NASA Tech Briefs

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National Aeronautics and
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November 1993 Vol. 17 No. 11

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Advanced Manufacturing

TECHNOLOGY 2003
Exhibits Preview

Low Profile 15-W DC/DC Converters

The new AHV 2800 Series of 15W DC/DC Converters features high power densities and ruggedized low profile packages only 0.405 inches high. They are available in single, dual and triple output models and are fully compliant with MIL-STD-704 (A-E), MIL-STD-883 and MIL-H-38534. All AHV 2800 DC/DC converters withstand the 80-Volt surge requirement of MIL-STD-704A and operate over the full military temperature range of -55°C to +125°C with no derating of power output. These devices all have nominal 28 VDC inputs and operate over a 16 VDC–40 VDC range.
The AHV 2800 Series feedback design is impervious to temperature, radiation, ageing or variations in manufacture. The unique circuitry provides high control loop gain, high phase margin, and an extremely wide bandwith.

For More Information Write In No. 516

Low Profile 12-W DC/DC Converters

The AHF 2800 Series of DC/DC Converters feature single or dual outputs over the full military temperature range. No derating in output power is required, making them suitable for use in rugged military applications. The low profile, small outline package is ideally suited to the tight board space requirements of many industrial and aerospace applications. Designed for nominal 28 VDC inputs, this family of converters meets all the requirements of MIL-STD-704D.

The proprietary magnetic feedback circuit provides for an extremely wide bandwidth control loop with a high phase margin. These converters are manufactured in a facility fully qualified to MIL-STD-1772. Two temperature ranges and screening grades are available to satisfy a wide range of requirements.

For More Information Write In No. 517

Triple Output 30-W DC/DC Converter

The ATR 2815T triple output DC/DC Converter provides 30 watts of output power over the full military temperature range with no derating. This device is pin compatible with ATO Series converters but offers twice the maximum output power in a lower profile package. A custom CMOS ASIC pulse width modulator and a patented magnetic feedback circuit reduce circuit complexity and enhance reliability. This converter provides 500-Volt input to output isolation and operates in a highly efficient single forward mode.

The advanced design features an extremely wide bandwidth control loop with high gain and phase margin. The control loop is compensated to provide optimum performance over the full military temperature range and over the 16- to 40-Volt input voltage range.

For More Information Write In No. 518

High-Power 40-W DC/DC Converter

The AFW 2805S hybrid DC/DC Converter features high power density and full military temperature range operation without output power derating. The advanced feedback design provides fast loop response for superior line and load transient characteristics and offers greater reliability than devices incorporating optical feedback circuits. The basic circuit topology is a push-pull configuration operating at a nominal switching frequency of 500KHz.

This device is designed to meet MIL-STD-704A input requirements offering full performance over a 16- to 50-Volt input range and operating at 80 Volts for 100 milliseconds or 100 Volts for up to 5 milliseconds. The AFW 2805S is packaged in a rugged parallel seam welded steel case using ceramic feedthrough pins to assure true long term hermeticity.

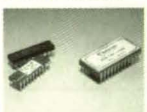
Write In No. 519

Space Application DC/DC Converters

Advanced Analog's high-performance DC/DC Converters are now being shipped for mission-critical space applications. To meet space requirements, proven radiation-hardened components are used in all necessary areas, such as the custom integrated circuits and power MOSFETs. And, because the magnetic pulse feedback circuits do not use opto-couplers or generate spurious RF energy, they are unaffected by time, temperature or radiation. These converters are all implemented using thick film hybrid technology and are fully certified and qualified to MIL-STD-883.

Write In No. 520

Military Video DACs



Advanced Analog introduces two new video D-to-A converters: the VDAC 1800 Series and the RGB DAC 3400SW. Both DACs are screened to MIL-STD-883.

The VDAC 1800 Series consists of 8-bit monolithic devices that provide latches for input data, and produce clean video output signals, driving 75- or 37.5-ohm loads at an update rate of up to 80 MHz. All models can also produce composite sync and blanking signals, plus reference black, reference white, and 10% bright.

The RGB DAC 3400SW combines three video-speed DACs, internal temperature-compensated reference, and all the control lines necessary for a complete RGB graphics color monitor interface. All this in a single, monolithic, low-power, CMOS/TTL-compatible IC.

Write In No. 521

Introducing a true 100K rad-hard DC/DC Converter for aerospace programs.

For mission-critical satellite and space probe systems, now there's a high-density power source specifically designed to stand up to hostile radiation environments: The ART2800 Series from Advanced Analog.

This new design uses thick-film hybrid technology and proven rad-hard components. It delivers up to 30 watts of single, dual or triple output power, over the full military temperature range. And it's guaranteed to withstand a total dose of 100K rad (Si)–with a 2:1 design margin–and to tolerate extreme dose-rate upset, latchup and neutron fluence.

The ART2800 Series meets the derating requirements of MIL-STD-975 and MIL-STD-1547, is designed to comply with MIL-H-38534, and is manufactured to space application requirements in a facility fully qualified to MIL-STD-1772.

Advanced Analog is the recognized technology leader in high-reliability microcircuits for military and aerospace applications. The first DC/DC Converter supplier approved by DESC on Standard Military Drawings, our DC/DC Converters and other devices have tested the outer limits from the Patriot missile to the MLRS to the Space Shuttle to the C-17 aircraft.

To get your rad-hard project off the ground quickly, call (408) 988-4930 today. Or fax us at (408) 988-2702.

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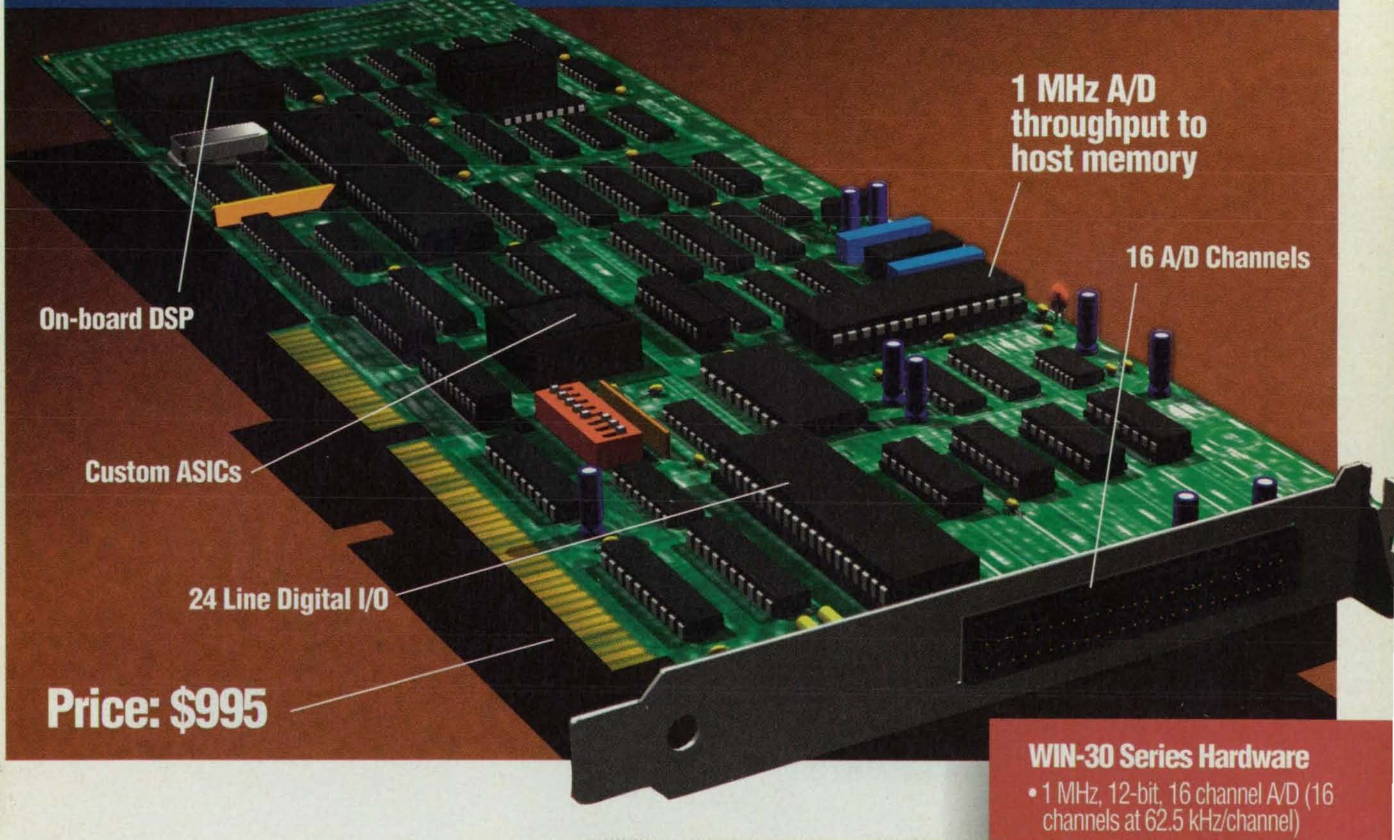
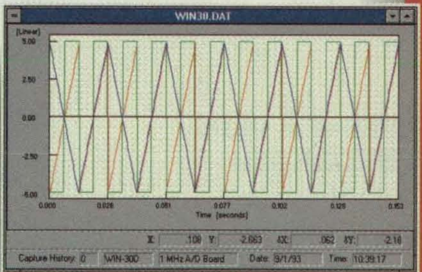


For your Data Acquisition needs, you don't have to sacrifice performance for cost. The WIN-30D has it all. Speed, Power, Performance and Price. The WIN-30D features a 1M-sample/sec, 12-bit, 16-channel A/D with 24 digital I/O lines, and the power of Windows. At $995 the WIN-30D gives you a board you'd expect to pay up to three times more for. Call **800-829-4632** for a free catalog and demonstration and see for yourself.



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RECORDING AT UP TO 32 Mb/SEC ISN'T ITS MOST ATTRACTIVE FEATURE.

THE METRUM BUFFERED VLDS DIGITAL DATA RECORDER

A data rate of up to 32 megabits per second is nothing to sneeze at. It can let you do a lot of things. And do them very well.

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This full-featured cassette machine costs about half of what you'd expect to pay for such impressive specifications.

Plus, the new Metrum BVLDS is virtually maintenance-free. Needs no calibration or head cleaning. Takes only seven inches of rack space. And uses compact, economical ST-120 cassettes, which can save you a lot in storage hassles and media costs.

The BVLDS also comes with a parallel, serial or SCSI interface.

All things considered, it's hard to say what this unique machine's best feature is.

But its low price is a great place to start.

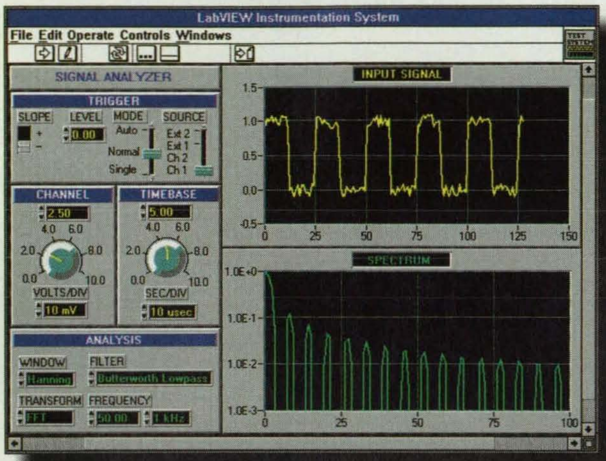
METRUM

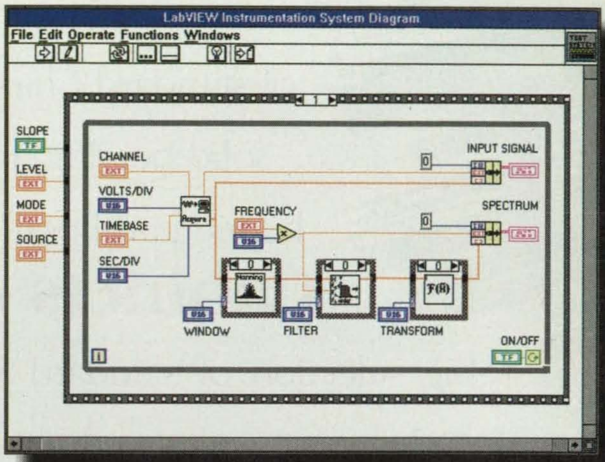
FOR TECHNICAL LITERATURE ON THE METRUM BUFFERED VLDS, CALL 1-800-METRUM-2.

For literature write in 559

For a product demo write in 560

More than Just Ease of Use ...





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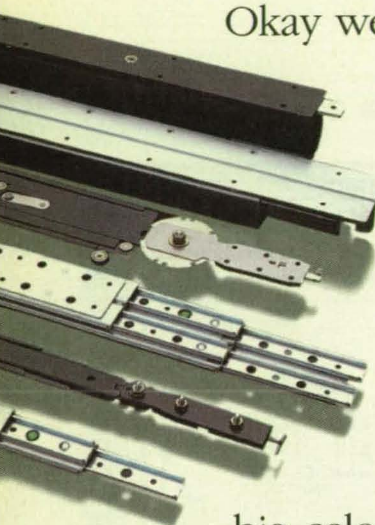
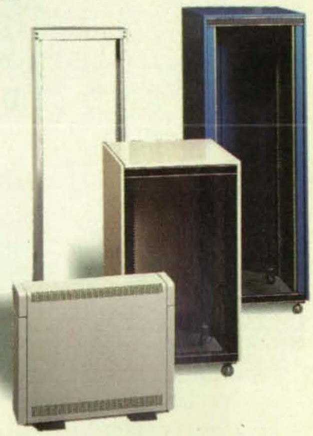
For More Information Write In No. 550

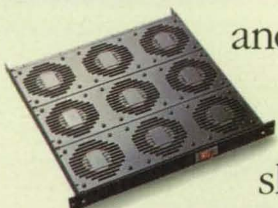
"General Devices? Don't they make..."



Okay we admit we don't have the most descriptive company name in the world. Just so you'll know, here's what we make. **Slides:** Hundreds of standard Chassis Trak® telescoping slides — solid bearing, roller bearing, ball bearing and bottom mount models.



Cabinets & Racks: A big selection of standard Vent Rak® products for electronics, telecommunications equipment, and more. **Accessories:**



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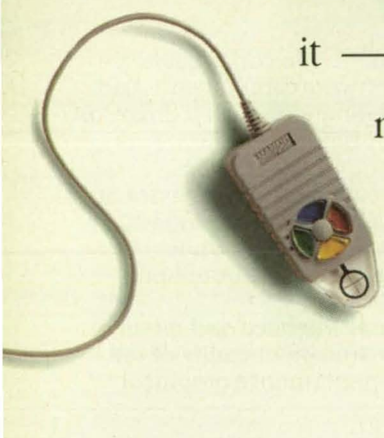

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Volume 17 Number 11

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FEATURES

TECHNICAL SECTION

(continued on page 8)

To Backup 50 GB, Two Recording Heads Are Better Than One.

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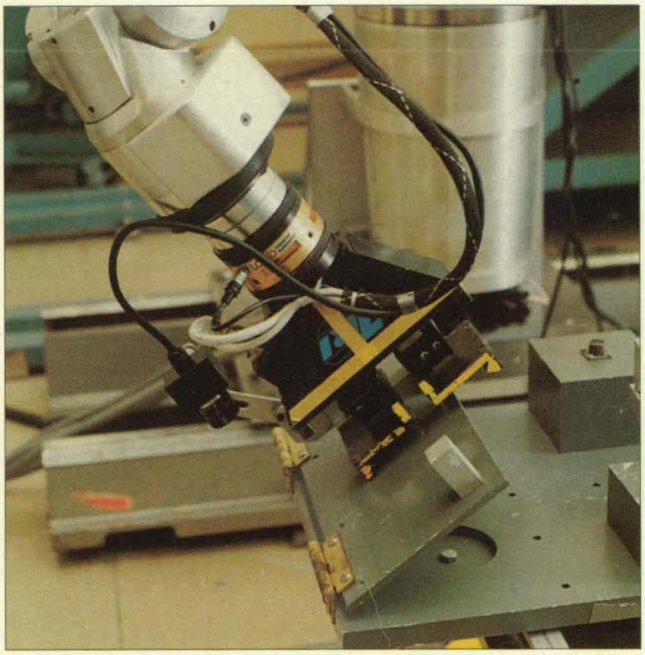

A robot-control scheme developed at Jet Propulsion Laboratory enables autonomous supervisory, shared, and teleoperative control of a manipulator arm equipped with multiple position, force, and velocity sensors. The manipulator acts as a different specified impedance to each real or virtual sensor source and permits easy integration of new sensors into the system. See the tech brief on page 108. Photo courtesy Jet Propulsion Laboratory

Editor's note:
NASA Patents did not run last month as scheduled due to a printer's error. It appears instead on page 12 of this issue.

108 Books and Reports

DEPARTMENTS

On the cover:

The NPO Energomash engine marketed by the Government Engines and Space Propulsion division of Technology 2003 exhibitor Pratt & Whitney is designed to power vertical takeoff/horizontal landing single-stage-to-orbit vehicles. See the Technology 2003 Exhibits Preview beginning on page 14.

Photo courtesy Pratt & Whitney Government Engines and Space Propulsion

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In a concerted effort to save our planet, NASA will be enlisting 30 different sensors to collect data on key environmental conditions. At the heart of this multisatellite program, called Mission to Planet Earth, is Hughes Aircraft Company's MODIS sensor — or Moderate Resolution Imaging Spectroradiometer. MODIS will help scientists estimate the amount of radiation that enters the Earth's atmosphere, the amount absorbed into it, the amount radiated back into space, and the amount trapped in our atmosphere — causing global warming. Expected to be launched in 1998, MODIS will be based on a polar-orbiting platform, where it will collect data for at least five years.

The first-ever cable TV system in the sky, WorldLink™, designed by Hughes, offers airline passengers a new level of comfort and convenience. Now in operation on Northwest Airlines 747 flights to the Pacific Rim, WorldLink provides a range of entertainment, shopping, business, communications, and tourist information. WorldLink gives each passenger a personal touch-screen, high-resolution liquid crystal display monitor, with full control of whatever programs and services they want. Passengers can even tap into the airliner's 200-megabit on-board computer, accessing a huge database of up-to-the-minute information on worldwide currency valuations, connecting flights, and hotel accommodations. Northwest eventually plans to install WorldLink systems on its entire fleet of airplanes.

Thailand will have its first domestic communications satellite system in 1993. Hughes will provide Bangkok's Shinawatra Computer Company with two HS 376 spin-stabilized satellites, as well as ground equipment and training support. These new spacecraft will be smaller, lighter-weight versions of the standard HS 376. Hughes' spacecraft have helped many countries establish commercial communications services, beginning with Canada in 1972.

Four major airports in the Ukraine may be completely modernized, with advanced technology and systems built by Hughes. The plan, which would focus on airports at Kiev, Odessa, Lviv, and Symferopol, is designed to automate these airports through electronic data interchange. Its objective is to integrate aircraft operations, passenger handling, air traffic control, security, and administration into one highly efficient unit. Using computer technology can dramatically enhance an airport's efficiency and service, and help it increase revenues and adhere to more stringent regulations.

A new laser transmitter could help the U.S. Army detect and identify chemical agents on the battlefield. Designed for fixed-site, vehicle, and airborne applications, this Hughes-built laser is the key component for a sensor system that provides stand-off coverage for detection of nerve gas, blister and other chemical warfare agents. It is capable of very high pulse repetition rates, enabling it to rapidly scan a wide area and detect low concentrations of chemical agents at extended ranges. In addition to military applications, this laser technology could be applied to environmental uses such as monitoring industrial chemical emissions and urban pollution.

For more information write to: P.O. Box 80032, Los Angeles, CA 90080-0032

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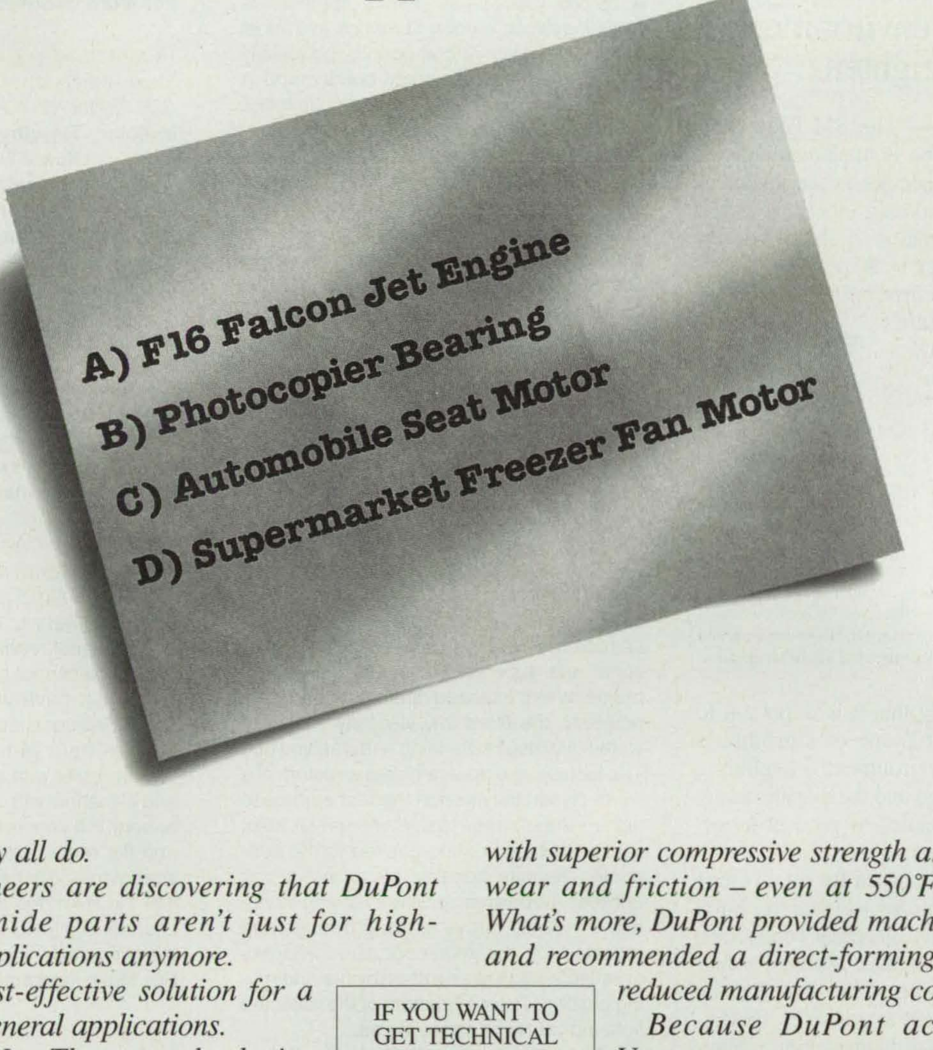

Actually, they all do.

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3M Reduces Solvents Used In Electrical Tape Manufacturing

Reduction of solvent usage assures users of future tape availability as worldwide environmental concerns heighten

AUSTIN, Tex. — The 3M Electrical Specialties Division is implementing solvent reduction processes in the manufacture of OEM insulating electrical tapes. The established goal is to reduce solvent purchases and usage by 80 percent.

Customers incorporating these insulating tapes in present products, re-designs and new products will be assured of a reliable source well into the 21st Century.

New sixteen page brochure describes over 50 Scotch electrical tapes for OEM applications, and other electrical insulation products.

3M is also taking a holistic view of its efforts to achieve a cleaner environment, believing that it is important to examine the full scope of a product's impact on the environment – beginning with product design and the manufacturing process, and extending to product usage, packaging and disposal.

The tapes are designed for use in OEM electrical applications to insulate, hold, protect and identify electrical conductors, components and circuits. Solvent reduction processes will be extended to as many OEM electrical tapes as possible. The following tapes with a thermosetting rubber-resin adhesive have already been released:

No. 2 and 38 Crepe Paper
No. 27 Glass Cloth
No. 46, MR 98 Polyester Film/Glass Filament
No. 44, 55, 1174, MR 93, MR 93B, MR 94, MR 94B Polyester Film/MAT
MR 96 Polyester Film

For more information, contact a 3M Electrical Specialties Division representative or authorized distributor, or call 1-800-328-1368.

3M Electrical Specialties Division
6801 River Place Boulevard
Austin, Texas 78726-9000

3M

NASA PATENTS

NASA has a portfolio of 3000 patents and pending applications available now for license by businesses and individuals, including these recently patented inventions:

Apparatus for Intercalating Large Quantities of Fibrous Structures

(US Patent No. 5,225,171)

Inventor: **James R. Gaier**, Lewis Research Center

A device intercalates fibrous compounds including silicon, carbon, ceramics, and, most importantly, graphite compounds, potentially advantageous as electrical conductors. A mat or cloth of a fibrous compound is rolled and inserted into a rotatable reaction chamber, which is sealed and evacuated. Sufficient liquid-phase intercalation to submerge the material and trigger a reaction when heated, cooled, or pressurized goes into the chamber, which is rotated. The resulting compounds yield conductivities two-ten times greater than untreated graphitized material and resistivities similar to silver.

For More Information Write In No. 740

Shear-Sensitive Monomer-Polymer Laminate Structure and Method of Using Same

(US Patent No. 5,223,310)

Inventors: **Jag J. Singh**, **Abe Eftekhari**, and **Devendra S. Parmar**, Langley Research Center

Shear-sensitive monomer cholesteric liquid crystals are used for flow visualization and surface temperature measurement in subsonic and supersonic wind-tunnel experiments. When exposed directly to wind flow, however, the film's low viscosity and poor wettability result in thinning and washing out. The technique uses a laminate structure of a liquid crystal polymer on the test surface to aid in shear-stress determination. A thin, light-absorbing coating applied to the substrate permits bonding steric interaction between the polymer and the overlying monomer thin film. Light is directed through and reflected by the monomer film, whereas unreflected light is absorbed by the underlying coating. The wavelength of the reflected light indicates the shear stress.

For More Information Write In No. 741

Miniature Modular Microwave End-to-End Receiver

(US Patent No. 5,218,357)

Inventors: **Lin M. C. Sukamto**, **Thomas W. Cooley**, **Michael A. Janssen**, and **Gary S. Parks**, Jet Propulsion Laboratory

Microwave communication and radiometric components are susceptible to errors due to temperature fluctuations in different parts of the system. These errors can affect measurement accuracy at radiation levels around 20-30 GHz that indicate atmospheric moisture concentration in studies of aircraft-wing ice formation and global warming. JPL researchers have devised an end-to-end modular microwave water vapor radiometer, including an antenna and single heat sink, contained in a hybrid package several centimeters in length and a few centimeters in height and width. Use of an L-shaped substrate permits the mounting and connection of many integrated circuits and provides unlimited access along three orthogonal directions, as well as a temperature-impervious digital signal at the output end.

For More Information Write In No. 742

Programmable Remapper With Single Flow Architecture

(US Patent No. 5,208,872)

Inventor: **Timothy E. Fisher**, Johnson Space Center

Mapping and transforming a real-time video image to produce rotation and scale invariance in the output, while still in the spatial domain, substantially eliminates the rotation and scale sensitivity requirements of a transformed image's optical correlators. A novel remapper comprises numerous subprocessors for parallel reception and transformation of a digital image and for producing an output matrix of the transformed image that is the same size and shape regardless of changes in size or rotation of the input image.

For More Information Write In No. 743

Fill Yarn Insertion and Beatup Using Inflatable Membrane

(US Patent No. 5,188,153)

Inventor: **Gary L. Farley**, Langley Center

Conventional reeds used to beatup fill yarn in a fabric cannot be used in structural preforms that have yarns oriented along the fabric bias because elements of the reed hit the bias warp yarn. Mr. Farley's apparatus uses a rapier with a means for holding yarn and a channel with a flexible inflatable cover or boot. Fill yarn is inserted into the channel and the rapier extended into a shed in the warp yarns. After actuators push the rapier into the fell of the fabric, the cover over the channel is inflated, inserting the yarn into the fell and performing beatup along the bias.

For More Information Write In No. 744

Planar Microstrip Yagi Antenna Array

(US Patent No. 5,220,335)

Inventor: **John Huang**, Jet Propulsion Laboratory

Mr. Huang has designed a directional microstrip antenna array that includes a dielectric substrate having a groundplane on the first surface and a driven patch on the second. The driven patch's surrounding isolated reflector and one or more coplanar directors are separated from the groundplane by 0.1 wavelength or less. This provides endfire beam directivity without requiring power dividers or phase shifters. The configuration can conform to the shape of a mobile unit such as an airplane wing while providing the highly directional antenna patterns achievable with Yagi dipole arrays.

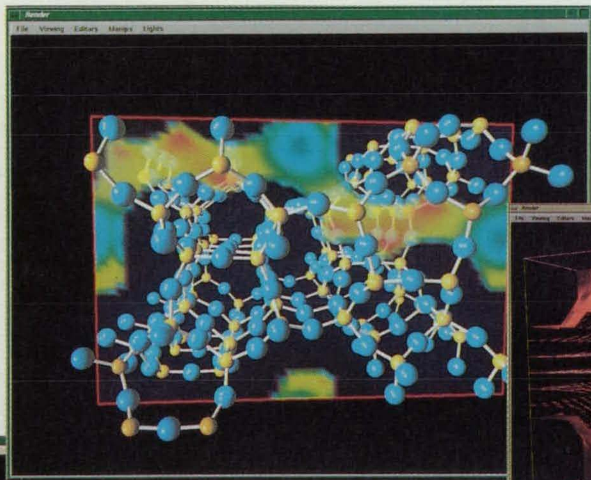
For More Information Write In No. 745

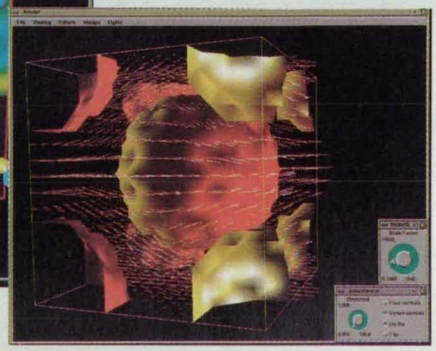
IRIS Explorer™

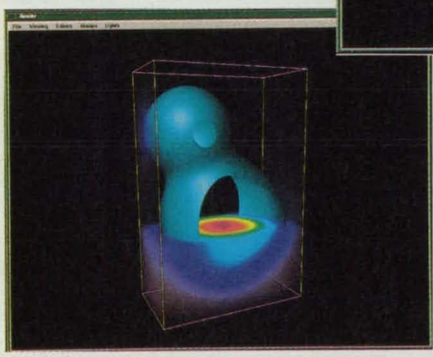
Get back to the business of problem solving

Take a look at IRIS Explorer. -the new generation visualisation package.

It can provide you with real understanding of your data with the minimum of effort. Already in use at thousands of sites on Silicon Graphics systems, IRIS Explorer is now becoming available on computers from Sun Microsystems, Hewlett-Packard, IBM, Digital Equipment Corporation and Cray Research.







Make it easy

With IRIS Explorer, you can inter-actively create applications for analysing complex multi-dimensional datasets – often without any programming at all. Simply choose modules from the IRIS Explorer library, connect them together using a point-and-click interface, then run the application you've created.

It's as easy as that.

Plug and play time

You can select from an extensive range of visualisation techniques. Try out contours, slices, vectors, streamlines, edge detection or filtering; combine techniques – add a key to the image – create an animation – annotate it – move it round. It's right in front of you.

Get it all together

Over 140 modules are bundled with IRIS Explorer to read, sample, transform and display data. IRIS Explorer also contains powerful tools which make writing your own modules easy. Many of your existing programs will make suitable IRIS Explorer modules, with little work!

When you've got your application the way you want, you can deliver it as a stand-alone solution. IRIS Explorer makes it easy to interactively design the user interface by choosing the control widgets from the modules which your users will want to see. They get just the functionality they require – you get their solution to them faster.

Use your power

You can use the full range of workstations in your organisation to solve your problem. You can use the same simple point-and-click interface to select modules from any machine on the network which is running IRIS Explorer and then distribute your computing or visualisation task across the network.

Get the picture

When you can visualise your data, you can work with it in a new way – see what you"re doing – show it to others – make the right decisions.

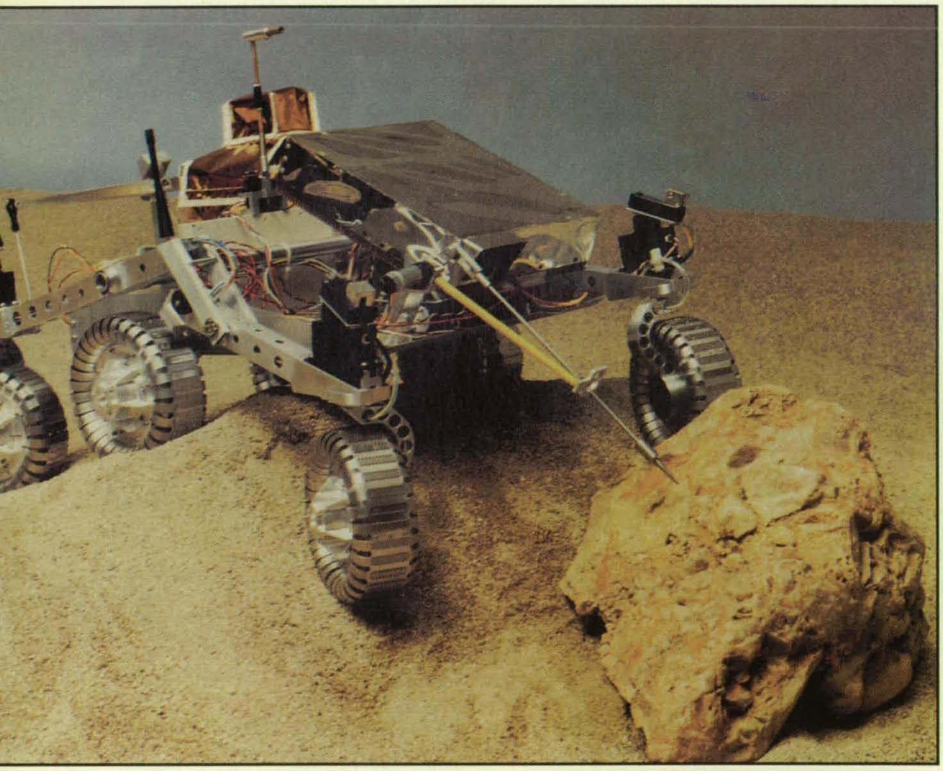
Why not take a look at IRIS Explorer. It's just waiting to help you.

IRIS Explorer Centre (Europe) PO Box 50 OXFORD OX2 8JU UK. Tel: +44 (0)865 516377 Fax: +44 (0)865 516388 e-mail: helpdesk@iec.co.uk
IRIS Explorer Centre (N. America) 1400 Opus Place Suite 200 Downers Grove IL 60515-5702 USA Tel: +1 708 971 2376 Fax: +1 708 971 2706 e-mail: infodesk@nag.com

For More Information Write In No. 554

Exhibits Preview

Technology 2003 (December 7-9, 1993, Anaheim, CA convention center) will feature 80,000 square feet of exhibits by federal labs, industry, and academia demonstrating new inventions, products, and processes offered for license or sale. The event began in 1990 as a showcase of NASA technology, and has grown to become the world's largest and most diverse technology transfer conference and exhibition. Following is a list of this year's exhibitors.



Jet Propulsion Laboratory will demonstrate Rocky IV, an intelligent microrover developed to validate possible NASA mission scenarios, particularly Mars exploration. The robot's navigation and sensing technologies may prove useful on Earth for remote surveying and environmental monitoring.

Booth

Aerospatiale 809
Les Mureaux Center, France,
will highlight its role in various European space projects and exhibit new products and technologies in such areas as thermal protection, magnetic bearings, and HP filament winding.

Alberta Economic Development and Tourism 1133
Edmonton, Canada,
will feature resources for technology development in the province of Alberta as well as university technology transfer centers. Co-exhibitors include the Alberta Microelectronic Center, Calgary Research and Development Authority, Economic Development Edmonton, Alberta Heritage Foundation for Medical Research, Alberta Research Council, University Technologies International, and the University of Alberta.

Allied-Signal—Kansas City Division 230
Kansas City, MO,
will showcase manufacturing process capabilities with an emphasis on rapid and environmentally-conscious manufacturing.

Altron Inc. 810
Anoka, MN,
provides custom electronic assembly from printed circuit boards to complete products to UL, CSA, MIL, and FDA requirements. Also available are SMT and through-hole capabilities with in-circuit or functional testing and special process development for production of unusual projects.

American Inventors Corp. 309
Westfield, MA,
will exhibit new inventions and patents available for licensing or sale to manufacturers, small businesses, or venture capitalists. Categories include toys, security, housewares, sporting goods, and novelties.

Arnold Engineering Development Center 132
Arnold Air Force Base, TN
The AEDC will demonstrate unique aerospace ground test capabilities in simulating flight and space environments, including specialized test and analysis technologies developed at the center.

Austrian Trade Commission 1032
Los Angeles, CA,
will showcase high technology, R&D, patents, products, and services available for licensing and joint ventures, including opportunities for US companies for technical and R&D cooperation in Austria.

Axiomatics Corp. 225
Woburn, MA,
will feature leading-edge technology for microcellular foam, ice detection, and moisture detection.

Ballistic Missile Defense 329
Organization Technology Applications Program
Washington, DC,
is responsible for transferring BMD-funded technologies to the commercial marketplace and other government agencies. Spinoffs with medical, electronics, optics, computer, energy, materials, and manufacturing applications will be exhibited.

BF Goodrich Aerospace/Simmons Precision 311
Vengennes, VT,
will highlight optical speed and torque measurement, noncontact fuel interrogation systems, and integrated vehicle utilities management systems.

BHK Inc. 525
Pomona, CA,
will demonstrate two new light sources—MAXIR™ and HOTSPOT™—and electro-optics capabilities.

Boeing Defense & Space 420
Huntsville, AL,
will highlight Space Station, an international laboratory in space where scientists and technologists will carry out unprecedented research.

Brookhaven National Laboratory 341
Upton, NY,
will focus on basic and applied research in the physical, biomedical, and environmental sciences and in selected energy technologies.

Bulova Technologies Inc. 304
Lancaster, PA
"Watchworking" skills for ultra-precision machining are available in Bulova's design, prototype, and manufacture of mechanical, electronic, and electromechanical assemblies.

California Manufacturing Technology Center 641
Hawthorne, CA,
assists small- and medium-sized manufacturers to increase their productivity and competitiveness through improved methods of manufacturing and management of the total enterprise.

Canadian Consulate General 1127
Los Angeles, CA,
promotes high technology goods and services from Canada to interested US companies and assists US companies seeking Canadian strategic partners for mutually beneficial technology exchange.

Canon Communications Inc. 324
Santa Monica, CA,
publishes trade magazines and other publications for the medical device and contamination control industries. Titles include *Medical Device & Diagnostic Industry, Medical Manufacturing News, Microcontamination,* and *Designer's Handbook: Medical Electronics.*

Catalyst Advertising 409
Fallbrook, CA,
will focus on 3000 patents for license. More than 10,000 product requests have been received from manufacturers, newspaper publishers, and databases.

Center for Optics Manufacturing 910
Rochester, NY
Center representatives will provide materials on current programs such as Opticam, Opticim, Process Science, Optimod, and Magnetorheological Finishing.

Centro Estero 1016
Torino, Italy
The Centro Estero Camere Commercio Piemontesi is a foreign trade center established to promote and develop international business relations and high technology exchanges.

Coastal Systems Station 744
Panama City, FL
Federal laboratories and four research universities will describe unique technology and test facility assets available in numerous technological fields, including materials, biology, environmental science, explosives, sensory, and superconductivity.

The Consortium of Navy Laboratories 408
China Lake, CA
Ten US Navy laboratories will be represented at this exhibit. The product areas in which they perform research encompass a broad spectrum of technical research and development. The laboratories to be represented are: Naval Air Warfare Center: Aircraft Division—Indianapolis, IN; Patuxent River, MD and Warminster, PA. Weapons Division—China Lake, CA and Point Mugu, CA. Training Systems Division—Orlando, FL. Navy Command, Control, and Ocean Surveillance Center: RDT&E Division—San Diego, CA. Naval Facilities Engineering Service Center, Point Hueneme, CA. Naval Surface Warfare Center, Dahlgren Division, Silver Spring, MD. Naval Undersea Warfare Center, Newport, CA.

Corning Inc. 212
Corning, NY,
is seeking to license or partner its materials science and process engineering technologies involving glass, ceramics, glass-ceramics, and composite materials.

COSMIC/The University of Georgia 819
Athens, GA
NASA's Computer Software Management and Information Center (COSMIC) will demonstrate software developed or funded by NASA and available for use in industry, education, and government.

Cybernet Systems Corp. 122
Ann Arbor, MI,
will showcase a six-axis, force-reflecting robotic handcontroller interfaced to a virtual reality graphical world. Applications include molecular modeling and teleoperation for hazardous environments.

DATATAPE Inc. 204
Pasadena, CA,
will display high-performance rotary digital and analog magnetic tape recording systems for various military, aerospace, and commercial applications.

Delta Tau Data Systems 308
Northridge, CA,
will display DSP-based multi-axis controllers with sophisticated, flexible control algorithms, motion descriptions, and analytic tools.

Diamonex Inc. 426
Allentown, PA,
manufactures polycrystalline and amorphous diamond-coated products for the electronics, optics, and medical industries that offer high-performance, scratch and corrosion resistance, and longer wear.

Earth Data Analysis Center and ASPRS 522
Albuquerque, NM,
will highlight remote sensing and geographic information system applications. The American Society for Photogrammetry & Remote Sensing is a scientific association serving over 8000 members worldwide, including remote sensing specialists, photogrammetrists, GIS specialists, cartographers, surveyors, and geodesists.

Earth Observation Magazine 520
Aurora, CO,
is an international publication integrating GIS, remote sensing, and gas image processing to find solutions in environmental resource infrastructure management.

Edgewood Research, 439
Development, and Engineering Center
Aberdeen Proving Ground, MD,
provides opportunities in passive IR/IMS sensor technology, air purification/ventilation, bioremediation, molecular modeling, aerosol science, toxicology, animal test alternatives, and biopolymer/tandem mass spectrometry.

EG&G Mound Applied Technology 327
Miamisburg, OH,
is a Department of Energy technology development/production site specializing in developing manufacturable products using an on-site, fully-equipped scientific laboratory, a modern machine shop, and production capabilities.

The Enright Company 715
Tustin, CA,
will exhibit Coreco frame grabber boards, communication specialties, "scan-do" scan converters, and PULNIX video cameras.

Ergonomic-Interface Keyboard Systems 403
La Jolla, CA,
will display a novel keyboard design that offers a potential solution to repetitive motion injuries suffered by computer users. The invention's easy-to-use, vertically-arranged keyboard halves reduce the risk of injury by permitting users to position their bodies in optimal alignment with the keyboard.

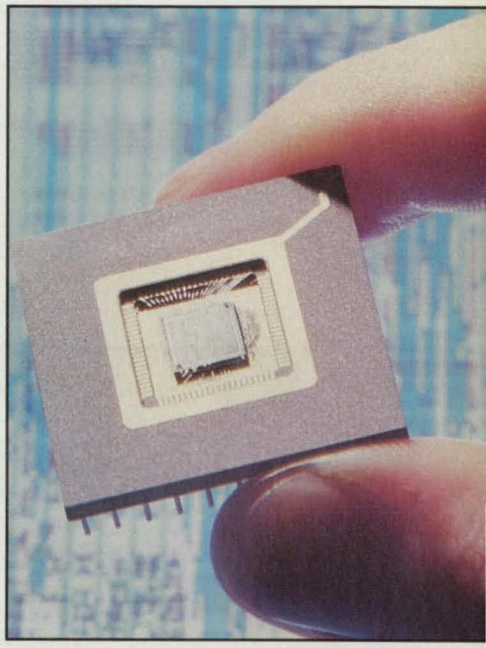
ESL Inc., a subsidiary of TRW 208
Sunnyvale, CA,
will demonstrate its VP5000 wideband signal analysis system, an integrated wideband data acquisition, playback, and processing workstation based on custom and commercial NuBus cards and high-performance application software.

ETH Zurich Electronics Laboratory 1028
Zurich, Switzerland,
is a research/technology transfer center for electronics, biology, chemistry, physics, mechanical engineering, and computer science. The exhibit will feature a desktop supercomputer.

Federal Aviation Administration 644
Atlantic City, NJ,
will showcase technologies currently under development/deployment in the FAA including GPS, aircraft safety, ATC, airport capacity and runways, human factors, surveillance, and radar technology.

Federal Highway Administration 237
Capitol Heights, MD,
will highlight the latest technologies for pavements, structures, safety, and traffic, as well as the Intelligent Vehicle-Highway Systems.

Federal Laboratory Consortium 229
Sequim, WA,
provides access to technical expertise and unique facilities available in the federal laboratories.



Hughes' exhibit will include integrated circuit and multi-chip advances for OEM design applications.

Great Lakes Composites Consortium 305
Kenosha, WI,
will detail its role in developing composites technology through the Navy Center of Excellence for Composites Manufacturing Technology and the transfer of that technology to commercial applications.

HEMCO Corp. 816
Independence, MO,
will exhibit the Unilab, a preengineered modular room structure built to meet cleanroom, environmental control, and insulated self-contained lab enclosure specifications.

Hewlett-Packard Co. 804
Rockville, MD,
will display industry-leading, high-performance workstations available on the SEWP contract, as well as applicable software, including imaging technology.

Hughes Microelectronics 921
Newport Beach, CA
The firm manufactures silicon semiconductors, hybrid packaging, multichip modules, RF subsystems, and microwave/millimeter-wave ICs.

Idaho National Engineering Laboratory 233, 938
Idaho Falls, ID,
will showcase nuclear reactor research, waste treatment technology, materials research, biotechnology, chemical sciences, applied engineering, and rapid prototyping. INEL also will exhibit the CyberTran system, an affordable, high-speed, energy-saving mass transit system that is an electrically-powered steel-wheel-on-steel-rail.

IIT Research Institute 323
Rome, NY
IITRI's Engineering and Information Systems Division focuses on reliability, logistics, software science and engineering, manufacturing technologies, environmental remediation, and pesticide residue analysis. IITRI applies these technologies to problem solving services for industry and government.

IIT Research Institute, MTIAC 542
Chicago, IL
The Manufacturing Technology Information Analysis Center (MTIAC) is a full-service DOD Information Analysis Center, providing manufacturing-related information services to government agencies, contractors, and the US manufacturing community. MTIAC features the SIMON Database of MANTECH Projects, the Directory of Manufacturing Research Centers, and the *Current Awareness Bulletin*, along with customized research and referral services.

Indiana University 407
Office of Technology Transfer
Bloomington, IN,
is dedicated to the transfer or commercialization of intellectual property and the development of industry collaboration at all IU campuses, including the Schools of Medicine and Dentistry.

Infolytica Corp. 512
Montreal, Quebec,
will demonstrate MagNet5, a 2D/3D electromagnetics software package that runs on PCs, workstations, and superminicomputers. MagNet5 is available as a yearly lease or purchase.

Information Handling Services 128
Englewood, CO
IHS provides the world's largest collection of technical and regulatory information systems, including military standards and specifications, industry and international standards, and manufacturer catalogs on CD-ROM.

Ingenieurschule Biel 1026
Biel, Switzerland,
will exhibit the "Spirit of Biel" solar car, a microspace PC for embedded industrial controlling, and the Spoken Teletext, an information source for the blind.

INPEX 603
Pittsburgh, PA
The Invention/New Product Exposition (INPEX) is an international event showcasing inventions, new products, and innovations to business and industry. The 1993 event featured 500 exhibits displaying over 1000 inventions.

Integrated Sensors Inc. 910
Utica, NY
The firm's Object Position and Attitude Determination System tracks an object in real time and provides measurements of its position and angular orientation. Typical applications include robotic control, automatic docking, and assembly line analysis/position and tracking.

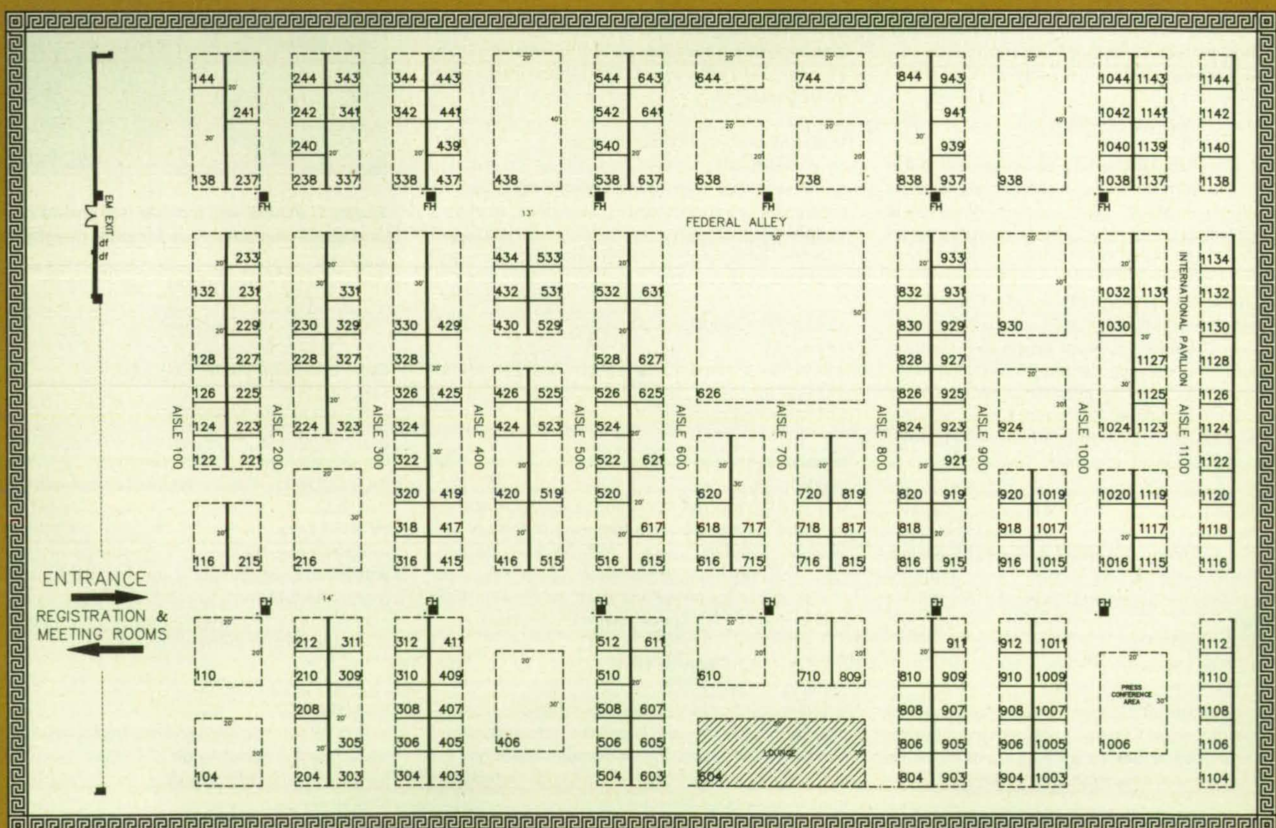
JFW Industries 228
Indianapolis, IN,
a leading designer and manufacturer of RF and microwave products, will exhibit RF switches, manual, fixed, and programmable attenuators, and switch matrices.

KINESIX 231
Houston, TX,
will exhibit Sammi, a dynamic user interface builder/prototype tool that presents and manages data, commands, and events from multiple processes in a single integrated graphical interface. Sammi supports both client/server and peer-to-peer communication models.

Knowledge Express Data Systems 516
Wayne, PA,
provides a unique collection of databases to significantly enhance technology matchmaking. Subjects include: government solicitations, ongoing research, licensable technologies, company R&D activities, corporate partnerships, and company technology/product needs.

Lawrence Berkeley Laboratory 312
Berkeley, CA
LBL is a major national laboratory with 3000+ employees, a $260M annual budget, and expertise in energy, environment, materials, computing, and biotechnology.

Exhibit Hall Floor Plan



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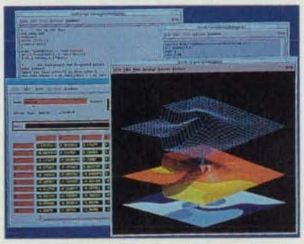

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For More Information Write In No. 494

Lawrence Livermore National Laboratory 425
Livermore, CA,
specializes in measurement and diagnostics, computational science and engineering, lasers and optics, manufacturing engineering, electronic systems, engineered material, applied physics and chemistry, atmospheric science and geosciences, bioscience, and environmental sciences.

Lockheed Missiles & Space Co. 110
Sunnyvale, CA,
will highlight new technology and advanced projects that have non-defense-related applications such as medicine, health, safety, infrastructure, and environment.

Los Alamos National Laboratory 241
Los Alamos, NM,
will demonstrate its latest advances in manufacturing technology, materials sciences, computational modeling and simulation, environmental technology, and biotechnology.

Machida Inc. 912
Orangeburg, NY,
will exhibit a complete line of flexible fiber-optic borescopes for visual inspection. Light sources, video systems, and borescope accessories also will be displayed.

Macsyma 316
Arlington, MA,
offers a powerful mathematical software package that combines symbolic, numerical, and graphic mathematics in a user-friendly environment.

Metro Utah Inc. 417
Salt Lake City, UT
Three major research universities will highlight state-of-the-art resources and leading-edge technology development in the state of Utah.

Mid-Atlantic Technology Applications Center (MTAC) 718
Pittsburgh, PA
MTAC provides a wide range of technology management services and specializes in technology transfer from federal agencies and a broad variety of other organizations.

NAC Visual Systems 716
Woodland Hills, CA,
will demonstrate visual systems featuring high-speed video, color, and up to 100 pictures per second.

NASA 626
Washington, DC
NASA's R&D mission programs will be highlighted together with a "theater island" describing key technologies resulting from the nation's space program. Spinoffs from aeronautics and space research will be displayed along with new technological advances from the National AeroSpace Plane (NASP).

NASA Ames Research Center 625, 627
Moffett Field, CA,
will demonstrate its Virtual Wind Tunnel, which generates 3D simulations of flows around aircraft, and other demonstrations based on artificial intelligence, imaging, and simulator training.

NASA Center for AeroSpace Information 626
Baltimore, MD
NASA's technology transfer program will exhibit spinoff products developed by industry utilizing NASA-generated technology. Technology transfer specialists will explain how the professional community can tap into NASA's vast storehouse of available technology.

NASA Far West RTTC 818
Los Angeles, CA,
is an agent of new technologies providing local access to national laboratories serving Alaska, Arizona, California, Hawaii, Idaho, Nevada, Oregon, and Washington.

NASA Goddard Space Flight Center 832
Greenbelt, MD
Exhibits will include an Earth alert system, a handheld device that detects and warns against severe weather conditions such as typhoons and hurricanes. An instrument flown on small aircraft for topographical agriculture and oceanographic studies also will be on display.

NASA Jet Propulsion Laboratory 824
Pasadena, CA
JPL's Technology Affiliates Program provides technical services to transfer JPL-developed technology to private industry.

NASA Jet Propulsion Laboratory/ Robotics Display 820
Pasadena, CA,
will demonstrate NASA-wide telerobotics dual-use capabilities and technologies in surface inspection, servicing and maintenance, planetary exploration space science experiments, and remote operation.

NASA John C. Stennis Space Center 826
Stennis Space Center, MS

NASA Johnson Space Center 830
Houston, TX,
will feature various hardware, computer, and video demonstrations of commercial applications for virtual reality, artificial intelligence, robotics, antenna technology, photonics, environmental technology, and biotechnology.

NASA Kennedy Space Center 631
Kennedy Space Center, FL,
will display an advanced visual database, a self-configuring universal signal-conditioning amplifier, a digital wireless voice network, an internal water-driven pipe/tube cleaning device, a visual wind direction indicator, and a kinestatic platform.

NASA Langley Research Center 720
Hampton, VA,
will demonstrate hardware and software for medical, materials, instrumentation, and fabrication applications. The ASTER (Advanced Software Technology for Engineering Reliability) will be displayed.

NASA Lewis Research Center 828
Cleveland, OH
This exhibit will feature three multi-use technologies: dielectric sensors to continually measure aircraft wing icing; an ion exchange material for removal of heavy metals from waste water; and a diamond-like carbon coating that makes prescription eyeglass lenses scratch-resistant.

NASA Marshall Space Flight Center 621
Huntsville, AL,
will display a new lithium-aluminum alloy, industrial computed tomography, robotics simulation software, a water window x-ray microscope, a versatile shuttle-derived foam for industrial uses, and other technologies.

NASA Regional Technology Transfer Centers 717
Washington, DC
This exhibit will spotlight the six regional technology transfer centers that work with federal and state technology transfer activities to help US industry gain access to over 700 federal laboratories and other sources of technology for commercial and industrial use.

NASA STI Program 817
Arlington, VA,
a leader in the production, dissemination, and retrieval of scientific and technical information, includes research organizations around the nation and information exchange partners around the world.

NASA Tech Briefs 617
New York, NY
Reaching over 200,000 engineers and executives throughout industry and government, *NASA Tech Briefs* magazine has first publishing rights to the latest technologies developed by NASA and its contractors.

National Center for Toxicological Research 242
Jefferson, AR,
will highlight research programs focusing on: analytical methods development, applied and environmental microbiology, applied toxicology, biochemical and molecular markers of cancer, developmental toxicology, neurotoxicology, nutritional modulation of risk and toxicity, and transgenics.

National Institute of Standards and Technology 637
Gaithersburg, MD
NIST's Technology Services help businesses take advantage of federally-funded research. The group manages the regional Manufacturing Technology Centers program, distributes standard reference materials and data, and coordinates equipment calibrations for improving industrial, environmental, and medical quality control.

National Security Agency 933
Fort Meade, MD,
will exhibit microelectronics, advanced communications, high-performance computing, high-speed networking, and information security technologies and techniques.

National Space Society 504
Washington, DC
This exhibit will feature materials for space advocates, including the bimonthly magazine *AD ASTRA*, and information on participating in educational activities and political grassroots support of the civil space program.

National Technology Transfer Center 620
Wheeling, WV
Services include a toll-free telephone gateway (800-678-NTTC) providing callers from business and industry with free person-to-person contacts leading to technology, expertise, and facilities in the federal laboratory system.

Naval Research Laboratory 416
Washington, DC,
will exhibit R&D programs available for licensing in the areas of advanced materials, bio-molecular engineering, chemical processing, electronics, optics, sensors, and information technology.

NERAC Inc. 124
Tolland, CT,
provides problem-solving assistance through a unique combination of highly-skilled technical specialists, multi-database investigations, technology and competitive tracking, and expert matching and document retrieval.

Neuralware Inc. 223
Pittsburgh, PA,
will display the Professional II/Plus version 5.0, the world's standard in network development systems, and its latest releases specific to the control industry.

Novecon Technologies 1115
Reston, VA,
provides world-class technology from Eastern Europe and the CIS, delivered in less time and at less expense than any competitor or individual company acting alone.

CyberResearch PC Products for Scientists & Engineers

NEW PRODUCT SHOWCASE

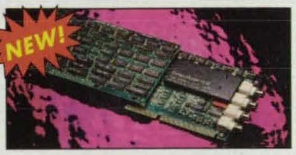
CyberDAS MetraByte™ Compatible Data Acquisition I/O Boards

A NEW Family of High Performance Direct Replacements for the DAS-8 & DAS-16.

• The Lowest Prices* • DOS & Windows Support • 100% Keithley MetraByte Compatibility

Part Number	#CYR-DAS	8	16	800	801/2	1201/2	1401/2	1601/2
Price		$185	$785	$285	$345	$365	$385	$585
Analog Inputs	Channels	8 SE	16 SE/8 Diff	8 SE	8 SE/8 Diff	16 SE/8 Diff	16 SE/8 Diff	16 SE/8 Diff
	Resolution	12-bit	12-bit	12-bit	12-bit	12-bit	12-bit	12-bit
	Max Sample Rate	4-20 KS/s	50 KS/s	40 KS/s	40 KS/s	50/100 KS/s	100 KS/s	100 KS/s
	Input Range:	±5V	±10V	±5V	±10V	±5V	±10V	±10V
	Gain:	Fixed Input	.5,1,2,5,10 1,2,4,8	Fixed Input	1,10,100,500 or 1,2,4,8	1,10,100,500 or 1,2,4,8	1,10,100,500 or 1,2,4,8	1,10,100,500 or 1,2,4,8
	Gain Set	N/A	Switch Sel.	N/A	Programmable	Switch Select	Programmable	Programmable
Analog Outputs	Channels, Resolution Ranges	-	2 Channels, 12-bit, 0-5V	-	-	-	-	2 Channels, 12-bit 0-5,10V; ±5,10V
Digital I/O	Number of Bits	3 in, 4 out	4 in, 4 out	3 in, 4 out	3 in, 4 out	32	4 in/ 4 out	32

*Call for Details on Quantity Discounts for Large Volume Users and OEMS.



NEW 12-Bit, 20 MHz Digital Oscilloscope Card Breaks Old Speed Records by an Order of Magnitude

If you've been looking for a precision 12-bit A/D board with the fastest possible conversion rate, then you know that there just aren't any out there faster than 1MHz – 2MHz. Until now. Our new **CompuScope™** bursts through the old limits. It doesn't just improve the old record by 10% or even by 100%. It achieves sampling rates **10 times faster than anything on the market.**

Our **DSO 2012** uses 2 monolithic flash converters, each running at 10MHz. In single-channel mode, the 2 ADC's are clocked in a "ping-pong" mode to achieve up to 20 MSamples/second. Programmable gain amplifiers and offset control circuits ensure measurement accuracy. On-board memory is mapped in the PC's own system memory for the fastest possible data transfers.

#DSO 2012 20MHz, 12-bit A/D Digital Scope Card with 512K RAM **$4995**
#DSO 2012-1M 20MHz, 12-bit A/D Digital Scope Card with 1 MByte RAM **$5495**

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- Hold-Down for Firmly Seated Expansion Cards.
- Floppy & IDE Hard Disk Controller Included.
- Dual-Fan Cooling System w/Honeycomb Filter.
- Rack-Mounting Slide Rails Included FREE.

#VRK 486-33 Rack-Mount 33MHz 80486 PC w/VGA Monitor, Rack-Mount Keyboard, & 4MB RAM **$4295**
#VRK 486-50 Rack-Mount 50MHz 80486 PC w/VGA Monitor, Rack-Mount Keyboard, & 4MB RAM **$4595**
#VRK 486-50E Rack-Mount 50MHz EISA-Bus 80486 PC w/VGA Mon., R-M Keyboard, & 16MB RAM ... **$5995**
#OIX 3010 Low Cost Rack-Mount Keyboard........... **$295**
#OIX 6010 Rack-Mount Industrial Keyboard......... **$395**

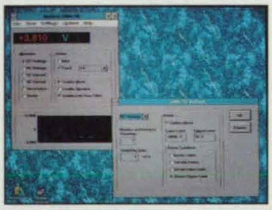
Rack-Mount Keyboards

New OIX rugged industrial keyboards fit into any EIA 19" rack. Only 1 rack space (1.75" high). A door keeps keys safe when not in use. Full 101-key layout.

Low-Cost Digital Multi-Meter from Quatech

The NEW **QDMM 100** features an on-board micro-controller which allows it to perform intelligent functions. In addition to taking measurements of:

- AC/DC voltages
- AC/DC current
- resistance & continuity



Its on-board intelligence allows it to handle such functions as:

- averaging
- alarm state monitoring
- auto-calibration & auto-ranging

The **QDMM 100** comes complete with both ready-to-run menu-driven software and software drivers for custom applications. Menu-driven software runs under DOS and Windows and provides curve plotting and data logging to disk. Drivers are supplied for C, Turbo Pascal, QuickBASIC, Visual BASIC, and a DLL for Windows application development.

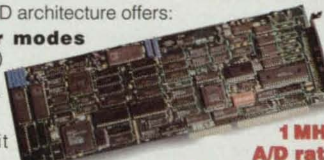
#QDMM 100 3.75-Digit Multi-Meter with Software for Windows & DOS....... **$495**

NEW!

Breakthrough 1 MHz A/D Board from UEI

Samples over 1 million times per second, for less than $1,000!

The high performance **WIN 30D** A/D architecture offers:



- **High speed data transfer modes** (Burst Mode DMA & REP INSW) allow 1MHz data transfer direct to PC memory. No need for expensive RAM buffers.
- Data packing fits four 12-bit samples into three 16-bit Words.
- Software configured, with user-defined channel scan listing.
- **Includes:** ***Status 30*** Menu-Driven Software, Source code in C, and Drivers for DOS & Windows 3.1, NOTEBOOK, LabWindows & SnapMaster.

1 MHz A/D rate w/On-board DSP & FIFO Buffer Memory

#WIN 30D 1 MHz AT-Bus Data Acquisition Board... **$995**
#WIN 30GL/H 1 MHz A/D Board with Programmable Gains-Low & High-Level... **$1295**
#WIN 30S 16-Channel Simultaneous Sampling A/D Board (750kHz)............ **$1495**
#INST 347Z 50-Pin Screw Terminal Block with Shielded Cable **$165**
#WIN BNC BNC Terminal Interface with Shielded Cable................................. **$395**

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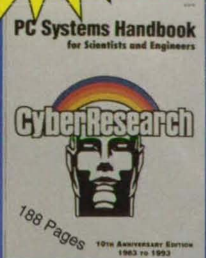
10th Anniversary Edition – 188 Pages Combination Tutorial/Catalog Includes Many Examples of PC-based Systems



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Novespace 710
Paris, France,
will describe European technology transfer networks established around Novespace and will feature various technology catalogs.

Oak Ridge National Laboratory 429
Oak Ridge, TN
The Metals and Ceramics Division will exhibit technologies available for licensing to private industry in the areas of intermetallic alloys, ceramics and ceramic matrix composites, polymer matrix composites, and various testing devices.

Olympus Corp.—IFD 224
Lake Success, NY,
will feature high-magnification borescopes and fiberscopes for vacuum video inspections and industrial applications.

Pacific Coast Technologies 911
Wenatchee, WA
PCT manufactures high-reliability hermetic connectors, feedthroughs, packages, cases, modules, and fiber-optic termini using polycrystalline ceramic seals.

Pacific Northwest Laboratory 338
Richland, WA
The Department of Energy's Pacific Northwest Laboratory offers federally-developed technologies to the private sector through licenses, cooperative research and development agreements, technical assistance, and staff exchanges.

Princeton University Plasma Physics Lab 937
Princeton, NJ,
will highlight federal technology developed at this DOE Plasma Physics Laboratory.

Proto Manufacturing 310
Detroit, MI,
develops automated nondestructive test systems and services utilizing eddy current, ultrasonic, and x-ray diffraction techniques. Products include the world's smallest XRD stress measurement system.

R.G. Hansen and Associates 919
Santa Barbara, CA,
provides laboratory cryogenic systems and components supporting spectroscopy sample cooling, materials research, IR detector cooling, and custom cryogenic systems, including Joule-Thomson cryostats.

RAMOT/University Authority for Applied 1117
Research and Industrial Development Ltd.
Tel-Aviv, Israel,
coordinates R&D and technology transfer from Tel-Aviv University in the fields of electronics/electro-optics, computer sciences, biotechnology, and health care (pharmaceuticals and diagnostics).

Racal-Dana Instruments Inc. 210
Irvine, CA,
will display test and measurement products including modular VXIbus products as well as complete system solutions.

Ragan Technologies Inc. 227
San Diego, CA,
offers a new system for manufacturing green tapes that is compatible with nearly all ceramic, glass, metal, and organic powders.

Research Systems Inc. 1011
Boulder, CO,
will exhibit IDL, an integrated scientific computing environment for developing custom science and engineering applications. Its comprehensive mathematical analysis and graphical display capabilities help researchers to make discoveries in physics, remote sensing, astronomy, test and measurement, and medical imaging.

Resonetics Inc. 221
Nashua, NH,
will exhibit advanced laser micromachining technology, including excimer laser systems, accessories, optics and beam delivery systems, excimer laser machining and microprocessing capabilities, and contract processing services.

Rexham Custom 411
Matthews, NC,
provides custom coating, laminating, and film casting from development to worldwide production. The company specializes in precision, high-performance materials for the electronic, medical, aerospace, and graphic arts markets.

Rockwell International 104
Canoga Park, CA
Rockwell's Rocketdyne and Space Systems divisions will display NASD/Space Shuttle Main Engine (SSME)-derived transferrable technologies, as well as related Defense Conversion projects.

SAMPE 915
Covina, CA,
is an international society dedicated to the exchange of data on new materials and processes. The society sponsors technical conferences and exhibitions, and publishes proceedings and technical publications.

Sandia National Laboratories 216
Albuquerque, NM
Sandia's Remote Sensing and Verification Program supports US treaty negotiation/monitoring, national defense/security, and space, nonproliferation, environmental, seismic research, and other public/private programs. The Intelligent Systems and Robotics Center is developing core technologies that enable solutions to critical national problems in manufacturing, the environment, and defense.

Society of Automotive Engineers Inc. 615
Warrendale, PA
SAE publications and databases are recognized worldwide as a premier source of automotive and aerospace technology. This exhibit will demonstrate how SAE's resources can help locate or transfer leading-edge technologies.

Sonic Perceptions Inc. 815
Norwalk, CT,
specializes in binaural sonic capture and analysis (psychoacoustic workstations), eight-channel binaural mixing console (real-time/program-controlled directionalization for auditory display), virtual reality, and communications analysis systems.

Sonoscan Inc. 303
Bensonville, IL,
will feature Acoustic Micro Imaging (AMI) Systems and laboratory services for nondestructive analysis of materials, micro-electronics, and assemblies for internal flaws and defects such as cracks, delaminations, voids, porosity, and inclusions.

Spire Corp. 318
Bedford, MA
The company's epitaxial III-V compound semiconductor wafers and devices for optoelectronic applications include diode lasers, LEDs, optical waveguides, laser power converters, and solar cells.

State/Industry-University 322
Cooperative Research Center
San Antonio, TX,
is a liaison between industry and university researchers facilitating technology transfer and communication. Research areas include cell regulatory mechanisms, aging, and biomaterials.

Swiss Federal Office of Industry and Labor 1024
Bern, Switzerland,
will highlight Switzerland's place in the center in Europe's high-tech industry, providing an innovative environment for new business and investment.

TCAM Technologies 808
Eastlake, OH,
will display a radical new mechanical actuation system that projects many engineering improvements over the state of the art. TCAM is seeking potential licensees for its technology in fields including valve actuators, automotive and appliance actuators, and aerospace actuation products.

Technology 2004/ 1303
Technology Utilization Foundation
New York, NY
Information will be available on Technology 2004, the fifth national tech transfer conference and exposition, to be held November 9-11, 1994 in Washington, DC

Technology Access Report 306
San Rafael, CA,
is an independent 20-page monthly newsletter for news, advice, and opportunities in technology transfer, policy, commercialization, and defense conversion that links companies, universities, and government.

Technology Transfer Society 126
Indianapolis, IN,
is a non-profit organization created to promote the growth and enhance the effectiveness of technology transfer. Through timely publications and multi-disciplinary membership, the society provides a networking system for the technology transfer professional.

Thiokol 519
Brigham City, UT,
will highlight technologies developed in internal IR&D or DOD/NASA programs that show potential for commercialization, new propulsion concepts, or enhanced environmental processes.

Tiodize Co. 116
Huntington Beach, CA,
will feature anti-corrosion coatings, solid film lubricants, Teflon coatings, self-lubricating composites, composite fastener products, degreasers, hard anodize with Teflon, mold releases, water base coatings, and titanium anodize with no dimensional change.

TRI-E Inc. 605
Edison, NJ,
will show an electronic ovulation monitor, a microprocessor-based thermometer-like probe that can tell a woman (or other female mammals) whether a viable egg is present in her body at a given time.

US Air Force, Armstrong Laboratory 540
Brooks Air Force Base, TX,
will focus on human-centered technologies available for collaborative research and/or licensing opportunities in aerospace, medicine, occupational and environmental health, training, human engineering, and environics.

US Air Force, MANTECH 538
Dayton, OH
MANTECH will provide information on more than 100 projects with technology commercialization and transfer potential in electronics, integration technology, processing and fabrication, industrial base analysis, and concurrent engineering.

US Air Force, Materiel Command 438
Wright-Patterson Air Force Base, OH
This exhibit will display various modules highlighting the latest dual-use technologies developed by Air Force laboratories.

US Air Force Phillips Laboratory/Advanced Manufacturing 544
Albuquerque, NM,
will showcase opportunities available through the US Air Force Phillips Laboratory and Advanced Manufacturing Technology Center for technology transfer and manufacturing applications.

US Army Aeromedical Research Laboratory 437
Washington, DC
This exhibit will depict ongoing research at the US Army Aeromedical Research Laboratory in Fort Rucker, AL.

US Army Armament Research Development and Engineering Center 515
Picatinny Arsenal, NJ,
will feature MDARS, a security/inventory robot, a panoramic camera capable of recording a 360° image, and packaging technology.

US Army Corps of Engineers Laboratory 331
Vicksburg, MS,
will highlight technologies that are ready for commercialization from the Corps' labs. These labs conduct research in the areas of facilities and construction, infrastructure remediation, railroads, pavements and soils, environmental sustainment, waterways and harbors, and cold climate facilities.

US Army Research Laboratory 238
Fort Monmouth, NJ
The Electronics and Power Sources Directorate, ARL exhibit will feature electronics technology and devices available for commercialization with emphasis on technology transfer through patent licensing and cooperative agreements.

US Army Research Laboratory 419
Adelphi, MD,
conducts a broad-based, multidisciplinary program of basic and applied research, exploratory development, and analysis.

US Army Tank Automotive Research 326
Development & Engineering Center (TARDEC)
Warren, MI,
promotes "dual use" tank/automotive R&D and technology transfer between government, industry, and academia.

US Army Test and Evaluation Command 138
Aberdeen Proving Ground, MD,
will highlight the diversity and technology of TECOM's extensive test facilities.

US Department of Agriculture/Agriculture Research Service 344
Beltsville, MD
With 133 laboratories nationwide, ARS offers opportunities for small and large corporations. Information on technology transfer programs and research projects will be exhibited by the ARS Office of Technology Transfer.

US Department of Energy/Technology Utilization Office 930
US Department of Energy/Small Business Initiative 931
Washington, DC
The US DOE technology transfer exhibit can help identify technologies available for transfer to private industry, or assistance and collaboration at the DOE laboratories across the nation.

US Department of Energy, Energy Efficiency, and Renewable Energy 924
Golden, CO,
will provide an overview of research and development programs and activities for the building, transportation, industrial, and utility sectors.

US Department of Energy, National Renewable Energy Laboratory 924
Golden, CO,
conducts R&D in energy efficiency and renewable energy. Programs include: photovoltaics, wind energy, biofuels, biomass power, fuels utilization, solar industrial and building technologies, solar thermal electric, and waste management.

US Department of Energy/Triodyne Inc. 337
Niles, IL,
will present examples of improved technologies for environmental restoration and waste management. The exhibit will highlight DOE's Research, Development, Demonstration, Testing, and Evaluation (RDDT&E) program.

US Department of the Interior 330
Washington, DC,
will display results of federally-funded mining, materials, water resources, and other research and information studies.

US Naval Academy 415
Annapolis, MD,
has faculty and facilities in immune response, combustion engine/pump design, corrosion/metallurgy, radioactive/liquid waste treatment, artificial intelligence, and low-level contaminants.

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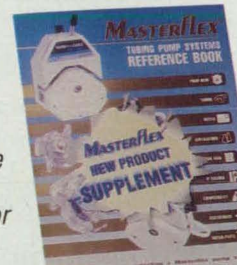

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USDA-CSRS Office of Agricultural Materials 240
Washington, DC
This display will feature advanced materials ranging from lubricants to polymers to composites, all derived from renewable agricultural products.

US Space Foundation 405
Colorado, CO,
will highlight Space Commerce Expo '94, the tenth national space symposium, the Space Technology Hall of Fame, and membership and corporate support opportunities.

United Technologies Corporation 610
Hartford, CT
Pratt & Whitney Waterjet Systems will exhibit its Automated Robotic Maintenance Systems™ (ARMS), which use ultra-high-pressure water under precision robotic control to remove coatings (including plasma-sprayed), paints, seals, etc., in a sound, cost-effective manner. USBI Co. will feature its work as a prime contractor on the space shuttle program and also will provide information on environmentally-sound emerging spinoffs such as convergent spray technology.

University of Dayton Research Institute 320
Dayton, OH,
conducts both basic and applied research for government and industrial sponsors. Information will be available on UDRI's research capabilities and technologies available for licensing.

Veritec Inc. 215
Chatsworth, CA,
will demonstrate the Vericode Symbol for item identification, along with advanced shop-floor modular systems E/D 1300 and 1500, capable of capturing and decoding the Vericode Symbol.

LITERATURE PARTICIPANTS

The following companies will have literature available at the Technology 2003 Literature Exhibit (booth 1238):

Abaris Training Resources Inc.
Reno, NV,
specializes in advanced composite structural materials, such as graphite fiber and Kevlar® fiber-reinforced epoxy systems. Classes are available in damaged composite structure repair, tooling, ultrasonic inspection, adhesive bonding, blueprint reading, and manufacturing.

Addison-Wesley Publishing Co.
Reading, WA,
will preview new books including: *Breaking Through* by Tom Logsdon, *Learning to Manage Technical Professionals* by Richard Stein, *SPC for the Rest of Us* by Hy Pitt, and *Geo-Metrics III* by Lowell Foster.

Automation Gages Inc.
Rochester, NY
Literature will describe the company's high-precision ball and cross roller linear bearings with travels from 1/2 inch to 35 inches, available in aluminum, steel, and cast iron.

Ayers Engineering and Manufacturing
Ramona, CA,
manufactures and distributes Nernst Glower infrared light sources and controls, and provides design and fabrication of furnaces for operation up to 2000 °C in air.

Cornell Theory Center
Ithaca, NY
One of four National Science Foundation supercomputer centers, the Cornell Theory Center offers scalable parallel computing resources and training to small, medium, and large companies.

CorpTech
Woburn, MA
Product information will be available on 35,000 US technology manufacturers to help identify technology partners, locate potential sources of technology or funding, and to bring technologies to market.

Dr. Dvorkovitz & Associates Inc.
Ormond Beach, FL
Literature will detail the firm's system of licensable technologies, containing over 30,000 products and processes from worldwide sources. Listing developments is free of charge. Inexpensive access services to augment R&D efforts are offered.

Freewing Aircraft Corp.
College Park, MD
Literature will describe revolutionary manned and unmanned aircraft that use a proprietary freewing principle, manned light planes that are safer and more comfortable, and thrust-vectoring S/VTOL UAVs.

Geophysical Survey Systems Inc.
North Salem, NH
Available literature will describe GSSI's Subsurface Interface Radar (SIR) Systems, used to nondestructively locate buried utilities, artifacts, underground storage tanks, buried hazardous waste, and to delineate landfill boundaries, and identify geological features and structures of roads, bridges, and buildings.

Lamptronix Co. Ltd.
Crystal Lake, IL
Literature will be available on the SAE AS4156 color-coded lamp standard.

Laser Diode, Inc.
Edison, NJ,
is a manufacturer of fiber-optic transmitters and receivers, subsystems, and components for commercial applications such as SONET, and ruggedized applications such as SAFENET and ARINC networks.

MCNC, Center for Microelectronics
Research Triangle Park, NC,
specializes in ASIC design and fabrication services, microstructure processing, materials analysis, and specialized integrated circuits for DNA sequence comparison, fuzzy logic control, and massively parallel processing.

MicroPatent
New Haven, CT,
a leading CD-ROM publisher of patent information, will offer a free trial subscription to the *Patent Bulletin*, a monthly update of US, European, and world patents.

National Center for Research Resources
Bethesda, MD
The NCRR Access Guide provides a comprehensive overview of programs, resources, grants, and publications supported by the National Center for Research Resources.

Neutrik USA Inc.
Lakewood, NJ
Literature will spotlight Neutrik's Cortex Audio Workstation, a psychoacoustic analyzer that records, measures, edits, and synthesizes audio signals for real-time quantification of subjective hearing sensations.

New Technology Week
Washington, DC,
is the premier publication following set policy, corporate strategies, government programs, and the potential of emerging technologies.

Northrop B-2 Division
Pico Rivera, CA,
is a high technology company with experience in composites manufacturing, aircraft design, avionics, aircraft subsystems, training, logistics, mission planning, and laboratory support.

Photonics Analysis Ltd.
Waterloo, Ontario
The company's brochure describes the PALSYS I, a Particle and Projectile Electronic Motion Analysis system. The PALSYS I is comprised of the PALFLASH 500 pulsed very-high-illuminance flash light source, the PALSEQ 400 sequencer, the PALSTOR 100 high-speed single frame grab and store unit and software. The PALFALSH 500 has applications in spray atomization, ballistics, detonics, Schlieren studies, and shadowgraphs.

RIBTEC
Bahanna, OH,
is a manufacturer of metal fibers and nonwoven fabrics from 0.20" to .0004" diameter in nickel, titanium, and stainless steel. Other metals and alloys also are available.

Technologies Tomorrow
Albuquerque, NM,
is a newsletter identifying key technologies that will emerge in the next three to five years. Each issue focuses on a different technology.

Westinghouse Hanford Co./International Environmental Institute
Richland, WA
The International Environmental Institute seeks to create and nurture partnerships among industry, government, academia, and the public to ensure the rapid development, application, and commercialization of environmental technologies to support Hanford site remediation and restoration.

EDITOR'S NOTE:
The final, complete list of exhibitors and booth locations will be contained in the official program distributed on-site in the show registration area.

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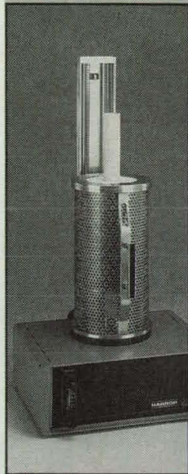
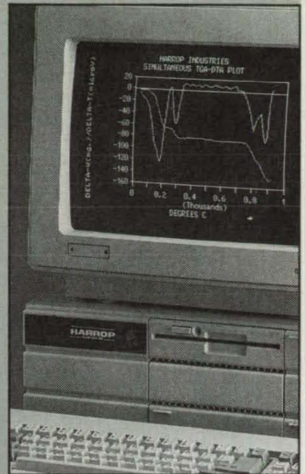
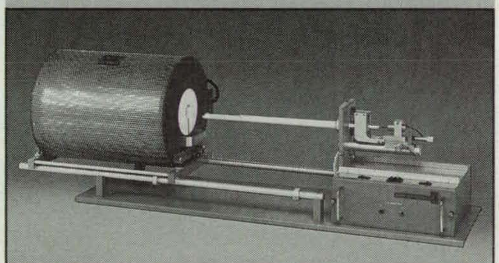

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For more information, contact *Harrop Industries, Inc.*, 3470 E. Fifth Ave., Columbus, Ohio 43219-1797. Phone: 614/231-3621. TELEX: 810 482 1645 FAX: 614/235-3699.

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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 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 Technology Utilization Office of the sponsoring NASA center (see page 26). NASA's patent-licensing program to encourage commercial development is described on page 26.

Subsurface Growth of Silicide Structures in Silicon

This technique shows promise of fabrication of novel electronic, optoelectronic, and electro-optical devices. Experiments have demonstrated the feasibility of growing microscopic single-crystal $CoSi_2$ structures beneath the surfaces of Si substrates.
(See page 98.)

Quantitative Tester and Reconditioner for Hand and Arm

A new apparatus measures the torques, forces, and motions of the hand, wrist, forearm, elbow, and shoulder. The apparatus can be used to determine the strengths and endurances of muscles, the motion of joints, and reaction times, or it can serve as an exercise machine to restore muscle performance.
(See page 106.)

Electroluminescent Displays Made With Alternative Dopants

A fabrication technique for a single-layer, thin-film electroluminescent display device uses a ZnS host layer doped to form color phosphors. Column and row conductors separated by transparent layers of SiO_2 form electric fields at intersections to excite specific phosphors into luminescence.
(See page 46.)

Techniques for Mass Production of Tunneling Electrodes

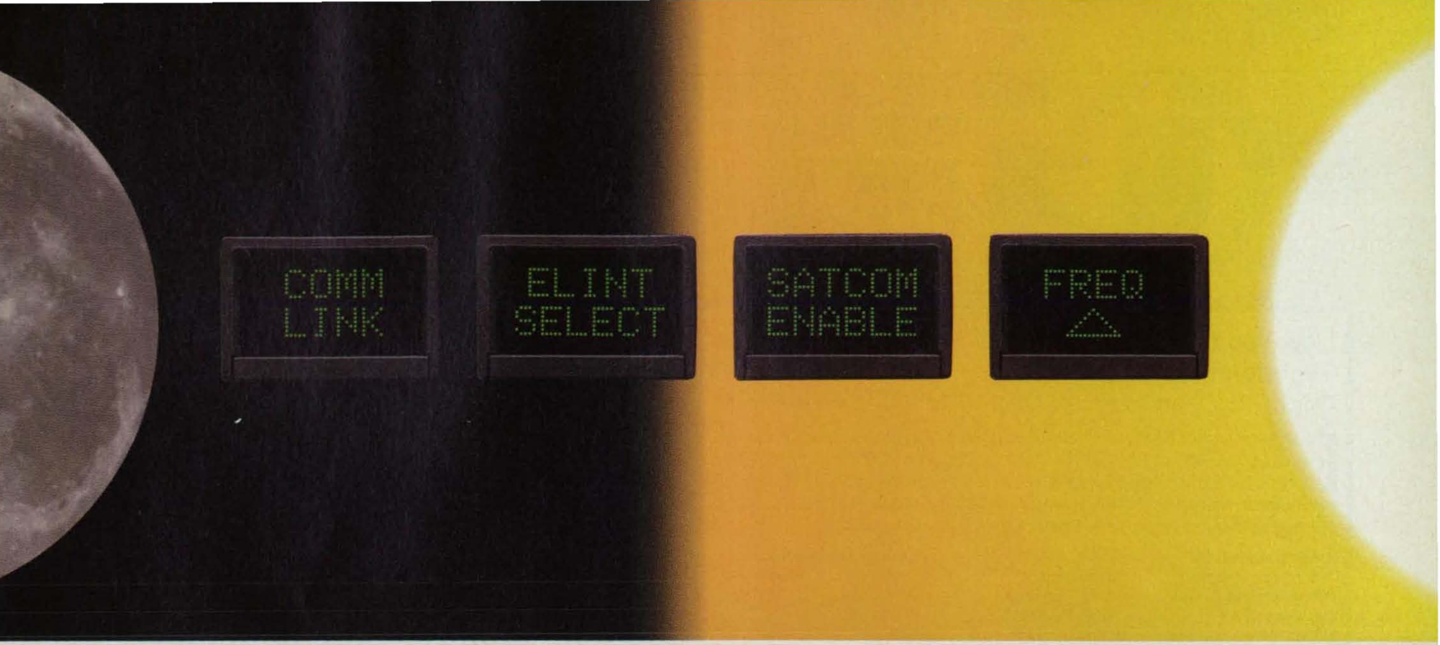
New techniques have been developed from silicon-micromachining, lithographic patterning, and related processes to produce tunneling electrodes. The electrodes are integral parts of tunneling transducer/sensors. Such devices are essential components of scanning tunneling microscopes and related instruments.
(See page 30.)

Porous Forebody

A porous forebody improves the performance of an aircraft at both high and low angles of attack. Such structures could lead to safer and better-handling aircraft.
(See page 91.)

Pump Propels Liquid and Gas Separately

A conceptual design would handle mixtures of liquid and gas efficiently. Potential application for such pumps include turbomachinery in powerplants and superchargers in automobile engines.
(See page 96.)



The NVIS-Sunlight Readable Electro-Optical Display System.

The VIVISUN 5000 electro-optical display system incorporates LED lighting that is both NVIS compatible and sunlight readable per MIL-L-85762A. This interactive system also provides rugged reliability and meets the environmental extremes that military programs demand.

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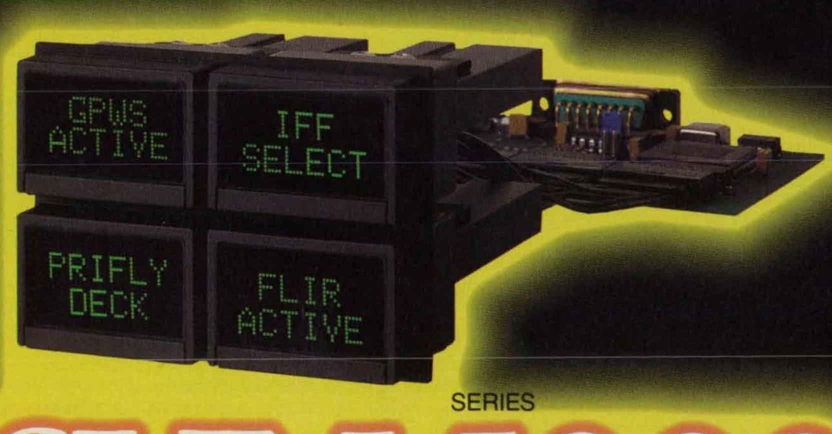

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We've outlined below NASA's Technology Transfer Network—named the participants, described their services, and listed the individuals you can contact for more information relating to your specific needs. We encourage you to make use of the information, access, and applications services offered.

How You Can Access Technology Transfer Services At NASA Field Centers:

Technology Utilization Officers & Patent Counsels—Each NASA Field Center has a Technology Utilization Officer (TUO) and a Patent Counsel to facilitate technology transfer between NASA and the private sector.

If you need further information about new technologies presented in *NASA Tech Briefs*, request the Technical Support Package (TSP). If a TSP is not available, you can contact the Technology Utilization Officer at the NASA Field Center that sponsored the research. He can arrange for assistance in applying the technology by putting you in touch with the people who developed it. If you want information about the patent status of a technology or are interested in licensing a NASA invention, contact the Patent Counsel at the NASA Field Center that sponsored the research. Refer to the NASA reference number at the end of the Tech Brief.

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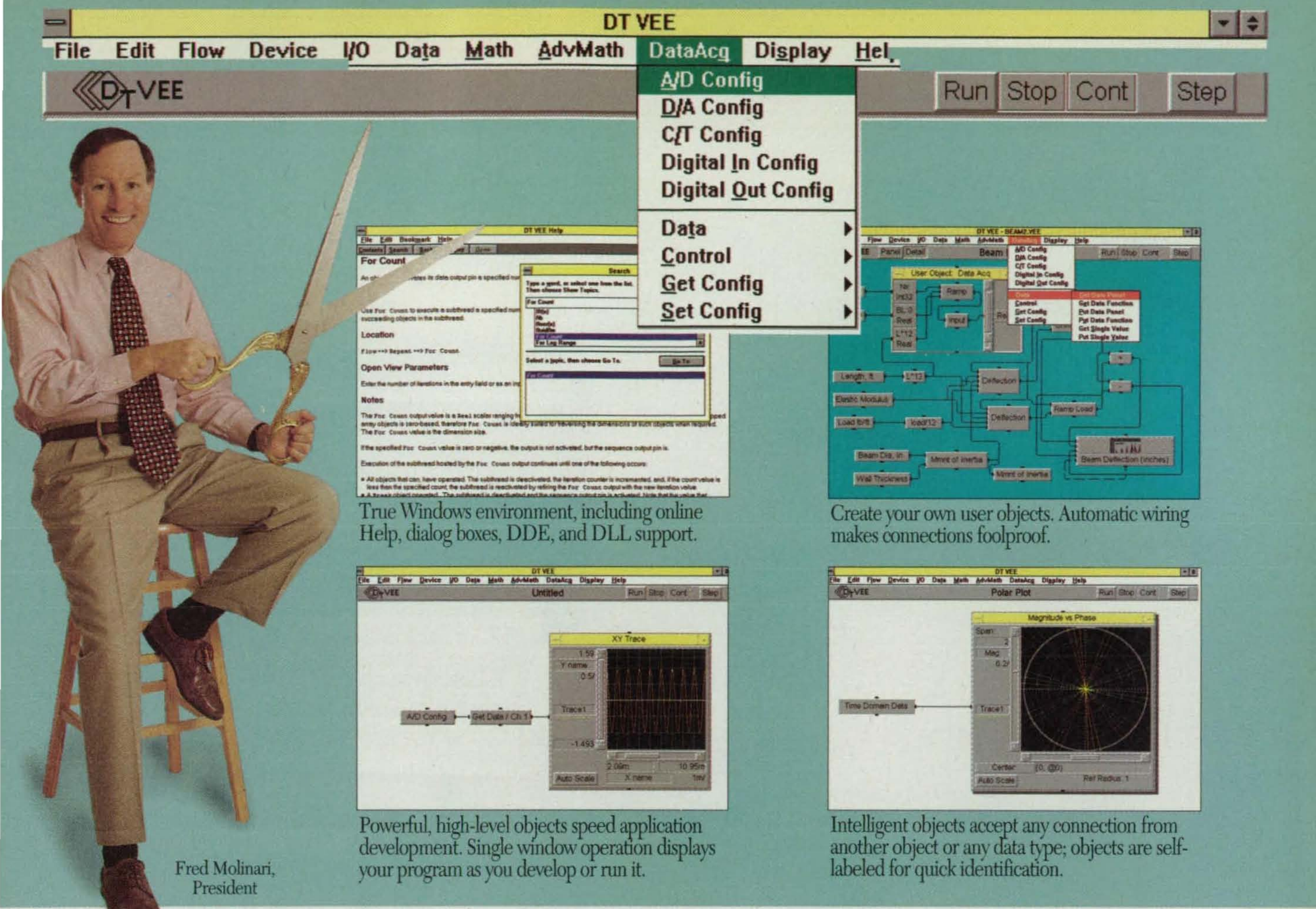
If you represent a public sector organization with a particular need, you can contact NASA's Application Team for technology matching and problem solving assistance. Staffed by professional engineers from a variety of disciplines, the Application Team works with public sector organizations to identify and solve critical problems with existing NASA technology. **Technology Application Team, Research Triangle Institute, P.O. Box 12194, Research Triangle Park, NC 27709; *Dr. Doris Rouse, Director,* (919) 541-6980**

A Shortcut To Software: COSMIC® For software developed with NASA funding, contact COSMIC, NASA's Computer Software Management and Information Center. New and updated programs are announced in the Computer Programs section. COSMIC publishes an annual software catalog. For more information call or write: **COSMIC®**, 382 East Broad Street, Athens, GA 30602 *John A. Gibson, Director,* (706) 542-3265; FAX (706) 542-4807.

If You Have a Question..NASA Center For AeroSpace Information can answer questions about NASA's Technology Transfer Network and its services and documents. The CASI staff supplies documents and provides referrals. Call, write or use the feedback card in this issue to contact: **NASA Center For AeroSpace Information,** Technology Transfer Office, 800 Elkridge Rd, Linthicum Heights, MD 21090-2934. *Walter M. Heiland, Manager,* (410) 859-5300, Ext. 245.



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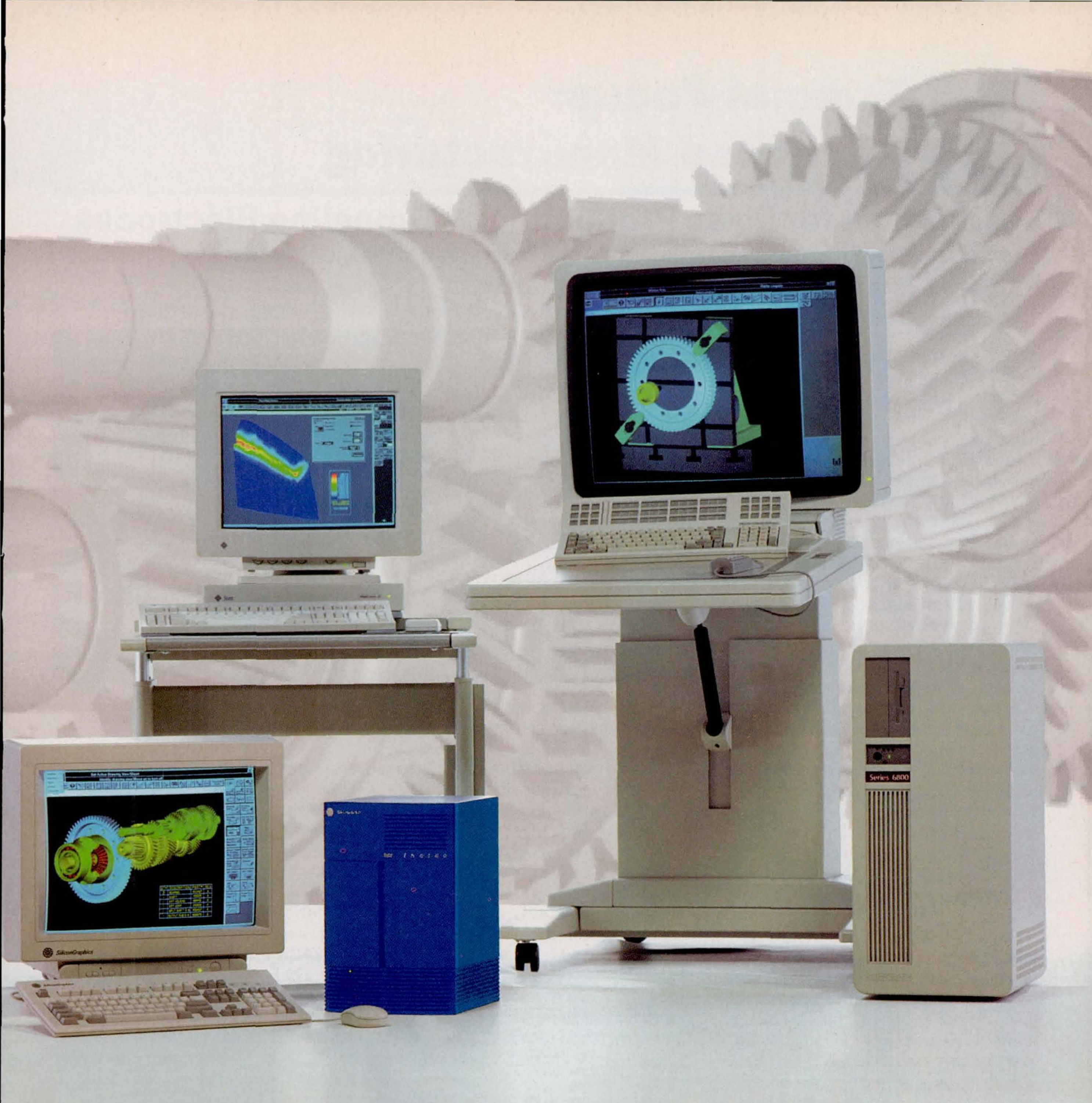

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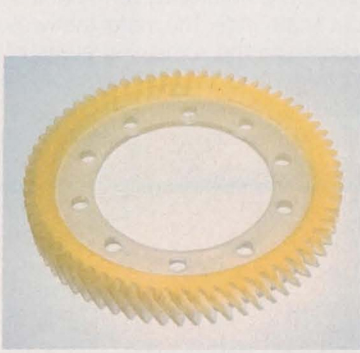

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For More Information Write In No. 597

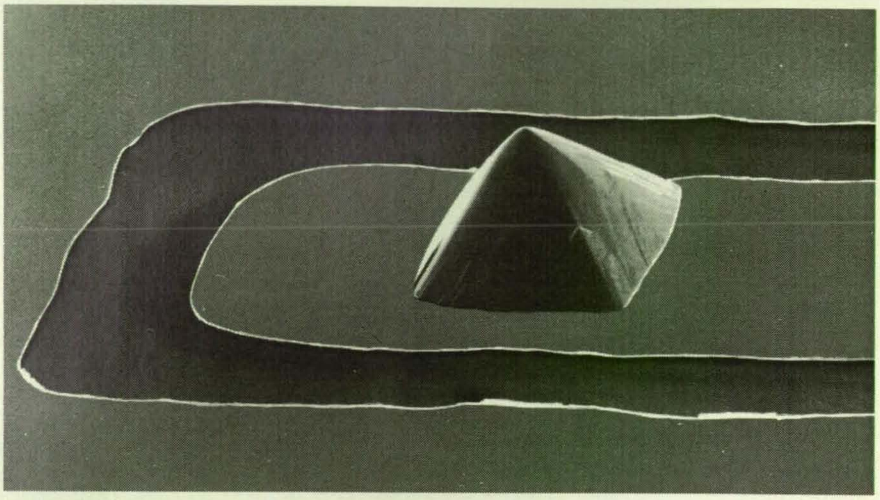
Special Focus: Advanced Manufacturing

Techniques for Mass Production of Tunneling Electrodes

Electrode patterns are formed by lithography, and extreme cleanliness is essential.

NASA's Jet Propulsion Laboratory, Pasadena, California

Techniques for the mass production of tunneling electrodes have been developed from silicon-micromachining, lithographic patterning, and related microfabrication processes. Tunneling electrodes are so named because electrons travel between them by quantum-mechanical tunneling; tunneling electrodes are integral parts of tunneling transducer/sensors, which act in conjunction with feedback circuitry to stabilize tunneling currents by maintaining electrode separations of the order of 10 Å. Such transducer/sensors are essential parts of scanning tunneling microscopes and related instruments, and can be used as force and position transducers in novel microscopic accelerometers and infrared detectors, for example.



This **Scanning Electron Micrograph** shows an electrode film deposited on and around a micromachined silicon tip.

In developing the techniques for mass production of these devices, it was necessary to overcome difficulties posed by the need to fabricate silicon into microscopic parts with three-dimensional shapes, including cantilevers, pyramidal tips, and recesses. In addition, an important prerequisite to the operation of a tunneling transducer/sensor is the deposition and maintenance of atomically clean gold electrode surface films.

Production begins with the use of established micromachining techniques to fabricate silicon wafers into the desired complicated shapes with recesses and tips. The wafers are then passivated by forming surface layers of SiO_2 1 µm thick in a standard steam oxidation process. The passivated wafers are spin-coated with photoresist and exposed to a lithographic pattern that defines the electrode areas. Because the pattern is typically formed in the recesses, where the surfaces cannot be in contact with the lithographic mask, the edges of the pattern are somewhat blurred. After a development process in which the exposed photoresist is removed, the wafers are treated in an oxygen plasma, which cleans the open areas in the photoresist pattern and sharpens the edge profile of the photoresist.

The gold electrodes are then deposited on the photoresist-coated wafer. Because gold does not adhere to clean SiO_2, an adhesion layer of another metal must be deposited first. In particular, it has been determined experimentally that when a titanium adhesion layer 150 Å thick is followed by a platinum barrier layer 150 Å thick followed by a gold electrode layer 2,000 Å thick, the gold electrodes turn out to be sufficiently clean for long-term, stable tunneling. (The barrier layer prevents diffusion of the gold into the substrate.)

After deposition of the metal layers, the wafer is submerged in acetone or another solvent that dissolves the photoresist and is agitated ultrasonically. This agitation is necessary to make the solvent soak under the metal that was deposited on the remaining areas of the photoresist, so that the metal can be lifted off those areas.

Finally, the wafers are diced by a standard dicing saw; degreased with trichloroethylene, acetone, and methanol; and then treated in an oxygen plasma. The figure shows a typical result of this fabrication process.

This work was done by Thomas W. Kenny, Judith A. Podosek, Joseph K. Reynolds, Howard K. Rockstad, Erika C. Vote, and William J. Kaiser of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 1*** *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
4800 Oak Grove Drive
Pasadena, CA 91109

Refer to NPO-18865, volume and number of this NASA Tech Briefs *issue, and the page number.*

Electroform Welding

Metal parts can be joined without heating them.

Lewis Research Center, Cleveland, Ohio

Electroform welding can be used to join a variety of parts without the addition of detrimental heat associated with conventional welding and brazing. Conventional welding results in a heat-affected zone, where the materials in the workpieces being joined are weakened, and which therefore constitutes a weak link in the structure. Brazing usually involves

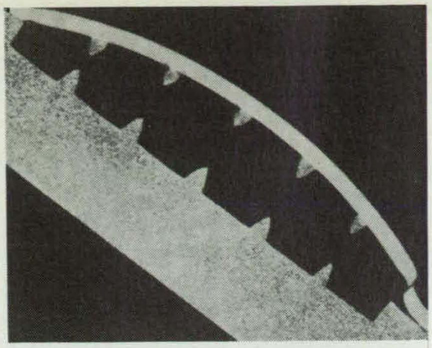


Figure 1. The **Electroform Bonds** in this specimen remained intact even when the base material was broken.

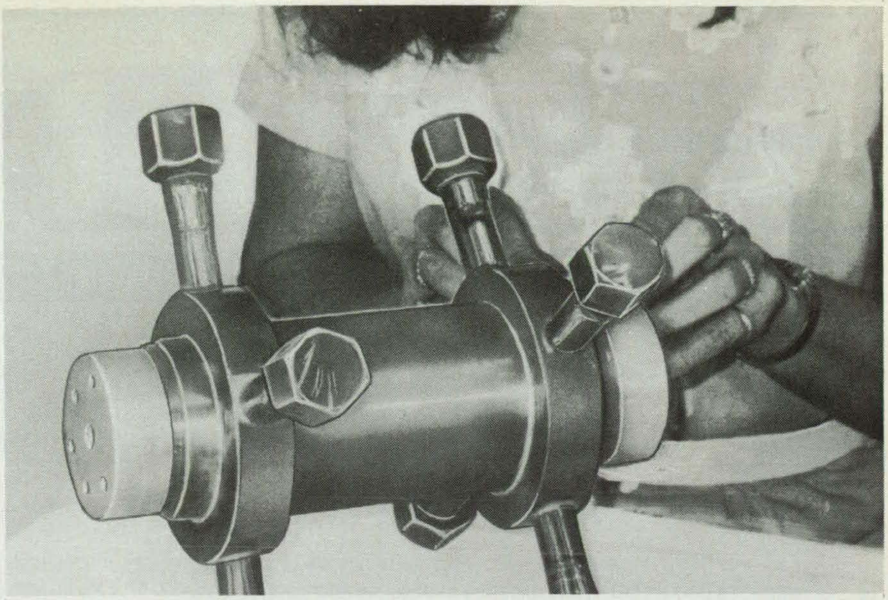


Figure 2. **Prefabricated Manifold Inserts** are installed on a tube assembly in preparation for electroforming.

heating of the entire structure, thus lowering the strengths of the materials.

Electroform welding involves the application of the techniques of conventional electroforming to bridge the gap between two parts, thus bonding them together at essentially room temperature. This enables one to join parts made of similar or dissimilar alloys while maintaining those properties that were imparted to the alloys by heat treatment and mechanical work.

For years, NASA has been using electroforming to produce rocket-chamber liners with superior bonds such that the base materials break before the electroform bonds do (see Figure 1). This technique is being developed so that large and/or complexly shaped parts can be joined without degrading the properties of the materials of which they are made.

The initial development of this technique was intended to enable attachment of coolant feed manifolds to the combustion chamber of a rocket engine (see Figure 2). The two pieces (the manifold and the combustion chamber) are assembled and appropriately masked or shielded. Then the joint is formed by concentrating the electroforming in the joint area. The joint is built by electroforming up to a thickness that corresponds to a desired joint strength. The assembly is then removed from the electroforming bath, unmasked, and rinsed, leaving a no-heat weld.

This technique has been demonstrated with copper, nickel, and alloys thereof. The tensile strengths of the materials as deposited have ranged from 50 to 150 kpsi (about 0.34 to 1.03 GPa). Commercial uses could include joining dissimilar alloys where fusion welding would be impossible. Also, this technique would be beneficial for suppression of distortion or for maintenance of very close tolerances in precise components, the heating of which would be detrimental.

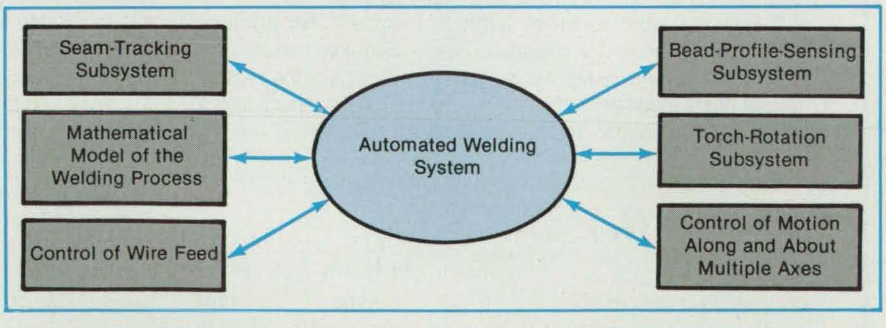
This work was done by John M. Kazaroff and Robert S. Jankovsky of **Lewis Research Center** *and Glen Malone and Richard Edwards of Electroformed Nickel Inc. For further information,* ***write in 94*** *on the TSP Request Card.*
LEW-15598

Automated Welding System

Sensors, robots, and a controls model are being integrated.

Marshall Space Flight Center, Alabama

A fully automated variable-polarity plasma arc (VPPA) welding system is being developed at Marshall Space Flight Center. The system is expected to eliminate those defects that are caused by human error. The system (see figure) integrates many sensors with a mathematical model of the weld and computer-controlled welding equipment. The sensors provide real-time information on the geometry of the weld bead, the location of the weld joint, and the wire-feed entry. The mathematical model relates the geometry of the weld to critical parameters of the welding process.



The **Automated Welding System** is being developed in subsystems that will be put in operation as they become available.

Parts of the system are in various stages of development and will be put in operation as they become available. The system can also be expanded to include automated optoelectronic inspection of the dimensions, peaking, and mismatches of welds.

Stereoscopic-imaging sensors intended to track weld seams are being evaluated. A laser sensor for profiling the weld bead and controlling the rotation of the welding torch has been demonstrated. A seam-tracking sensor based on artificial intelligence is also being evaluated. A wire-feed-controlling sensor has been conceived and is being implemented on an industrial computer by use of a multitasking operating system.

The system will coordinate more than 10 axes of motion. Both macro and task-level programs are being developed to simplify the motion of the welding robot.

A number of organizations in NASA, universities, and industry are contributing to the multidisciplinary development proj-

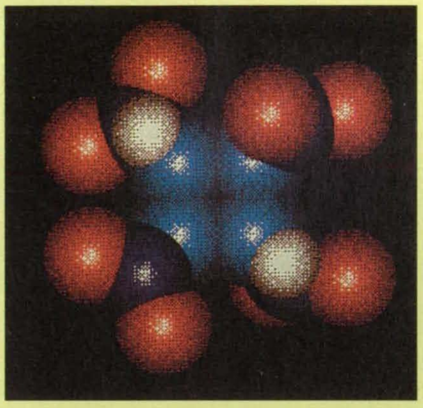
UPDATE

The Latest News About The Premier US Technology Showcase

America's Best Inventions And Top Technologists Are Coming To Anaheim This December

'93 Event Will Be Biggest Ever

Over 8000 engineers and executives from industry and government — a new record — are expected to pack the Anaheim, CA convention center on December 7-9 for **Technology 2003**, the fourth national technology transfer conference. They will visit the largest US exhibition of federal and private sector inventions and products available for license or sale, and will attend over 100 symposia presentations by government technologists/contractors spotlighting commercially-promising research innovations in such critical areas as manufacturing, electronics, computing, materials, biotechnology, and environmental technology.



The Army-developed Cubane molecule, subject of a Dec. 7 presentation, shows great potential both as a "super-explosive" and as a pharmaceutical for treatment of cancer and other illnesses.

The event has tripled in size since its inception in 1990. This growth has come as both the government and industry have embraced technology transfer as a key to economic growth. "The Clinton Administration has made technology reinvestment and the generation of dual-use technologies an important part of its economic plan," explained James R. Thompson, **Technology 2003** general conference chairman. "That's what this conference is all about — helping US businesses to take advantage of the treasure-trove of ready-made innovations in the nation's 700+ federal labs to develop new products, solve engineering problems, and improve their manufacturing and production techniques."

Participating federal agencies include NASA (the show sponsor along with *NASA Tech Briefs* and the Technology Utilization Foundation), the Environmental Protection Agency, the Federal Aviation Administration, the Federal Highway Administration, the National Security Agency, and the departments of Agriculture, Commerce, Defense, Energy, Health and Human Services, Interior, and Veterans Affairs.

Vice President Invited To Keynote

US Vice President Al Gore is the invited keynote speaker for the opening plenary session starting at 8:30 am on Tuesday, Dec. 7, which will focus on Defense Conversion and the government's Technology Reinvestment Project, a program of matching grants in various technological areas to explore commercial uses of federally-funded R&D. California governor Peter Wilson is expected to speak Tuesday evening at a reception in the exhibits hall (6:00 pm, open to all **Technology 2003** registrants) commemorating National Technology Transfer Week (Dec. 5-11), which also will include conferences sponsored by the National Technology Transfer Society and the American Society for Photogrammetry and Remote Sensing.

In a plenary session on Wednesday morning, federal tech transfer experts will explain how to license government patents, apply for SBIR grants, and successfully enter into Cooperative R&D Agreements, in which companies and government labs share resources to bring dual-use technologies to the commercial stage.

Thursday's workshops will include an International Technology Transfer Forum; high-level speakers from Russia, Israel, Italy, France, Switzerland, and Canada will unveil their portfolio of inventions available for US companies' benefit, and will provide contacts for follow-up. Dr. Yuri Ossipyan, former science adviser to Mikhail Gorbachev, is expected to open this session.

For a complete conference program, including info on hotel and air travel discounts, call Wendy Janiel at (800) 944-NASA.

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On-Site Registration Hours

Monday, Dec. 6	**8:00 am - 5:00 pm**
Tuesday, Dec. 7	**7:00 am - 5:00 pm**
Wednesday, Dec. 8	**7:00 am - 4:00 pm**
Thursday, Dec. 9	**7:00 am - 2:00 pm**

Fax or Mail the card above to preregister.

Preregistrants will receive written confirmations via mail along with their name badges and imprinter cards. Badge holders, programs, and dinner tickets must be picked up in person at the Anaheim Convention Center (Hall C) during the above hours.

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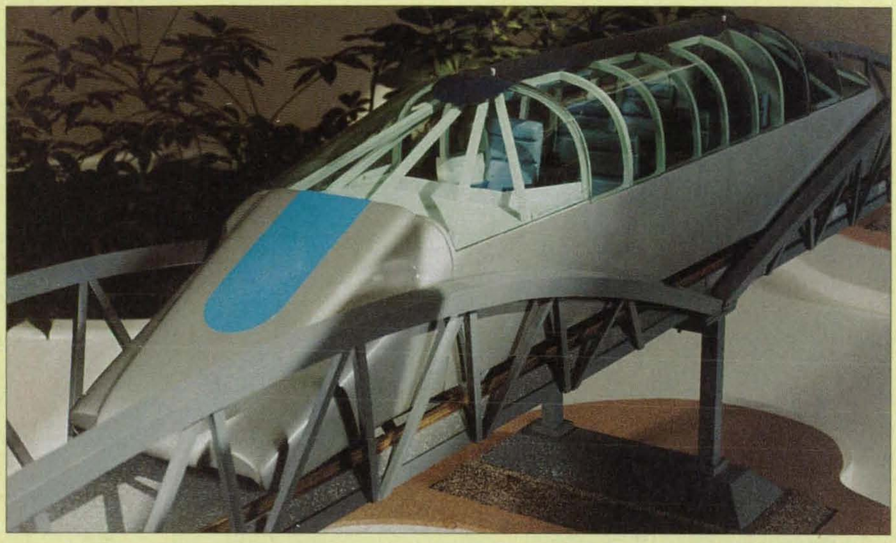


The Cybertran lightweight electric transport system

The Cybertran, a breakthrough concept in high-speed mass transit, will be displayed by Idaho National Engineering Lab in the giant **Technology 2003** exhibits hall. The computer-controlled, electrically-powered vehicle would travel between cities in elevated guideways at speeds up to 150 mph. It would cost just 10-20% of conventional rail systems and use just 30% of the energy of existing automobile and aircraft systems.

Other exhibit highlights include:

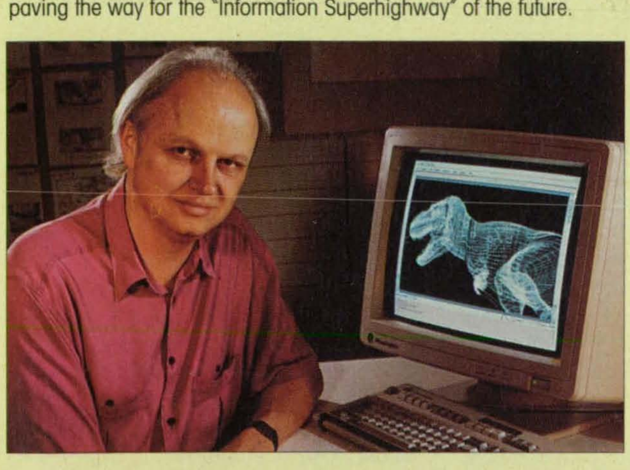
- Δ NASA's Ames Research Center will demonstrate its Virtual Wind Tunnel, a computer system that generates incredible 3D simulations of flows around aircraft;
- Δ Lawrence Berkeley Lab will exhibit Silica Aerojel, a unique transparent material featuring the best thermal insulation properties of any solid;
- Δ Ten US Navy labs will jointly display hundreds of dual-use technologies that could help businesses enhance their productivity and competitiveness;
- Δ The Marshall Space Flight Center's booth will highlight an award-winning x-ray microscope that could revolutionize biological and medical research by generating the first ultra-high-resolution images of DNA molecules, chromosomes, and other parts of living cells;
- Δ NASA's main exhibit will include a scale model and spinoffs of the National Aero-Space Plane, a future hypersonic aircraft that will take off from conventional runways and then fly into orbit.

The exhibits hall will be open 10:00 am - 6:00 pm on 12/7, 10:00 am - 5:00 pm on 12/8, and 9:00 am - 3:00 pm on 12/9.

Silicon Graphics Founder To Speak At Technology Transfer Awards Dinner

From "Jurassic Park" To The Info Superhighway

They're one of the hottest names in high-tech industry: Silicon Graphics Corp. of Mountain View, CA pioneered high-performance 3D visual computing; their computers created the dinosaurs in "Jurassic Park" and the special effects in "Terminator 2"; they're at the forefront of virtual reality technology both for entertainment and design applications; and now they've teamed with Time Warner Cable to create the first interactive digital cable television network — paving the way for the "Information Superhighway" of the future.



Above: Dr. James Clark, founder of Silicon Graphics

Left: SG's 3D graphics computers were used to create the dinosaurs in "Jurassic Park." Onscreen they served as the "eyes and ears" of the high-tech theme park.

Dr. James Clark, chairman and founder of Silicon Graphics, will be the guest speaker at the fourth annual Technology Transfer Awards Dinner, to be held December 8 at the Anaheim Marriott Hotel. Dr. Clark will discuss how his company, recently named for the second time to *Fortune* magazine's list of 100 fastest-growing companies, rose to success, and will share his vision of the future of computing and what it could mean to the nation's global competitiveness.

The dinner, the central event of **Technology 2003**, will feature awards to federal technologists and private sector firms who have made important strides in transferring research innovations into practical products that improve daily life and the national economy. Dinner tickets are $50 (one dinner ticket is included in the complete conference registration fee) and can be ordered using the registration card above. Seating is limited and will fill quickly, so reserve your tickets today.

Multiple Pages Intentionally Left Blank

ect. The system is believed to be the first to incorporate fundamental knowledge of the physics and chemistry of the welding process with feedback from sensors and coordinated control of welding parameters and of the motion of the welding torch.

This work was done by E. O. Bayless, K. G. Lawless, C. Kurgan, A. C. Nunes, B. F. Graham, D. Hoffman, C. S. Jones, and R. Shepard of **Marshall Space Flight Center**. *For further information,* ***write in 47*** *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 26]. Refer to MFS-28578

Manufacturing Complicated Shells and Liners

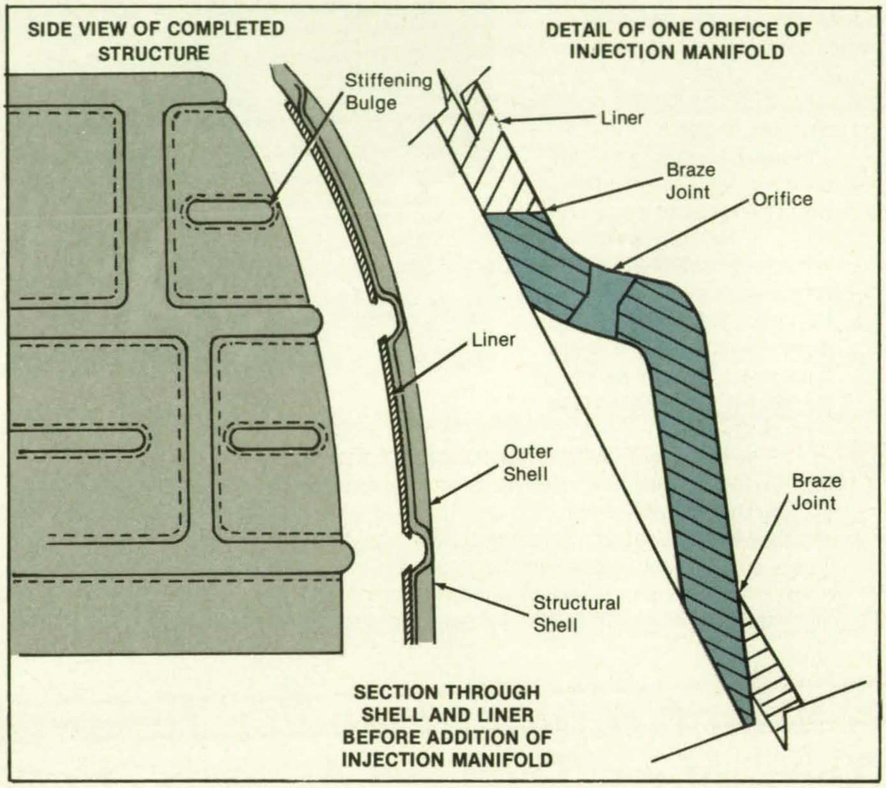
Several advanced fabrication techniques would be used in sequence.

Marshall Space Flight Center, Alabama

Explosive forming, wax filling, and any one of welding, diffusion bonding, or brazing would be used in a proposed method of manufacturing large, complicated shell-and-liner vessels or structures. The method was conceived for the manufacture of film-cooled rocket nozzles but is applicable to joining large coaxial shells and liners in general.

A thick-walled structural shell would first be formed by use of explosives to the required size and shape, with regularly spaced bulges for stiffening the shell and cavities for directing coolant to injection points (see figure). Next, the bulges and cavities would be filled with wax, and a prefabricated sheet-stock liner would be formed explosively to the inside of the structural shell. In this step, the wax filler would prevent the liner from entering the bulges and cavities.

The formed liner would be machined to accept film-cooling injection manifolds, and the wax would be removed. The liner and the structural shell would then be welded, diffusion-bonded, or brazed together for strength and to prevent the flow of coolant into undesired regions. The film-cooling injection manifolds would then be welded or brazed to the liner.



Selected Aspects of the proposed method of manufacture of the shell and liner are depicted.

This work was done by Paul J. Sobol and Joseph E. Faucher of United Technologies Corp. for **Marshall Space Flight Center**. *For further information,* ***write in 6*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 26]. Refer to MFS-28646.

Computer Programs for Automated Welding System

Expected benefits include reduced workload for the technician and more-consistent welds.

Marshall Space Flight Center, Alabama

Computer programs are being developed for use in controlling the automated welding system described in the preceding article (MFS-28578). These programs, together with the control computer, computer input and output devices (including graphical display), and control sensors and actuators, are expected to provide a flexible capability for the planning and implementation of schemes for the automated welding of specific workpieces.

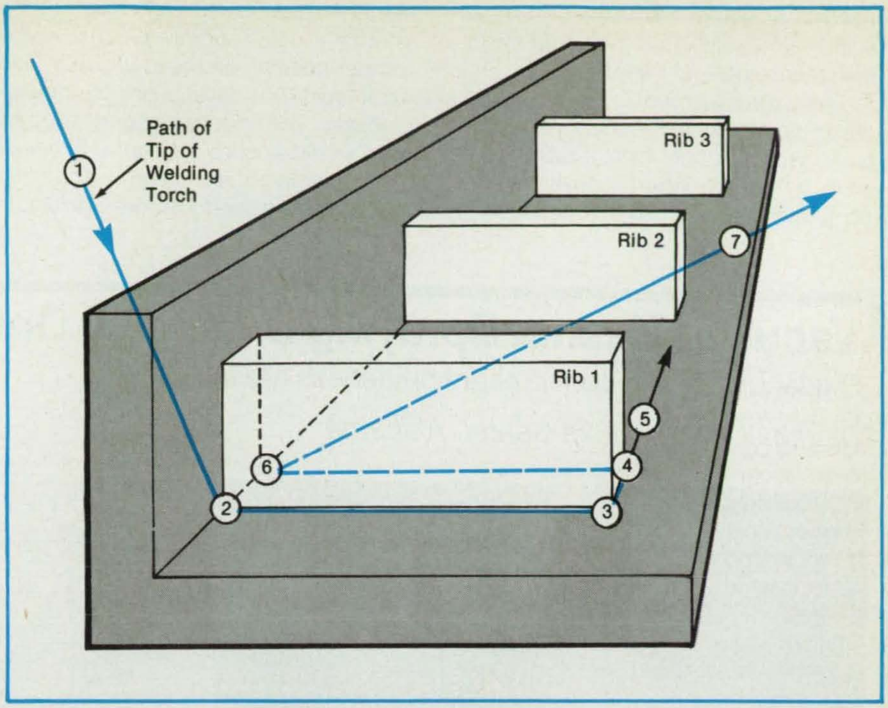
Heretofore, in the programming of a welding robot, it has been necessary for a technician to specify the welding path, typically by specifying the position and orientation of the welding torch at several principal points between which the path is defined as a straight line or as an explicit curved line. In addition, the technician has had to specify the speed of the torch and the parameters of the welding process (polarities and durations of welding-current pulses) at all points along the path. Such an extensive involvement of a person or persons in "teaching" the welding system may result in a lack of consistency between programs taught at different stations by different technicians or even between welds on the same part taught by the same technician. In addition, the cost of extensive involvement of a technician in teaching significantly raises the minimum number of identical parts that must be produced on each batch before robotic automation is economically justifiable.

The computer programs for the automated welding system are being developed according to macro- and task-level programming schemes, which can increase both productivity and consistency by reducing the amount of "teaching" of the system by the technician. In task-level programming, the technician specifies only goals for high-level tasks, rather than detailed robot motions to achieve those goals. In macro-level programming (see figure), programs for welding complicated workpieces are generated through hierarchical calls to macroinstructions, which, in turn, encapsulate all the sequences of motions and welding parameters needed to weld generic classes of workpieces. In this approach, the specifications of the welding process can be enforced more strictly and uniformly by encoding them into the rules that govern the decomposition of macroinstructions into other instructions.

For further enhancement of productivity and consistency and suppression of programming errors, the developmental system will provide for three-dimensional mathematical modeling (with graphical depiction) of workpieces, work cells, robots, and positioners. Robot paths will be simulated before welding of real workpieces is attempted by a combination of off-line programming with macro-level programming, coupled with direct teaching of a few principal locations and orientations of the welding torch. Off-line programming will be effected directly on the robot controller, using the welding robot to calibrate the mathematical models and using the kinematics of the robot arm and the motion-planning algorithms in the controller. This approach helps to take advantage of computer-aided design, the implementation of which could require complicated robotic-welding programs that would be very difficult to "teach."

This work was done by John E. Agapakis of Automatix Inc. for **Marshall Space Flight Center**. *For further information,* ***write in 5*** *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 26]. Refer to MFS-26145.



The **"Rib Macro"** programming utility generates a computer program for welding a rib into a box. The technician has to "teach" the welding robot by specifying the pose of the welding torch and the path of approach or recession at only a few principal points.

Robot Would Apply Brazing Foil Automatically

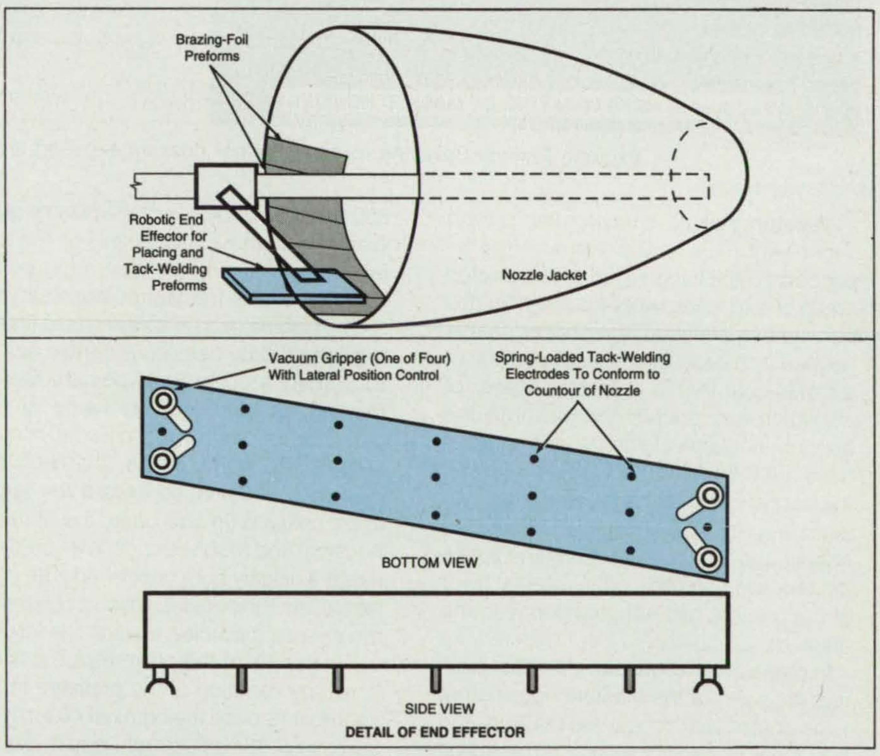
A conceptual system would ensure consistency.

Marshall Space Flight Center, Alabama

A proposed robotic system would position brazing-foil preforms accurately and tack-weld them in place in or on large workpieces in preparation for brazing. The system would automate the time-consuming, skill-dependent, labor-intensive brazing-foil-application procedure. The robotically attached preforms would satisfy specifications better and more consistently than manually installed preforms do.

The robotic foil-application system was conceived for use in applying brazing foil to the nozzle jacket of the main engine of the Space Shuttle (see figure). The preforms would be applied in five main bands. Preforms 0.004-in. (0.1-mm) thick would be placed in the forward end of the jacket; the rest of the jacket would be covered with preforms 0.0015-in. (0.038-mm) thick. The last piece inserted in each band would be custom-fitted to allow for dimensional tolerances.

Currently, brazing-foil preforms are cut manually from foil sheets by use of paper-cutting shears. A technician fits the preforms individually in or on the part to be brazed, and trims or recuts them as



The **End Effector Would Pick** and place foil preforms inside the nozzle jacket.

necessary. Often, the technician must shift them to eliminate gaps and slit or shift them to prevent wrinkles.

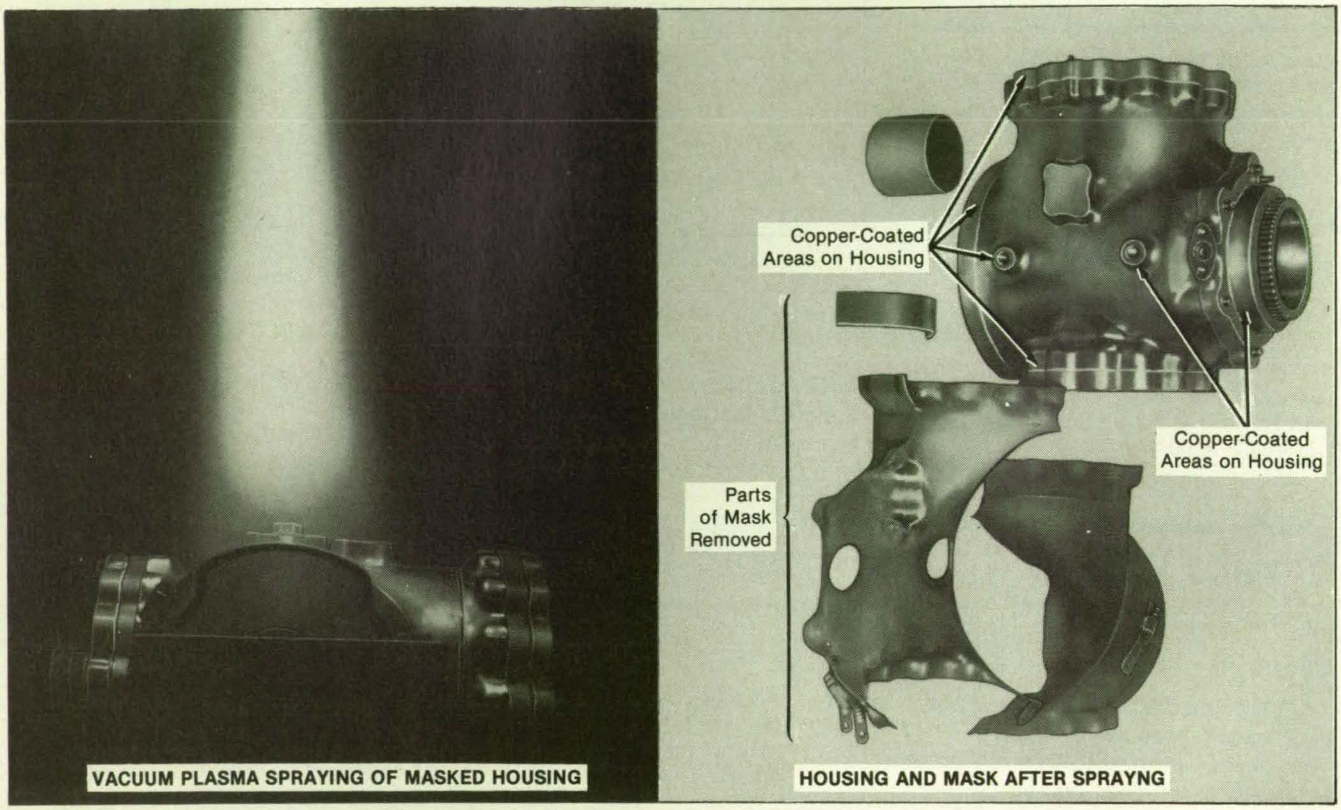
The proposed robotic system would use preforms cut automatically by electrical-discharge machining. A robot guided by a machine-vision subsystem and equipped with a vacuum-pickup end effector would pick up each foil preform, stretch it out smoothly, place it in the proper position on the workpiece, and tack-weld it at several points simultaneously. The machine-vision subsystem would ensure that gaps between preforms do not exceed specifications. Specially developed software would control the system.

This work was done by Jeffrey L. Gilbert and David A. Gutow of Rockwell International Corp. for **Marshall Space Flight Center**. *For further information,* ***write in 30*** *on the TSP Request Card.*
MFS-29923

Vacuum Plasma Spraying of Copper Onto Titanium

Oxidation and the concomitant brittleness are eliminated.

Marshall Space Flight Center, Alabama



Vacuum Plasma Spraying forms a copper coat on exposed areas of a titanium housing.

Vacuum plasma spraying has proved successful in depositing a tenacious copper coat on the flanges and other selected areas of a titanium valve housing. (In this particular application, the copper coat is needed as a base for electrodeposition of a nickel coat that is to protect a layer of insulation and anchor the nickel to the housing, because electrodeposited nickel does not adhere to titanium.) Heretofore, the copper coat has been deposited by air plasma spraying, but oxidation of both the copper and the titanium during the spraying process has resulted in a brittle layer of copper that has adhered poorly to the titanium.

In preparation for vacuum plasma spraying, the parts of the titanium housing not to be coated with copper are masked. The housing is placed in the vacuum chamber, where it is heated to a temperature of 850 °F (454 °C) by use of the plasma gun. Oxides and other contaminants on the surface of the housing are then removed by reverse-polarity, transferred-arc cleaning.

The plasma used in spraying (see figure) is generated by passing a carrier gas of 80 percent argon and 20 percent helium through an electrical discharge in the chamber. In the low-pressure [40-torr (5-kPa)] environment of the chamber, the plasma is accelerated toward the target to be sprayed (in this case, the titanium housing) and reaches speeds as great as mach 3. Highly pure copper powder is injected into the plasma, which accelerates the powder particles toward the target.

The length of the plasma plume is adjusted by variation of the pressure in the chamber (around the nominal 40 torr): the purpose of this adjustment is to make the particles of powder stay in the plume for just enough time to be softened by heating to a thoroughly malleable condition (and not to be heated to a liquid condition in which they splatter upon impact on the target). The particles attain a speed of about mach 1.5 just before impact. The combination of high purity, high impact speed, and absence of reactive gases results in a tenacious coat that can be removed only by machining.

This work was done by Chris Power, W. H. Woodford, Richard R. Holmes, David H. Burns, Timothy N. McKechnie, and Ron Daniel of **Marshall Space Flight Center**. *For further information,* ***write in 12*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 26]. Refer to MFS-28664.

MODEL #	FEATURES	APPLICATIONS
GP-KS152	■ Digital Signal Processing (DSP) ■ 1/2" Microlens CCD color microcamera ■ Electronic Light Control (ELC) ■ Minimum illumination 0.5fc ■ On-screen programmable features ■ 25 zone backlight compensation ■ Remote camera head 2/3" D x 1-1/2" L (without lens)	■ Endoscopic vision ■ Inspection ■ Nondestructive analysis ■ Laparoscopic vision
GP-KS202	■ 1/3" CCD color microcamera ■ 330 lines horizontal resolution ■ Auto tracing white balance ■ Remote camera head 1/2" D x 1-3/8" L (without lens)	■ Inspection ■ Nondestructive analysis ■ Machine vision ■ Endoscopic vision ■ Laparoscopic vision
GP-KS102	■ 1/2" CCD color microcamera ■ 430 lines horizontal resolution ■ Detachable head ■ Y/C (SVHS) and composite outputs ■ Auto gain control ■ Selectable TTL auto tracing ■ 12V DC operation ■ Camera head 2/3" D x 1-7/16" L (w/o lens)	■ Engines & machinery ■ Endoscopic vision ■ Nondestructive analysis ■ Surface mount inspection ■ Inspection ■ Laparoscopic vision
GP-MS112	■ 1/2" CCD B/W microcamera ■ 500 lines horizontal resolution ■ Detachable head ■ 12V DC operation ■ Camera head 2/3" D x 1-7/16" L (w/o lens)	■ Robotics ■ Machine vision ■ Inspection ■ Nondestructive analysis
GP-KR212	■ Digital Signal Processing (DSP) ■ 1/2" Microlens CCD color camera ■ 430 lines horizontal resolution ■ Minimum illumination 0.3fc at f1.4 ■ ELC and auto backlight comp. ■ 2H enhancer, aperture correction & knee circuitry	■ Microscopy ■ Measurement & inspection ■ Robotics ■ Surface mount inspection
GP-KR412	■ Same as GP-KR212 in addition to: ■ Full on-screen programming ■ 25 zone auto backlight comp. ■ Genlock capability	■ Microscopy ■ Measurement & inspection ■ Robotics
GP-KR402	■ 1/2" CCD color camera ■ 430 lines horizontal resolution ■ Variable speed electronic shutter ■ Y/C (SVHS) & composite outputs ■ 12V DC operation	■ Test & measurement ■ Inspection ■ Motion analysis
GP-MF552	■ Asynchronous electronic shutter ■ 2/3" CCD, 768 (H) x 495 (V) pixels ■ 570 lines horizontal resolution ■ Minimum illumination 0.05fc at f1.4 ■ External sync HD, VD	■ High speed analysis ■ Image processing ■ Process measurement
GP-MF502	■ 2/3" CCD, 768 (H) x 495 (V) pixels ■ 570 lines horizontal resolution ■ External sync HD, VD	■ Image processing ■ Process measurement
GP-MF702/D	■ 2/3" MOS image sensor 649 (H) x 491 (V) pixels ■ Asynchronous VD reset ■ Sq. pixels 13.5mm x 13.5mm with pixel clock in/out ■ Selectable scanning system (525 full line non-interlace) ■ Double speed scanning	■ Robotics ■ Inspection ■ Machine vision ■ High speed analysis
GP-MF200	■ 2/3" CCD, 768 (H) x 493 (V) pixels ■ 570 lines horizontal resolution ■ Remote head ■ External sync HD, VD	■ Factory automation ■ Robotics ■ Machine vision ■ Inspection

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Cameras shown with optional lenses.

Capacitive Proximity Sensors With Additional Driven Shields

Sensitivities can be adjusted electronically.

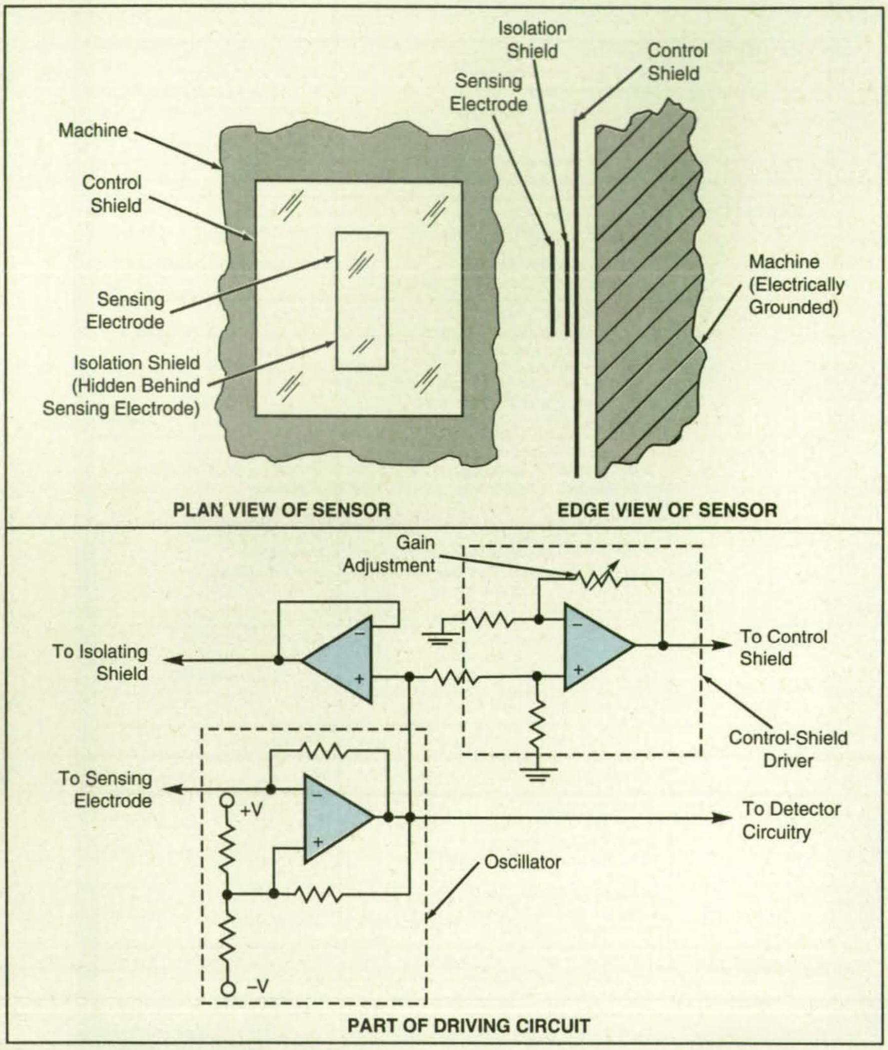
Goddard Space Flight Center, Greenbelt, Maryland

Improved capacitive proximity sensors can be constructed by incorporating one or more additional driven shield(s). The sensitivity and range of a sensor can be altered by adjusting the driving signal(s) applied to the shield(s). This is an extension of a simpler driven-shield capacitive-sensor concept described in "Capacitive Proximity Sensor Has Longer Range" (GSC-13377), *NASA Tech Briefs*, Vol. 16, No. 8, August 1992, page 22.

Typically, a capacitive proximity sensor is mounted on a robot or some other machine that is electrically grounded. An improved capacitive proximity sensor includes a sensing electrode and a driven isolating shield that correspond to the sensing electrode and driven shield of the prior driven-shield sensor. The improved sensor shown schematically at the top of the figure also includes one additional driven shield, called the "control" shield.

An object in the vicinity of the sensor is detected via a change in the frequency of an oscillator; the frequency varies with the capacitance between the sensing electrode and the electrical ground of the oscillator circuit. As explained in more detail in the noted prior article, the driven isolating shield increases the sensitivity and range of the device by concentrating more of the sensing electric field into the exterior space to be probed.

The control shield in the improved sensor is driven by an adjustable-gain amplifier. When the gain is set at 1, the sensitivity and range of the sensor are the same as those of a prior simpler driven-shield sensor that has an identical sensing electrode and a driven shield of the same overall dimensions as those of the present control electrode. Similarly, when the gain is set at a value greater or less than 1, the sensitivity and range are greater or less, respectively.



The **Driven Control Shield(s)** provide(s) additional, adjustable sensitivity and range.

This work was done by Robert L. McConnell of West Virginia University for **Goddard Space Flight Center**. *For further information,* ***write in 23*** *on the TSP Request Card.*
GSC-13475

Improved Circuit for Hot-Film Anemometer

This circuit is suitable for automation or computer control of setup and operation.

Langley Research Center, Hampton, Virginia

The figure is a block diagram of a constant-temperature hot-film or hot-wire anemometer with improved electronic circuitry. As in conventional hot-film and hot-wire anemometer circuits, a wire or film resistive heated component exposed to the flow to be measured (the sensing resistor) lies in one of the arms of a wheatstone bridge, while a reference resistor (which has nominally the same resistance and temperature in the absence of flow) lies in the other arm. A variable inductor is included in the reference arm in series with the reference resistor to enhance the frequency response by compensating for the inductance of the sensing resistor and its connecting cable.

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$$\nabla\times H = J + \epsilon\frac{\partial E}{\partial t} \quad \nabla\times E = -\mu\frac{\partial H}{\partial t} \quad \nabla\cdot E = \frac{\rho}{\epsilon} \quad \nabla\cdot H = 0$$

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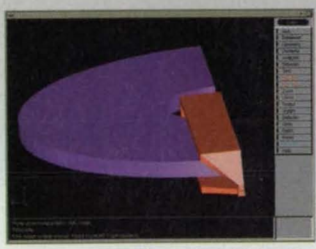

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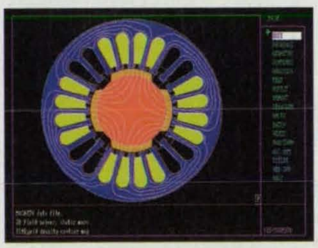

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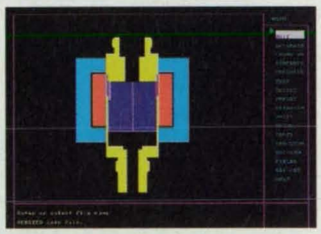

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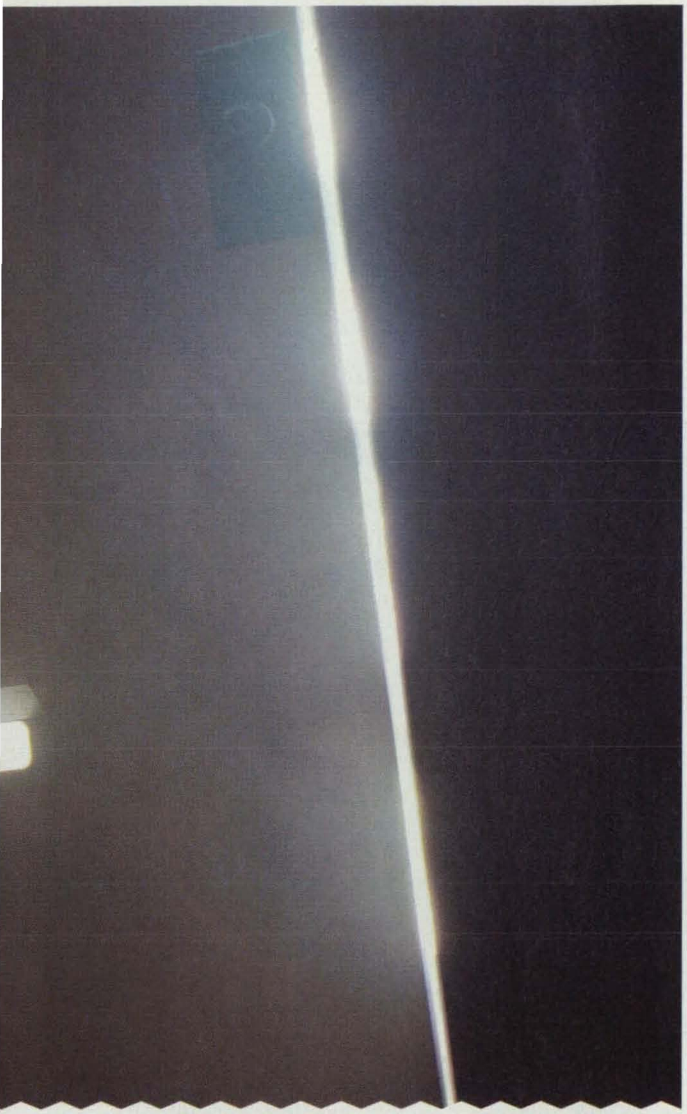

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Speed (System Clock)	5MHz	60MHz	100MHz	250MHz
Cost (Relative)	100	10	5	1
Pins	68	240	350	600
Design Methodology	Equation	Schematic	HDL	System

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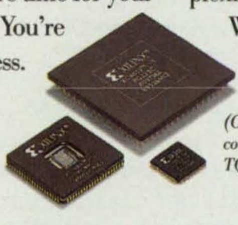

(Clockwise from left) Our XC7300 EPLD for PAL conversion, our new 13,000 gate XC4013 FPGA, and a TQFP, one of our more than 250 packaging options.

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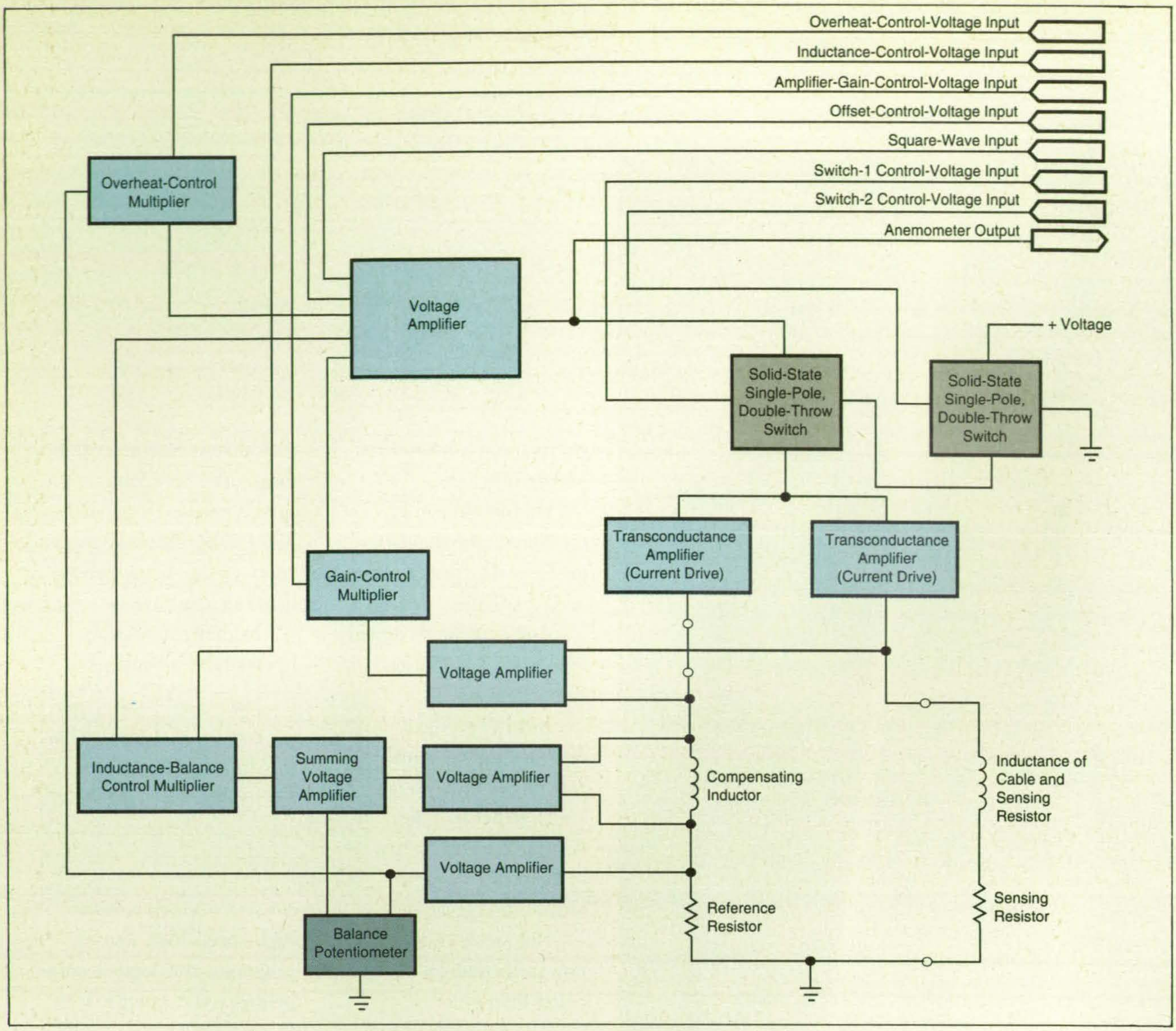

This **Hot-Film or Hot-Wire Anemometer Circuit** features individual current drives for the two arms of a wheatstone bridge, plus other features that provide improved calibration and automated or computer-controlled operation.

In a conventional anemometer circuit, a driving voltage is applied to the two arms in parallel and is controlled by feedback of the differential output voltage of the bridge in such a way as to maintain the sensing resistor at constant resistance (and, therefore, at constant temperature). The change in voltage needed to restore the temperature to the value set by the reference resistor is taken as a measure of the flow over the sensing resistor.

The ratio between the sensing resistance during heating and the sensing resistance at some nominal temperature is called the overheat ratio and is controlled and set by switching various reference resistances into the reference arm of the bridge. Calibration is difficult and time consuming because the transfer of heat due to the flow is nonlinear. The conventional design also has other disadvantages, including undesired interactions between the arms of the bridge, with consequent degradation of frequency response; lack of flexibility in setting the overheat ratio; difficulty in providing compensating inductances over a sufficiently wide range; uncertainty in calibration when dynamic variations in flow are large; lack of adequate means to measure frequency response; and no provision for automation to provide continuous overheat settings, compensation adjustments, and offset control.

The improved anemometer circuit provides for separate current feeds in the arms of the bridge instead of a common voltage feed, thereby eliminating some of the undesired interactions between the arms, leading to enhanced frequency response. Unlike in a conventional anemometer circuit, inductive balance is not a function of the sensing resistance, overheat ratio, or flow, for the model assumed so, that one can perform the inductive compensation initially, and there is no need to do it again each time these parameters change.

In the improved circuit, overheat settings are made by adjusting a voltage over a continuous range, making it possible to compensate for small differences in the reference and sensing resistances. This feature allows for fluctuations in overheat (including sinusoidal changes) and enables computer or automated control of overheat.

The inductive balance is voltage-controlled, making it possible to use a fixed compensating inductor instead of a variable one. This feature provides a greater balance range and allows computer or automated control of compensation for improved frequency response.

This work was done by David L. Gray 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 26]. Refer to LAR-14856.

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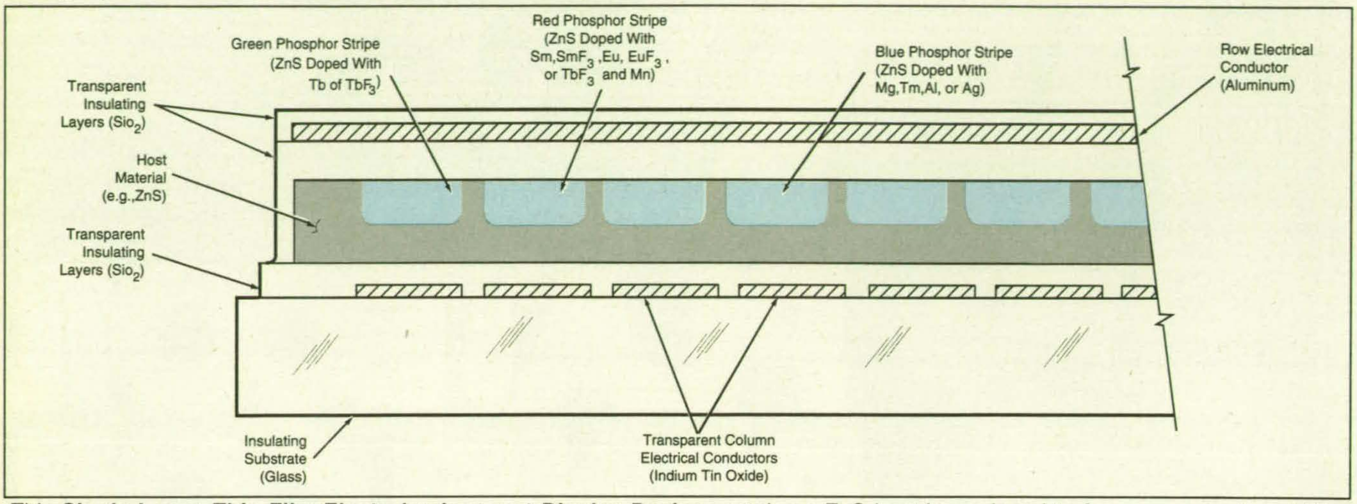
Electroluminescent Displays Made With Alternative Dopants

Metals and metal fluorides are deposited in ZnS to form color phosphors.

Langley Research Center, Hampton, Virginia



This **Single-Layer, Thin-Film Electroluminescent Display Device** contains a ZnS host layer doped to form green, red, and blue phosphors. Luminescence in the chosen colors at the chosen intersections between rows and columns is produced by the application of voltages to the appropriate row-and-column pairs of conductors.

Single-layer, multicolor, thin-film electroluminescent display devices can be made with alternative dopants in the phosphors. Such devices and phosphors in them were described in "Single-Layer, Multicolor Electroluminescent Phosphors" (LAR-13616), *NASA Tech Briefs*, Vol. 12, No. 5 (May 1988), page 18.

The figure illustrates an example of a three-color device. Fabrication begins with the deposition of stripes of indium tin oxide on a glass substrate to form transparent column conductors. A transparent insulating layer of SiO_2 is then deposited, typically by sputtering. ZnS, which serves as a host material for the dopants, is deposited on the SiO_2 by evaporation, sputtering, or other thin-film deposition technique.

Color phosphor stripes, aligned along the columns in this example, are formed by thermal diffusion and/or ion implantation of various impurities (dopants) through a metal or photoresist mask. One dopant is deposited at a time, and the mask is repositioned before the deposition of the next dopant. The dopants in a three-color device mentioned in the noted prior *NASA Tech Briefs* article were TbF_3 (green), Mn plus TbF_3 (red), and Mg (blue). The alternative dopants are Tb (green); Eu or EuF_3 (red); and Tm, Al, or Ag (blue).

The host ZnS layer containing the phosphor stripes is annealed. It is then covered by a second transparent insulating layer of SiO_2. Row conductors of aluminum are deposited on this SiO_2 layer, then covered with a final insulating layer of SiO_2. The row and column conductors constitute an addressable matrix: The application of a voltage to any row-and-column pair of conductors generates an electric field at their intersection, causing green, red, or blue luminescence, the color depending on which phosphor is in the column.

This work was done by James B. Robertson of **Langley Research Center**. *For further information,* ***write in 18*** *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 26]. Refer to LAR-14811.

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Reducing Magnetic Fields Around Power Cables

Four power conductors are arranged symmetrically about a fifth grounded conductor.

Lewis Research Center, Cleveland, Ohio

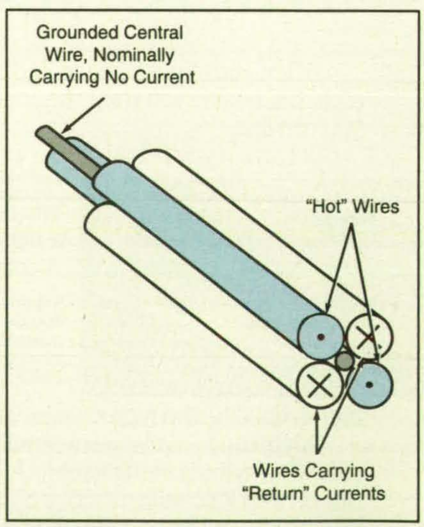
In a technique for reducing the magnetic field around a power cable, a grounded wire that nominally carries little or no current is added in a symmetrical arrangement with the current-carrying wires. The technique is intended for use when the size of the wires in the cable makes twisting impractical. (Twisting is a conventional technique for reducing the magnetic field in the vicinity of a cable.)

The technique utilizes four current-carrying wires in a quadrupole configuration that is composed of two sets of parallel wire pairs with equally but oppositely directed currents. The four current-carrying wires are positioned at equal intervals around a central grounded fifth wire, with the two "hot" wires diametrically opposite to each other and the "return" current-carrying wires similarly disposed, as shown in the figure. The central fifth wire is connected to ground via the backshell of the cable connectors and/or structures at the ends of the cable.

The central fifth wire is not necessarily large enough to handle fault currents; its diameter is chosen to fill the gap in the cable while maintaining close spacing of the four current-carrying conductors. One side benefit of this five-conductor configuration is that the current on each current-carrying wire is nominally half that of a conventional two-conductor cable that carries the same current, and the size of the wires can be reduced accordingly.

Both common-mode and differential-mode currents on a power cable are sources of magnetic-field emissions. In experiments, magnetic-field emissions were measured 1 meter from cables that had various configurations and that carried 1 A of current in differential mode. The data from measurements on a pair of wires and on a four-wire cable with central grounded fifth wire compare favorably with calculated magnetic-flux densities. The magnetic-flux density around the four-wire cable was found to be smaller than that of the pair of parallel wires at any measurement distance and to be 20 dB below that of a pair of twisted wires (four twists per meter).

Similar measurements were performed with respect to magnetic-field emissions from common-mode currents between the current-carrying wires and the ground-



Four Current-Carrying Wires are arranged symmetrically around a central grounded wire that nominally carries no current. In comparison with other cable configurations, this one results in smaller magnetic fields around the cable.

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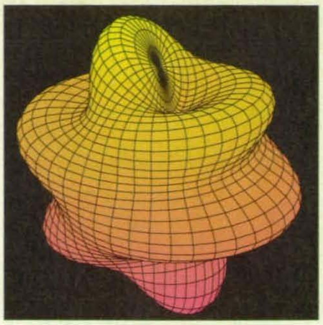
Visualization of a spherical harmonic function, created with the new Symbolic Math Toolbox.



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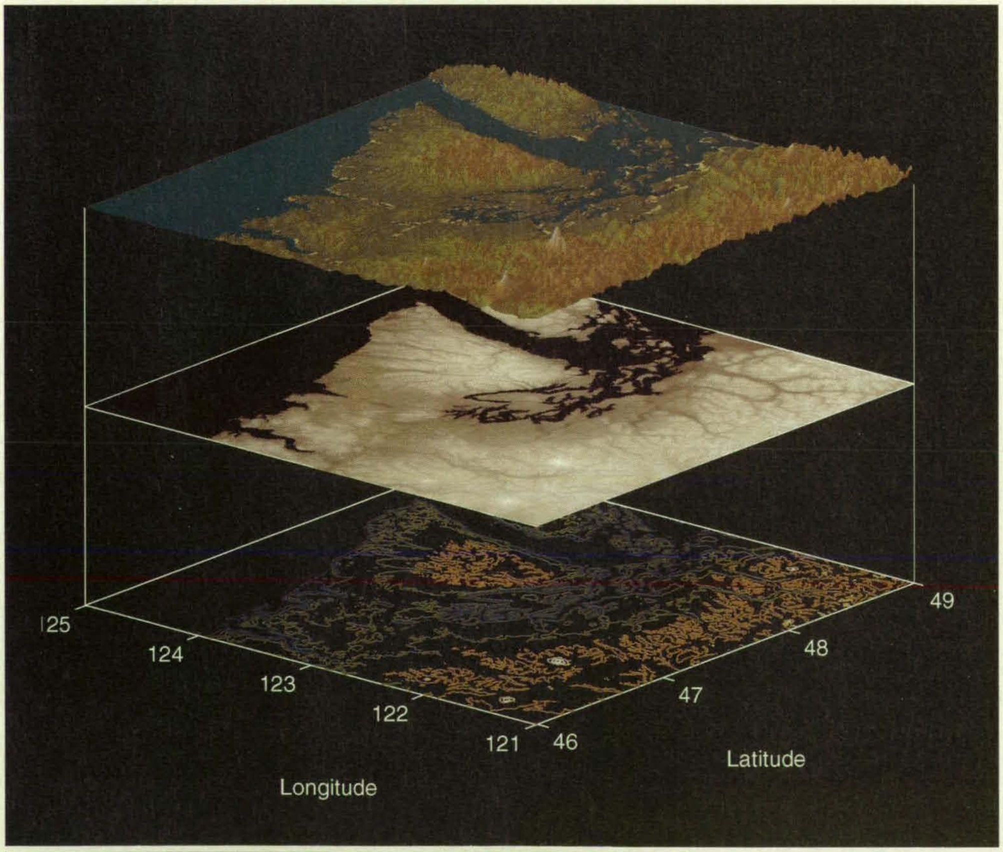

Altitude data of the Puget Sound region of the United States and Canada. Data was enhanced with the Image Processing Toolbox and rendered with MATLAB Handle Graphics. Data courtesy of NOAA.

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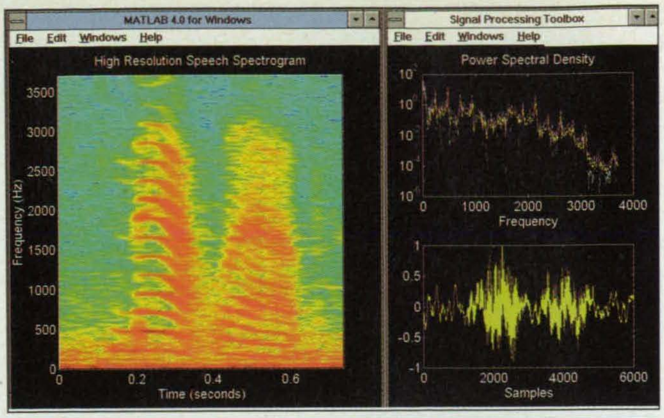

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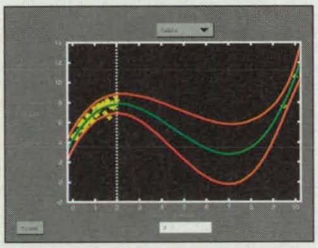

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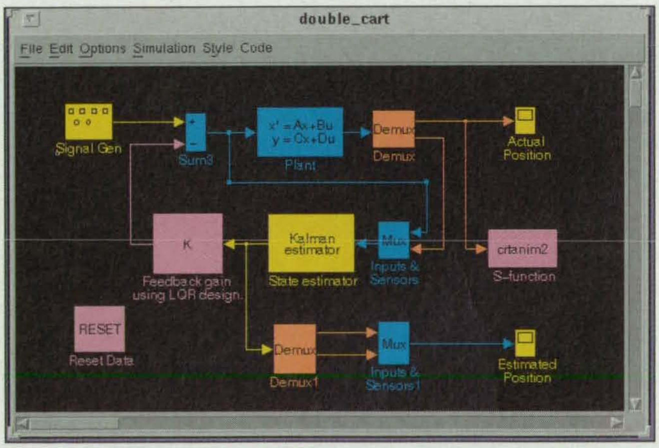

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ed wire. In practice, common-mode circuits are usually completed through such unintentional ground paths as the safety ground wires that are often color-coded green, cable trays, cable shields, and other conductive structures. The four-wire cable with central grounded fifth wire was found to generate common-mode emissions nearly 30 dB below those of a cable of two current-carrying wires with adjacent green wire.

This work was done by Noel B. Sargent of **Lewis Research Center** *and Florida Gitelman, Edward Pongracz-Bartha, and John Spalding of Rocketdyne International, Corp. No further documentation is available.*
LEW-15454

Direct-Current Monitor With Flux-Reset Transformer Coupling

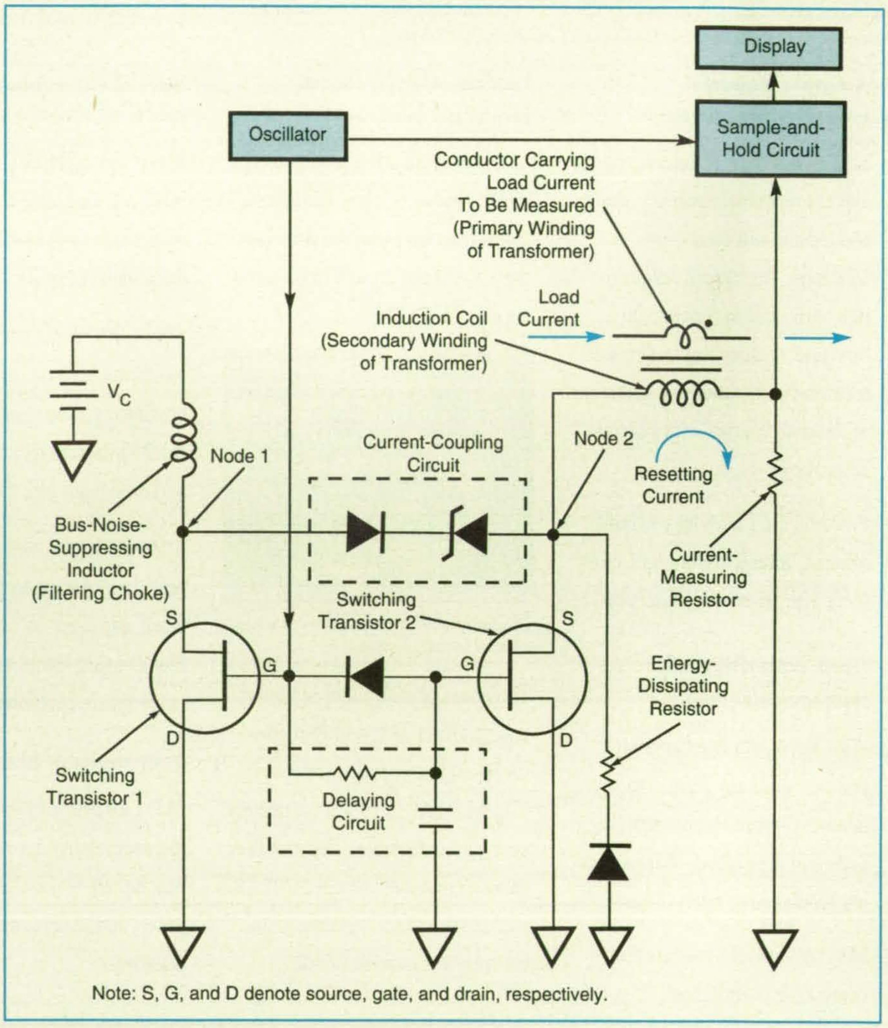
Flux is reset periodically to prevent saturation from distorting measurements.

Lewis Research Center, Cleveland, Ohio

The figure illustrates a circuit that measures a constant or slowly-varying unidirectional electrical current (load current) by use of flux-reset transformer coupling. The measurement is nonintrusive in the sense that there is no need for direct contact with the wire that carries the load current to be measured, and there is no need to install a series resistive element in the load-current path. Instead, a toroidal magnetic core (e.g., a clamp-on core) wrapped with a coil of wire is placed around the load-current-carrying wire. The toroidal core acts as a transformer core, the load-current-carrying wire acts as the primary winding of the transformer, and the coil wrapped on the core acts as the secondary winding.

In flux-reset transformer coupling, the flux in the core is periodically reset to prevent magnetic saturation of the core from distorting the measurements. The frequency of reset is the frequency of the oscillator (typically, between 100 and 2,000 Hz), which puts out rectangular pulses, each lasting 90 percent of the cycle. The pulses govern the reset-and-measurement sequence.

At the beginning of a cycle, the output of the oscillator goes high, causing switching transistor 1 to turn on, pulling the voltage on node 1 down to ground level. A short time thereafter, as determined by the resistor/capacitor delaying circuit, switching transistor 2 turns on, pulling the voltage on node 2 down to ground level. Because the flux in the transformer core has been reset (as will be explained subsequently), the flux induced by the load current reappears in the core, inducing a voltage and current in the secondary winding. This secondary current flows through the current-measuring resistor, the voltage across which is measured by the sample-and-hold circuit. As long as the core is not saturated, this voltage is representative of the primary current, and is processed into an indication of the current, which is displayed. The sample-and-hold circuit, synchronized by the oscillator, measures the voltage during this part of the cycle.



This **Circuit Measures the Load Current** without making contact with the load-current conductor, by use of flux-reset transformer coupling.

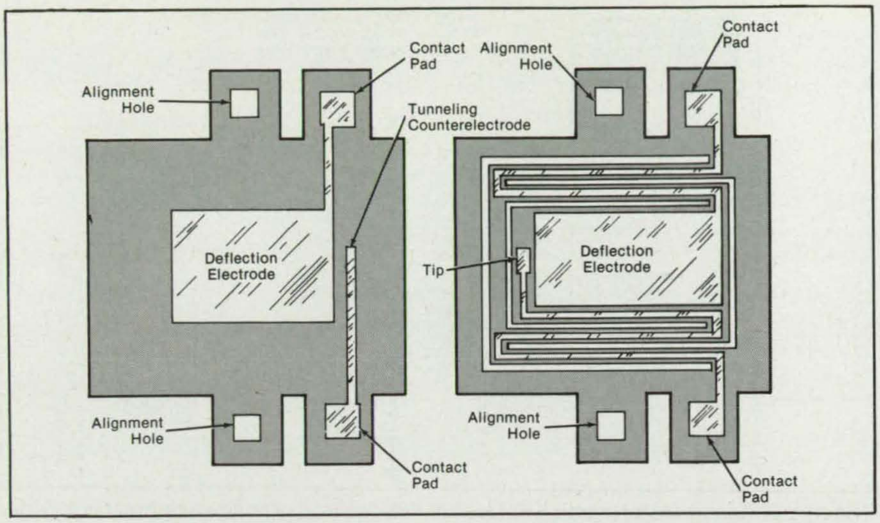
The reset portion of the cycle is timed to begin before saturation is reached. First, the output of the oscillator goes low, causing both switching transistors to turn off, allowing the voltages at nodes 1 and 2 to rise above ground level. This causes the resetting current to flow from the power supply Vc through the diode/zener-diode current-coupling circuit and the secondary winding to ground, driving the core into reverse saturation. At the beginning of the next cycle, the output of the oscillator goes high again, disconnecting the secondary winding from the source of resetting current. During the short delay before switching transistor 2 turns on, the magnetic energy stored in the transformer is discharged in the energy-dissipating resistor. The flux in the core has now been reset, and when switching transistor 2 turns on, the measurement can be repeated.

This work was done by Stanley Canter of Ford Aerospace Corp. (now Space Systems/Loral) for **Lewis Research Center**. *For further information,* ***write in 72*** *on the TSP Request Card.*
LEW-15224

Micromachined Tunneling Accelerometer

Separation of the tunneling electrodes is adjusted by varying an electrostatic force.

NASA's Jet Propulsion Laboratory, Pasadena, California



The **Major Components of the Tunneling Transducer** are formed on two silicon chips by microfabrication techniques.

A sensitive miniature force or displacement transducer operates on the same principle as that of a scanning tunneling microscope. The quantum-mechanical-tunneling current of electrons across a gap between two electrodes (a sharp tunneling tip and a relatively flat counterelectrode) is measured and used as a feedback signal to adjust the position of one of the electrodes to maintain a constant distance across the gap. The control signal applied to the adjustable electrode thus serves as a measure of either the displacement of the other electrode or a disturbing force applied to the adjustable electrode. In this case, the measured quantity is a disturbing force proportional to acceleration of the device along the axis of displacement of the adjustable electrode. In other cases, the disturbing forces could represent intensities of infrared radiation, pressures, or magnetic fields, for example.

The miniature transducer contains two chips that are fabricated from two single-crystal silicon wafers by techniques of photolithography, micromachining, and metallization (see figure). Unlike older tunneling transducers, which contain piezoelectric actuators, this one contains an electrostatic actuator. In this case, the adjustable tunneling electrode is the sharp tunneling tip and is formed on a micromachined folded cantilever spring along with a larger deflection electrode on one of the chips. The tunneling counterelectrode and the other deflection electrode are formed on the other chip. When the chips are aligned and mounted together, the voltage between the two deflection electrodes is regulated to adjust the electrostatic force between them, thereby also adjusting the gap. The use of electrostatic instead of piezoelectric deflection reduces the sensitivity of the transducer to thermal drift and simplifies its design.

Prototypes of this transducer have been fabricated and found to operate within an order of magnitude of the limitation imposed on sensitivity by shot noise. Specifically, a displacement-measuring version with dimensions of 2 by 2 by 0.05 cm exhibited a displacement sensitivity of 10^{-4} Å/$\sqrt{Hz}$ at a frequency of 1 kHz and 10^{-3} Å/$\sqrt{Hz}$ at 10 Hz. This sensitivity is several orders of magnitude superior to that of any conventional displacement transducer of similar dimensions. An acceleration-measuring version (which includes a lumped mass on the cantilever to increase the deflecting force) exhibited a sensitivity of 10^{-7} g/$\sqrt{Hz}$ at 10 Hz (where g = standard Earth gravitational acceleration, about 9.8 m/s^2).

This sensitivity is suitable for applications in which much larger acceleration-sensing instruments would otherwise be required.

This work was done by Thomas W. Kenny, Stephen B. Waltman, William J. Kaiser, and Joseph K. Reynolds of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 61*** *on the TSP Request Card.* *NPO-18513*

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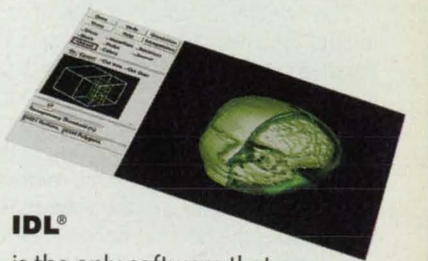

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Circuit Provides Negative Reference Voltage

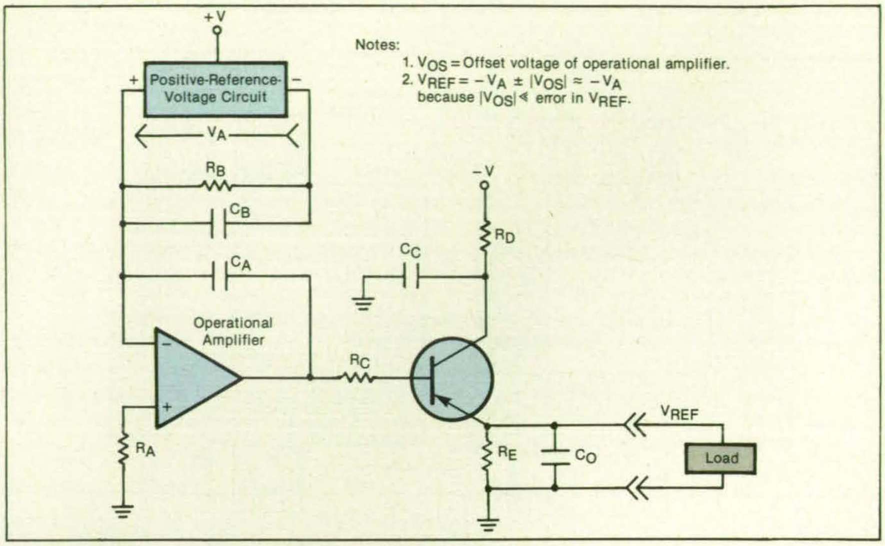
The circuit maintains a precise output voltage at relatively large load current.

Lewis Research Center, Cleveland, Ohio

The figure illustrates a circuit that supplies a precise negative reference voltage. To meet requirements of accuracy and stability, it incorporates a highly precise positive-reference-voltage circuit, and the positive reference voltage is converted to a negative-reference voltage by use of a high-gain, stable feedback booster circuit.

The booster circuit includes an operational amplifier and a transistor, which handles the load current. Typically, a positive-reference-voltage circuit can handle only relatively small load currents. This consideration does not apply in the present circuit because the positive-reference-voltage unit is placed in the voltage feedback loop of the booster circuit in parallel with resistor R_B. Thus, from the perspective of the positive-reference-voltage unit, R_B is a constant load. This feature enhances the stability of the circuit by removing the load regulation factor.

Provided that the offset voltage of the operational amplifier is low, the accuracy of the overall circuit depends only on the accuracy of the positive-reference-voltage unit. The overall circuit draws very little power for its own operation. It can handle unexpectedly heavy loads; the feedback configuration and the high gain provided by the combination of the operational amplifier and the transistor give the circuit a very low output impedance. The capacitors reduce the noise voltage and help stabilize the circuit. In the event that the load becomes a short circuit, R_D protects the transistor by limiting the load current.

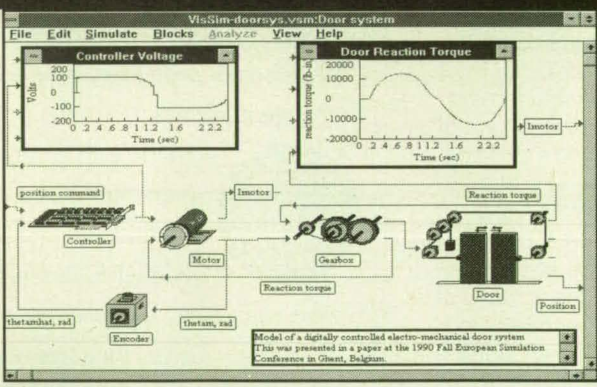


The **Circuit Generates a Negative Reference Voltage** from a positive reference voltage. It consumes little power and can handle relatively large load currents.

This work was done by Mort Arditti and Barbara Chernus of Rockwell International Corp. for **Lewis Research Center**. *No further documentation is available.*

LEW-15238

Visual Simulation for the 90s



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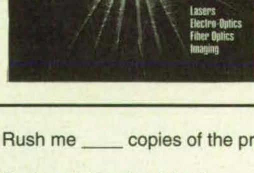

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For more information, write in the corresponding number on the Reader Action Request Form (page 103)

DMS-20PC SUBMINIATURE DIGITAL VOLTMETER

DATEL's component-style Digital Voltmeter is a complete 3.5 digit precision measurement module available in 5 LED colors as well as LCD. Available in 4 full scale input signal ranges, its very low cost ($29 ea.), modular size, and large LED (0.37") display make the DMS-20 ideal for OEMs and end-users everywhere.

Datel Inc.

For More Information Write In No. 300

DMS-40PC MINIATURE DIGITAL VOLTMETER

The compact (0.9" x 2.1" x 0.5"), 4.5 digit DMS-40 is available in 5 standard LED colors covering 3 full scale signal input ranges. Optional BCD output and display hold pins coupled with standard dual range signal inputs and 5 VDC operation, make this very low cost voltmeter ($79 ea.) perfect for large OEMs and end-users alike.

Datel Inc.

For More Information Write In No. 301

DMS-30PC MINIATURE DIGITAL VOLTMETER

The DMS-30PC is the only self-contained, encapsulated digital voltmeter available in 9 LED colors or LCD. Covering 3 full scale input signal ranges, this ruggedized, low cost ($29, qty. 100) digital voltmeter is perfect for virtually all voltage measurement applications.

Datel Inc.

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High-reliability computer systems from portables to rack-mount workstations. Architectures include IBM PC/AT, SUN SPARCstations, VME and custom hardware; also keyboards, monitors and turn-key systems. Brochure details industrial, aviation and military models.

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Route 9, Box 160, Cold Spring, NY 10516
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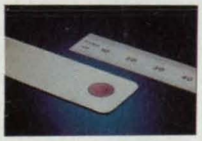
For More Information Write In No. 303

ARE YOU STILL TRYING TO MEASURE VERY THIN GAPS THE HARD WAY?



Capacitec HPS Series of thin (back to back) sensors can measure gaps as small as 0.010" (.254 mm) inboard 84" (2133.6 mm) with accuracies of 0.0003" (7.6 mm), without scratching delicate surfaces.

Capacitec
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For More Information Write In No. 304

MICROSCOPES FOR MATERIAL SCIENCES

Microscope product line brochure details upright, inverted, stereo and laser scan microscopes; microscope cameras; microscope photometers; microtomes. All transmitted and reflected light techniques for material sciences and microelectronics inspection can be accommodated. Advantages of Zeiss ICS infinity optics are discussed.

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Tel: 800-982-6493; Fax: 914-681-7432

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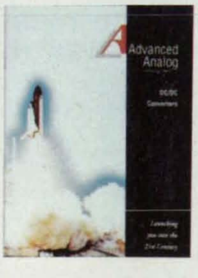
DESC APPROVED STANDARD MILITARY DRAWING HYBRID DC/DC CONVERTERS



Featured will be Advanced Analog's family of DESC approved Standard Military Drawing Hybrid DC/DC Converters. These converters are used in Military and Aerospace Applications. Output power range is 5-75 watts with Space Level and Radiation Hardened devices available. For more information please call 408-988-4930.

For More Information Write In No. 306

AUTOMATED PRESSURE CONTROL SYSTEM

Fully Programmable Pressure Generation System, available in pressure ranges from vacuum up to 60,000 psi, interfaces to virtually any computer system. Software provided for IBM-PC Compatible Systems. Both electronic and mechanical over-pressure fail-safe systems with automatic pressurizing fluid refill system. For details call 607-257-5544. Toll free in USA and Canada: 1-800-APP-VALVE. Fax: 607-257-5639.

Advanced Pressure Products

For More Information Write In No. 307

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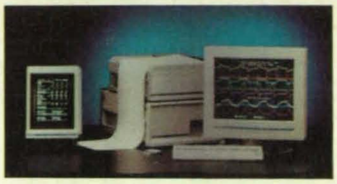

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For More Information Write In No. 311

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(216) 328-7000

For More Information Write In No. 312

Portable Recorder Has Integral, Real-Time Monitor and Signal Capture to 20 Mb PCMCIA Memory Cards

The WindowGraf® recorder gives you the power of recording systems with the simplicity of traditional recorders. You can monitor signals on the built-in, real-time monitor without running paper, capture signal data to disk or memory card, and automatically trigger and capture signals.

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For More Information Write In No. 313

A Recording System In A Portable Package

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PULNiX

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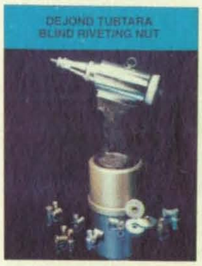

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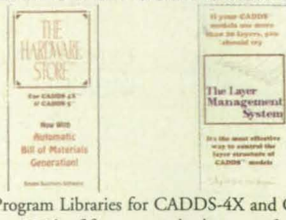

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(215) 358-4054

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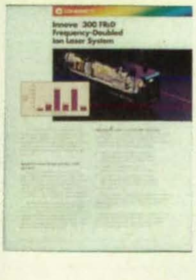

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Coherent, Inc.
Laser Group

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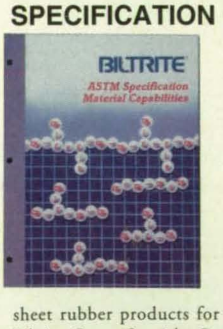
ASTM MATERIAL SPECIFICATION GUIDE



A handy, four-page guide to the qualities, capabilities of sheet rubber materials, as specified by the ASTM is now available from the Specialty Products Division of the Biltrite Corp. Featuring a two-page, full-color specification table of sheet rubber materials, this brochure makes it easy to order sheet rubber products for a given application. The Biltrite Corp., Specialty Products Division, Two University Office Park, 51 Sawyer Road, PO Box 9045, Waltham, MA 02254-9045. Tel: 1-800-877-8775.

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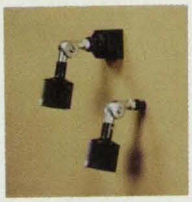

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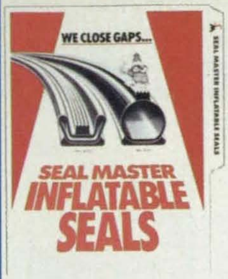

Brochure shows configurations of custom-built inflatable rubber seals. When inflated, a positive seal is formed between two surfaces. It's the solution for sealing out weather, water, noise, heat, cold, light, dark, pressure, vacuum, radiation, dust and contaminants. Design assistance available. Tel: 216-673-8410. Fax: 216-673-8242.

Seal Master Corporation

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This 106-page catalog gives information, including prices, on X-Y tables, microfinishing equipment, toolmakers' microscopes, stereo microscopes, alignment microscopes, monocular zoom microscopes, microtelescopes, pocket microscopes, borescopes and minibore-scopes, and fiber optic and miniature illumination systems. Also described are centering microscopes, optical cutting tool geometry analyzers, and more.

Titan Tool

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StressTel Corporation

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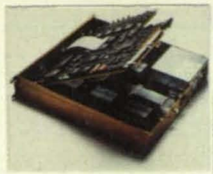

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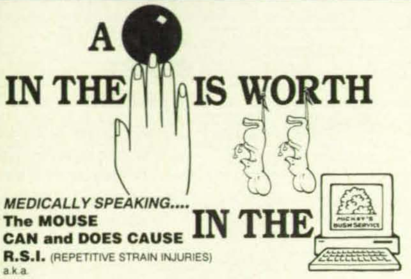

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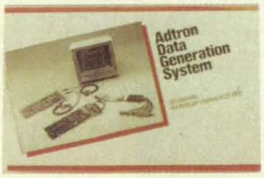

Adtron's PC-based Data Generation System facilitates testing, development and evaluation of digital components and systems, performing the work of numerous specialized instruments. DGS offers the capabilities of pattern, word and pulse generators while employing the cost-effectiveness and convenience of IBM personal computers.

Adtron

For More Information Write In No. 341

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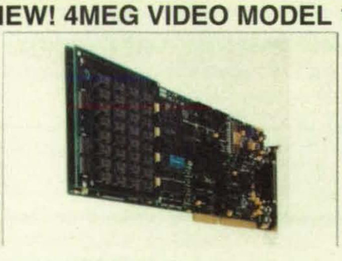
NEW! 4MEG VIDEO MODEL 12



The 4MEG VIDEO MODEL 12 provides image acquisition, processing, and display on PC/AT compatible computers, and offers up to 64 Mbytes of image memory, sampling/display rates up to 50 MHz, and a 12 MIPS on-board processor. The board interfaces to almost any video source. Tel: 708-498-4002; Fax: 708-498-4321.

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Astro-Med

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Gemini Incorporated manufactures industry standard cases for electronics, test equipment, instrumentation, and sales demos. These cases offer the best protection for delicate equipment and come in many sizes, styles and options. Gemini cases are designed to provide protection during shipping, carrying or out in the field.

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Advanced Pressure Products

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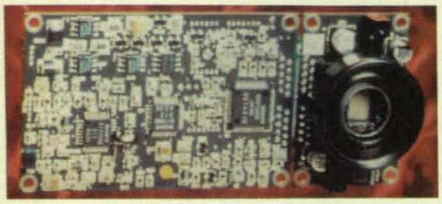

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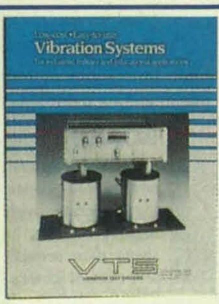

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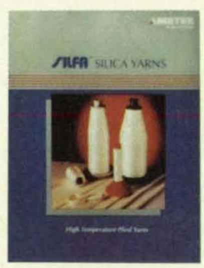

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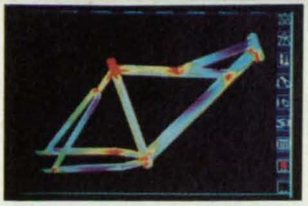

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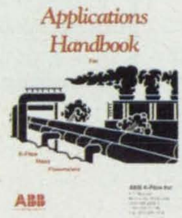

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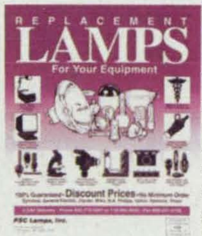

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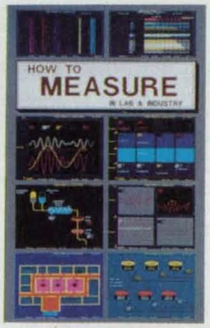

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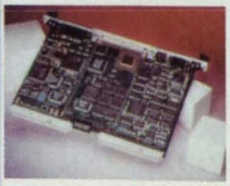

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Goddard Space Flight Center, Greenbelt, Maryland

Figure 1 illustrates schematically an apparatus that measures the curvature of a pipe or the displacement of some part of the pipe from a middle position or angle. The apparatus includes a sensor assembly that contains a rotatable, electrically conductive plate that covers an eddy-current sensing coil or coils to a degree that varies with the curvature, angle, or displacement to be measured. The sensor assembly is pushed or pulled along the pipe by a crawler assembly, which can contain a motorized driver or can be driven by a stiff cable from a stationary driver. Thus, the sensor assembly can take measurements at remote or inaccessible locations — for example, inside a buried water main.

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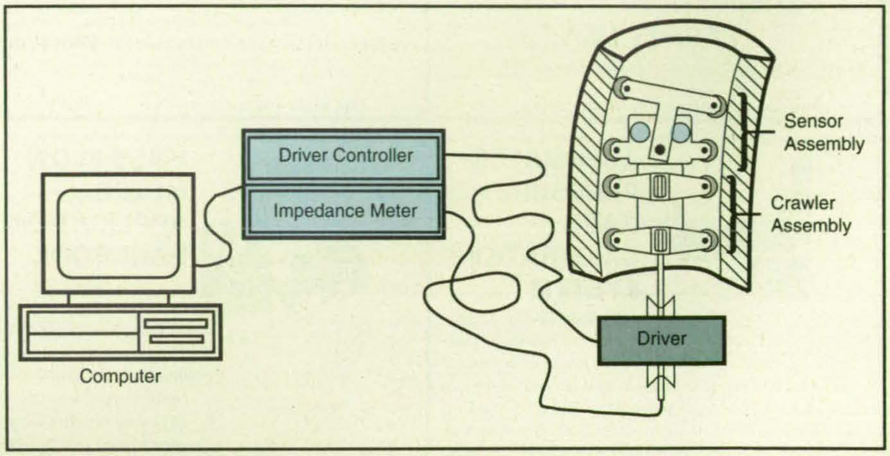

Figure 1. **Curvature of a Pipe** at a remote or otherwise inaccessible location inside the pipe can be measured by use of a relatively simple angular-displacement eddy-current probe.

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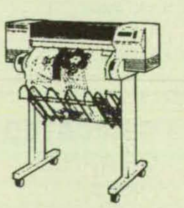

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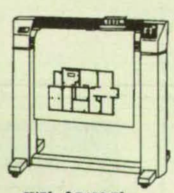

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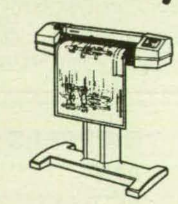

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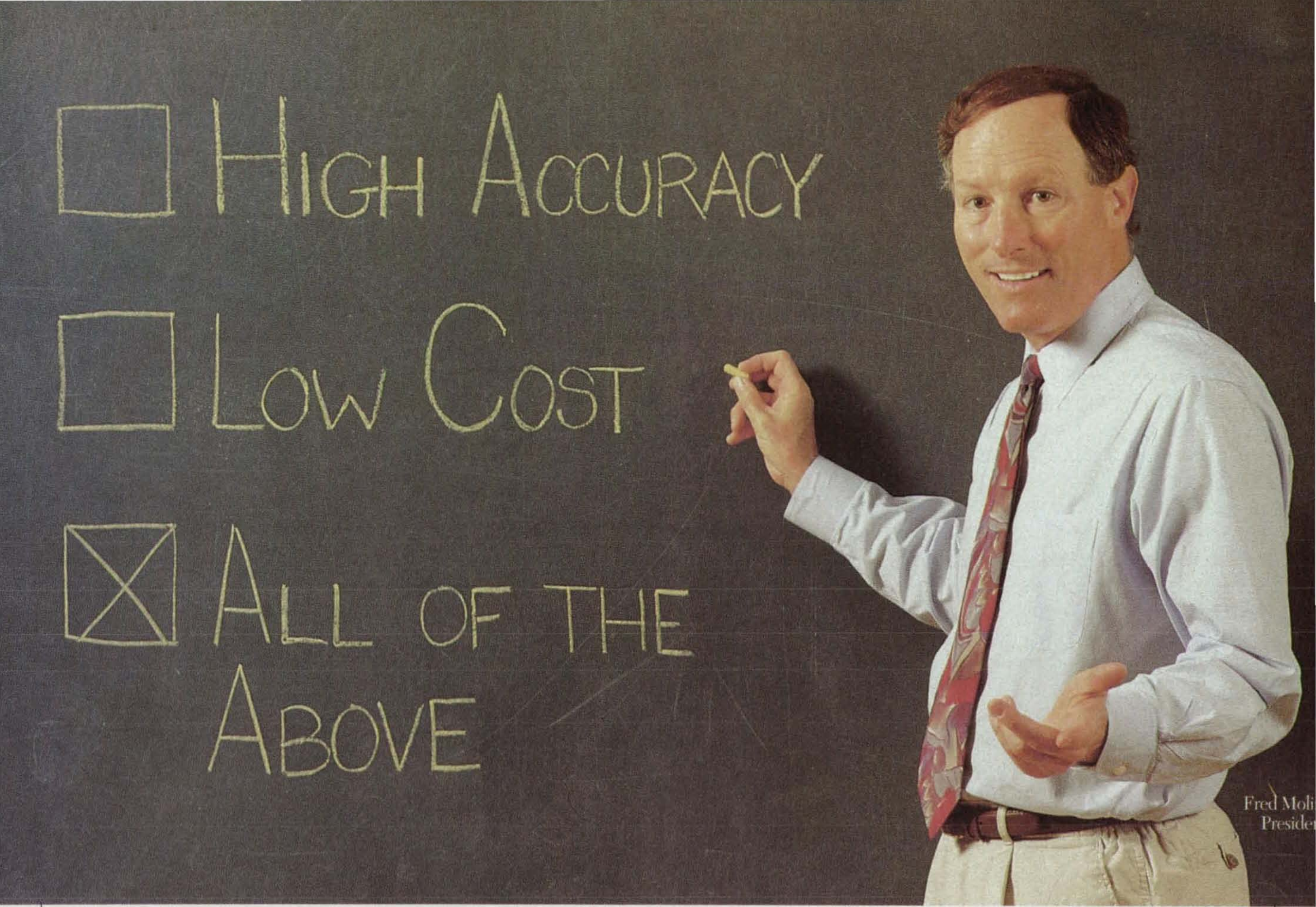

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an external controller, and the sensor assembly is connected by another cable to an impedance meter, which measures the impedance or change in impedance of the eddy-current coil. The driver controller and the impedance meter function under overall control by a computer, which also processes the impedance-measurement data into data on the curvature or displacement to be determined.

Figure 2 shows one version of the crawler and sensor assemblies in more detail. Wheels on both assemblies make contact with the inner wall of the pipe, and spacers on the crawler assembly help to stabilize it during travel along the pipe. Two sensing coils are mounted on the electrically nonconductive base plate on the sensing assembly, spaced apart by a suitable distance — e.g., the width of the electrically conductive plate. The electrically conductive plate pivots about a point on the centerline of the sensing assembly. Wheels on a crossmember on the electrically conductive plate make contact with the wall.

Thus, the electrically conductive plate pivots right or left by an angle that depends on the local curvature of the pipe. The conductive plate partly covers one or both other eddy-current coils by amounts that depend on the angle, and thereby affects the impedance of one or both coils to a degree that depends on the angle. The angular depen-

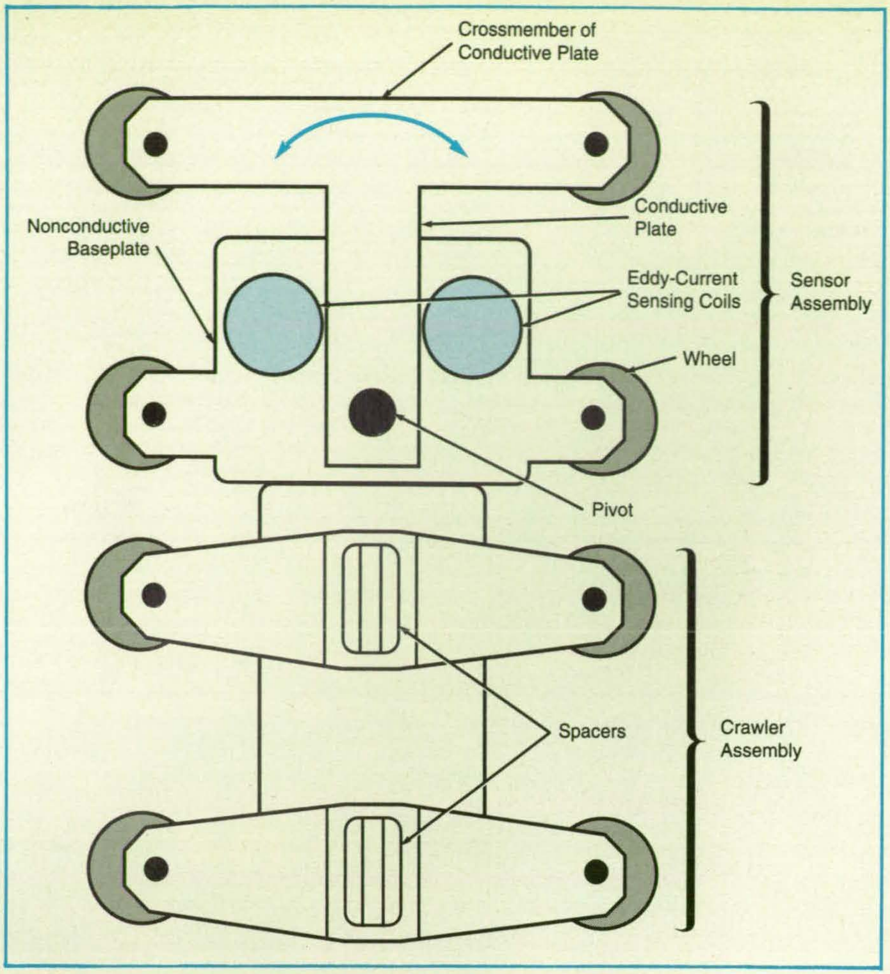

Figure 2. The **Crawler and Sensor Assemblies** move along the inside of the pipe on wheels. The conductive plate pivots to follow the curvature of the pipe, partly covering one of the eddy-current coils to a degree that depends on the local curvature of the pipe.

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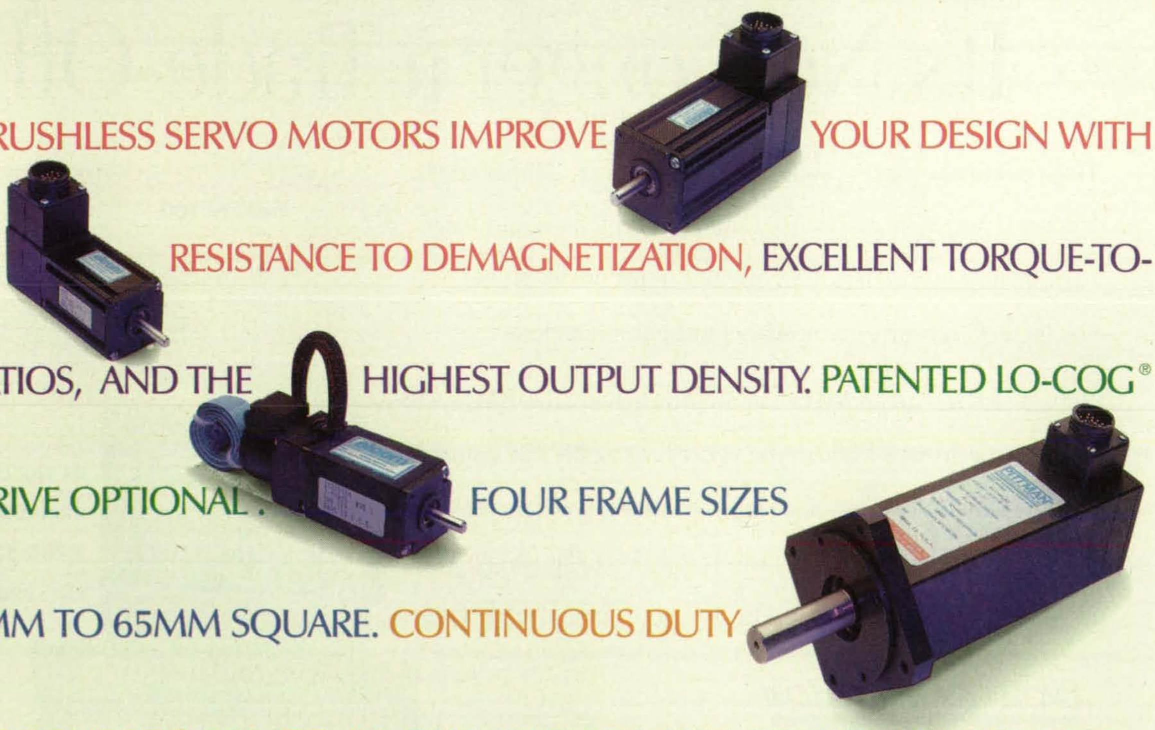

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[1]Sample suite of GPIB programmed audio measurements included 1) noise measurement (20Hz-22kHz bandpass), 2) 31 point single tone frequency response sweep over 20Hz-22kHz range, and 3) 11 point distortion sweep over 20Hz-22kHz range.
[2]*FAST*TEST uses multi-tone stimulus and analysis to make the same measurements listed above.

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dence of the impedances of the coils having been determined previously in calibration measurements and inverted in a straightforward manner, the present angle and the curvature of the pipe can now be computed from the present impedance measurements.

This work was done by Engmin J. Chern of **Goddard Space Flight Center**. *For further information,* ***write in 8*** *on the TSP Request Card.*
GSC-13506

Laser Transmitter Aims at Laser Beacon

The transmitter is part of a developmental optical communication system.

NASA's Jet Propulsion Laboratory, Pasadena, California

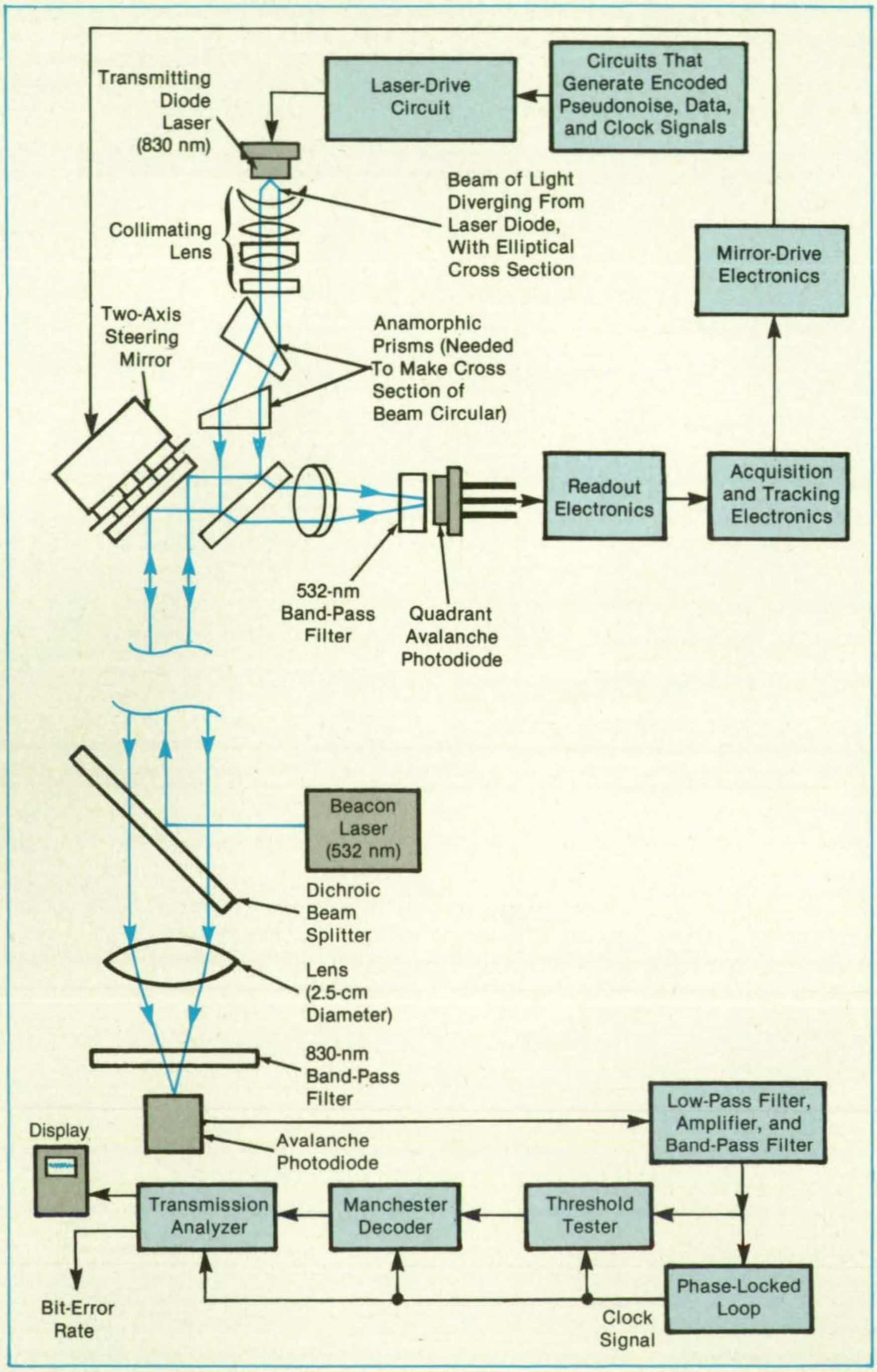
The prototype of a compact, lightweight, partially-self-aiming laser transmitter has been built to verify some of the capabilities of a developmental free-space optical communication system. The design is capable of providing 0.5 Mbps data return over a range equal to the Moon–Earth distance. The breadboard of this transmitting terminal was constructed and tested in the laboratory.

The transmitter (see figure) is intended to operate in conjunction with a laser beacon located at the receiving station. Once the transmitter package is mechanically aligned to within about 30 mrad (about 1.7°) of the line of sight to the receiver, a quadrant avalanche photodetector can measure the relative direction of the beacon. The output of this detector is processed into drive signals for a two-axis, voice-coil-actuated steering mirror; the mirror is thereby adjusted to bring the line of sight to the receiver into alignment with the optical axis of the transmitter package.

The optical components other than the steering mirror are not adjustable. For simplicity, ruggedness, and light weight, these other optical components are mounted in fixed positions on surfaces that are machined precisely into a single aluminum block. The optical portion of the package weighs about 310 g. The mass of the entire package is under 5 kg. Because the transmitted 830-nm beam that emerges into free space from the steering mirror has a divergence of 110 μrad, beam pointing tolerances can be relaxed, and there is no need to implement a separate point-ahead angle for most applications.

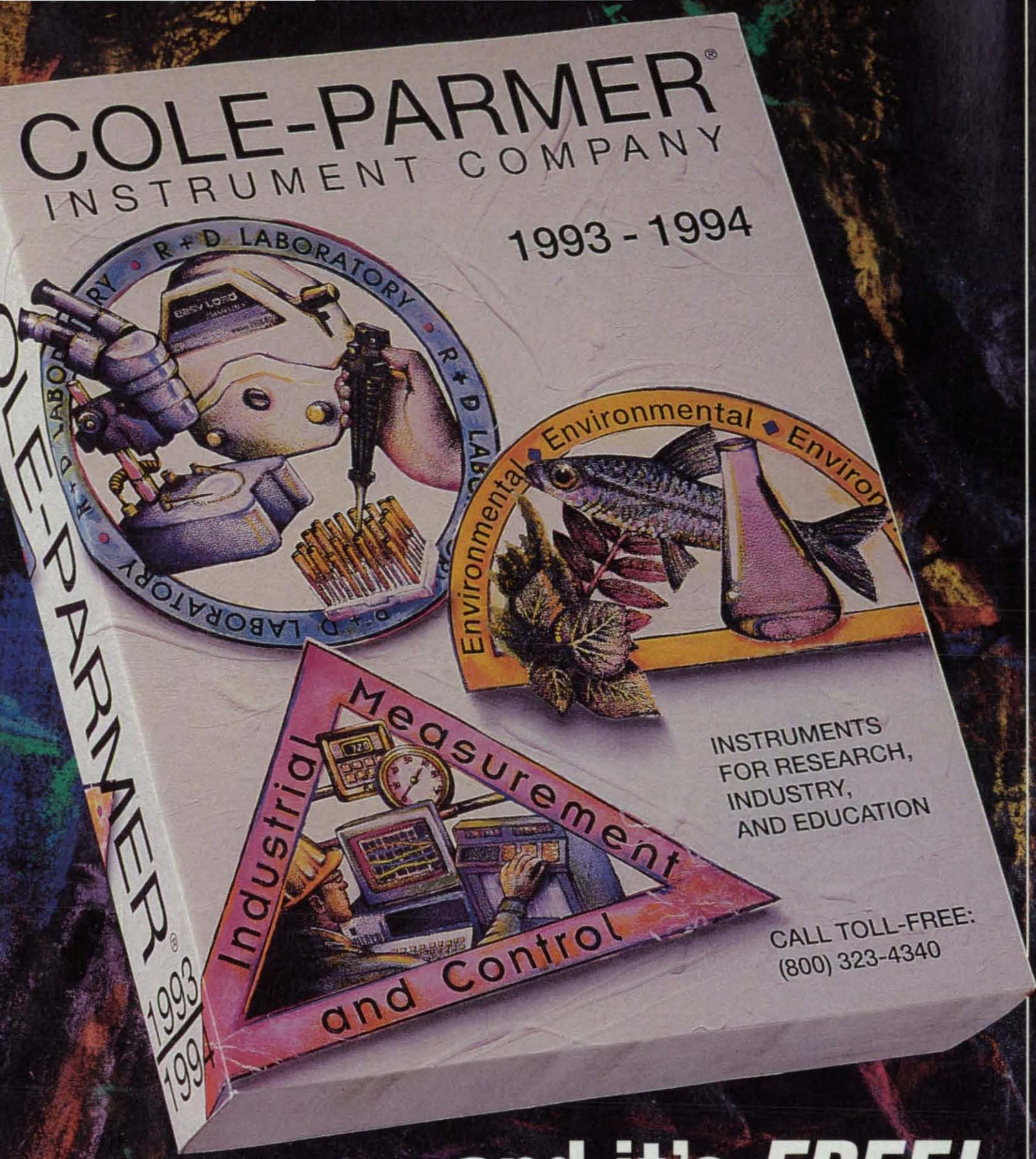
The laser beacon operates at a wavelength of 532 nm, while the diode laser in the transmitter package operates at a wavelength of 830 nm. The incoming 532-nm beam and the outgoing 830-nm beam share the long optical path between the receiving station and the steering mirror. They also share a short optical path between the steering mirror and a dichroic beam splitter, which separates them.

During a test, the output of the transmitting diode laser is modulated at 1 MHz with coded pulses. In the test receiving station, a dichroic beam splitter separates the 830-nm and 532-nm beams, and a lens of 2.5-cm diameter focuses the 830-nm beam onto an avalanche photodiode. The detected signal is amplified, filtered, threshold-tested, Manchester-decoded, then sent to a transmission analyzer, which compares it with the original encoded signal to compute the bit-error rate and other measures of performance.



The **Prototype Transmitter** includes receiving circuitry that keeps it aimed at the beacon, once it is brought into initial alignment within about 1.7° of the line of sight to the beacon.

This work was done by Hamid Hemmati and James R. Lesh of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 14*** *on the TSP Request Card.*
NPO-18537



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Stereoscopic Vision System for Robotic Vehicle

Distances are estimated from images by cross-correlation.

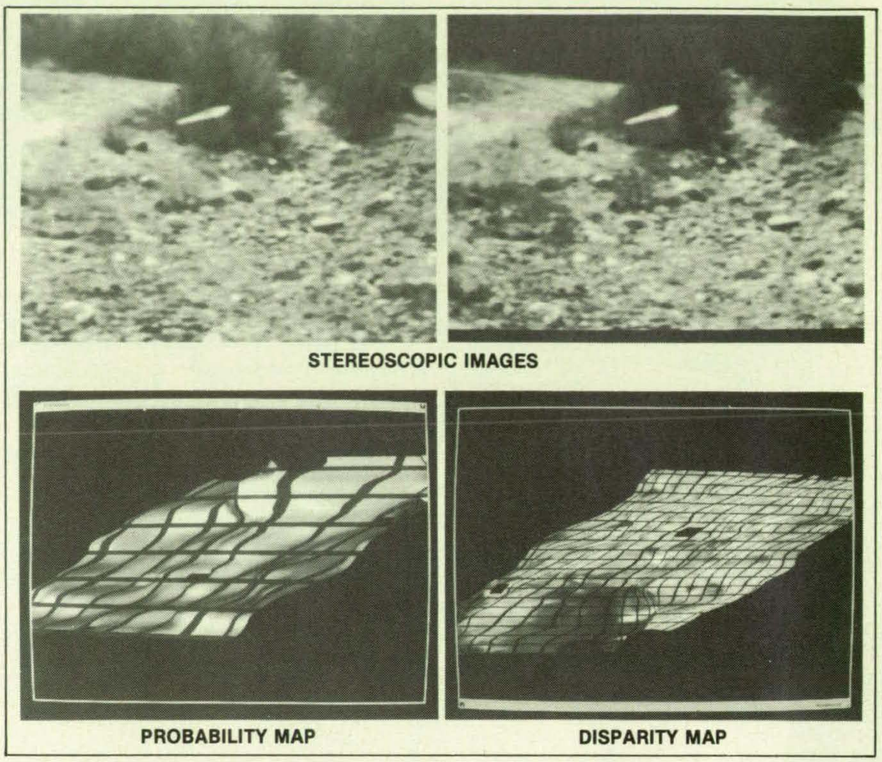
NASA's Jet Propulsion Laboratory, Pasadena, California

A two-camera stereoscopic vision system with onboard processing of image data has been developed for use in guiding a robotic vehicle semiautonomously. In tests, a prototype of the system has proved successful in guiding the JPL Planetary Rover "Robby" on 100-meter traversals of outdoor terrain. The combination of such semiautonomous guidance and teleoperation could be useful in tasks that involve remote and/or hazardous operations, including clean-up of toxic wastes, exploration of dangerous terrain on Earth and other planets, and delivery of materials in factories where unexpected hazards or obstacles can arise.

Previously, the slowness of computation in stereo vision systems has impeded the development of semiautonomous guidance. In this system, nearly real-time performance is achieved partly by sacrificing image resolution for speed and partly by exploiting special-purpose computing hardware. The design of the system was derived from (1) a statistical formulation of the stereo vision problem, in which correlation-type operators are used to estimate the disparity field (defined below) and associated models of uncertainty, and (2) simple, fast optimization algorithms.

In stereo vision, "disparity" denotes the displacement between the image locations of a scene feature, as seen in the left and right images of a stereo image pair. "Disparity field" denotes the two-dimensional array of disparity measurements made at each pixel of an image. Distances to objects in the scene can be estimated from the disparity field and used for guidance, for example by using the distance measurements to detect obstacles in the path of the vehicle.

Estimating disparity requires automatically determining which pixels in the left and right images of the stereo pair are projections of the same feature in the scene. This is referred to as "stereo matching". This is achieved by taking windows of 7×7 pixels around each pixel of the left image and comparing them (via least squares) to corresponding windows around candidate pixels in the right image. Candidate pixels are determined from a fixed set of possible displacement (or disparity) values. The candidate with the best least-squares match produces the disparity (hence distance) estimate. A statistical formulation of this operation is used to compute associated uncertainty measures that indicate the reliability of the distance estimates.



A Stereo Image Pair and a 3-D Reconstruction for an outdoor scene are shown. The left and right image of the stereo pair are shown on top. Perspective renderings of a 3-D reconstruction of the scene are shown on the bottom; synthetic shading (left) and texture-mapped intensity (right) are used, together with superimposed grid lines, to help visualize the estimated shape of the terrain.

To achieve a near real-time implementation, the stereo matching algorithms compute "Laplacian image pyramids," which reduce resolution of the images from the original 480×512-pixels down to 60×64-pixels. The stereo matching algorithms are applied to images at the 60×64-pixel resolution. The image pyramids are computed by a set of eight special-purpose image processing boards; the rest of the stereo matching algorithms are computed by a 68020-based processor board. The system produces disparity fields from the 60×64-pixel level of the image pyramids at rates of up to 2 seconds per image pair.

The figure shows a stereo pair of images and a three-dimensional scene model produced by the system. The scene contains a rocky foreground, a large boulder, two clumps of bushes in the upper center and right of the image, and a dirt road receding in the upper left. Processing of the stereo image pair produced a three-dimensional model of the scene, which is rendered in perspective in the figure in two different ways. On the left, the shape of the terrain is indicated by synthetic shading and by a pattern of grid lines that has been overlaid on the surface. On the right, the same perspective view of the terrain is shown with the texture of the original images, plus a finer overlaid grid to illustrate the terrain shape. The renderings show that the system correctly perceives a relatively flat foreground, with the large rock and one clump of bushes showing up as higher terrain in the middle of the background. Such 3-D information is used by the semiautonomous guidance system to detect obstacles in the path of the vehicle.

This work was done by Larry H. Matthies and Charles H. Anderson of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 3*** *on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Resident Office–JPL [see page 26]. Refer to NPO-18593.

Predictive Algorithm for Aiming an Antenna

Tracking would be improved by taking advantage of anticipated control input.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed method of computing control signals to aim an antenna would be based on a predictive control-and-estimation algorithm that would take advantage of control inputs anticipated into the near future. The method was conceived for controlling an antenna in tracking spacecraft and celestial objects, the near-future trajectories of which are known. The method should also prove useful in enhancing the aiming performances of other antennas and instruments that track objects that move along fairly well known paths.

The figure is a block diagram of a digital tracking control system based on the method. One of the notable features of this system and method is that the increment of the control signal in a given sampling period (e.g., the *i*th sampling period) would not be determined with respect to only the most recent value of the control input; instead, it would be determined with respect to the input horizon, which would be the set of control inputs anticipated for some preset number of sampling periods into the near future, and which would be based partly on the input commands anticipated into the near future, partly on the estimated present dynamical state of the antenna, and partly on the predicted future dynamical state of the antenna. Another notable feature would be an output-weighting matrix that would include a forgetting factor. Both features would improve performance significantly.

A conceptual tracking control system for the 70-m-diameter NASA/JPL antenna was designed according to this method and tested by computer simulation. The results of the simulation showed that the performance of the conceptual system would be significantly better (in terms of speed of response) than that of the linear/quadratic controller and estimator now in use. The results also show that the performance of the conceptual system would be robust (in the mathematical sense) in the presence of variations in parameters and that the system would suppress disturbances fairly well. The disturbance-suppression properties could be enhanced if a disturbance filter were incorporated.

This work was done by Wodek K. Gawronski of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 10*** *on the TSP Request Card.*
NPO-18511

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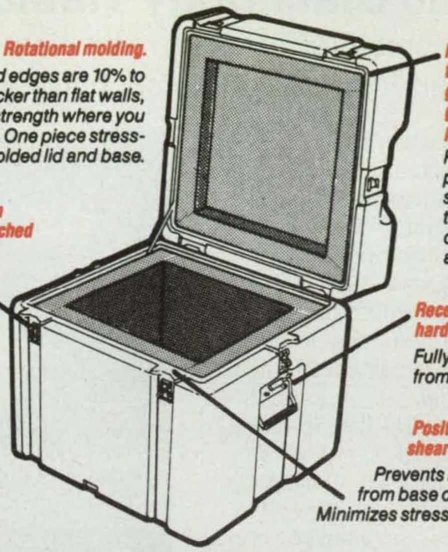

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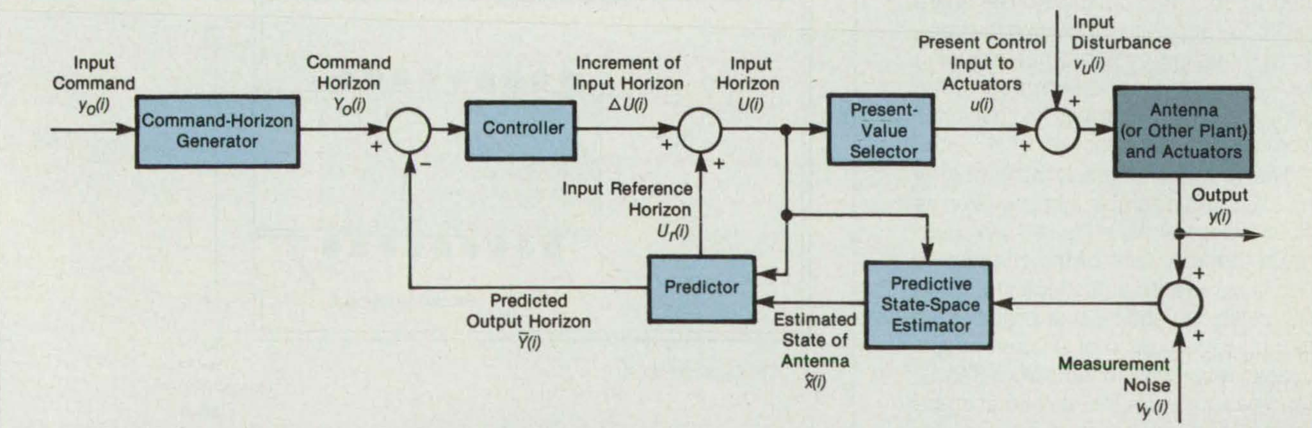

This **Predictive Control-and-Estimation System** would provide improved performance by using anticipated near-future inputs and outputs (in addition to the present input and output) to modify the present and near-future control inputs.

Cryogenic Blackbody-Radiation Calibration Source

Operating temperatures range from ambient down to –100 °C.

Langley Research Center, Hampton, Virginia

A blackbody-radiation source is designed for use in calibrating infrared imaging systems that operate at wavelengths from 8 to 12 μm. The source can be set at any specified operating temperature between 30 and –100 °C. Unlike prior commercial low-temperature blackbody sources, this one does not have to be operated in a vacuum of 0.01 torr (about 1 Pa) or better.

The main blackbody that is maintained at the specified operating temperature is a copper billet 10 cm long and 5 cm in diameter, with concentric circular "V" grooves machined into one face and coated black. This face is recessed into a blackened sleeve (see Figure 1). The temperature of the body is measured by a platinum resistance thermometer and a thermocouple inserted in holes drilled from the side to the axis of the body at locations about 1.6 mm and 3.2 mm, respectively, in from the V-grooved face. The thermocouple is the sensor for a digital temperature controller, while the platinum resistance thermometer is connected to a digital readout to provide an independent measure of the temperature of the blackbody.

The blackbody is heated by four 500-Ω, flexible strip heaters that are wrapped around the body and connected electrically in parallel to a dc power supply controlled by the digital temperature controller. The heaters are wrapped in aluminum foil and fiberglass tape. Wrapped around the tape is a cooling coil made of 0.25-in. (6.35-mm) copper tube, through which liquid nitrogen is circulated to cool the blackbody. The entire blackbody apparatus, including the cooling and heating coils but not including the V-grooved face, is wrapped with a foam insulating blanket to minimize heating and cooling losses.

The entire blackbody assembly is mounted into a semiairtight chamber, as shown schematically in Figure 2. An opening on the front face of the chamber is then fitted with an antireflection-coated zinc selenide window that provides 98 percent transmission of electromagnetic radiation at wavelengths from 8 to 12 μm. The window is maintained at ambient temperature by use of an electrical resistance heater wrapped around the support flange of the window. This pre-

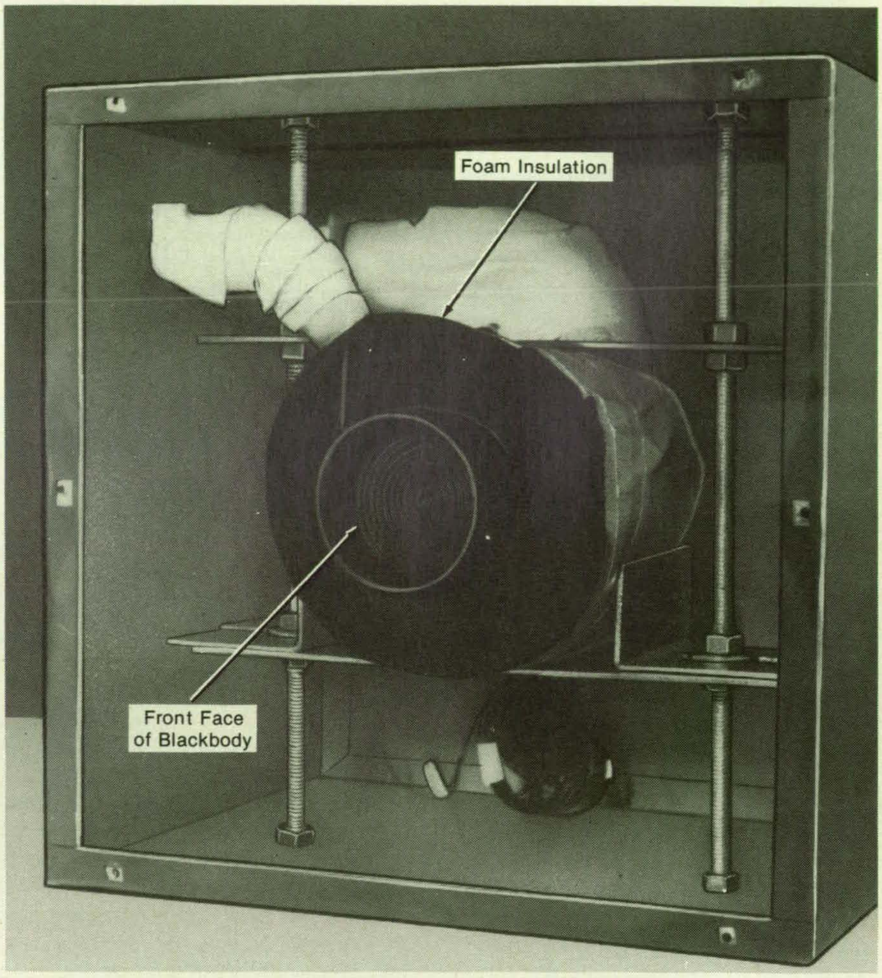

Figure 1. The **V-Grooved Front Face** of the source body is blackened and recessed in a black sleeve.

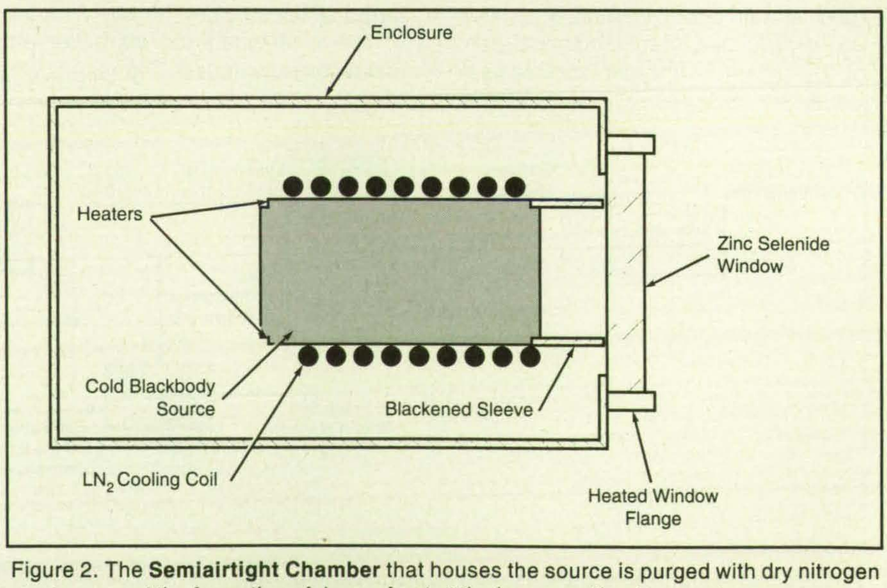

Figure 2. The **Semiairtight Chamber** that houses the source is purged with dry nitrogen gas to prevent the formation of dew or frost at the low operating temperature.

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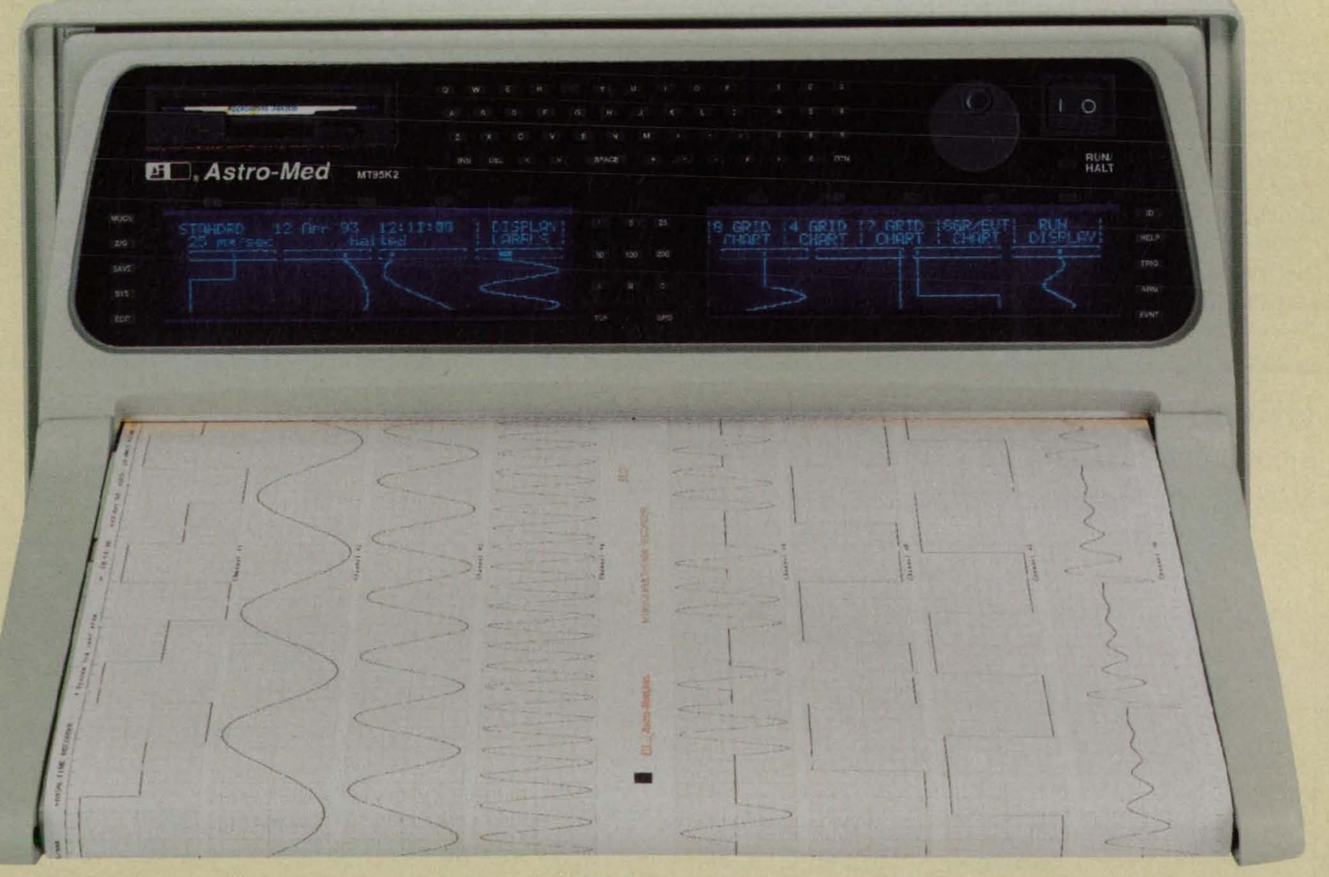

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vents the window from cooling to below the ambient dewpoint and fogging up.

To make it possible to cool the blackbody to an operating temperature as low as −100 °C, it is necessary to bring the dewpoint and frost-point temperatures inside the chamber below the operating temperature to prevent the buildup of frost on the front surface of the blackbody. This is done by purging the chamber with dry nitrogen gas from a Dewar flask containing liquid nitrogen.

This work was done by Cecil G. Burkett, Jr., and Kamran Daryabeigi of **Langley Research Center**. *For further information,* ***write in 82*** *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 26]. Refer to LAR-14943.

Measuring Moduli of Elasticity at High Temperatures

Shorter, squatter specimens and higher frequencies are used in an ultrasonic measurement technique.

Lewis Research Center, Cleveland, Ohio

An improved version of the piezoelectric ultrasonic composite oscillator technique is used to measure the moduli of elasticity of solid materials at high temperatures. The utility of the previous version of the technique is limited by the need for cylindrical specimens that have length/diameter ratios > 5; for example, typical specimens of CoAl, FeAl, and NiAl must be 45 mm long and 3 mm in diameter (length/diameter = 15). In many cases, newly developed materials cannot be fabricated into specimens that have such sizes and shapes, but they can be formed into shorter, squatter specimens.

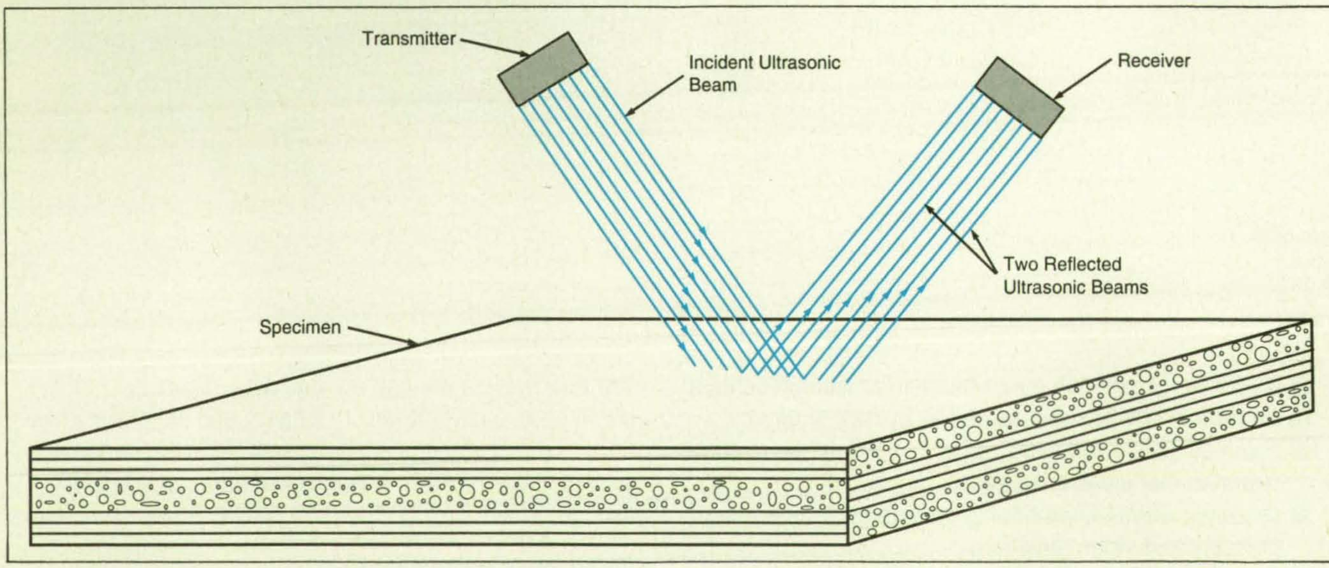
In the prior version of the technique, the operating frequency was 20 kHz. In the improved version, piezoelectric crystals of higher resonant frequency are used, enabling measurements on specimens as short as 8 mm. Furthermore, a review of the literature revealed a correction term, published in 1938, that enables measurements to be taken at length/diameter ratios less than 5. The improved version of the technique has been used to determine the modulus of elasticity of polycrystalline alumina as a function of temperature up to 1,473 K (2,192 °F) and that of single-crystal copper from room temperature to 923 K (1,202 °F).

This work was done by Alan Wolfenden of Texas A&M University for **Lewis Research Center**. *For further information,* ***write in 78*** *on the TSP Request Card.* *LEW-15138*

Ultrasonic System Measures Elastic Properties of Composites

Measurements with leaky Lamb waves yield data on properties and defects of panels.

NASA's Jet Propulsion Laboratory, Pasadena, California



Two **Ultrasonic Transducers** operating in pitch/catch mode excite and detect leaky Lamb waves in the specimen. Elastic properties of the specimen and defects within it can be characterized from the dispersion curves of the leaky Lamb waves.

An ultrasonic testing system nondestructively measures elastic properties of, and defects in, a panel of laminated fiber/matrix (e.g., graphite/epoxy) material. The system acquires data on the dispersion of ultrasonic waves at various angles of incidence and reflection and inverts the data to obtain the moduli of elasticity of the material.

As shown in the figure, the specimen panel is immersed in water along with two ultrasonic transducers that operate in a pitch/catch mode. The positions and orientations of the transducers and specimen are controlled simultaneously so that the fibers in the specimen are oriented at a desired angle with respect to the plane of incidence and so that the angle of reflection at the receiving transducer equals the angle of incidence.

The angle of incidence and the frequency or frequencies of the ultrasonic waves are chosen to excite leaky Lamb waves in the specimen. (Lamb waves denote guided elastic waves in a plate of finite thickness having free surfaces. Leaky lamb waves are guided waves in a plate immersed in fluid.) The leaky component of the waves interferes with specular reflection of the incident acoustic wave, giving rise to two reflected beams with a null between them. The receiving transducer is positioned in this null.

The frequencies at which Lamb waves can be excited in the specimen depend on the angle of incidence, the orientation of the fibers in the specimen, the thickness of the specimen, and the elastic properties of the specimen material. The frequency at which two reflected beams with an intervening null are excited at a given angle of incidence can be used to identify a leaky-Lamb-wave mode. The dispersion curves (phase velocities vs. frequencies) of leaky-Lamb-wave modes at various orientations of fibers and at bonds between the specimen and other materials (e.g., metals) provide significant information about defects and about the properties of the specimen composite material. An inversion algorithm extracts this information from the dispersion curves. In particular, it computes five stiffness coefficients that are needed to characterize the composite laminate as an orthotropic material.

This work was done by Yoseph Bar-Cohen of Caltech and Ajit K. Mal of UCLA for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 7*** *on the TSP Request Card.*
NPO-18729

Slow-Wave Acoustic Isolation for Measurement of Flow

Propagation of interfering signals is delayed.

Lewis Research Center, Cleveland, Ohio

Experiments have demonstrated the utility of slow-wave isolation between the transmitting and receiving transducers in acoustic measurements of sound speed and/or flow velocity in ducts. More specifically, this finding pertains to acoustic measurements of speeds of flow of low-molecular-weight gases at pressures low enough to be contained in thin-walled metal conduits.

In an acoustic measurement of the flow of a gas in a duct, a transmitting and a receiving transducer are attached at different positions along the conduit. The measurement process includes the propagation of ultrasonic pulses through the gas from the transmitting to the receiving transducer. Ultrasonic pulses can also propagate in the wall of the conduit from the transmitter to the receiver, causing interference that can degrade the measurements or make them useless. Therefore, to obtain accurate and reliable measurements, it is necessary to isolate (with respect to acoustic propagation in the wall) the receiver from the transmitter. Heretofore, in a typical measurement of this type, the acoustic-isolation problem was solved by (1) coupling the transducers to the gas via ports in the conduit and (2) mounting the transducers with isolating gaskets.

In the slow-wave acoustic-isolation technique, it is not necessary to make holes in the wall. Instead, the equipment is configured so that ultrasonic pulses propagate more rapidly in the gas than in the wall. Thus, each "gas" pulse can reach the receiver and be processed into measurement data before the associated interfering "wall" pulse arrives at the receiver.

The experiments on the slow-wave-isolation technique were performed in flow cells made of thin-wall stainless-steel (SS) conduit. Some of the walls were about 0.5 mm thick; others were only 0.1 mm thick and convoluted. The cells contained helium at room temperature. It was found that 100-kHz ultrasonic pulses that propagated through the helium could be made to arrive at the receivers in advance of the pulses that propagated in the walls.

The lower speed of propagation in the wall is attributed to the low phase velocity of the asymmetrical (flexural) wave of lowest order at wavelengths much greater than the wall thickness. If this is the predominant mode, then effective acoustic isolation is obtained. However, other modes are not necessarily delayed as long as this one is; consequently, there is no guarantee that they will not interfere with measurements.

Fortunately, a method was eventually found to attenuate nearly all of the interfering conduit-borne noise, so that by 1992 a commercial version of an all-SS-bounded cell became available, suitable for gas pressures from about 3 to 515 psia (2.1×10^4 to 3.55×10^6 N/m^2). These cells are now in use to measure flow and/or the average molecular weight of binary gas mixtures (gas-concentration analysis).

General background information is contained in Lynnworth, Lawrence C., *Ultrasonic Measurements for Process Control,* 720 pp: (1989), Academic Press, accessible through public libraries.

This work was done by Lawrence C. Lynnworth and Marco Aurilio of Panametrics, Inc., for **Lewis Research Center**. *No further documentation is available.*
LEW-15131

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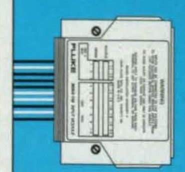

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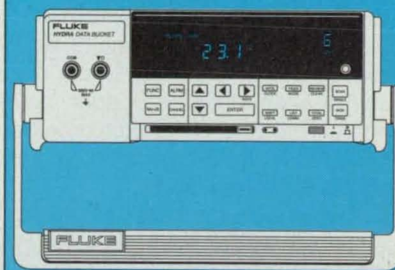

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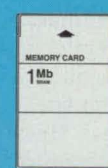

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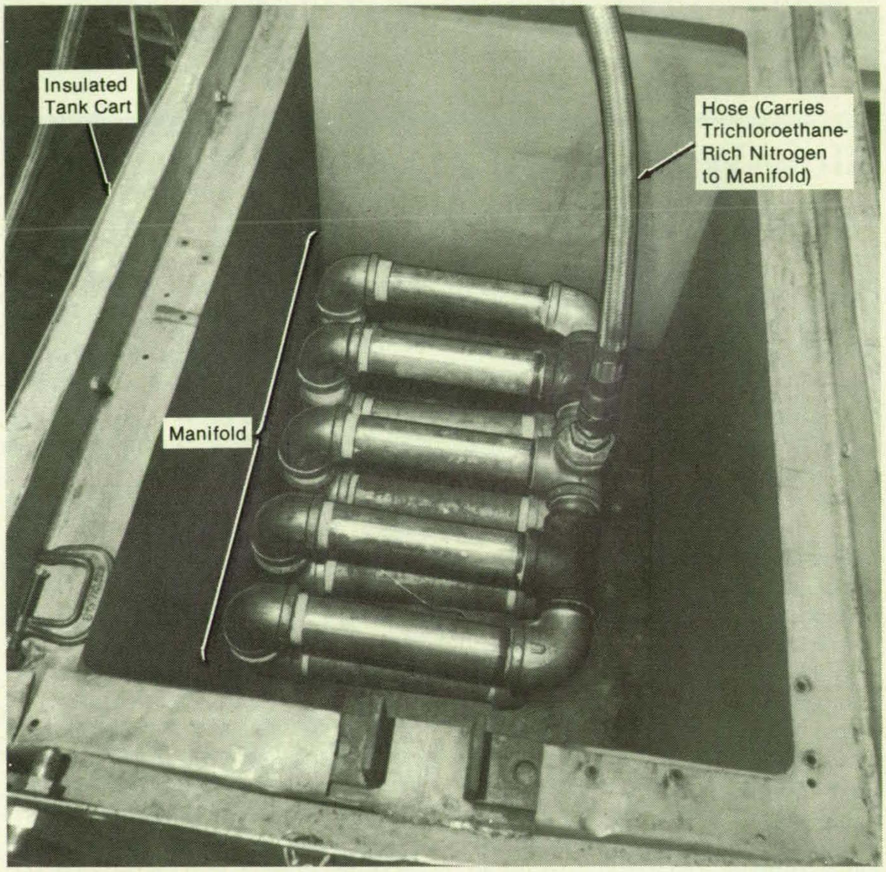
Marshall Space Flight Center, Alabama

A simple apparatus recovers trichloroethane from nitrogen gas. The apparatus is useful where hardware is cleaned with trichloroethane solvent, then dried with hot nitrogen gas. Inevitably, the hot gas absorbs some solvent, and if the gas is simply released to the atmosphere, the entrained solvent can constitute a health hazard and contribute eventually to the depletion of ozone from the upper atmosphere. The release of trichloroethane may also make a user liable for emission fees required by law.

The apparatus consists of a manifold immersed in liquid nitrogen in an insulated tank cart (see figure). The manifold comprises five parallel U-shaped sections filled with pall rings, which are normally used as packing in distillation columns to increase the contact surface area and add turbulence to the flow. Trichloroethane-rich nitrogen gas flows from a hose into the manifold, then spreads into the five sections, emerges from the open ends of the five sections, then bubbles up through the liquid nitrogen. The gas cools as it passes through the manifold and liquid, and most of the trichloroethane content condenses in the liquid nitrogen.



The **Manifold** promotes the condensation of trichloroethane. Each of the U-shaped sections is packed with pall rings to increase the contact area and create turbulence for increased transfer of heat to the liquid nitrogen that normally fills the tank.

The apparatus was tested, using simulated hardware from which the effluent nitrogen gas contained more than 350 ppm trichloroethane (as measured at the inlet to the manifold). The concentration of trichloroethane measured above the liquid-nitrogen bath was only 28 ppm.

After condensing the trichloroethane, the liquid nitrogen can be transferred to another open tank. There, the liquid nitrogen boils off, leaving the trichloroethane. The trichloroethane can be recycled further reducing the cost of the cleaning process.

This work was done by Timothy S. Shepard and Michael L. Cassident of Rockwell International Corp. for **Marshall Space Flight Center.** *No further documentation is available.* *MFS-29891*

Chemical Strips Anodic Film From Aluminum

A phosphoric acid solution offers advantages over other stripping solutions.

Lyndon B. Johnson Space Center, Houston, Texas

A chemical solution that consists of about 30 volume percent phosphoric acid and 70 volume percent deionized water dissolves anodic films from aluminum and aluminum-alloy detail parts. In comparison with alternative strippers, phosphoric acid solution is very effective: it is 99 percent as effective as the most-effective stripper, which is a solution that contains chromate, and it is more effective than other strippers are. It is also safer to use in that it does not have to be heated, it is noncarcinogenic, and it contains no fluorides. It is also relatively environmentally benign, especially in comparison with chromate, so that disposal of the used solution is easier and regulatory permits for stripping processes can be obtained more easily. Also in comparison with other stripping solutions, which attack aluminum metal after dissolving the overlying anodic (aluminum oxide) film, the phosphoric acid stripper ceases its chemical attack

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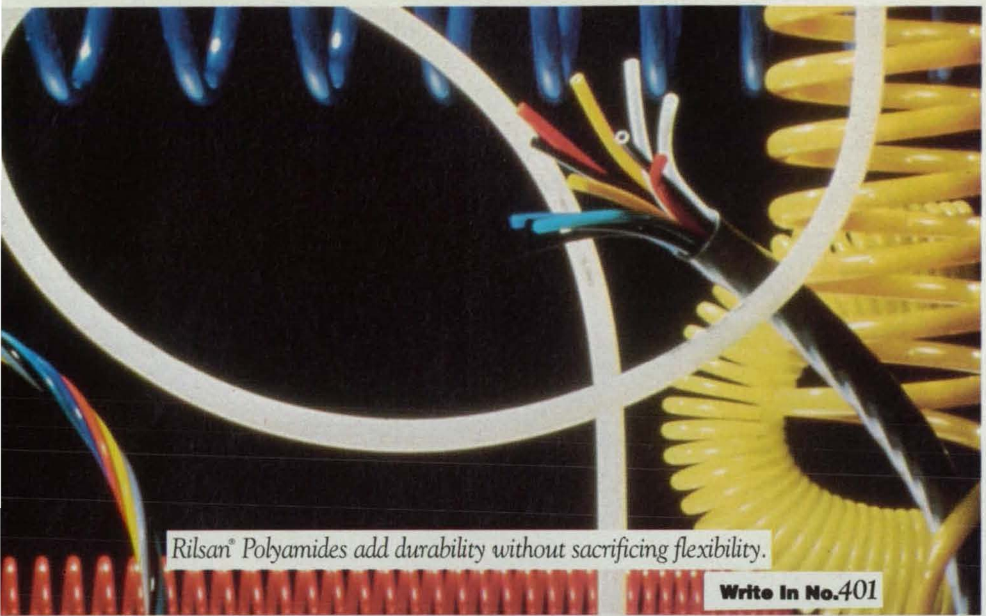

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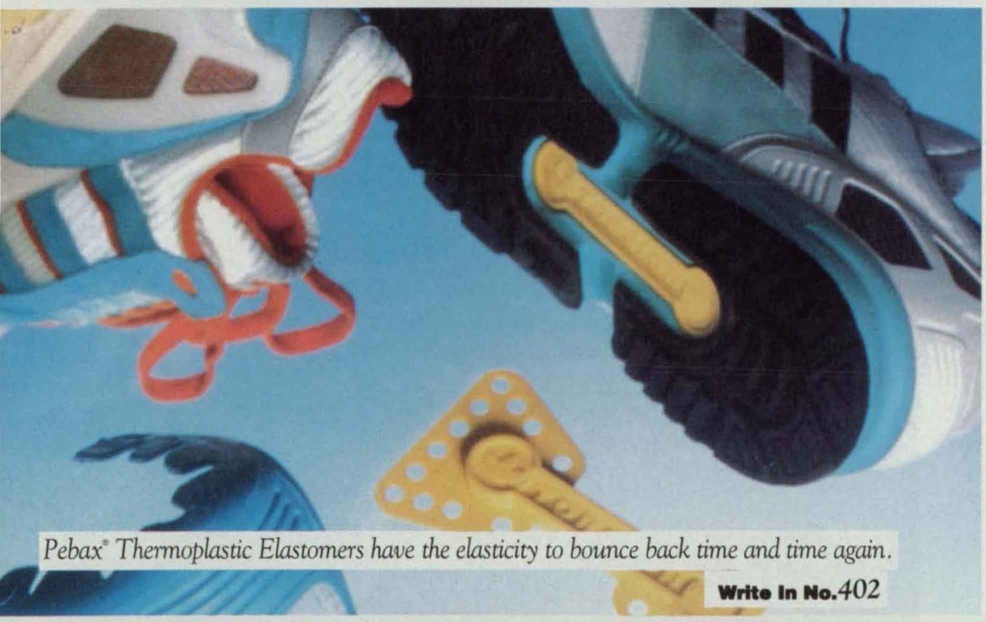

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to a much greater extent after having dissolved the anodic film, so that less process control is needed in its use.

The concentration of acid in the stripper can vary by ±5 percent without loss of effectiveness. A small amount (<0.05 percent by volume) of surfactant (a wetting agent like dodecylbenzenesulphonic acid) can be added. Parts can be stripped of anodic coats by immersing them in this solution at room temperature in 5 to 10 minutes. Parts to be thus stripped should not include areas that could trap the stripping solution.

This work was done by Eric C. Eichinger of Rockwell International Corp. for **Johnson Space Center**. *No further documentation is available. MSC-22136*

Spray-Deposited Superconductor/Polymer Coatings

Coatings that exhibit the Meissner effect can be formed at relatively low temperature.

Langley Research Center, Hampton, Virginia

High-temperature (ceramic) superconductor/polymer composite coatings have been formed by spray deposition followed by heating to a temperature much lower than the temperature that would be needed (about 950 °C) to form thick, continuous coatings of pure high-temperature superconductor. The polymer in the coating mixture not only provides the mechanical support that eliminates the need for the high-temperature treatment but also helps to protect the superconductor from degradation caused by humidity. High-temperature-superconductor/polymer coatings that exhibit the Meissner effect (the expulsion of magnetic flux) can be deposited onto components in a variety of shapes and materials. Because only simple, readily available equipment is needed in the coating process, the coatings can be produced economically. The coatings could be used to keep magnetic fields away from electronic circuits in such cryogenic applications as magnetic resonance imaging and detection of infrared, and in magnetic suspensions to provide levitation and/or damping of vibrations.

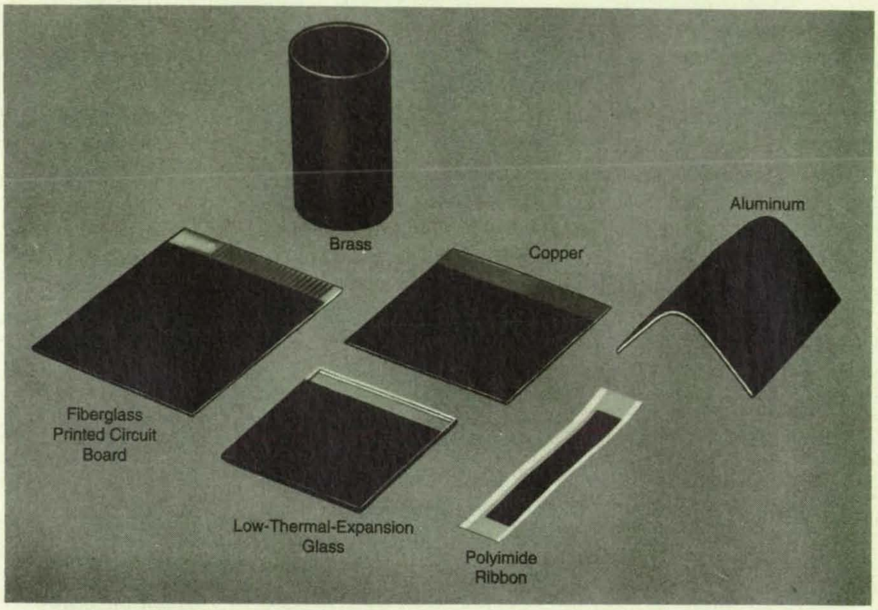

Figure 1. **Substrates of Various Shapes and Materials** were coated with continuous surface layers of superconductor/polymer composite.

The high-temperature superconductor material used in a demonstration of the coating process was $YBa_2Cu_3O_{7-x}$ powder with an average particle size of 5 µm. The powder, as received from the manufacturer, was blended with a two-part epoxy resin and methyl alcohol to produce slurries. The slurries were sprayed onto parts of various shapes and materials (see Figure 1) by use of a conventional spray apparatus. The coated parts were then placed in an oven at 120 °C to remove all of the methanol and to cure the epoxy resin. The resulting coatings were approximately 3 mils (about 0.08 mm) thick and contained about 85 percent superconductor by weight.

The composite coating adhered strongly to the surface of each part. Scanning-electron-microscope analysis of the composites showed that the superconducting ceramic particles were well distributed throughout the epoxy matrix, as shown in Figure 2.

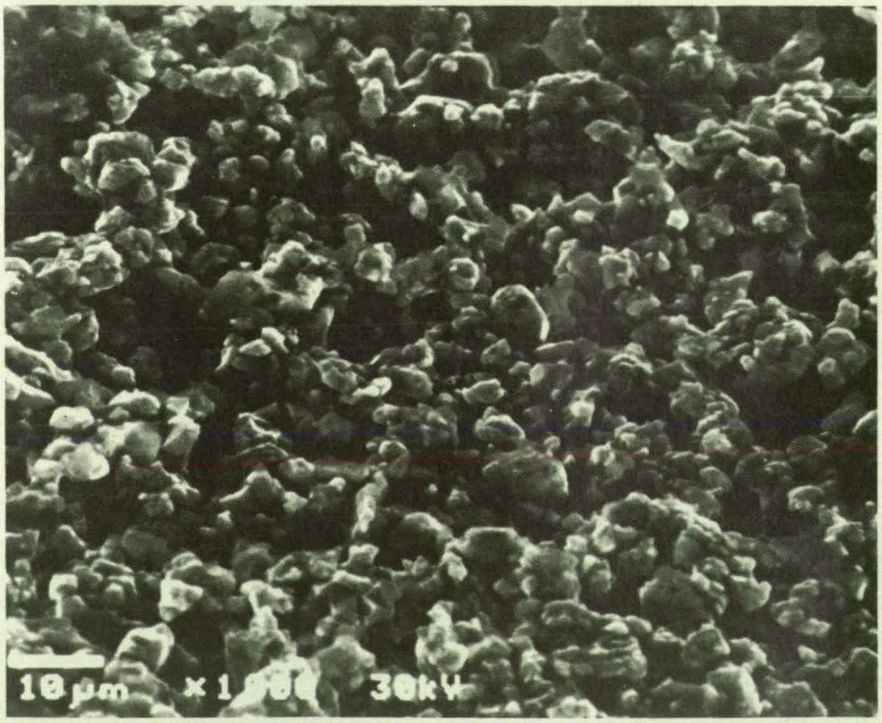

Figure 2. This **Scanning Electron Micrograph** shows that the superconducting ceramic particles are well distributed throughout the epoxy matrix.

To test the integrity of the composite coatings, several specimens were cycled between room temperature and 77 K 10 times. Except in the case of a glass substrate, this thermal cycling did not cause the coatings to crack or to sepa-

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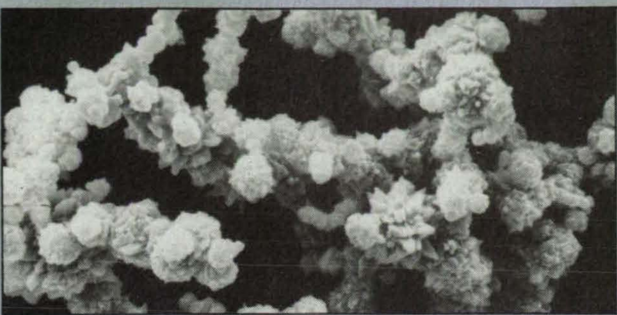
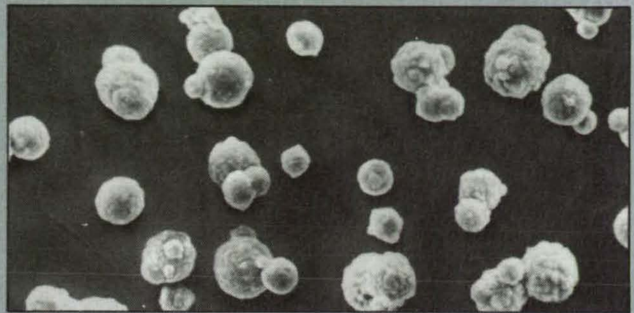
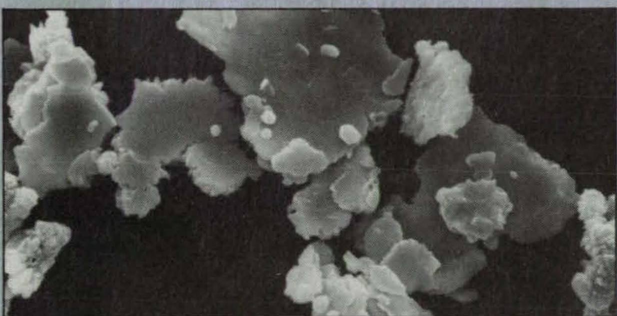


Inco Type T 287 Filamentary Powder, particle size (FSSS) 2.6-3.3 microns, apparent density 0.75-0.95 g/cc, relative surface resistivity 0.30 ohms per square ($\square$).



Novamet Silver Coated Nickel Spheres, 15% Ag, 2.5 g/cc apparent density, particle size 10 microns, screen mesh 99%-250, surface resistivity 0.03 $\Omega/\square$.



Novamet HCA-1 Flake, screen mesh 98% minus 400, apparent density 0.90 g/cc, thickness 1.0-1.1 microns, surface resistivity 0.25 $\Omega/\square$.

Novamet Nickel Coated Graphite, 60% fully encapsulated Ni, apparent density 1.6 g/cc, particle size (FSSS) 100 microns, screen mesh 63% −150/+250, surface resistivity 0.3 $\Omega/\square$.

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rate from the substrates. Specimens were also immersed in water: x-ray diffraction patterns of these specimens made before and after immersion showed that the superconducting powder had not deteriorated during immersion.

The spray-application process should be readily adaptable to ceramic superconducting compounds other than $YBa_2Cu_3O_{7-x}$ and to commercially available polymers other than the epoxy used in the demonstration. Such other coating techniques as painting or dipping could also be used.

This work was done by Stephanie A. Wise and Sang Q. Tran of **Langley Research Center** *and Matthew W. Hooker of Clemson University. For further information,* ***write in 93*** *on the TSP Request Card.*

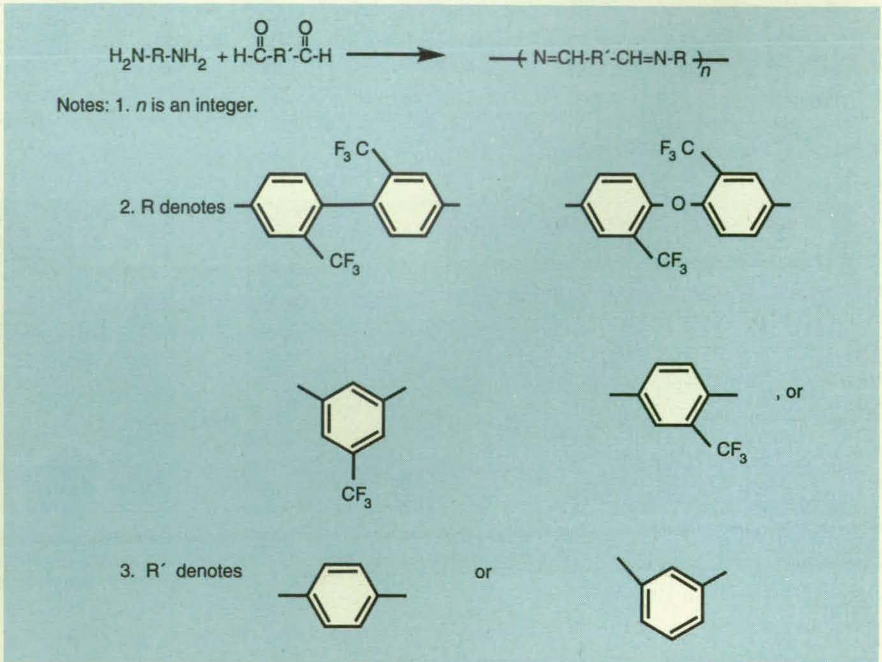
This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Langley Research Center [see page 26]. Refer to LAR-14729.

Processible Polyazomethines

The processibility is enhanced by incorporating trifluoromethylbenzene units into the molecules.

Langley Research Center, Hampton, Virginia

Aromatic polyazomethines (polymines) that contain pendent trifluoromethyl groups demonstrate enhanced processibility in comparison with their nonfluorinated counterparts. This enhanced processibility is the result of two unexpected properties: high solubility in common organic solvents and lack of crystallinity. These properties coupled with the ability of this class of polymers to undergo exchange reactions at elevated temperatures allow these materials to moderate their molecular weights during processing, which affects the resulting mechanical properties after processing. These fluorinated polyazomethines form amorphous (isotropic) films that have excellent mechanical properties. They may be used in moisture-free environments as electronic semiconducting films and adhesives, and as matrix resins for advanced structural composites.



Polyazomethines Containing Trifluoromethylbenzene Units were synthesized according to this general reaction scheme.

The general proedure to synthesize these fluorinated polyazomethines involved treating terephthalaldehyde or a mixture of terephthalaldehyde and isophthalaldehyde with one or more of the following diamines: 2,2′-bis(trifluoromethyl)benzidine (Marshallton Labs Inc.), oxybis-4,4′-diamino-2,2′-bis(trifluoromethyl)benzene, 3,5-diaminobenzotrifluoride (Occidental Chem. Corp.), and 2,5-diaminobenzotrifluoride. The reaction (see figure) was carried out in refluxing DMAc for 18 h at a 10 weight-percent solids concentration. The resulting polymers were precipitated into methanol, forming bright yellow powders. These powders were collected by filtration and dried under vacuum at 135 °C.

Several polymers that contained less than a 50 percent molar equivalent of fluorinated monomers were also synthesized by the same method. The fluorinated monomers were partially substituted with 3,4′-oxydianiline or benzidine. Unlike their nonsubstituted counterparts, these polymers precipitated from the reaction mixture in a few hours, forming intractable, insoluble powders.

The fluorinated polyazomethines were redissolved in DMAc at a 20 weight-percent solids concentration, and poured onto glass plates. These solutions were dried under flowing air until tack-free, and the resulting films were heated under vacuum in 2 h increments at 100°, 150°, 180°, 210°, and 240 °C, respectively; or alternatively, 100°, 150°, 200°, 250°, and 300 °C. Depending on the monomer(s) chosen for generating the polyazomethine, the thermal treatment either increased or decreased the molecular weight of the polyazomethine.

The polyazomethines did not display any transitions by differential scanning calorimetry, but the glass-transition temperatures from thermal mechanical analysis, and from the tan δ in dynamic mechanical spectrometry, ranged from 200 °C to 250 °C. The resulting polymer films were soluble in a variety of solvents (including DMAc, N-methylpyrolidinone, dimethyl sulfoxide, tetrahydrofuran, *m*-cresol, and chloroform) and displayed excellent mechanical integrity. Except for their elongation at break (which ranged from 3.7 to 12.3 percent), their mechanical and physical properties were comparable with those of Kapton™ HN100 polyimide film (which exhibited an elongation at break of 82.2 percent).

Wide-angle x-ray diffraction (WAXD) patterns of these polymers showed a lack of crystallinity and long-range order. The coefficients of thermal expansion of films of a few of these amorphous polyazomethines were found to range from 8.5×10^{-6}/°C to 15.6×10^{-6}/°C and in some cases were linear from 60° to 150 °C.

This work was done by Robert G. Bryant of **Langley Research Center**. *For further information,* ***write in 100*** *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 26]. Refer to LAR-14896.

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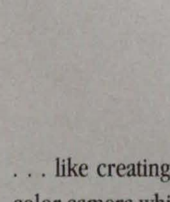

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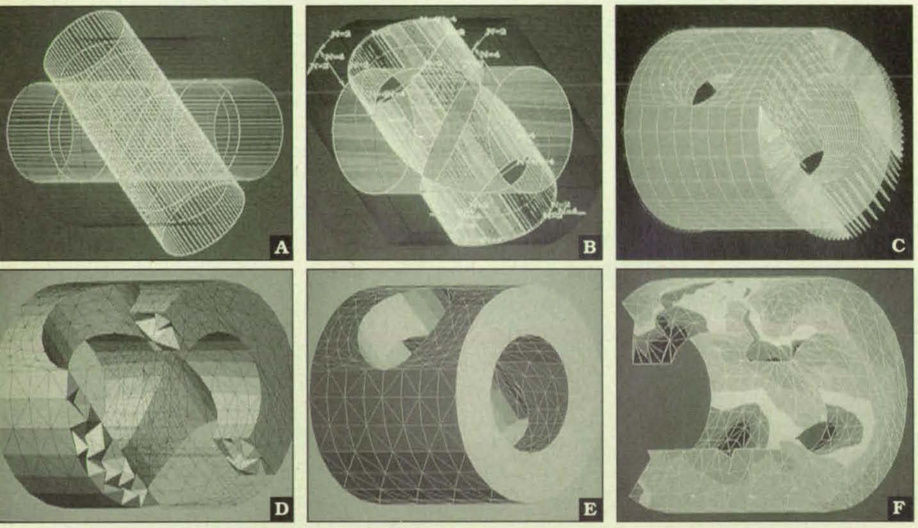

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Mechanics

Simulating Orbital Operations of Spacecraft

OOS can model orbital proximity and docking operations.

The Orbital Operations Simulator (OOS) computer program was developed to implement mathematical models of complex outer-space vehicular systems and be a "testbed" for new flight software. This program has a multi-vehicular-simulation capability to model on-orbit proximity and docking operations. Version 1.0, with its Prepare Processor and User Interface Shell (UI), was designed to be a true multivehicle dynamic simulator with the capability to change the mathematical models of spacecraft subsystems easily.

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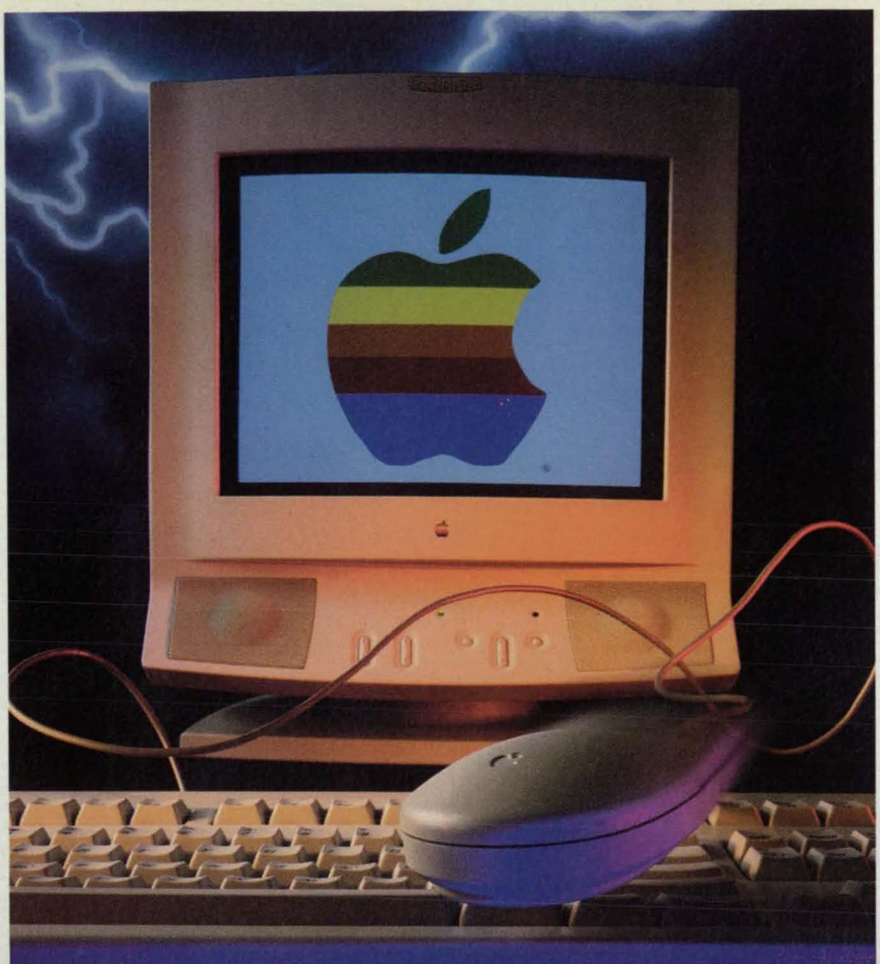

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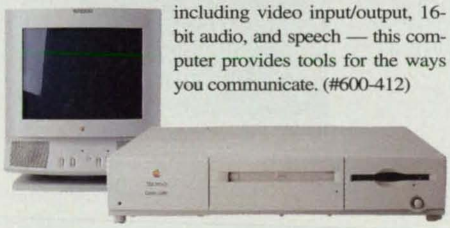

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eralized for such given planets as Earth or Mars, and define atmospheric-density profiles, planetary gravitational fields, and the like.

The OOS testbed-execution-data-file software Prepare Processor provides the OOS user with "programmable" data-file capabilities via lexical interpretation of the contents of the data file. The Prepare Processor software has the capability to interpret several forms of data-file entries, including mathematical operations and subroutine calls. It checks all run-data-file inputs for consistency and compatibility and checks the syntax and variable attributes for the entire execution data file.

The User Interface Shell (UI) software in OOS "surrounds" the rest of the OOS software system. It provides an interface between the OOS user and the UNIX operating system by utilizing the Bourne Shells of the UNIX operating system to provide simple commands for complex operations. The UI operates three major areas of the OOS testbed system: assembly of simulation application programs, operation of application programs, and postprocessing of data generated by application programs.

During assembly of an application program, the OOS user simply specifies which vehicle(s) to simulate and the environment in which these vehicles fly. The UI performs several complex tasks to assemble the user's application program on the basis of the input. The UI automatically generates application executive source code to incorporate all software modules specified in the application-definition file. The UI then compiles the new executive source code, links the new object code to the OOS testbed object library, and creates data bases unique to the user's application. The UI utilizes high-level OOS testbed data bases, which define software-module interfaces and define vehicle models.

Version 1.0 of the Orbital Operations Simulator was developed on a Sun workstation in 1987, and replaces the previous version that was developed in 1984 (MSC-20941). The program is written in K & R standard C, LEX, and YACC languages and operates under a System V shell. The program requires approximately 180KB of random-access memory. OOS 1.0 is distributed on four diskettes in PC/MS DOS format.

This program was written by Carter Edwards and Robert W. Bailey of LinCom Corp. for **Johnson Space Center**. *For further information,* ***write in 2*** *on the TSP Request Card.*
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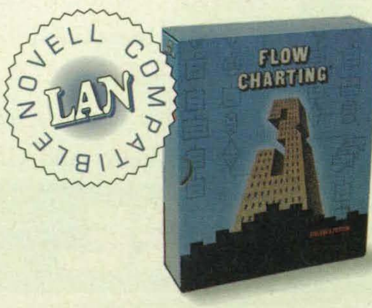

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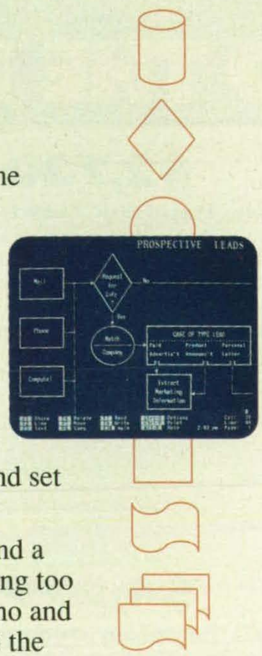

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Mathematics and Information Sciences

Semi-Markov Unreliability Range Evaluator

SURE calculates upper and lower bounds on probabilities of death states.

The Semi-Markov Unreliability Range Evaluator (SURE) computer program is a software tool for the analysis of reconfigurable, fault-tolerant systems. Traditional reliability analyses are based on aggregates of fault-handling and fault-occurrence models. SURE provides an efficient means for calculating accurate upper and lower bounds for the probabilities of death states for a large class of semi-Markov mathematical models, and not merely those that can be reduced to critical-pair architectures.

The bounds calculated by SURE are close enough (usually within 5 percent of each other) for use in reliability studies of ultrareliable computer systems. The SURE bounding theorems have algebraic solutions and are consequently computationally efficient even for large and complicated systems. SURE can optionally regard a specified parameter as a variable over a range of values, enabling an automatic sensitivity analysis.

Highly reliable systems employ redundancy and reconfiguration as methods of ensuring operation. When such systems are modeled stochastically, some state transitions are orders of magnitude faster than others; that is, recovery from faults is usually faster than arrival of faults. SURE takes these time differences into account. Slow transitions are described by exponential functions, and fast transitions are modeled by either the White or Lee theorems based on means, variances, and percentiles.

The user must assign identifiers to every state in the system and define all transitions in the semi-Markov model. SURE input statements are composed of variables and constants related by such FORTRAN-like operators as =, +, *, SIN, EXP, and the like. There are a dozen major commands, such as READ, READO, SAVE, SHOW, PRUNE, TRUNCate, CALCulator, and RUN. Once the state transitions have been defined, SURE calculates the upper and lower probability bounds for entering specified death states within a specified mission time. SURE output is tabular.

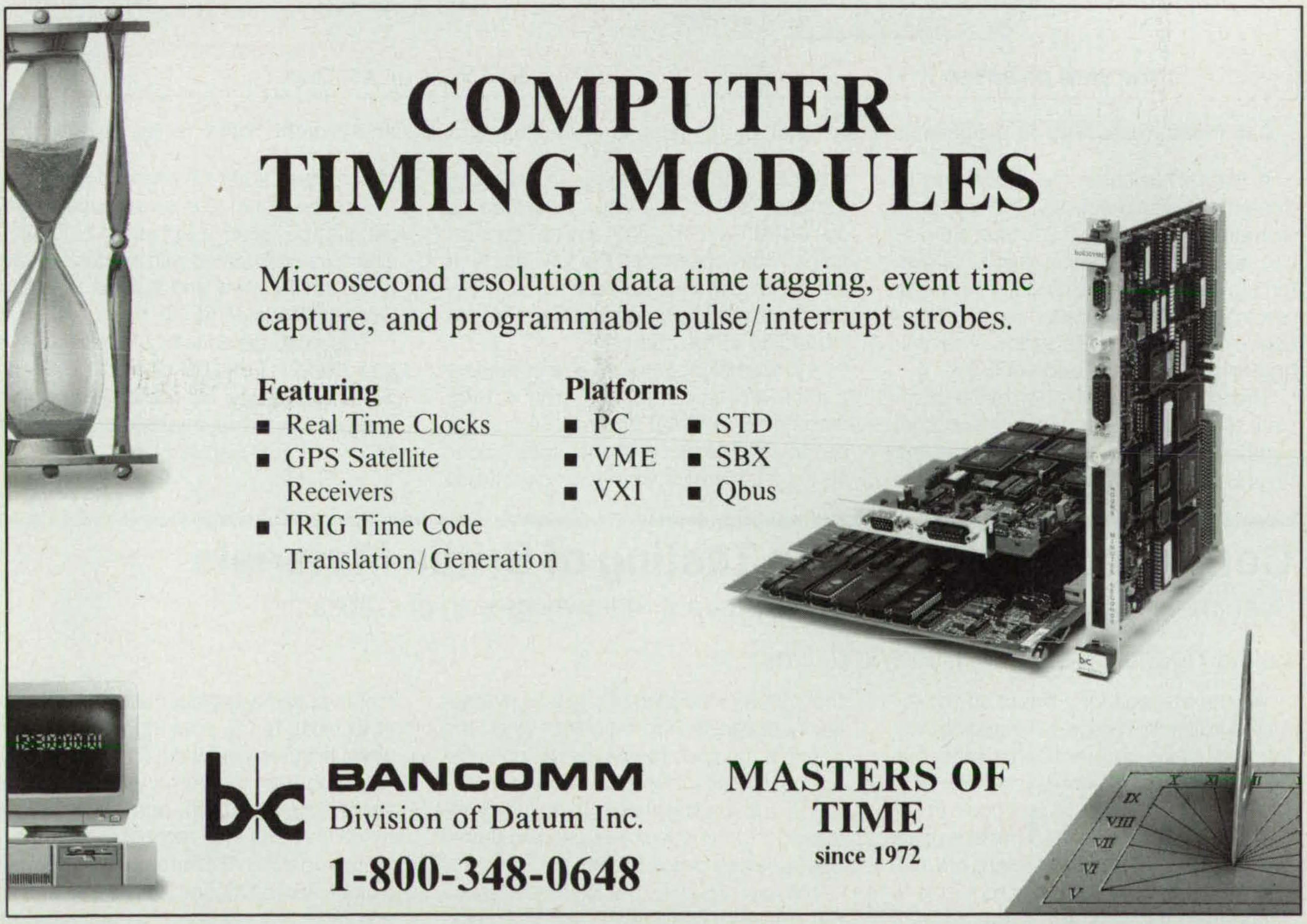
The mathematical approach chosen to solve a reliability problem can vary with the size and nature of the problem. Although different solution techniques are utilized on different programs, it is possible to have a common input language. The Systems Validation Methods group at NASA Langley Research Center has created a set of programs that form the basis for a reliability-analysis workstation. The set of programs are the SURE reliability-analysis program (COSMIC program LAR-13789, LAR-14921); the ASSIST specification interface program (LAR-14193, LAR-14923); the PAWS/STEM reliability-analysis programs (LAR-14165, LAR-14920); and the FTC fault-tree tool (LAR-14586, LAR-14922). FTC is used to calculate the probability of the top event in a fault tree. PAWS/STEM and SURE are programs that interpret the same SURE language but utilize different methods of solution. ASSIST is a preprocessor that generates SURE language from a more abstract definition.

SURE, ASSIST, and PAWS/STEM are also offered as a bundle. Please see the abstract for COS-10039/COS-10041, SARA — SURE/ASSIST Reliability Analysis Workstation, for pricing details.

SURE was originally developed for DEC VAX-series computers running VMS and was later ported for use on Sun computers running SunOS. The VMS version (LAR-13789) is written in PASCAL, C language, and FORTRAN 77. The standard distribution medium for the VMS version of SURE is a 9-track, 1,600-bit/in. (630-bit/cm) magnetic tape in VMSINSTAL format. It is also available on a TK50 tape cartridge in VMSINSTAL format. Executable codes are included. The Sun UNIX version (LAR-14921) is written in ANSI C language and PASCAL. An ANSI-compliant C compiler is required to compile the C portion of this package. The standard distribution medium for the Sun version of SURE is a 0.25-in. (6.35-mm) streaming-magnetic-tape cartridge in UNIX tar format. Both Sun3 and Sun4 executable codes are included. SURE was developed in 1988 and last updated in 1992.

DEC, VAX, VMS, and TK50 are trademarks of Digital Equipment Corp. UNIX is a registered trademark of AT&T Bell Laboratories. Sun OS, Sun3, and Sun4 are trademarks of Sun Microsystems, Inc.

This program was written by Ricky W. Butler of **Langley Research Center** *and David P. Boerschlein of Lockheed Engineering & Sciences Co. For further information,* ***write in 92*** *on the TSP Request Card.*
LAR-14921

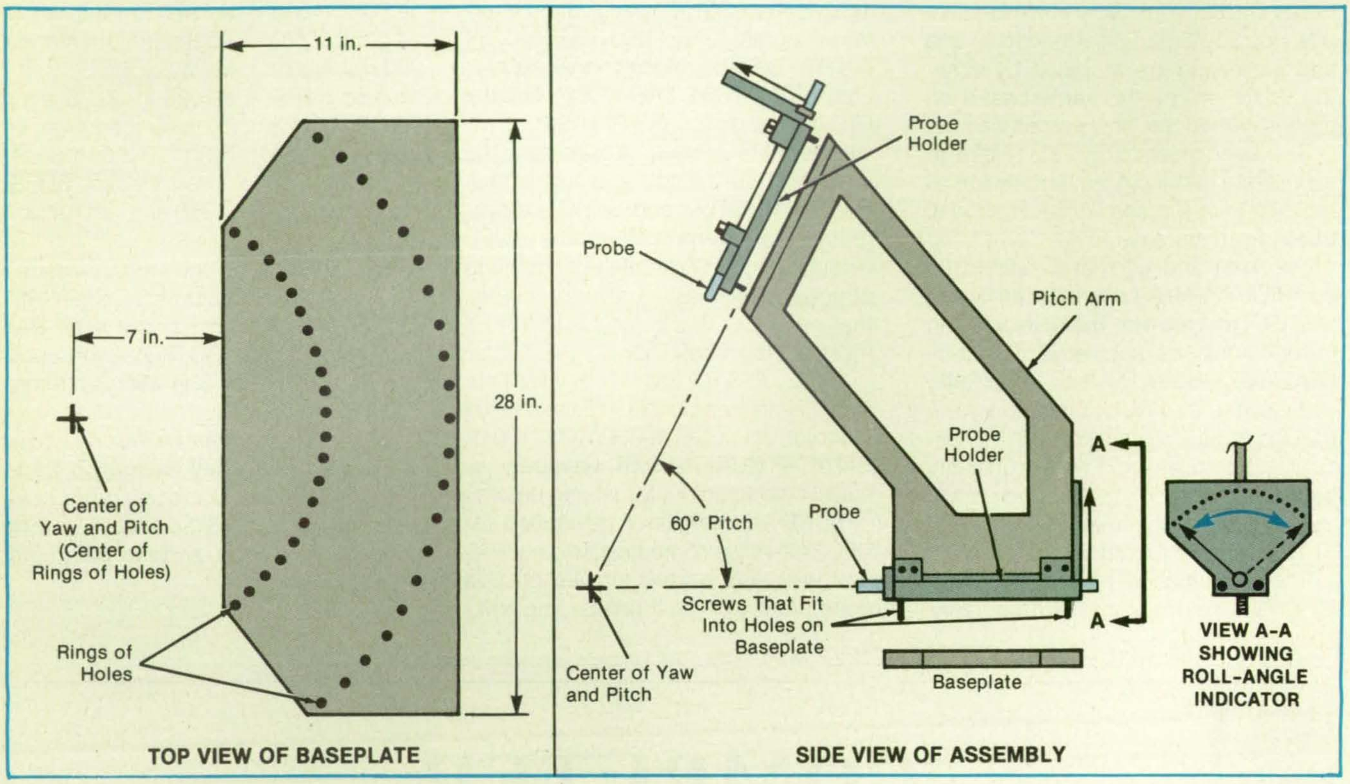


For More Information Write In No. 532

Calibration Fixture for Anemometer Probes

The probe can be positioned repeatably at a number of different angles.

Lewis Research Center, Cleveland, Ohio



One **Probe Holder Fits** on the baseplate; the other, on the pitch arm, which in turn, fits on the probe holder on the baseplate.

A fixture facilitates the calibration of three-dimensional sideflow thermal anemometer probes. With the fixture, a probe can be oriented at a number of angles throughout its design range. The probe readings can then be calibrated as a function of orientation in the airflow. The calibration is repeatable and verifiable.

The fixture includes a horizontal baseplate (see figure) that contains two concentric rings of holes. The center of the rings is at a point 7 in. (17.8 cm) out from one edge of the plate. A pair of screws on the underside of a probe holder can be placed (with a sliding fit) in any two coradial holes in the baseplate. The yaw angle of the probe can thus be selected in 5° increments within a range of ±50° from the centerline of the plate.

A probe holder can also be mounted on a pitch arm and the pitch arm, in turn, mounted on another probe holder on the baseplate. The probe on the probe holder on the pitch arm is aimed 60° downward toward the center of yaw and pitch.

A probe mounted in either probe holder can also be rolled ±45° about its longitudinal axis while aimed with the desired yaw and pitch. Pointers and scribed scales indicate the angles of roll, pitch, and yaw.

This work was done by Charles R. Lewis and Robert T. Nagel of North Carolina State University for **Lewis Research Center**. *For further information,* ***write in 85*** *on the TSP Request Card.*
LEW-15165

Controlled-Crack-Growth Testing of Brittle Materials

Specimens and fixtures are designed to prevent runaway growth of cracks.

Lewis Research Center, Cleveland, Ohio

A simple design for a fixture and specimen significantly improves the crack-growth fracture testing of ceramics and other brittle materials. The task is to obtain controlled, stable growth of a mode-I crack (in essence, a through-the-thickness pried-open crack in a plate specimen). Heretofore, it has been difficult or impossible to accomplish this task with a specimen in the primary load path of a typical hydraulically driven testing machine: when the crack in the specimen extends, potential energy stored in the elasticity of the machine and loading fixture is suddenly released into the specimen, causing unstable, runaway crack growth.

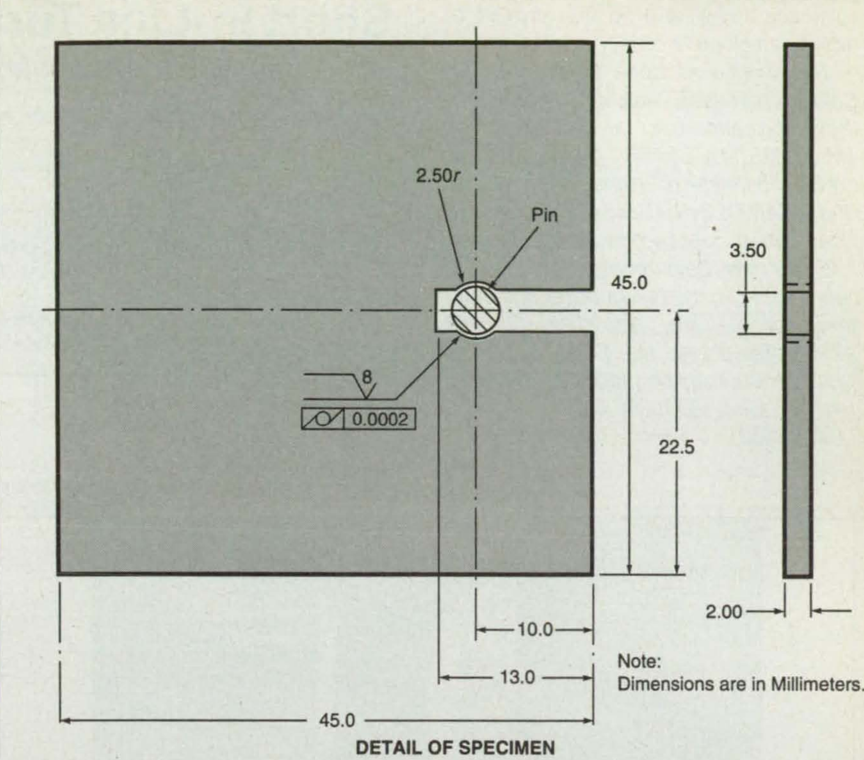
The new design for the fixture and specimen makes it possible to impose a crack-mouth-opening displacement that remains at or close to the prescribed value even when the crack extends. The specimen is removed from the primary load path to a secondary load path, and the fixture is made very stiff with respect to the crack-mouth-opening displacement, so that, to a close approximation, the fixture acts as an unyielding actuator that enforces the prescribed displacement.

Each specimen is machined into a flat plate, a hole near the edge is cut and ground with diamond-coated tools, and a notch is cut from the inner edge of the hole part way into the plate (see figure). A high-speed-steel circular loading pin fits snugly in the hole. The pin, with the specimen attached, is placed in the load path of a compression-testing machine.

When the pin is compressed axially by the machine, it bulges outward, opening the crack mouth. The amount of opening that can be enforced in this way is very small (about 8 μm at a typical maximum pin compression of 22 kN). However, very little opening is needed (only about 5 μm in a typical test), and one important advantage of this design is that by controlling the compressive load on the pin, one can obtain very fine control (typically within 7 nm) of the crack-mouth opening.

The new design also offers important secondary advantages. The geometry of the specimen is simple, making the specimen easy to machine. The fit between the pin and the specimen provides a self-aligning grip. Because the crack-opening force is spread over the entire surface of contact between the pin and specimen, contact stresses and the probability of failure at or near the loading spot are reduced.

The only significant potential elastic energy stored outside the specimen that can be transferred into the specimen upon extension of the crack is the energy stored in the radial compressive strain superimposed on the pin by the crack-mouth-



A **Typical Specimen**, is machined to the dimensions shown here. The pin fits snugly in the hole specimen. When the pin is compressed axially, it bulges outward (in Poisson expansion), pushing on the hole and forcing the crack to open by the amount of the bulge.

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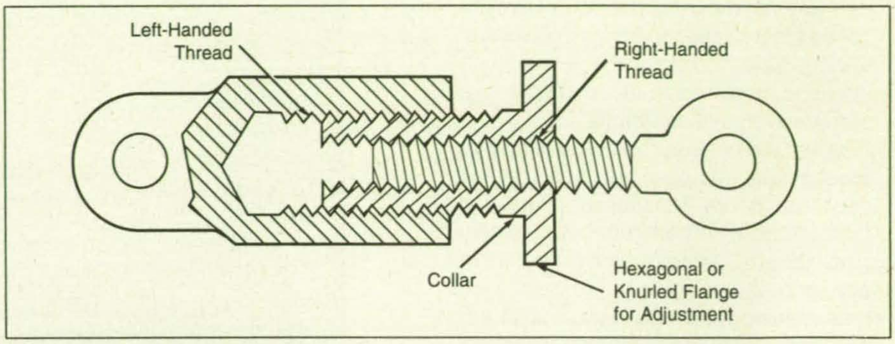
This work was done by Anthony M. Calomino of **Lewis Research Center**. *Further information may be found in NASA TM-105565 [N92-24984], "Advanced Rotorcraft Transmission Program Summary," and TM-103126 [N90-23543], "Controlled Crack Growth Specimen for Brittle Systems."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700.
LEW-15388

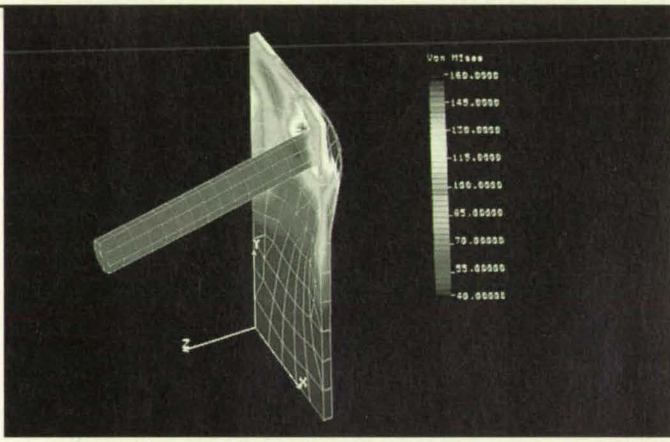
Short In-Line Turnbuckle

Short body is achieved without offset.

NASA's Jet Propulsion Laboratory, Pasadena, California



The **Three Parts of the Turnbuckle** would fit together in threaded, telescoping fashion.



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A proposed turnbuckle would be shorter than conventional turnbuckles are and could therefore fit in shorter spaces. At the same time, its ends would be coaxial, unlike another short turnbuckle in which the ends and the axes that pass through them are laterally offset. [The laterally offset short turnbuckle was described in "Short Turnbuckle," *NASA Tech Briefs*, Vol. 16, No. 7 (July 1992), page 71.]

The turnbuckle would consist of the following parts (see figure):

- An eye on a shank with internal left-handed threads,
- An eye on a shank with external right-handed threads, and
- A flanged collar with left-handed external threads to mate with the shank of the first-mentioned eye and right-handed internal threads to mate with the shank of the second-mentioned eye. The flange would be knurled or hexagonal so that it could be turned by hand or wrench to adjust the overall length of the turnbuckle.

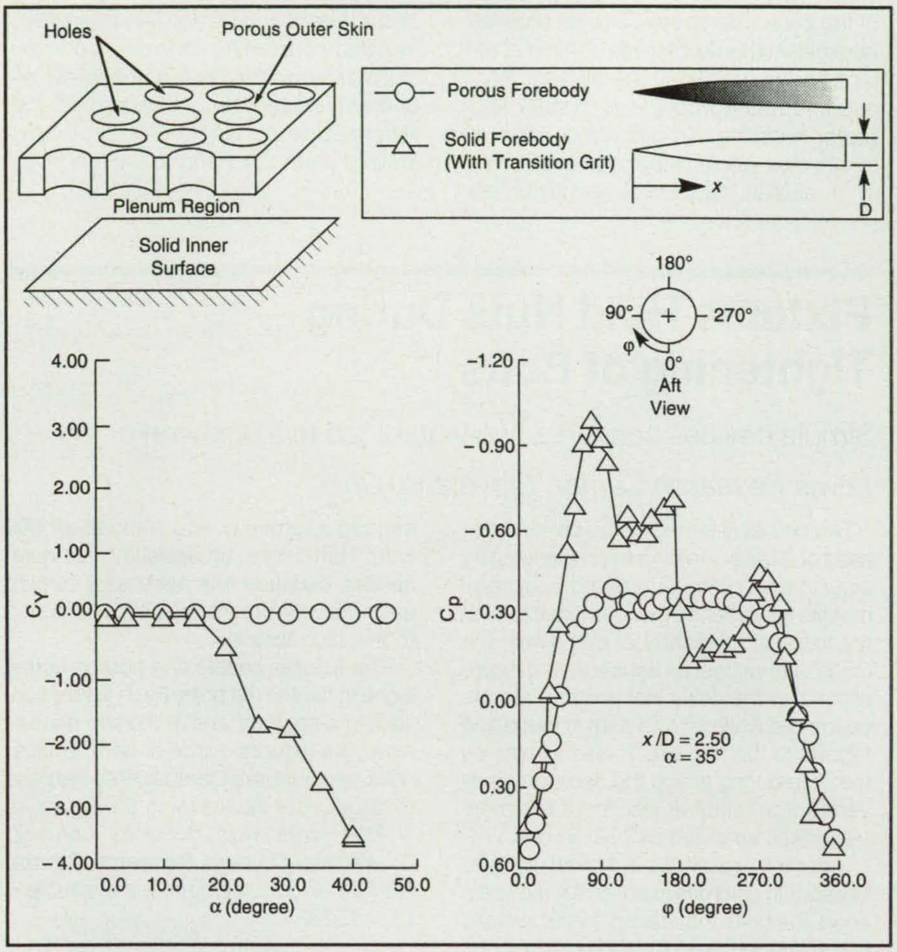
For fine adjustments of length, the collar could be made with only right-handed threads and different pitches inside and out. (Of course, the threads on the mating shanks of the eyes would be made to match the threads on the collar.) For example, with a right-handed external thread of 28 per in. (pitch ≈ 0.91 mm) and a right-handed internal thread of 32 per in. (pitch ≈ 0.79 mm), one turn of the collar would change the length approximately 0.0045 in. (about 0.11 mm).

This work was done by Earl Collins and Malcolm MacMartin of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 51*** *on the TSP Request Card.*
NPO-18449

Porous Forebody

This passive device reduces asymmetries in flows and aerodynamic loads.

Langley Research Center, Hampton, Virginia



A **Porous Forebody,** (in this case, an ogive/cone) improves the performance of an aircraft at both high and low angles of attack.

A wide range of active devices have been conceived and developed to control the degree of asymmetry of flows and aerodynamic loads on the forebodies of aircraft. These devices, which are designed to inhibit or promote separations of flows on the forebodies, typically consist of strakes, flaps, rotating nose apexes, slots, bumps, and other devices. In contrast, the porous forebody is a passive mechanical device. Porous forebodies should significantly enhance the flight characteristics of all aircraft by minimizing the influences of aerodynamics of the forebodies upon those characteristics.

A porous forebody includes a porous outer skin and a solid inner skin. The two forebody skins are separated by a distance of the order of two boundary-layer thicknesses. The arrangement can be regarded as that of a porous skin placed over a minimum-depth cavity. The porous skin can be created by perforating a solid skin or by fabricating the outer skin from a porous material. The internal cavity region should have minimum blockage in both the circumferential and longitudinal directions.

The porous skin acts in combination with the cavity to reduce or eliminate all gradients of pressure that exist on the external side of the porous skin. The external pressures on the forebody are modified by a combination of an equalization of the pressures within the cavity and a modification of the boundary layer about the forebody due to a minimum transfer of mass into and out of the cavity.

At high angles of attack and/or high-lift conditions, the porous nature of the forebody eliminates asymmetry and unsteadiness in the flow about the forebody. It also eliminates the resultant asymmetry and unsteadiness in the aerodynamic loads. This asymmetry and unsteadiness can (if not eliminated) dominate

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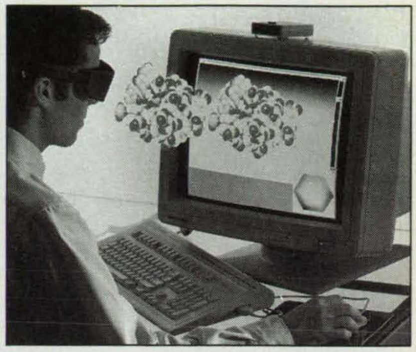

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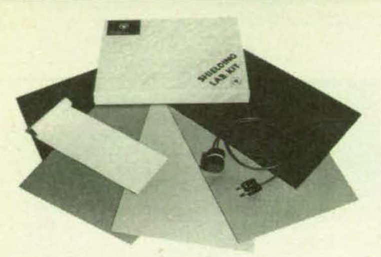

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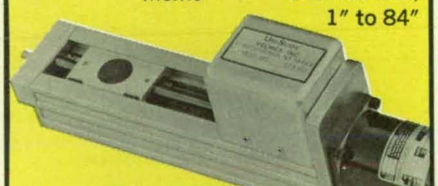

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the flight characteristics of the aircraft. At low angles of attack and/or low-lift conditions, the porous forebody reduces the pressure drag at all speeds.

Because of the passive nature of the porous forebody, there is no need for any mechanical, pneumatic, or electrical support equipment. The implementation of the porous-forebody concept requires negligible volume and has a minimal effect on the weight of the aircraft. Porous forebodies could lead to safer and better-handling aircraft. While porous forebodies would likely be used primarily on aircraft, they might also be useful on fast land vehicles and structures or devices subject to high winds.

This work was done by Richard M. Wood and Steven X. S. Bauer of **Langley Research Center**. *For further information,* ***write in 105*** *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 26]. Refer to LAR-14547.

Fixtures Hold Nuts During Tightening of Bolts

Simple devices convert a two-worker job to a one-worker job.

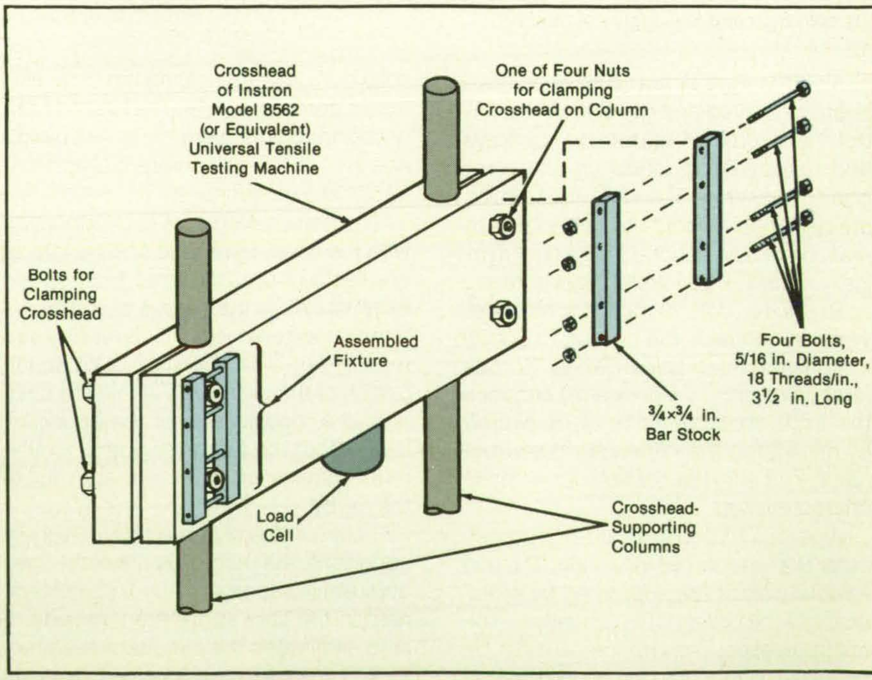
Lewis Research Center, Cleveland, Ohio

Two fixtures designed for use on the crosshead of a tensile testing machine simplify adjustments of the crosshead to accommodate specimens of various lengths. With the fixtures, a researcher can adjust the crosshead without an assistant. The fixture eliminates the delay that is otherwise encountered while an assistant is found and reports to the test site. It also eliminates the time during which the assistant is diverted from another job (the adjustment task takes as much as half an hour).

After the crosshead is moved along its supporting columns to adjust for the specimen, the bolts that clamp the crosshead to the supporting columns must be tightened to a torque of 810 N•m (about 600 lb•ft). Heretofore, an assistant has been needed because it is necessary to hold each nut while its mating bolt is tightened to this high torque.

The fixtures enable one person acting alone to tighten the bolts. Each fixture consists of a cage for one of the two pairs of nuts. The fixtures, made of bars, smaller bolts, and nuts, are clamped onto the pairs of larger nuts as shown in the figure.

This work was done by John Z. Gyekenyesi of **Lewis Research Center**. *No further documentation is available.* *LEW-15292*

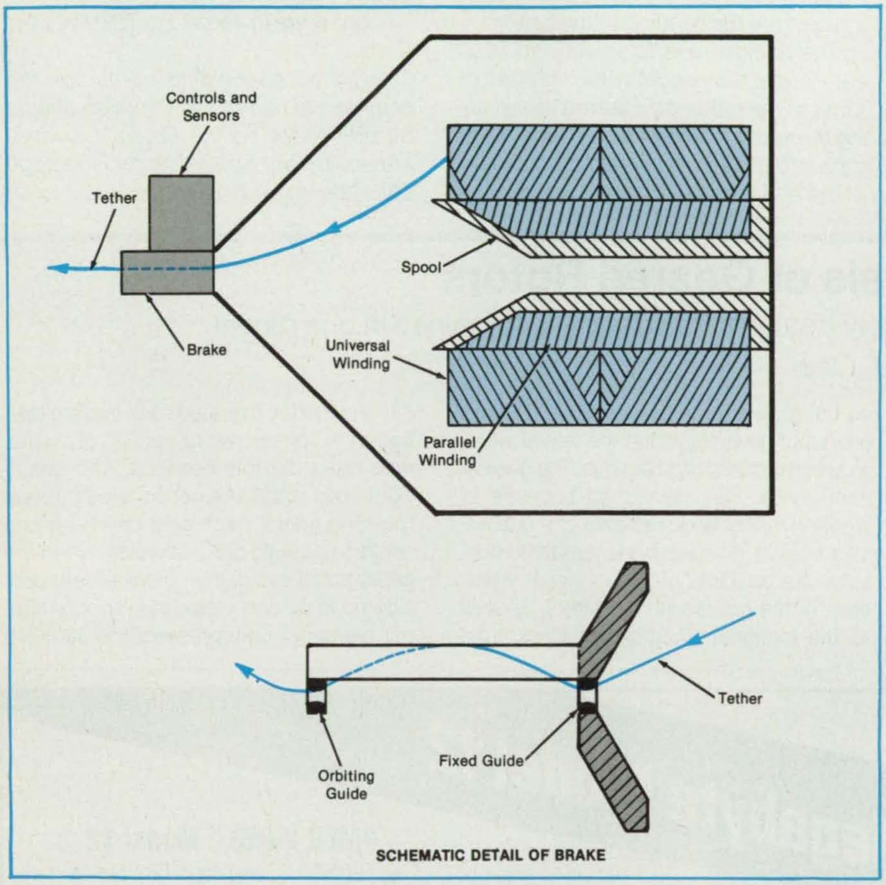


Two Cagelike Fixtures hold pairs of nuts, preventing the nuts from turning while bolts are tightened.

Tether Deployer and Brake

A design concept promises speed, control, and reliability.

Marshall Space Flight Center, Alabama



The Reel of the Tether would include a small cylindrical core with conical flanges to hold about 15 percent of the line in a parallel winding. The remaining 85 percent of the tether would be wound on the core in a universal winding. The tether would eventually pass to a brake, where an orbiting guide would wrap the tether around a post. The braking force would increase with the number of wraps.

A proposed scheme for deploying a tether provides for fast, free, and snagless payout and fast, dependable braking. Developed for small, expendable tethers in outer space, the scheme may also be useful in laying transoceanic cables, deploying guidance wires to torpedoes and missiles, paying out rescue lines from ship to ship via rockets, deploying antenna wires, releasing communication and power cables to sonobuoys and expendable bathythermographs, and even in reeling out lines from fishing rods.

The concept calls for a fixed reel rather than a rotating one. With a fixed reel, only the tether to be paid out has to accelerate quickly. Therefore, there is less chance of overrunning and jamming so long as the rate of deployment is high enough that the tether does not unwind on its own inside the dispensing device before deployment. In comparison with a rotating reel, a fixed reel weighs less, is more compact, and allows lower tension. Furthermore, it avoids large rotating masses and high-speed bearings.

Outside payout was selected in preference to inside payout. That is, the tether is released from the outer circumference of the wrapped reel rather than from its inside circumference. Outside payout avoids the need for a light adhesive to hold the winding together at its unsupported inside circumference. Outside payout also makes it easier to provide feedback braking.

The tether is wrapped in a combination of universal and parallel windings (see figure). In a parallel winding, each turn lies parallel and next to the previ-

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ous turn. In a universal winding, the tether is wrapped at an angle of 7° to 15°; it is self-supporting at the ends and thus needs no flange as a parallel winding does. The universal portion of the winding minimizes the mass of the core and flanges. The inertial properties of the small parallel portion of the winding facilitate braking and control when the end of payout approaches.

The enclosure for the proposed payout device includes a thin-walled cylindrical metal shroud surrounding the winding. It is capped by a cone with a hole at its apex, through which the tether passes as it pays out.

The brake includes a post around which the line can be wrapped a desired number of times by an orbiting guide, as shown schematically in the detail in the figure. This simple brake provides tension that increases approximately exponentially with the number of wraps. Computer simulations suggest that 0 to 5 wraps should be adequate for the first experiments and that 3 to 7 wraps will be sufficient for large loads. The brake can be located at a distance from the deployer, with the line passing through a tube from the winding to the brake.

The enclosure is fitted with an optical device that counts the number of turns of the tether as it leaves the winding. A microprocessor can convert these data into the cumulative paid-out length of line and the rate of payout. Other useful instrumentation includes a microphone (to help identify the sources of possible malfunctions from sounds emitted by the tether), temperature sensors, a tensiometer, and an optical sensor to measure the angle of departure of the tether.

This work was done by Joseph A. Carroll and Charles M. Alexander of Energy Science Laboratories for **Marshall Space Flight Center**. *For further information,* ***write in 15*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Flight Space Center [see page 26]. Refer to MFS-26077.

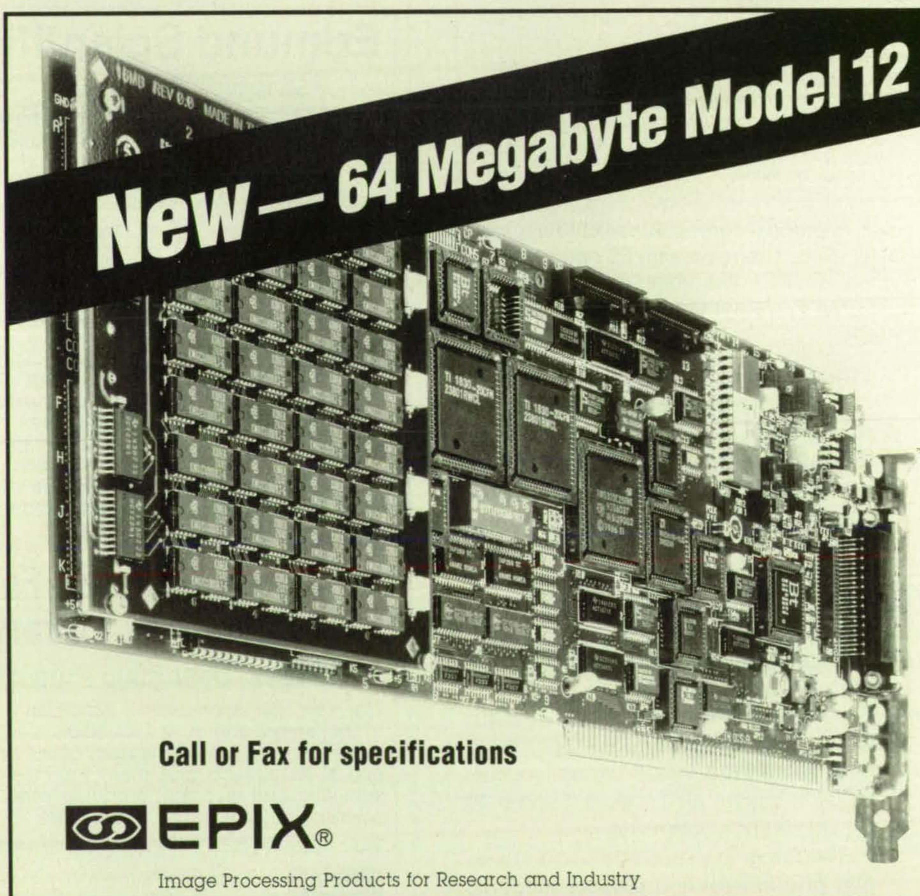
Finite-Element Analysis of Geared Rotors

Rotor and gear dynamics, previously treated separately, are combined in one model.

Lewis Research Center, Cleveland, Ohio

A finite-element mathematical model represents the dynamics of a geared-rotor system with flexible bearings. Until recently, the dynamics of gears and rotors were studied separately: early finite-element models for rotors represented the dynamic behaviors of elastic shafts carrying rigid disks, while most previous finite-element models for gears have typically represented the torsional properties of shafts and gears but have neglected the lateral vibrations of the shafts and bearings. The geared-rotor model was developed because in studying the dynamic behavior of a geared-rotor system, it is usually necessary to consider the coupling of the torsional vibrations of the gears with the lateral as well as the torsional vibrations of the shafts.

In the model, a geared-rotor system (see figure) is considered to consist of shafts, rigid disks, flexible bearings, and gears. When two shafts are not coupled through meshing gears, each gear can be represented as a rigid disk. However, when the gears are in mesh, the rigid disks are considered to be connected by a spring/damper element that represents the stiffness



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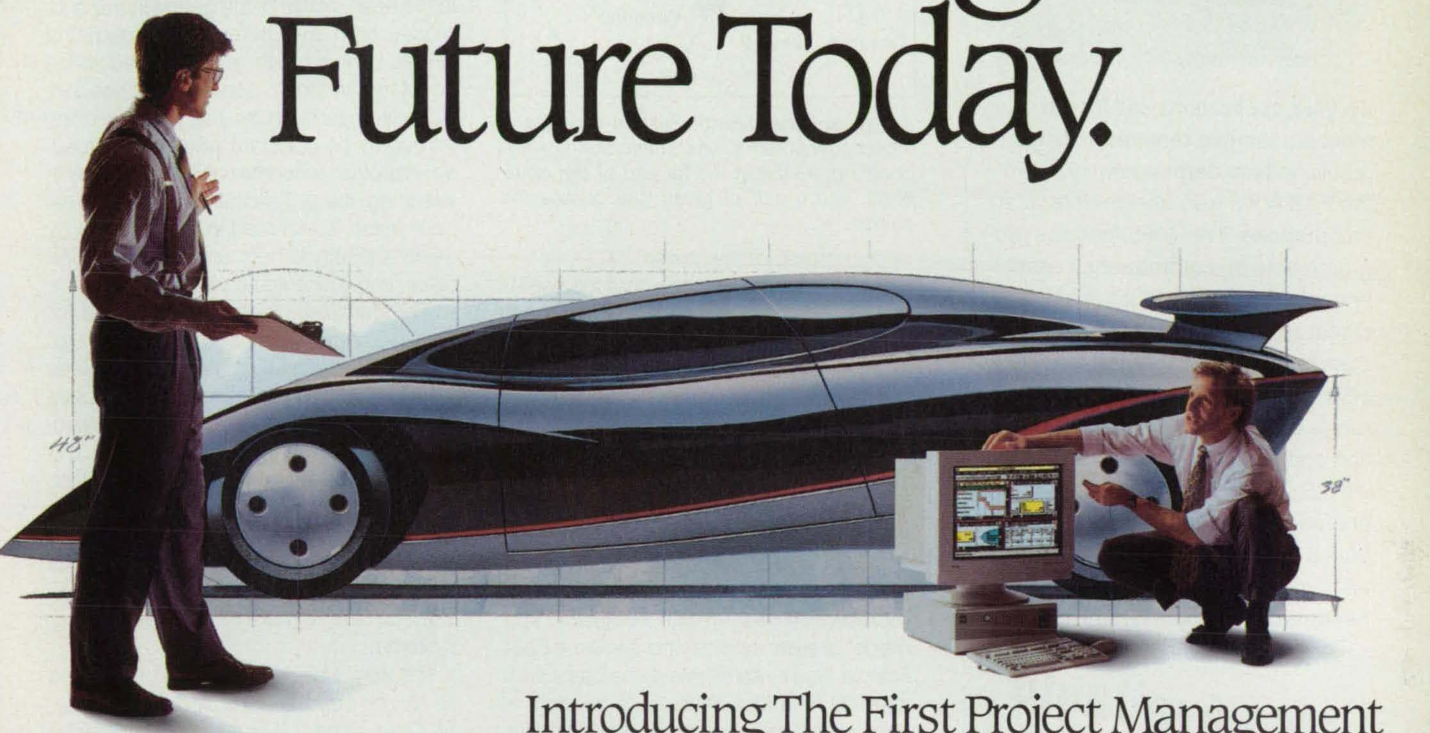

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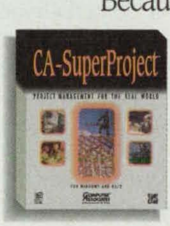

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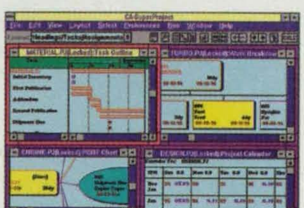

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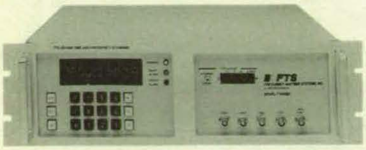

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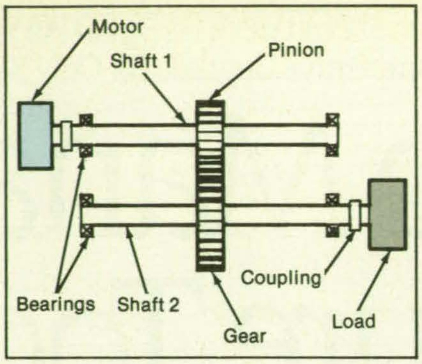

A **Typical Geared-Rotor System** includes a motor connected to one of two shafts via a coupling, a load at the far end of the other shaft, and a pair of gears that couple the shafts.

and damping of the mesh.

The portion of the model that represents the shafts, disks, and bearings is a modified version of the ROT-VIB computer program — a general-purpose rotor-dynamic program developed in 1983 that calculates whirl speeds, the shapes of corresponding vibrational modes, and the unbalance responses of shafts, rigid disks, and bearings. ROT-VIB includes the effects of rotary and transverse inertia, shear deformations, internal hysteretic and viscous damping, axial loads, and gyroscopic moments. It represents a bearing with a classical submodel of eight springs and damping coefficients, and it represents a shaft as a finite element with four degrees of freedom at each node (excluding axial motion and torsional rotation).

One of the modifications of ROT-VIB is intended to prevent the system matrices from becoming nonsymmetrical and thereby giving rise to a complex eigenvalue problem. In this modification, the gyroscopic-moment effect is ignored, and internal damping of the shaft is included only in the damping matrix. The second modification is performed because the gear mesh causes coupling between the torsional and transverse vibrations of the system, making it necessary to include the torsional degree of freedom. Therefore, the mass and stiffness matrices of ROT-VIB are expanded to include the torsional motions of the shafts.

In modeling the meshing of two gears, the spring/damper element that represents the connection between them is considered to lie along the pressure line tangent to the base circles of the gears. In this submodel, both the stiffness and damping values of the mesh are assumed to be constant, and tooth separation is not considered, inasmuch as the gears are assumed to be constant and heavily loaded. Although a constant mesh stiffness is assumed, the self-excitation effect of a real gear mesh is included in the analysis by using a displacement excitation function representing the static transmission error.

The complete model can be used for forced-vibration analyses of geared-rotor systems by calculating the critical speeds and determining the response of any point on the shaft to mass unbalances, eccentricities of gears, and displacement-transmission-error excitation at the mesh point. The dynamic mesh forces caused by these excitations can also be calculated. The model has been used in parametric studies on the effects of compliances of the bearings on the dynamics of geared-rotor systems.

This work was done by Ahmet Kahraman, H. Nevzat Ozguven, and Donald R. Houser of Ohio State University and James J. Zakrajsek of **Lewis Research Center**. *Further information may be found in NASA TM-102349 [N90-16286], "Dynamic Analysis of Geared Rotors by Finite Elements."*

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LEW-15103

Pump Propels Liquid and Gas Separately

The pump is a combination of a centrifuge, pitot pump, and blower.

Lyndon B. Johnson Space Center, Houston, Texas

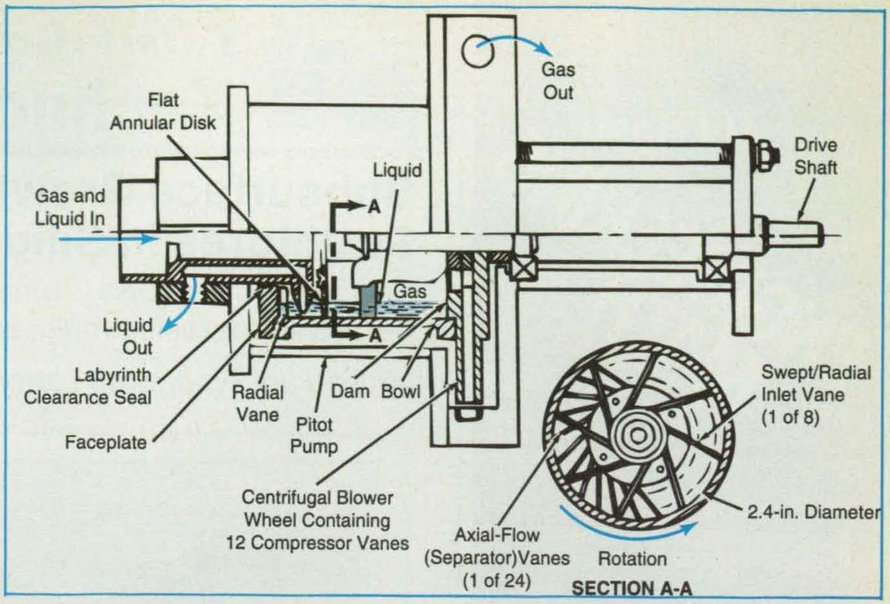
A conceptual design has been proposed for a pump that would handle mixtures of liquid and gas efficiently. Containing only one rotor, the pump would be a combination of a centrifuge, a pitot pump, and a blower. Potential applications include turbomachinery in powerplants and superchargers in automobile engines.

The centrifuge section is a cylindrical rotating bowl that has internal swept/radial vanes that help to ingest the inlet liquid/gas flow, and swirl the flow to the speed of the bowl. Axial-flow vanes guide the swirled flow while liquid mist is slung outward from the gas/liquid mixture (see figure). The inlet tip of a stationary pitot pump reaches outward in the rotating bowl to the radius of the liquid annulus trapped at the outer wall of the bowl by centrifugal force. The pitot pump scoops the liquid out by ram pressure due to the rotational velocity.

At the end of the rotor bowl opposite the inlet, a centrifugal blower wheel is attached directly to the bowl. The wheel is like that of any turbocompressor, except that its inlet flow has been preswirled by the centrifuge. A dam extends inward from the wall of the bowl to a radius smaller than that of the constrained liquid annulus, so that the blower receives only dry gas.

Gas fills the space between the rotor and the housing. A flat annular disk separates the rotor chamber of the pitot pump from the flow streaming out the eight inlet vanes; gaps at the outer radius of this disk allow liquid to enter the pitot chamber, and radial vanes on the inside of the faceplate of the bowl keep the flow swirling to enable the pitot pump to function.

Overall, the action of the pump is quite simple: a few vanes sling whatever comes in the inlet outward to the bowl; then many vanes stabilize and segregate gas and liquid; then the pitot pump and the blower do their work separately. One very important advantage is that in a centrifuge rotor, as opposed to a cyclone, secondary and boundary-layer flows are suppressed and favorable, so that the separation of liquid and gas is assured within the widest range of parameters, and flow-energy losses are minimized.



A **Centrifuge and Blower** mounted on a common shaft operate in conjunction with a pitot pump to separate liquid and gas, then expel them at higher pressure.

Initial calculations show that the desirable speed range of the pitot pump and the blower wheel do not match well. The diameters selected for the components on a common shaft are a compromise that accepts a higher-than-needed increase in the pressure of the liquid, but only the minimum acceptable increase in the pressure of the gas. The efficiencies will probably be lower than those that could be achieved in separate components. Nevertheless, the design is still practical and should result in low consumption of power.

This work was done by Andrew Harvey and Roger Demler of Foster-Miller, Inc., for **Johnson Space Center**. *For further information,* ***write in 59*** *on the TSP Request Card.*
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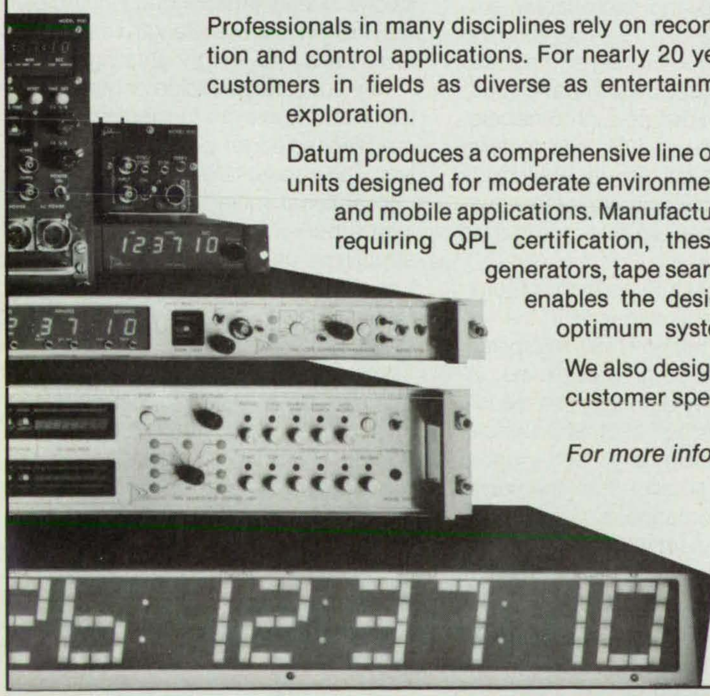

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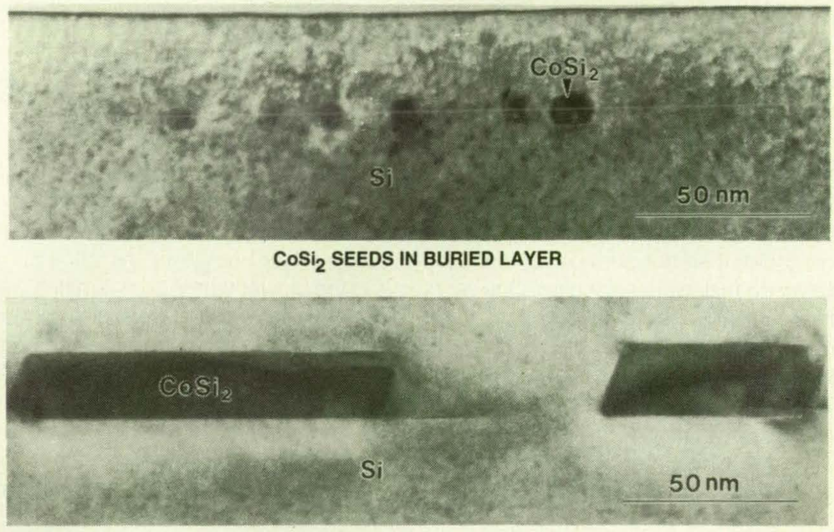
Fabrication Technology

Subsurface Growth of Silicide Structures in Silicon

This technique shows promise for fabrication of novel electronic, optoelectronic, and electro-optical devices.

NASA's Jet Propulsion Laboratory, Pasadena, California



$CoSi_2$ SEEDS IN BURIED LAYER

$CoSi_2$ CRYSTALS IN BURIED LAYER

These **Cross-Sectional Transmission Electron Micrographs** show examples of the growth of crystals of $CoSi_2$ in Si substrates. The $CoSi_2$ seeds were formed and buried by depositing Co in an amount equivalent to a thickness of 0.05 nm on an Si(111) substrate at 650 °C, then capping with 40 nm of Si at 650 °C. The $CoSi_2$ crystals were formed in the buried seed layer by depositing an additional 2 nm (equivalent) of Co at 800 °C at 0.009 nm/s.

Experiments have demonstrated the feasibility of growing microscopic single-crystal $CoSi_2$ structures beneath the surfaces of Si substrates. It may also prove feasible to form subsurface structures of the silicides of such other elements as Ni, Fe, and Cr, and to form subsurface structures of analogous chemical composition in such other substrates as germanium and compound semiconductors.

In the case of $CoSi_2$ (which is metallic), potential applications lie in the formation of such buried $CoSi_2$ microelectronic structures as ground planes, interconnections, and metal or permeable bases for transistors. In other advanced applications, columns of $CoSi_2$ about as large as or smaller than the wavelength of electromagnetic radiation that one seeks to detect would be buried in silicon, with dimensions and spacing chosen to tailor absorption peaks or other spectral responses or to obtain desired linear or nonlinear optical, optoelectronic, or electro-optical properties. Yet other advanced applications might involve buried semiconducting silicides like $ReSi_2$ in long-wavelength infrared detectors and $FeSi_2$ in light-emitting diodes.

The subsurface silicide or other crystalline structures are formed by use of a modified molecular-beam epitaxial process. The substrate is first prepared, by conventional molecular-beam epitaxy, with a buried layer that contains seed structures on which the buried structures can nucleate and grow. Then in the modified process, the deposited atoms (e.g., Co) diffuse into the substrate (e.g., Si) and accrete onto the surfaces of the seed structures, forming buried single-crystal structures (see figure). This diffusion-assisted growth can be continued until the seed structures coalesce to form a buried single-crystal layer. It is also possible to form a buried polycrystalline layer without disrupting the single-crystal nature of the top layer through which the deposited atoms diffuse.

In the case of $CoSi_2$ in Si, the seed

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particles could be microscopic particles of $CoSi_2$ or oxides. In addition to the buried seed layer, two other conditions are essential to the growth of the buried structure(s): a deposition temperature high enough for diffusion at a sufficient rate, and a rate of deposition low enough that diffusion of the atoms into the substrate predominates over competing processes at the surface. Typical growth temperatures and rates of deposition for $CoSi_2$ in Si are 700 to 800°C and 0.003 to 0.01 nm/s, respectively.

Fortuitously, the maximum temperature of 800 °C makes this process compatible with other semiconductor-fabrication processes that involve higher temperatures. This process offers advantages over a competitive process in which Co (or other metal) ions are implanted in an Si substrate, the implantation damages the substrate, and annealing must be performed at 1,000 °C.

This work was done by Robert W. Fathauer, Thomas George, and William T. Pike of Caltech and Leo Schowalter of Rensselaer Polytechnic Institute for **NASA's Jet Propulsion Laboratory**. *For further information, **write in 83** 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 26]. Refer to NPO-18624 and NPO-18625.

Plugs Prevent Contamination of Passages During Machining

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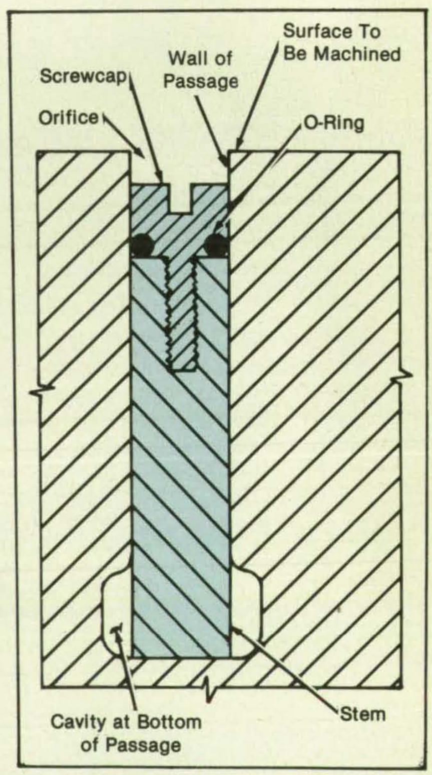
Marshall Space Flight Center, Alabama

Simple plug devices prevent debris from entering internal passages of a hardware assembly while it is being machined. The plug devices replace paraffin-wax seals on orifices; hot metal chips cannot melt through the plugs as they do through the wax and thus cannot accumulate in the passages and cavities of the hardware.

The device consists of a stem with a screwcap and O-ring (see figure). The stem is inserted through an orifice into a passage until it bottoms in the passage or in a cavity at the end of the passage. The screwcap is then tightened so that it forces the O-ring outward, forming a tight seal against the wall of the passage. This seal keeps debris out of the passage and cavity.



The **Plug Is Inserted in the Passage**, with its stem resting at the bottom and its screwcap slightly recessed from the orifice. Tightening the screwcap squeezes the O-ring outward. Loosening the screw releases the O-ring inward, so that the plug can be removed.

This work was done by R. Michael Malinzak and Gary N. Booth of Rockwell International Corp. for **Marshall Space Flight Center**. *For further information, **write in 27** on the TSP Request Card.*

MFS-29890

Backward Assembly Planning With DFA Analysis

Algorithms help to plan assembly sequences and to optimize parts to be assembled.

NASA's Jet Propulsion Laboratory, Pasadena, California

A system of algorithms is being developed to automate the planning of sequences of manufacturing or field operations in which components are put together into assemblies. The system is based partly on the concept of recursive decomposition of an assembly into subassemblies. To guide the generation of a preferred assembly plan, the system incorporates design-for-assembly (DFA) analysis, in which the designs of subassemblies and components are analyzed for their effects on the feasibility and cost of the assembly sequence; the results of DFA analysis can also be used to modify the designs to optimize them with respect to assembly considerations.

The planning system takes account of special processes (for examples, cleaning, testing, and labeling), which must occur during the assembly, and handles nonreversible as well as reversible assembly tasks through backward assembly planning. To increase the planning efficiency, the system avoids the analysis of decompositions that do not correspond to feasible assembly tasks: this is achieved at each stage of the sequence by grouping and merging those parts that cannot be decomposed at this stage because of the requirements of special processes and the constraints imposed by the feasibility or infeasibility of the affected interconnections between parts.

The system proceeds as follows: First, the special processes involved in making the product assembly are represented by a symbolic tree or set of trees called a "special process forest" (see Figure 1) and are incorporated into the backward assembly planning via a grouping principle. Given the special process forest, the grouping principle governs the identification of those parts that should be grouped together in a subassembly at the current stage of backward assembly planning, to enable the special processes to be carried out properly. In addition to the grouping principle, there is a merging principle, according to which those parts that are not decomposable at the current stage of backward assembly planning because of the infeasibility of interconnection are merged. Together, these two principles help to

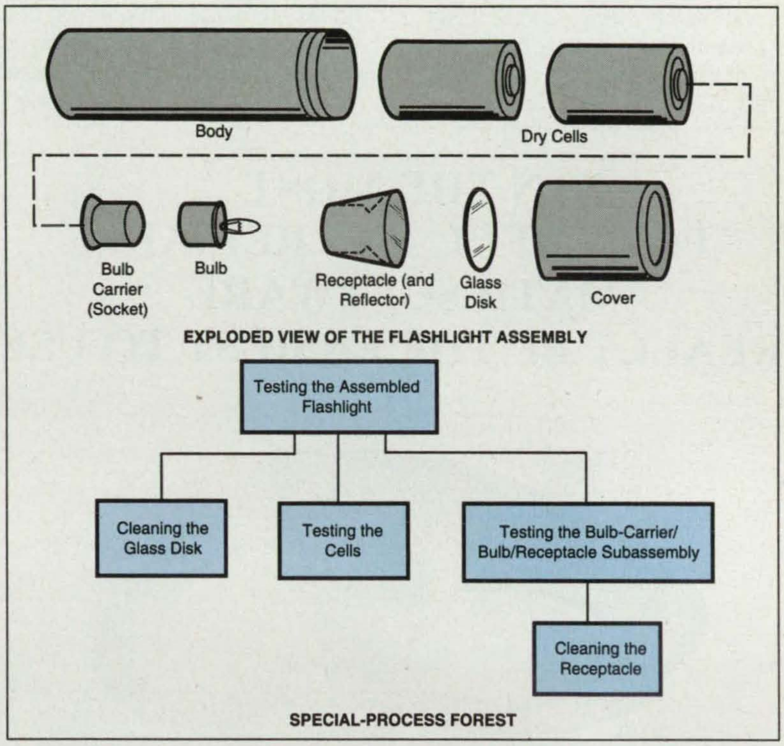


Figure 1. The **Special Process Forest for Assembly of a Flashlight** contains one symbolic tree that shows the precedence relationships among several testing and cleaning processes.

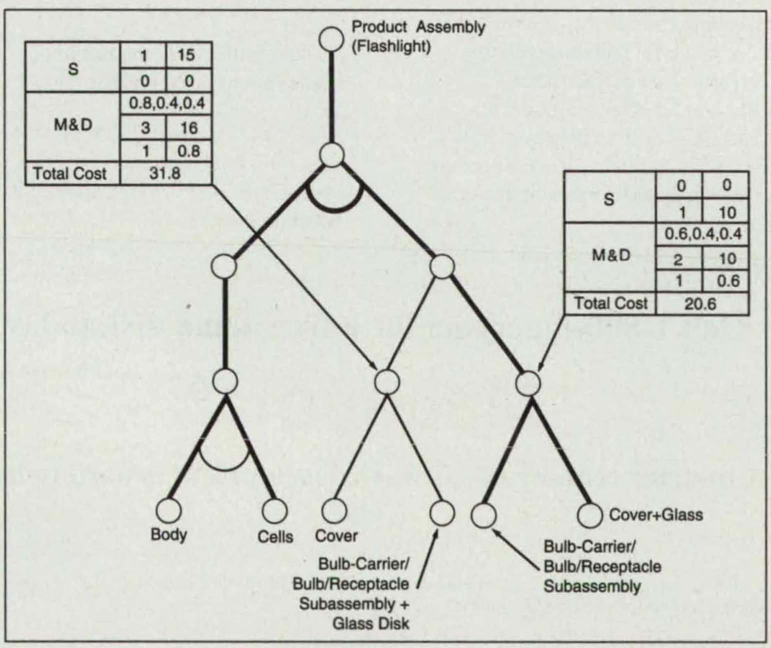


Figure 2. The **Search for an Optimal Plan** for assembly of the flashlight involves the generation of DFA-analysis tables of the nodes of the tree. S, M, and D in the tables denote stability, manipulability, and directionality, respectively.

reduce the complexity of the space of alternative sequences that has to be searched.

The system then proceeds to introduce criteria of stability, directionality, assembly pose, manipulability, process planning, and parallelism, and to quantify these criteria for use in selection of the best subassemblies in backward assembly planning. Most significantly, these criteria are evaluated with a direct connection to the cost of assembly on the basis of (1) the identification of the number of holding devices to stabilize assembly operations, (2) the derivation of the number of reorientations required during mating operations, (3) the determination of the best assembly poses for individual subassemblies generated during planning, and (4) the estimation of the effect of the manipulability of parts and subassemblies on the cost of mating.

Next, a globally optimal plan is found by an algorithm called "AO*," which searches a symbolic tree (see Figure 2) that represents alternative sequences of decomposition of the assembly into its components. The tree contains AND and OR nodes. The decisions at the OR nodes are made with the help of a cost function and a heuristic function defined in terms of the criteria mentioned above. In the process of searching for an optimal assembly plan, DFA analysis is performed for each assembly operation on the basis of the detailed evaluation of these criteria. The result is summarized into a DFA analysis table.

This work was done by Sukhan Lee of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 103*** *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 26]. Refer to NPO-18817.

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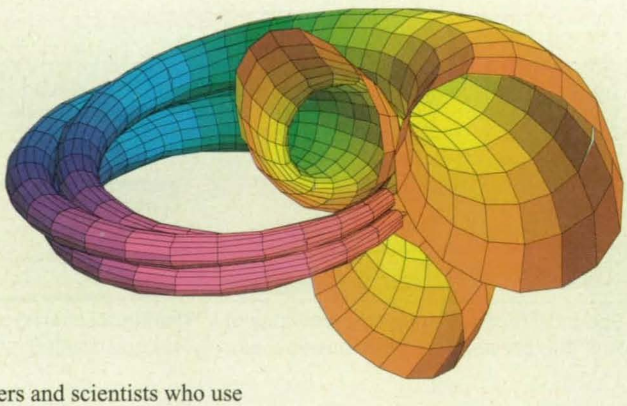

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A new formulation takes advantage of modern computers.

Lyndon B. Johnson Space Center, Houston, Texas

A new formulation for Nystrom integrators offers increased precision and speed of computation. When Nystrom developed his numerical-integration technique in 1925, the only computing machines available were crude mechanical adding machines; because of this and because the original version of the technique required large amounts of labor, only simple fractions could be used as integration constants. The new formulation takes advantage of the capabilities of modern electronic computers, which can rapidly process even such complicated fractions as irrational numbers with enough precision at each integration time step to preserve the overall accuracy over many such steps (long integration times).

A Nystrom integrator is an algorithm for the numerical integration of the second-order vector differential equation

$$\ddot{z} = g(z, \dot{z}, t)$$

where z is the dependent variable and t denotes time. Typically, z denotes the position of an object, and g denotes an acceleration, which could include gravitational, drag, and/or other components. Equations of this form can be used to describe the motions of such diverse mechanical systems as the solar system, orbiting spacecraft, vehicles on rough roads, vibrating beams, aircraft, and baseballs.

The integration constants in a Nystrom integrator must satisfy a set of constraint equations, which are obtained by matching the terms in a Taylor-series approximation of the integral. The order of a

Multiple Pages Intentionally Left Blank

Nystrom integrator depends on the number of terms used. An approximation of higher order yields greater precision, but as the order increases, the number of derivatives that have to be evaluated increases, and the amount of computation quickly becomes unmanageable. Heretofore, in a typical case, an investigator would spend weeks or even months deriving the constraint equations.

In the new formulation, the independent and dependent variables and the various partial and total derivatives are expressed via a compact tensor notation. Two different sets of tensor terms equations are developed, making it possible to derive the constraint equations by matching coefficients of the identical tensor in the two sets. In this approach, a typical set of constraint equations can be derived in about 1 day.

The solution of the complicated, nonlinear constraint equations remains a difficult task. Usually, one starts with more equations than there are unknowns, theoretically impossible to solve. Many of the equations turn out to be redundant and can be eliminated, usually leaving more unknowns than there are equations. In this case, either additional constraint equations can be introduced to improve performance or else some of the integrator constants can be chosen to improve the performance or simplify the constraint equations. At this point, one has a set of equations that, in principle, can be solved, but the solution by conventional methods may take several weeks.

In the new formulation, the solution of the constraint equations is speeded by the SEARCH computer program. SEARCH is a general-purpose optimization program, which maximizes or minimizes a cost function defined by the user. The program searches for the maximum or minimum by perturbing each parameter individually in each cycle of a repetitive process in which the perturbation step size is changed from cycle to cycle. SEARCH has been used successfully, for example, to make a least-squares fit of about 4,000 equations in 12 unknowns.

This work was done by William M. Lear of Charles Stark Draper Laboratory, Inc., for **Johnson Space Center**. *For further information,* ***write in 74*** *on the TSP Request Card.*
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Quantitative Tester and Reconditioner for Hand and Arm

A computer-controlled system measures and/or provides resistance to the subject's muscle force.

Lyndon B. Johnson Space Center, Houston, Texas

An apparatus measures the torques, forces, and motions of the hand, wrist, forearm, elbow, and shoulder and aids in reconditioning the muscles involved. The design of the apparatus specifically addresses the muscles of the left or right arm and shoulder considered in isolation from other body muscles. That is, it measures forces, torques, and motions produced by these muscles only, and not those produced by muscles elsewhere in the body.

The apparatus can be used to determine the strengths and endurances of muscles, the ranges of motion of joints, and reaction times. Thus, it provides quantitative data that can be used, for example, to assess the extent to which disuse, disease, or injury causes deterioration of muscles and of motor-coordination skills. The same apparatus can serve as an exercise machine to restore muscle performance by imposing electronically controlled, gradually increasing loads on the muscles. It is suitable for such diverse uses as training and evaluating astronauts, field testing for workers' compensation claims, and physical therapy in hospitals.

When the apparatus is used to evaluate the performances of muscles and joints, its readings replace subjective estimates by a physical therapist or quantitative measurements by more-limited special-purpose devices. When the apparatus is used for reconditioning, it offers advantages over exercise with free weights, providing the added benefits of controlled speed of movement and loading.

The apparatus includes a console that contains a rotatable drum mechanism, associated electronic circuitry, and a computer (see Figure 1). Peripheral equipment includes a video monitor, a keyboard, and a printer.

A test subject is asked to move a bar on the drum with respect to a fixed bar on the console. Various attachments can be added to the mechanism to isolate effects produced by selected muscle groups and measure particular motions of the wrist, forearm, elbow, or shoulder separately.

The rotatable drum mechanism turns

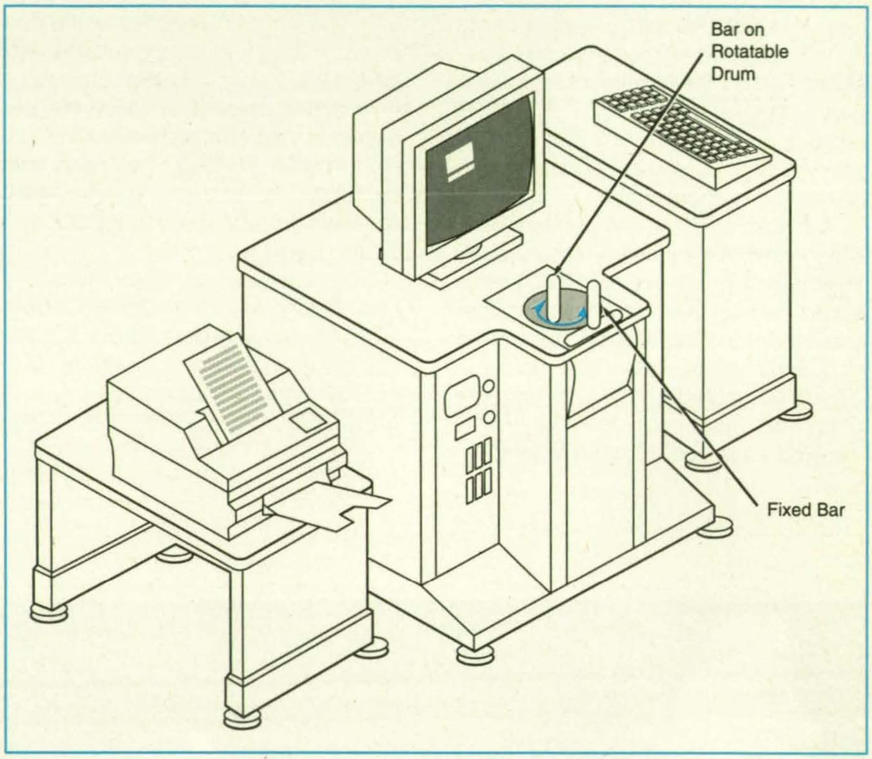

Figure 1. The **Console** holds the rotatable testing/reconditioning drum, electromechanical and electronic components, and a computer. Peripheral equipment is conveniently close.

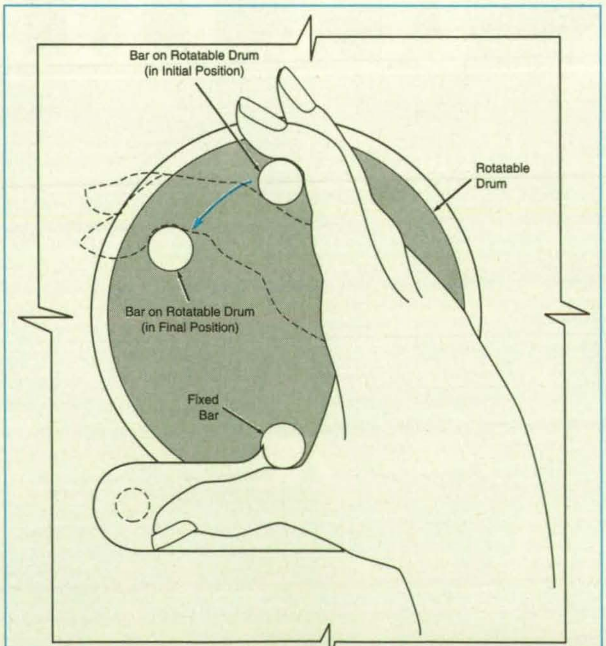

Figure 2. **To Test or Build Up Strength**, a subject grasps rotatable and fixed bars. The system automatically applies a resistive force according to the mode chosen — isokinetic, isotonic, isometric, or proprioceptive.

in a clutchlike or brakelike resistance device, which is filled with a magnetic powder that flows freely until a magnetic field is applied to it by a stationary coil in the device housing. The device then develops a resistive torque proportional to the magnetic field. Its output is measured by a torque sensor. The magnetic-particle resistance device was selected because it produces a high torque, applies and removes it smoothly, and is free of backlash.

The computer controls the current to the coil according to the particular test (or reconditioning plan) being used on the subject. For example, the testing/reconditioning can be isokinetic: in this mode, the apparatus exerts a variable resistance on the subject's hand so that the rotatable bar is moved at a constant speed. Alternatively, the isotonic mode can be selected: in this mode, the resistance is held constant and the speed of rotation is allowed to vary. Yet another alternative is the isometric mode, in which a resistance that exceeds the subject's strength is applied while the force or torque exerted by the hand is measured. Still another mode is that used in proprioceptive reaction-time testing, in which the drum is driven by a motor, the direction of rotation is suddenly changed, and the subject's reaction time (for the subject to feel the reversal and then resist it) is measured.

With the aid of various attachments, the system can be adapted to measure such special motions as pinching, rotation of the wrist, and supination and pronation of the forearm. The attachments are in the form of gloves, wristlets, and sleeves.

This work was done by Gary Engle and Malcolm Bond of Cedaron Medical and Theodore Naumann for **Johnson Space Center**. *For further information,* ***write in 101*** *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

Cedaron Medical, Inc.
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P.O. Box 2100
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Electronic Systems

Unified Robot-Control Scheme

A report describes a unified scheme for autonomous supervisory, shared, and teleoperation control of a robotic manipulator equipped with multiple position, force, and velocity sensors. The scheme was developed according to an impedance-control approach in which the manipulator acts as a different specified impedance to each sensor source, which can be real or virtual. This approach leads to a relatively simple control system that has a wide range of capabilities, and enables the relatively simple integration of new sensors into the system. This control scheme is a product of evolution from a prior multiple-sensor-based control scheme, called "generalized compliant motion task-execution primitive," which was formulated according to a force/compliance-control approach.

This work was done by Paul G. Backes of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Multi-Sensor Based Impedance Control for Task Execution,"* ***write in 89*** *on the TSP Request Card.* *NPO-18709*

Numbers and Gains of Neurons in Winner-Take-All Networks

A report presents a theoretical study of (1) the gains required in neurons to implement a winner-take-all electronic neural network of a given size and (2) the related question of the maximum size of a winner-take-all network in which the neurons have a specified sigmoid transfer or response function with a specified gain. These questions are important because the winner-take-all phenomenon and generalizations of it arise repeatedly in research on neural networks. From previous research, it is known that in general, the necessary gain increases with the size of a neural network. On the other hand, the gains of practical neural circuits are limited to finite values. Therefore, it is important to conduct this and other studies that contribute to understanding of the gain-vs.-size problem.

This work was done by Timothy X. Brown of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Calculating Necessary Neuron Gains for Winner-Take-All Networks,"* ***write in 70*** *on the TSP Request Card.* *NPO-18640*

Physical Sciences

Effect of Auger Recombination in an Ion Track

A report presents theoretical calculations of the contribution of Auger recombination to the depletion of charge carriers (electrons and holes) from the ionization track left by the passage of an energetic heavy ion through a sili-

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con-based electronic device. These theoretical calculations are needed to assist in the interpretation of data from tests in which silicon-based electronic logic circuits are exposed to energetic ions, causing single-event upsets (shifts between "one" and "zero" logic states). To the degree to which Auger recombination depletes charge, it can affect susceptibility to SEU.

This work was done by Larry D. Edmonds of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Theoretical Prediction of the Impact of Auger Recombination on Charge Collected From an Ion Track,"* ***write in 9*** *on the TSP Request Card. NPO-18565*

Slush-Hydrogen Technology

A report briefly describes some developments in the technology of the use of slush hydrogen as a fuel in the proposed National Aero-Space Plane (NASP). These developments consist, principally, of the experimental acquisition of data on handling characteristics and the development of three computer design codes to model mathematically the transfer, pressurization, and pressurized expulsion of slush hydrogen.

This work was done by Margaret V. Whalen, Terry L. Hardy, Thomas M. Tomsik, Nancy B. Mahoney, and Richard L. DeWitt of **Lewis Research Center**. *To obtain a copy of the report, "Slush Hydrogen Technology,"* ***write in 73*** *on the TSP Request Card. LEW-15526*

Improved Estimation of Delays in Radio Interferometry

A report dated October 2, 1991, describes the status of a mathematical model of the delays in the propagation of radio signals that originate at extragalactic or other distant sources and are received at widely separated terrestrial antennas engaged in very-long-baseline interferometry. The model — more precisely, a collection of mathematical models for various components of delay — is implemented in the multiparameter estimation computer program MODEST (for MODel and ESTimate). This program is needed, in such applications as geodynamics and astronomy, to extract the significant parameters from observed signal delays. The MODEST program and the present report are updated versions of the MASTERFIT program and the accompanying report dated December 15, 1987.

This work was done by Ojars J. Sovers of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Observation Model and Parameter Partials for the JPL VLBI Parameter Estimation Software,"* ***write in 39*** *on the TSP Request Card. NPO-18575*

Detecting Planets Outside the Solar System

A report describes the proposed Astrometric Imaging Telescope, which would be used to detect planets in orbit around distant stars. The Astrometric Imaging Telescope would operate for 10 to 20 years in orbit around the Earth at an altitude of 100,000 km. The report includes an executive summary and statement of scientific objectives of the Astrometric Imaging Telescope program. In addition to describing the telescope, it also describes the spacecraft and the spacecraft mission that would be needed to implement the program.

This work was done by Steven H. Pravdo and Richard J. Terrile of Caltech, Christ Ftaclas of Hughes Danbury Corp., and George Gatewood of the University of Pittsburgh for **NASA's Jet Propulsion Laboratory.** *To obtain a copy of the report, "Astrometric Imag-*

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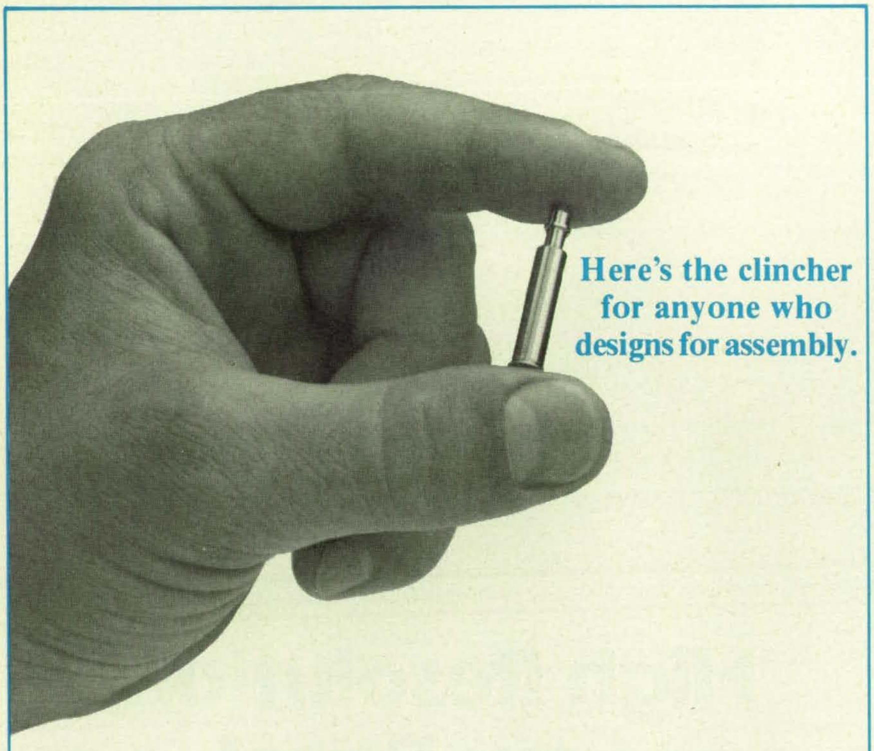
Study of Directional Solidification of Succinonitrile

Two reports describe experimental and computational-simulation studies of the growth of succinonitrile crystals by directional solidification in a horizontal Bridgman apparatus. The apparatus used was a specially designed laboratory furnace that produces a thermal gradient in the specimen, in this case succinonitrile. A translation system causes the gradient to move along the specimen, progressively solidifying it from one end to the other. In this case, the long axis of the ampoule and furnace and the direction of translation are horizontal.

This work was done by Henry de Groh, III, of **Lewis Research Center** *and Minwu Yao of the Ohio Aerospace Institute. To obtain copies of the reports, "Segregated Solution in 3-D Modeling of Crystal Growth" and "Application of the Segregated Solution Approach in 3-D FEM Modeling of Crystal Growth,"* ***write in 29*** *on the TSP Request Card. LEW-15672*



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Materials

Corrosion of Anodized 2219-T87 Aluminum

A report describes electrochemical studies of the effectiveness of three surface treatments in protecting 2219-T87 aluminum alloy against corrosion. In particular, this alloy is subject to pitting corrosion when exposed to a humid environment and especially when exposed to an environment that contains chloride ions. Two of the surface treatments studied were type-II and type-III anodizing. The other treatment was Magnaplate HCR™, a high-technology synergistic coating that produces a surface harder than that of steel.

This work was done by M. D. Danford of **Marshall Space Flight Center**. *Further information may be found in NASA TM-103540 [N91-26312], "The Corrosion Protection of 2219-T87 Aluminum by Anodizing."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700. MFS-27271

Mechanics

Multishock Shields Containing Aluminum Mesh

A collection of conference papers, reports, notebook entries, and other, less-formal documents depict aspects of continuing research on multilayer shields to protect spacecraft against impacts by micrometeoroids or projectiles. Shields of this general type consist of multiple, lightweight, thin layers of material. They are called "multishock" shields because the incident micrometeoroids and debris generated by impacts of the micrometeoroids upon the outer shielding layers are subjected to shocks as they strike succeeding layers. The shocks pulverize and vaporize the particles into harmless slower-moving, smaller ones.

This work was done by Eric Christiansen of **Johnson Space Center**. *Further information may be found in AIAA paper A90-32035, "Advanced Meteoroid and Debris Shielding Concepts."*

Copies may be purchased [prepayment required] from AIAA Technical Information Service Library, 555 West 57th Street, New York, New York 10019, Telephone No. (212) 247-6500. MSC-21792

For More Information Write In No. 569

Fabrication Technology

Effects of Geometry on Tensile Strengths of Butt Welds

A report presents the results of an empirical evaluation of a theoretical equation that predicts the ultimate tensile strength of a butt weld as a function of some properties of the welded metal and of the geometry of the weld. The geometrical independent variables in the equation include the fusion-line angles, the mismatch, the thickness of the base metal, the peaking angle, and the width of the weld. The report does not present the equation directly: however, an appendix presents a computer program that implements the equation.

This work was done by Stephen S. Gordon of Nichols Research Corp. for **Marshall Space Flight Center**. *To obtain a copy of the report, "An Investigation into Geometry and Microstructural Effects Upon the Ultimate Tensile Strengths of Butt Welds,"* ***write in 26*** *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 26]. Refer to MFS-27283.

Mathematics and Information Sciences

Integrated Optimization by Multilevel Decomposition

A report presents a method of integrated optimization of a structure and its control system by multilevel decomposition. During the last decade, increasing attention has been given to problems of interactions between control systems and structures, and to the integrated design of a structure and its controller.

In general, the approaches to integrated design can be categorized as either sequential or simultaneous. A sequential approach is one in which a design iteration in one discipline is completed before a design iteration in another discipline begins. A simultaneous approach is one in which different disciplinary design problems are combined into a single design problem.

Multilevel decomposition is an alternative simultaneous approach to the design of a large system, each of the multiple subsystems (e.g., structures or controls) of which would heretofore normally have been designed according to a distinct design discipline. In multilevel decomposition, the large system is broken down into smaller subsystems according to the applicable conventional design disciplines and according to hierarchical lines. The designs of these subsystem can be managed more easily than can the design of the complete, integrated system.

This work was done by Thomas A. Zeiler of Lockheed Engineering & Sciences Co. and Michael G. Gilbert of **Langley Research Center**. *To obtain a copy of the report, "Integrated Control/Structure Optimization by Multilevel Decomposition,"* ***write in 16*** *on the TSP Request Card.*
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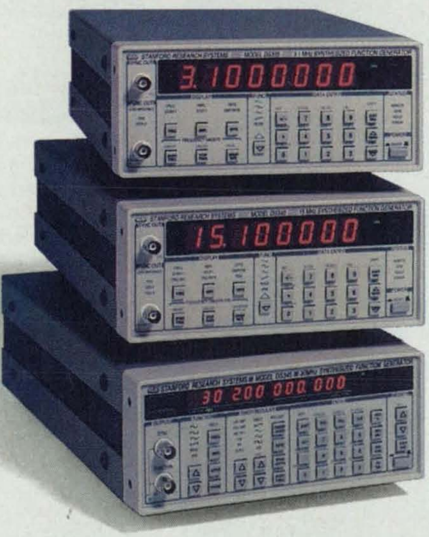

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New on the Market

Surface Conversion Technologies Inc., Cumming, GA, has patented a **process for depositing a diamond-like coating on virtually any substrate** capable of withstanding 200 °C. A 5-micron-thick monofilm on metals, carbides, and plastics yields the properties of diamond. The coating is extremely wear resistant, improves electrical conductivity, and increases the life of any product harmed by friction, such as saws, drills, gears, engine components, and bearings.

For More Information Write In No. 707

Identity Systems Technology Inc. has announced a 486SLC-based **notebook computer** that features a 500 MB MAXTOR hard disk with an access speed of 8 ms. Weighing under 7 pounds, the IDENTITY™ notebook features 4 MB of memory, upgradable to 8 MB, and costs $2995.

For More Information Write In No. 704

A low-power, five-channel **GPS power receiver** from Rockwell International Corp., Newport Beach, CA, measures 2.0" x 2.8" x 0.53" and weighs just 2 ounces. The NavCore® MicroTracker™ features power levels as low as 670 mW, time-to-first-fix of 20-30 seconds, normal operating temperature range of 30-75 °C, and dynamic tracking.

For More Information Write In No. 706

WINDAQ/200, Windows-compatible **data acquisition software** from Dataq Instruments Inc., Akron, OH, allows users to acquire, record, and analyze waveform data while simultaneously running other Windows operations. Data can be stored at speeds up to 83,000 samples/sec. on as many as 16 channels. The software features a flexible real-time display and permits time and date markers with comments.

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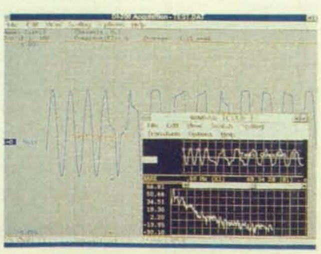

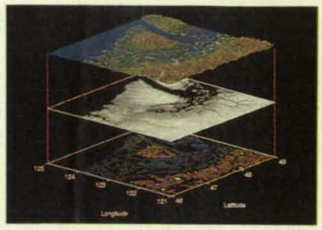

The MathWorks Inc., Natick, MA, has announced the MATLAB Image Processing Toolbox, the first software to provide **advanced image processing and numeric computation in an integrated environment**. Based on MATLAB's visualization and computational tools, the software allows users to visualize, manipulate, and analyze images and 2D signals. More than 100 functions are included for linear and nonlinear filter design, filtering and image restoration, image enhancement and statistics, 2D transforms, and color, geometric, and morphological operations.

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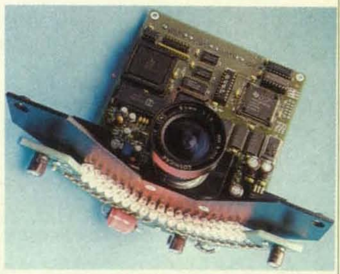

A 2048-pixel, **CCD line scan camera** for industrial measurement applications has been announced by Wintriss Engineering Corp., San Diego, CA. The Smart Camera incorporates the onboard processing power of a Texas Instruments' TMS320C31 DSP, and can both image and determine the velocity of objects moving at high speed. Software tools allow control of the camera from a Windows environment.

For More Information Write In No. 705

EPIX Inc., Northbrook, IL, has introduced a board enabling **image acquisition, processing, and display on PC/AT—compatible computers**. The 4MEG VIDEO Model 12 features up to 64 MB of image memory, sampling/display rates up to 40 MHz, and a 12 MIPS DSP for accelerating image processing. Memory can be configured to 31,000 pixels per line for high resolution or to lower resolutions for image sequences of over 65,000 frames. In addition to standard RS-170 and CCIR sources, the Model 12 can interface to line scan, high-resolution, and high-frame-rate cameras.

For More Information Write In No. 703

New on the Market

The first **CD recorder** capable of reading and recording data at double and quadruple speed is available from Yamaha Corporation, San Jose, CA. The CDR100 handles all standard formats, including CD-ROM, CD-ROMXA, CD-I, and CD-DIGITAL AUDIO, and can be used with high-precision CD-R disks. The compact unit fits into a 5¼" disk drive and uses the PC power supply, making it suitable for use as an internal or external drive.

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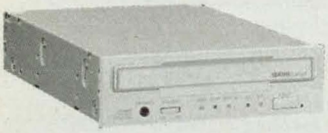


The PROBE™ **human interface tool** has been introduced by Immersion Corp., Palo Alto, CA, for use in computer 3D environments. The pen-like stylus allows users to dexterously manipulate position and orientation of objects in 3D space with minimal fatigue. The tool uses magnetic sensor elements to eliminate noise, interference, and shadowing problems associated with some tracking devices.

For More Information Write In No. 713

Quantitative Technology Corp., Stoughton, MA, has created a **mathematical library** of algorithms for the PC and Macintosh. MATH ADVANTAGE™ 5.0 for the PC contains 462 routines, including matrices, interpolation, integration, polynomial and rational functions, and signal, image, and vector processing. The Macintosh version's interface package for input/output, graphics, and formatting includes functions coded with the MPW, Microsoft, or Think C compilers.

For More Information Write In No. 712

Oscilloscope cards introduced by PC Instruments Inc., Winsburg, OH, combine the features and performance of portable oscilloscopes with the convenience of PCs. Occupying one PC/AT expansion slot, the single-channel 420 series and dual-channel 430 series provide 200 MHz bandwidth, 500 ps/div minimum timebase setting, and a 200 gigasample/second equivalent sampling rate.

For More Information Write In No. 708

Virtual reality software from Division, Inc., Redwood City, CA, creates a 3D user interface as a seamless extension to conventional CAD and modeling systems. Dubbed dVISE™, it requires no programming and employs existing interfaces or head-mounted 3D viewers and other VR displays to provide immersive viewing. dVISE can import design data from AUTOCAD, ProEngineer, MicroStation, Alias, MultiGen, and Wavefront.

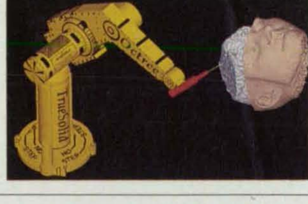
For More Information Write In No. 714

The Quickvision™ high-performance **3D graphics and image processing card** has been introduced by Fairchild Defense, Germantown, MD. Designed for use with Sun SPARCstations and compatibles, the dual slot Sbus card features hardware texture mapping and image warping at 1.25 million pixels/sec. Quickvision has 16 MB of onboard memory and can draw Z-buffered, lighted, Gouraud-shaded, meshed triangles at 150 K/sec.

For More Information Write In No. 711

Octree Corporation, Cupertino, CA, has released TrueSolid PC, the first advanced **volume graphics software** for PCs. Users can manipulate, visualize, and analyze large volumetric data sets (up to tens-of-millions of voxels with attached properties) combined with complex geometric models. Hierarchical recursive subdivision methods provide fast rendering times regardless of object complexity.

For More Information Write In No. 710



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Model 5100 has all the features and options you've come to expect from Magtrol for simultaneous measurement and display of amps, volts, watts and power factor for nearly any electrical device. But now Magtrol also gives you greater accuracy, a wider band width and improved noise attenuation for better machine stability. Magtrol is better than ever!

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For More Information Write In No. 437

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The C45 series of solid state ac relays are optically isolated to 4000 Vrms. The units contain back-to-back photo SCRs and a zero crossing circuit developed by Teledyne. The tight zero switch window ensures reliable transient free switching of AC loads and very low EMI and noise generation. The optical isolation of control from output affords noise free power switching. This series can switch from 10 ma to 1.0 amp rms at 250 Vrms. The C45 is packaged in a low profile 16 pin DIP package.

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For More Information Write In No. 652

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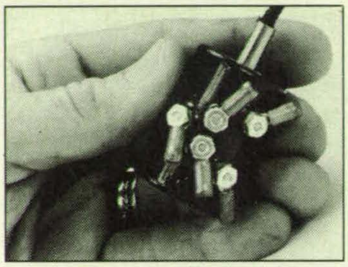

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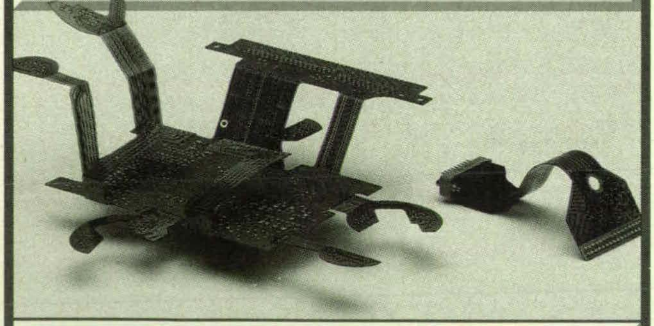
FORM



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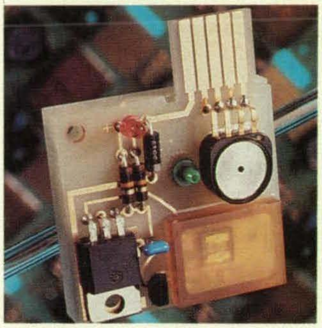
New on the Market

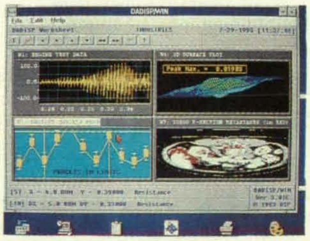
The first **electro-fluidic multi-chip module** for proportional control of gas pressure has been unveiled by Redwood MicroSystems, Menlo Park, CA. Based on the company's patented Fluistor™ silicon micromachined microvalve, the hybrid printed circuit board's smaller size (1.5" x 1.6" x 0.8") and improved accuracy (±1% of full scale over a 0.1 cc to 1500 cc per minute range at 20 psid) offer an alternative to conventional electromechanical technology in analytical and medical instrumentation.

For More Information Write In No. 721



A **PC expansion card for developing artificial neural networks**, offered by NeuroDynmX Inc., Boulder, CO, significantly reduces the processing time for such applications as pattern recognition, signal classification, and image processing. Networks that require three hours to train on a 486/25 converge in under four minutes with the NDX Neural Accelerator XR25. Featuring 2 MB of RAM (upgradable to 64 MB), the card employs an Intel i860 RISC processor operating at 25 MHz to deliver up to 22.5 million connections per second in recall mode.

For More Information Write In No. 716



DSP Development Corp., Cambridge, MA, has released a 32-bit Windows version of DADiSP, its **graphical data analysis software** designed to collect, analyze, and display scientific and technical data. Fully compatible with previous releases, DADiSP/32-WIN enables the user to run multiple applications, import data via a notepad utility, automate worksheets for background operation, and manage memory allocation.

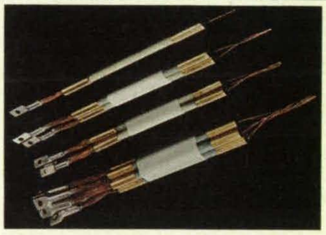
For More Information Write In No. 719

SigmaPlot® **scientific graphing software** from Jandel Scientific, San Rafael, CA, is now available for Windows. The new release features automatic error bars, huge data set handling, nonlinear curve fitting, axis breaks, multiple axes, regression lines, confidence intervals, and reference lines.

For More Information Write In No. 720

G&H Technology Inc., Camarillo, CA, has introduced the PGD series of PULSE-GUARD® **electrostatic discharge protection products** for use with standard and high-density D-subminiature and other I/O connectors. The products feature a patented composite over-voltage suppression material applied to a ground plant suspended between two insulating membranes. The thin (.015") array can be installed in seconds with no loss in performance.

For More Information Write In No. 718



The first commercial **high-temperature superconducting current leads** have been announced by ZerRes Corp., Boston, MA. Designed to power superconducting magnets that operate at just above absolute zero, the new leads have demonstrated helium savings up to 66% when compared to conventional copper vapor-cooled leads. Their current-carrying capacity is up to 100 amps in a single element and over 1000 amps when bundled.

For More Information Write In No. 715

Tayco Engineering Inc., Cypress, CA, has announced the commercial availability of a **solid-state thermostat** (SST) originally developed for the space shuttle. Unlike bimetallic thermostats, the SST is an electronic device activated by a solid-state platinum resistance temperature sensor and has no moving parts to fatigue with repeated cycling. The SST offers increased reliability and operation at higher vibration levels.

For More Information Write In No. 717

POSITIONS WANTED

Successful, dynamic systems engineer, MBA in Engr/BSAAE, 12 years in large and small aerospace/defense programs. Seeks growth position. Strong background in design/development of products & requirements, performing analyses, evaluation and testing of hardware/software, and defining training programs. Knowledge of federal regulations, standards, and acquisition practices. DOD and NATO clearances. Will travel/relocate.
Box number 35B

Theoretical scientist, grand quantum gravitational research, development energy work, electronics, microwave, laser work. Interested in working with someone or an organization on a full-time or part-time basis, or in consulting, advisory service. Ronald R. Kotas, Grand Quantum Research, P.O. Box 1471, Fort Myers, FL 33903.
Box number 36B

Senior/project engineer, BSME, 12 years experience on government/commercial projects, including program management, bids and proposals, and analysis. Proven record spanning R&D, manufacturing, quality using design for assembly and concurrent engineering on mechanical/electrical systems. Computer hardware/software expertise, FORTRAN, Basic, C, CAD/CAM, FEA. Multilingual. Willing to travel/relocate.
Box number 37B

Degreed industrial photographer with extensive experience providing high-quality photography to engineers and researchers in scientific and technical areas. Easily interfaces with those providing technical reports, manuals, and publications—including publicity, news, brochures, and all types of visual presentations. Familiar with data recording, standard high-speed motion pictures as well as video and digital imaging.
Box number 38B

Ph.D (physiology & neurophysiology), MS (medical electronics), 29 years of R&D and academic experience, expertise in respiratory, cardiovascular and exercise physiology, medical science and exercise equipment (patents), mass spectrometry, and analog electronics. Has an idea for an exercise system with a potential for diagnostic, rehabilitation, and training applications. Seeking an academic or R&D position.
Box number 39B

11-year electrical engineer wants overseas job. Full range background in EE, hardware & software, PCs, etc. Great communication and leadership skills. Also, some unique skills: usable German and Turkish (non-technical, but learn fast), some Spanish experience, private pilot license, extra class amateur license.
Box number 40B

Contamination control engineer and precision cleaning specialist with over 20 years experience with a Malcolm Baldridge high technology electronics company. Expert on latest cleaning and drying technologies in support of chlorofluorocarbon elimination. Strong leadership, organizational, and writing skills. BS in chemistry with knowledge of statistical techniques and statistical process control. Will relocate.
Box number 41B

Ph.D in physics with over 25 years experience in plasmas, gaseous electronics, lasers, electro-optics, and fiber optics. "Front end man" capable of solving new problems, before others have identified the issues. Willing to work on a wide variety of technical problems, under a wide variety of work arrangements.
Box number 42B

MS chemist/engineer. 15+ years in development, field testing, engineering, and technical service on process chemical analyzers. Applications: photometric, chromatographic, electrochemical analyzers to gaseous, liquid, solid samples. Process control, product control and quality, air/water pollution, health/safety applications. Strong skills in technical writing, public speaking, organizing, and quality management. Tel: 504-751-5259.
Box number 43B

Materials/metallurgical engineer. Registered PE and CWI. 20 years experience as metallurgist and welding/quality engineer. Specified NDT requirements for NASA/ASRM project. Have commercial and Navy nuclear experience. Specialized in ASME, NAVSHIPS, AWS, and API codes. Had DOE/DOD clearances. Seeking staff, management, or R&D position.
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Flight simulation experience (17 years) to manager of engineering level. BSCS, MS Simulation System. Commercial/military device experience. R&D, program, department management, and new business experience. Mil-Stds experience. Excellent communications skills. Technical analysis and proposal writing skills. Customer/vendor interface skills. Spouse senior visual database engineer. Will relocate. Tel: 407-292-3361.
Box number 45B

BSEE graduate seeking position in digital or analog hardware design. Strong interests in image processing, audio, and HDTV. Senior design project involved building a PC-compatible audio capture and playback interface. Knowledgeable in control systems, C programming, UNIX shell scripts, circuit simulation, X-Windows, and DOS. Enjoy working in groups, a quick learner, and a good teacher. Tel: 302-453-8147.
Box number 46B

To submit an ad for inclusion in this column, send a copy of your resume and a 50-word summary to: *NASA Tech Briefs*, 41 East 42nd St., New York, NY 10017, ATTN: Gregg McQueen.

Ph.D, over 12 years in finite element development and applications in aerospace industries. Extensive experience in classical structural mechanics and in the use of NASTRAN, PATRAN, XL, SAPIV, AGGIE. Expertise includes static, dynamic (modal, random, transient vibrations), buckling, fatigue, nonlinear solutions. Excellent oral/written communication and computer skills. Willing to relocate.
Box number 47B

Innovative product designer/mechanical problem solver. Listed: expert consultant in those categories with Teltech Resources Network. MIT education in industrial management (mechanical engineering option) and architecture. Fellowship with Frank Lloyd Wright. Extensive experience in a wide range of product design and development. Available anywhere for consultation or full-time employment.
Box number 48B

BS in medical engineering, MS in applied optics, Ph.D in biomedical engineering (vision/neuroscience) and post-doc experience. More than ten years of research experience. Seeking R&D engineer/scientific position related to biomedical instrumentation, visual science, electrophysiology, and biomedical optics. Strong experience in physics, lasers, optical and mechanical design, optical imaging, and computer modeling.
Box number 49B

BS in mechanical engineering with 2.5 years in satellite mechanism and systems design. Designs developed from concept to final design, including manufacture and test. Three design patents pending. Extensive knowledge of AutoCAD and PCs. MS in engineering mechanics (composite materials) pending thesis completion in Dec. '93. Army veteran with previous Top Secret clearance.
Box number 50B

Ph.D physicist, 16 years industry R&D experience, seeks technical/management position in Houston, TX. Experience: development/application automated neutron/gamma detection systems for materials studies/NDT, cryogenic infrared/visible photodetector R&D, measurement/modeling radiation damage and transitory effects, project proposal/planning/management. Security clearance.
Box number 51B

Mechanical design/analysis position. MS in structural mechanics, BS in mechanical engineering. 13 years structural design/analysis of aerospace components, including composites. Fluent in linear, nonlinear, static, and dynamic analysis using MSC/NASTRAN, ABAQUS, and NIKE finite element codes, and PATRAN modeling software. Fluent in VAX/VMS and Cray/UNIX. CAD experience.
Box number 52B

Experienced, multiple-skilled senior-level toolmaker, highly motivated, industrious, creative, objective, team-oriented, on-line production problem-solver, who is keenly knowledgeable in tooling design concepts. Reputation as being reliable, punctual, dedicated, and possessing a strong work ethic. Seeking long-term growth opportunity with a stable, industry-leading company.
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Welding engineer/metallurgist with 20 years experience. Ph.D in materials science and engineering. Results from expertise, creativity, and judgment in selecting steels, aluminum, processes, and finishes for low cost and flowtime to reliable fatigue and fracture products. Failure analysis and correction. R&D and managing first-time technologies. Engineering drawings, specifications, customer justifications.
Box number 54B

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To obtain resumes corresponding to the above **Positions Wanted Ads**, fill out this form and mail to: *NASA Tech Briefs*, 41 East 42nd St., New York, NY 10017. ATTN: Gregg McQueen, or call 1-800-944-NASA and ask for Gregg McQueen.

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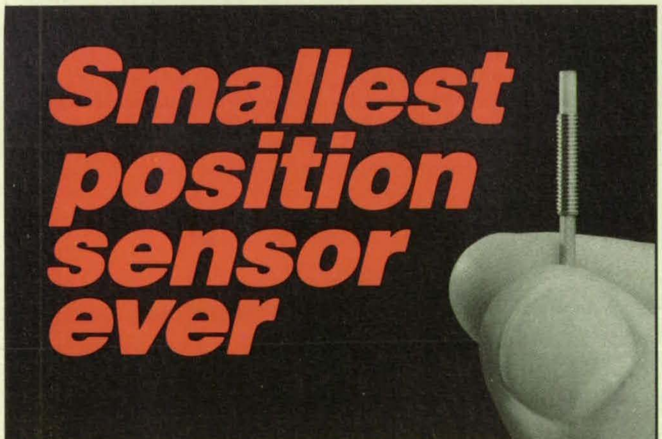

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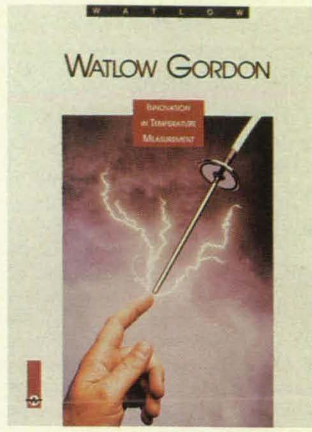
New Literature

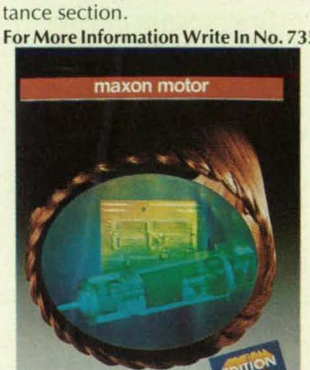
Kistler Instrument Corp., Amherst, NY, has released an 88-page catalog of its quartz piezoelectric, silicon micromachined, piezoresistive **transducers** for pressure, force, and acceleration. Also included are signal conditioners, charge amplifiers, calibrators, cables, and connectors. Applications include modal analysis, vibration measurements, combustion research, plastics molding, and industrial monitoring.
For More Information Write In No. 725



A **temperature sensing** guide published by Watlow Gordon, Richmond, IL, describes the company's thermocouples, RTDs, thermistors, related instruments, wire, cable, and thermowells. The eight-page guide addresses processes in which precise contact temperature measurements are needed in cryogenic (-200 °C) to extremely high-temperature (2315 °C) refractor use.
For More Information Write In No. 733

Bearing handling, maintenance, and lubrication procedures are illustrated in a 336-page handbook released by SFK, King of Prussia, PA. Designed with vinyl-coated pages for use on the shop floor, the book offers guidelines on bearing mounting and dismounting, inspection, shaft alignment, and cleanliness, as well as a troubleshooting section.
For More Information Write In No. 724

A 130-page catalog from Maxon Precision Motors Inc., Burlingame, CA, presents a wide range of **miniature motors and motion control products**, DC moving coil and brushless motors, spur and planetary speed reducers and gearheads, analog tachometers, optical encoders, and electronic drives. The catalog provides technical data tables, schematics, and an extensive applications sizing and technical assistance section.
For More Information Write In No. 735



An **instrument motor/generator** catalog from Vernitron Corp., Herndon, VA, features tutorials on its precision subfractional servo, hysteresis/synchronous, and stepper motors. Topics include the effects of fixed and variable winding voltages on control of motor speed and direction, the relationship of pole count to motor rpm, motor construction techniques, and methods of integrating gearheads to increase output torque.
For More Information Write In No. 730

Analog Devices, Norwood, MA, has released its *1993 Short Form Designers Guide*, providing information on **electronic components and subsystems** for use in real-world signal processing. Featured new products include a range of fast DACs, ADCs, and amplifiers designed for display, signal processing, radar, ATE, disk drive, and communications applications.
For More Information Write In No. 734

 For More Information Write In No. 602

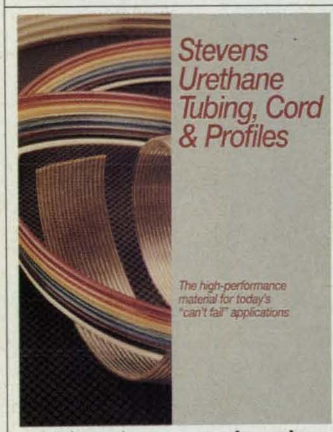
New Literature

A 16-page **capacitor** catalog from Cornell Dubilier Electronics (CDE), New Bedford, MA, showcases high peak current snubbers and resonant power supplies. Tested using a 20-PET power switch that discharged the units in as little as 40 ns, CDE's mica and polypropylene capacitors can take up to 9000 amps of peak current. Capacitances from 100 pF to 1 °F and voltages from 200 to 2000 Vdc are available.

For More Information Write In No. 731

MicroENERGY Corp., Longwood, FL, has published a 32-page reference entitled *Considerations When Specifying Switchmode Power Supplies.* Topics include reliability, agency approvals, EMC, power factor correction, specification writing, strife testing, thermal management, and power density.

For More Information Write In No. 722



A high-performance **polyurethane tubing** brochure has been published by JPS Elastomerics, East Providence, RI. The guide provides technical characteristics, configurations, and sizes for PluroTubing™ and other extruded profiles.

For More Information Write In No. 726

A **VLSI products** selection guide from Qualcomm Inc., San Diego, CA, describes Viterbi decoders, trellis codecs, variable-rate vocoders, direct digital synthesizers, digital-to-analog converters, phase-locked-loop frequency synthesizers, and voltage-controlled oscillators. Applications include communications systems, RF/microwave equipment, and medical instrumentation.

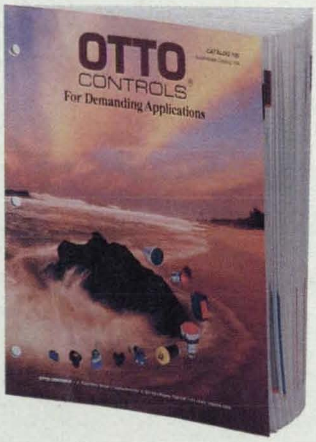
For More Information Write In No. 723

The Technology Transfer Toolkit, a compilation of **technology transfer tools, methods, and techniques**, has been published by the Technology Transfer Society, Indianapolis, IN. Each tool is described in terms of its functionality, utility, and experience, and contacts and/or organizations are identified.

For More Information Write In No. 727

A wide range of pushbutton, toggle, environmentally-sealed, special purpose, and basic **switches** are showcased in a 72-page catalog from OTTO Controls, Carpenterville, IL. It features the new K series of sealed rocker switches. Unique switch mechanisms provide excellent wiping action to keep contacts clean.

For More Information Write In No. 728

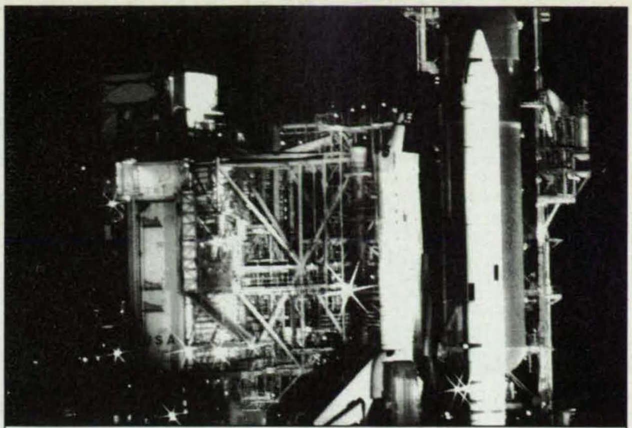


The Motor & Control Division of Pacific Scientific Co., Rockford, IL, is offering a capabilities brochure that highlights its value-added motion management™ approach. Offering flexible **motion control** solutions, the approach includes PacSizit!™ product sizing/selection in Windows and the PacLAN™ local area network to simplify multiaxis control, machine control integration, system integration, and process monitoring.

For More Information Write In No. 732

General Magnaplate, Linden, NJ, has issued an illustrated report showing how its **coatings for metal parts** can solve mold and die application problems. Multi-step surface enhancement treatments become an integral part of a super-hard, nonstick surface that can improve mold release, eliminate corrosion and premature wear, and help keep production lines moving.

For More Information Write In No. 729



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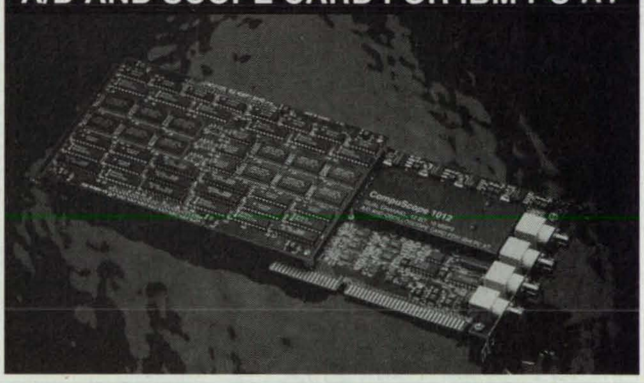

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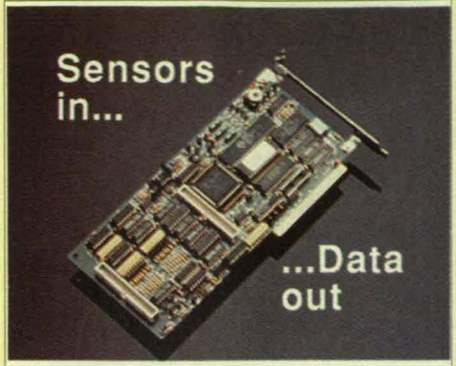

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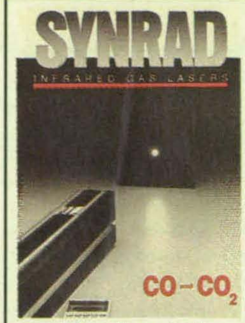

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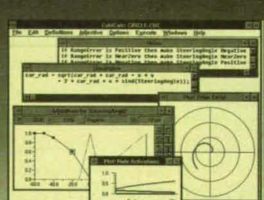

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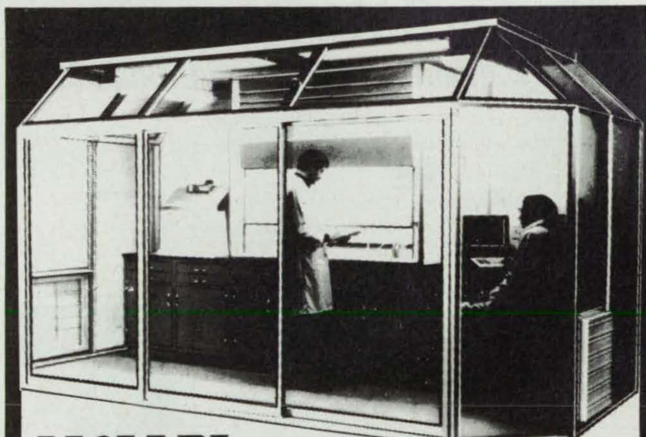

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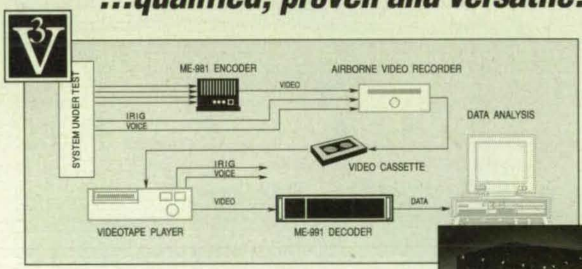

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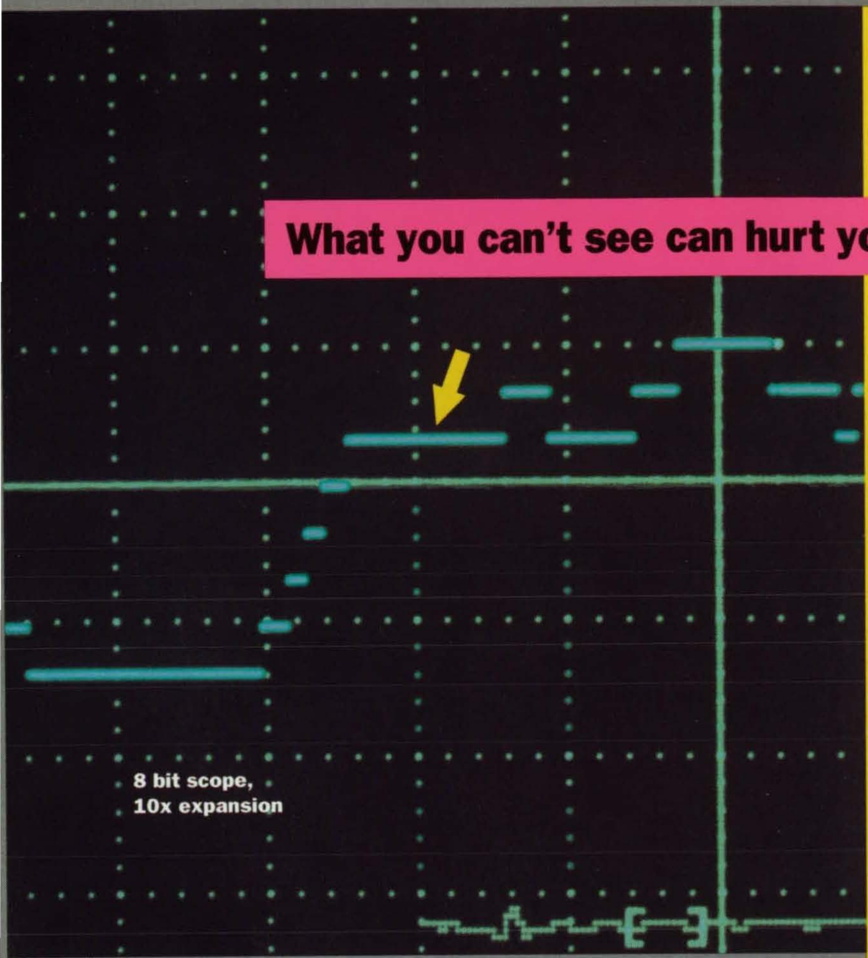

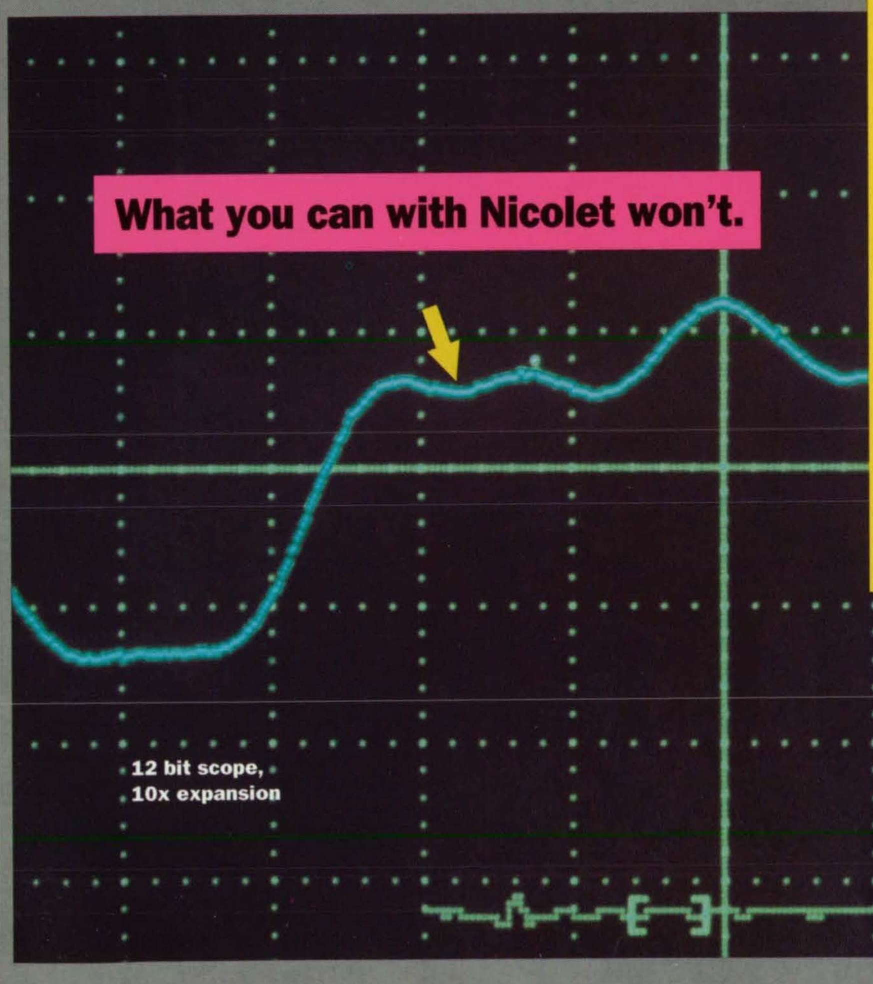

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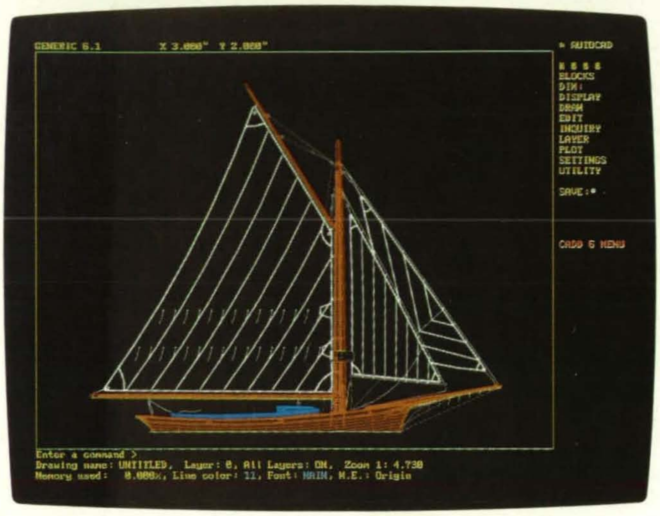

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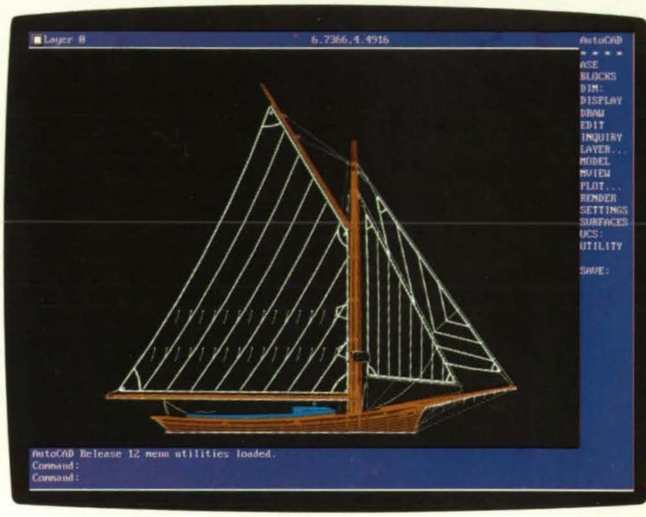

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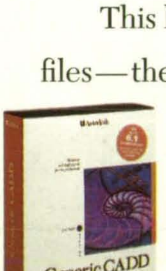

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