminants.

The nitrogen flowing into the wand is activated by a dc discharge between two electrodes. Fiber-optic cables are positioned to receive some of the light emitted by excited molecules entrained in the outflowing activated nitrogen gas. The fiber-optic cables are also aimed and positioned so as not to pick up light from the discharge and from short-lived excitation of residual contaminant molecules carried in from the nitrogen supply. The fiber-optic cables carry the light to bandpass filters, one of which passes the 385-nm light characteristic of cyanogen, the other of which passes the 380-nm light characteristic of nitrogen. The outputs of the filters are sensed by photodetectors, which thus give readings approximately proportional to the amount of contaminants and the amount of nitrogen, respectively. The cyanogen reading can be divided by the nitrogen reading to obtain a normalized contaminant reading that may fluctuate less with fluctuations in the degree of activation of nitrogen.

The instrument as described thus far gives only a qualitative or semiquantitative indication of the amount of surface contamination. An alternative version (not shown in the figure) to measure the amount of contamination would include a pulsed laser and time-gated integrating circuits to process the outputs of the photodetectors. The laser pulse would be adjusted so that it was powerful enough to vaporize all organic contamination from the inspected spot, but not powerful enough to damage the spot. The time-gated, integrated 385-nm photodetector reading following a single laser pulse would thus be indicative of the total amount of contamination that was present on the surface before the pulse.

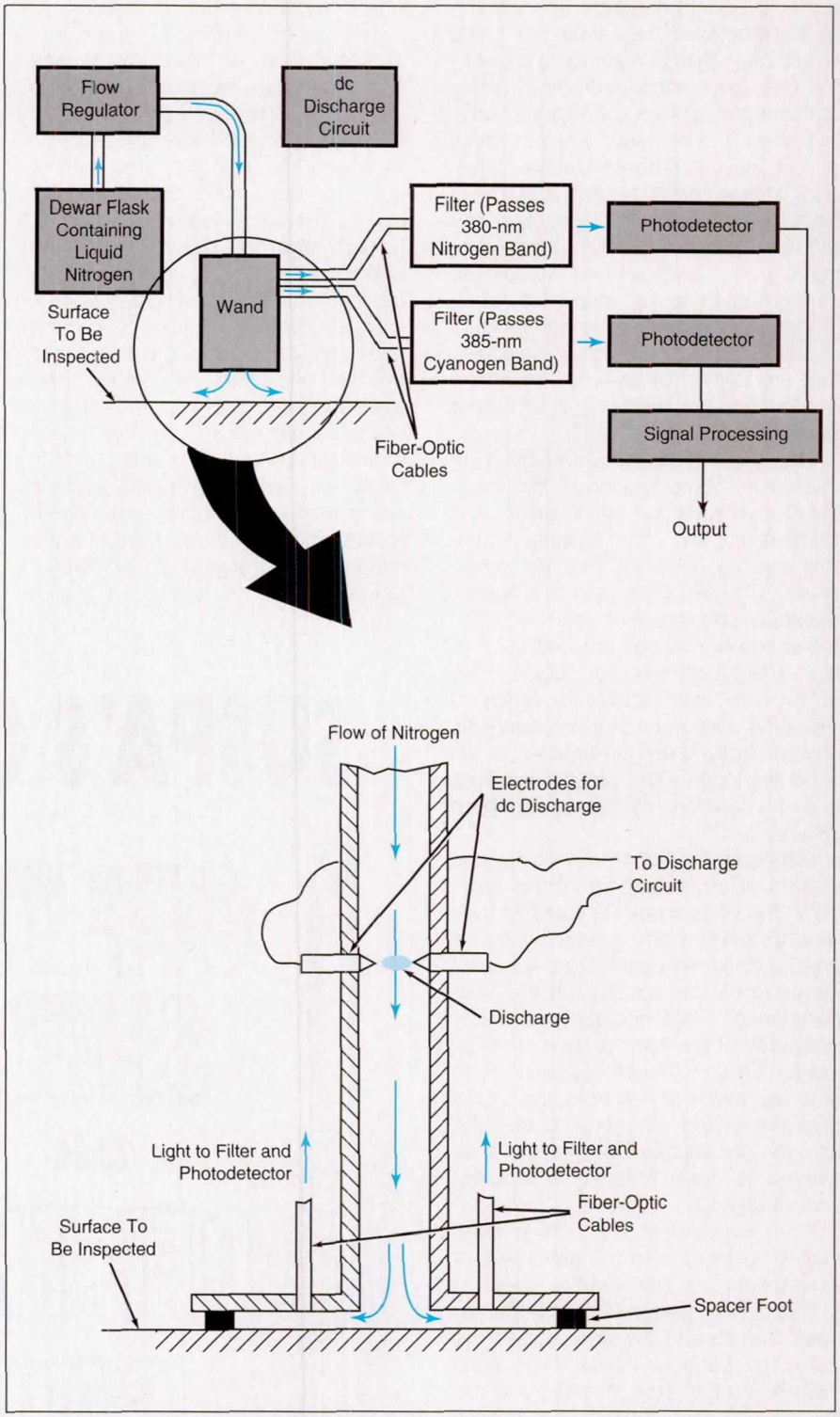
This work was done by Steven Adler-

Golden and Michael W. Matthew of Spectral Sciences, Inc., for **Kennedy Space Center**. *For further information,* ***write in 36*** *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

Steven Adler-Golden
99 South Bedford St. No.7
Burlington, MA 01803-5169

Refer to KSC-11660, volume and number of this NASA Tech Briefs issue, and the page number.



This **Instrument Detects Organic Surface Contamination** by applying a flow of activated nitrogen gas, then measuring light emitted by excited molecules formed in chemical reactions between the contaminants and the activated nitrogen.

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For More Information Write In No. 551

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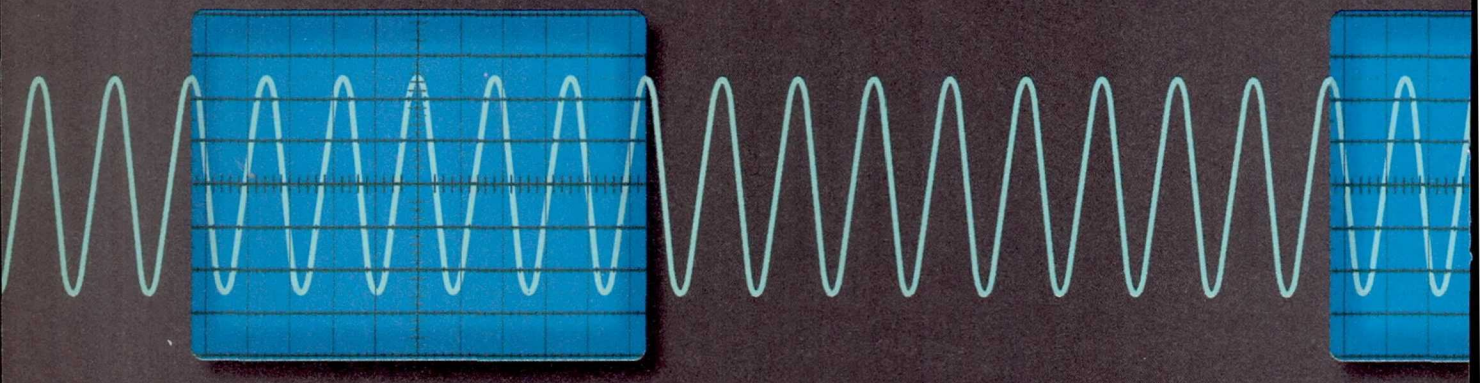

Imagine driving in rush-hour traffic. And every so often, you close your eyes for a few seconds. You'd better pray nothing critical happens while you're not collecting visual information.

Scary, right? Yet that's exactly what it's like to use most digital troubleshooting scopes.

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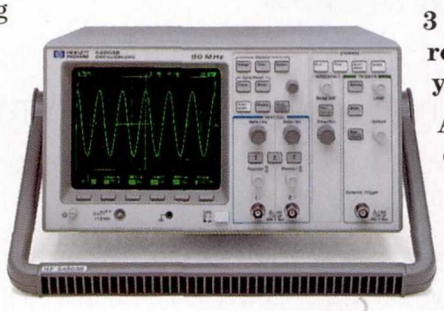

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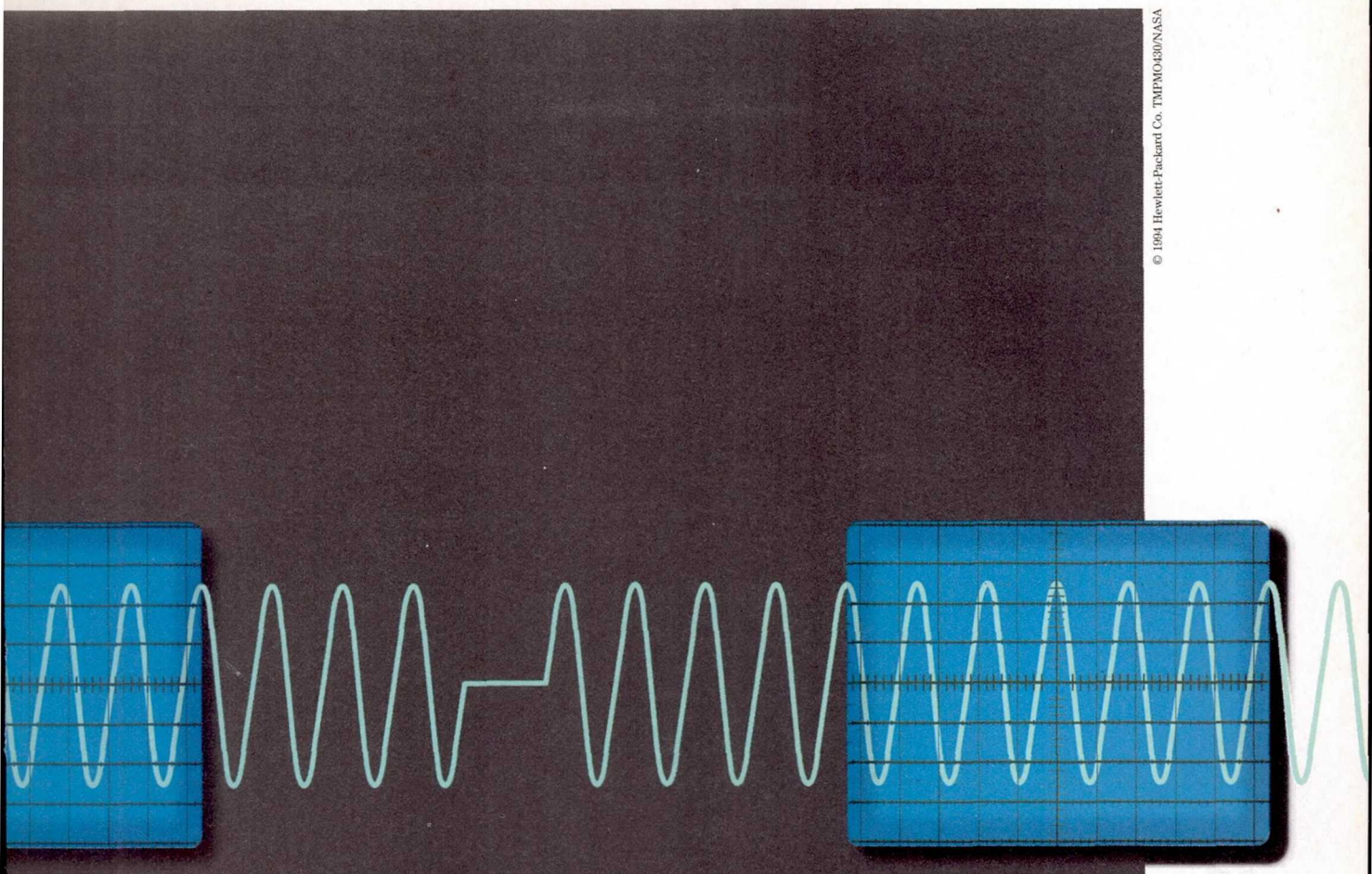

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Flame-Resistant Composite Materials for Structural Members

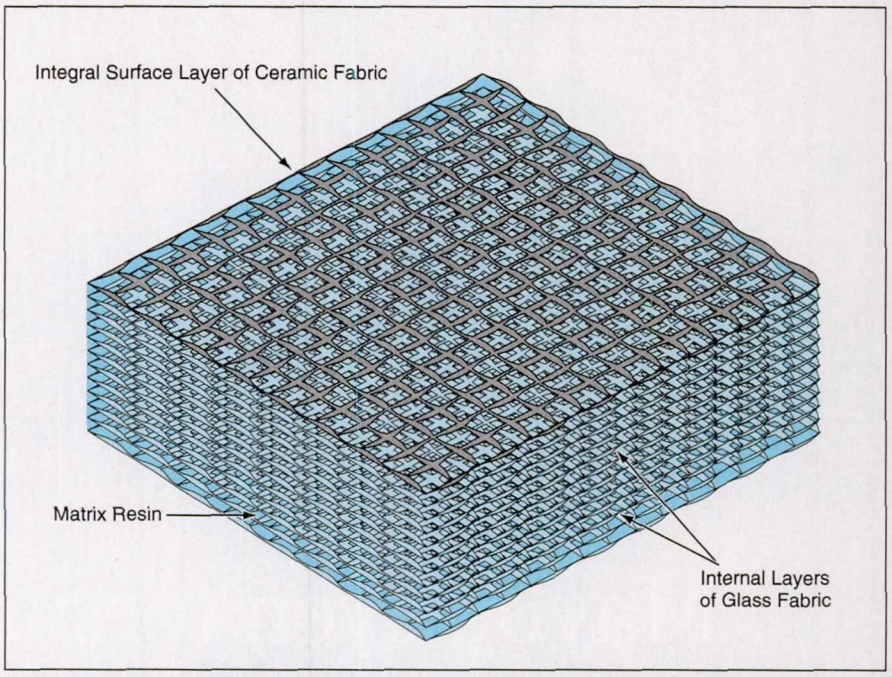
Surface layers of ceramic fabric are integrated into the members.

John F. Kennedy Space Center, Florida

Matrix/fiber composite materials are being developed for structural members that are occasionally exposed to hot, corrosive gases. In the original intended application, the composite members would replace steel structural members of rocket-launching structures that deteriorate under the combined influences of the atmosphere, spilled propellants, and rocket exhaust. The composites may also be attractive for other applications in which corrosion- and fire-resistant structural members are needed.

A typical composite-material member considered in this development work comprises a phenolic or other heat-resistant thermosetting resin reinforced by internal layers of glass fabric, plus a surface layer of ceramic fabric that is molded together with the internal layers and matrix material into a single, integral piece (see figure). The ceramic-fabric surface layer resists flames, protects against erosion, provides strength, and resists chemicals. By so doing, it retards deterioration of the entire underlying composite material.

Experimental composite specimens have been made by resin-transfer molding, but in production, the composite structural members would likely be made by pultrusion. Further work must be done to develop the parameters of a pultrusion process. Until now, high volume production pultrusion, in which reinforcement fibers are impregnated with resin and fed to forming and curing dies, has been confined to polyesters, vinyl esters, and epoxies. The pultrusion process will have to be adapted to phenolic resins, and this requires study of the temperatures, viscosities, and curing characteristics of phenolic formulations.



The **Integral Ceramic Fabric Surface Layer** would be essential for resistance to flames and chemicals. This layer endures high temperature, impedes a flame from penetrating to the interior, inhibits the diffusion of oxygen to the interior where it would degrade the matrix resin, resists attack by chemicals, helps to resist erosion, and provides additional strength.

This work was done by Richard K. Spears of Largo Scientific, Inc., for **Kennedy Space Center.** *For further information,* ***write in 31*** *on the TSP Request Card.*

KSC-11613

Polyimides Made From 3,5-Diaminobenzotrifluoride

Characteristics include thermo-oxidative stability, solubility in polar solvents, low dielectric constants, and transparency.

Langley Research Center, Hampton, Virginia

Polyimides have been synthesized from 3,5-diaminobenzotrifluoride (DABTF). Polyimides are an important class of polymers for use at high temperatures because they exhibit high thermo-oxidative stability. One monomer of major importance in preparing these high-temperature polymers is 1,3-phenylenediamine (mPDA). DABTF is a newly synthesized diamine derived from mPDA. DABTF contains a symmetrically substituted polar CF_3 group.

Fluorinated polyimides exhibit characteristics that make them potentially attractive for aerospace and electronic applications. These characteristics include optical transparency, solubility in common polar solvents, enhanced

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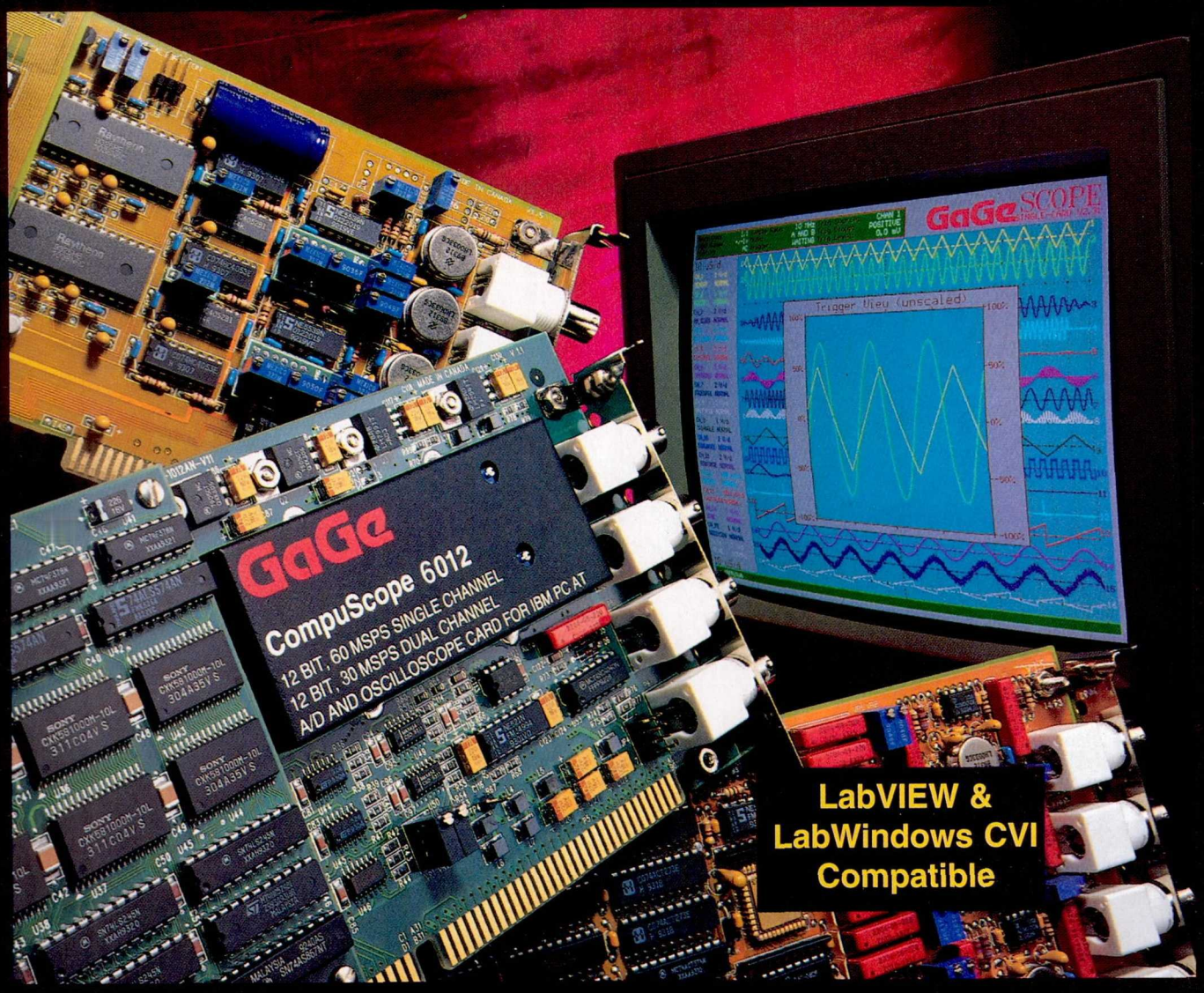

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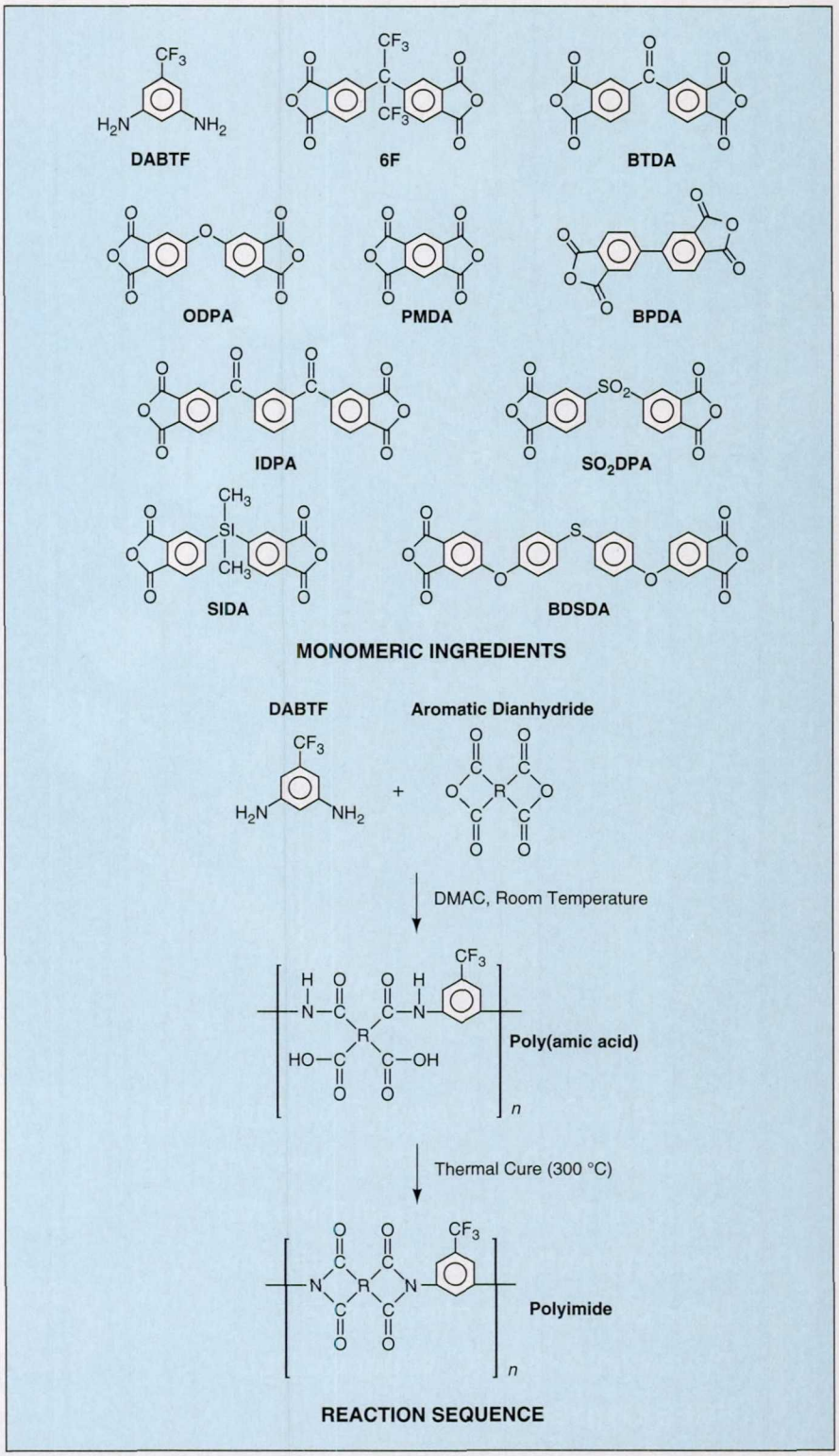
thermo-oxidative stability, low dielectric constants, and high glass-transition temperatures. Therefore, experiments were conducted with a view toward synthesizing polyimides with these characteristics, starting from the newly synthesized fluorinated diamine DABTF.

In the experiments, DABTF was reacted with each of the following dianhydrides: 2,2-bis (3,4-dicarboxyphenyl) hexafluoropropane dianhydride (6F); 3,3',4,4'-benzophenonetetracarboxylic dianhydride (BTDA); 4,4'-oxydiphthalic anhydride (ODPA); pyromellitic dianhydride (PMDA); 3,3',4,4'-biphenyltetracarboxylic dianhydride (BPDA); isophthaloyldiphthalic anhydride (IDPA); sulfonyldiphthalic anhydride (SO2DPA); bis(3,4-dicarboxyphenyl)dimethylsilane dianhydride (SiDA); and 4,4'-bis(3,4-



DABTF and Dianhydrides can be reacted to obtain fluorinated polyimides suitable for electronic and aerospace applications.

dicarboxyphenoxy)diphenylsulfide dianhydride (BDSDA).

The figure illustrates the molecular structures of DABTF and of these dianhydrides, and shows the reaction sequence. In each case, the dianhydride and DABTF monomers were dissolved in N,Ndimethylacetamide (DMAc) at a solids concentration of 20 percent, and the polymerization reaction proceeded at room temperature in the solution thus formed. The product of the reaction was a poly(amic acid), which was then thermally cyclized to convert it to the corresponding polyimide.

In comparison with the other state-of-the-art polyimides available at the time, the polyimides synthesized in these experiments were found to have greater solubility in polar solvents, less color, and lower dielectric constants. These polyimides can be used to form free-standing films, coatings, and moldings.

This work was done by Terry L. St. Clair and Anne K. St. Clair of **Langley Research Center** *and Margaret K. Gerber and J. Richard Pratt of Planning Research Corp. For further information,* ***write in 296*** *on the TSP Request Card.*

This invention has been patented by NASA (U.S. Patent No. 5,218,083). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Langley Research Center [see page 20]. Refer to LAR-14206.

Intercalated-Graphite-Fiber Composites

Electrically conducting composites have been made from bromine-intercalated graphite fibers in an epoxy matrix.

Lewis Research Center, Cleveland, Ohio

Although electrically conductive polymers have attracted much interest as candidate materials for incorporation into lightweight, electrically conductive composites, an alternate approach to making conductive composites is to increase the conductivities of the fibers. Carbon fibers based on polyacrylonitrile have appreciable conductivity (500 Ω–1cm–1), and graphite fibers based on pitch have even higher conductivity (4,000 Ω–1cm–1), but these conductivities are still well below those of common metals (10,000 to 550,000 Ω–1cm–1). However, by intercalation (the process of introducing donor or acceptor atoms between the layers of graphite crystalline lattices), one can increase the conductivities of pitch-based graphite fibers into the metallic range (as high as 50,000 Ω–1cm–1).

Although most elements and compounds to be intercalated into graphite are sensitive to moisture and high temperature, bromine-intercalated graphite fibers have conductivity of about 20,000 Ω–1cm–1 and have been found to be stable in the presence of moisture (the fibers can even be submerged for indefinite times) and at reasonably high temperature (200 °C). Conventional epoxy resins, which typically require curing temperature of 175 °C, can be used with such fibers.

Composite materials that contain 50 percent bromine-intercalated graphite fibers have promising properties. The mechanical properties of such composites are similar to those of composites made with pristine fibers: The tensile and flexural strengths and the Young's and bending moduli are essentially unchanged, and the interlaminar shear strengths are slightly enhanced. The thermal conductivities of the composites also show very little degradation from those of the pristine composites. However, the electrical conductivities of the composites increase from 700 to 2,800 Ω–1cm–1 as a result of the use of the intercalated-graphite fibers. This fourfold increase in conductivity invites the application of these composites in electrical grounding planes and in shields against electromagnetic interference.

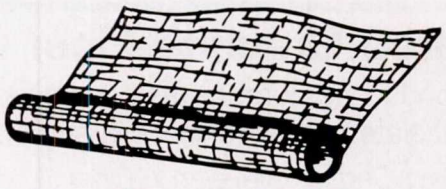
The intercalation process (see figure) is simple and straightforward. A cloth made of the graphite fibers is rolled up and placed into a cylindrical glass reaction tube. Liquid bromine is then introduced into the tube. The intercalation reaction occurs in both the liquid and the gas regions in the tube, though more quickly and evenly in the liquid. The tube is slowly rolled to expose every part of the graphite to the liquid. After the reaction is complete, the bromine is removed from the tube, and the cloth is washed in bromoform. This wash removes the residual bromine and lubricates the cloth so it can be easily handled and formed. A composite can then be made of the cloth and a film-type epoxy, which is cured by use of the standard procedure recom-

mended by the epoxy manufacturer.

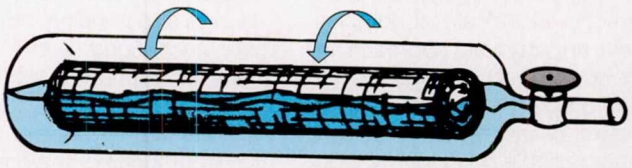
The determination of the electrical conductivity of a specimen of composite is not straightforward because the conducting fibers are embedded in the insulating matrix. A contactless radio-frequency eddy-current technique, of the type used in the semiconductor industry, has been used to characterize specimens of this type. Although this technique avoids the difficult problem of how to make contact, the electrical conductivity of the composite has a complicated directionality, which cannot be measured by this technique. Currents that flow along the fibers flow approximately like those in parallel conductors and can be treated by a simple rule-of-mixtures mathematical model. Currents that travel in other directions must percolate from fiber to fiber through the insulating matrix. The conductivity measured by use of radio-frequency eddy currents is about half that measured in the fibers and predicted by a simple rule of mixtures.

This work was done by James R. Gaier of **Lewis Research Center** *and Paul D. Hambourger and Melissa E. Coan of Cleveland State University. For further information,* ***write in 71*** *on the TSP Request Card.*

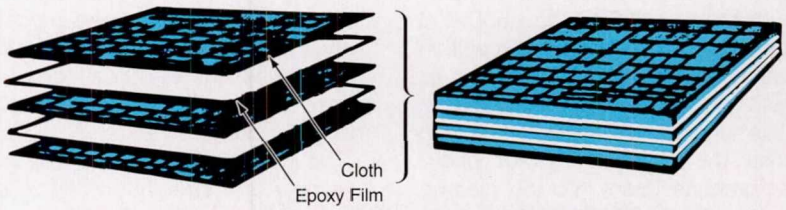
This invention has been patented by NASA (U. S. Patent No. 5,073,412). Inquiries concerning nonexclusive or exclusive license or its commercial development should be addressed to the Patent Counsel, Lewis Research Center [see page 20]. Refer to LEW-15077.



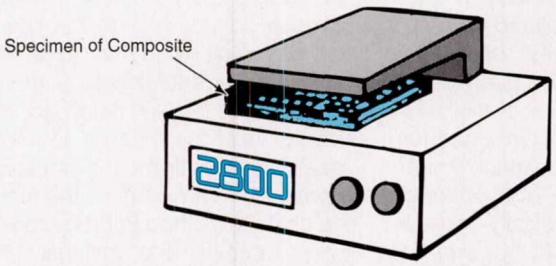
STEP 1: GRAPHITE CLOTH ROLLED UP



STEP 2: CLOTH PLACED IN REACTION TUBE AND ROTATED WITH LIQUID BROMINE



STEP 3: COMPOSITE FORMED BY STACKING LAYERS OF TREATED CLOTH WITH EPOXY FILMS, THEN PRESSING AND CURING



CONDUCTIVITY OF COMPOSITE MEASURED BY EDDY-CURRENT APPARATUS

Bromine Is Intercalated Into Graphite-Fiber Cloth, then the cloth is used to make a fiber/epoxy composite. The electrical conductivity of the composite can be measured by use of radio-frequency eddy currents.

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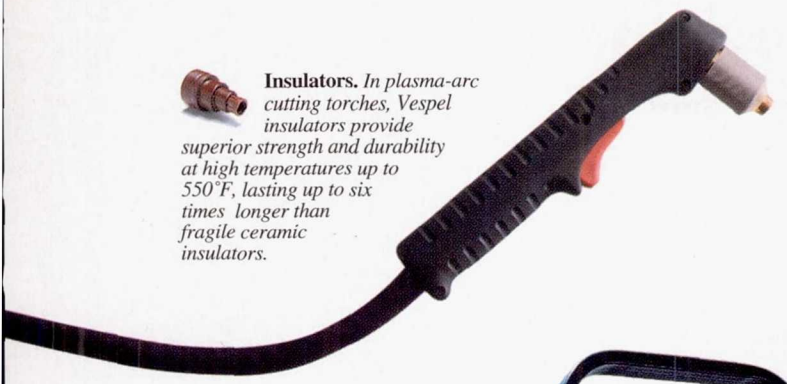

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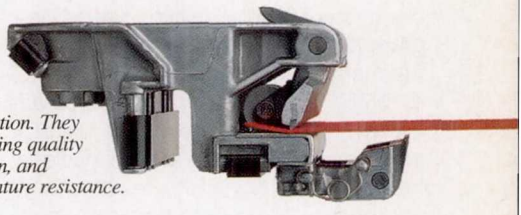

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Physical Sciences

Computer Model of Fragmentation of Atomic Nuclei

This semiempirical model accounts for the principal physical effects.

The High Charge and Energy Semiempirical Nuclear Fragmentation Model (HZEFRG1) computer program was developed to be a computationally efficient, user-friendly, physics-based program for generating data bases on the fragmentation of atomic nuclei. (The "Z" in "HZE" is the customary mathematical symbol for the number of units of positive charge in an atomic nucleus; hence, "HZE" signifies "high charge and energy.") The data bases generated by HZEFRG1 can be used in calculations that pertain to such radiation-transport applications as shielding against radiation in outer space, radiation dosimetry in outer space, cancer therapy in laboratories with beams of heavy ions, and simulation studies for designing detectors for experiments in nuclear physics. The program provides cross sections for production of individual elements and isotopes in breakups of high-energy heavy ions by the combined nuclear and Coulomb fields of the interacting nuclei.

In HZEFRG1, the contributions to breakups of nuclei are estimated by use of an energy-dependent, abrasion/ablation mathematical model of fragmentation of heavy ions. The abrasion step involves removal of nucleons by direct knockout in the region of overlap of the colliding nuclei. The abrasions are treated on a geometric basis, and uniform spherical distributions of densities in nuclei are assumed. Empirical radii of nuclei obtained from tabulations of electron-scattering data are incorporated. Nuclear-transparency effects are included by use of an energy-dependent, impact-parameter-dependent average transmission factor for the projectile and target nuclei, which factor accounts for the finite mean free paths of nucleons in nuclear matter.

The ablation step, as implemented by Bowman, Swiatecki, and Tsang (LBL report LBL-2908, July 1973), is treated as an emission of a single nucleon for every 10 MeV of excitation energy. Contributions to fragmentation from electromagnetic dissociation processes that arise from the interacting Coulomb fields are estimated by use of the Weiszacker-Williams theory, extended to include the contributions of electric dipoles and quadrupoles to the cross sections for removal of single nucleons.

HZEFRG1 consists of a main program, seven function subprograms, and thirteen subroutines. Each subprogram and subroutine is fully explained by comments contained within it and begins with a brief description of its functionality. The inputs, which are provided interactively by the user in response to questions displayed on the computer video screen, consist of the energies of the projectile nuclei in units of MeV/nucleon and the masses and charges of the projectile and target nuclei. With proper inputs, HZEFRG1 first calculates the cross sections for electromagnetic dissociation and then begins the calculations of fragmentation of nuclei by searching through a specified number of isotopes for each charge number (Z) from Z=1 (hydrogen) to the charge of the incident fragmenting nucleus (Z_p). After computing the cross sections for fragmentation of the nuclei, HZEFRG1 sorts through the results and writes the sorted output to a file in descending order, based on the charge numbers of the fragmented nuclei. Details of the theory that underlies the computer code, extensive comparisons of its predictions with available experimental cross-section data, and a complete description of the computer code are given in the program documentation.

HZEFRG1 is written in ANSI FORTRAN 77 to be machine-independent. It was originally developed on a DEC VAX-series computer, and has been successfully implemented on a DECstation computer running RISC ULTRIX 4.3, a Sun4-series computer running SunOS 4.1, an HP 9000-series computer running HP-UX 8.0.1, a Cray Y-MP-series computer running UNICOS, and IBM PC-series computers running MS-DOS 3.3 and higher. HZEFRG1 requires 1MB of random-access memory for execution. In addition, a FORTRAN 77 compiler is required to create an executable code. A sample output run is included on the distribution medium for numerical comparison. The standard medium for distribution of this program is a 3.5-in. (8.89-cm), 1.44MB MS-DOS-format diskette. Alternate distribution media and formats are available upon request. HZEFRG1 was completed in 1992.

This program was written by John W. Wilson and Lawrence W. Townsend of **Langley Research Center** *and Ram K. Tripathi of Vigyan, Inc., John W. Norbury of Rider College, Ferdous Khan of Old Dominion University, and Francis F. Badavi of Christopher Newport University. For further information,* ***write in 298*** *on the TSP Request Card. LAR-15230*

Mathematics & Information Sciences

Program for Editing Graphical Displays of Schedules

This program provides WYSIWYG editing capabilities.

XOPPS is a window-based software tool from graphics that provides easy and fast "what you see is what you get" (WYSIWYG) on-screen editing capabilities. It provides an area, analogous to a canvas, on which it displays a full image of a schedule being edited. The canvas contains a header area (for text) and a schedule area (for plotting graphical representations of milestone objects in a flexible time line).

XOPPS is object-oriented, but it is unique in its capability for creation of objects that have date attributes. Each object on the screen can be treated as a unit for moving, editing, and other operations. There is a mouse interface for simple control of location of a pointer. The user can position objects to pixel resolution, but objects with which dates are associated are positioned automatically in their correct time-line positions in the schedule area.

The schedule contains horizontal lines across a page, with capabilities for multiple pages and for editing the number of lines per page and the line grid. The text on a line can be edited, and a line can be moved in which case all objects on the line move with the line. The time-line display can be edited to plot any time period in a variety of formats from fiscal year to calendar year and from days to years. Text objects and image objects (rasterfiles and icons) can be created for placement anywhere on the page. Milestone event objects, each with a single associated date (and optional text and milestone symbol) and activity objects with beginning and ending dates (and an optional completion date) include unique editing panels for entering data. A representation for schedule slips is also provided with the capability to automatically convert a milestone event to a slip. A milestone schedule can be saved to an ASCII file on another computer to be read by XOPPS. The program can also print a schedule to a PostScript file. Dependencies between objects can also be displayed on the chart by use of precedence lines.

This program is not intended to replace a commercial scheduling-and-project-management program. Because XOPPS includes an ASCII file interface, it can be used in conjunction with a project-management software tool to produce schedules with an appearance of quality.

XOPPS is written in C language and runs under X/Motif on a Sun Workstation with SunOS 4.0 or higher. The memory required for use of XOPPS consists of 375KB of main memory and 1.5MB of free disk space. XOPPS was developed in 1992, based on the Sunview version OPPS developed in 1990. XOPPS is a copyrighted work with all copyright vested in NASA.

SunOS and Sunview are trademarks of Sun Microsystems, Inc. Sun Workstation is a registered trademark of Sun Microsystems, Inc. X-Motif is a trademark of Open Software Foundation (OSF). PostScript is a trademark of Adobe Systems Incorporated.

This program was written by Cassie L. Mulnix and Kevin Miller of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 2*** *on the TSP Request Card.*

NPO-19348

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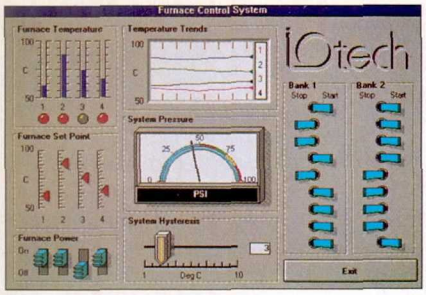

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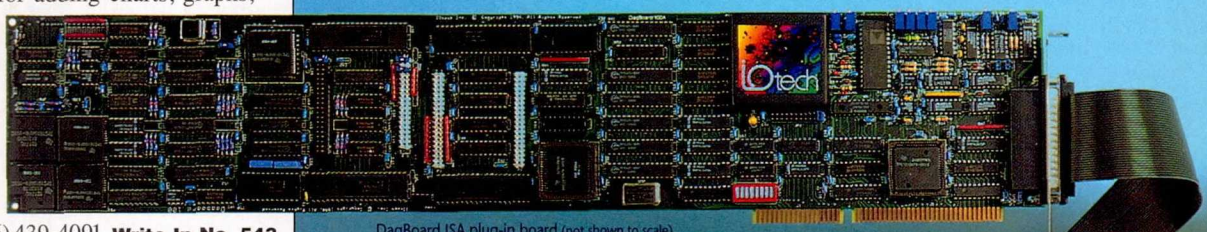

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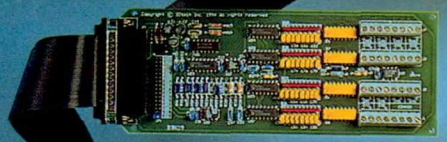

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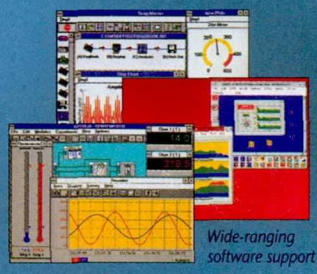

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Blending Velocities in Task Space in Computing Robot Motions

The computational burden is less than that of blending positions and orientations.

NASA's Jet Propulsion Laboratory, Pasadena, California

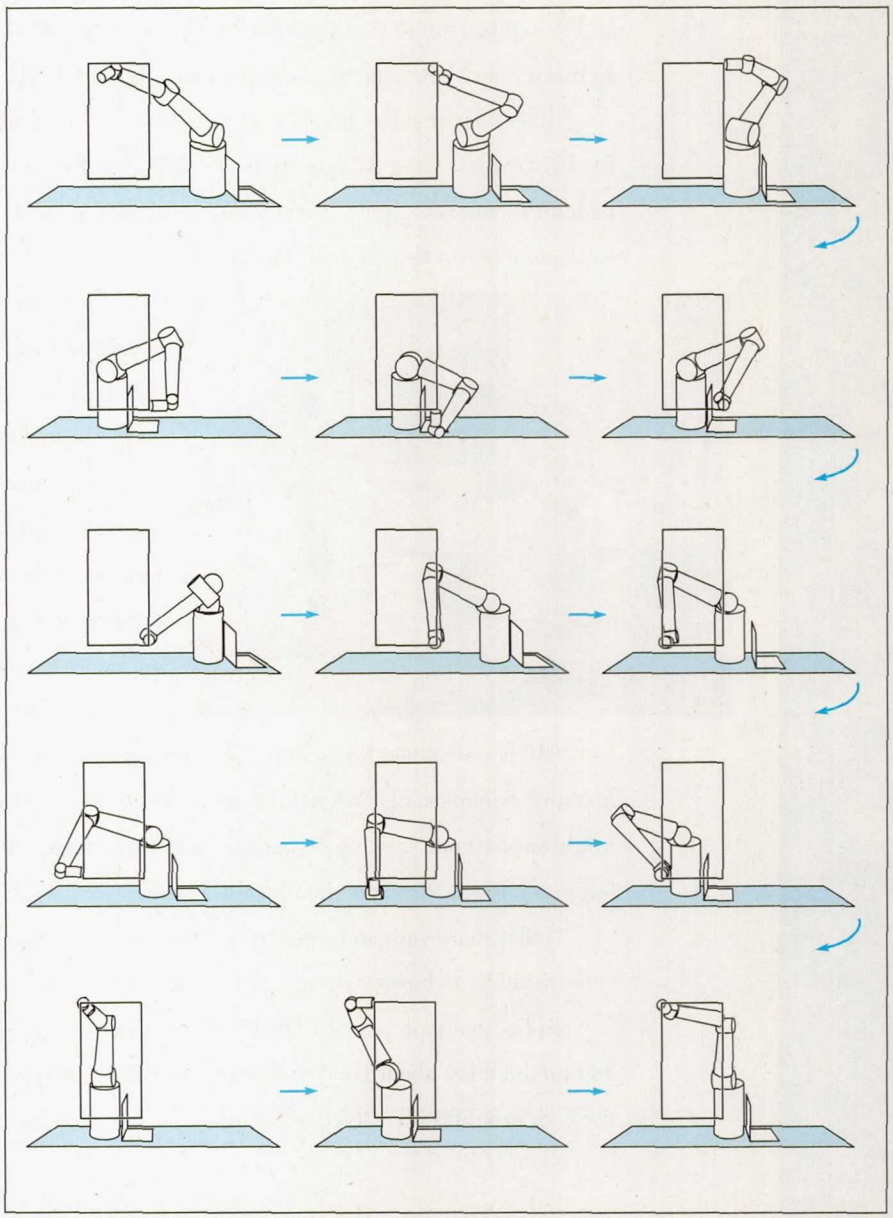
Blending of linear and angular velocities between sequential specified points in task space constitutes the theoretical basis of an improved method of computing trajectories to be followed by robotic manipulators. Task space denotes the coordinate transformation describing the end-effector position and orientation, as well as other parameters (e.g., arm angle, base position) which completely and conveniently describe the arm pose without explicit specification of the joint angles. A related prior method of generating trajectories involves blending of positions and orientations between sequential points in task space. The present improved method achieves the same results as does the prior method, but with much less computation.

In the improved method, a generalized velocity-vector-blending technique provides a relatively simple, common conceptual framework for blending linear, angular, and other parametric velocities. The velocity vectors originate from straight-line segments that connect the specified task-space points, which are called "via frames" and which represent specified robot poses (see figure). Linear-velocity-blending functions can be chosen from among first-order, third-order-polynomial, and cycloidal options (see figure). Angular velocities are blended by use of a first-order approximation of a previous orientation-matrix-blending formulation. The angular-velocity approximation yields a small residual error, which is quantified and corrected.

The method was tested, both by computer simulation and by experimentation on a computer-controlled seven-degree-of-freedom robot arm on a one-degree-of-freedom platform, as shown in simplified form in the figure. Linear blending was arbitrarily chosen for these tests. The results of both the simulation and experiments showed that the method offers both the relative simplicity and the speed needed for generation of robot-manipulator trajectories in real time.

This work was done by Richard A. Volpe of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 256*** *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 [see page 20]. Refer to NPO-19022.



A **Sequence of Robotic Poses** corresponds to a sequence of task-space points between which velocity vectors are defined. The velocities are then blended according to the improved method to obtain a smoothed trajectory. In this case, the robotic manipulator is commanded to move through a sequence of specified poses to inspect a rectangular object.

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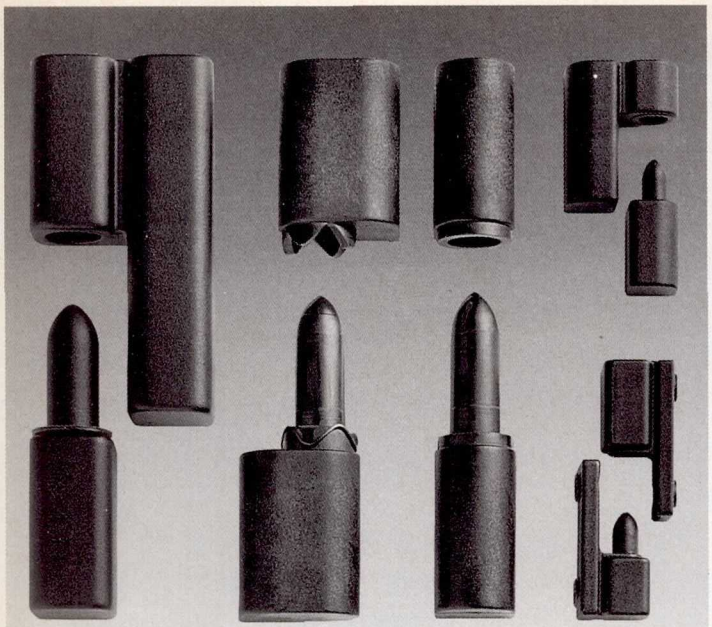

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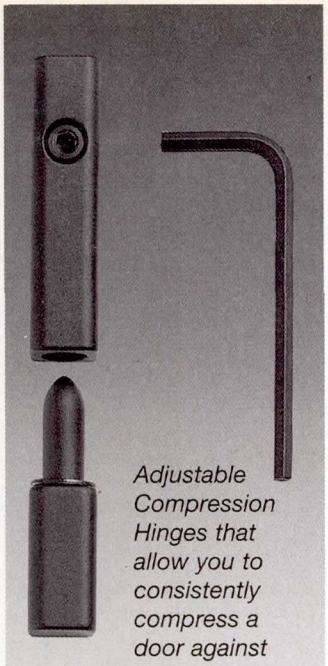

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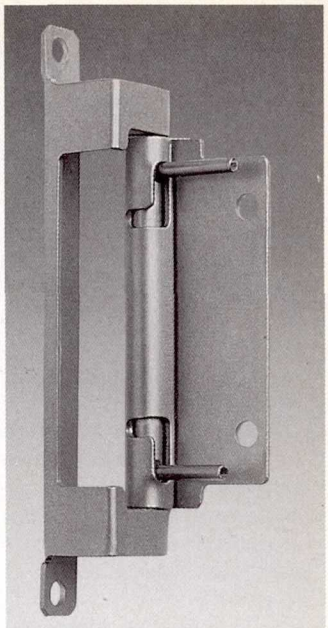
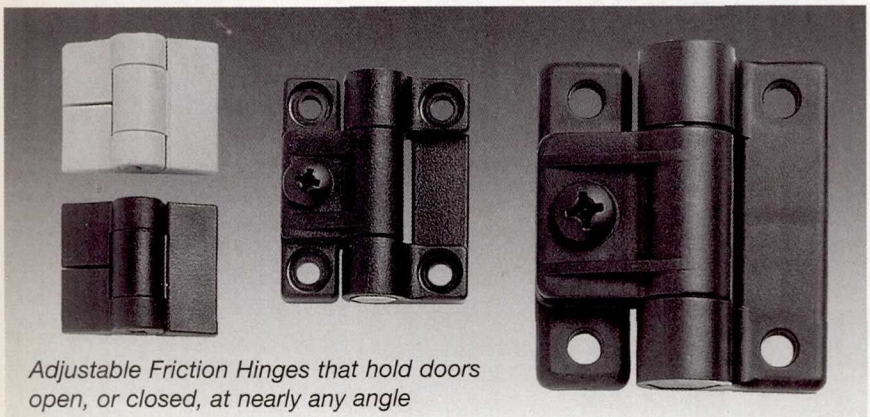


Hinges for concealed mounting



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Calculating 3-D Crack-Opening Behavior of a Fatigue Crack

Predicted values of fatigue-crack-opening loads are close to experimental values.

Langley Research Center, Hampton, Virginia

A method for calculating through-the-thickness, three-dimensional (3-D) crack-opening behavior in standard fatigue-crack-growth test specimens has been devised. The method involves determination of crack-opening loads from crack-propagation data and finite-element analyses.

The techniques used heretofore to obtain through-the-thickness fatigue-crack-opening behaviors are complex, time-consuming, and entail considerable investment in equipment. The present method was developed in an effort to provide simpler means for obtaining fatigue-crack-opening behavior loads.

The through-the-thickness variations in the crack-opening stress-intensity factors are calculated from a combination of experimental data and finite-element computations. In this method, one considers (1) the variation in the rate of crack growth along a crack front, (2) the relationship between the rate of crack growth and the effective stress intensity factor, and (3) the variation in the three-

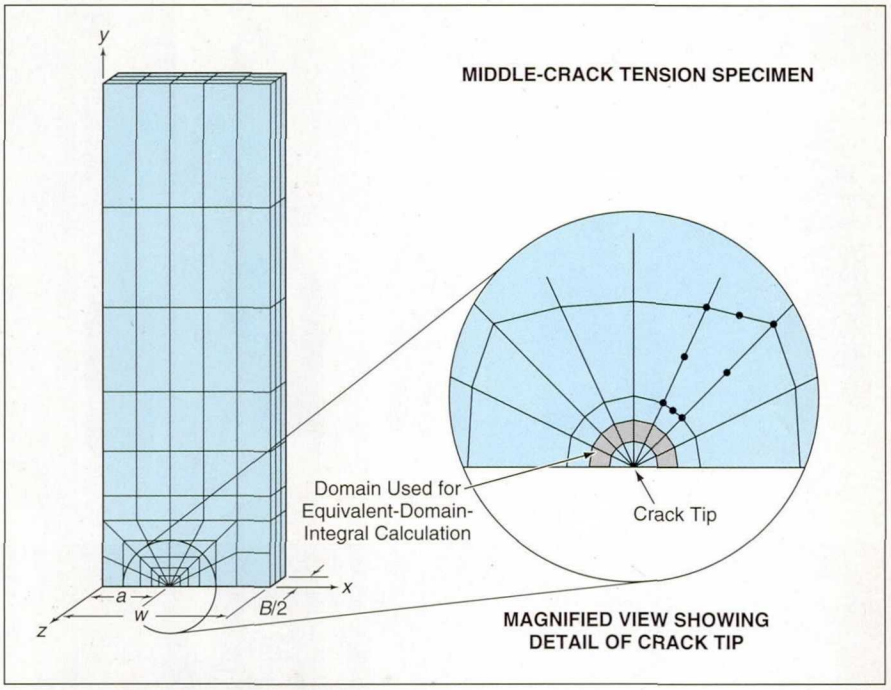

Figure 1. A **Three-Dimensional Finite-Element Model** is used to calculate crack-front stress-intensity factors.

dimensional stress-intensity factor along the crack front.

The variation in the rate of crack growth is obtained by comparison of experimentally observed changes in the crack front. The relationship between the rate of crack growth and the effective stress-intensity factor is estimated from data obtained in high-stress-ratio, constant-load-amplitude fatigue-crack-growth tests. The variation in the three-dimensional stress-intensity factor along the crack front is computed as a function of the stress ratio and a normalized crack-opening load (among other quantities) by use of a mathematical model developed previously. The through-the-thickness variation of the effective stress-intensity factor for a specific crack observed experimentally is computed by use of the three-dimensional equivalent-domain-integral method in conjunction with a finite-element mathematical model of the specimen and crack (see Figure 1).

Figure 2 presents examples of through-the-thickness variations of normalized fatigue-crack-opening stress-intensity factors as calculated by the method and as determined experimentally by use of fatigue striations, near-tip strain gauges, remote (back-face) strain gauges, and remote displacement gauges. In both examples, the values calculated appear in reasonable agreement with the experimental values.

This work was done by J. C. Newman, Jr., of **Langley Research Center,** *D. S. Dawicke and K. N. Shivakumar of Analytical Services and Materials, Inc., and A. F. Grandt, Jr., of Purdue University. For further information,* ***write in 199*** *on the TSP Request Card. LAR-14598*

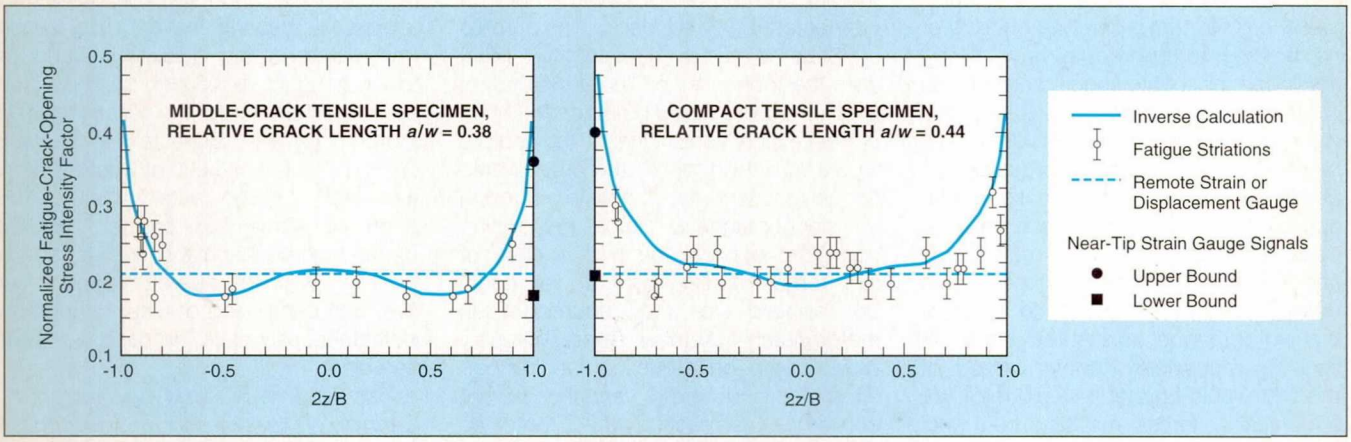

Figure 2. **Theoretical and Experimental Values** of through-the-thickness variations of fatigue-crack-opening stress-intensity factors for two specimen types are shown.

Power Tool Would Require Little Bracing Torque

Torque would be reacted internally.

Lyndon B. Johnson Space Center, Houston, Texas

A proposed rotary power tool would exert the required torque on the workpiece (e.g., to turn a drill bit), but little or no bracing torque would have to be applied to the tool to keep it from turning in the opposite direction. Instead, the working torque would be neutralized by a nearly equal and opposite torque generated within the tool. In comparison with a conventional rotary power tool, the proposed tool could be used more easily underwater, on slippery surfaces, or in other environments in which external bracing of the tool against rotation is difficult or impossible. Another benefit of this tool would be that it would minimize armbreaking forces resulting from tool binding (i.e., a drill bit suddenly becoming locked up).

The tool would be based on the reaction-wheel, or countertorque, concept. The tool drive would contain electric motors, the frames of which would be connected back to back. The frames could be isolated (with respect to torque) from the tool housing. The armatures of the two motors would be made to turn in opposite directions. One of the motors would turn the tool bit; the other would turn a reaction wheel, possibly through an electromagnetic clutch (depending upon the application). In the case of high-torque applications, power could be applied to the countertorque motor/clutch assembly. Control circuitry would sense the torque load on the tool-bit motor and would vary the current applied to the reaction-wheel motor so that an equal but opposite torque would be applied to the reaction wheel.

When the tool-bit motor is stripped–upon connection of drilling, for example–the kinetic energy accumulated in the reaction wheel and its motor to coast to a stop via bearing friction. The torque transmitted to the operator's hand or tool-holding jig via bearing friction would be low. Alternatively, the reaction-wheel motor could be connected to a static load (in effect, a brake) that would absorb the kinetic energy faster, albeit at the price of somewhat greater residual torque that would have to be reacted via the tool bit or the operator's hand--but over a longer period of time, rather than instantaneously as in the case of a sudden bind.

This work was done by Joseph H. Canniff of Lockheed Engineering & Sciences Co. for **Johnson Space Center.** *For further information,* ***write in 93*** *on the TSP Request Card.*
MSC-22153

Heat-Transfer Head for Stirling-Cycle Machine

Two heat acceptors are replaced by the single heat-transfer head.

Lewis Research Center, Cleveland, Ohio

A new common heat-transfer head for the two cylinders of an opposed-cylinder Stirling-cycle machine performs the function formerly performed by two heat acceptors–one for each cycle. (The heat acceptors are heat exchangers that are described more fully below.) The heat-transfer head was invented to simplify the structure of the machine and to increase the efficiency of operation by (1) reducing the resistance to the flow of the working gas and/or (2) increasing the transfer of heat to or from the working gas during its flow between the compression and expansion spaces of the machine.

The Stirling-cycle machine can be a heat engine or a heat pump. The upper part of the figure gives a simplified view of one cylinder of such a machine in an older configuration. A displacer (essentially a piston) slides axially back and forth past a clearance seal in the cylinder, interacting with the working gas in the compression and expansion spaces. As the working gas flows between the compression and expansion spaces of the cylinder, it passed through three heat exchangers: the heat acceptor, the regenerator, and the heat rejector. Within the heat acceptor, the working gas exchanges substantial amounts of heat with an external source. Typically, the heat acceptor contains elongated, U-shaped tubes or other heat-transfer passages in which the direction of flow of the working gas must be turned 180°; this turning increases the resistance to flow.

The lower part of the figure gives a simplified view of an opposed-piston Stirling-cycle machine with a common heat-transfer head. In this machine, the working gas is not made to flow between the compression and expansion spaces of the same cylinder, and it is not necessary to turn the flow 180° in a heat exchanger. Instead, the common heat-transfer head is configured to take advantage of the opposed motion of the displacers (simultaneous compression or expansion in both cylinders). The gas flows between the expansion space of one cylinder and the compression space of the other cylinder along a path that includes crossflow heater tubes or passages in the heat-transfer head.

In comparison with the U-shaped heater tubes or passages in a heat acceptor, the crossflow heater tubes or passages are more nearly straight, with consequent lower resistance to flow. Compared to another opposed-cylinder design that uses straight tubes for the heat acceptors, the crossflow arrangement reduces the dead volume in the expansion space, yielding improved specific power. Although the crossflow paths are shown as simple tubes in the figure, the passages in a practical and efficient design would more likely be incorporated into and between integral

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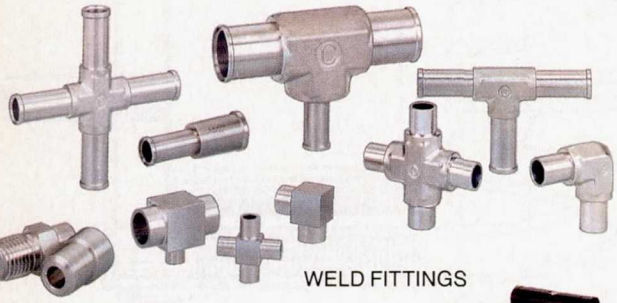

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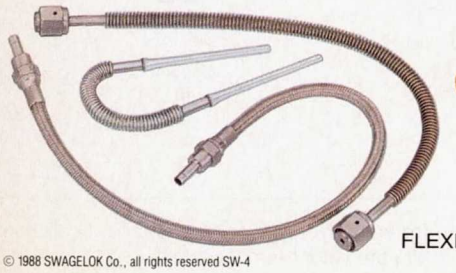

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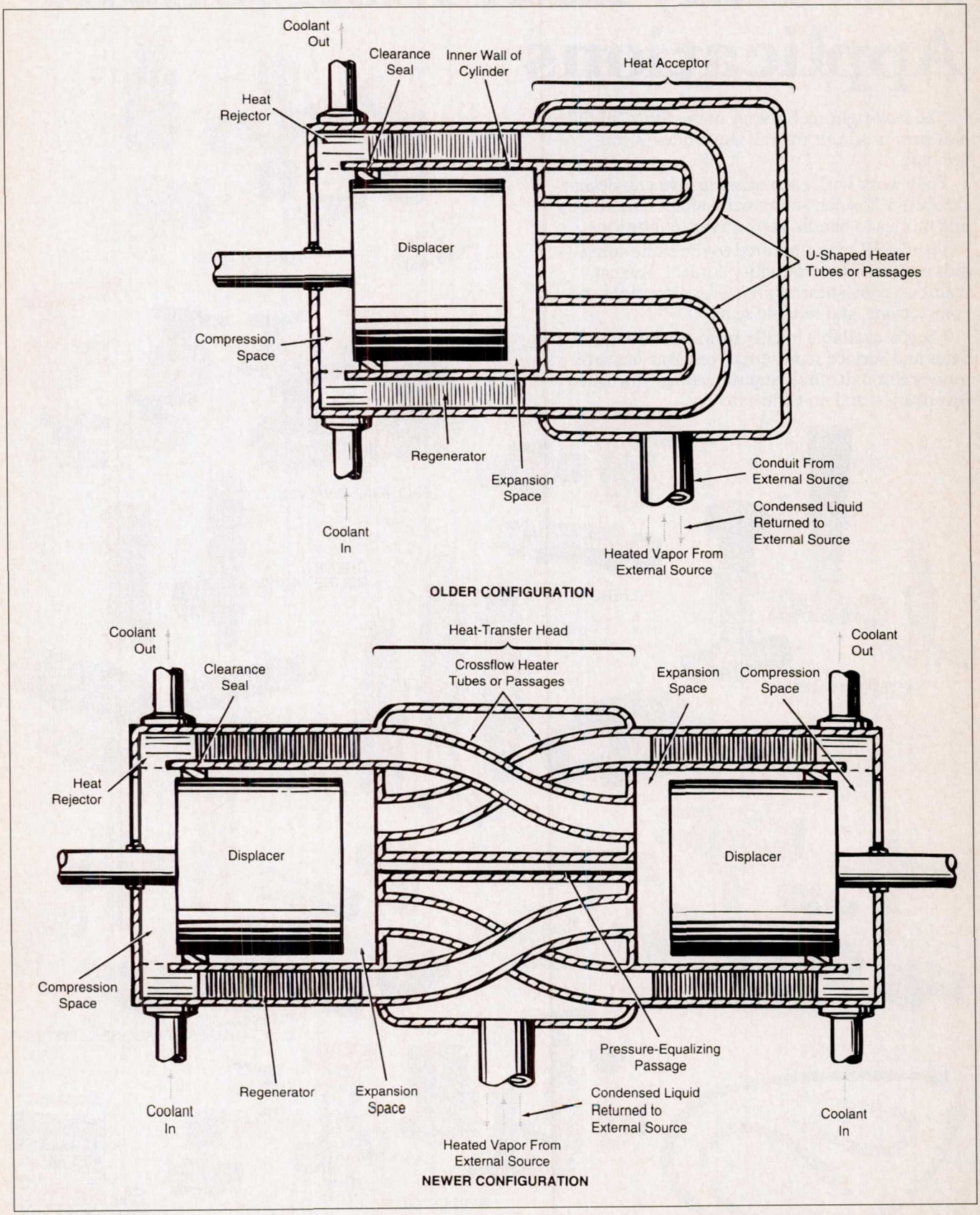
structural ribs, and the rubs and passages would be optimized with respect to considerations of flow, transfer of heat, and the size and shape of the cylinders.

This work was done by Stuart G. Emigh, Gregory A. Lehmann, and Jack E. Noble of Stirling Technology Co. for the Power Technology Division of **Lewis Research Center.** *For further information,* ***write in 52*** *on the TSP Request Card. LEW-15270.*



The **Heat-Transfer Head** is common to both cylinders and replaces the heat acceptors (one for each cylinder) of the older configuration. The heat-transfer head offers less resistance to the flows of heat and of working gas than do the previous heat acceptors.

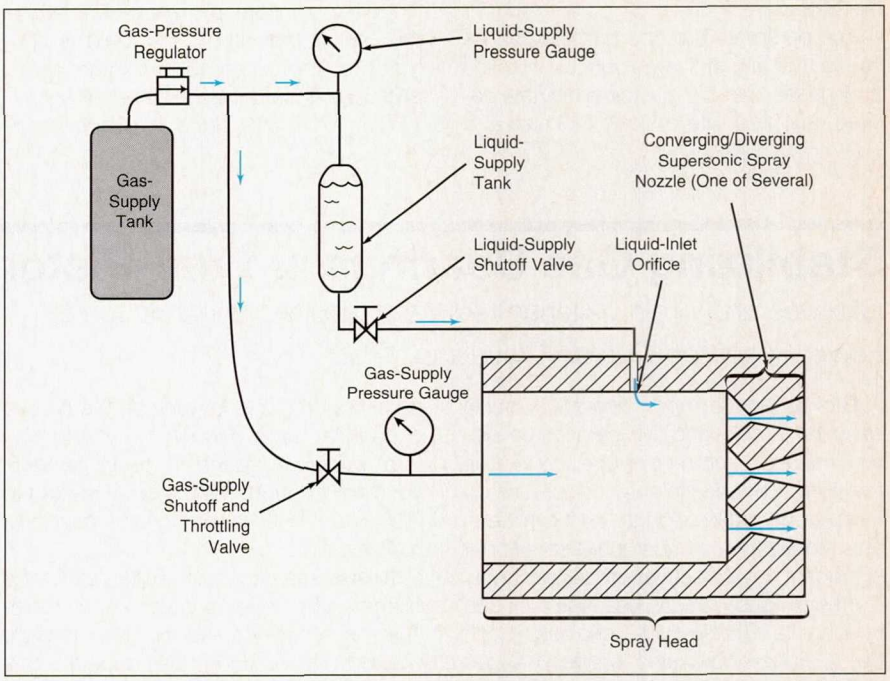
Supersonic-Spray Cleaner

A reduced amount of liquid is needed.

John F. Kennedy Space Center, Florida

A spraying system for cleaning mechanical components uses less liquid than does a typical older spray cleaner of similar capability, and it operates at pressures significantly lower than those of conventional pressure washers. The lower consumption of liquid helps alleviate the problem of safe disposal. The liquid currently being used at KSC is water. This system was designed to replace the chlorofluorocarbon (CFC) solvent-based cleaning and cleanliness verification methods. (CFC's contribute to the depletion of ozone from the stratosphere.)

The system imparts a supersonic velocity to a stream of liquid, giving the liquid droplets sufficient kinetic energy to dislodge contaminants and carry them off. The system consists of a spray head containing supersonic converging/diverging nozzles, a source of gas at regulated pressure, a pressurized liquid tank, and various hoses, fittings, valves, and gauges (see figure). The gas flows through a throttling valve to the spray head. The liquid is injected into the flow-



The **Liquid/Gas Mixture Is Accelerated in the Nozzles** to supersonic velocity. The gas serves as a pressurizing agent for the liquid tank and as a transport medium for the liquid.

ing gas through an orifice in the spray head just upstream of the nozzles. The liquid/gas mixture enters the nozzles, wherein the flow accelerates it to supersonic speed. The supersonic flow from the nozzle is directed at the part to be cleaned.

The parameters of the nozzles can be set so that any of a large variety of liquids and gases can be combined in the desired ratio and rate of flow. The size and number of nozzles can be varied so that the system can be built in configurations that range from small hand-held spray heads to large multinozzle cleaners.

The system can also be used to verify that a part has been adequately cleaned. Runoff liquid from the spray directed at the part is collected. The liquid is analyzed for the presence of contaminants, and the part is recleaned if necessary.

This work was done by Raoul E. B. Caimi, Feng-Nan Lin, and Eric A. Thaxton of **Kennedy Space Center**. *For further information,* ***write in 82*** *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, Kennedy Space Center [see page 20]. Refer to KSC-11641.

Stabilizing Gas Bearings in Free-Piston Machines

Grooves and drain galleries reduce undesired dynamic loads.

Lewis Research Center, Cleveland, Ohio

Gas bearings and clearance seals between pistons and cylinders in free-piston machines can be designed to reduce undesired dynamic forces and torques on the pistons, gas bearings, and cylinders. This stabilization can be achieved without significant adverse effect on performance.

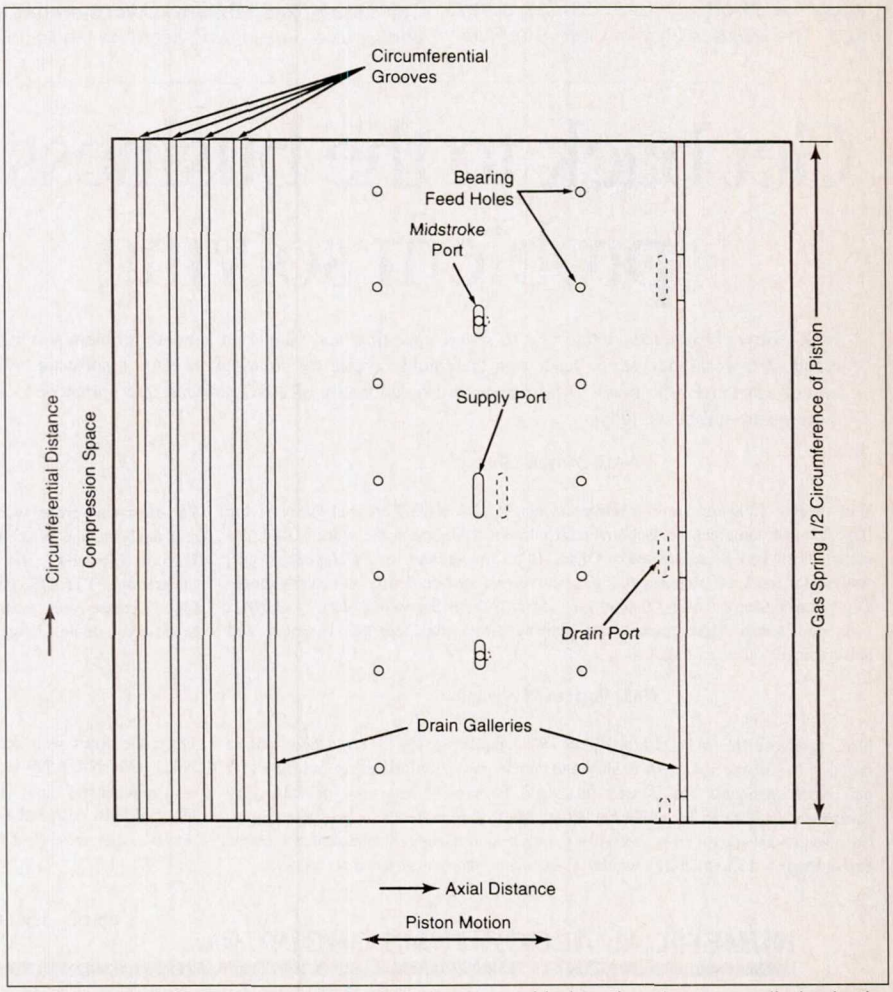
Free pistons with gas bearings are used in long-life Stirling-cycle engines. Each free piston reciprocates between a gas spring at one end and the working gas of the engine at the other end. The gas spring provides reactive flow of power (in mechanical analogy to reactive flow of power in electrical capacitors and inductors), alternately accelerating and decelerating the piston. The clearance seal isolates the pressure waves in the gas spring from the pressure waves in the working space. Because these pressure waves are not in phase with each other, they give rise to time-varying gradients of pressure across and along the seal. The gradients give rise to leakage (with consequent loss of power) and to unwanted time-varying forces and torques.

The undesired dynamic loads are proportional to the length of the seal, while the leakage power loss is inversely proportional to the length. Therefore, in prior designs, it was necessary to sacrifice efficiency to reduce undesired dynamic loads, or vice versa. The improved design provides stabilization without significant reduction in the length of the seal and, therefore, without significant increase in leakage and the consequent reduction of efficiency.

One principal feature of the improved design is the incorporation of circumferential grooves into either the inner wall of the cylinder or the mating surface of the piston (see figure). The optimum number and dimensions of the grooves depend on other geometric parameters of the gas bearings/seals, the frequency of reciprocation, and the magnitude of the pressure gradient. In general, the groove should be large enough to ensure uniform pressure around its circumference, yet small enough that the time needed to fill it is a small fraction of the period of reciprocation.

To suppress angular oscillations of the piston and cylinder relative to each other, it is necessary to isolate the pressure waves in the working gas and in the gas spring from the gas bearing. For this purpose, drain galleries are provided. These galleries connect some of the grooves with a mean-pressure volume in the engine.

This work was done by Manmohan Dhar of Mechanical Technology, Inc., for **Lewis Research Center.** *For further information,* ***write in 27*** *on the TSP Request Card. LEW-15122*



Circumferential Grooves and Drain Galleries are added to the piston or cylinder in the improved design.

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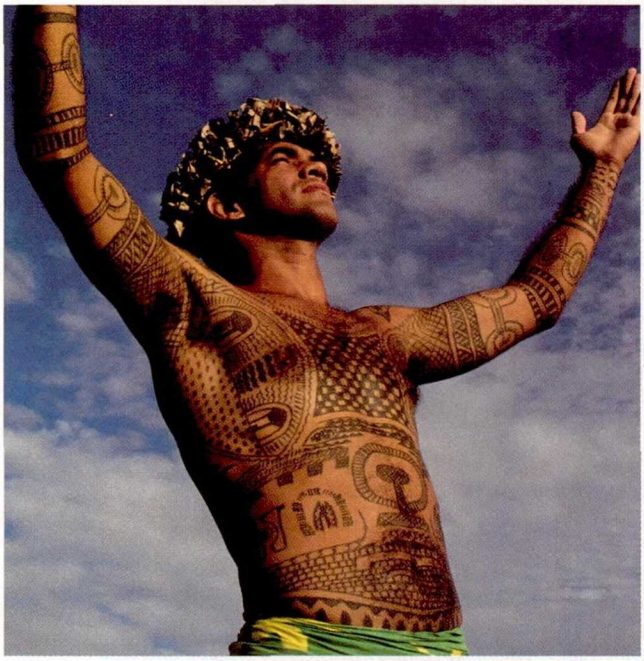

Photo by Claude Coirault, Tahiti.

Laser marking technology is making its indelible mark on thousands of applications worldwide—from intricate artwork on sporting goods, to miniscule part numbers on semiconductors.

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* Patent Pending

For More Information Write In No. 538

Improved Screw-Thread Lock

A hammer blow activates the locking.

NASA's Jet Propulsion Laboratory, Pasadena, California

An improved screw-thread lock can be engaged after the screw has been tightened in a nut or other mating threaded part. Unlike some other screw-thread locks, this one does not resist engagement of the screw with the mating threaded part without resistance from a mating part. In addition, this device does not release contaminating material during tightening of the screw, unlike some other screw thread locks that are sheared during tightening and thus release contaminating particles.

The improved screw-thread lock (see figure) includes a pellet of soft material that is encased in the screw and retained by a pin (see figure). The pin protrudes from the screw head. A hammer blow to the pin compresses the pellet and extrudes it through a hole into a slot on the shank of the screw, where the deformed pellet material locks the mating threads together. The pellet and slot can be positioned to lock the screw thread in a threaded hole or in a nut.

This work was done by Malcolm MacMartin of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 87*** *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

William T. Callaghan, Manager
Technology Commercialization
(M/S 79-23)
Jet Propulsion Laboratory
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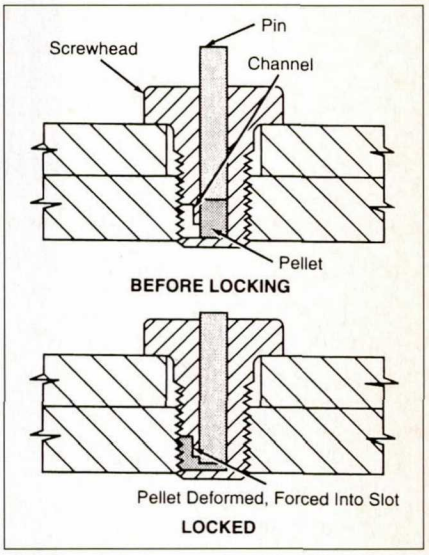
Refer to NPO-19010, volume and number of this NASA Tech Briefs issue, and the page number.



A **Hammer Blow on the Pin** extrudes the pellet into a slot, where it engages the threads in a threaded hole or in a nut.

Screen-Cage Ion Plating of Silver on Polycrystalline Alumina

The silver adheres tenaciously and reduces friction.

Lewis Research Center, Cleveland, Ohio

A screen-cage ion-plating (SCIP) process applies silver films to complexly shaped substrates of polycrystalline alumina. The SCIP process is a modified version of an older direct ion-plating process that yields adherent coats on electrically conductive materials, but not on electrically nonconductive materials like alumina and other ceramics. The success of SCIP holds promise for applying lubricating soft metallic films to high-temperature ceramic components of advanced combustion engines to reduce friction and wear. Other potential uses for SCIP include coating substrates with metal for protection against corrosion, depositing electrical conductors on dielectric substrates, making optically reflective or electrically or thermally conductive surface layers, and applying decorative metal coats to ceramic trophies or sculptures.

The effectiveness of ion plating is attributed to its ability to provide a high-energy flux of ions and energetic neutral atoms that contribute to the adherence and desirable microstructure of the deposited film. An important additional advantage of this technique is known in the industry as "throwing power" — the ability to deposit a substantial amount of the anode material all over the substrate, including places that are not on direct lines of sight from the anode.

The older ion-plating process involves a diode configuration in which the substrate to be coated is connected as the cathode in a high-voltage dc circuit, while an evaporative source of material to be deposited is connected as the anode. Prior to deposition, the deposition chamber is evacuated, then backfilled with argon. Typical deposition conditions are: potential between –2 and –5 kV applied to the substrate, argon pressure between 10 and 20 mtorr (between 1.3 and 2.7 Pa), and current density between 0.2 and 0.5 mA/cm^2. Because the substrate must be conductive to act as the cathode, this process does not work for nonconductive substrates.

The present screen-cage version of the ion-plating process also involves a diode configuration, but in this case, the substrate (alumina or another electrically nonconductive material) is surrounded by a 20-mesh silver screen cage, to which the negative potential is applied. The cage functions as both an electronic grid and as part of a cathode. A combination of effects maintains zero electric field between the screen cage and the substrate: Ions pass through the grid to the substrate, while secondary electrons emitted by the grid neutralize the positive charge that the incident ions contribute to the surface of the substrate. The gap between the screen

Mathematics and Information Sciences

Reducing Truncation Error in Integer Processing

Signs of contributing errors are changed on alternate occurrences.

NASA's Jet Propulsion Laboratory, Pasadena, California

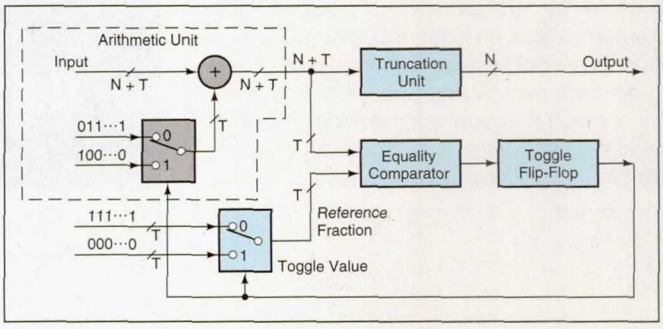
An improved method of rounding off (that is, truncation of least-significant bits) in integer processing of data has been devised. The method provides for the reduction, to an extremely low value, of the numerical bias that would otherwise be generated by accumulation of truncation errors from many arithmetic operations. The method was devised for use in integer signal processing, in which rescaling and truncation are usually performed to reduce the number of bits, which typically builds up in a sequence of operations. The essence of this method is to alternate the direction of roundoff (+, then –) on alternate occurrences of truncated values that contribute to the bias.

As an example, a 2's complement 5-bit integer is commonly reduced to a 3-bit integer by first adding the binary number 10 and truncating the last 2 bits. The possible errors in this truncation are –1/4, 0, and +1/2 relative to the retained integers. These truncation errors average to zero when a properly distributed population of integers is processed and combined, except for the error of –1/2. For example, errors of +1/4 and –1/4 cancel each other if the distribution of processed errors is symmetrical about zero, but errors of –1/2 cannot be combined with errors of +1/2 to average out to zero because there are no errors of +1/2 in this scheme. Instead, errors of –1/2 combine to contribute a bias of –Nb/2, where Nb is the number of occurrences of –1/2 in the processed population.

In the improved method, digital logic checks every input value to determine whether it can cause a truncation error of –1/2. Each time it encounters such a value, it changes the direction of roundoff to opposite the direction of roundoff on the most recent previous occurrence of such a value. Thus, errors of –1/2 become –1/2, +1/2, –1/2, and so forth. This forces the overall bias to be either 0 or –1/2, depending on whether the string contains an even or odd number of –1/2's. Thus, this method reduces the cumulative truncation error from Nb/2 to 0 or 1/2. Since Nb can be a very large number, this reduction can be enormous. Further, when it is known that Nb is odd, the bias of 1/2 will be known and can be removed.

In one of several possible implementations of the method (see figure), the current toggle value determines whether an increment of 011···1 or 100···0 is to be added to the current incoming integer which has N most significant bits and T least significant bits (LSBs). After the addition, the fractional part, the T LSBs, is compared with either 111···1 or 000···0, again according to the current toggle value to determine whether the incoming fractional part had been 100···0. If it was, the toggle is flipped and the alternate increment is applied to all subsequent integers until the next time that the LSBs are equal to 100···0. With this scheme, the –1/2's are alternately rounded up and down, while all other fractional values are rounded in the conventional manner.

This work was done by J. Brooks Thomas, Jeffrey B. Berner, and J. Scott Graham of **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 291*** *on the TSP Request Card.*
NPO-18968



A **Truncation Circuit** that implements the improved method includes a comparator that determines whether the fractional part, *T* bits, of the incoming number equals 100···0. If it does, the toggle flip-flop resets the toggle value to the alternate position.

Computer-Assisted Search of Large Textual Data Bases

Retrieved paragraphs are ranked according to measures based on semantics and relevance.

John F. Kennedy Space Center, Florida

"QA" denotes a high-speed computer system for searching diverse collections of documents including (but not limited to) technical reference manuals, legal documents, medical documents, news releases, and patents. QA incorporates both previously available and emerging information-retrieval technology to help a user intelligently and rapidly locate infomation found in large textual data bases. This technology includes (1) provision for inquiries in natural language; (2) statistical ranking of retrieved information; (3) an artificial-intelligence implementation of semantics, in which "surface level" knowledge found in text is used to improve the ranking of retrieved information; and (4) relevance feedback, in which the user's judgements of the relevance of some retrieved documents are used automatically to modify the search for further information.

A typical commercially available text-retrieval system uses a Boolean combination of key words supplied by the user to retrieve documents. In general, such a system does not rank the retrieved documents in any order of importance, so that the user needs to examine every retrieved document: this is a serious shortcoming when large collections of documents are searched. QA, however, does perform such a ranking.

cage and the surface of the substrate is critical and generally should be kept small (of the order of 6 mm). If the gap is too large, a hollow-cathode discharge occurs and causes excessive heating.

In one experiment to demonstrate the process, a film of silver 2 to 3 μm thick was deposited on an alumina substrate under the following conditions: effective cathode area 48 cm^2, potential of –3 kV applied to the screen cage, and current 80 mA. Because of the high throwing power, all exposed alu-

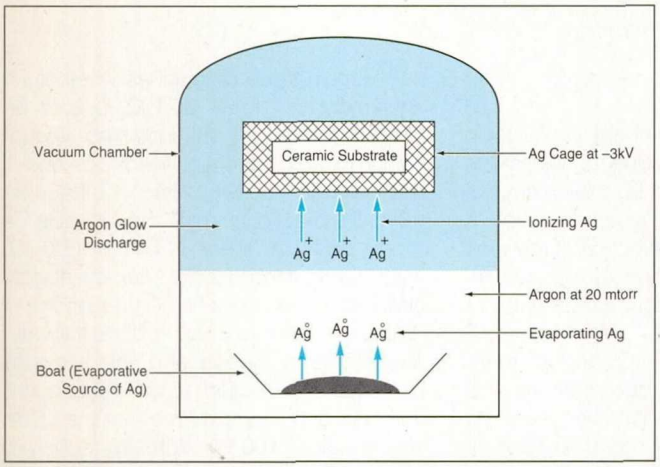


Figure 1. **Screen-Cage Ion Plating** is a cost-effective technique that offers high throwing power for deposition of adherent metal films on ceramic substrates.

mina surfaces were coated with silver. Even the surface facing away from the source was coated to a thickness about 1/3 that of the surface facing the source.

To assess the adherence and the lubricating ability of films deposited by this process, scratch tests and scratch-test measurements of friction were performed with a commercial scratch tester with a diamond stylus on both uncoated and silver-coated alumina surfaces. Subsequent analyses of the scratches by scanning electron microscopy and x-ray energy-dispersive spectrometry showed that significant amounts of silver remained, even where high stylus loads gave rise to severe crack patterns in the alumina. Coefficients of friction were lower

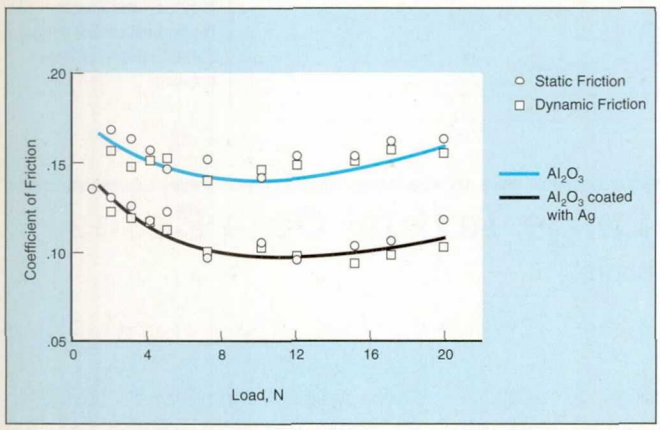


Figure 2. **Coefficients of Friction** of silver-coated and uncoated alumina surfaces were measured in constant-load scratch tests.

on the alumina-coated surfaces, as shown in Figure 2.

This work was done by Talivaldis Spalvins, Harold E. Sliney, and Daniel L. Deadmore of **Lewis Research Center.** *For further information,* ***write in 236*** *on the TSP Request Card.*
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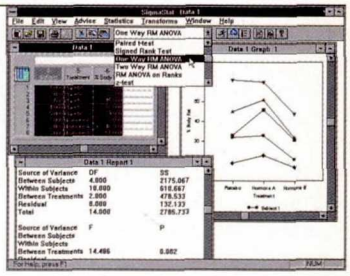

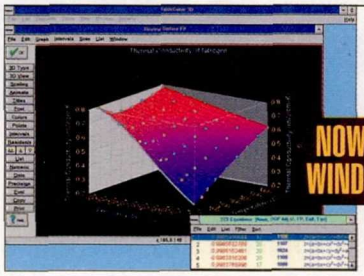

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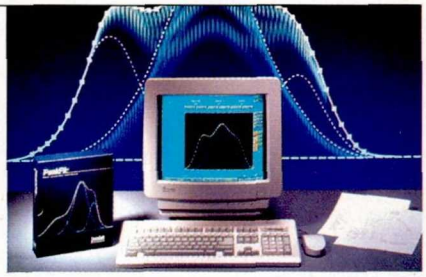

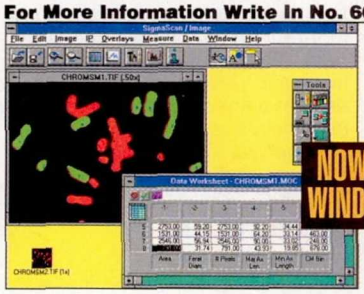

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The natural-language-inquiry and statistical-ranking features are not unique to QA but they are rare; they are available in only three commercial text-retrieval systems in the United States. The semantic and relevance-feedback features are not available in a commercial text-retrieval system and have been shown to yield a substantial improvement in the statistical ranking of retrieved information.

The semantic feature involves mathematical modeling on the basis of two concepts useful in talking informally about the real world: the concept of entities (objects in the real world) and the concept of relationships among entities (actions in the real world). Both entities and relationships have attributes. There are basic or surface-level attributes for entities in the real world. Examples of surface-level attributes of entities include size, color, and position. Words for these properties are prevalent in natural language. In linguistic research, the basic properties of relationships are called, variously, "thematic roles," "semantic roles," and "case roles." Thematic roles are prevalent in natural language; they reveal how sentence phrases and clauses are semantically related to the verbs in a sentence.

The primary goal of the QA System has been to detect thematic and attribute information (see table) contained in natural-language queries and documents. When such information is present, QA uses it to help find the paragraph most relevant to a query. The use of this information involves quantification of the relevance of the paragraph in terms of a similarity measure. Statistical weights used in computing the similarity measure are related to the frequency with which the words in the query trigger thematic roles and/or attributes as found in the Semantic Lexicon.

The relevance-feedback feature overcomes one of the deficiencies of commercial information-retrieval systems; namely that often, a system of this type retrieves only a few relevant documents if the search process is based solely on the initial query. This indicates a need to modify the query to improve performance; thus, it is customary to search the relevant documents iteratively in a sequence of partial searches. In other words, the results of earlier searches are used as feedback information to improve the results of later searches. In QA, this feedback concept is formalized and automated. QA asks the user to judge the relevance of some of the retrieved documents. The resulting data on relevance are used to formulate an improved query and recalculate the similarities between documents and the query in order to re-rank the documents.

This work was done by James R. Driscoll of the University of Central Florida for **Kennedy Space Center.** *For further information,* ***write in 22*** *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

James R. Driscoll
University of Central Florida
Computer Science
P.O. Box 162362
Orlando, FL 32816–0450

Refer to KSC-11707, volume and number of this NASA Tech Briefs issue, and the page number.

Thematic-Role Categories	Attribute Categories
Accompaniment	Color
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Beneficiary	Form
Cause	Gender
Condition	General Dimensions
Comparison	Linear Dimensions
Conveyance	Motion Conjoined with Force
Degree	Motion in General
Destination	Motion with Reference to Direction
Duration	Order
Goal	Physical Properties
Instrument	Position
Location/Space	State
Manner	Temperature
Means	Use
Purpose	Variation
Range	
Result	
Source	
Time	

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

Computing Microwave Force via Boltzmann-Ehrenfest Principle

A report describes the first application of the Boltzmann-Ehrenfest principle of adiabatic invariance to prediction of the restoring force on a dielectric sphere levitated in a microwave resonant cavity in the absence of gravitation.

The report describes an experiment in which a microbalance was used to measure the restoring force of an alumina sphere supported on a thin quartz rod in a single-resonant-mode microwave field in a cylindrical cavity. The restoring force computed as a function of position by use of the equation agreed very well with the measured force.

This work was done by Colleen C. McDonough, Martin B. Barmatz, and Henry W. Jackson of Caltech for **NASA's Jet Propulsion Laboratory.** *To obtain a copy of the report, "Application of the Boltzmann-Ehrenfest Principle to Containerless Microwave Processing in Microgravity,"* ***write in 88*** *on the TSP Request Card. NPO-19220*

Machinery

Magnetic Bearings for Turbopumps

A report presents a study of the feasibility of magnetic bearings in turbopumps. The liquid-oxygen turbopump in the space shuttle main engine was selected for the study. Other potential applications include manned and unmanned spacecraft, gas turbines for commercial and military aircraft, turbomachinery for petrochemical and gas operations, suspension systems for precise machinery, and precise pointing and tracking systems. In the past, magnetic bearings and their controls have been too large, heavy, and power consuming to be considered seriously for most applications. That view has now been changed by technological advances in permanent-magnet and ferromagnetic materials, rotor-position sensors, and compact electronic circuits for controlling electromagnets.In the study, candidate magnetic-bearing systems were evaluated on the basis of the need to minimize size, weight, and power. The preferred approach was found to involve a homopolar, permanent-magnet bias, electromagnet-control magnetic bearing.

This work was done by Crawford R. Meeks and Antonio J. Mendez of Avcon–Advanced Controls Technology, Inc., for **Marshall Space Flight Center.** *To obtain a copy of the report, "Innovative Magnetic Suspension Technology for Space Shuttle Main Engine Turbopumps,"* ***write in 42*** *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 [see page 20]. Refer to MFS-27304.

Finger-Circumference-Measuring Device

An easy-to-use device provides data on volumetric changes.

Lyndon B. Johnson Space Center, Houston, Texas

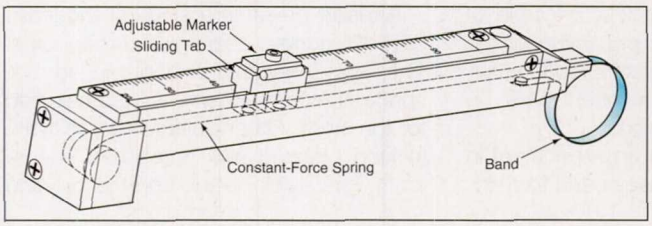
An easy-to-use device quickly measures the circumference of a finger (including the thumb) on a human hand. The device was designed to facilitate measurements at various points along the fingers to obtain data for studies of volumetric changes of the fingers in microgravity. It could also be used in normal Earth gravity; for example, in studies of growth and in assessment of diseases like arthritis.

The device includes a polytetrafluoroethylene band 1/8 in. (about 3 mm) wide, bent into a loop and attached to a tab that slides on a scale graduated in millimeters (see figure). The sliding tab is preloaded with a constant-force tension spring, which pulls the tab toward closure of the loop. Holding the device with either hand, the user pushes the sliding tab to expand against the spring force to expand the loop, then slips the band over a finger and holds it at a point of interest such as a joint or the midlength position along a phalange. The user then releases the sliding tab, allowing the spring to pull the band snugly around the finger. The position of the sliding tab on the scale indicates the circumference of the finger in millimeters.

The spring is made of stainless steel and exerts a constant force of 3 oz (about 0.8 N) on the band. The spring is wound on a polytetrafluoroethylene spool at the end of the scale opposite the band. The sliding tab is made of DelrinTM acetal polymer. The materials of each part were selected for resistance to wear, low friction, nonflammability, flexibility, and/or elasticity, as applicable. The device weighs only 4 oz (has a mass of about 110 grams).

For calibration, the band is tightened around a rod machined to a known diameter or circumference. The marker on the sliding tab is then adjusted to obtain the correct reading.

This work was done by Suy Le of **Johnson Space Center**. *For further information,* ***write in 160*** *on the TSP Request Card. MSC-22332*



This Device Measures Circumference of a finger or other round object placed in the loop. Measurements are accurate to within ±1 mm in a range of 25 to 100 mm.

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National Instruments

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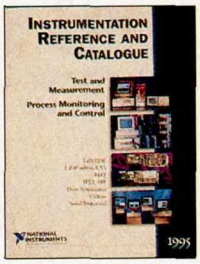

FREE INSTRUMENTATION REFERENCE AND CATALOG

National Instruments is providing a 1995 catalog detailing computer-based data acquisition, instrument control and data analysis products. Includes information on exciting new products and technologies such as Plug and Play boards, Power Macintosh software, Test Executives, SPC and SQL add-ons, HP-UX instrument control, PCMCIA interfaces and VXI*plug&play*. There is also information on customer education classes. Tel: 512-794-0100; 800-433-3488 (US and Canada); Fax: 512-794-8411.

National Instruments

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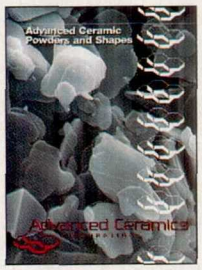


NONOXIDE CERAMIC POWDERS

The properties of boron nitride, titanium diboride and other nonoxide ceramic powders are described in a full-color brochure. Also included is information on various electronic and metallurgical applications, and the company's manufacturing, quality analysis and customer service capabilities. Tel: 800-822-4322; Fax: 216-529-3975.

Advanced Ceramics Corp.

For More Information Write In No. 302

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. 303

FREE ELECTRONIC HARDWARE CATALOG

Broadest selection of quality hardware for electronic assemblies. 350-page catalog includes a full range of standoffs, captive screws and nuts, chassis fasteners, handles, ferrules, spacers and washers. Special sections include: new/unusual products, metric information, and Mil-plating specifications. Full inventory, fast turnaround, samples. Accurate Screw Machine Co., Fairfield, NJ. Tel: 1-800-237-0013; Fax: 201-244-9177.

Accurate Screw Machine Co.

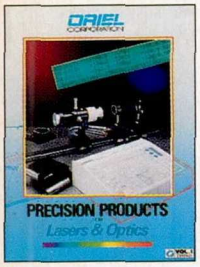
For More Information Write In No. 304

FERROFLUIDS FOR STEPPER MOTORS

FerroMotion brochure explains the unique advantages of adding ferrofluids in motion control applications. Exclusive technology increases positional accuracy, improves settling time, damps out vibration and midrange resonance, extends motor life in damp or corrosive environments. Small lots can be retrofitted or use viscous inertial dampers. 40 Simon Street, Nashua, NH 03061. Tel: 603-883-9800; Fax: 603-883-2308.

Ferrofluidics Corp.

For More Information Write In No. 305

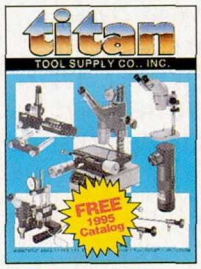


PRECISION PRODUCTS FOR LASERS & OPTICS

This 264 page product guide from describes micropositioning instruments and mounting hardware. It features the components that are an integral part of any light measuring system. Included are: optical tables, manual and motorized optical mounts, translators and rotators, fiber optic positioners, laser mounts and steerers, and many other products. For a **FREE** copy, contact Oriel today. Tel: 203-380-4376; Fax: 203-375-0851; E-mail 73163.1321@ compuserve.com.

Oriel Instruments

For More Information Write In No. 306



OPTICS FOR METEOROLOGY

New 1995 Catalog contains 120 pages of information and prices on toolmaker's microscopes, stereo microscopes, alignment microscopes, monocular zoom microscopes, microtelescopes, 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. Tel: 716-873-9907; Fax: 716-873-9998.

Titan Tool Supply Co., Inc.

For More Information Write In No. 307

MICRO-MINIATURE CONNECTORS

Omnetics Connector Corporation's new 24 page catalog contains data on a variety of microminiature .050" connector products based on the Omnetics' patented Flex Pin® design. Catalog contains photos, illustrations, features, data and performance specifications for two-piece, circular, socket, dual-row, cross-over and test-point connectors as well as a new Nano connector series featuring .025" spacing. Tel: 800-343-0025 or 612-572-0656; Fax: 612-572-3925.

Omnetics Connector Corp.

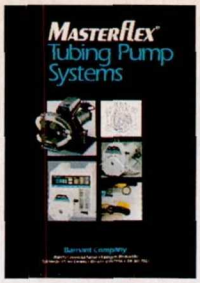
For More Information Write In No. 308

GEOMETRIC TOLERANCING STANDARD VIDEO

New Training video. 2 videos and 10 Comparison Charts describing over 40 revisions for the new ASME Y14.5M-199? Geometric Tolerancing standard. A quick, economical way to update your department. From the noted author and authority, Alex Krulikowski, the Doctor of Dimension'g. Dept. 50. Tel: 313-728-0909; Fax: 313-728-1260.

Effective Training, Inc.

For More Information Write In No. 310



NEW MASTER-FLEX® TUBING PUMP SYSTEMS FROM BARNANT COMPANY

Slurries, corrosives, adhesives, dyes, inks, chemicals are easily handled by our wide selection of non-contaminating pump systems as detailed in our new 64-page catalog. Systems are used in a wide range of applications from Industrial to Biotech for metering, blending, dispensing, proportioning, and sampling of chemicals, food, and drugs. A wide selection of chemically compatible, disposable tubing is available; most are autoclavable and NSF listed. Tel: 800-637-3739; Fax: 708-381-7053.

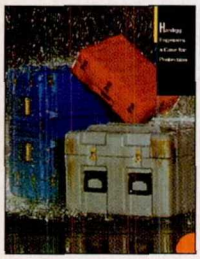
For More Information Write In No. 311

ELECTRONIC CLINOMETERS

These highly accurate devices, with no moving parts, provide a dc voltage output that is proportional to the angle of rotation from true vertical. The clinometer is compact, rugged, lightweight, and easily integrated into your system. Also described is a stand-alone Angular Measurement System for applications that require no external power or additional electronics. Tel: 602-582-3022; Fax: 602-582-1312.

Cline Labs, Inc.

For More Information Write In No. 312



Hardigg Cases offers over 225 standard rotationally molded transit cases, including a full line of 19" EIA rack mount cases, deck cases, and flangemount cases. Hardigg's expert engineering, manufacturing, and test facilities provide start to finish custom design capability. A complete list of standard cases allows for rapid delivery...as few as three working days! Take advantage of over forty years of experience...design a Hardigg case into your next project!

HARDIGG CASES

Tel: 1-800-JHARDIGG; Fax: 413-665-8062

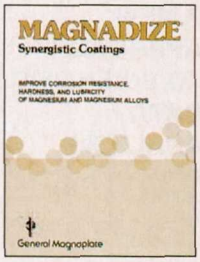
For More Information Write In No. 313

CATALOG DESCRIBES DATA ACQUISITION SYSTEMS

designed to meet exacting measurement requirements. Components feature fast throughput and highly accurate digitizers (overall 0.1% accuracy with 100 k to 200 Msps, and 32 Megapoints/channel). Automatic setups, analysis and touch screen controls in PC-based software add excellent user interfaces for high speed dynamic measurements in the physical and material sciences. Demo disks available on request. Tel: 608-221-7500; Fax: 608-221-7509.

Hi-Techniques, Inc.

For More Information Write In No. 314



COATINGS PROTECT MAGNESIUM PARTS AGAINST WEAR, CORROSION

MAGNADIZE® surface-enhancement coatings protect magnesium parts against wear, corrosive chemicals, moisture, and sticking. Magnaplate-applied coatings dramatically increase surface hardness and provide permanent dry lubricity. Available in four thicknesses, they also exhibit high dielectric strength and excellent release properties. Tel: 908-862-6200; Fax: 908-862-6110.

General Magnaplate Corp.

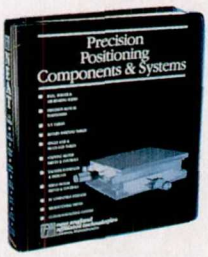
For More Information Write In No. 315

PIEZOELECTRIC CERAMICS

A 28-page brochure is a design guide for piezoelectric ceramics in a variety of shapes and sizes. Piezoelectric 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. 316



PRECISION POSITIONING AND MOTION CONTROL

155 page catalog covers NEAT's expanding line of Precision Positioning Components and Systems. Featured are single-axis, X-Y, multi-axis, rotary, high vacuum, and air bearing stages. NEAT provides complementary stepping and servo motor drives and controls, as well as turnkey solutions to automation, inspection, and production requirements. Stage travels range from 2-30+ in. with a repeatability of 1 µm, speeds to 80"/sec. and resolutions to 5 nm.

New England Affiliated Technologies

For More Information Write In No. 317

NEW! OPTICAL REFERENCE CATALOG

Edmund Scientific's free 236-page, color technical reference catalog features one of the largest selections of precision off-the-shelf optics and optical instruments, plus a complete line of components and accessories for both large volume OEM users as well as smaller research facilities and optical laboratories. Contains over 8,000 hard-to-find items, including a large selection of magnifiers, magnets, microscopes, telescopes, and "machine vision" products. Tel: 609-573-6259; Fax: 609-573-6233.

Edmund Scientific Co., Dept. 15B1, N954

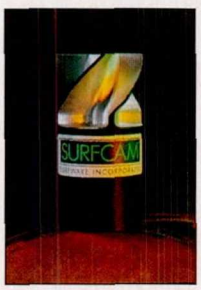
For More Information Write In No. 318

MECHANICAL TESTING CATALOG

MTS Direct is your one-stop source for mechanical testing equipment. Select from hundreds of products offered by leading companies, including: hardness testers, grips, data acquisition systems, and many others. Toll-free phone and fax ordering. Direct shipment. 30-day money-back guarantee. Free 150-page catalog. Tel: 800-925-0505.

MTS Systems Corporation

For More Information Write In No. 319



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 and Windows NT. Call 800-SURFWARE (800-787-3927).

Surfware Incorporated

For More Information Write In No. 320

New DA95 catalog offers 288 different "ready to use" precision acme and precision ball screw drives. Screw drives come totally assembled with machined ends, precision end bearings and feature standard NEMA motor mounts and couplings. Complete linear slides featuring precision rail assemblies are offered in seven sizes with strokes to 135 inches. CAD files are available to speed designs. Contact: Greg Traeger, Sales Manager, Ball Screws & Actuators, San Jose, CA 95136. Tel: 800-882-8857.

Ball Screws & Actuators

For More Information Write In No. 321

ZERO GAUSS CHAMBERS

Magnetic Shield Corporation offers its triple layered Zero Gauss Chambers, providing an internal work space having an extremely low magnetic field. Standard sizes and custom variations are available. Fully annealed CO-NETIC AA Alloy provides high attenuation factors required for research, equipment calibration and scientific applications. For more information, request catalog ZG-2B. Tel: 708-766-7800.

Magnetic Shield Corporation

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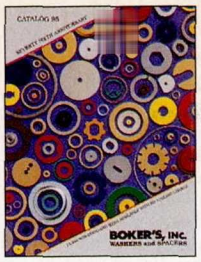

WASHERS AND SPACERS

NEW FOR '95! Boker's free 32-page Catalog 95 offers 12,000 non-standard sizes with no tooling charges. Outside diameters of 0.080" to 2.631", a wide variety of inside diameters and thicknesses, and 2,000 material variations create millions of possibilities. Materials include low carbon, cold rolled strip and sheet steel; five types of spring steel; stainless steel; aluminum; brass; copper; nickel silver; and such nonmetallic materials as Delrin®, Teflon®, Mylar®, and nylon. Metric sizes also. Tel: 1-800-927-4377; Fax: 612-729-8910.

Boker's Inc.

For More Information Write In No. 323

SURFACE MEASUREMENT SYSTEM

The WYKO RST Plus surface measurement system rapidly measures the three-dimensional surface texture of a wide variety of materials such as plastics, film, glass, ceramics, paper, machined parts, metal, etched silicon, and much more. The system provides quantitative surface height measurements up to 500 µm with subnanometer resolution. Results are displayed as three-dimensional color images with industry-standard surface statistics. For more information, contact WYKO Corporation at 1-800-FON-WYKO.

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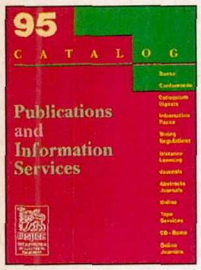


1995 PUBLICATIONS AND INFORMATION SERVICES CATALOG

INSPEC and the IEE combine their catalog: INSPEC Publications and Services; Abstracts Journals, Online Database, Tape Services, CD-ROM: INSPEC OnDisc, IEEE/IEE Periodicals Ondisc (IPO)—are featured along with the Books, Conference Proceedings, Professional Journals and Distance Learning (Video and CBT) materials of The Institution of Electrical Engineers (IEE). Tel: 908-562-5554; Fax: 908-562-8737.

IEE/INSPEC

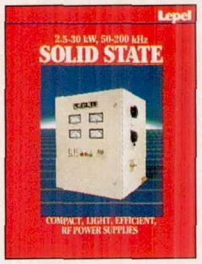
For More Information Write In No. 325

FULLRANGE™ VACUUM GAUGES

Low-cost, FullRange™ gauge is two gauges in one. It features Pirani and ionization gauges integrated with electronics into a single head. The gauge gives a linear output signal across the vacuum range from atmosphere to UHV. It can be used with or without a controller. Craig Lazinsky, Balzers, 8 Sagamore Park Road, Hudson, NH 03051. Tel: 603-889-6888; Fax: 603-889-8573.

Balzers

For More Information Write In No. 326



INDUCTION BRAZING, SOLDERING

Lepel introduces a line of high performance, 100% solid-state RF low-power induction heating power supplies designed to provide superior process stability. These new LSS Models ranging from 2.5 to 30 kW, 50-200 kHz, are among the smallest and lightest RF power supplies available. They can be used for numerous induction heating applications such as brazing, soldering, and stress relieving. Lepel, 50 Heartland Blvd., Edgewood, NY 11717.Tel: 516-586-3300.

Lepel

For More Information Write In No. 327

AIR FILTERS

Universal Air Filter Company manufactures custom-designed filter products for original equipment manufacturers. Universal filters are used extensively in the electronics, HVAC, digital switch, medical, defense, and data processing industries. The brochure describes applications and engineering and production capabilities. Universal Air Filter Company, 3400 Missouri Avenue, East St. Louis, Illinois 62203. Tel: 800-541-3478; Fax: 618-271-8808.

Universal Air Filter Company

For More Information Write In No. 328

HIGH POWER RF RESEARCH TOOLS

Radar systems, track, search, and GCA. RF sources 10 KHz to 35 GHz at 1 W - 5 mW. Pulse modulators 1 KW - 25 mW, Microwave components, Tracking and Search pedestals, Parabolic dishes to 60' diameter, Microwave tubes, Klystrons, Magnetrons, TWT's, etc. Much more available from stock, completely tested. Also, high power microwave test facility to test microwave devices. Send for free catalog. Tel: 203-753-5840; Fax: 203-754-2567.

Radio Research Instrument Co., Inc.

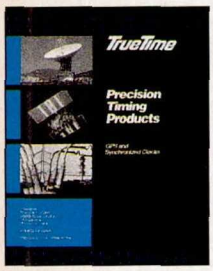
For More Information Write In No. 329

STANDARD AND CUSTOM MOLDED RUBBER PRODUCTS

An Elastomer Selection Guide summarizing the physical properties of the most commonly used materials in the molding, casting, extruding, and die-cut fabrication of parts is included in this package of materials from AME. Also included are data sheets on the company's line of O-Rings, switch seals (boots), self-sealing fasteners, and electrically conductive parts.

AME Corporation

For More Information Write In No. 330

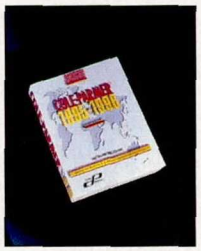


TIME AND FREQUENCY PRODUCTS

TrueTime's Precision Timing Products catalog features GPS-Synchronized Clocks in rackmount, portable, and board-level configurations. Includes illustrations and product specifications for our complete line of Synchronized Clocks, Time Code Products, and Remote Displays to fit a variety of time and frequency applications.

TrueTime, Inc.

For More Information Write In No. 331



NEW 1995-96 COLE-PARMER® INSTRUMENTS CATALOG

The new, free 1995-96 Cole-Parmer instruments catalog contains over 1700 full-color pages and features more than 40,000 products covering scientific instruments, equipment, and supplies. The catalog includes a detailed 40-page product index and table of contents, informative introductory pages for many of the catalog sections, "Hot Tips," and an 8-page section of late-breaking products. Contact Cole-Parmer Instrument Company—in the USA or Canada, call toll-free 1-800-323-4340.

For More Information Write In No. 332

TOOLS, TOOL KITS, CASES & TEST EQUIPMENT

Installation/repair tools, tool kits, test equipment, telecom equipment, LAN testers & instrument/shipping cases are detailed in this 300+ page full-color catalog. Includes products for field service & depot repair. Indexed catalog features over 100 standard tool kits & complete information on "customizing" to meet specific customer requirements. Complete specs & prices are provided for all products. Tel: 800-866-5353; Fax: 800-234-8286.

Specialized Products Co.

For More Information Write In No. 333

PRECISION TEST AND MEASUREMENT EQUIPMENT

Stanford Research Systems' 1994-95 Catalog contains complete specifications, technical discussions and application notes on their line of scientific and engineering instruments. This 200 page catalog includes the latest function generators, spectrum analyzers, lock-in amplifiers and delay generators, and is a useful reference for a wide range of test and measurement applications. Tel: 408-744-9040.

Stanford Research Systems

For More Information Write In No. 334

PCMCIA DESKTOP ADAPTORS

The PCMCIA standard is the newest technology in data storage and I/O for desktop and mobile computers. Now ENVOY DATA offers the most complete line of PCMCIA Databook adaptors (reader/writers) for your desktop computer. External models connect through the parallel port while internal models use an ISA interface card. All models read and write Types I, II, or III memory cards. Tel: 602-892-0954; Fax: 602-892-0029.

Envoy Data Corporation

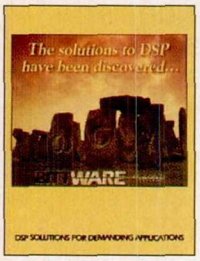
For More Information Write In No. 335

WAVE/COMPRESSION SPRINGS

Just updated, Catalog #WS-93 contains **NEW stock sizes** of wave/compression springs available from stock, including spring design formulas, materials guide and typical applications. The manual describes the many advantages of Smalley's exclusive edgewinding manufacturing process. Smalley springs, available from 3/8" to 84" in diameter, are produced by circle-coiling flat wire to exact specifications involving **no dies or special tooling charges**. Tel: 708-537-7600; Fax: 708-537-7698.

Smalley Steel Ring Co.

For More Information Write In No. 336



FREE DSP CATALOG

BittWare has the widest range of analog and digital I/O available for your groundbreaking DSP applications. Call us today for a catalog full of our heavy-duty ADSP 210x0-family of floating point DSP and I/O products, along with our complete set of development tools. BittWare Research Systems, 33 North Main St., Concord, NH 03301, 800-848-0436; Fax: 603-226-6667.

BittWare Research Systems

For More Information Write In No. 337

FREE LAMP CATALOG

This catalog features replacement lamps at discount prices for all types of equipment. Lamps for audio-visual, photographic, micrographic, and graphic arts equipment. 100% guaranteed brand names—toll-free ordering—no minimum order. All deliveries via Second-Day Air at NO extra cost. Also, lamps for medical and electronic instruments, microscopes and video use. Tel: 800-772-5267; Fax: 800-257-0760. PSC Lamps Inc., 435 W. Commercial St., E. Rochester, NY 14445.

PSC Lamps Inc.

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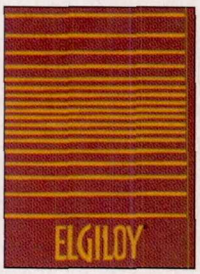

PRECISION STRIP/WIRE

Elgiloy® is a combination strip and wire mill. We process a variety of alloys including Inconel®, Hastelloy®, Monel®, MP35N®, Titanium and Stainless. Our sales and engineering staff are qualified to handle your custom material requirements, and our on site testing lab assures you of prompt deliveries. Tel: 708-695-1900; Fax: 708-695-0169.

Elgiloy® Limited Partnership

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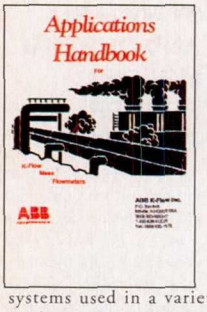

MASS FLOW METER APPLICATIONS HANDBOOK

The new handbook consists of a series of K-Flow application solutions. The "Application Handbook" illustrates the flow process configuration and ABB K-Flow flowmeter/transmitter systems used in a variety of process applications. Applications covered include Mass (Liquid, Gas, Multi-Component), Density (SG, API, Brix), %Solids, %Liquids, PID, Ratio Blending, Batching, Proportioning, etc.

ABB K-Flow

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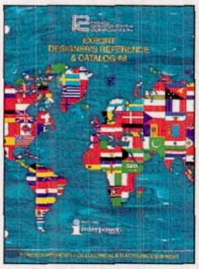
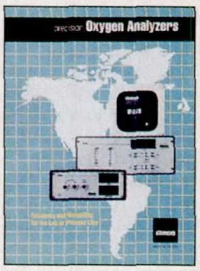


INTERPOWER™ EXPORT DESIGNER'S REFERENCE CATALOG

New 224 page Reference Catalog #8 helps in designing primary power circuits of international products. Designer's Reference section shows world plug/-socket patterns, voltages and frequencies, international safety agencies and important standards published by IEC, UL and CSA. Tel: 515-673-5000; Fax: 515-673-5100.

PANEL COMPONENTS CORPORATION

For More Information Write In No. 341



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.

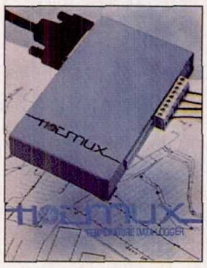
For More Information Write In No. 342

OVENS & FURNACES UP TO 2700 °F

Capabilities, specifications and prices 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; clean room and pharmaceutical ovens; laboratory and industrial furnaces and environmental test chambers. For baking, drying, preheating, annealing, stress relieving, curing, sterilizing, depyrogenation and heat treating. Tel: 708-546-8225.

The Grieve Corporation

For More Information Write In No. 343



LOW-COST PC-COMPATIBLE DATA LOGGER

Puts eight thermo couple channels on monitor, printer, or disk for $279 complete. Specifically for laboratory and industrial temperature monitoring. Avoids complex set-up or installation and is functioning within minutes. RS-232 interface powers converter and eliminates sensor wires at computer. Quick-Basic®MS source code and compiled program provided. 16-channel and linear sensor options. Tel: 609-662-7272.

DCC Corporation

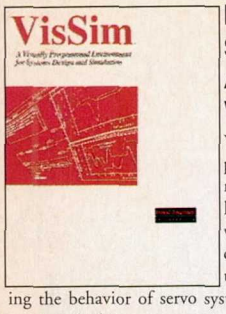
For More Information Write In No. 358

"HANDS-ON" ADVANCED COMPOSITE WORKSHOPS—SINCE 1983

The brochure describes 13 different "hands-on" workshops in advanced composite materials technology. These workshops cover fabrication, repair, manufacturing, tooling, blueprint reading, adhesive bonding, ultrasonic inspection of composites, and 4 engineering workshops. Emphasis is placed on prepreg carbon and aramid fiber materials and processes, utilizing vacuum bagging and high-temperature curing methods in the oven and autoclave. Three workshops are Canadian DOT approved. REFRESHER WORKSHOPS OFFERED. For a free brochure, call 1-800-638-8441; Fax: 702-827-6599.

Abaris Training Resources

For More Information Write In No. 344



NONLINEAR SIMULATION AND CONTROL WITH VisSim

VisSim provides a complete, visual software environment to design, simulate, and perform real-time verification of complex, dynamic systems. VisSim is used worldwide for modeling the behavior of servo systems, drive systems, digital communication systems, power systems, and biomedical processes. VisSim runs on MS/Windows, MS/Windows-NT, and Unix/X operating systems. **Call 608-392-0100 for a free working demo.**

Visual Solutions, Inc.

For More Information Write In No. 346

NEW PRODUCTS FOR LIGHT RESEARCH

This NEW product guide from Oriel Instruments features the latest instruments for making, moving and *measuring light. You'll find* pulsed sources, nitrogen lasers, calibrated irradiance sources, low cost to fully featured imaging monochromators and spectrographs, a full line of UV-IR detectors and detection systems including a digital lock-in and CCDs and ICCDs, and fiber optics. Tel: 203-377-8282; Fax: 203-375-0851; E-mail 73163.1321@compuserve.com.

Oriel Instruments

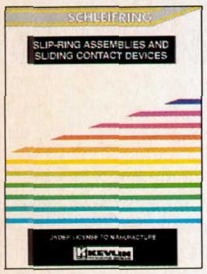
For More Information Write In No. 347

MID-WEST EXPRESS STOCK SPRINGS CATALOG

New, 56-page catalog describes over 1,500 different stock springs and spring kits available for immediate delivery. Compression, extension, torsion, continuous, hot wound, die, extension and specialty springs are described. Mid-West Express, a division of Mid-West Spring Manufacturing Company, 1404 Joliet Road, Unit C, Romeoville, IL 60441; Tel: 800-619-0909.

Mid-West Express

For More Information Write In No. 348



SLIP RINGS

KEVLIN MICROWAVE, the world leader in RF Rotary Joint technology, is now manufacturing SLIP RINGS under a partnership agreement with Schleifring GmbH *of Germany, the world* leader in slip ring technology. Kevlin now offers the broadest line of sliding contact devices available in the industry, from Military and Aerospace systems to low-cost high-volume commercial grade components. Together, Kevlin and Schleifring have the capability to satisfy all your technical requirements with the right product at a competitive price. Tel: 508-657-3900; Fax: 508-658-5170.

Kevlin Microwave Division

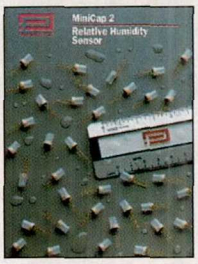
For More Information Write In No. 349

B92 CATALOG RELEASE

The latest catalog from W.M. Berg, Inc., coincides with Berg's silver anniversary. Founded in 1967, Berg has grown to become a recognized industrial leader of miniature precision mechanical components. A significant number of new items are added as well as expanding previous product lines. Featuring 50,000 standard components, 80% of which we are able to ship from stock within 24 hours. Available in metric version too: M92. Tel: 516-596-1700; Fax: 516-599-3274.

W.M. Berg

For More Information Write In No. 350



MINICAP 2 RH SENSOR

The MiniCap 2 RH Sensor is a low-cost, general-purpose, thin-film polymer, capacitive-type relative humidity sensor designed for the OEM market. Its TO-18 header configuration makes it compatible with a wide range of applications. It has excellent stability and linearity in the range of 0% to 100% RH. The MiniCap 2 is unaffected by water condensate, most reagent vapors and temperatures up to 180 °C. Tel: 617-899-2719; Fax: 617-894-8582.

Panametrics

For More Information Write In No. 351

TYGON® TUBING, BROCHURE AND SAMPLE CARD

The most comprehensive literature available from the number one brand of flexible plastic tubing. This 20-page 4-color brochure describes the entire line of Tygon® flexible plastic tubing for applications in medical, *laboratory, food/beverage, dairy and general industrial* markets. It also covers other Norton tubing products such as Norprene® thermoplastic elastomer tubing, PharMed® medical/biotechnology tubing, Chemfluor® fluoropolymer tubing, Tygothane® polyurethane tubing and Fluran® fluoroelastomer tubing. Norton Performance Plastics Corporation, Tel: 216-798-9240.

For More Information Write In No. 352

NETWORK FOR VIRTUAL REALITY SYSTEMS

The SCRAMNet®-LX Network, a real-time communications system based on a replicated shared-memory concept, is optimized for the high-speed transfer of data among *computers. This FREE Application Note shows how* SCRAMNet made one virtual reality simulation possible. Tel: 513-252-5601; 800-252-5601; Fax: 513-258-2729.

Systran Corp.

For More Information Write In No. 353

NEW MSC/NASTRAN BROCHURE

12-page brochure details *latest features of leading* FEA software, used worldwide to optimize and predict behavior of complex designs from aerospace and automotive to medical and consumer goods. Analysis types include static, normal modes, buckling, dynamic response, heat transfer, nonlinear, acoustic, and aeroelastic, using both h- and p-elements. Open architecture works with all modeling/CAD systems. MacNeal-Schwendler Corp., Los Angeles, CA. Tel: 800-642-7437, ext. 500.

MacNeal-Schwendler Corp.

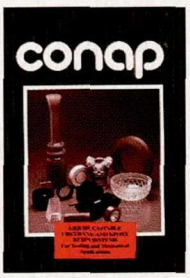
For More Information Write In No. 354

NEW EMI SHIELDING PRODUCT INFORMATION CATALOG

New 20-page catalog describes EMI shielding products for doors, panels, covers, connectors, enclosures, and cabinets. Describes wire mesh, gasket materials, fan vents, filters, and honeycomb vents. Mesh options include elastomer core and Twinseal for environmental seal. Technical drawings, special finishes, standard and custom options, and ordering information.

Tech-Etch, Inc.

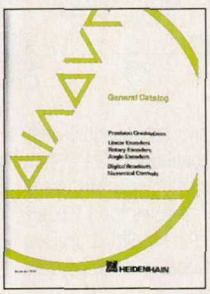
For More Information Write In No. 355



POLYURETHANE AND EPOXY TOOLING RESIN SYSTEMS

New Selector Chart ES-160 describes the CONATHANE® TU-401 and UC-Series of non-MBOCA, non-TDI, non-MDA liquid castable tooling resin systems. TU-401 Series flexible elastomers provide high elongation, high tensile and tear strength, and excellent abrasion resistance. CONAP® and CONATHANE® UC-Series provide tough, high hardness, high impact resistant, dimensionally stable castings. CONAP, INC., Tel: 716-372-9650; Fax: 716-372-1594.

For More Information Write In No. 356



HEIDENHAIN'S 52 page General Catalog features mechanical and technical information on Linear and Rotary Encoders, Digital Readouts, Numerical Controls and Digital Height Gages for measurement and inspection applications. Metal-cutting and metal-forming machines, inspection equipment, general automation and the electronics industry are just a few of the various types of *applications that require measurement systems for* position and speed control feedback.

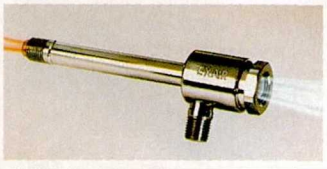
Heidenhain Corporation

For More Information Write In No. 357

New on the Market

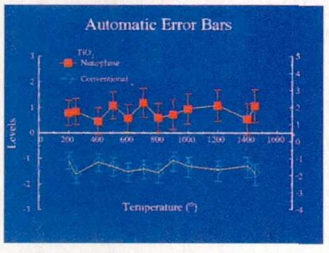
Using compressed air as a power source, **vortex tubes** from EXAIR Corp., Cincinnati, OH, produce a flow of cold air from one end and hot air from the other, with temperatures adjustable from ambient to 121 °C for the hot and from ambient to -46 °C for the cold. Available in three sizes with flow rates from 1-100 SCM, the compact and durable tubes operate at pressures down to 20 psig and have a refrigeration rating up to 6000 BTU/hr.

For More Information Write In No. 707



i Sight Inc., Cedar Knolls, NJ, has introduced the iSC2050 **digital video camera** for applications with a wide range of illumination or contrast. Providing a dynamic range of over 72 dB, the system includes a remote camera head, features on-screen menus and push-button controls, provides standard color or monochrome video output formats, and requires no frame grabber board to convert images to digital.

For More Information Write In No. 708

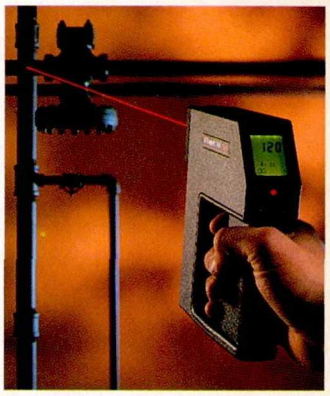


TriMetrix Inc., Seattle, WA, has announced Axum 4.0 for Windows, the first drag-and-drop **technical and data analysis package**. Based on Axum for DOS, the new software allows users to create publication-quality technical graphs instantly by dropping data from OLE 2 applications onto plot buttons. The new program offers 75 2D and 3D graph types and enables the user to click on any object to edit its properties.

For More Information Write In No. 704

Measuring 16 mm in diameter by 41 mm long, a **DC motor** from Maxon Precision Motors Inc., Burlingame, CA, employs neodymium rare-earth magnets and capacitor long-life commutation to achieve an assigned power rating of 3.2 W with a typical efficiency of 86 percent. Precious-metal brushes and precision sleeve bearings contribute to the high efficiency of the RE016-039 by minimizing friction losses.

For More Information Write In No. 705

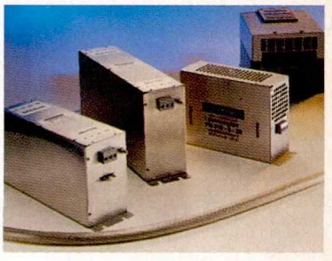


Raytek Inc., Santa Cruz, CA, has announced the Raynger PM line of **IR thermometers** featuring a distance-to-spot ratio of 50:1, response time of under 350 msec, and a useful temperature range of -18 to 870 °C. In the datalogging models—PM 30, PM 40, and PM 50—a number of temperature readings can be internally recorded and later downloaded via an RS-232C port. Laser sighting is standard on all models.

For More Information Write In No. 711

Biosym Technologies Inc., San Diego, CA, has released ESOCS (Electronic Structure of Close-packed Solids), fast and easy-to-use **materials research and design software** that reveals many fundamental properties of materials on an atomic level. It performs electronic structure calculations on solids, thin films, layered compounds, and surfaces, and is designed to determine magnetic and optical properties as well as diagnostic properties such as core level shifts and NMR.

For More Information Write In No. 701



Output filters for frequency inverters from Schaffner EMC Inc., Springfield, NJ, are designed to increase inverter efficiency and system reliability, eliminate EMI problems, and reduce acoustic noise. The FN 500 series includes inexpensive rise-time limiting filters to reduce peak current demands and eliminate voltage overshoot, filters that optimize PWM waveforms, and comprehensive units that employ voltage feedback to allow long—even shielded—cables to be used for EMC-compliant applications.

For More Information Write In No. 702

New on the Market

IEPS Electronic Inc., Houston, TX, has unveiled its Digital UPS series of **uninterruptible power supplies** that provide from 400 to 1250 VA for personal computers and peripherals. Instead of a surge protector, each unit contains a patented electronic power filter that not only protects against lightning but against all types of spiking to increase uptime and preserve computer operation. It features a pure sinewave output and microprocessor-based interface for power management and control.

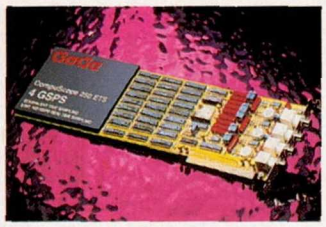
For More Information Write In No. 713

The SWAM Blaster Model MV-1 **micro-abrasive sandblasting machine** from Crystal Mark Inc., Glendale, CA, removes conformal coatings from electronic assemblies prior to desoldering without removing solder plating or causing damage to the board's butter coat. The machine introduces a graded microabrasive powder into a controlled stream of compressed gas through an abrasive resistant pathway and out a manually or automatically positioned miniature nozzle.

For More Information Write In No. 709

The SV series of **solenoid valves** from Circle Seal Controls, Corona, CA, is designed for use with liquids or gases and provides positive shutoff and fast response regardless of flow direction or pressure. The valves insure bubble-tight sealing from vacuum to 6000 psi and can be used to control flow in remote locations.

For More Information Write In No. 706

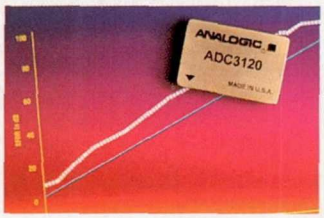


Gage Applied Sciences Inc., Montreal, Quebec, has introduced the CompuScope 250 ETS, an IBM PC/XT-compatible **ISA bus card** capable of performing 8-bit A/D conversion at equivalent time sampling rates up to 4 GSPS and real-time sampling rates up to 100 MSPS. Because these sampling rates are much faster than what the ISA bus can handle, A/D data is stored in onboard memory.

For More Information Write In No. 703

An **imaging system** from H.P. White Laboratory Inc., Street, MD, is designed to document short duration events. It features computer-controlled operation of a compact gated video camera and all peripherals required for triggering, viewing, printing, and storing images at exposure times as short as 0.1 µsec. The system supports up to four cameras and can capture multiple exposures from a single camera.

For More Information Write In No. 712



Analogic Corp., Peabody, MA, has unveiled the ADC3120 Hybrid Sampling **A/D converter**, which provides 14-bit accuracy at conversion rates up to 20 MHz, with 90 dB of spurious free dynamic range. The converter provides 85 dB total harmonic distortion and 75 dB signal-to-noise ratio, with a power consumption of 4 W.

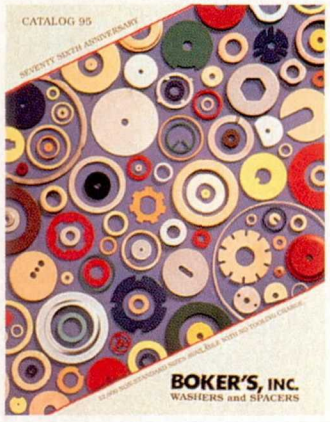
For More Information Write In No. 710

The Terranalyzer from Terranalysis Corp., Santa Barbara, CA, adapts to any foundation or standard top-head drill rig for rapid on-line **screening of hazardous waste sites** while drilling. The unit's small-diameter smart drill module houses an integrated family of optical sensors and measuring devices to determine chemical, radiological, and physical properties of the subsurface while simultaneously collecting soil temperature, moisture, pH, density, and other geological data.

For More Information Write In No. 700

New Literature

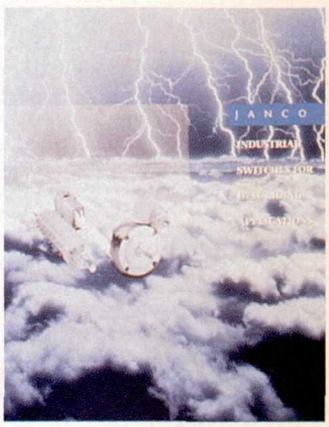
A 32-page catalog of **washers and spacers** from Boker's Inc., Minneapolis, MN, lists 12,000 non-standard sizes available with no tooling charges. Outside diameters range from 0.080 to 2.631 inches with a wide variety of inside diameters and thicknesses. The products are available in 2000 materials including steel, aluminum, brass, copper, nickel silver, and numerous plastics and non-metallic materials such as Delrin®, Teflon®, Mylar®, and nylon.
For More Information Write In No. 724



Advisor in Metals, Union, NH, has published the *Simplified Tool Steel Heat Treatment and Selection Guide.* Providing answers to **heat treatment** problems in easy-to-understand non-metallurgical terms, the book offers assistance in tool steel selection, shows how various tool steels relate to one another, and addresses cryogenics, welding, EDM, and grinding.
For More Information Write In No. 715

Soliloquess Communications, Worcester, MA, has announced *Science & Engineering Network News,* a monthly newsletter focusing on news, reviews, and tutorials of **science and engineering resources available on the Internet and related bulletin boards**. Resources covered include FTP and Telnet sites, electronic mailing lists, USENET newsgroups, World Wide Web pages, and FAQs.
For More Information Write In No. 726

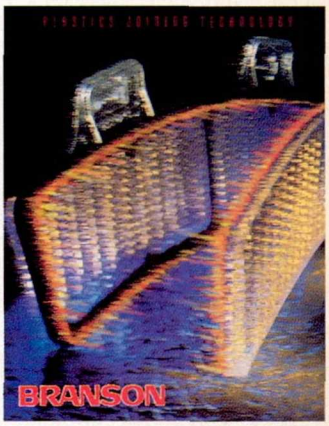
Elwell-Parker Electric Co., Cleveland, OH, has released a brochure describing the methodologies of various **die handling** vehicles including side-loading, end-loading, and angle-end-loading. *Fundamentals of Die Handling* also explains differing bollards, their use, key features, and design innovations. Highlighted are the company's cushion tire, electric vehicles available in operational powers of 36, 48, or 72 V and with carrying capacities of 7.5 to 62.5 tons.
For More Information Write In No. 717



An **industrial switches** brochure from Janco Corp., Burbank, CA, highlights the company's engineering resources and in-house manufacturing and testing capabilities. The publication provides examples of rugged and highly reliable switching systems developed for demanding industrial switching applications and critical medical equipment.
For More Information Write In No. 716

Samtec Inc., New Albany, IN, has released a guide to its **application-specific interconnect solutions** ranging from simple modifications of standard board-to-board connectors to advanced custom IC-to-board interconnects. Applications include modified and custom pins, insulators, plating, and packaging. Samtec's socketing capabilities include high-speed connectors, impedance-matched connector sets, and interstitial and SMT PGA sockets.
For More Information Write In No. 721

A brochure on **plastics joining technology** has been published by Branson Ultrasonics Corp., Danbury, CT. It describes a wide range of plastics assembly processes and equipment, including ultrasonic assembly, linear and orbital vibration welding, and hot plate welding. It also includes basic guidelines for choosing a plastics joining process.
For More Information Write In No. 727



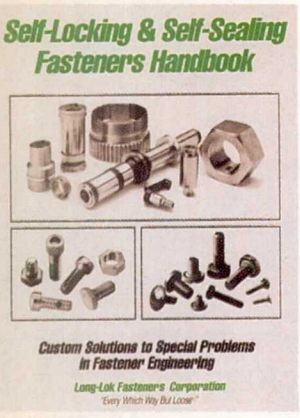
New Literature

A brochure from Futura Coatings Inc., St. Louis, MO, describes the features and cost savings of its spray-applied **in-mold coatings, structural resins, high-performance finishes, sprayable flexible foams, and soft foam composite fabrication** designated the SOFT-TECH™ system. It illustrates how Futura's advanced polyurethanes technology and spray-applied materials can improve the performance, longevity, and durability of diverse products.

For More Information Write In No. 719

Addison-Wesley Publishing Co., Reading, MA, has published *The Cross-GUI Handbook For Multiplatform User Interface Design*, which provides detailed comparisons of the features, capabilities, and strengths of currently available **GUIs**—including Microsoft Windows and Windows NT, IBM OS/2 Presentation Manager, OSF/Motif, Apple Macintosh, and NeXTSTEP. The book decribes the terminology, appearance, interaction, and common behavior of each GUI to enable designers to create a consistent look and feel across multiple platforms.

For More Information Write In No. 720

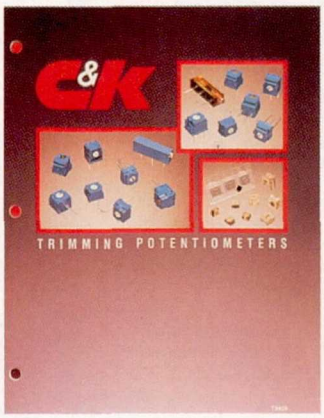


A handbook to **self-locking and self-sealing fasteners** has been published by Long-Lok Fasteners Corp., Cincinnati, OH. The 48-page book explains how self-locking fasteners work in specific applications and includes sections on installation data and torque calculations.

For More Information Write In No. 718

The latest edition of the *PC Systems Handbook for Scientists & Engineers* is available from CyberResearch Inc., Branford, CT. The 100-page volume features comparison charts of **data acquisition boards** from various manufacturers and chapters on the new CyberDAS line of Keithley/Metrabyte-compatible boards, data acquisition for remote applications and portable PCs, boards for digital I/O, and cards for analog output.

For More Information Write In No. 722

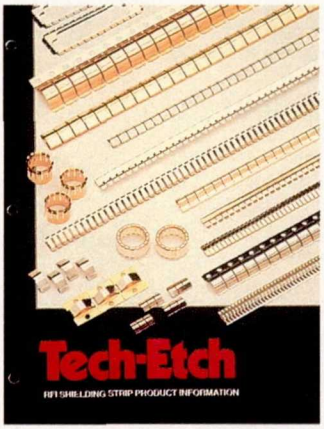


A catalog from C&K Components Inc., Watertown, MA, describes its new line of **trimming potentiometers**, which includes single-turn and multi-turn models and features space-saving 3-mm and 4-mm surface mount terminal styles as well as top- and side-actuated thru-hole versions. All models are enclosed, process sealed, and employ cermet resistive elements, high-temperature UL 94V-0 materials, and tin-lead plated terminals with epoxy seal.

For More Information Write In No. 714

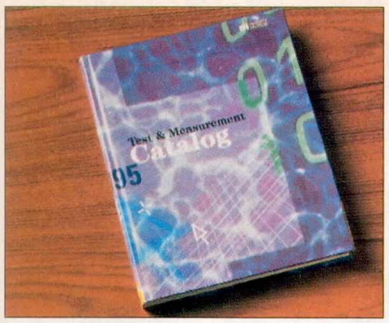
EIL Instruments Inc., Hunt Valley, MD, has released its **test, measurement, and control instrumentation** handbook and buyer's guide featuring thousands of products from more than 200 manufacturers. Featured products include electronic test and power measurement equipment, calibrators, testers and programmers, and plant engineering equipment.

For More Information Write In No. 725



A 24-page catalog of beryllium copper **RFI/EMI shielding products** has been published by Tech-Etch Inc., Plymouth, MA. It describes a variety of shielding strips including soft and no-snap fingers, omni contacts, panel and strip gaskets, reverse bend and twisted contacts, cylindrical and spherical radius contacts, and "D" connector gaskets.

For More Information Write In No. 723



FREE 1995 HP Test & Measurement Catalog

With over 700 pages, the 1995 HP Test & Measurement Catalog is loaded with tutorials, descriptions, specifications and prices for more than 1,500 HP products and services. And it's free. Call HP at 1-800-452-4844, Ext. 8774.

For More Information Write In No. 575

FREE! 130 Page Catalog ------ "Optics for Industry"

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For More Information Write In No. 576

4MEG VIDEO™ Model 12

Flexible Image Capture, Processing, & Display Board for the PC

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More than 500 pages of tooling components!

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This illustrated complete line catalog includes component parts for jigs and fixtures, chuck jaws, plug gauges, threaded inserts, stainless steel tooling components, toggle clamps, SWIFTSURE power workholding devices, drill jig bushings, locking pins, and modular fixturing. Completely illustrated. **Send for your free copy.**

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For More Information Write In No. 578

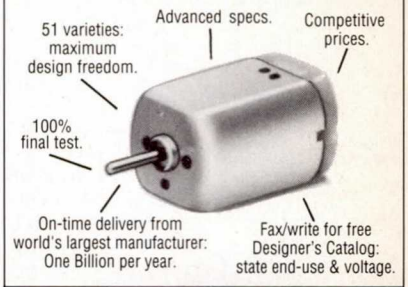
RUGGED MINIATURE LIGHTED AND UNLIGHTED SWITCH

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 providing design flexibility. An optional dripproof/splashproof seal may also be installed. StacoSwitch, Inc., Costa Mesa, CA 92626. Phone (714) 549-3041. Fax (714) 549-0930.

For More Information Write In No. 585

MOTORIZE WITHOUT COMPROMISE

Mabuchi subfrac pm dc mini-motors:



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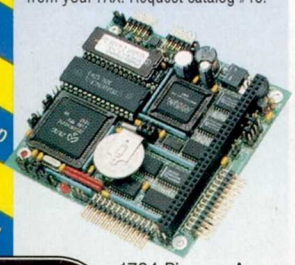

ZWORLD ENGINEERING

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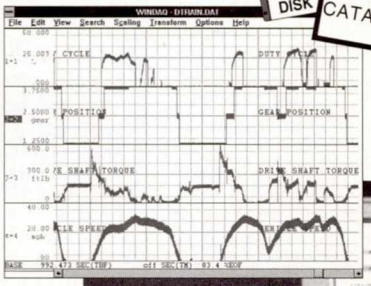

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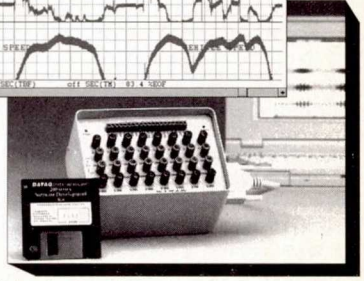

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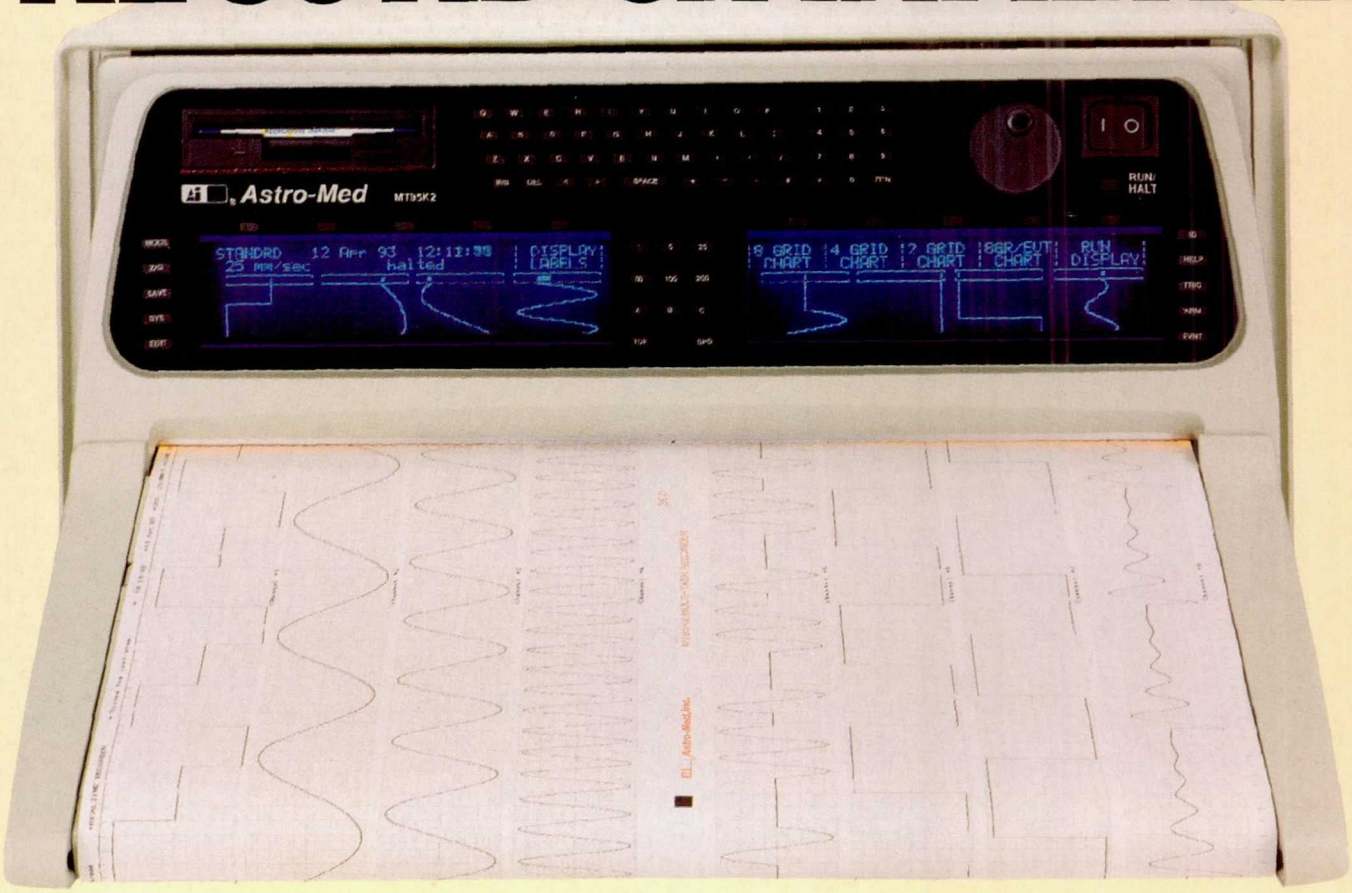

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