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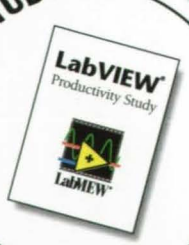

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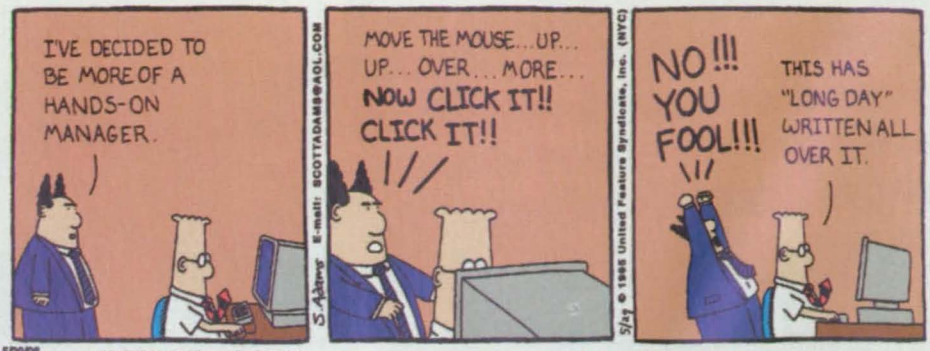

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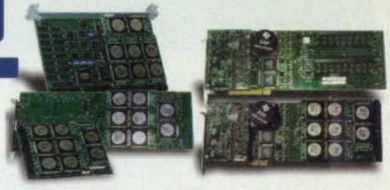

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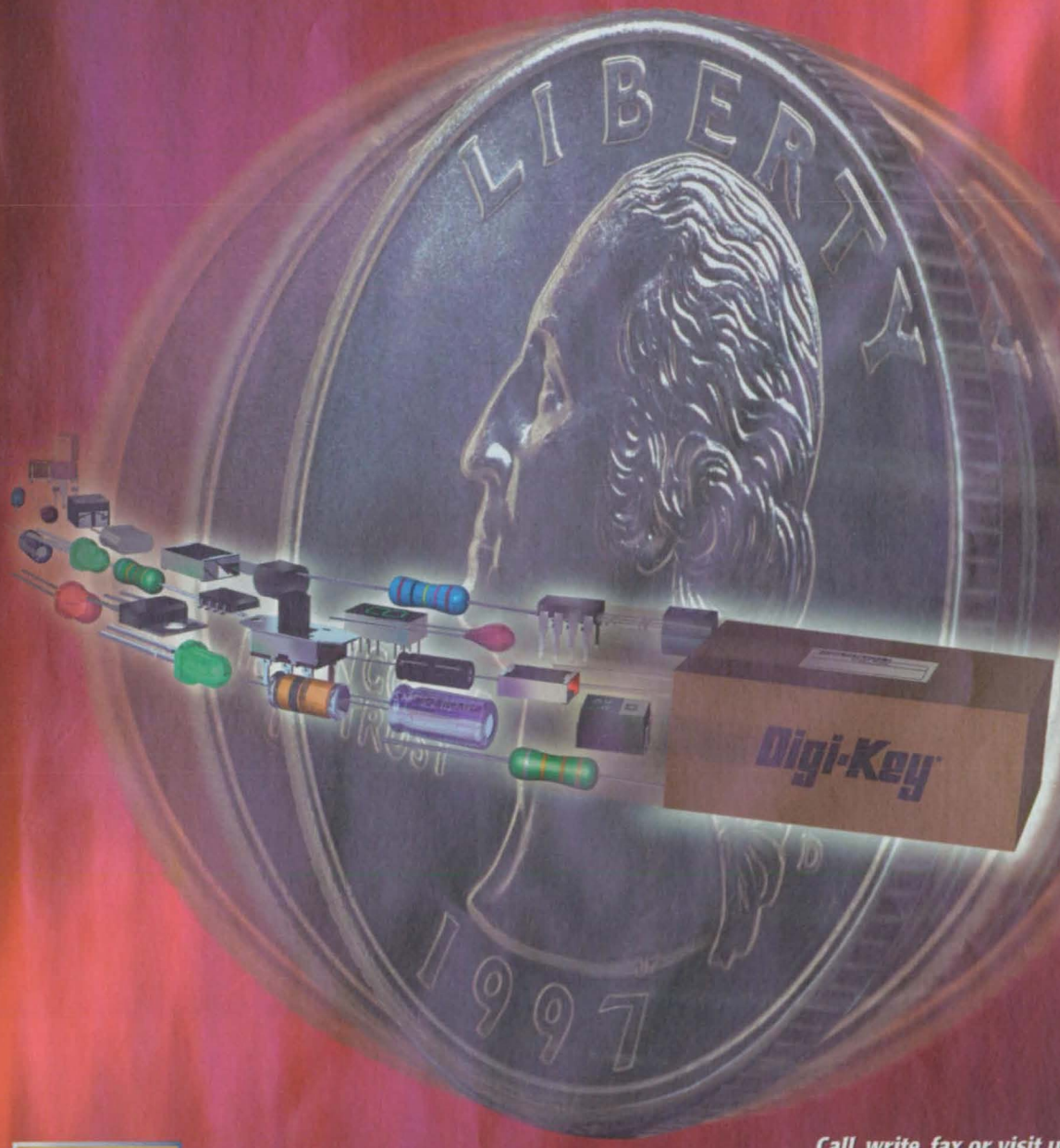

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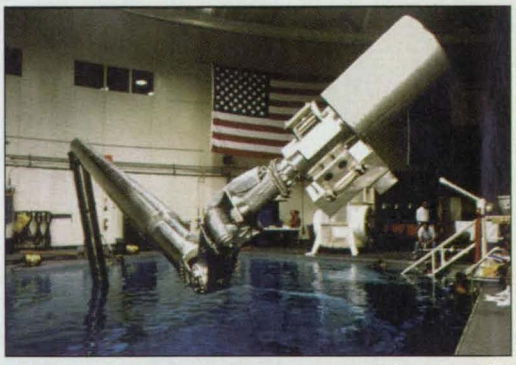

The Weightless Environment Training Facility Remote Manipulator System (WRMS) is a computer-controlled, seven-jointed robot arm that operates underwater in a 25-foot tank at NASA's Johnson Space Center in Houston, TX, to simulate weightlessness for astronaut training. ANSYS software from ANSYS, Inc., Houston, PA, was used to simulate and analyze arm movement during the design process. A new feature this month, Application Briefs highlights this and three other examples of how NASA is using commercial off-the-shelf products. *See page 22.*

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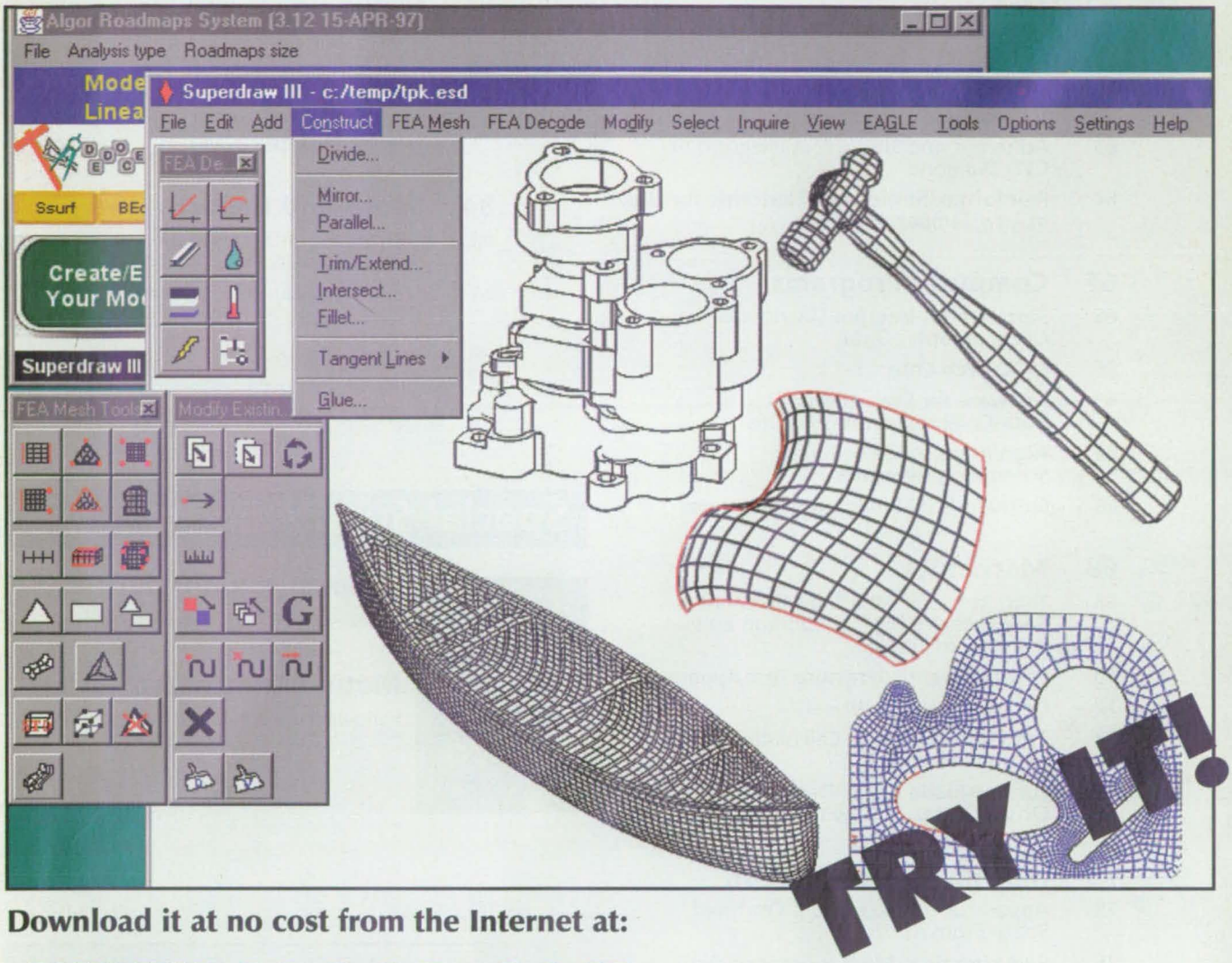

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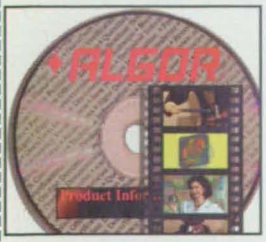

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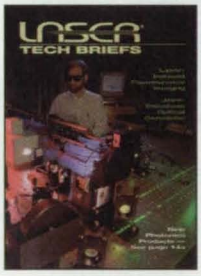

On the cover:

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(Photo courtesy of Kontron Elektronik)

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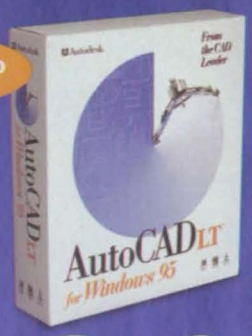

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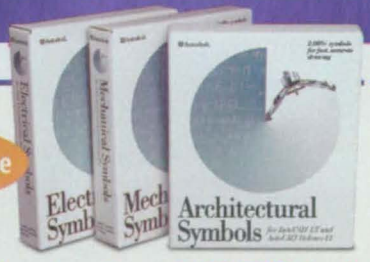

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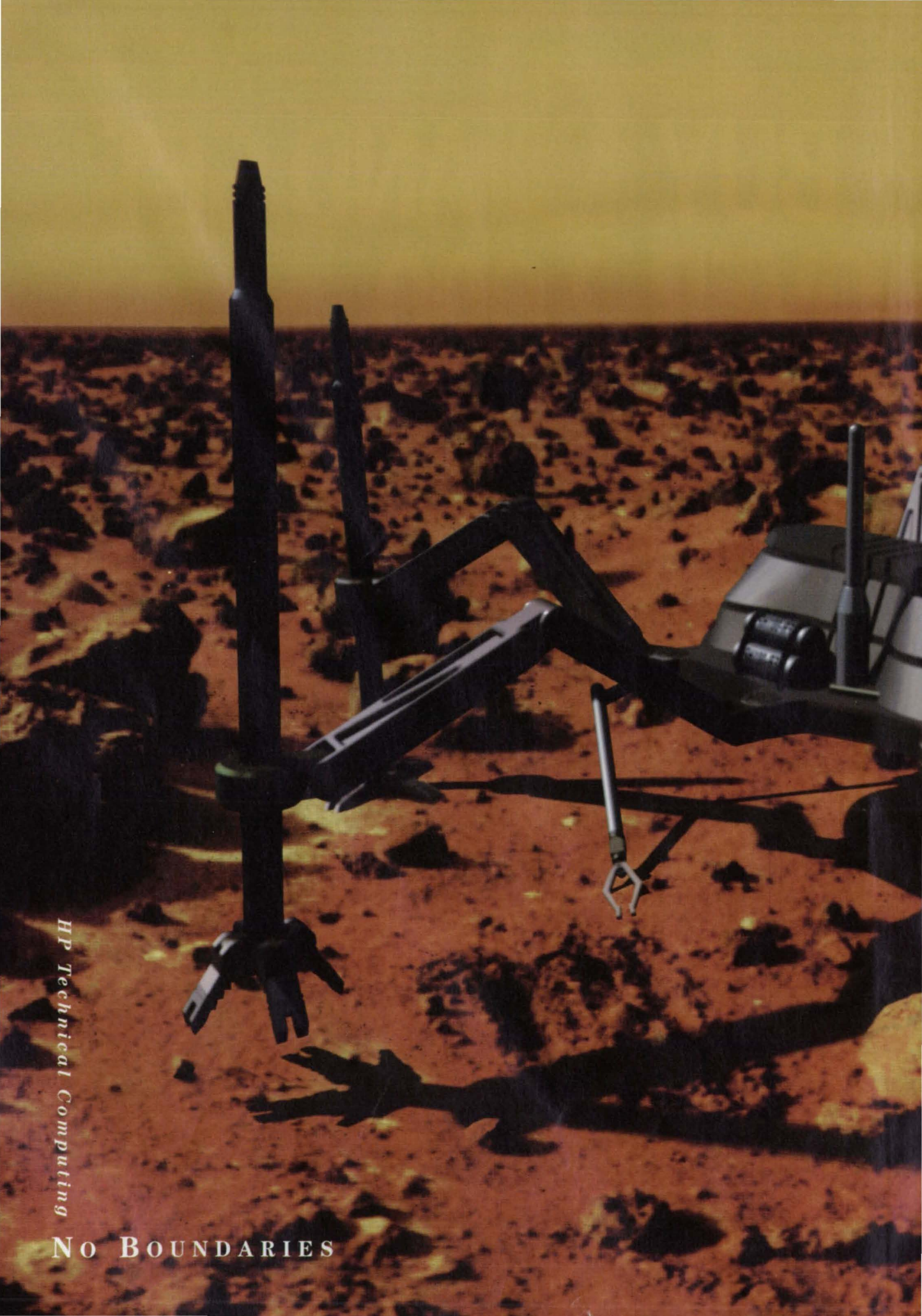
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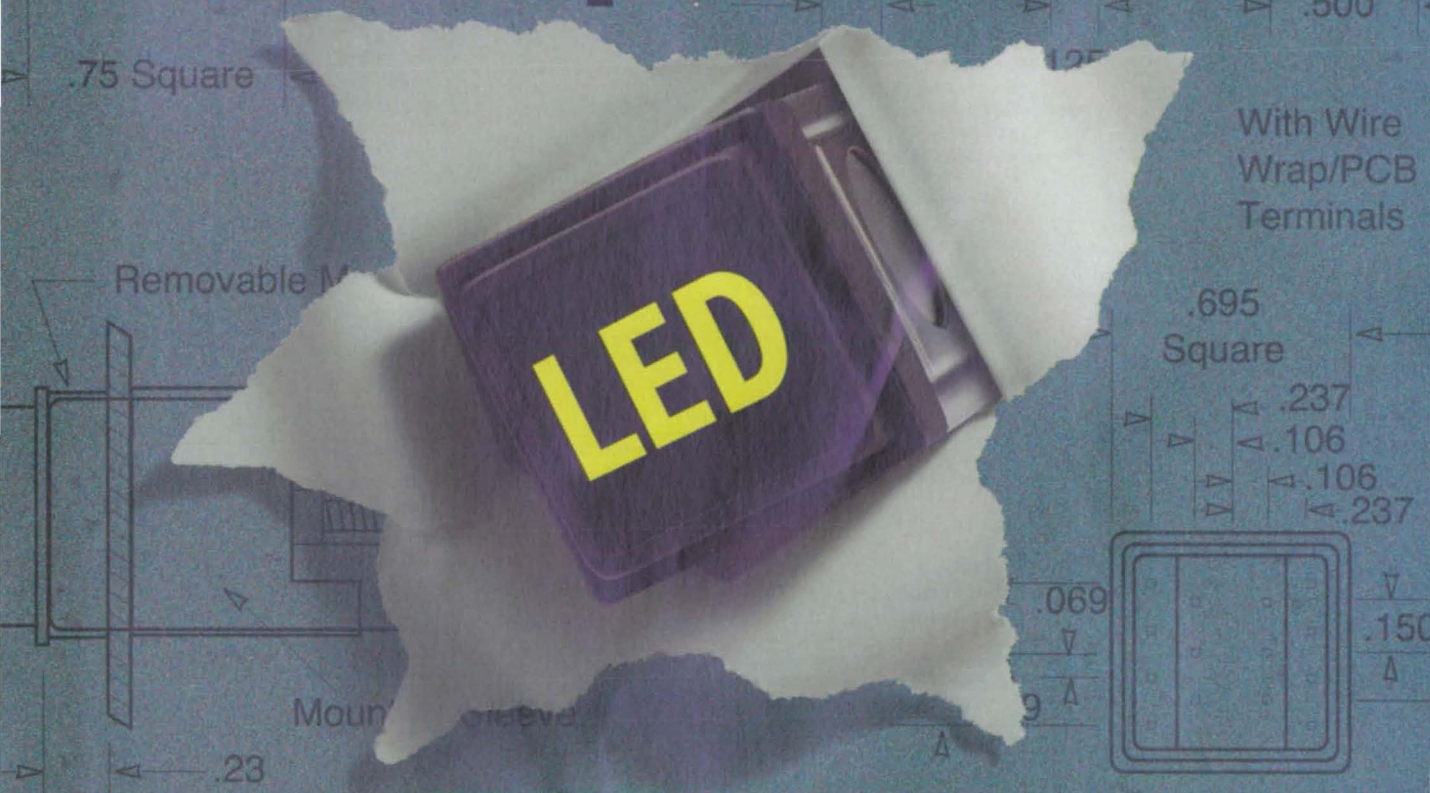

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At NASA Headquarters there are seven major program offices that develop and oversee technology projects of potential interest to industry. The street address for these strategic business units is: NASA Headquarters, 300 E St. SW, Washington, DC 20546.

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

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

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

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

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

Bert Hansen
Office of Microgravity Science Applications (Code U)
(202) 358-1958
bhansen@gm.olmsa.hq.nasa.gov

Granville Paules
Office of Mission to Planet Earth (Code Y)
(202) 358-0706
gpaules@mtpe.hq.nasa.gov

NASA's Business Facilitators

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

Karen Robbins
American Technology Initiative
Menlo Park, CA
(415) 325-5353

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

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

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

If you are interested in information, applications, and services relating to satellite and aerial data for Earth resources, contact: Dr. Stan Morain, **Earth Analysis Center,** (505) 277-3622. For software developed with NASA funding, contact the **Computer Software Management and Information Center (COSMIC)** at phone: (706) 542-3265; Fax: (706) 542-4807; E-mail: http://www.cosmic.uga.edu or service@cosmic.uga.edu.

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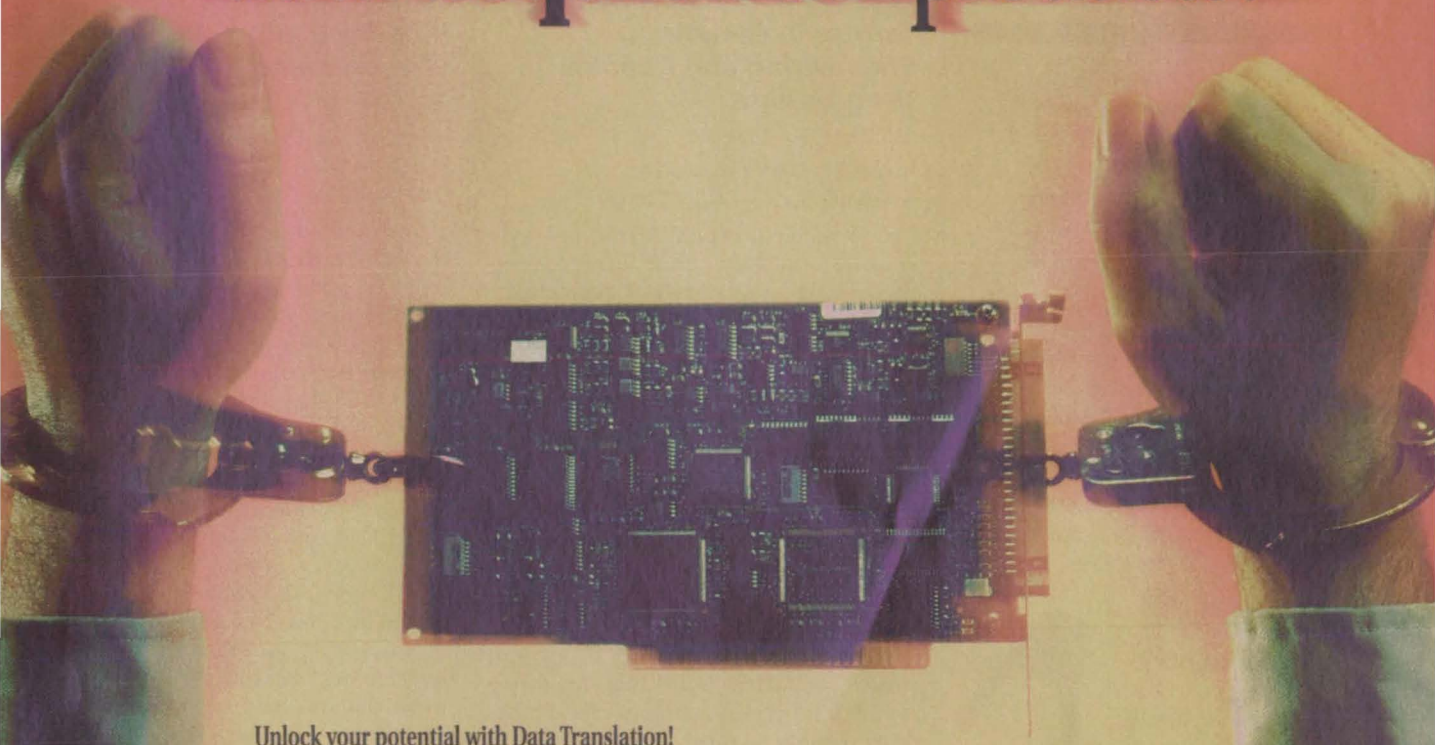

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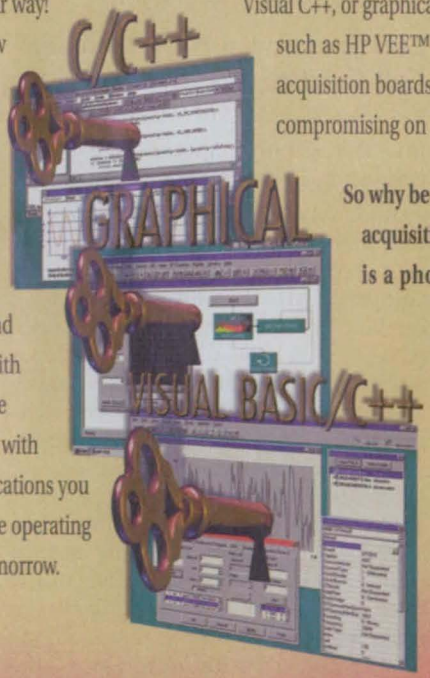

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NASA PATENTS

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

Crystals of Serum Albumin for Use in Genetic Engineering and Rational Drug Design

(U.S. Patent No. 5,585,466)

Inventor: Daniel C. Carter, Marshall Space Flight Center

It is widely accepted in the pharmaceutical industry that distribution, metabolism, and efficacy of many drugs can be altered based on their affinity to serum albumin. The invention is a method of producing high quality crystal forms of serum albumin from human, baboon, and canine serum albumin that are suitable for conducting drug and ligand binding experiments because of their superior x-ray diffraction quality. Monoclinic plate-like crystals of human serum albumin are grown from a precipitant solution of polyethylene glycol or ammonium sulfate, with concentration of reagents and pH carefully controlled within prescribed limits. Of the three methods for growing protein crystals, the hanging-drop method is preferred in this instance.

For More Information Write In No. 770

Constructing a High-Density Cell Culture System

(U.S. Patent No. 5,589,112)

Inventor: Glenn F. Spaulding, Lyndon B. Johnson Space Center

Mammalian cell culture is more complex than bacterial culture because such cells are more delicate and have a more complex nutrient requirement for development. The invention is an annular bioreactor culture vessel with an open end closed by an endcap. It is rotatable around a horizontal axis by roller systems commonly used in culture laboratories. The wall of the endcap has tapered access ports that receive the ends of hypodermic syringes that permit the introduction of fresh nutrients and the withdrawal of spent nutrients. Nuclear or laser bombardment of the polymeric inner and outer walls of the vessel form minute gas-permeable perforations, thus making the walls' surface area available for oxygenation and increasing culture productivity.

For More Information Write In No. 771

Capacitance Probe for Fluid Flow and Volume Measurements

(U.S. Patent No. 5,596,150)

Inventors: G. Dickey Arndt, Thanh X. Nguyen, and James R. Carl, Lyndon B. Johnson Space Center

A reliable and accurate technique is needed for detecting the presence of fluid in a combination of multiple fluids and the flow volume of the material under test within a multiphase flow, one of which may be a gas. This apparatus uses an electromagnetic flow monitor with a first probe having two parallel elongate electrodes, the spacing between them functionally related to the droplet size of the fluid to be monitored. A cable applies a reference signal to the probe and conducts a reflection signal to detection circuitry. The percentage of a fluid present in a flow stream can be identified by measuring permittivity variations between the electrodes. A conductivity probe can also be provided to measure flow volume of the material. In a specific embodiment, a volume of urine entrained in an air stream is measured.

For More Information Write In No. 773

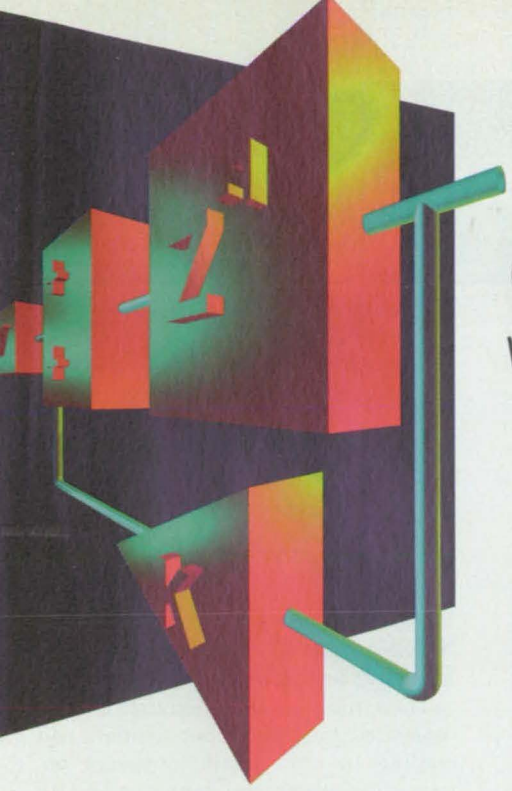
On-Line Method and Apparatus for Coordinated Mobility and Manipulation of Mobile Robots

(U.S. Patent No. 5,550,953)

Inventor: Homayoun Seraji, Jet Propulsion Laboratory

The invention proposes a method and apparatus to control mobile robots that consist of a manipulator arm mounted on a mobile base. It departs from previous approaches by adding the base's degrees-of-mobility to the arm's degrees-of-manipulation, and using the overall degrees-of-freedom to accomplish a set of user-defined tasks in addition to end-effector motion. A simple on-line control scheme allows the user to assign weighting factors to individual degrees-of-mobility and degrees-of-manipulation, as well as to each task specification. The computational efficiency of the control algorithm makes it particularly suitable for real-time implementation.

For More Information Write In No. 774



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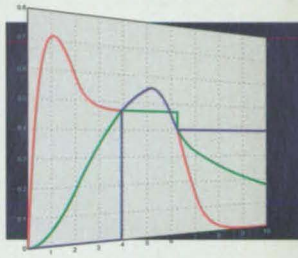

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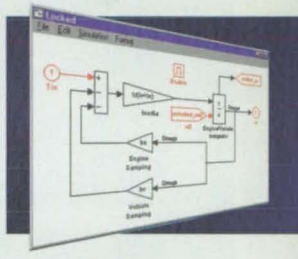

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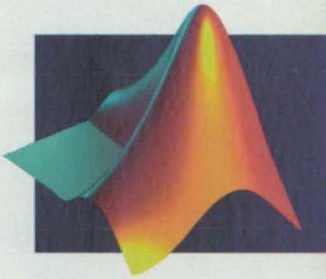

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Commercialization Opportunities

Millennium Modem/Channelizer Special Test Equipment

This test equipment is a fully programmable assembly of bit-error rate electronic test equipment for broadband characterization of modems and multichannel demultiplexer/demodulator systems. The test set is available for use in industry.
(See page 28.)

Ag/Zn Contacts on Shallow-Junction p-Doped InP Devices

These contacts demonstrate unprecedentedly low electrical resistivities. A sintering step in the fabrication process prevents degradation or destruction of the underlying devices.
(See page 45.)

Concept for a Wide-Area Differential GPS Navigation System

A proposed system would incorporate a number of recent and anticipated advances to achieve decimeter real-time positioning accuracy. The system is intended for civil aviation.
(See page 48.)

Window Units for Solar-Assisted Heating and Cooling

These units are designed to minimize undesired heating in hot weather and cooling in cold weather. Spaces between the inner and outer panes are connected to inside or outside circulation paths, depending on the outside temperature.
(See page 54.)

Adherent and Stable Metallization of CVD Diamond

Amorphous Ti+Si+N layers permit good metal contacts on chemical vapor-deposited carbon. This finding is important in fabrication of some electronic devices, particularly those intended for high-temperature applications.
(See page 63.)

Low-Differential-Pressure Test Apparatus

This apparatus can be used to test a variety of low-differential pressure transducers in the laboratory and in the field. Originally, it was designed to test cleanroom-air-conditioner differential-pressure transducers.
(See page 70.)

Apparatus for Access to a Confined Space From Above

A proposed apparatus called an "access kit" would enable technicians and equipment to enter and leave a confined space through a relatively narrow opening in the ceiling. Large confined spaces such as chemical tanks, vats, and silos could be easily accessed from above.
(See page 75.)

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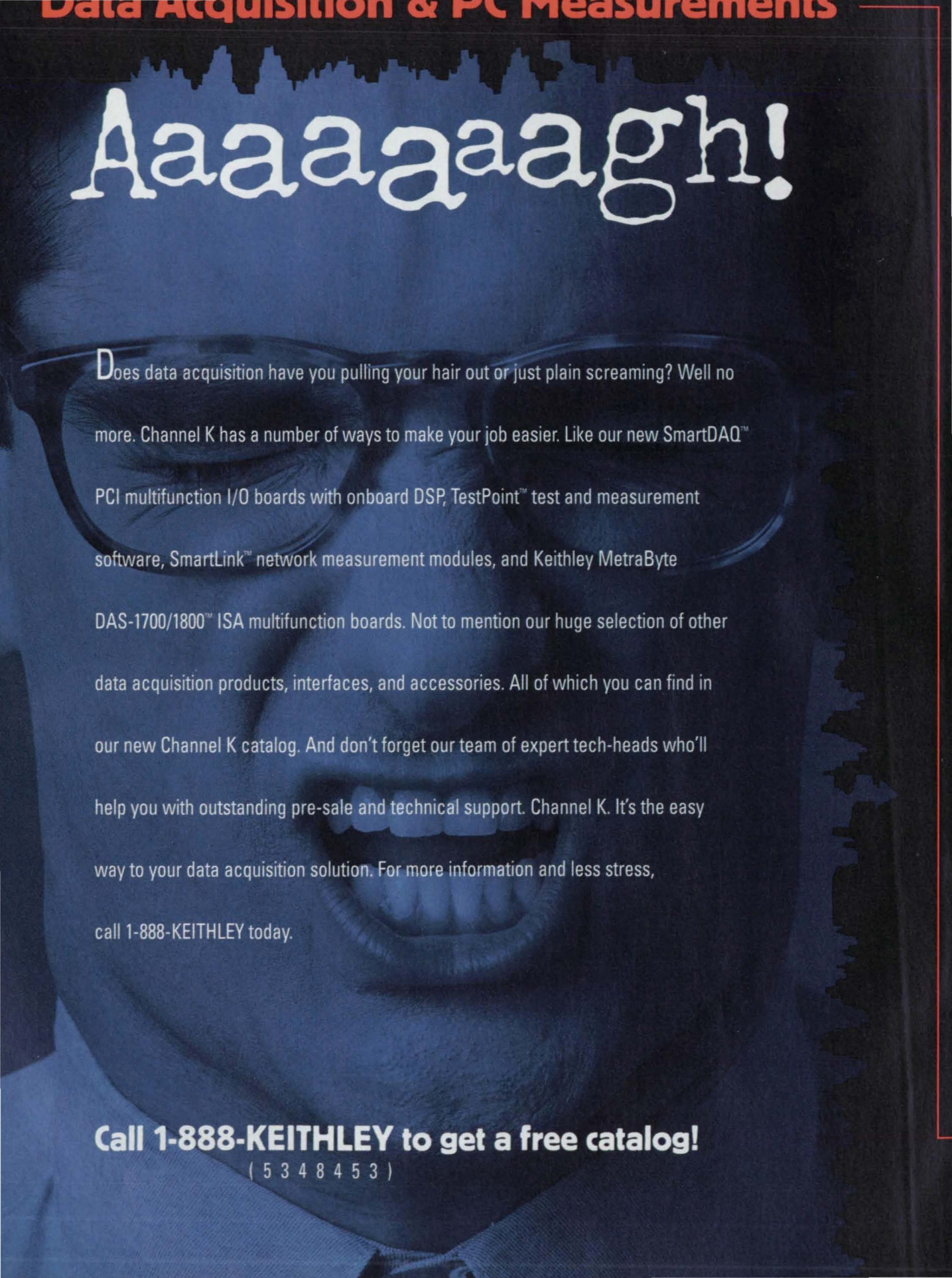

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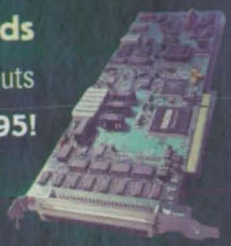

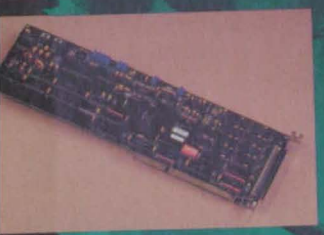

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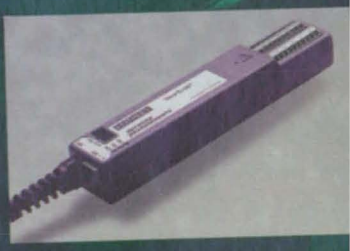

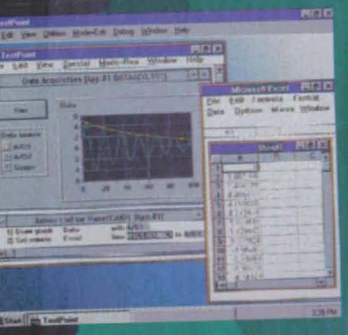

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Design Team Collaborates Via the Internet

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The X-33 will launch vertically like a rocket and land horizontally like a plane.

Coast-to-coast, engineers developing the X-33 spacecraft prototype are working as a team, as if they were all in the same location. Over the next three years, they will prepare the vehicle for the first of 15 test flights to take place between March and December 1999. The X-33, which has been dubbed VentureStar, will launch vertically like a rocket and land horizontally like a plane.

The X-33 designers are working concurrently with access to the same information in real time via encrypted data accessed from the Internet. They are using as their primary design tool CATIA™ solid modeling software, which provides a common and consistent database of design information.

Engineers at the X-33's main assembly location, Lockheed Martin's Skunk Works in Palmdale, CA, are coordinating the effort, working with design engineers in companies developing X-33 parts in Colorado, New Orleans, New Jersey, and California. In addition, Skunk Works is supplying data continuously to NASA centers in Virginia, Alabama, Texas, and California.

They are using CATIA to generate 3D concepts and update them to the point that the designs can be analyzed for their aerodynamic and structural features. When an individual part is ready, it is sent to Skunk Works for integration into the prototype.

Many of the parts will be produced without any hands-on production; they will go directly from 3D modeling to numerically controlled machines for manufacture. "CATIA provides us with more complete data early and makes it possible to see the total picture of a particular design earlier in the development process," said design engineer Mark Wexler, senior specialist at Skunk Works. "It provides visualization for groups outside the actual design process, which is a significant advantage since they could know something we aren't aware of and thereby help us to keep moving in the right direction."

Software Tools Guide NASA's Automated Spacecraft

MULTI software development environment
Green Hills Software
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NASA's New Millennium Program (NMP) is an initiative intended to increase the frequency and effectiveness of near-Earth and deep-space missions. To do so, the NMP will utilize a fleet of smaller, simpler, less expensive craft that work in concert to solve complex problems. The craft will be endowed with advanced planning and decision-making capabilities that enable them to solve complex navigation, data collection, and other mission problems autonomously with minimal input from ground control.

NASA's Jet Propulsion Laboratory and Ames Research Center are developing and validating technologies needed for autonomous operation and multi-craft coordination. The first validation flight is scheduled for July 1998, beginning with Deep Space 1, which will be the first planetary spacecraft flown with completely automated navigation, guidance, and control systems. The first missions will be flybys of small celestial bodies such as comets and asteroids.

NASA's Deep Space 1 craft will be controlled autonomously.

JPL selected MULTI software development tools, optimizing compilers, and C and C++ compilers to develop software that implements the bulk of Deep Space 1's mission planning, flight system control, navigation, and attitude control functions. A VMEbus system will provide all of the navigation, guidance, control, propulsion, instrumentation, and telemetry electronics for Deep Space 1. A radiation-hardened PowerPC-based CPU board running the VxWorks real-time operating system will serve as the main controller. It executes a LISP program that handles fault recovery, a C++ program that provides mission planning, and a C program that handles flight systems control, attitude control, and navigation.

Deep Space 1 will be used to validate several NMP technologies, including an autonomy remote agent that provides overall mission planning and control for the craft; autonomous cruise optical navigation and control; beacon mode operations that simplify ground control and reduce telemetry costs; and an advanced celestial sensor.

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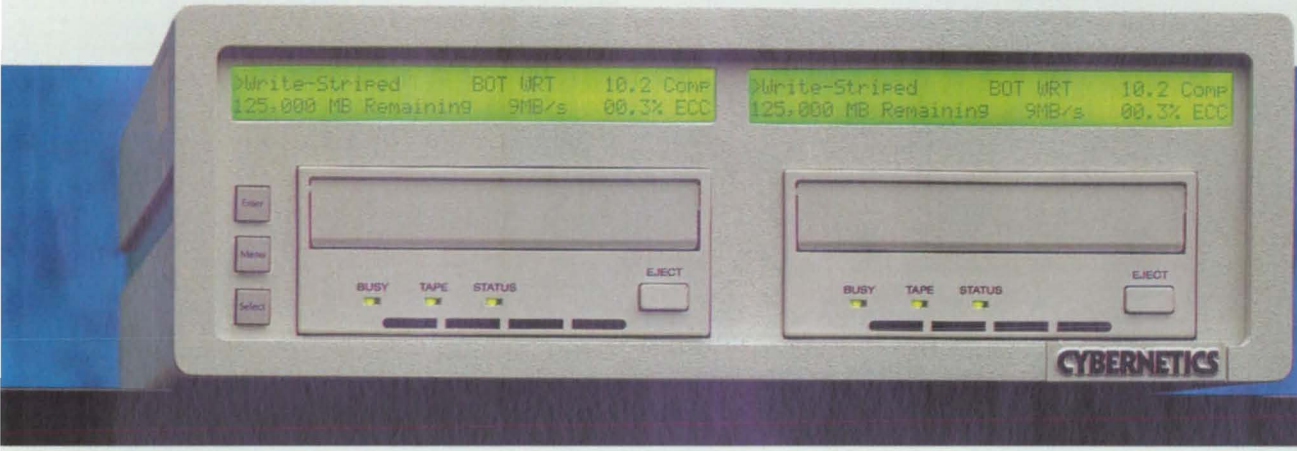

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In addition to superior design, the CY-8000 offers unbeatable performance. Able to store ***25 GB at 3 MBS***, uncompressed, you can achieve up to ***125 GB at 9 MBS*** with optional data compression. With 257% more capacity and 500% greater speed* than industry standard 8mm drives, the CY-8000 can backup faster to fewer tapes.


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Automate access to up to six drives and 126 tapes with our intelligent tape library.

Available in a single or multi-drive desktop, rack mount, or library configuration, the CY-8000 is scalable to ***15.75 terabytes***. If you need to ensure the safety of your company's critical data, don't trust anything less.

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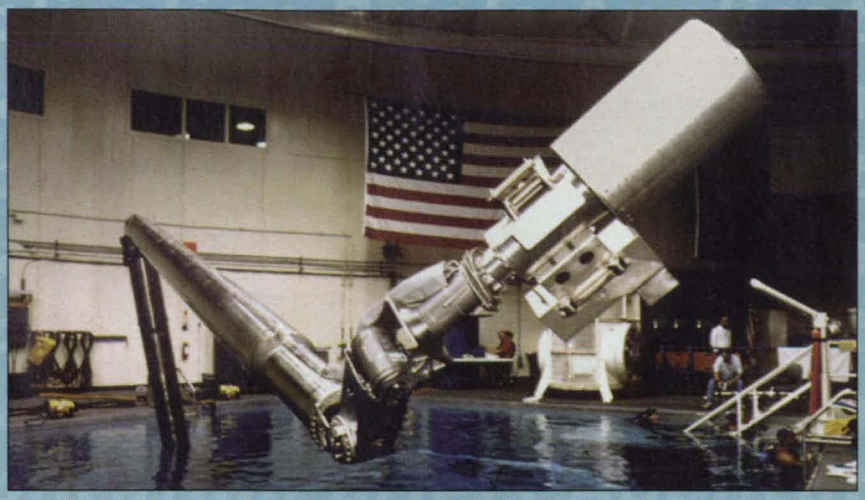

The WRMS wrist and end effector are shown out of the water in the 25-foot tank at Johnson Space Center's Weightless Environment Training Facility.

Streamlining Design of an Astronaut Training Device

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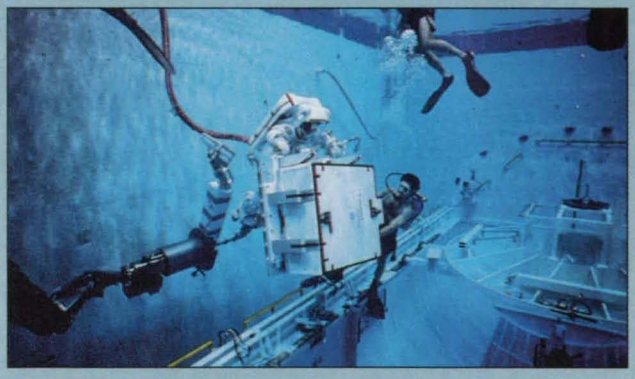
The Weightless Environment Training Facility Remote Manipulator System (WRMS) is a computer-controlled, seven-jointed robot arm that is 50 feet long and built almost entirely of titanium. It operates underwater in a 25-foot tank at NASA's Johnson Space Center's Weightless Environment Training Facility, which is used to simulate weightlessness for astronaut training. Johnson Engineering Corp. of Webster, TX worked with engineers at Engineering Cybernetics of San Antonio to redesign the arm, which weighs 300 pounds less than its predecessor, but can lift 200 pounds compared to the 50-pound limit of the original arm.

The design of the WRMS is completely different than that of the shuttle arm, since the shuttle arm operates in zero gravity, not on Earth. The challenge was to simulate the operation of the shuttle arm during flight. "The WRMS has the same volume and controls as the real thing, but it is run with hydraulic instead of electric power," said David McMahon, a Johnson Engineering project engineer at Johnson Space Center.

To evaluate lifting capacity, torque calculations were necessary at thousands of different positions of the wrist, elbow, and shoulder joints. Further, at certain positions, some portions of the arm rise above the water's surface. A variety of simulation methods, including non-linear buckling and contact analyses, were performed with the ANSYS design analysis and optimization software. An in-house proprietary loads analysis routine was combined with the ANSYS capabilities to design the new arm.

For the robot arm optimization, ANSYS was not performing a finite-element analysis with each design iteration. It used the results from the Johnson Engineering loads program as though they were analysis results. "Our program gave ANSYS the forces and torques, and it used that information to determine the maximums at each joint," said McMahon. ANSYS also was used to perform a non-linear buckling analysis of the arm's two booms.

All analyses were performed while the robot arm design was in progress. Several parts of the arm underwent major changes when analysis showed the original design would not meet stress and deflection requirements.



Using the WRMS, an astronaut is trained to handle a shuttle payload in a weightless environment.

NASA Tracks Satellites With Commercial Software

Epoch 2000 software
Integral Systems Inc.
Lanham, MD
301-731-4233; fax: 301-731-9606
http://www.integ.com/

The number of personnel necessary to track NASA's low-earth-orbit (LEO) satellites is being reduced, and the capabilities of ground systems are being boosted with the aid of Epoch 2000 software. Several satellite command and control functions, including launch control and monitoring, and in-orbit operations support are provided by the UNIX-based software, which is being integrated by engineers from AlliedSignal of Columbia, MD into a ground system called Low Earth Orbit Terminal (LEO-T). LEO-T will be installed at NASA facilities at Wallops Island, VA and Fairbanks, AK this year.

The software will generate its own schedule for monitoring LEO satellites and automate other satellite monitoring functions that formerly required the expertise of a NASA specialist. "The big improvement in the system is the automation," said Steve Bundick, a NASA engineer with Goddard Space Flight Center's Wallops Flight Facility. "Our statement of work required the system to operate unmanned." Bundick said NASA chose the off-the-shelf software to "keep costs down and give better reliability."

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Apparatus Measures Directional Reflectance Properties

Advantages include precision and automation.

NASA's Jet Propulsion Laboratory, Pasadena, California

A computer-controlled, semiautomated apparatus measures the bidirectional reflectance distribution functions (BRDFs) of panel specimens of materials at three wavelengths. Other visible and near-infrared wavelengths can be conveniently added. Designed originally for characterizing nearly Lambertian panels that will serve as internal diffuse-reflection calibration standards for a spaceborne imaging radiometer, the apparatus can also be used to characterize other diffusely reflective panels. In comparison with other apparatuses that also measure BRDFs, this apparatus offers advantages of a four-axis angular-positioning capability that facilitates characterization of anisotropic specimens, greater measurement precision, and computer control of the acquisition and processing of data.

The apparatus (see figure) includes a helium/cadmium laser with a wavelength of 442 nm, a helium/neon laser with a wavelength of 632.8 nm, and a gallium aluminum arsenide semiconductor diode laser with a wavelength of 859.9 nm. The laser output is directed sequentially through a beam-expanding telescope to produce a magnified collimated beam. This beam is then reflected through a linear polarizer, which separates the beam into a reference beam and a signal beam that are decoupled from each other. The reference beam goes directly to a silicon photodetector (the reference photodetector), which thus provides a measure of the intensity of the signal beam. The signal beam strikes the panel specimen, and the portion of light reflected from the specimen in a given direction is measured by another photodetector (the reflected-radiance detector) that is positioned and oriented to receive light in that direction. By using the ratio between the output of the reflected-radiance detector and the reference detector as the raw reflectance signal, this apparatus inherently minimizes the effects of any amplitude instability in the selected laser.

The panel specimen is centered on the optical axis of the signal beam, and the reflected-radiance photodetector is mounted on a 30-cm-long boom that extends radially outward from the center of the panel. The panel specimen and the boom are mounted on a four-axis goniometer that includes rotary stages driven by high-torque dc motors and monitored by shaft-angle encoders. Under computer control, the rotary stages can reproducibly orient the specimen panel and the reflected-radiance photodetector at various angles to obtain BRDFs over wide ranges of angles. The level of repeatability and resolution of angular positioning is 0.01°. The overall precision with which the apparatus can determine the BRF of a specimen is represented by a standard deviation of a factor of 0.002.

This work was done by Brendan T. McGuckin, David A. Haner, Robert T. Menzies, Carlos Esproles, and Alan M. Brothers of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 11*** *on the TSP Request Card.*
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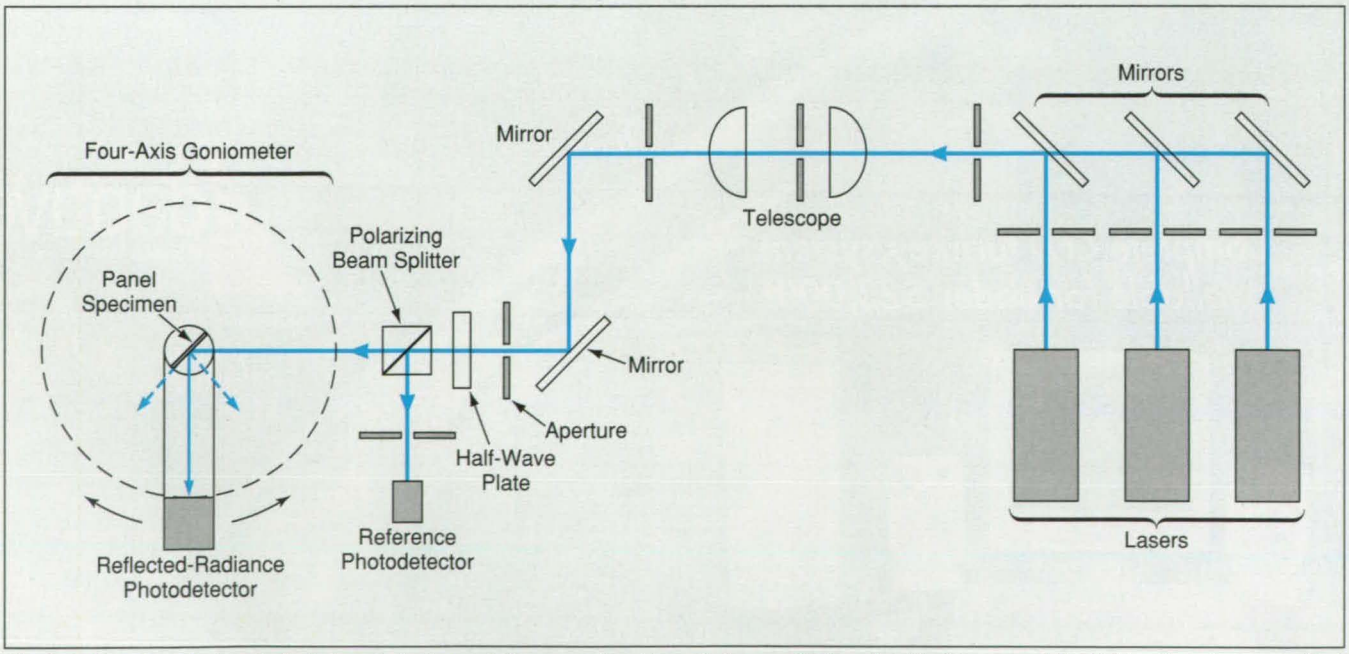

The **Panel Specimen Is Illuminated** at a selected one of three wavelengths and at a specified angle of incidence, and the light reflected at a specified other angle is measured. All angular settings, acquisition and processing of photodetector readings, and other functions are performed under computer control.

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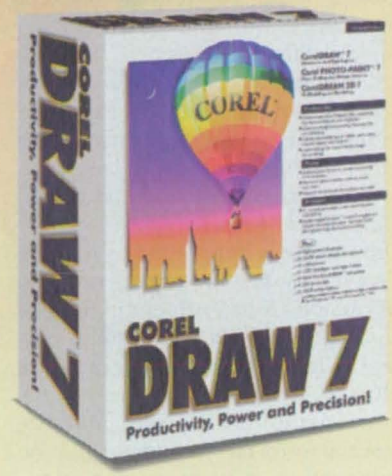

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Millennium Modem/Channelizer Special Test Equipment

The equipment can be modified for testing different modems and multichannel demultiplexer/demodulator systems.

Lewis Research Center, Cleveland, Ohio

The Millennium modem/channelizer special test equipment ("test set" for short) is a fully programmable assembly of bit-error-rate electronic test equipment for broadband characterization of modems and of a multichannel demultiplexer/demodulator. The test set in its baseline configuration was designed for testing a specific wideband modem and channelizer that is capable of demultiplexing fifteen 80-MHz-wide channels stacked across the frequency band from 1.20 to 2.48 GHz. The test set is also designed to be readily modifiable for testing other modems and multichannel demultiplexer/demodulator systems. Developed for the Advanced Research Projects Agency, in a teaming effort with Honeywell, TRW, Raytheon, E-Systems, and Wright Patterson AFB, the test set is also available for use in industry.

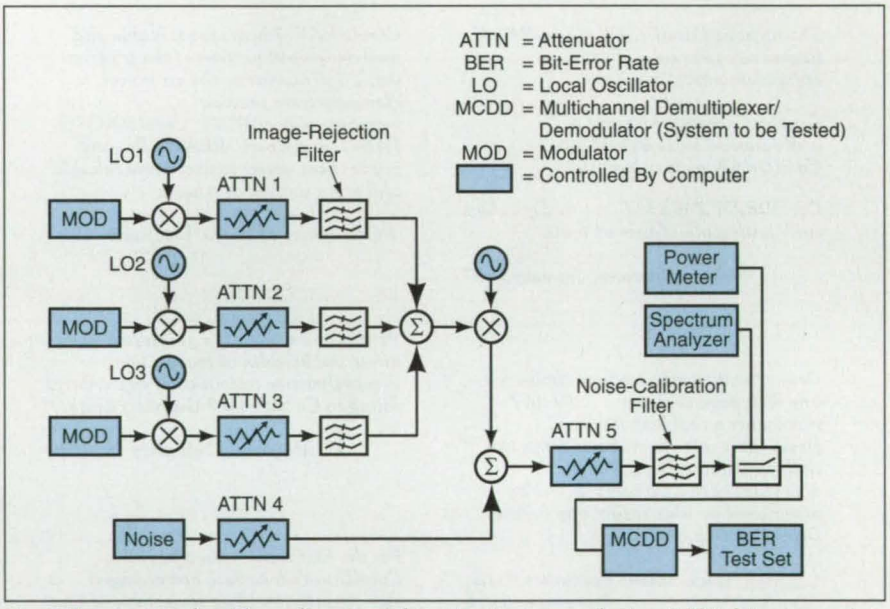
The test set (see figure) contains three Broadband Integrated Services Digital Network (B-ISDN) modulators that generate octonary-phase-shift-keyed (8-PSK) data signals like those encountered in operation. These signals are mixed with local-oscillator signals for up-conversion and stacking in frequency in three adjacent channels in the set of communication channels to be passed through the multichannel demultiplexer/demodulator system to be tested. An attenuator is used to adjust the power of the signal in each channel. The test set then measures the bit-error rates of the signals put out by the modem, providing a characterization of both the demultiplexing and demodulation functions of the system.

In addition to the requirement of reconfigurability for testing different systems, two important requirements in developing the test set were to keep the cost down and to complete the test set in a timely fashion. These requirements were satisfied by using, as much as possible, a combination of purchased off-the-shelf equipment and equipment already in NASA's possession.

The test set is automated to provide the capability for expedient, reliable, reproducible tests. All equipment is computer-controlled via a general-purpose interface bus (GPIB), a Versa Module Europa Bus Extensions for Instrumentation (VXI) bus, and RS-232 serial interfaces. Signals can be coupled off to a power meter and a spectrum analyzer for continuous monitoring, without need to remove connections during calibration or debugging. All clock and local-oscillator signals are supplied by digitally synthesized signal generators. Attenuation and switching functions are provided via VXI circuit cards.

This work was done by William D. Ivancic of **Lewis Research 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 NASA Lewis Research Center, Commercial Technology Office, Attn: Tech Brief Patent Status, Mail Stop 7–3, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16428.



The **Millennium Modem/Channelizer Special Test Equipment** synthesizes 8-PSK data-communication signals for processing via the system under test, then measures the bit-error rates of the processed signals.

Portable FTIR Scatterometer Measures Surface Contaminants

Nondestructive measurements can be performed in the field.

Marshall Space Flight Center, Alabama

A rugged, portable Fourier-transform infrared (FTIR) scatterometer has been developed for use in rapidly and nondestructively identifying and measuring quantities of greasy and oily contaminants on solid surfaces. This instrument is meant to be used in conjunction with other contamination-measuring instruments to ensure that inspected surfaces are clean enough for subsequent coating and/or adhesive-bonding treatments.

Typical contaminants include fluorocarbons, silicones, hydrocarbons, and other organic compounds. Commercial laboratory FTIR spectrometers can be used to identify and measure such contaminants, but are too large and delicate to be carried into the field to inspect surfaces at all orientations in situ; thus, it is necessary to engage in destructive inspection procedures wherein one cuts small coupons out of inspected sur-

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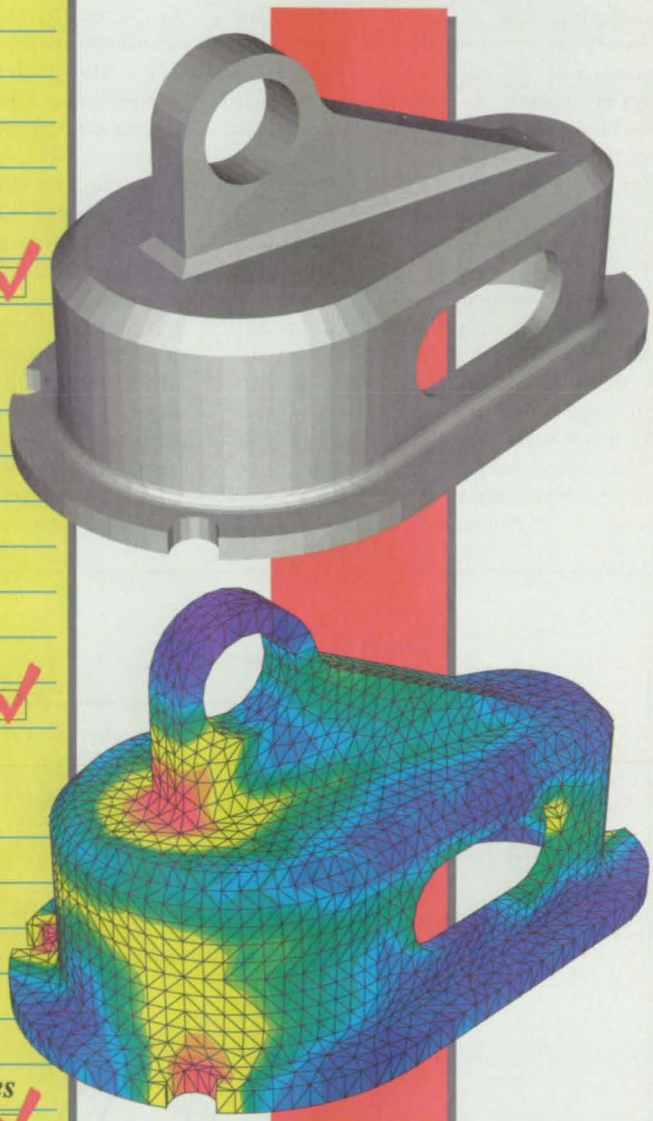

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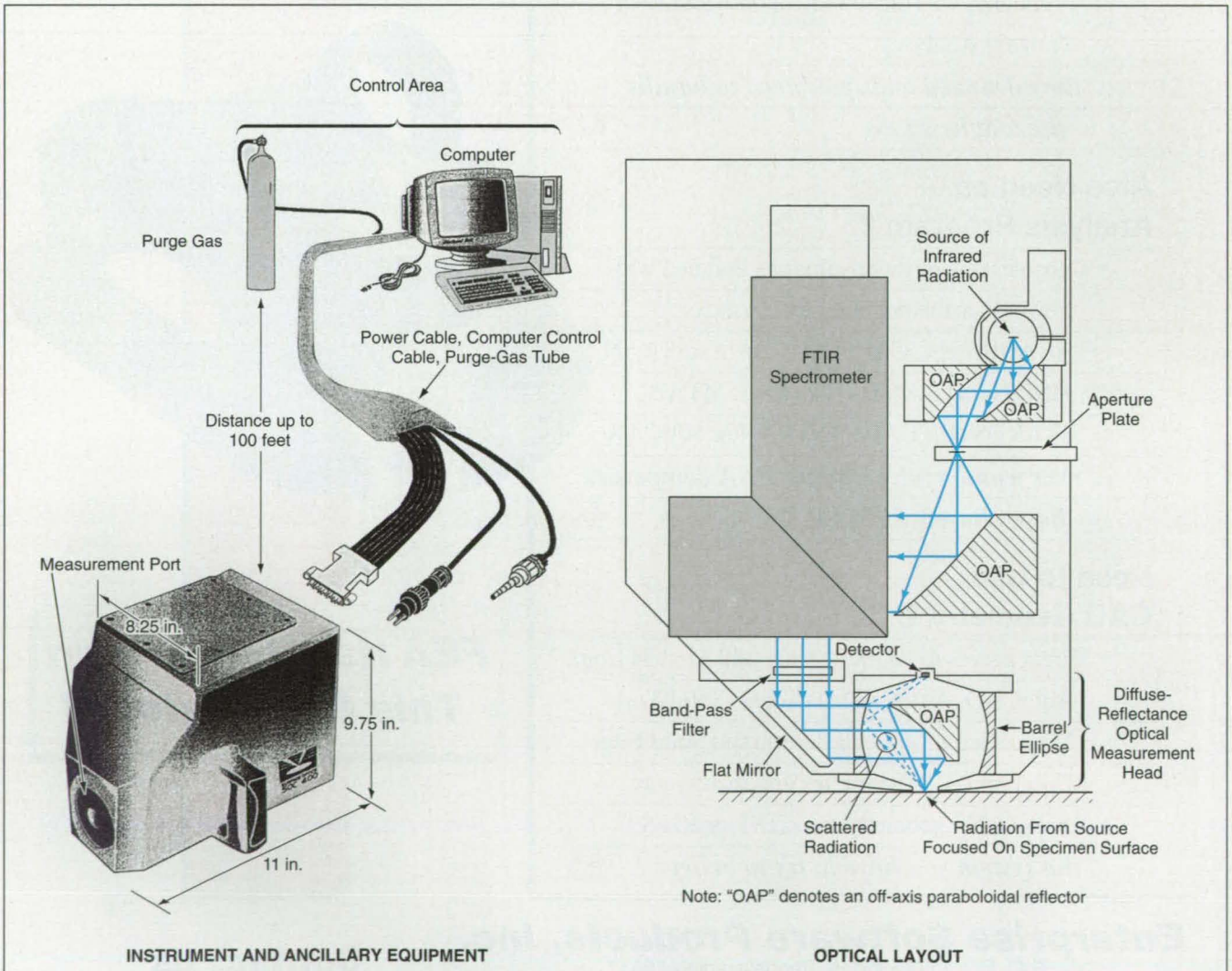
FTIR spectroscopy is a powerful tool for chemical analysis and is a mature discipline that has made excellent use of recent progress in computer hardware and software. In a typical FTIR spectrometer, a collimated beam of infrared light in the wavelength range of 2 to 25 μm (the predominant wavelength range of black-body radiation at a temperature of about 1,600 K) is modulated by a Michelson interferometer, focused onto or through a specimen, and refocused onto a detector. The detector outputs are digitized and the resulting data are Fast-Fourier-transformed into a spectrum of beam intensity, in arbitrary units, as a function of wavelength or wave number (reciprocal of wavelength). The spectrum gives data on the identities and amounts of chemical functional groups.

In a given application, FTIR spectroscopy involves measurement of either transmittance, diffuse reflectance, or specular reflectance. Each of the three types of measurement is advantageous for some kinds of specimens. The present instrument utilizes diffuse reflectance, which is preferable for measurements on rough and/or curved surfaces; e.g., flat or curved surfaces that have been sandblasted.

The present instrument (see figure) is an automated, computer- controlled, high-performance FTIR spectrometer with an integral measurement head that includes a diffuse-reflectance optical measurement head, all in a compact, lightweight package that features rugged construction for use in the field. The FTIR spectrometer is a commercially available unit adapted to fit into the package. The diffuse-reflectance optical measurement head is a half-scale version of a commercial unit that contains ellipsoidal ("barrel ellipse") and off-axis paraboloidal reflectors; the barrel-ellipse design provides for collection of scattered radiation and excludes specularly reflected radiation. The instrument weighs less than 13 lb (6 kg). The computer can be programmed to provide spectral matched filtering, enabling automated identification of spectral features.

This work was done by Bill H. Nerren of **Marshall Space Flight Center**, *G. Louis Powell of Martin Marietta Energy Systems, Inc., and John T. Neu and R. Samuel Dummer of Surface Optics Corp. For further information,* ***write in 22*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center; (205) 544-0021. Refer to MFS-26421.



The **Portable FTIR Scatterometer** includes a scaled-down version of a commercial diffuse-reflectance optical measurement head combined with a commercial FTIR spectrometer in a compact, lightweight package. The instrument operates under computer control, is nondestructive, and can be used in any orientation.

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Full-Flow-Field-Tracking Particle-Image Velocimetry

Velocities and accelerations can be determined over entire flow fields.

Lewis Research Center, Cleveland, Ohio

Full-flow-field-tracking (FFFT) particle-image velocimetry (PIV) is a technique for obtaining quantitative and qualitative data on flows from sequences of images of small seed particles entrained in the flows. FFFT PIV is closely related to other velocimetric methods, described in several previous articles in *NASA Tech Briefs*, that are also denoted by "PIV" and by similar names like "particle-tracking velocimetry" (PTV) and "particle-displacement tracking" (PDT).

The figure schematically illustrates a flow experiment conducted with a FFFT PIV apparatus, which is similar to the apparatuses used in the other techniques mentioned above. Illumination is supplied by a continuous-wave argon-ion laser with a power of 8 W. An assembly of cylindrical lenses forms the laser beam into a sheet of light to illuminate a plane of interest in the test section of a wind tunnel, water tunnel, oil tunnel, or other flow apparatus.

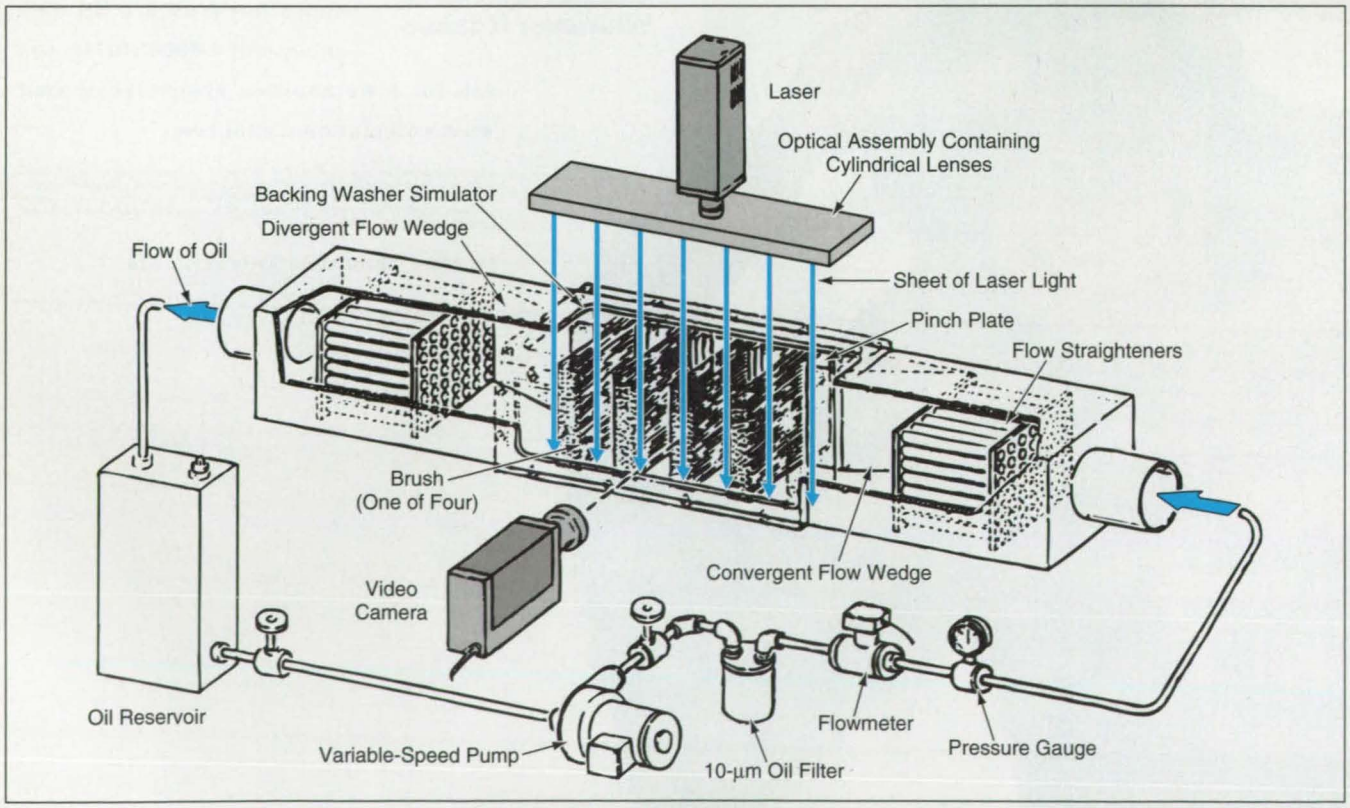
The flow is seeded with highly reflective particles with sizes up to about 10 μm. For studying flows of water or oil, a suitable particle material is MgO_2, which is nearly neutrally buoyant in those liquids. For studying flows of air, the selection of particle materials is more problematic; care must be taken to eliminate spurious particle motions (e.g., bouncing off surfaces of objects) in specific experimental regimes.

A low-luminosity charge-coupled-device video camera with a resolution of 756 horizontal pixels by 581 vertical pixels is focused on the illuminated plane. The camera is equipped with long-distance-microscope optics that can magnify a selected portion of the plane by a factor as large as 100 to reveal details of the flow field. The output of the camera can be either digitized and stored directly in a computer memory or else recorded on video tape and subsequently digitized for processing by the computer.

The camera operates at a frame rate of 30 Hz; this frame rate is adequate as long as the flow under observation is not so fast that images of particles become continuous streaks across the field of view. To provide stroboscopy for viewing such rapid flows, the optical system includes a rotating laser-beam-chopping disk. The speed of rotation can be chosen to obtain strobing frequencies at integer multiples of 30 Hz, up to a maximum of several kilohertz.

Sequences of images are processed by a computer integrated image-quantification (CIIQ) method, which is a partly manual, partly automated method for identifying images of individual particles and tracing their motions across the flow field during a chosen observation interval. The CIIQ method involves three computer programs called "FACT," "SNAP," and "VADT." Using calibration images obtained by focusing the video camera on graph paper, FACT generates magnification factors for the recorded images. Then by use of a digitizing puck (similar to a mouse) and pad along with SNAP, a technician visually identifies and digitizes the position of each particle of interest in the succession of strobe or frame intervals that, collectively, constitute the observation interval. The technician continues this process until the digitized particle trajectories are sufficiently numerous to represent the flow field to the desired level of detail.

The digitized trajectory data are fed to VADT, which fits the sequence of



An **Oil Tunnel Is Instrumented** with an FFFT PIV apparatus to study flows through brushes that represent brush seals in turbomachines. The FFFT PIV apparatus has also been used to study flows of water past cylinders, airfoils, and other objects, and flows of air past an array of pins in staggered rows.

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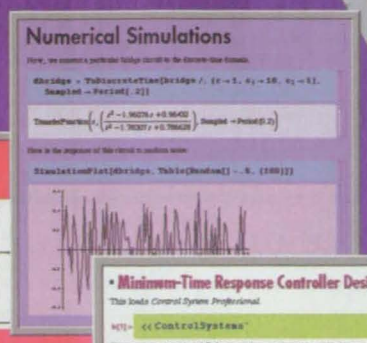

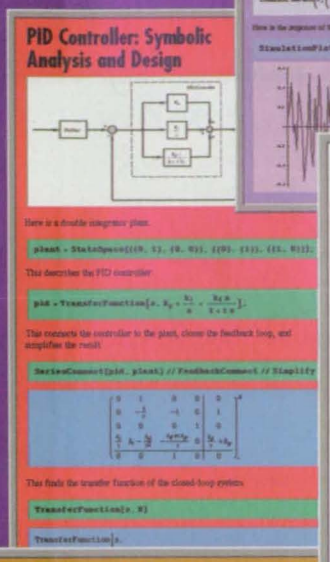

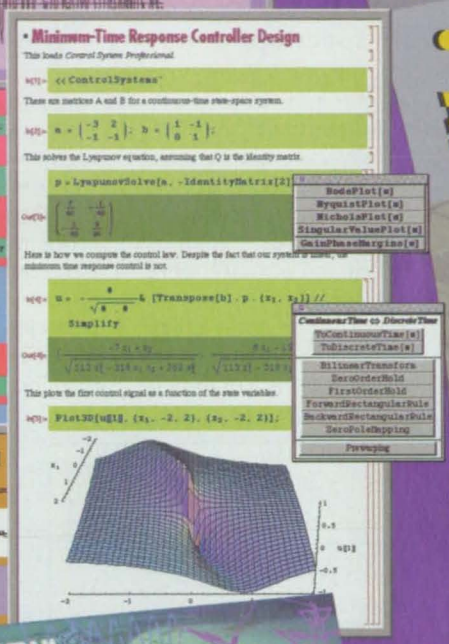

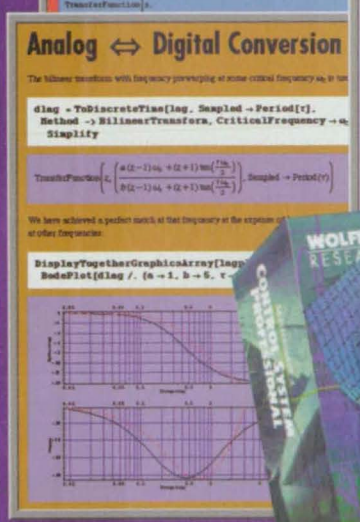

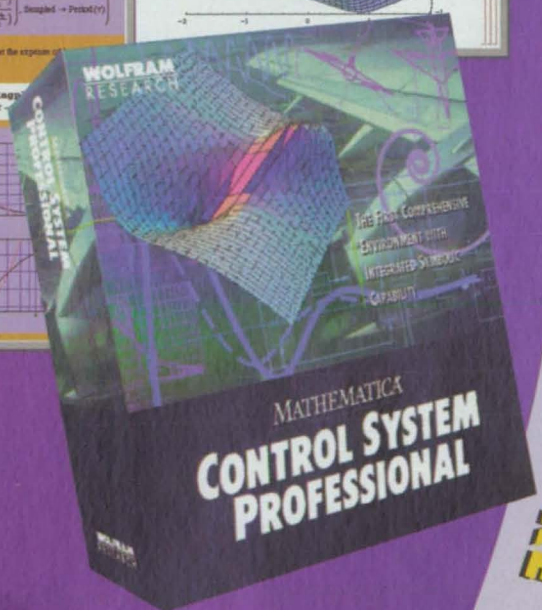

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positions of each particle to a polynomial (up to ninth order) function of time. Velocities and accelerations are computed as the first and second derivatives, respectively, of the polynomials. The resulting velocity and acceleration data from the magnified small areas of the plane of interest are then computationally assembled to obtain a representation of the flow field throughout the plane.

This work was done by Victor A. Canacci and M. Jack Braun of the University of Akron for **Lewis Research Center**. *For further information,* ***write in 94*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Lewis Research Center, Commercial Technology Office, Attn: Tech Brief Patent Status, Mail Stop 7-3, 21000 Brookpark Rd., Cleveland, OH 44135. Refer to LEW-16309.

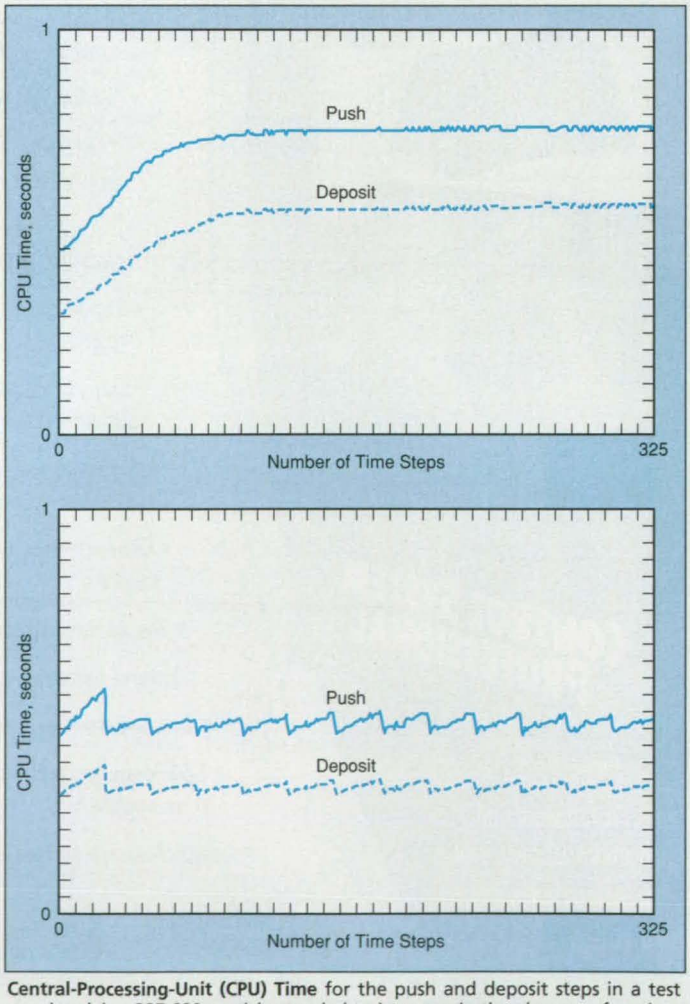
Optimization of Particle-in-Cell Codes on RISC Processors

A combination of strategies yields appreciable speedup.

NASA's Jet Propulsion Laboratory, Pasadena, California

Several strategies for maximizing the speed of execution of particle-in-cell (PIC) codes on reduced-instruction-set-computer (RISC) processors have been developed. PIC codes have long been used in plasma physics to compute motions of charged particles in electric and magnetic fields generated by themselves. Algorithms for efficient execution of PIC codes on parallel processors were available prior to the development of the present strategies, but these algorithms do not address the efficient implementation of the codes on individual processors. The present strategies are intended to fill this gap.

The strategies were evaluated in computational experiments, using an established and previously well-tested Fortran electrostatic-field/charged-particle PIC code. The particular code was chosen because it is conceptually simple yet adequate for demonstrating the strategies. The time step in an electrostatic PIC code comprises three main parts: deposit, field solve, and push. In the deposit step, charge is deposited from the particles onto a grid to find the charge distribution. Each particle deposits charge to several nearby grid points and many particles deposit charge to each grid point. In the field-solve step, a Poisson equation is solved on the grid to find the electric field. In the push step, the electric field is interpolated to the particles to find their accelerations. Each particle reads the electric field from several nearby grid points and each grid point is read by many particles. These three main parts are repeated for as many time steps as desired. The deposit and push steps are characterized by memory references that are effectively random and change from one time step to the next, making these steps challenging for computer-memory systems that are optimized for regular reference patterns.



Central-Processing-Unit (CPU) Time for the push and deposit steps in a test case involving 327,680 particles tended to increase, in the absence of sorting, as particles became randomized by the computation. A simple bin sorting routine applied every 25 time steps proved effective in limiting the increase in CPU time without incurring excessive sorting overhead.

The optimization strategies fall into two categories, one of which involves reorganization of data to improve utilization of cache memory. This category includes strategies for storing data on particles, or on both particles and fields, at contiguous memory locations. Also included in this category is a strategy for improving reuse of cache memory by occasional sorting of particles (see figure).

The second category involves reorganization of code to increase the efficiency of pipelined arithmetic. Strategies in this category include removing "IF" statements, reordering calculations, precalculating integer conversions, using one-dimensional addressing, and separation of "load" and "store" operations in the deposit step.

The results of the tests showed that no single strategy made a huge difference when applied alone, but that substantial improvements in performance (in terms of increases in processing speed) were achieved by aggregating the strategies. The amounts of improvement differed among processors and ranged between factors of 1.38 and 3.43.

This work was done by Viktor Decyk, Steve R. Karmesin, and Paulett C. Liewer of Caltech and Aeint de Boer of UCLA for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 12*** *on the TSP Request Card.*

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For More Information Write In No. 660

Digitized X-Radiographs Indicate Densities in Ice Samples

Modern image-processing techniques are used.

Lewis Research Center, Cleveland, Ohio

An improved method for measuring the local and total densities of ice accreted on airfoils incorporates contact x-radiography, along with modern image-acquisition and image-processing techniques (see Figure 1). The method was developed to facilitate a more detailed study of internal characteristics of ice formed on airfoils in wind-tunnel experiments under conditions that resemble those encountered in flight. Measurements of density, like those provided by this method, are needed to study the structure and formation of ice and to improve density values employed in computer programs that mathematically model the accretion of ice.

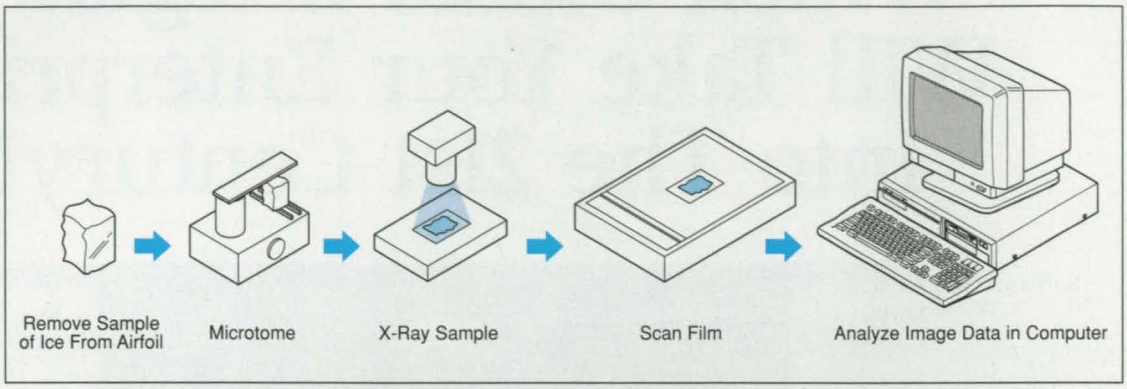


Figure 1. A **Sample of Ice From an Airfoil** is sliced thin on a microtome and used to make an x-radiograph. The radiographic image is digitized and processed to determine the local density of ice throughout the sample.

The improved method was derived partly by extending an older contact-x-radiographic technique for measuring the densities of ice in hailstones. In the improved method, the first step is to remove samples of accreted ice from a test airfoil and store them in a freezer. Next, while maintaining a temperature of 0 °F (–18 °C), the samples are sliced on a band saw to a thickness of about 10 mm, then further cut on a microtome to obtain samples with parallel sides and with a thickness of 3 mm. Each sample is placed on polyethylene terephthalate film on top of a sealed packet of x-ray film. Also placed on the film is a 3-mm-thick reference sample of clear ice. The samples and film are then exposed to x rays. Typical exposure conditions are a source potential of 25 kV, source current of 1 mA, and exposure time of 30 seconds.

To extract fine detail, the radiographs are scanned by a high-resolution film scanner with a resolution of 1,100 pixels per inch (433 pixels per centimeter). Then the digitized image data is processed to convert local image-intensity values into local ice-density values, using the image intensities and the known density of the reference samples as calibration data.

This method affords several advantages. The radiographs reveal interior density variations that would ordinarily be concealed from the naked eye. Digitization of the images makes it possible to use image-processing techniques to determine the positions of image features with high repeatability and accuracy. Image-processing techniques can be used to evaluate ice formation and morphological anomalies or to reveal features (see Figure 2) or characteristics that might otherwise go unnoticed. Digitization also makes it convenient to store and retrieve image data, and eliminates the need to handle original radiographs for each analysis.

Variability in the results obtained by this method can be attributed to two sources: (1) quantization error and (2) nonuniformity in the thicknesses of ice samples. Quantization error can be reduced by digitizing the images to greater numbers of bits. Thicknesses of samples can be made more nearly uniform by taking smaller slices to reduce flexing of the microtome blade.

This work was done by Mario Vargas of **Lewis Research Center** *and Howard Broughton and James Sims of Cortez III Service Corp. For further information,* ***write in 48*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Lewis Research Center, Commercial Technology Office, Attn: Tech Brief Patent Status, Mail Stop 7–3, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16430.

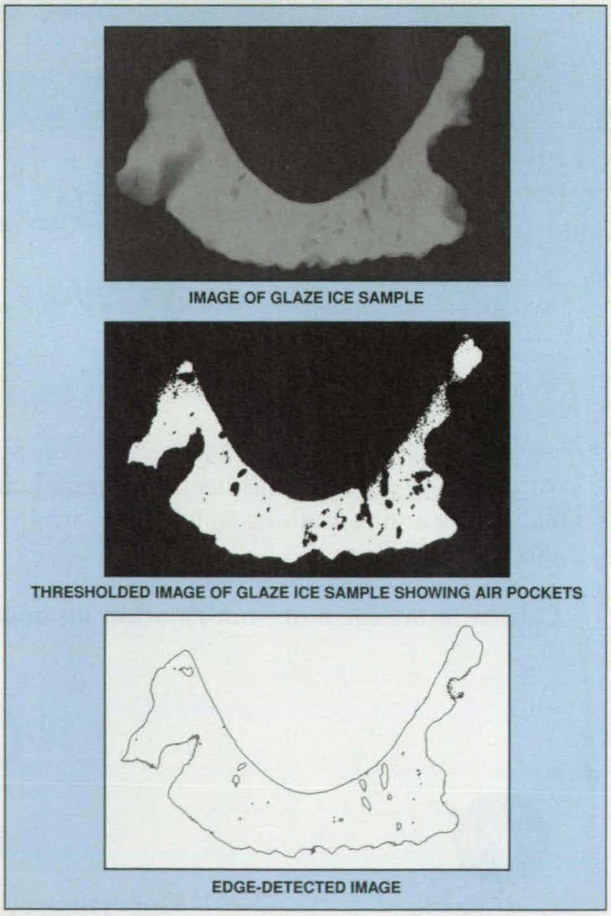
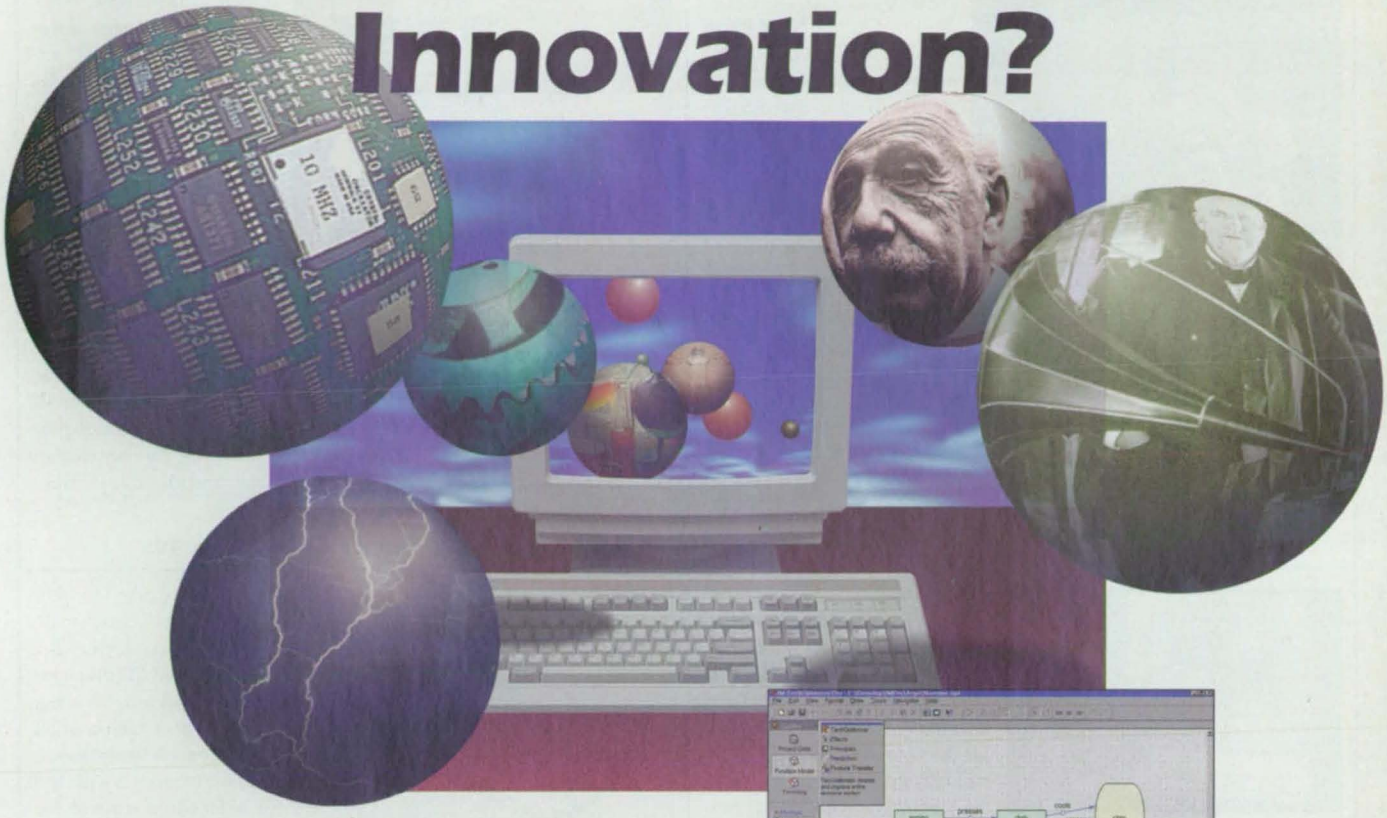


Figure 2. These **Images Were Obtained by Digital Processing** of an x-radiograph of a sample of glaze ice. Note how thresholding of density levels and the application of an edge-detection algorithm reveal different aspects of pockets of air trapped in the ice.

What Is Boundless Innovation?



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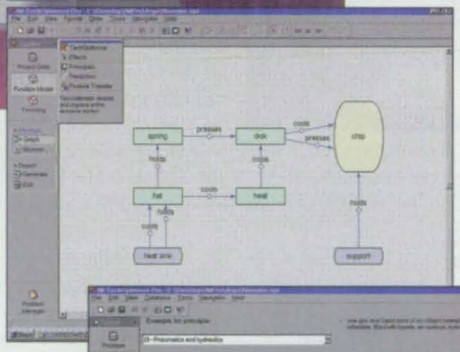

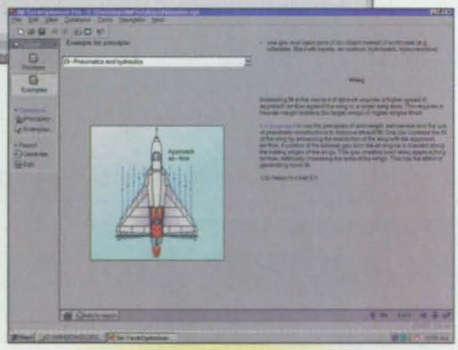

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For More Information Write In No. 639

National Instruments, Austin, TX, offers the PCMCIA-232 and PCMCIA-485 **serial interfaces** that connect to RS-232 and RS-485 devices, respectively. They give notebook computers control of serial devices for portable or remote applications. The asynchronous interfaces are Windows 95 Plug and Play compatible and feature serial transmission rate of more than 115 kb/s.

Both interfaces include a COM driver for Windows 95 and are compatible with standard PC COM ports. The PC operating system performs all board configuration. Users can connect with most serial devices by sending strings to, and reading from, the COM port. Application software packages and development environments can access the interfaces using standard serial I/O functions.

For More Information Write In No. 703

Kontron Elektronik, Newport Beach, CA, has introduced an enhanced version of the IN Lite P series of rugged **notebook computers**, which is equipped with a 166-MHz Intel Pentium® processor with MMX™ technology. The computer includes a full-length slot and two PCMCIA slots, and is enclosed in a sealed magnesium case. A universal AC/DC power supply, internal battery operation, and a 2 GB hard disk also are included.

The computer is available with 32 Mb RAM, expandable to 64 Mb, and features a 10.4" TFT VGA display, 2 Mb graphics controller for all color resolutions, and optional 512K cache. A 12.1" TFT XGA display with 1024 x 768 resolution also is available. The unit can be used in environments exposed to dust, moisture, shock, and vibration. Prices start at less than $10,000.

For More Information Write In No. 705

Intergraph Computer Systems, Huntsville, AL, has announced the TD Series of Windows/Windows NT-based **3D personal computers** powered by Intel Pentium® processors with MMX™ media enhancement technology. Users can perform 3D Web content creation, view Web sites in 3D with a VRML viewer, CAD, or animation with the Intense 3D graphics accelerators — the Intense 3D Pro 1000 for workstation-class 3D graphics, or the Intense 3D 100 for general-purpose 2D/3D applications.

The TD-22 system features a single 133, 166, or 200 MHz Pentium processor; and 16-64 Mb RAM. The TD-25 features a single 166 or 200 MHz Pentium processor with MMX technology and 16-64 Mb RAM; and the TD-220 offers a single 180 or 200 MHz Pentium Pro processor with 16-256 Mb RAM. All systems are equipped with 3D sound technology, and come with Microsoft Office 97 and Intergraph DMI-compliant InterSite software.

For More Information Write In No. 709

Spacetec IMC Corp., Lowell, MA, offers the Spaceball® 3003™ **3D input device** for workstation-based 3D mechanical design and engineering applications. It enables users to simultaneously pan, zoom, and rotate 3D models with six-degree-of-freedom control. To move or rotate a 3D model, the user grasps the ball around its equator and pushes, pulls, or twists the ball. The model then moves in the direction of the force or twist applied. The device is used in conjunction with a mouse, which is used for picking, pointing, and menu selection.

A SoftButton user interface incorporates functions such as Translation On/Off, Rotations On/Off, Sensitivity Controls, Single Axis Filter, and Reset View. SpaceWare®, a proprietary software module, is integrated with and supported by CAD/CAM/CAE applications such as Catia, EUCLID, MSC/PATRAN, Pro/ENGINEER, and CADDS5.

For More Information Write In No. 707

The ViewSonic P815 Professional Series Mega-Monitor™ **flat-screen monitor** from ViewSonic Corp., Walnut, CA, is a 21" monitor that provides 250 MHz video input bandwidth and a horizontal scan range of 20 to 115 KHz for resolutions of 1800 x 1440 at 76 Hz refresh and 1600 x 1200 at 90 Hz refresh. The Super Contrast screen utilizes glass with a low transmission rate and features anti-glare ARAG® screen treatment.

OnView® controls allow users to make screen adjustments such as pincushion, contrast, degauss, moire, and brightness via an on-screen menu. ViewMatch® enables accurate matching of colors on the screen with a color output from a printer. The monitor, with Plug & Play+, supports the Windows 95 standard for automatic monitor configuration and installation.

For More Information Write In No. 711

National Hybrid, Ronkonkoma, NY, has introduced the NHI-15164 PCET handheld **test and development instrument** that enables a PC or laptop computer with an enhanced parallel port to function as a bus controller, bus monitor, remote terminal, or concurrently as a remote terminal and bus monitor.

Weighing one pound, and in conjunction with a laptop, the interface can be used for field servicing applications. It comes with a 9V rechargeable battery for 2-1/2 hours of minimum operation before charging. A 9Vdc power adapter allows continuous operation while recharging the battery. The instrument kit includes menu-driven software, battery and charger, 3' parallel port interface cable, and carrying case.

For More Information Write In No. 708

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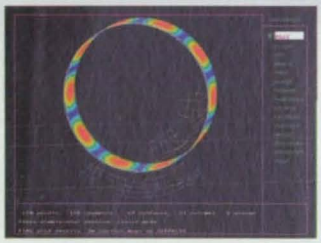

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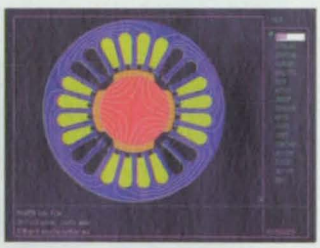

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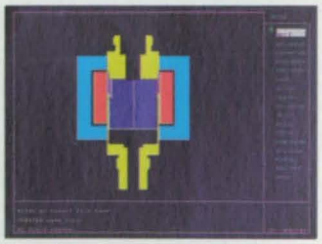

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For More Information Write In No. 644

The ICC-7000™ NEMA 4-rated **flat-panel computer** from Nematron Corp., Ann Arbor, MI, features a 14" color TFT display with resolution of 1024 x 768 pixels for Windows NT applications and hard drive capabilities up to 6 Gb. Options such as an integrated CD-ROM accessible from the front of the PC and a removable hard drive are available.

The computer features a hinged rear chassis design that swings open for easy access, backlighting that can be changed in less than five minutes, and an electrical chassis that can be exchanged without tools. Options include up to 512 Mb RAM; a choice of 100, 135, 166, or 200 MHz Intel Pentium processors; a 200 MHz Intel Pentium Pro processor; preinstalled industrial network cards; and Microsoft Windows NT operating system pre-loaded.

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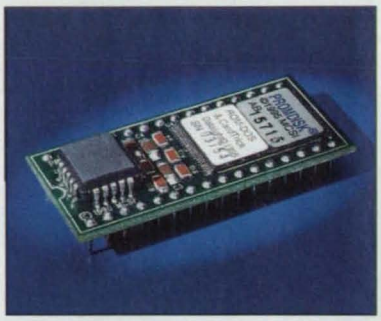


Micro Computer Specialists, Vista, CA, offers the PROMDISK-Chip **disk emulator chip** that plugs into any standard 32-pin EPROM socket in the BIOS extension address space of a personal computer. It is bootable as a fixed disk ranging from 2 Mb to 4 Mb by utilizing non-volatile NOR flash memory. It is DOS and Windows compatible, allowing users to copy and erase files using standard DOS commands.

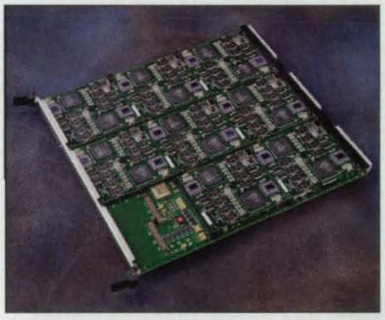
The chip replaces mechanical disk drives in systems designed to operate in environments where temperature, shock, vibration, or reliability are concerns. It operates at bus speeds and features no mechanical parts and low-power CMOS technology. The chip comes with the onboard Datalight VBF Flash File System, Datalight ROM-DOS v.6.22 disk operating system, and utility diskette.

For More Information Write In No. 701

Cherry Electrical Products, Waukegan, IL, offers the Cherry 6000 **keyboard** that is compatible with PS/2 and AT systems. The 104-key, low-profile keyboard features a large L-shaped "enter" key and comes with five- or six-pin mini-DIN AT or PS/2 connectors. The housing is available in beige matte; matte-finish beige/gray or white/gray keycaps are wear-resistant. All keys retain the standard 3/4" spacing.

The keyboard features a small internal printed circuit board and uses an injection-molded rubber dome/mat for tactile feel and laser printing for clearly printed keycaps. The Windows® 95 version bears the "Apps" key near the spacebar, as well as two keys bearing the Windows flag for quick access to Windows applications.

For More Information Write In No. 700



Mercury Computer Systems, Chelmsford, MA, has introduced RACE® scalable **multicomputing systems** based on the 200 MHz PowerPC 603e microprocessor from Motorola. The processor delivers up to 4.4 GFLOPs on a single 9U VME motherboard and 1.1 GFLOPS on a 6U motherboard. The systems' RACE heterogeneous architecture features a building-block approach designed for embedded multicomputing requirements with power- and space-constrained applications.

Systems can be configured with hundreds of PowerPC processors connected with the RACEway switched-fabric interconnect. Programming is simplified by the heterogeneous single-system model, allowing users to optimize their system configuration for a target application.

For More Information Write In No. 704

Aydin Corp., Fort Washington, PA, has released a series of high-definition small-screen **monitors** that are microprocessor-controlled and available in sizes from 10" to 17". The Autosync® capability provides 15 to 40 KHz or 30 to 64 KHz with either BNC or D connectors. Digital operation and security disable are provided as standard features.

Also available are VGA, SVGA, and 1024 x 768 monitors in a fixed frequency format. All monitors are designed for industrial environments operating to 55°C. Optional touchscreens and magnetic shielding are available.

For More Information Write In No. 702

The Model 121 industrial/ruggedized **keyboard** from Cortron, Methuen, MA, features a sealed pointing device and is resistant to dust, shock, explosions, and spills. Available features include interfaces for IBM, SUN, Digital Equipment, NCD, RS-232, and RS-422; backlighting with a brightness-control knob; rack-mount or tabletop configurations; and conformal coating.

A force sensor or touch-pad pointing device; 1-3/8" or 2" sealed trackballs; EMI/RFI protection; custom colors, protocols, codes, and durable key legends; and keyboard options including slides and wrist rests are available. It can be customized to meet specific requirements and meets MIL-STD-461, 810, 167, 108, and 901 standards.

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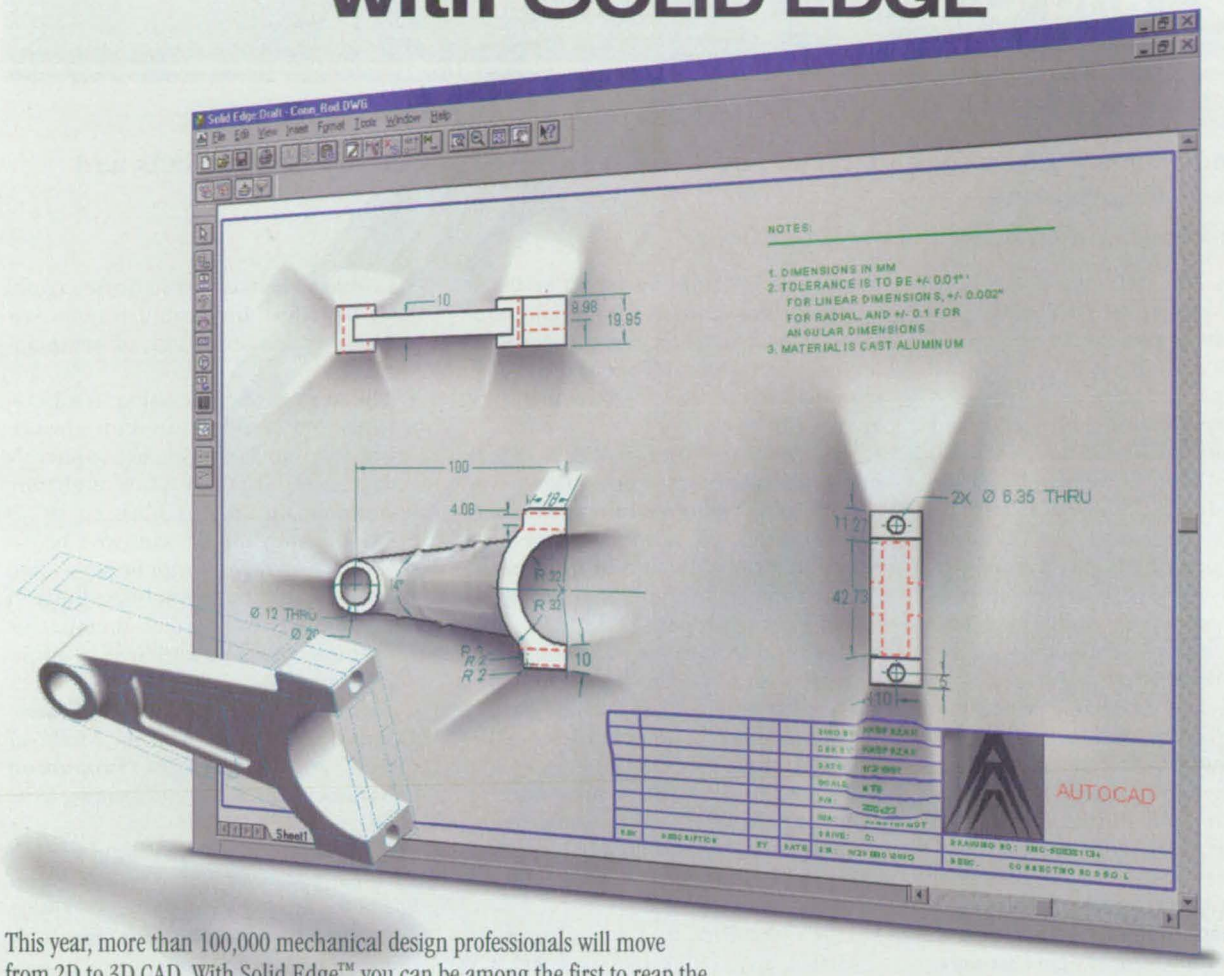

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[1] *Computer Aided Design Report*, Vol. 16, No. 6, June 1996

Diffusion Barriers for GaAs and InP Devices

Amorphous ternary alloys for gate metal and ohmic-contact diffusion barriers in GaAs and InP devices are proposed.

NASA's Jet Propulsion Laboratory, Pasadena, California

Thin films of ternary, amorphous refractory compounds have been proposed for use as gate metals and ohmic contact diffusion barriers to improve the reliability of GaAs- and InP-based devices. The proposed gate metals and diffusion barriers would be of general composition $M_xSi_yN_z$, where M denotes Ta, W, or Mo; such diffusion barriers have proven effective in Si-based devices, as described, for example, in "Amorphous Ta-Si-N thin film alloys as diffusion barriers in Al/Si metallizations," J. Vac. Sci. Technol. Vol. A8, No. 3, p 3006 (1990).

In GaAs- and InP-based electronic devices, diffusion of metal and semiconductor materials is especially problematic at the high processing temperatures encountered during fabrication, and in some cases can continue at significant rates during use of devices at lower temperatures. Such diffusion alters semiconductor channel thicknesses and other Schottky gate parameters and, in so doing, degrades performances and operational lifetimes. During operation of devices in atmospheres that contain hydrogen, diffusion of hydrogen can also degrade performances and lifetimes. This degradation has been associated with Pt and Pd, which are constituents of typical gate-metal alloys used heretofore. It has been hypothesized that the Pt or Pd in a metallic gate contact catalytically converts hydrogen molecules to hydrogen atoms, which then diffuse into the gate channel, where they compensate free charge carriers.

The proposed use of $M_xSi_yN_z$ layers offers several potential advantages over the use of conventional metal contacts without diffusion-barrier layers:

- Elimination of Pd and Pt from metal gate contacts would eliminate degradation by hydrogen.
- $M_xSi_yN_z$ alloys are thermodynamically stable with respect to GaAs; this characteristic would help prevent chemical reactions between the semiconductor and other layers.
- Because of the amorphous nature of the $M_xSi_yN_z$ layers, there would be no grain boundaries and thus no paths for rapid diffusion into or out of GaAs substrates.
- The crystallization temperatures of $M_xSi_yN_z$ are so high (800 to 1,000 °C) that during fabrication heat treatments, amorphous structures of diffusion-barrier layers would persist and microstructures of the gates would remain unchanged.
- Because of the amorphous nature of $M_xSi_yN_z$, it would be possible to deposit uniform, continuous layers with thicknesses as low as 10 nm.
- Contact electrical resistivities could be kept low and would remain stable over a wide range of temperatures.
- The range of processing temperatures that could be used in fabricating contacts would be relatively wide, so that temperature and time controls would not have to be as strict as they might otherwise be.
- Contact surfaces would be smoother.
- There would be greater flexibility in the choice of contact metals; for example, Au, Al, and/or Cu could be used.

This work was done by Elzbieta Kolawa, Sammy Kayali, and Marc A. Nicolet of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 53*** *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

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Refer to NPO-19892, volume and number of this NASA Tech Briefs *issue, and the page number.*

Au/Ge/Au Contacts for Shallow-Junction InP Solar Cells

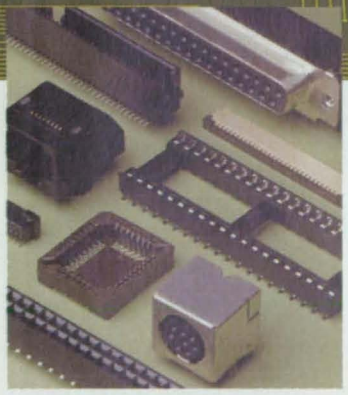
These contacts exhibit low electrical resistivity and high thermal stability.

Lewis Research Center, Cleveland, Ohio

Au/Ge/Au contacts on InP semiconductor devices have been found to exhibit extremely low electrical resistivities. They have also been found to be highly thermally stable in the sense that the interdiffusion of metal and semiconductor materials during the sintering step of the fabrication process is retarded, relative to such interdiffusion that occurs during the sintering of devices made with other contact materials. The nature of this retardation of interdiffusion is such that sintering can be completed before the adverse effects of interdiffusion degrade the underlying semiconductor devices.

The development of Au/Ge/Au contacts is one achievement of a continuing program of research on fabricating electrical contacts for InP semiconductor devices, both with and without sintering. Some other achievements of this program were reported in previous articles in *NASA Tech Briefs*, namely: "Sinterless Fabrication of Contact Pads on InP Devices" (LEW-15863), Vol. 19, No. 10 (October 1995), page 90; "Sinterless Formation of Contacts on Indium Phosphide"

How to stay out of the rough in surface mount technology.



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(LEW-15814), Vol. 19, No. 10 (October 1995), page 45; "Sinterless Formation of Contacts on Indium Phosphide: Part 2 (LEW-15815), Vol. 21, No. 4 (April 1997), page 45; and "Ultra-Low-Resistance Metal Contacts on InP" (LEW-15816), Vol. 21, No. 4 (April 1997), page 45.

The need for sintering and the desire to avoid sintering if possible can be explained as follows: To make a low-resistance electrical contact to an InP semiconductor device according to the standard approach, one must deposit contact metal on the semiconductor, then sinter the contact metal at a suitably high temperature. Although sintering desirably reduces contact resistance, it also undesirably induces substantial interdiffusion between the metal and the underlying InP. Unless limited by imposition of one or more diffusion barrier(s) or by use of such techniques as rapid annealing, this interdiffusion can quickly degrade or destroy the device. Such shallow-junction devices as junction field-effect transistors and solar cells are particularly susceptible to damage during sintering to form contacts.

The desirable properties of Au/Ge/Au contacts were observed in experiments on InP n/p diodes with (100)-oriented substrates doped with Zn to a density of 8×10^{16} cm^{-3} and 2,000-Å-thick epitaxially deposited emitters doped with Si to a density of 1.7×10^{18} cm^{-3}. By use of electron-beam evaporation, contact layers were deposited on InP in the following sequence: Au 400 Å thick, Ge 200 Å thick, and Au 1,600 Å thick. After deposition of contacts, the devices were sintered in a nitrogen atmosphere at a temperature of 350 °C.

Figure 1 shows the evolution of contact resistivities of these devices and of similar devices with Au (only) contacts tested in previous experiments. Whereas the resistivity of the Au (only) contacts remained above 10^{-3} $\Omega \cdot cm^2$ for tens of minutes at the sintering temperature, only 1 minute at that temperature was necessary to bring the resistivity of the Au/Ge/Au contacts down to about 10^{-7} $\Omega \cdot cm^2$. The resistivities of these Au/Ge/Au contacts were among the lowest resistivities of any contacts on InP tested up to the time when these experiments were performed.

One measure of the interdiffusion of Au and InP is the fraction of outer-sur-

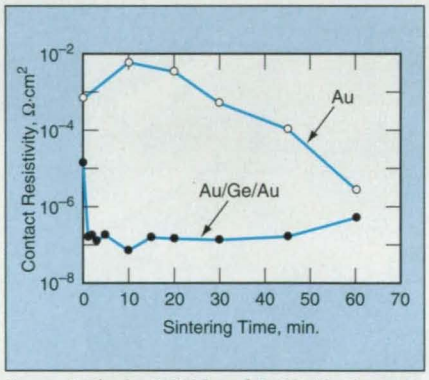

Figure 1. The **Resistivities of Au/Ge/Au Contacts** reached values much lower than those of Au (only) contacts after sintering for only 1 minute at 350 °C.

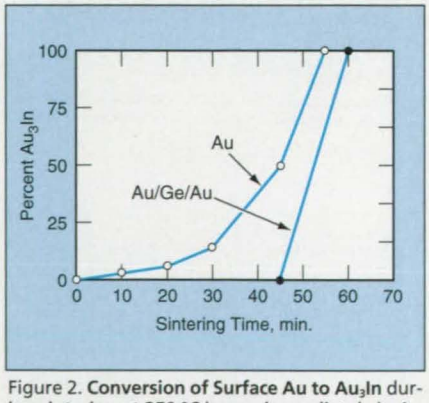

Figure 2. **Conversion of Surface Au to Au_3In** during sintering at 350 °C began immediately in Au (only) contacts but was delayed by 45 minutes in Au/Ge/Au contacts.

face Au converted to Au_3In as a function of time during sintering at 350 °C. Using this measure, Figure 2 illustrates the retardation of interdiffusion in the Au/Ge/Au contacts as compared to the Au (only) contacts: whereas the formation of Au_3In was observed immediately on Au (only) contacts, it was not observed on Au/Ge/Au contacts until 45 minutes into the sintering process.

This work was done by V. G. Weizer of **Lewis Research Center**; *N. S. Fatemi of Sverdrup Technology, Inc.; and A. L. Korenyi-Both of Calspan Corp. For further information,* ***write in 28*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Lewis Research Center, Commercial Technology Office, Attn: Tech Brief Patent Status, Mail Stop 7-3, 21000 Brookpark Rd., Cleveland, OH 44135. Refer to LEW-16280.

Ag/Zn Contacts on Shallow-Junction p-Doped InP Devices

Low-resistance contacts can be formed without substantial metal/semiconductor interdiffusion.

Lewis Research Center, Cleveland, Ohio

Ag/Zn contacts on p-doped InP semiconductor electronic devices have been found to exhibit electrical resistivities as low as 10^{-4} $\Omega \cdot cm^2$. The contacts are formed by deposition of a combination of Ag and Zn on the InP surfaces, then sintering. Unlike in the fabrication of contacts from some other materials, the sintering step in the fabrication of Ag/Zn contacts does not cause so much interdiffusion of metal and semiconductor materials as to degrade or destroy the underlying devices.

The development of Ag/Zn contacts is one achievement of a continuing program of research on fabricating electrical contacts for InP semiconductor devices, as noted in the preceding article. The role of sintering in the fabrication of contacts is also discussed in the preceding article.

Zn apparently exerts two major effects in the fabrication of Ag/Zn contacts. One effect is substantial retardation of the interdiffusion of the metal contact and underlying semiconductor materials; the interdiffusion is suppressed to such an extent that contacts can be formed directly on very-shallow-junction devices without damaging them. The other major effect of Zn is a significant reduction in contact resistivity.

This work was done by Victor G. Weizer of **Lewis Research Center** *and Navid S. Fatemi of Essential Research, Inc. No further documentation is available.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Lewis Research Center, Commercial Technology Office, Attn: Tech Brief Patent Status, Mail Stop 7-3, 21000 Brookpark Rd., Cleveland, OH 44135. Refer to LEW-16037.

Planar Quad-Bridge-Diode Frequency Doubler

Input and output circuits are isolated without complicated filter structures.

NASA's Jet Propulsion Laboratory, Pasadena, California

A quad-bridge varactor-diode 10-to-20-GHz frequency-doubling circuit features integrated planar construction on a quartz substrate, with quasi-optical input and output coupling via fully open antenna substructures. The design of this frequency doubler exploits electrical and geometrical symmetries to achieve a simple, compact overall structure with inherent isolation between input and output ports. This frequency doubler is a frequency-scaled prototype of proposed frequency multipliers that would operate at frequencies of the order of 1 THz and that would offer attractive alternatives to conventional waveguide-construction microwave and millimeter-wave frequency multipliers.

The quad-bridge circuit configuration (see Figure 1) results in balanced frequency-doubling action and provides frequency isolation between input and output ports, without need for complicated filter structures; this is because diodes in a quad-bridge configuration inherently reject even harmonics at the input port and reject odd harmonics at the output port. In comparison with the design of a single-diode frequency multiplier, the design of this multiplier maintains the same optimum conversion gain and optimum input and output load impedances but quadruples the power-handling capability.

Input and output couplings are implemented with two pairs of double-slot antennas that are polarized perpendicularly to each other (see Figure 2) to enhance input/output isolation. Compact coplanar transmission-line matching circuits are placed between the antennas and the diodes to maximize input coupling at the fundamental frequency and output coupling at the second harmonic, thus helping to maximize frequency-conversion efficiency. The circuit can be mounted on a dielectric lens or on the flat outer surface of a dielectric (quartz)-filled paraboloidal reflector to obtain the desired input/output radiation patterns.

This work was done by Moonil Kim, Jean Bruston, R. Peter Smith, Suzanne C. Martin, and Peter H. Siegel of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 100*** *on the TSP Request Card.*

NPO-19724

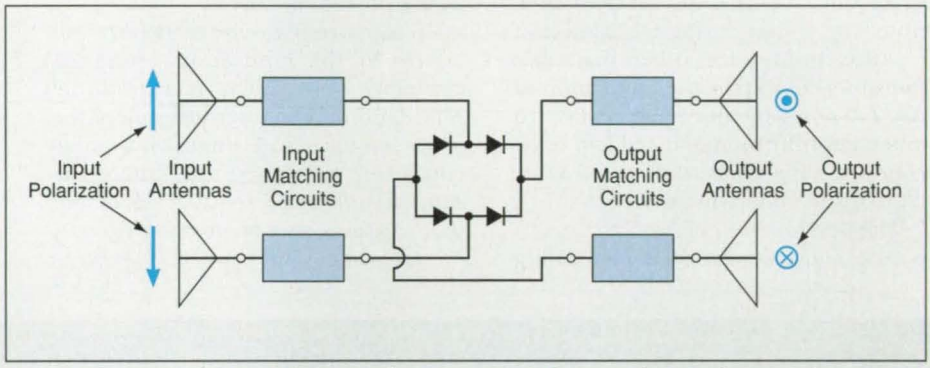

Figure 1. The **Diodes in a Quad-Bridge Configuration** provide frequency isolation between the input and output antennas.

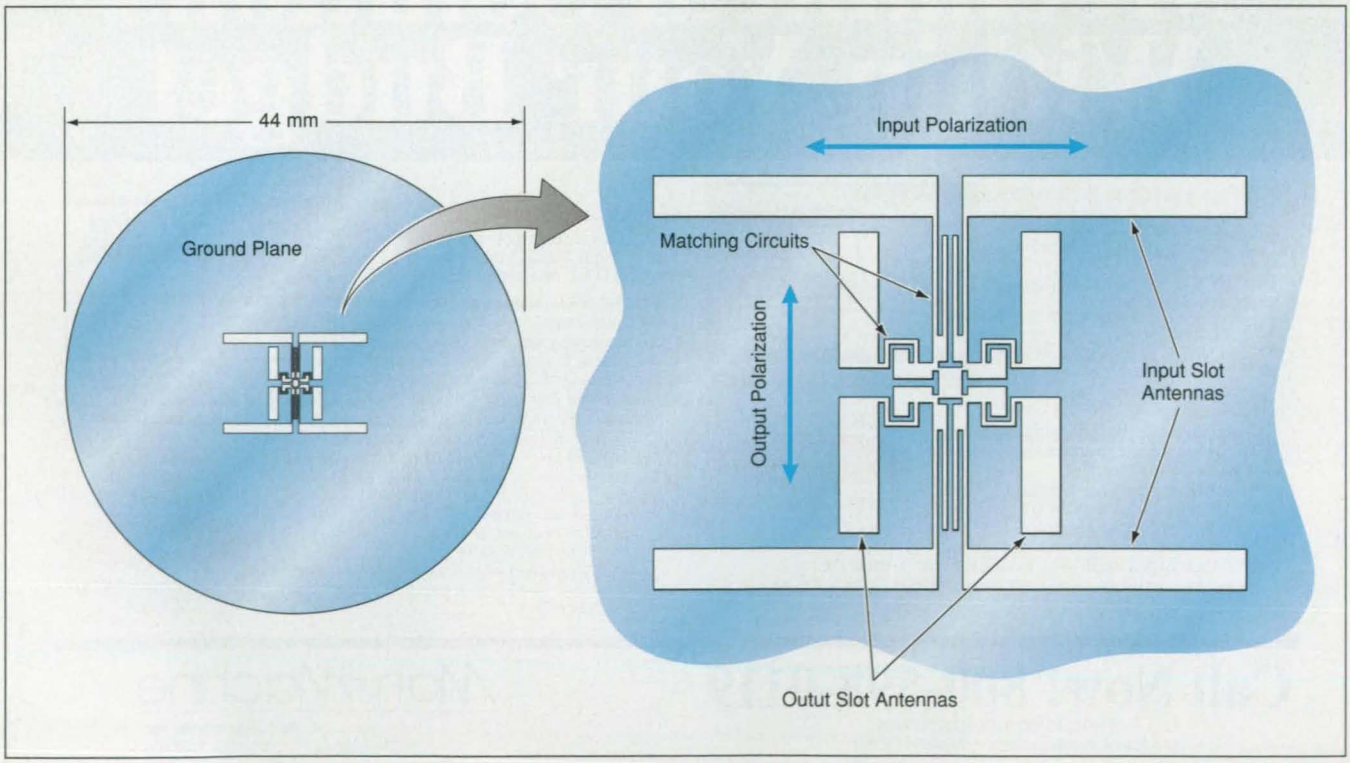

Figure 2. **Orthogonal Input and Output Slot Antennas** provide orthogonal input and output polarizations and thus polarization isolation between input and output antennas. A commercial quad-bridge diode chip is bonded to the center of the circuit.

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Concept for a Wide-Area Differential GPS Navigation System

Total user error would be reduced by an order of magnitude.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed improved navigation system for civil aviation would exploit the signals broadcast by the Global Positioning System (GPS) and would incorporate a number of recent and anticipated advances in GPS technology to achieve decimeter real-time positioning accuracy. The underlying concept is that of a real-time wide-area differential (WAD) GPS navigation system that could be incorporated into the Federal Aviation Agency's Wide Area Augmentation System (WAAS). The proposed system is required to provide an increase, over prior GPS-based systems, in the accuracy with which a user's equipment can determine its real-time position ("user position accuracy," for short); this entails a requirement to (1) estimate GPS satellite orbits and clock offsets in real time with accuracies greater than those broadcast by the GPS itself and (2) estimate ionospheric GPS-signal-propagation delays with high accuracy to provide further corrections to improve user position accuracy.

The system would satisfy the accuracy requirements via a combination of (1) long-arc dynamic orbit estimation by means of a real-time Kalman filter, (2) rapid clock estimation, and (3) the use of the same Kalman filter in generating a dynamic global map of ionospheric delay (see Figure 1). This would be the first WAD GPS-based system to feature tuned dynamic (rather than geometric) determination of the GPS satellite orbits, enabling complete separation of orbit and clock corrections and reducing GPS orbit error (which is usually dominant) to insignificance. Moreover, the accuracies of the ionospheric-delay corrections in the proposed system would be at least 3 times those of the best known alternative system.

The system would utilize an extensively modified version of the GPS-Inferred Positioning System/Orbit Analysis and Simulation Software (GIPSY/OASIS II), which was described briefly in "Software for Precise GPS Calculations" (NPO-19636), *NASA Tech Briefs*, Vol. 20, No. 12 (December 1996), page 84. To recapitulate: GIPSY/OASIS II accepts data collected by a permanent worldwide network of more than 60 Global Positioning System (GPS) reference receivers and continuously processes these data (see Figure 2), along with a network reference time, into precise three-dimensional position data on the orbits of GPS satellites, plus satellite and ground-station clock offsets. GIPSY/OASIS II incorporates the most precise available mathematical models of the dynamics of spacecraft, geophysical quantities, and propagation of radio signals and relativistic effects. The GIPSY estimator is formulated as a Kalman-type square-root information filter; this avoids matrix inversions and greatly enhances numerical stability. Any parameter estimated through the GIPSY Kalman filter/smoother can be modeled as a deterministic or stochastic process, or a combination of the two. The filter routinely solves simultaneously for thousands of parameters with data from dozens of receivers while maintaining submillimeter numerical precision globally.

GIPSY/OASIS II is highly modular in a way that makes it flexible and adaptable to almost any satellite-tracking estimation problem through simple modification of Unix script. In adapting GIPSY/OASIS II to the WAAS, different master-station functions to be performed by GIPSY could be performed in parallel, perhaps on several workstations, each directed by a different script designed to run the software optimally for its given task. These functions would include: (1) estimation of orbits and long-term satellite clock parameters, and computation of the associated slow corrections and their estimated errors;

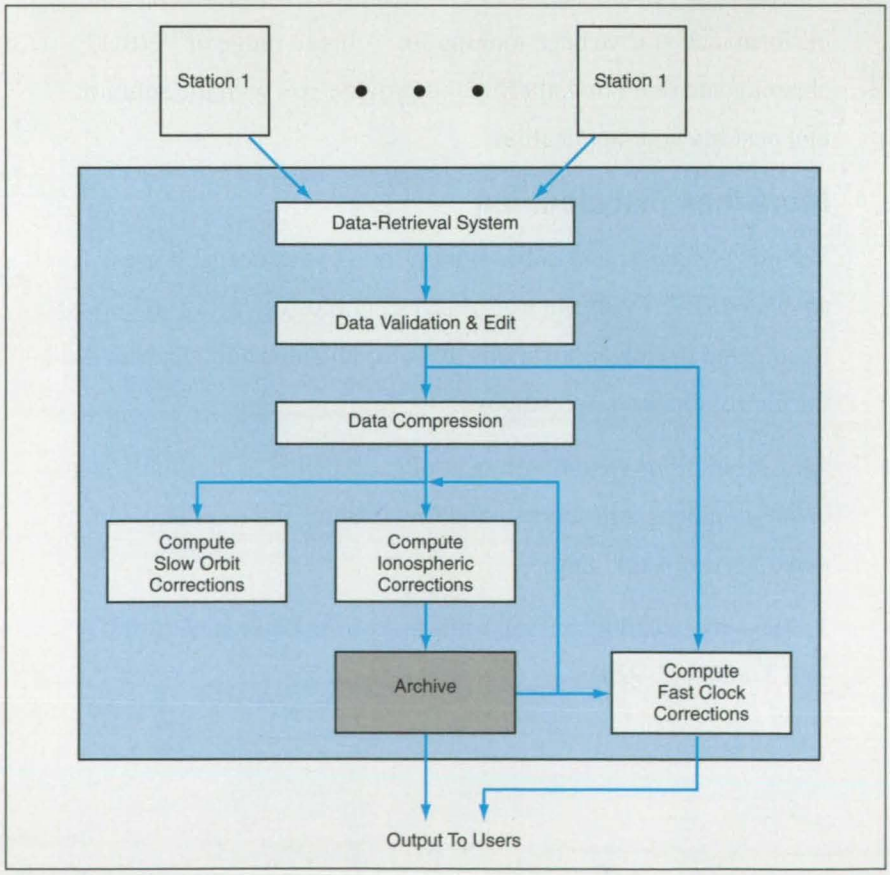
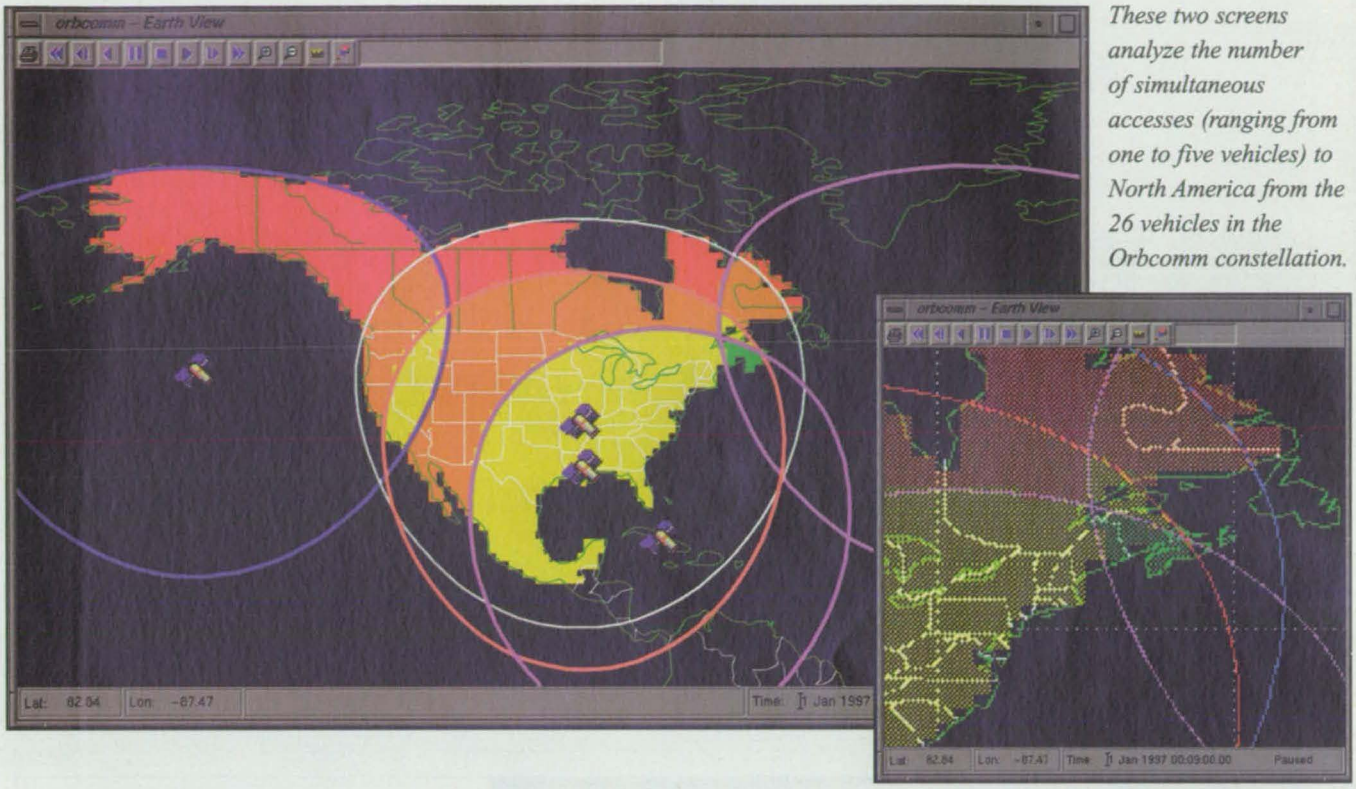


Figure 1. This **Flow Diagram** shows the sequence of computations in JPL's wide-area differential GPS navigation system.

Satellite Tool Kit Introduces:

The Coverage Module



These two screens analyze the number of simultaneous accesses (ranging from one to five vehicles) to North America from the 26 vehicles in the Orbcomm constellation.

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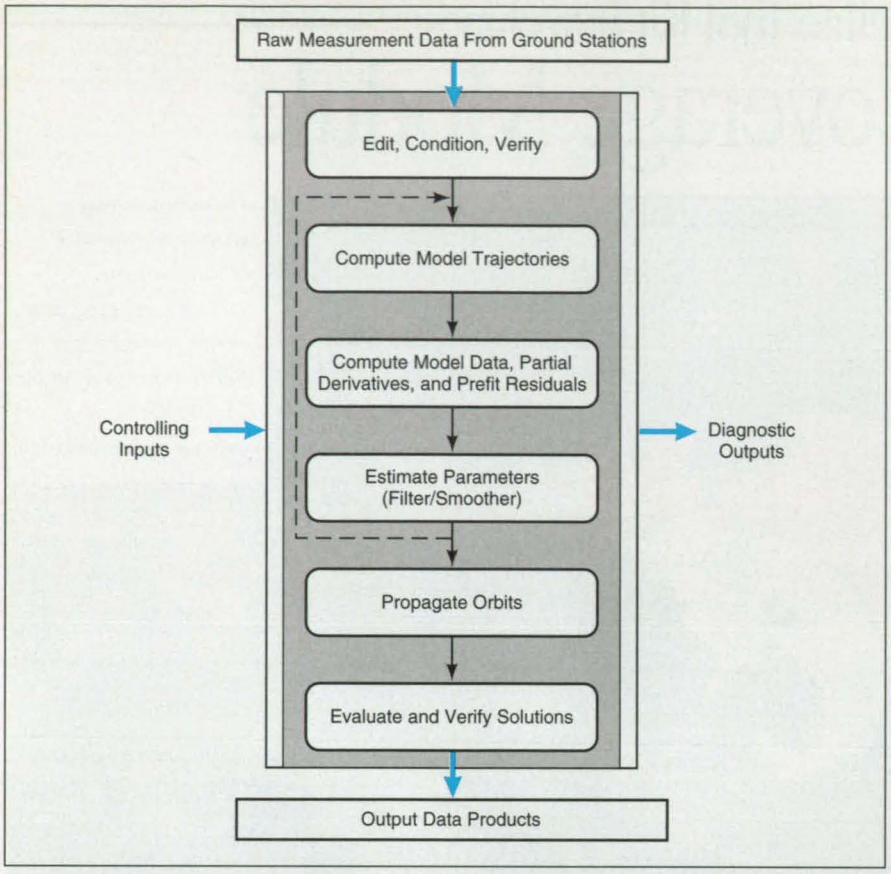


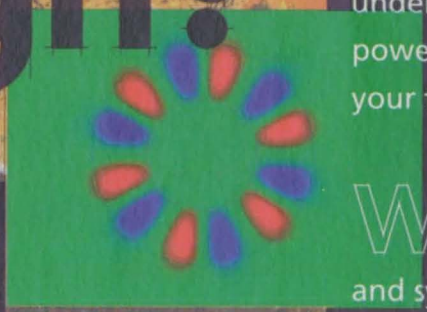
Figure 2. This **Flow Diagram** shows the sequence of computations effected by the GIPSY/OASIS II software.

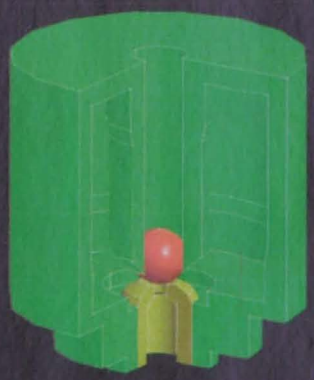
(2) computation of the predicted or a priori high-rate (1-second) GPS measurements in preparation for computing the fast corrections; (3) calculation of the fast clock corrections, together with their estimated errors, from the predicted and measured observables; (4) generation of ionospheric maps with high spatial and temporal resolution and computation of associated grid-point corrections; (5) computation of satellite integrity indicators; and (6) pre- and post-transmission independent validation of all data products. Each of these processes could be individually tuned for the job at hand without the need for a monolithic software package designed to perform all functions.

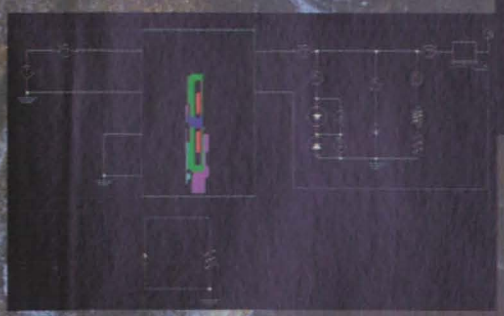
This work was done by Thomas P. Yunck, Willy I. Bertiger, Stephen M. Lichten, Anthony J. Mannucci, Ronald J. Muellerschoen, and Sien-Chong Wu of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 67*** *on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Resident Office–JPL; (818) 354-5179. Refer to NPO-19625.

what drives your design?







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Automated Tape Libraries for Mass Storage

Remote Sensing

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SONY

Window Units for Solar-Assisted Heating and Cooling

Spaces between inner and outer panes would be connected to inside or outside circulation paths.

Marshall Space Flight Center, Alabama

Window units containing inner and outer (storm) windows plus solar screens and mechanisms to control the circulation of air have been proposed. In the presence of sunlight, these window units would contribute some solar assistance for heating and cooling. At night or in cloudy weather, these units would act like ordinary inner-window/storm-window assemblies, suppressing the conduction and radiation of heat between the inside and outside to minimize undesired heating in hot weather or cooling in cold weather.

A typical proposed unit (see Figure 1) would include two window assemblies separated by a bay. Inlets and outlets through which air could enter and leave the space between the window panes would be located at the bottom and top, respectively, on both the outside and the inside. The bay would contain part of a mechanism that would open and close the inlets and outlets to control the circulation of air in the space between the window panes.

Each window assembly would contain a removable solar screen stretched across the space between the panes. In a conventional window equipped with a solar screen, the radiant solar energy intercepted by the screen heats the air trapped between the panes. In cold weather, this trapped hot air is wasted, though it could potentially be used for heating. In hot weather, some of the heat in the trapped air inevitably leaks into the building by conduction through the inner pane. The proposed window unit would utilize the trapped solar-heated air for heating the building in cold weather, and it would suppress leakage of solar heat into the building during hot weather. This would be accomplished by use of dampers at the top and bottom to control the flow of air through the inlets and outlets (see Figure 2), in response to the temperatures of the outside air and the air between the panes.

The mechanism for controlling the dampers would include levers and cams actuated by two hydraulic cylinders filled with temperature-sensitive material and opposed by springs. One of the hydraulic cylinders would be exposed to the outside air through louvers in the outer wall of the bay. The other cylinder would be exposed to the air between the panes through a hole between this space and the interior of the bay.

In the absence of appreciable solar heating (at night or in cloudy weather), the dampers would be positioned to close all inlets and outlets, so that the air between the panes would remain trapped as in an ordinary window assembly. In the presence of solar heating and cold outside air, the outside inlets and outlets would be closed, while the inside inlets

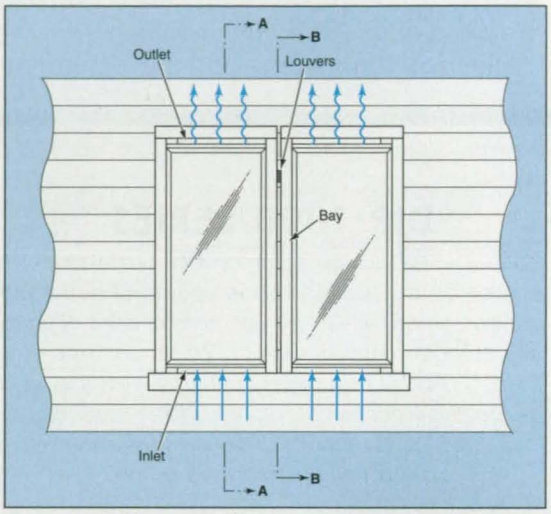

Figure 1. A **Thermally Efficient Window Unit** of the type described in the text would superficially resemble an ordinary window assembly in most respects, except that inlets, outlets, and louvers would be visible on closer inspection.

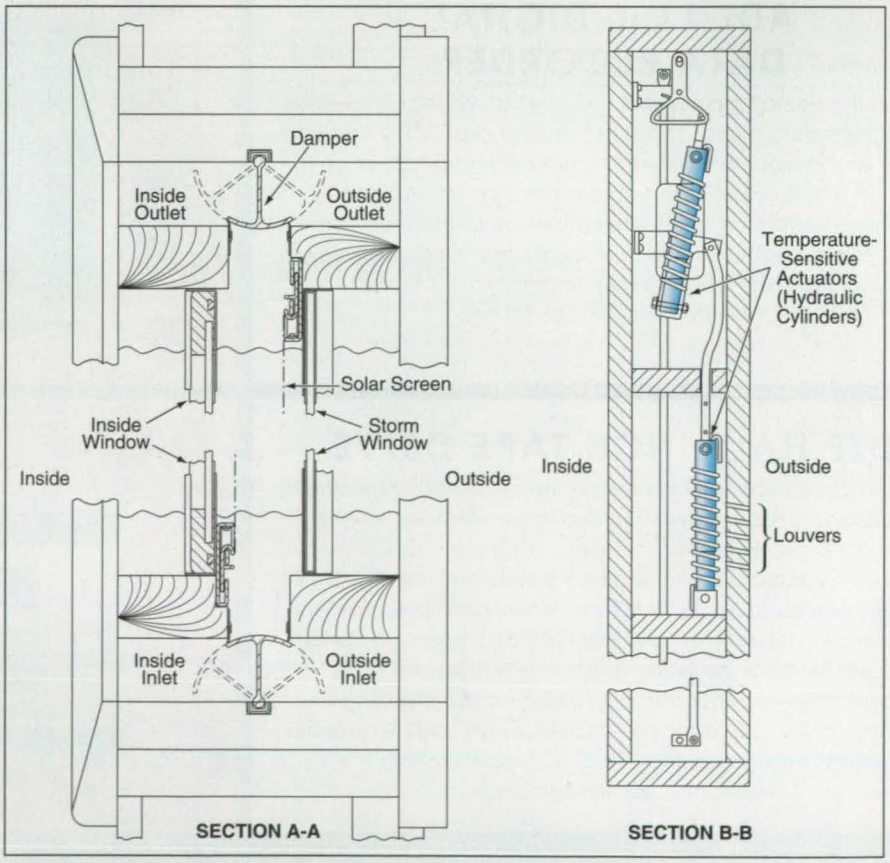

Figure 2. **These Enlarged Views of the Cross Sections** indicated in Figure 1 illustrate the major components of the air-circulation-control mechanisms of the window units.

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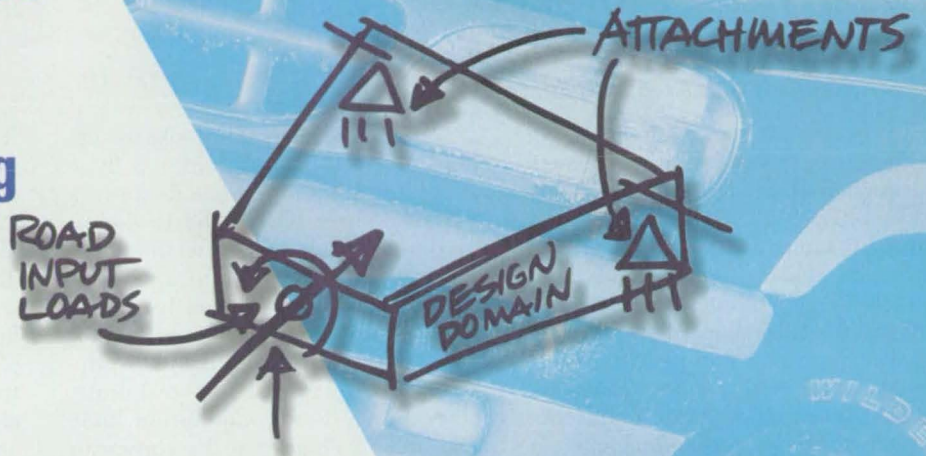

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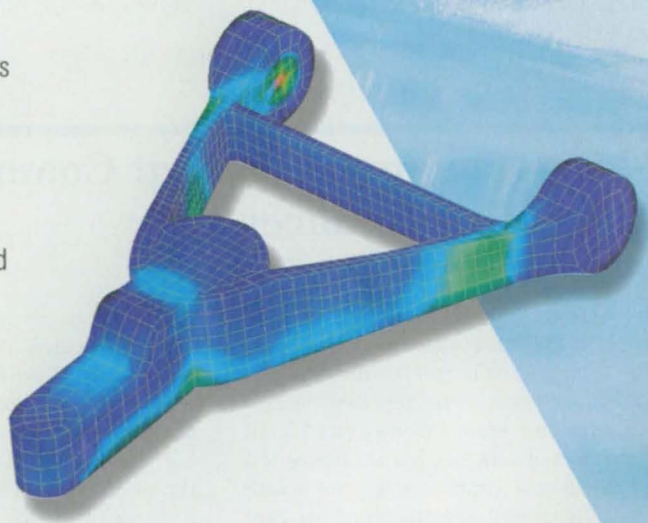

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and outlets would be opened to allow the solar-heated air to circulate from the window to the inside of the building. In the presence of solar heating and hot outside air, the inside outlets would be closed and the outside outlets would be opened, so that circulation of the solar-heated air to the outside would dissipate most of the solar heat from the window, reducing leakage of heat into the building.

This work was done by W. Neill Myers of **Marshall Space Flight Center**. *For further information,* ***write in 89*** *on the TSP Request Card.*
MFS-31088

Improved Data-Reduction Algorithm for Doppler Radar Wind Profilers

Wind profiles are generated more frequently.

John F. Kennedy Space Center, Florida

An improved data-reduction algorithm has been developed to enhance the availability, accuracy, and reliability of wind data extracted from outputs of Doppler radar wind profilers. The reduction of data from Doppler wind measurements includes, among other things, the extraction of weak wind-related spectral signatures from noisy signals that are contaminated with side lobes. The noise and side lobes contribute to errors and unreliability of wind data.

The original application for the present algorithm is in a 50-MHz Doppler radar wind profiler at Kennedy Space Center. Previously, a "consensus" algorithm was used to separate wind spectral signatures from noise and side lobes. The consensus algorithm involved extensive averaging, which took excessive time; only two wind profiles could be generated in an hour. Moreover, the averaging did not adequately suppress errors in that frequently, the consensus algorithm locked onto side lobes.

The present algorithm looks for the wind spectral signature within a "first-guess" spectral window based on previous valid data. Within the first-guess window, a median-filter technique is used to extract the current wind spectral signature for processing. Side lobes are usually rejected because they tend to fall outside the first-guess window. The median-filter technique takes much less computation time than does averaging in the consensus algorithm.

The major conceptual problems encountered in developing the present algorithm were selecting the width of the first-guess window and the parameters of the median filter to maximize the rejection of side lobes and noise while ensuring detection of the correct signal. In tests, the algorithm performed reliably and accurately, and was found to be capable of generating twelve wind profiles per hour. The root-mean-square wind-speed error of the present algorithm is of the same order of magnitude (1 m/s) as that of the consensus algorithm. Also in comparison with the consensus algorithm, the present algorithm produces large (> 5 ms) wind-speed errors less frequently, and produces wind data that are more reliable in the sense that they are valid a greater fraction of the time. The major weakness of the present algorithm is that the first-guess window occasionally fails to eliminate strong side lobe signals that are close to the true wind signal, and manual intervention is required to recognize and correct the situation.

This work was done by Robin Schumann of ENSCO, Inc., Timothy Wilfong of the University Space Research Association, and Steve Smith of Marshall Space Flight Center for **Kennedy Space Center**. *For further information,* ***write in 69*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Kennedy Space Center; (407) 867-2544. Refer to KSC-11860.

Using Langmuir-Blodgett Coatings To Calibrate Mass Microbalances

John F. Kennedy Space Center, Florida

Langmuir-Blodgett coatings can be used to calibrate mass microbalances like quartz-crystal microbalances and surface-acoustic-wave sensors. Microbalances are used to measure small quantities of solids or liquids deposited on surfaces. Calibration of a microbalance involves measurement of the response of the microbalance to a deposited surface film of known mass density. In comparison with other techniques for depositing a calibration film, the Langmuir-Blodgett coating technique offers advantages of less difficulty and repeatability without the use of an expensive surface tensiometer. In this technique, one prepares a monolayer of a suitable coating material in a Langmuir-Blodgett trough, then dips the microbalance in the trough to coat its sensory surface with the monolayer film. If necessary, the process can be repeated with different coating materials for a series of calibration measurements to determine the linearity of the response of the microbalance. The only major limitation on this technique is that one must select coating materials that do not chemically attack any part of the microbalance.

This work was done by Paul A. Mogan of **Kennedy Space Center** *and Lee Chow and Isaiah O. Oladeji of the University of Central Florida. For further information,* ***write in 76*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Kennedy Space Center; (407) 867-2544. Refer to KSC-11863.

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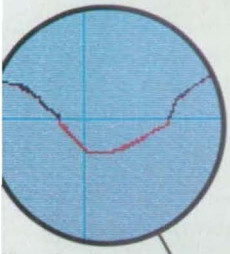

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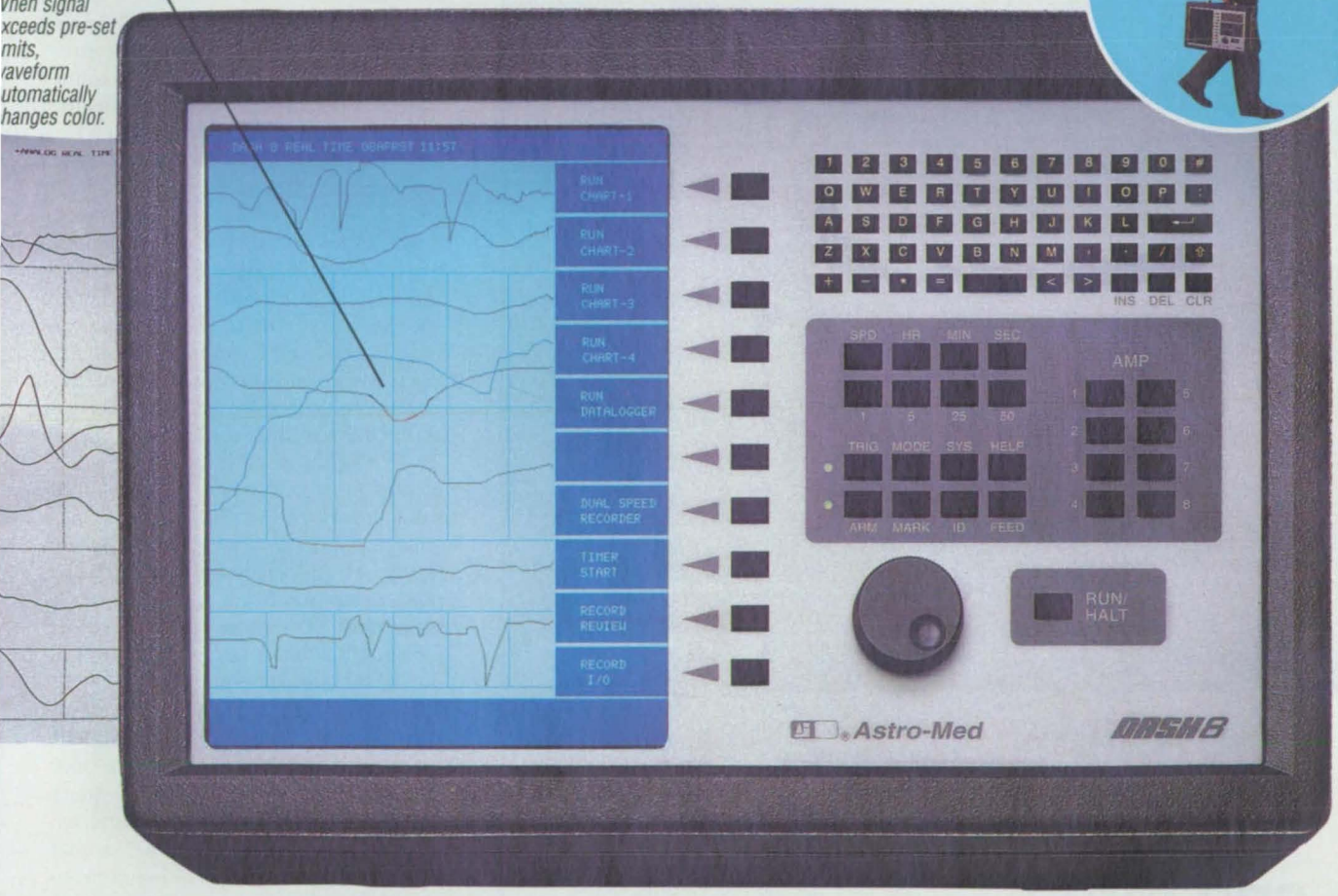

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Electrokinetic Evaluation of Surface Coatings

Measurements yield data on surface chemistries.

Marshall Space Flight Center, Alabama

An improved method has been devised for electrokinetic evaluation of surface chemistries of polymeric and other coating materials that are typically biocompatible and intended for use in suppressing, enhancing, and/or utilizing a variety of phenomena that could include wetting, adsorption of proteins, and/or electrophoresis. The method overcomes some of the limitations of conventional electrokinetic evaluation in terms of the zeta potential (the electric potential across the interface between a solid and a liquid).

Because the zeta potential of a chemical system can be related to a number of other properties of the system (e.g., agglutination, electrophoretic mobility, and surface charge density), it is widely used in industry and medicine to characterize particles in suspension and the surfaces of fixed apparatuses. However, it has been very difficult to use the zeta potential to derive such useful information as the densities of surface chemical groups, whether those groups are reactive, whether they have reacted with a coating polymer, and how long the coating has stayed attached. The improved method makes it possible to obtain such information.

The method involves measurements of the pH dependence of electroosmotic flow in an electrophoresis chamber in which the flow channel is typically a quartz capillary tube coated with a suitable polymeric material, which could be, for example, poly(ethylene glycol) (PEG). The measurement data are analyzed via a site-dissociation mathematical model of pH-dependent electroosmotic flow: the model, adopted from the classical theory of electrokinetics, is used to relate electroosmosis to surface chemistry. In the model, surface charge is represented in terms of acid/base site dissociation of ionizable surface groups. The distribution of electrostatic potential at the liquid/solid interface is related to surface charge by use of the Gouy-Chapman theory of the electrical double layer, plus exact solutions of the Poisson-Boltzmann equation. Electroosmotic mobility is related to zeta potential via the Smoluchowski equation.

In preparation for initial experiments according to this method, terminally activated derivatives of PEG were grafted onto the inner surfaces of quartz capillary tubes that had been functionally activated, variously, with 3-aminopropyltriethyoxysilane, 3-mercaptopropyltrimethoxysilane, or poly(ethylene imine). For each experiment, the capillary tube was inserted in a modified microelectrophoresis apparatus and the electrophoresis chamber (including the tube) was filled with an aqueous solution of 7.5 mM NaCl. To make the electroosmotic flow visible, the solution was formulated with a suspension of 1.02-μm-diameter sulfated polystyrene latex spheres at a concentration of < 0.01 percent solids. In the experiments, grafts and activated surfaces were electrokinetically characterized by measuring the pH dependence of induced electroosmotic flow. The figure illustrates the apparatus and the results of some of the measurements.

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TechniCom, Inc., Clifton, NJ, Mid-Range MCAD Benchmark Report, November 1996

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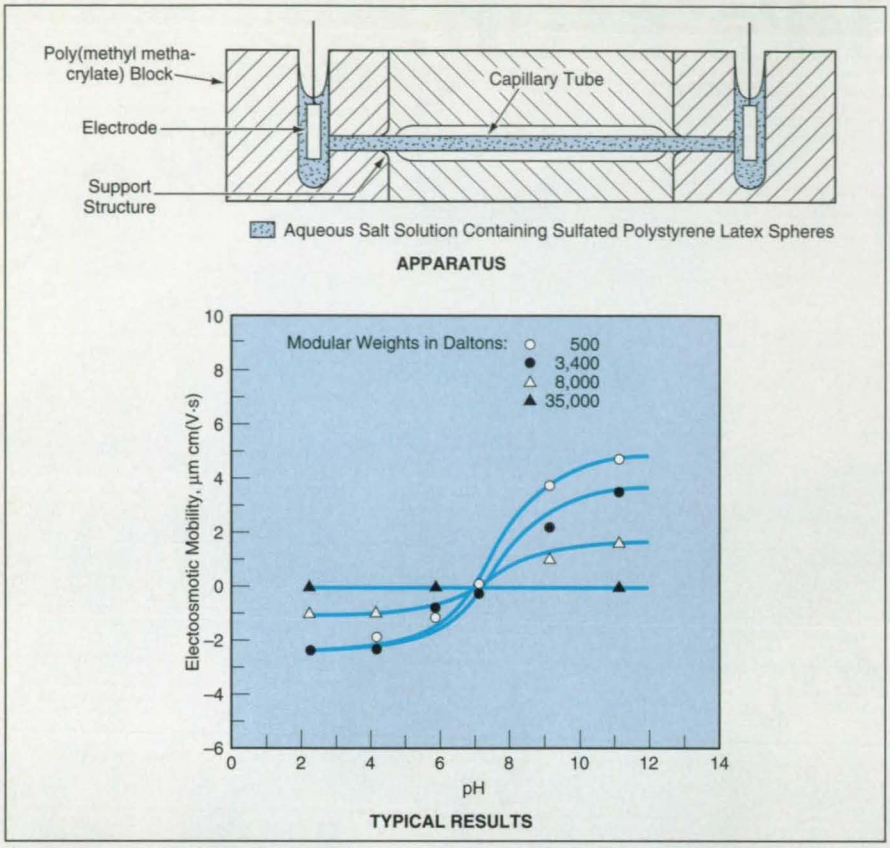
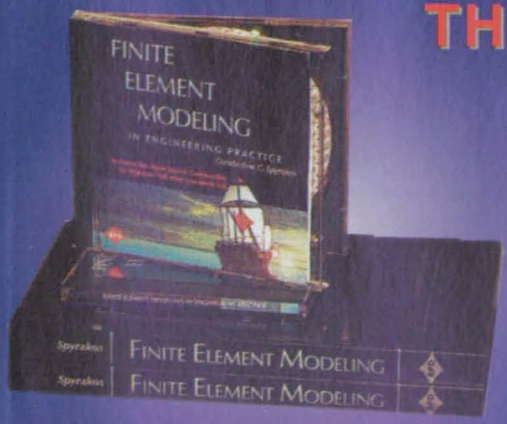


Electroosmotic Flow Was Measured in a modified microelectrophoresis apparatus. The curves were computed from measurements taken with capillary tubes coated with PEG of various molecular weights.

The mathematical model in this method provides means for quantitative determination of the densities of ionogenic surface molecular groups and of acidity and/or basicity in the near-surface environment. The model can also provide information on the effective coating thicknesses of adsorbed neutral polymers and, for some polymers, the relative graft densities. This information can be useful in interpreting complex chemical phenomena involved in applications of such PEG coatings as those used in preparation of nonfouling surfaces. In addition, electrokinetic characterization can provide information regarding stability of coatings, control of electroosmotic flow in analytical instrumentation, and the influences of adsorbed polymers on regulation of electric charges at aqueous/solid interfaces.

This work was done by J. M. Van Alstine, J. M. Harris, and N. L. Burns of the University of Alabama in Huntsville for **Marshall Space Flight Center**. *For further information,* ***write in 57*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center; (205) 544-0021. Refer to MFS-26360.



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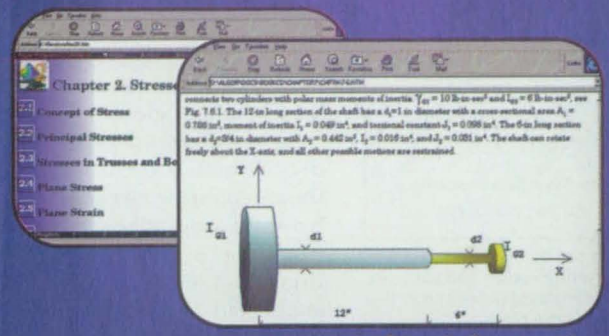

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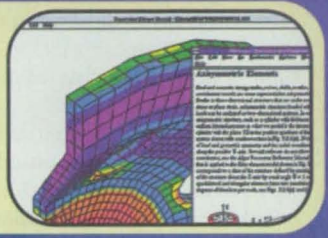

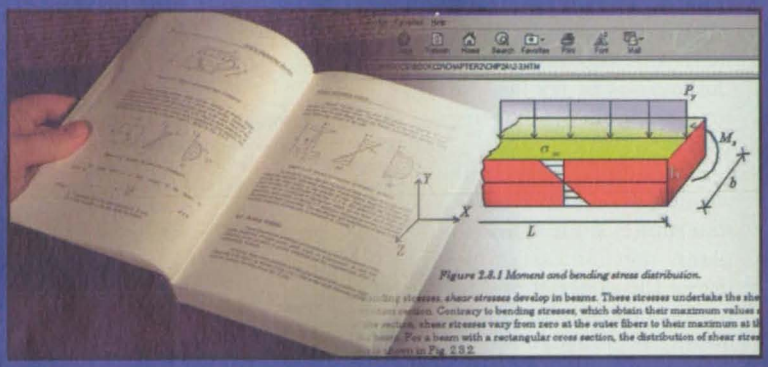

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Testing and Analysis of Clothlike Structural Components

Nonlinear properties are characterized by a combination of experimental and theoretical techniques.

Marshall Space Flight Center, Alabama

A method of testing and analysis has been developed to enable characterization of the nonlinear mechanical properties of three-dimensional structural components made of cloth and clothlike materials. This development was prompted by the need to understand the properties of proposed spacecraft aerobrakes that would be made of tailorable advanced blanket insulation (TABI) (see Figure 1). The method is also applicable to the analysis of textile structural components for terrestrial use.

An essential part of the method is a series of tests to determine some basic in-plane mechanical properties of the material or structural component of interest. Testing is necessary because manufacturers' data on the properties of individual filaments and yarns do not include the effects of slippage between filaments and yarns woven into fabrics, nor do they account for the weakening effects of contact stresses and residual stresses generated in the weaving process. The tests include tensile stress-vs.-strain measurements to obtain data on moduli of elasticity and strengths in the warp and fill directions, measurements of damping of free and forced vibrations under tension, and measurements of hysteresis curves under oscillating tension to obtain more complete information on the amount and type of damping. The results of initial tests of this type on TABI show that it stiffens as the applied load increases (see Figure 2) and that its in-plane damping behavior is consistent with that of a basic viscous damping mechanism for small vibration amplitudes.

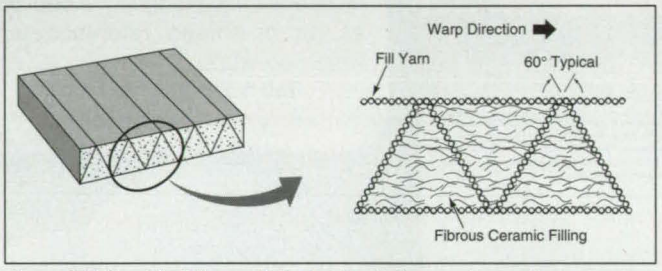


Figure 1. **Tailorable Advanced Blanket Insulation** can be used as a structural material. Because it has a three-dimensional configuration and complex mechanical properties, it must be analyzed by the method described in the text. Note that the fill direction is perpendicular to the page.

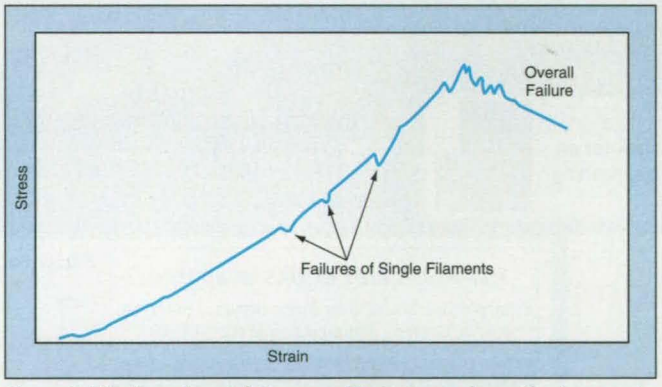


Figure 2. This **Experimental Stress-vs.-Strain Curve** shows the increase in stiffness with applied stress. It also shows that failure of the specimen occurred as a propagation of breakages of individual filaments rather than sudden failure of the entire specimen.

Another essential part of the method is prediction of the out-of-plane dynamic behavior of a clothlike structure from the in-plane data derived from tests and/or from mathematical models that incorporate these data. This is accomplished by use of a finite-difference mathematical model of the structure and the applicable differential equations of motion.

This work was done by Michael L. Tinker of **Marshall Space Flight Center** *and Joseph P. Clayton of Remtech, Inc. For further information,* ***write in 88*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center; (205) 544-0021. Refer to MFS-26357.

Water/Surfactant Solution as a Substitute for CCl_2F-$CClF_2$

John F. Kennedy Space Center, Florida

Commercial surfactants were tested to substitute for trichlorotrifluoroethane (CCl_2F-$CClF_2$) in special applications in which there is a need for solvent rinses to detect particulate contamination of workpieces. Deionized water without any additives has been found to dislodge fewer particles than does CCl_2F-$CClF_2$ because, it has been hypothesized, the high surface tension of pure water keeps the water from penetrating narrow passages, so that the water does not make contact with the entire surfaces of workpieces. In an experiment, water containing 25 parts per million of the commercial surfactant Zonyl FSN reduced the surface tension of the water from 72.8 dynes/cm to about 36 dynes/cm, and the water containing the surfactant was found to dislodge nearly the same amount of particulate matter as did CCl_2F-$CClF_2$. Unlike CCl_2F-$CClF_2$, the surfactant-treated water is nonpolluting and nontoxic. Moreover, in comparison with CCl_2F-$CClF_2$ the surfactant is inexpensive.

This work was done by Christian A. Clausen III of the University of Central Florida for **Kennedy Space Center.** *For further information,* ***write in 41*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Kennedy Space Center; (407) 867-2544. Refer to KSC-11906.

Adherent and Stable Metallization of CVD Diamond

The choice of adhesion and diffusion-barrier materials is critical.

NASA's Jet Propulsion Laboratory, Pasadena, California

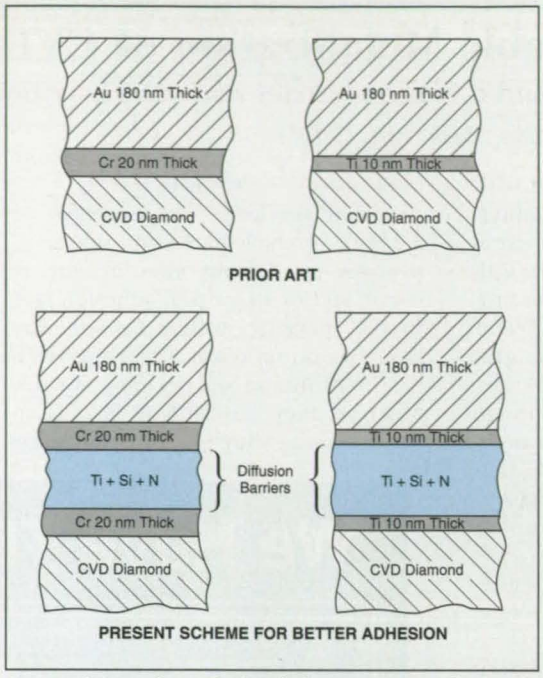
Experiments have shown that with the proper choice of materials, adherent and metallurgically stable metal contacts can be formed on chemical-vapor-deposited (CVD) diamond. Such contacts are needed for efficient thermal conduction and structural integrity in electronic devices designed for operation over a wide range of temperatures — especially in high-temperature electronic devices that exploit the electrically insulating and highly thermally conducting nature of diamond.

A metal contact on diamond is generally required to be both strongly adherent and stable at high temperature. The figure illustrates the material layers that are deposited in metallization of diamond, both (1) as practiced heretofore and (2) according to the present scheme for achieving adherence and metallurgical stability. To obtain strong adhesion, it is necessary to deposit a first layer of metal (the adhesion layer) that reacts chemically with diamond; to obtain high-temperature stability, it is necessary to deposit an overlayer.

Heretofore, adhesion layers have been made, variously, of Cr or Ti, while overlayers have been made, variously, of Au or Au/Sn alloy. Unfortunately, at high temperatures, Cr and Ti are soluble in Au and therefore diffuse from the adhesion layers into the overlayers, with resultant degradation of diamond/metal bonds and thus loss of adhesion. Typically, the maximum operating temperature at which minimum acceptable adhesion can be maintained is < 450 °C.

In the scheme for adherent and stable metallization of diamond, the adhesion layers and overlayers are made of the same materials as before, but in each case there are two adhesion layers separated by a diffusion-barrier layer. In this material system, a suitable diffusion-barrier layer is a film of amorphous Ti+Si+N that is reactively sputter deposited on the first adhesion layer, before depositing the overlayer. [Amorphous Ti+Si+N was previously developed for diffusion barriers between Si substrates and Cu overlayers.]

In the experiments, some CVD diamond specimens metallized variously as described above and illustrated in the figure were annealed for 30 minutes at each of a sequence of temperatures at intervals of 100 °C up to 900 °C. Each annealed specimen was subjected to 3.2-MeV-α-particle-backscattering spectroscopy to measure interdiffusion of metal, and to a tape-pull adhesion test. In the specimen with a Cr adhesion layer but no diffusion barrier, substantial interdiffusion and delamination was observed after annealing at 300 °C. In the specimen with Cr adhesion layers and a diffusion barrier, some interdiffusion was observed above the diffusion barrier, but the Cr adhesion layer below the diffusion barrier remained unchanged, and there was no delamination, even after annealing at 600 °C. In the specimen with Ti adhesion layer and no diffusion barrier, substantial interdiffusion was observed after annealing at 500 °C. The specimen with



Layers of Amorphous Ti+Si+N help to preserve adhesion at high temperatures by preventing diffusion of metal from the adhesion layers to the gold overlayers.

a Ti adhesion layer and a diffusion barrier performed the best of all: it exhibited no interdiffusion or delamination after annealing at 900 °C. In an additional test, this specimen also exhibited neither diffusion nor delamination after annealing for 100 hours at 400 °C.

This work was done by Andreas Bachli, Marc Nicolet, Elzbieta Kolawa, and Jan Vandersande of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 97*** *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

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Refer to NPO-19672, volume and number of this NASA Tech Briefs *issue, and the page number.*

Reinforced, Stretchable Elastomer for Use at Low Temperature

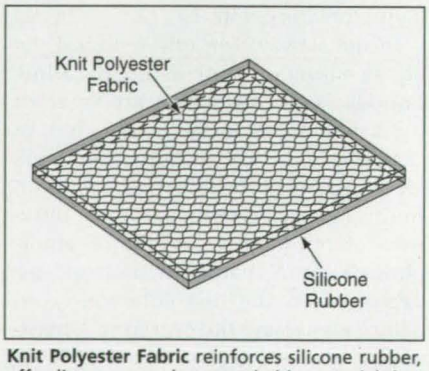
Knit fabric reinforcement prevents tears.

Lyndon B. Johnson Space Center, Houston, Texas

An elastomer reinforced with a knit fabric has been developed to satisfy the need for a material that remains flexible at temperatures down to –90 °F (–68 °C), can be stretched somewhat, and resists tearing. The material can be used in such diverse applications as lip seals, stretchable covers for machines, and Arctic structures.

The elastomeric matrix of this material is RTV 560 (or equivalent) silicone rubber, which remains flexible in the required temperature range, wherein most other elastomers become stiff or even brittle. However, this elastomer exhibits poor resistance to tearing. Accordingly, it is reinforced against tearing by incorporation of a knit polyester fabric (see figure).

The fabric stretches with the silicone rubber, but reaches a limit of stretchability below that of the rubber. The fabric thus stops the stretching at a predetermined tension, preventing tearing of the rubber. A knit (as distinguished from woven) reinforcing fabric was chosen because it stretches readily in any direction. A woven fabric, in contrast, stretches only on the bias and its fibers could slide relative to each other, allowing the rubber to tear.



Knit Polyester Fabric reinforces silicone rubber, affording a somewhat stretchable material that resists tearing and remains flexible in extreme cold.

This work was done by Scott A. Swan, Frederic Dawn, and Ernest Murry of **Johnson Space Center.** *No further documentation is available. MSC-22445*

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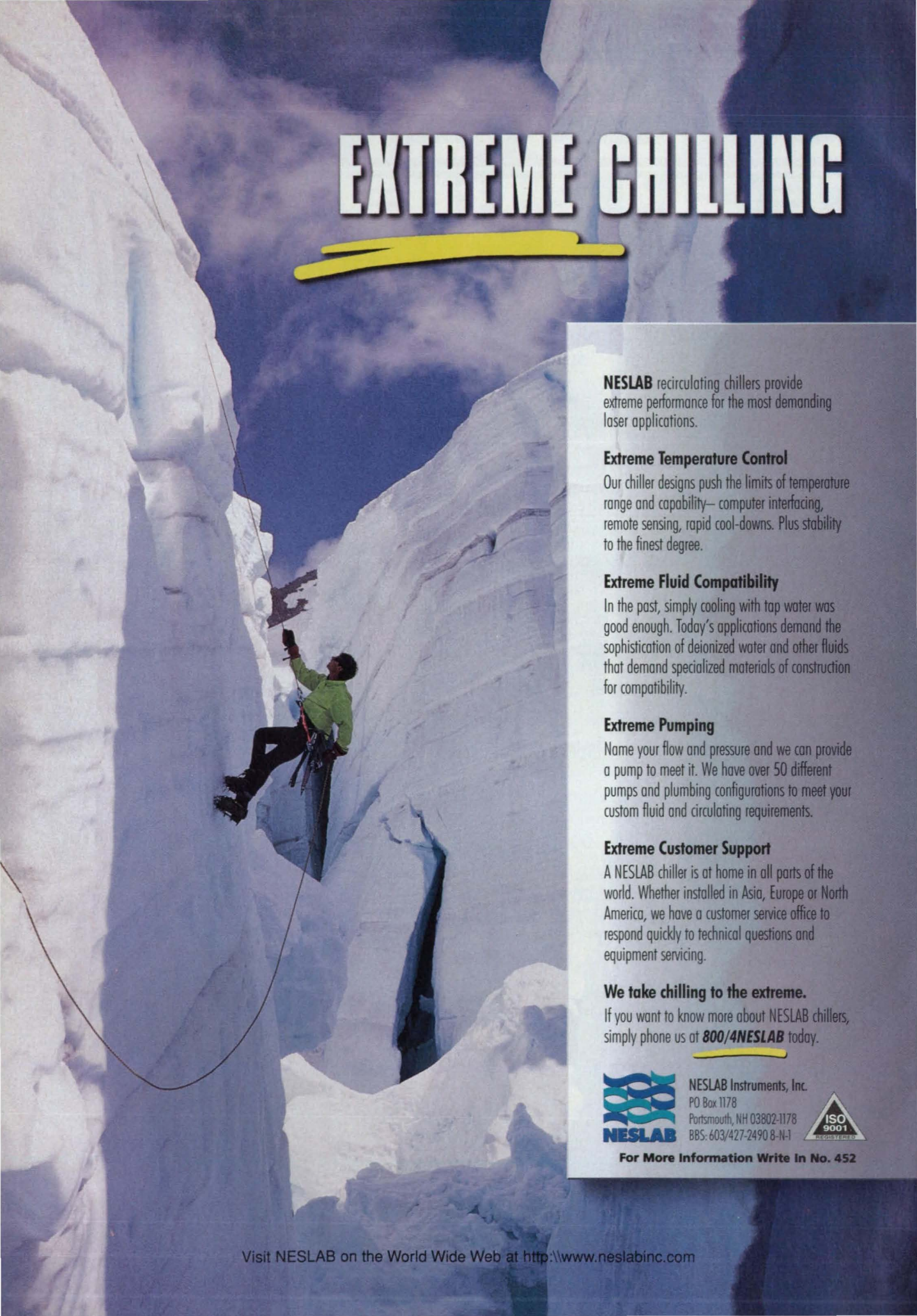

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DEPARTMENTS

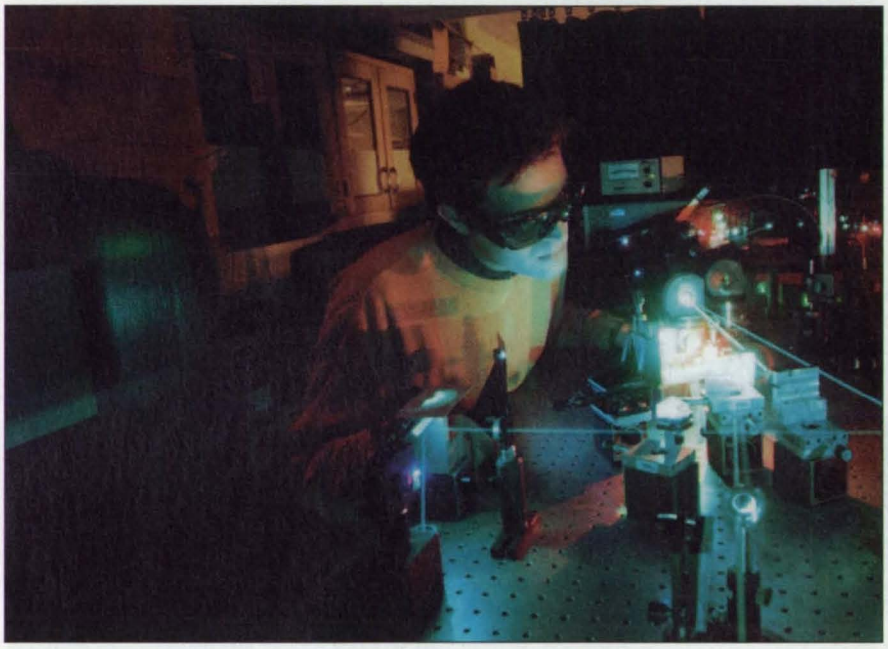
On the cover:

In addition to a standard line of solid-state scientific lasers, Continuum of Santa Clara, CA, supplies custom installations such as the one pictured here in a laboratory. The company specializes in high-energy Nd:YAG, glass, and ruby systems, macro-pulse designs, and terawatt benchtop lasers.

NEWS BRIEFS

Notes from Industry and the Federal Laboratories

In what **University of Michigan** (U-M) physicists call the first experimental modification of one of the fundamental quantum states of solid matter, they have used ultrafast laser pulses to "squeeze" atoms. It has been about a decade since scientists discovered how to create the squeezed state for photons, but the U-M experiment was the first to apply the technique to phonons, which carry vibrational energy through a solid.



University of Michigan graduate student Gregory Garrett with the laser system used in the "quantum squeezing" experiment. Photo: Bob Kalmbach, U-M

U-M graduate student Gregory Garrett conducted the experiment, using a Ti:sapphire laser at the Center for Ultrafast Optical Science. He aimed 70-femtosecond laser pulses at a tiny spot on a potassium tantalate crystal. Splitting the laser beam, Garrett diverted one part so that it arrived at the target a few picoseconds after the initial pump pulse. When the stronger pump pulse hits the atoms, it creates pairs of phonons and makes the atomic lattice oscillate, Garrett said. The weaker probe pulse is scattered by these phonons as it later passes through the lattice. Measuring the amount of probe pulse energy that gets through the crystal gives an idea of the atomic state inside.

One of the researchers, assistant professor Alberto Rojo, described the atoms in the lattice as bouncing balls tethered to a wall with elastic. When the initial laser pulse strikes, it stretches the spring constant of the elastic, expanding the quantum limits or the original range of the atom's movement. After the pulse passes, the elastic suddenly snaps back, reducing the atom's range of movement to a fraction of its original size. Thus for a very brief moment, equivalent to one-half its normal oscillation cycle time, the atom is "squeezed" below its quantum limit.

Along with Rojo and Garrett, other collaborators on the experiment included Roberto Merlin, professor of physics, A. K. Rood of the Indian Institute in Bangladore, and John F. Whitaker, associate research scientist at the U-M Center. The project was funded by the National Science Foundation and the Army Research Office.

SDL Inc., of San Jose, CA, announced that the Court of Federal Claims had granted summary judgment in its favor in a case brought against it by Rockwell. The judgment declared invalid key portions of a Rockwell patent for a metal-organic chemical vapor deposition (MOCVD) process used to manufacture optoelectronic devices. Rockwell had claimed that manufacturing processes SDL used to fabricate its semiconductor lasers infringed the patent.

Argonne National Laboratory has licensed to **Spawr Industries Inc.** of Lake Havasu City, AZ, the design for a monitor that aids in improving the quality of laser welds by identifying defects. The monitor was developed by the Dept. of Energy lab and **Delphi Energy and Engine Management Systems** of Flint, MI.

In cooperation with the Low Emissions Partnership (LEP) of the U.S. Council for Automotive Research (USCAR), Spawr changed the original design for the better by integrating the weld monitor into the focusing optics assembly, so that alignment is not necessary on the factory floor.

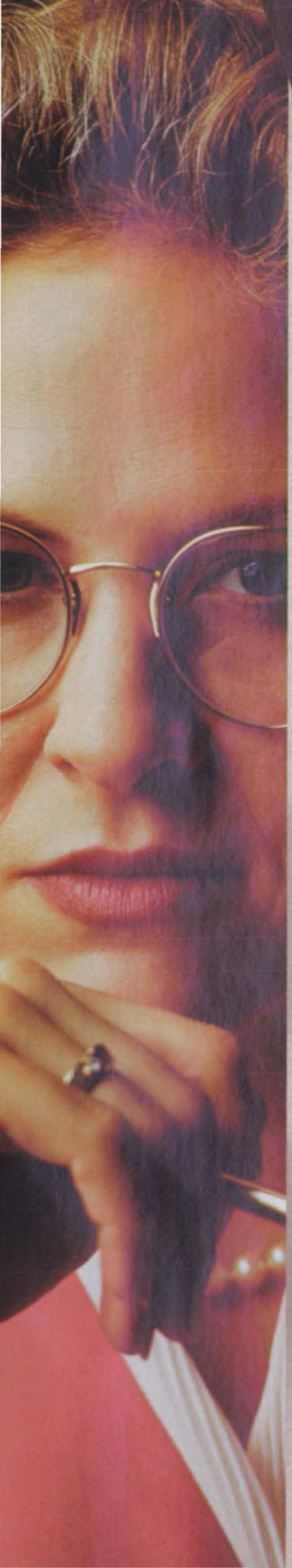
Designed to be rugged, low-cost, and simple to use, the system is based on a passive sensor and associated optics that measure infrared emissions related to weld penetration during processing. Thus the monitor can flag bad welds or automatically change laser power levels for a proper weld.

Spawr Industries also offers a stand-alone version of the monitor with laser aiming that is suitable for research and development applications, and another version that can be retrofitted on existing systems.

The project was funded through the Laboratory Technology Research Program in DOE's Office of Energy Research, and the Office of Transportation Technologies. One of 14 research consortia established by USCAR, which was formed by Chrysler, Ford, and General Motors, LEP explores and shares technology for reducing auto emissions.

The **U.S. Dept. of Commerce's** Economic Development Administration (EDA) has awarded the **Beckman Laser Institute** of Irvine, CA, a grant of $1 million to build a facility housing a Photonic-Based Defense Technology Incubator for Biomedical Devices and Systems. The facility will house a public-private consortium of medical device entrepreneurs, biotechnology firms, university biomedical researchers, and clinicians who will seek ways to apply lasers, optics, and detectors developed for military purposes to the diagnosis and treatment of disease. The Photonic Incubator will occupy a 10,000-sq.-ft. building expansion at the Institute, and will include engineering development and testing labs, a clinical applications suite, and program office space.

In addition to the grant from the EDA, which is approximately half of the construction funds, the project is getting operational funding from the California State Office of Strategic Technology, UC Irvine, and the Beckman Laser Institute. Dr. Arnold Beckman of the Beckman Family Trust has issued a challenge grant to provide construction funds.



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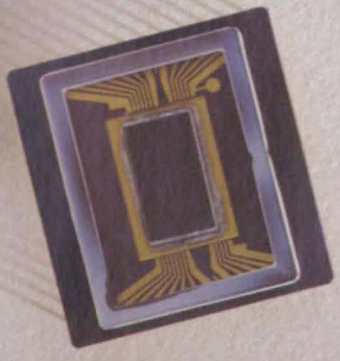

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Real-Time Fluorescence Imaging of Uranium, Polyaromatic Compounds, and Vegetation Stress

The laser-based technique maps emissions from spatially distributed materials.

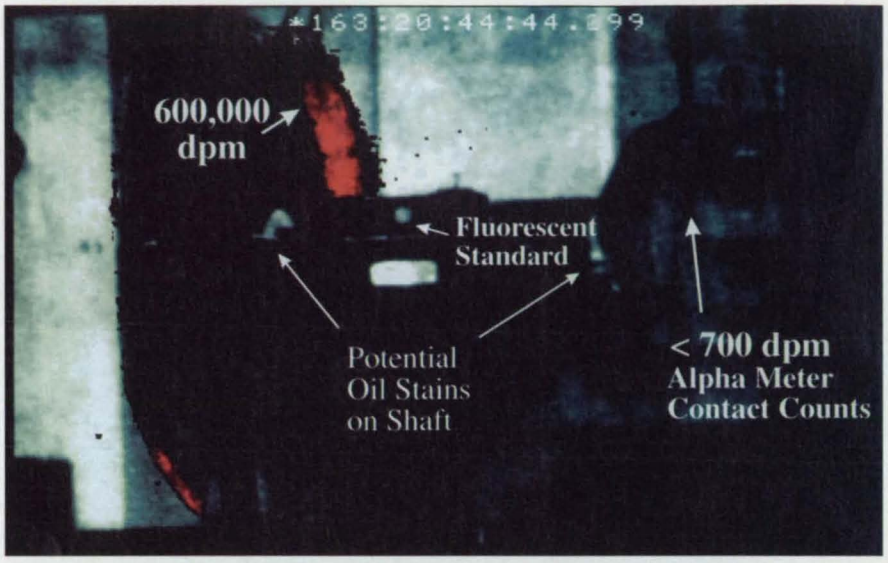
Special Technologies Laboratory, Santa Barbara, CA
Department of Energy, Assistant Secretary for Environmental Management, Office of Science and Technology (DOE/EM/OST)

A laser-induced fluorescence imaging (LIFI) system is being developed to aid in the detection, characterization, and monitoring of contaminants and the environment. LIFI is an optical technique based on the spatial imaging of fluorescent compounds irradiated with laser light. Initial LIFI work has focused on the detection of uranium during the decontamination and decommissioning (D&D) of buildings; the detection of polyaromatic (organic) compounds (PAHs) in water and soils; and vegetation stress as an indicator of subsurface contamination and general plant health.

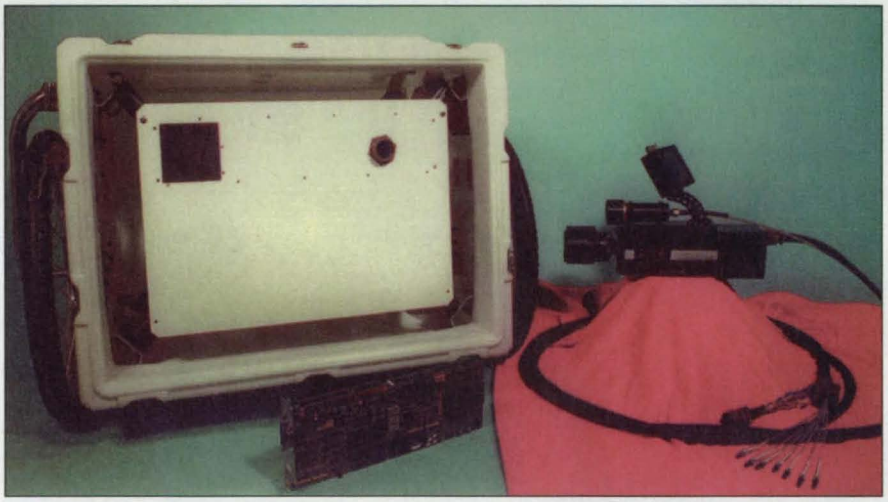
Compared with passive electro-optical imaging sensors, LIFI is capable of greater spectral selectivity and sensitivity and can be used during night/low-light operations. Compared with radiological sensors (*e.g.*, NaI and HPGe crystal-based sensors), LIFI offers better chemical speciation and greater spatial resolution for material identification and location.

Two operational versions of the LIFI system are currently being developed and evaluated: an airborne sensor for large-area surveys, and a handheld system for indoor and spot investigations. The current LIFI configurations include UV and visible laser sources (355- and 532-nm wavelengths), intensified charge-coupled device (CCD) cameras, and real-time image processing systems for instantaneous viewing. In the close-proximity systems, such as the uranium survey tool, video images are stored digitally for future display and analysis. The airborne system stores a large "cube" of imagery in multiple colors using a custom interface and disk array.

Although fluorescence spectra have been measured for decades, LIFI is truly innovative because it is an imaging system capable of mapping surfaces—a critical need for contaminant remediation in the environment. LIFI data are not simply one-dimensional fluorescence spectra, but image maps of fluorescent emissions from spatially distributed materials. In environmental terms, these image maps could represent uranium particles spread over a field or within a building, or they could be stressed trees, shrubs, and grasses that have been affected by subsurface contaminant flow.



Laser-Induced Fluorescence Imagery at the K-27 Gaseous Diffusion Facility at Oak Ridge, TN. The gray areas show the prompt fluorescence, with the electro-optic shutter open during illumination. The red areas show the uranium fluorescence view, with the delayed long shutter rejecting the prompt view. Photo courtesy of USDOE Special Technologies Laboratory.



The **Handheld Uranium Survey Tool**. Photo courtesy of USDOE Special Technologies Laboratory.

The spectral characteristics of material fluorescence are often a function of the excitation wavelength of the light source. This is especially true for complex materials such as plants. At a given excitation wavelength, material fluorescence can be defined by its emission spectrum and decay time. Most materials have peak-response wavelengths for excitation and emission, as well as a time period during which the emission occurs. In other words, a specific laser wavelength will induce the maximum fluorescence response from a given material during a specific period of time. Tests of laser fluorescence techniques for the U.S. Navy showed that environmental contaminants, including organic solvents, polyaromatic hydrocarbons (PAHs), and heavy metal oxides, had relatively unique fluorescent responses, or "signatures," when illuminated by a XeCl UV excimer laser system. Further tests in the laboratory

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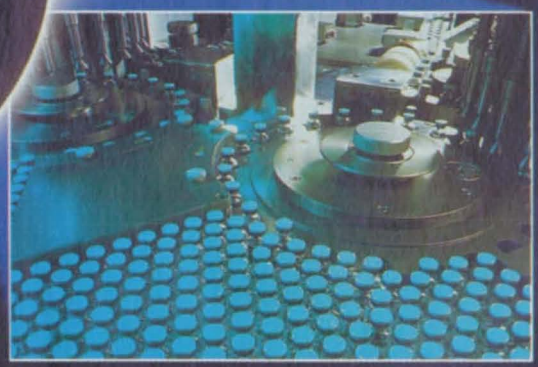

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defined a signature for uranium oxide.

The LIFI technique for uranium detection is based on the time-delayed fluorescent properties of uranium in the VI+ oxidation state. Most compounds that fluoresce, particularly such organics as chlorophyll in plants and hydrocarbon fuels. will do so promptly during excitation. When uranium is excited by a UV laser at 355 nm, however, its peak fluorescence is persistent (phosphorescent), lasting considerably longer than the laser pulse. By delaying the activation of the camera shutter after a laser pulse (on the order of nanoseconds), the prompt fluorescence of other compounds can effectively be removed, isolating the presence of uranium. Spectrally filtering with a bandpass filter decreases the total amount of ambient light that is collected during the camera's gate pulse and helps to reject any out-of-band phosphorescence associated with other materials. It also serves to increase image contrast.

In the current handheld system pictured, the laser and power supply are housed in a portable cart fiber-optically cabled to the handheld (camera/laser head) unit. In operation, the user has a head-up display on the handheld unit for the instantaneous display of data. In the system currently being fabricated, the cart is being replaced by a backpack unit weighing approximately 30-40 lbs., depending on system configuration. The airborne system was designed in modular units so that it can be flown on a number of different platforms. The system is scheduled for flight tests this year on a U.S. Army Blackhawk helicopter.

This work's principal investigator is Dr. John DiBenedetto of the **Department of Energy's Special Technologies Laboratory (STL)**. *For further information, contact Dr. DiBenedetto at (805) 681-2240 or E-mail: dibeneja@nv.doe.gov.*

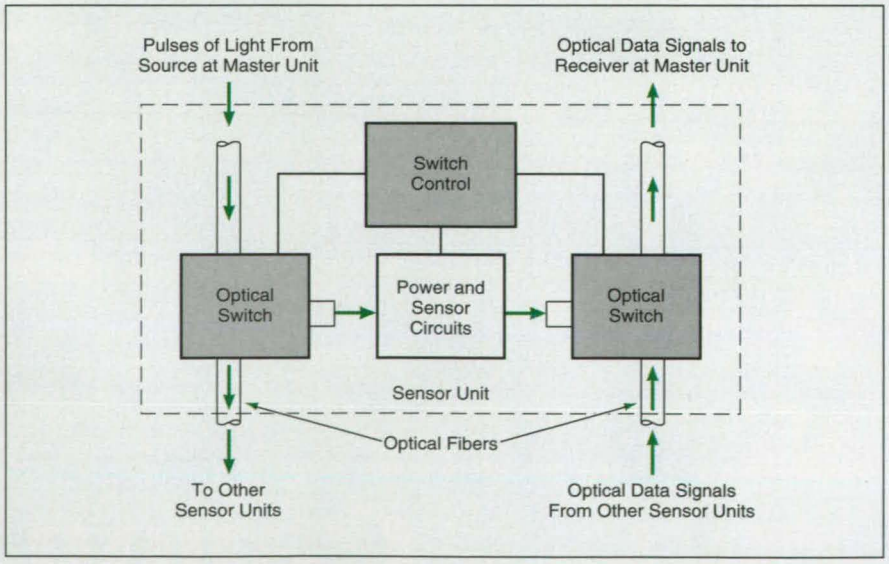
Inquiries concerning rights for the commercial use of this invention should be directed to Charles Hudson, STL, at (805) 681-2234.

Data Protocol for Optically Powered Sensors

Data-transmission intervals would coincide with power-interception intervals.

NASA's Jet Propulsion Laboratory, Pasadena, California

A data-transmission protocol has been devised for proposed optoelectronic sensor units that would be strung in series along optical fibers and powered by pulses of light. More precisely, the sensor units would be connected in series along two optical fibers; one fiber for distribution of power from a master unit to the sensor units, and one fiber for transmission of sensor data from the sensor units back to the master unit (see figure).



Two Optical Fibers would connect all units, as in a string of beads. Each unit, in turn, would extract power from the left optical fiber and transmit data to the master unit along the right optical fiber during part of the operating cycle.

The operation of the power-distribution subsystem was described in "Fiber-Optic Distribution of Pulsed Power to Multiple Sensors" (NPO-19420), *NASA Tech Briefs*, Vol. 20, No. 5 (May 1996), page 18a. To recapitulate: Pulses of laser light would be transmitted along an optical fiber from a power-supply unit. Each sensor unit would include an electronically controllable optical switch, which could be controlled to either (a) divert all of the optical power to a photovoltaic cell and power-conditioning circuitry to charge an energy-storage device in the sensor unit or else (b) allow the light to continue traveling along the power-distribution optical fiber to other sensor units downstream. Each sensor unit, beginning with the one nearest the laser source, would take all the optical power in the fiber for a fraction of each pulse period, and then would once again allow light to pass through to the next sensor. Thus, each sensor in turn would consume all the power for some fraction of the time of the pulse that remained after partial consumption by the preceding sensors.

The data-transmission protocol would be based on the power-distribution protocol and would be implemented with the help of a second electronically controlled optical switch in each unit. Success in building systems according to this concept would depend on the anticipated development of such optical switches with low insertion losses and the ability to operate on low control power. The data-transmission switch in each unit would be set in the pass-through state during the power-pass-through portion of the operating cycle. However, during the power-interception portion of the operating cycle, the data-transmission switch would be set to couple an optical data signal from the sensor unit into the fiber, propagating toward the master unit. This optical signal would bear sensory data stored since the previous transmission period. By relying on the power-transmission protocol for timing, one could ensure that each sensor unit, in turn, could have a clear optical channel to the master unit for optical transmission of data without interference from the other units.

This work was done by Harold Kirkham of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 6*** *on the TSP Request Card.*
NPO-19421

Insensitive Laser-Ignited Explosive Components

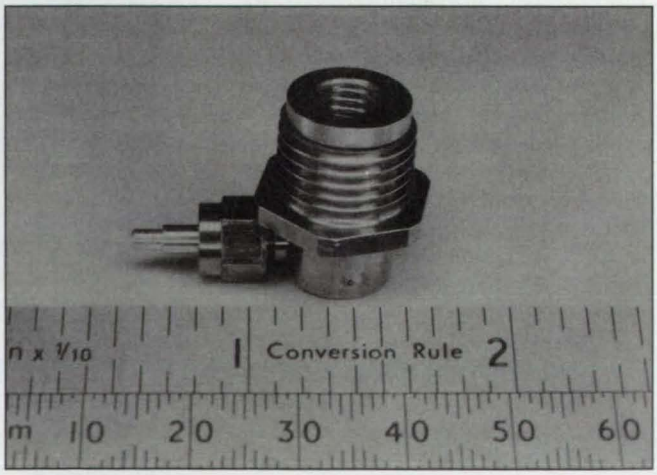
Explosive components are designed to be safe in adverse environmental conditions.

EG&G Mound Applied Technologies, Miamisburg, Ohio

Pyrotechnic and explosive components, which include ignitors, detonators, and actuators or squibs, are employed in a number of applications from the stage separation of rockets to the deployment of airbags in recent-model automobiles. Present-day devices are typically functioned by delivering an electrical signal through a metal pin or pins to the bridgewire. These pins are electrically isolated from each other and the metal shell by an insulating material, usually a ceramic, glass, or glass-ceramic. The energy obtained from the bridgewire ignites the surrounding energetic material, resulting in the component performing the required operation.

Over the years bridgewire components have been used in numerous applications despite having several inherent safety limitations. These safety concerns are based on the fact that the energetic or explosive material contained within the component is not truly isolated from the outside environment, making them susceptible to the effects of: (1) spurious levels of electromagnetic radiation (radars); (2) electrostatic discharges (lightning); and (3) temperature transients, principally fire-related, which may result in the undesired activation of the component. Therefore, these components are capable of premature ignition, which may result in catastrophic personal injury and/or property damage.

During the last several years laser-ignited explosive components which are impervious to electromagnetic radiation and electrostatic discharges have been developed. Laser-ignited explosive components utilize a combination of either a laser and optical fiber or a laser and a transparent window in place of a bridgewire and metal pins. These laser-ignited components can be initiated using a variety of rod or semiconductor lasers that produce sufficient energy through an optical fiber to ignite the energetic material. Even though these components are impervious to electromagnetic radiation and electrostatic discharges, they are still not completely environmentally safe since they are susceptible to inadvertent initiation due to bonfire or transient heating events. This fire safety concern has been the driving force in the development of insensitive bonfire-safe laser-ignited components that are equipped with safety valves.



An unloaded **Bonfire-safe Laser-Ignitable Right-angle Actuator** designed by EG&G Mound Applied Technologies.

Most explosive components are fabricated using energetic materials that are relatively stable at typical operating temperatures. In normal stockpile conditions the temperature transients are well known and frequently controlled. However, in an uncontrolled fire situation, the energetic material within a component may ignite once the storage temperature exceeds the autoignition temperature of the material, and this may function the component. Such functioning in a munitions storage situation has catastrophic potential.

The principal concept used in the design of bonfire-safe insensitive laser-ignited components is that in most cases energetic components will not properly function if the "burning" energetic material is not confined. An example is devices that are designed to grow to detonation (DDT). When the explosive is ignited it first burns or deflagrates, and only if the reaction is physically confined can it transition to a detonation. Devices such as actuators that are designed to be deflagration-only devices also will not perform their intended function if the gas pressure of the deflagration is allowed to escape from the burning charge cavity before sufficient pressure buildup is achieved. If the gases produced are not contained and transferred to the appropriate location then the device will not function as designed.

The photograph shows an unloaded bonfire-safe actuator that contains several important design attributes that demonstrate the adaptability of this technology. This actuator has been designed to be laser-ignitable, bonfire-resistant, and a compact right-angle component. The additional development of compact right-angle components is necessary since in many applications the amount of available space within the system of interest is minimal. Optical connections to laser-ignited components are made using optical fibers. Since the optical fibers are brittle, they have minimum bend-radius specifications that are dependent on the diameter of the fiber. In some applications these specifications would limit the use of laser-ignited components. Right-angle components such as the one shown greatly increase the application of laser-ignited components in space-limited situations.

Right-angle laser-ignited bonfire-safe energetic components have been fabricated and tested. Prior to loading with the energetic material the components were determined to be hermetic, with helium leak rates of less than 1×10^{-8} cm^2/s. The optical transmission of the unloaded component was also measured using a laser diode and a power meter, and the optical transmission was greater than 75 percent of the incident laser energy. After these tests were completed the test components were loaded with the secondary explosive HMX (autoignition temperature of ~250-300 °C), which was doped with 3 percent carbon black. Components of this design have been successfully functioned by connecting them to a laser diode via a 100/140-micron step-indexed optical fiber. Laser ignition tests were performed using ~750-mW/10-ms pulses that successfully functioned the components.

Bonfire tests on these components have been performed by placing loaded units in an oven and heating them at various ramp rates from room tempera-

ture to ~400 °C. Devices of the type in the photo have successfully passed bonfire tests in which the loaded components were placed within an explosion-proof oven and heated at ~8 °C/min from room temperature to ~400 °C. During the heating cycle the gases formed by the deflagration of the energetic material within the component were safely relieved without functioning the component.

It has been demonstrated that the fabrication of hermetic laser-ignited bonfire-insensitive explosive and pyrotechnic components is possible. Several types have been fabricated and tested using a variety of pyrotechnic and explosive materials. This new technology, based on a laser/optical fiber combination in place of bridgewires and pins, can readily be adapted to various engineering requirements. Several novel processing techniques have been developed for fabricating the devices that exhibit the required strength and hermeticity to ensure successful functioning. These results illustrate that there are no fundamental reasons why laser-ignited components should not be considered for future applications of pyrotechnic and explosive components in adverse environmental conditions.

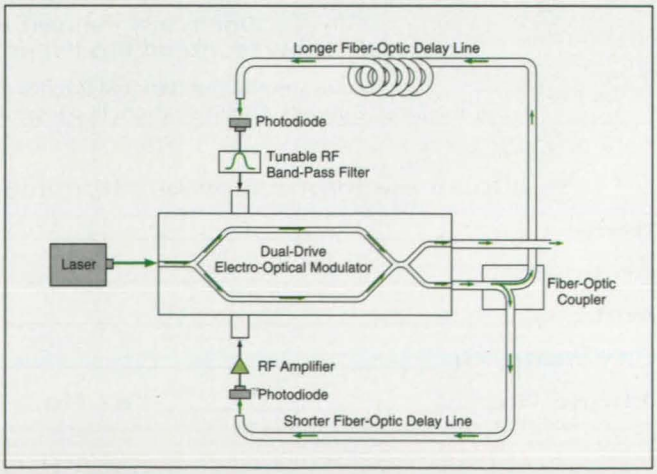
This work was done at **EG&G Mound Applied Technologies**, *which is operated for the U.S. Department of Energy under contract no. DE-AC04-88DP43495. For more information about this work, contact Dr. Daniel P. Kramer at EG&G Mound Technologies, Building 102, PO Box 3000, Miamisburg, OH 45343; (937) 865-3558; fax (937) 865-3223.*

Multiloop Photonic/Electronic Frequency Synthesizers

Advantages would include low phase noise, wide tuning range, and high frequency resolution.

NASA's Jet Propulsion Laboratory, Pasadena, California

Improved photonic/electronic oscillators with both optical and electrical outputs have been proposed in a continuing effort to develop frequency synthesizers with low phase noise, wide tuning range, and high resolution in frequency. A frequency synthesizer of this type would be an optoelectronic oscillator (OEO) with multiple parallel optical feedback loops and with a tunable radio-frequency (RF) filter.



An **OEO With Two Fiber-Optic Delay Lines** would offer the greater phase stability of a longer feedback loop and the greater tuning range and frequency selectivity of a shorter feedback loop.

OEOs were described (though not under the name "OEO") in three previous articles in *NASA Tech Briefs*, namely, "Electro-Optical Subcarrier Modulator as Microwave Oscillator" (NPO-19440), Vol. 20, No. 9 (September 1996), page 4a; "Electro-Optical Clock- and Carrier-Signal Regenerator" (NPO-19573), Vol. 20, No. 9 (September 1996), page 6a; and "Self-Injection-Locked Electro-Optical Microwave Oscillator" (NPO-19568), Vol. 20, No. 8 (August 1996), page 17a. These prior OEOs included single optical feedback loops. The use of multiple optical feedback loops in the proposed OEOs would be essential to their improved performance, as explained below.

In a basic OEO, a single optical feedback loop is concatenated with an electrical feedback loop. By including an RF filter with narrow pass band in the electrical feedback loop, one can allow oscillations to occur in one mode while suppressing oscillations in other modes. To reduce the phase noise of the OEO, the length of the optical feedback loop must be increased; this reduces the frequency interval between modes, necessitating a reduction in the bandwidth of the RF filter to ensure the selection of only the desired modal frequency. However, at a typical frequency that one seeks to generate (of the order of 10 GHz), it is difficult to make an RF filter with pass band narrow enough to discriminate between modes. In addition, the inclusion of a narrow-band RF filter sacrifices the tunability of the oscillator.

The proposed multiple-loop OEOs are intended to satisfy the need for both (1) longer optical feedback loops to reduce phase noise and (2) shorter optical feedback loops to facilitate discrimination against unwanted modes without narrow-band RF filters, while providing broad frequency tunability. The figure illustrates one of several dual-loop versions. This OEO would include a pump laser, a longer and a shorter fiber-optic delay line (longer and shorter optical feedback loops), a photodiode followed by an amplifier at the output end of each optical fiber, and a dual-drive electro-optical modulator driven by the outputs of the amplifiers.

Suppose that the loop gains were adjusted to be more than 1/2 but less than 1 in each loop. Then oscillation could occur at and only at a radio frequency at which the signals arrive in phase at the output ends of both optical fibers; this would constrain the frequency interval between oscillation modes to be the larger interval of the shorter loop. Because of the relatively large frequency interval between oscillation modes, an RF filter with a relatively wide pass band would suffice to ensure single-mode operation. At the same time, the phase noise would be dictated by the longer loop and would thus be relatively low.

The tuning range of the OEO would be determined by the mode spacing of the shorter loop and the tuning resolution would be determined by mode spacing of the longer loop. For a larger tuning range, a tunable RF filter could be used. The combination of the twin loop OEO and a tunable RF filter would result in a novel frequency synthesizer with wide frequency tuning range, low phase noise, and high frequency resolution.

The frequency of oscillation (f) of a basic OEO can be changed by changing the effective length (L) of the feedback loop. The fractional change in frequency is given by $\Delta f/f = -\Delta L/L$. Because a given change in length constitutes a larger fraction of L in the shorter loop of a dual-loop OEO, such an OEO could be tuned through a wider range by adjusting the length of the shorter loop. The tuning range would be determined by the frequency interval between modes of the shorter loop, while the tuning resolution would be determined by the frequency interval between modes of the longer loop. For example, if the fiber-optic delay lines in a dual-loop OEO were made of typical materials and the lengths of the loops were 20 cm and 10 km, respectively, then the tuning range would be about 1 GHz and the tuning resolution would be about 20 kHz.

A tunable RF filter could be used to widen the tuning range. The tuning of the middle frequency of the pass band of the RF filter should be synchronized with the tuning of the length of the shorter optical fiber. The incorporation of the tunable RF filter in this way should result in a frequency synthesizer with a tuning range of tens of gigahertz, low phase noise, and high frequency resolution.

This work was done by Xiaotian Steve Yao of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 40*** *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:

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Refer to NPO-19825, volume and number of this NASA Tech Briefs *issue, and the page number.*

Joint-Transform Optical Correlator With Holographic Memory

Many correlations could be made quickly, without a large computer memory or extensive computation.

NASA's Jet Propulsion Laboratory, Pasadena, California

A joint-transform optical correlator has been demonstrated as a prototype of a class of real-time and nearly-real-time pattern-recognition systems. Like other optical correlators, its overall function is to make a correlation image, which indicates, in effect, the closeness of match between an input image and a known stored image. One of the outstanding features of this apparatus is a memory device in the form of a photorefractive crystal that stores holograms of as many as 5,000 known reference images. This optical memory device eliminates the need for a large digital computer memory to store the data on the reference images. The input image can be correlated quickly with all of the reference images by mostly optical and some relatively simple electronic means, without need for time-consuming digital computation. This joint-transform optical correlator is also shift-invariant, so that it can also track the input image. Systems of this type could be useful in such diverse applications as recognition of military targets, identification of fingerprints, and robotic navigation.

The left side of Figure 1 illustrates schematically the recording and readout of reference-image holograms in the photorefractive crystal. A reference image to be recorded is illuminated by a plane-wave laser beam (denoted the input beam) that is projected at an angle into the photorefractive crystal. Another plane-wave laser beam (denoted the reference beam) is projected into the crystal at another angle and the hologram formed by the two beams is recorded by an appropriate exposure.

There are two methods of recording multiple reference images in the same crystal. The first method requires a tunable laser, which is set to different wavelengths to record different images. In the second method, the reference beam is made incident at different angles to record different images. These methods

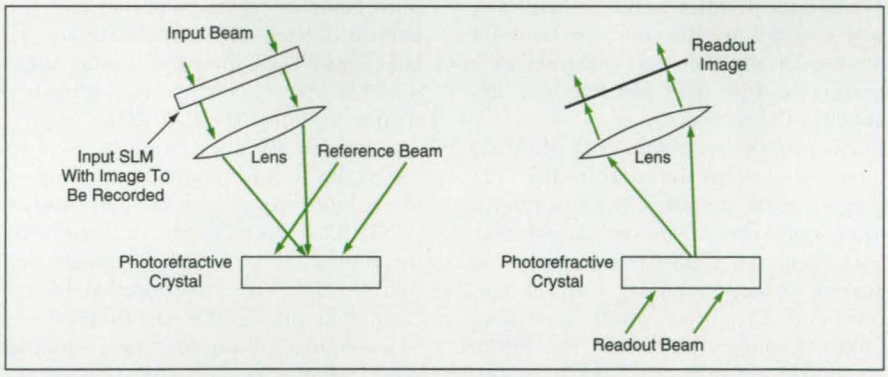


Figure 1. A **Photorefractive Crystal** can record multiple holograms formed at different wavelengths and different angles of incidence of the reference beam.

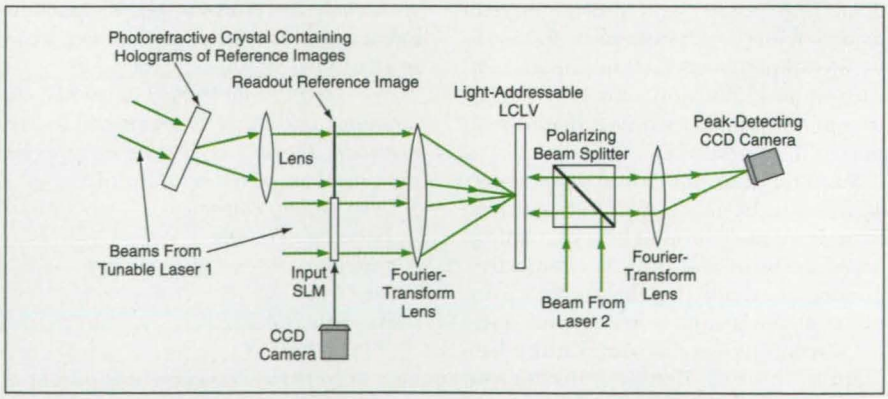


Figure 2. This **Joint-Transform Optical Correlator** includes a photorefractive-crystal memory device like that of Figure 1, containing thousands of reference images. The input image can be correlated with the reference images in rapid succession by varying the wavelength of the tunable laser and the angle of the laser beam incident on the photorefractive crystal.

can be combined in a wavelength- and angle-multiplexing scheme to enable the recording of thousands of reference images in a photorefractive crystal as small as a 1-cm cube. As shown on the right side of Figure 1, readout of the image previously recorded at a given angle and wavelength is effected by use of a readout laser beam that is conjugate to the reference beam used during recording; that is, a beam of the same wavelength and traveling along the same path but in the reverse direction. Thus, multiple recorded images could be addressed by varying the angle and wavelength of the readout laser beam.

Figure 2 is a schematic diagram of the joint-transform optical correlator. The beam from a tunable laser is split into two parts, one part being used to read out one of the reference images from the photorefractive crystal by the method described above. The other part of the laser beam is used to read out the real-time input image from an input spatial light modulator (SLM); this input image is fed to the input SLM from a charge-coupled-device (CCD) camera aimed at the scene or object that one seeks to recognize. The input SLM is placed alongside the reference image, in the same plane as that of the reference image.

The optical paths from the laser to the input and reference images are aligned to be within the coherence length of the laser, so that a hologram can be formed in the plane of a Fourier transform of the two images. By use of a lens, the two images are jointly Fourier-transformed, and they form an interference pattern on the Fourier-transform plane.

The input surface of a light-addressable liquid-crystal light valve (LCLV) is placed in the Fourier-transform plane. The output surface of the LCLV is illuminated with a collimated laser beam through a polarizing beam splitter. The reflected beam containing the Fourier-transform interference pattern travels through the beam splitter and through a lens, which forms the inverse Fourier transform on the focal plane of a peak-detecting CCD camera. If the input image matches the reference image, a pair of symmetric first-order correlation spots appears on the focal plane. The intensity of the correlation spots is proportional to the similarity between the images. The input image could be compared with multiple reference images in rapid succession by varying the wavelength and/or angle of the readout beam incident on the photorefractive crystal.

This work was done by Tien-Hsin Chao and Francis Yu of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 3*** *on the TSP Request Card.*
NPO-19139

NEW LITERATURE

Photonics Tools from Lasers to Mounts

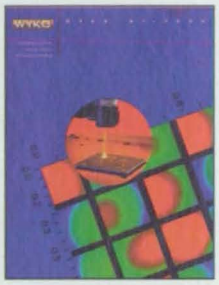
New Focus Inc., Santa Clara, CA, has issued its 1997-98 catalog. Among new products in its 164 pages are innovative mirror mounts, single-frequency lasers built to the customer's specified wavelength, autobalancing photoreceivers, aspheric lenses, and optical choppers. Other products available are DC-to-60-GHz photodetectors, continuously tunable narrow-linewidth diode lasers, optical modulators, motorized positioners, polarization components, and super-stable mounts.

For More Information Write In No. 811

Carbon Dioxide Laser Processing Systems

Mitsubishi Electric Corp., Wood Dale, IL, makes available a 24-page full-color catalog devoted to its Series LX carbon dioxide lasers used for cutting sheet metal and other materials. Models described are the ML2512LX and LXP and the ML3015LX and LXP. Application examples are shown, and specifications of movement and control methods, workpiece size, feed rate, and stroke are given. The booklet details such features as the 3-axis cross-flow gas excitation system and the sealed resonators. Also described are the options available with the basic systems.

For More Information Write In No. 815



Noncontact Optical Profiler

WYKO Corp., Tucson, AZ, describes its new NT-2000 optical profiler in an 8-page color brochure. The booklet has details on the noncontact surface metrology system for process analysis and control, which the company says combines advanced interferometric technology with full automation for 3D surface dimensions down to 0.1 nm. Additional features are highlighted, including the system's in-line production capabilities.

For More Information Write In No. 812

Laser Displacement Sensor

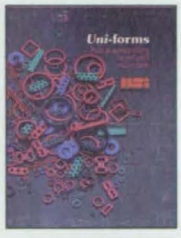
Kopplin Co., Jackson, MI, is distributing a 15-page catalog with details of the Wenglor line of laser displacement sensors with analogue and digital output, laser retroreflective sensors, and laser through-beam sensors. The catalog provides general technical data on the models available, and information on advantages of the different models, options, accessories, and applications.

For More Information Write In No. 816

Custom Solutions to Interconnect Challenges

"Advantages," distributed by AMP Inc., Harrisburg, PA, is a 6-page full-color brochure describing 18 ways the company can apply interconnection products, logistical expertise, industry knowledge, and manufacturing capabilities to make their customers more productive, efficient, and profitable. Starting with predesign involvement, simulation, and modeling, the company can ensure that tooling and equipment are available and operating as production begins, and with its forecast demand system, that a steady supply of products keeps lines up and running.

For More Information Write In No. 813



Epoxy Preforms for Sealing/Bonding

Multi-Seals Inc., Manchester, CT, has published a 4-page full-color pamphlet describing its *Uni*-form epoxy preforms designed for sealing and bonding electromechanical components in the communications, fiber optic, computer, and electronics industries. *Uni*-forms are one-part epoxy resins that are solid at room temperature. When heated they melt and cure, sealing the component against dust, moisture, and other contaminants. The booklet outlines the shape varieties of the preforms and has tips on their usage.

For More Information Write In No. 817

Laser and Fiber Optic Instrumentation

The 1997 short-form catalog from ILX Lightwave Corp., Bozeman, MT, supplies details about the company's laboratory benchtop instrumentation for laser diode control, laser measurement, and fiber optic test and measurement. It contains many new products, including the improved generation of LDC-3700 Series laser diode controllers with GPIB standard, the 7900 multichannel fiber optic system for applications requiring multiple fiber optic sources, and the MPS 8033/55 ASE broadband fiber optic source, among many others.

For More Information Write In No. 814

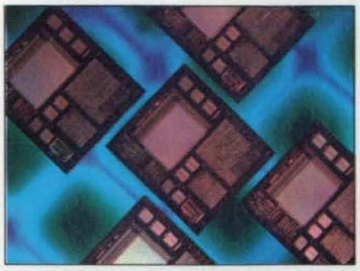
Heated Vacuum Valves

A 4-page brochure from MKS Instruments, HPS Division, Boulder, CO, includes descriptions, applications, specifications, and prices on the company's VacuComp™ Series 170/180 heated vacuum valves. They are designed for use in vacuum deposition systems where production byproducts can condense and build up, interfering with the operation of conventional valves. Heating the valve elevates the internal temperature, leaving the byproducts in gaseous form. They are available in 1 1/2-in., 2-in., 3-in. and 4-in. sizes with limit switch and solenoid options.

For More Information Write In No. 818

NEW PRODUCTS

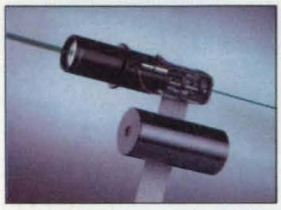
PRODUCT OF THE MONTH



Single-Chip NTSC Color Camera

VLSI Vision Ltd., Saratoga, CA, introduces the VV6405, which it calls the world's first single-chip NTSC color camera. Using VLSI's complementary metal-oxide semiconductor (CMOS) technology, the device delivers color video with just a single external crystal and single-rail 5-V power supply. It combines on a single standard CMOS chip a 1/4-in. Color MOS™ photoplane, video timing controller, 8-bit A/D video converter, 300-MIPS color DSP engine, video D/A converter to drive a 75-ohm load, 5 video line memories, auto exposure control and control balance, and NTSC composite video encoder. Packaged in a standard 48-LCC, the device is suitable for lighting environments from 100k lux down to 50 lux. The chip draws about 100 mA at 5 V, which VLSI says puts its power consumption at about 20-30 percent of CCDs.

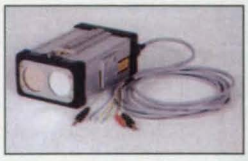
For More Information Write In No. 800



Motorized Beam Expander

The new motorized beam expander from Rodenstock Precision Optics Inc., Rockford, IL, is infinitely adjustable within a 2×-to-8× magnification range and designed for 1064-nm wavelengths. Maximum entrance-beam diameter is 4 mm, and maximum exit-beam diameter 31 mm. Its zoom and focus are adjustable to precise settings by remotely controlled stepper motors. Optional software for the remote controller is operated by a PC with Microsoft Windows™ Version 3.1 or 3.11, or Microsoft Windows™ 95.

For More Information Write In No. 802



Noncontact Pulsed Laser Rangefinder

Riegl USA, Orlando, FL, offers the LD90-3100 EHS-GF and LD90-3300 EHS-GF series noncontact pulsed laser rangefinders that the company says combines a glass-fiber-coupled remote optical head with a split optics design for easy integration with two- or three-dimensional profiling systems. Available with various remote heads, the LD90-3100 has a typical range capacity of 200 m with a ±2-cm accuracy and 4-mm resolution. The LD90-3300 series has a 300-m range with ±10-cm accuracy. The split optics design has a maximum combined lens diameter of only 62 mm to fit relatively small scanning mirror systems.

For More Information Write In No. 803

Turnkey Optical Analysis System

WaveFront Sciences Inc., Albuquerque, NM, designed its Complete Light Analysis System-2D/portable (CLAS-2D/p) as a portable version of its earlier system, which now makes possible phase measurement in field as well as laboratory conditions. Vibration-insensitive and rugged, the CLAS 2D/p measures both the intensity and phase of any optical source. It has an integral flat-panel display, but can also be used with separate large-screen monitors. The company says the instrument provides both a much greater dynamic range (>100 μm) and a higher sensitivity (<λ/100 resolution) than comparable systems.

For More Information Write In No. 801

Wavefront and Image Data Analysis

United Technologies Adaptive Optics Associates, Cambridge, MA, offers WaveLab™, a set of software tools for the reduction and analysis of wavefront and image data. A suite of Tcl/Tk scripts presents a graphical user interface to a unified Hartmann data reduction package. The company says virtually any type of sensor data may be analyzed to yield OPD, PSF, MTF, OTF, encircled energy, Zernike components, and fringe images. Users can create customized scripts and add their own algorithms to the toolset. WaveLab includes the WaveLab Manual and the Tcl Users Guide, and is available on 4-mm and 8-mm tape or CD-ROM.

For More Information Write In No. 804

Real-Time Thermal Image Analysis on a PC

FLIR Systems Inc., Portland, OR, says its Tracer™ is the first thermal imaging system capable of recording and analyzing long thermal event sequences at real-time frame rates (up to 60 Hz) on a Windows™ PC. In a base configuration, Tracer can record 5+ minutes of thermal activity at a 60-Hz frame rate with 12-bit pixels, capturing 9.3 MB of data per second for analysis. The system senses temperature differences of <0.1 °C at 30 °C, and can measure the temperature of objects from -10 °C to 2000 °C with an accuracy of ±2 percent or 2 °C. A complete system consists of a Prism DS infrared camera, Pentium PC, digital recording system, and software.

For More Information Write In No. 805

Single-Channel Laser Triangulation System

Aromat Corp., New Providence, NJ, offers the NAiS® brand LM-10 series laser triangulation system that uses a single-channel processing technology, reducing the number of circuit paths from the two of conventional systems to just one processing chip. It can be equipped with any of 9 sensor heads covering a measurement range from 40 mm to 400 mm. It offers laser spot size as small as 0.09 × 0.05 mm, and resolution to 1 μm. Two types of controllers, with single and double built-in comparators, are available.

For More Information Write In No. 806

Handheld Ultraviolet Viewer

The new FIND-R-SCOPE™ handheld ultraviolet viewer from FJW Optical Systems, Palatine, IL, enables users to observe the spectrum from 180-1250 nm, and optionally to 1550 nm. It can aid in examining and aligning excimer laser beams and other UV sources. Other applications include UV lithography, photorefractive keratotomy, excimer laser micromachining and wire-stripping, annealing of LCDs, fingerprint analysis, and botanical studies. Field of view is 40° and resolution 60 lp/mm. Prices range from $1895 for the 180-1250-nm model to $2195 for the 180-1550-nm device.

For More Information Write In No. 807

Spectral Attenuation Test System

EXFO E.O. Engineering, Quebec, Canada, says that its Model 5600 spectral attenuation test system, based on a proven interferometric concept, ensures rapid, accurate, and highly sensitive optical attenuation measurements in both multimode and single-mode silica fibers. Measurements can be made over the 800-1700-nm wavelength region with a 30-dB dynamic range, as well as over the 650-1000-nm wavelength region for plastic optical fiber. The HeNe reference laser makes wavelength accuracy better than 0.2 nm.

For More Information Write In No. 808

Whole-Field Vibration Measurement

Polytec PI, Auburn, MA, introduces the VibraScan™ family of scanning laser vibrometers for noncontact whole-field vibration mapping and analysis. The PSV-200-1, operating under Windows NT 4.0, brings together the laser, scanning mirrors, a video system, a high-end 2-channel FFT card, a vibration waveform generator, and a PC. It acquires and stores vibration spectra or time waveforms for each scanned point. Individual frequencies can be displayed as 2D or 3D color-coded maps that can be animated to visualize vibration shapes, concentrations, and flow.

For More Information Write In No. 809

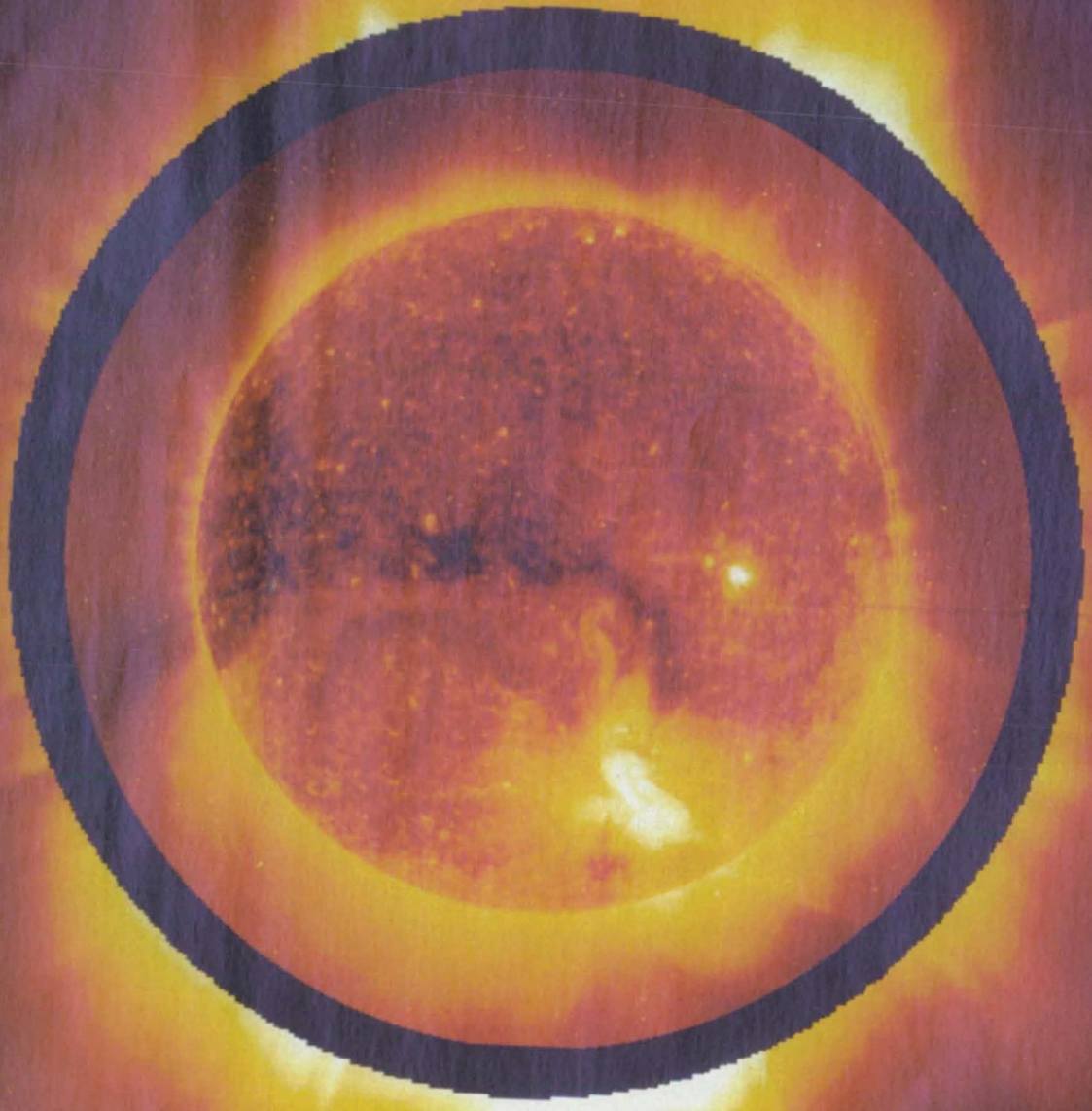
Lens System for Low-Light/UV Photography

The new image-intensifier lens system (ILS) from NAC Visual Systems, Simi Valley, CA, allows synchronized exposures down to 20 ns with light gains up to 100,000× plus, according to the company. ILS extends high speed imaging to the far-blue/UV spectrum down to 200 nm. NAC says ILS is compatible with virtually all 16- and 35-mm film cameras as well as video and image-converter cameras. Four models are available, including the ILS-4, or RangeCam40™, a fully integrated high-resolution short-exposure system for ballistic ranges.

For More Information Write In No. 810

WORLD AEROSPACE LEADERS

Featuring "Europe In Space"



Taken by two instruments aboard the SOHO spacecraft, a cooperative European Space Agency-NASA project, this composite image shows the solar wind (outside black circle) and the disk of the sun (inside circle).

Photo courtesy ESA/NASA.

Special Advertising Supplement to NASA Tech Briefs

The European Space Agency

Artist's impression of the ESA scientific space probe Huygens, starting its descent through the thick methane atmosphere of the Saturn moon, Titan, after jettisoning its 3-meter diameter front heat shield. Huygens will be deployed by the NASA-developed orbiter Cassini. The joint ESA/NASA Cassini/Huygens mission will be launched in 1997 and will enter the Saturn planetary system in October 2004.

The idea of creating an independent space power in Europe began in the early 1960s. Believing that union meant strength, six European countries — Belgium, France, Germany, Italy, the Netherlands, and the United Kingdom — in association with Australia, joined together in 1962 to form the European Launcher Development Organisation (ELDO), a group focused on developing and building launcher systems.

Likewise in 1962, these same countries joined forces with Denmark, Spain, Sweden, and Switzerland to form the European Space Research Organisation (ESRO), which undertook satellite programs. Ten years later, these partners decided to merge the activities of the two separate organizations into a single body. In July 1973, an interministerial conference of the ten European countries met in Brussels and laid down the principles of creating the European Space Agency (ESA). In 1975, Ireland applied for membership and was invited to join ESA. On October 30, 1980, the final signature ratifying the Convention gave legal existence to ESA.

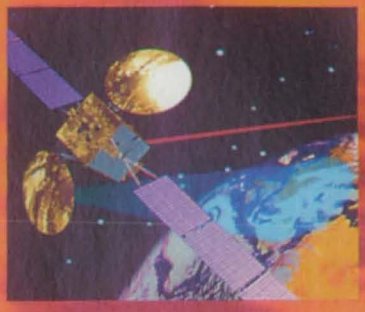
Since then, the founding members have been joined by Austria, Norway, and Finland. Cooperation agreements have been signed to allow Canada to participate in certain ESA programs and to sit on the ESA Council.

WHO IN EUROPE...

...Looks to the stars ?

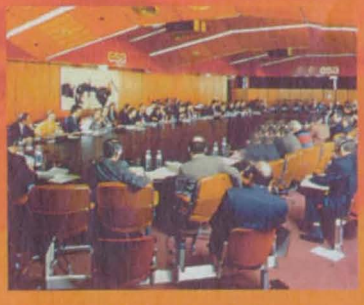
...Provides the transport thereto ?

...Leads in telecommunications technology ?

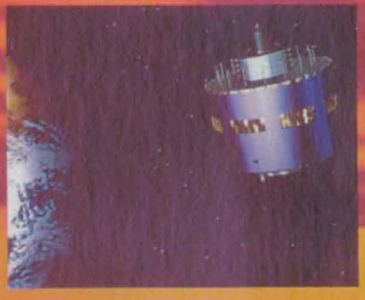


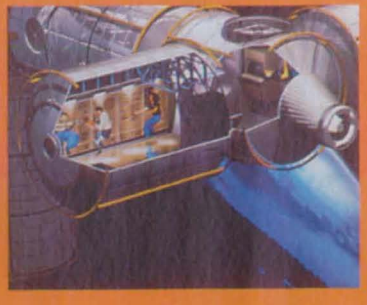
...Produced the Lynx's eye in the sky ?

...Strives for European unity ?



...Aids weatherforecasts ?





...Expands the frontiers of technology ?

and with all that is 35 years old !

esa

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Alcatel Telecom's Space Business Line

The Space Business Line of the powerful multinational group, Alcatel Telecom, is itself an international organization of 12 European companies: Alcatel Espace, Alcatel Telspace, and SAFT (France); Alcatel Bell and ETCA (Belgium); Alcatel Espacio (Spain); Alcatel Kirk (Denmark); AME Space (Norway); Alcatel Telettra (Italy); and Alcatel SEL AG, Alcatel ANS, and Euteltracs (Germany).

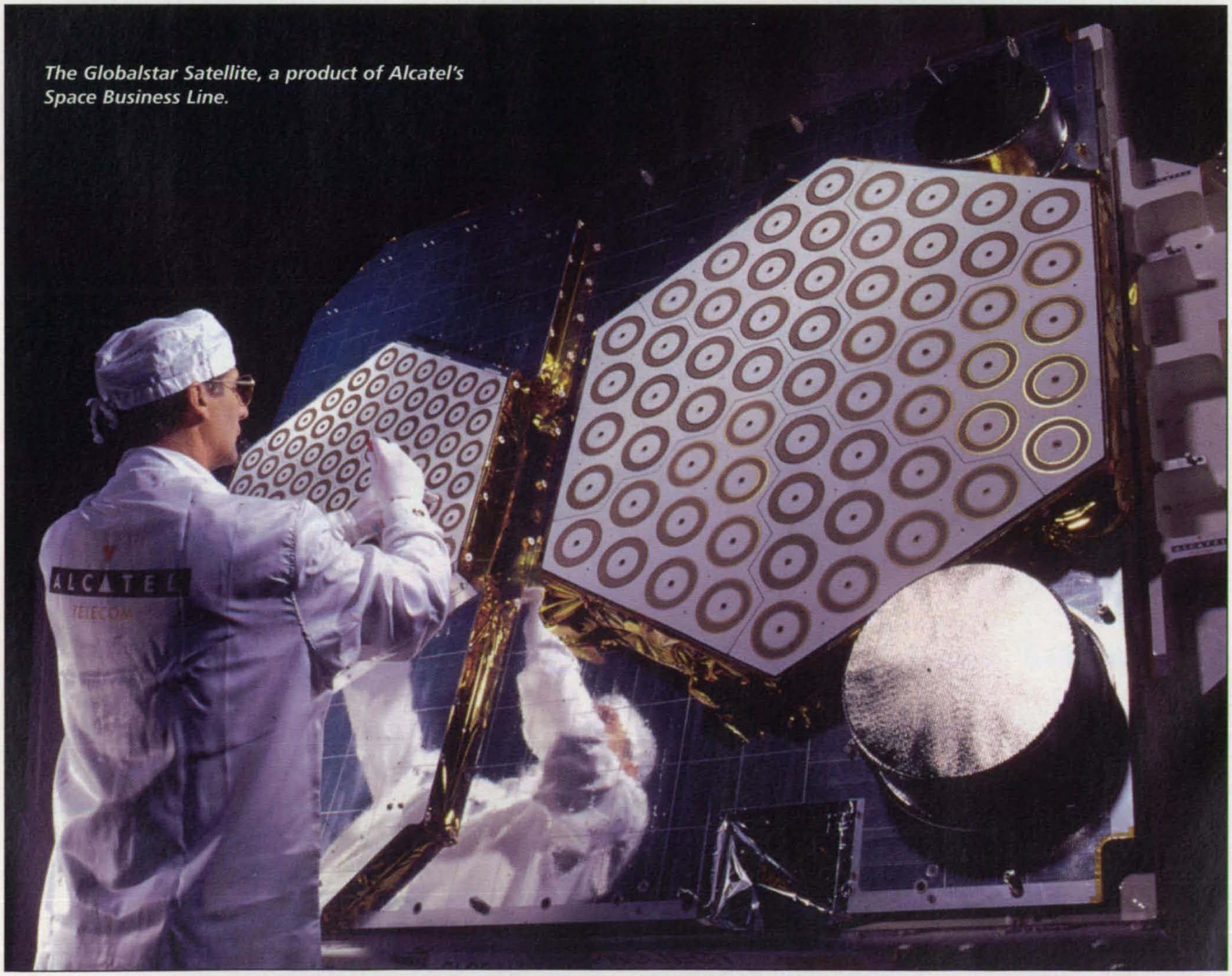
The European leader in satellite systems, the Space Business Line is also the second world leader in the field of communications payloads. Last year, its workforce of 4,000 achieved global sales exceeding $1 billion. Known as a manufacturer of electronic equipment, subsystems, and complete payloads for communications, observation, and scientific satellites, the group also manages complete communications satellite systems — including space and ground units — for both civilian and military sectors. In addition, the group participates in observation and scientific programs.

The Space Business Line is the industrial architect of complex communications satellite systems such as System Worldspace, Globalstar, and Syracuse. The international group also has demonstrated excellence in operations services through its participation in numerous space communications, observation, and scientific programs, including Intelsat, Eutelsat Telecom 2, Sinosat, Sesat, MT-Sat, Mabuhaysat, Turksat, M2A, Nilesat, Spot, Ulysses, Topex-Poseidon, Jason, and Envisat. At present, the Space Business Line is the main contractor for the worldwide interactive multimedia satellite transmission program, Skybridge.

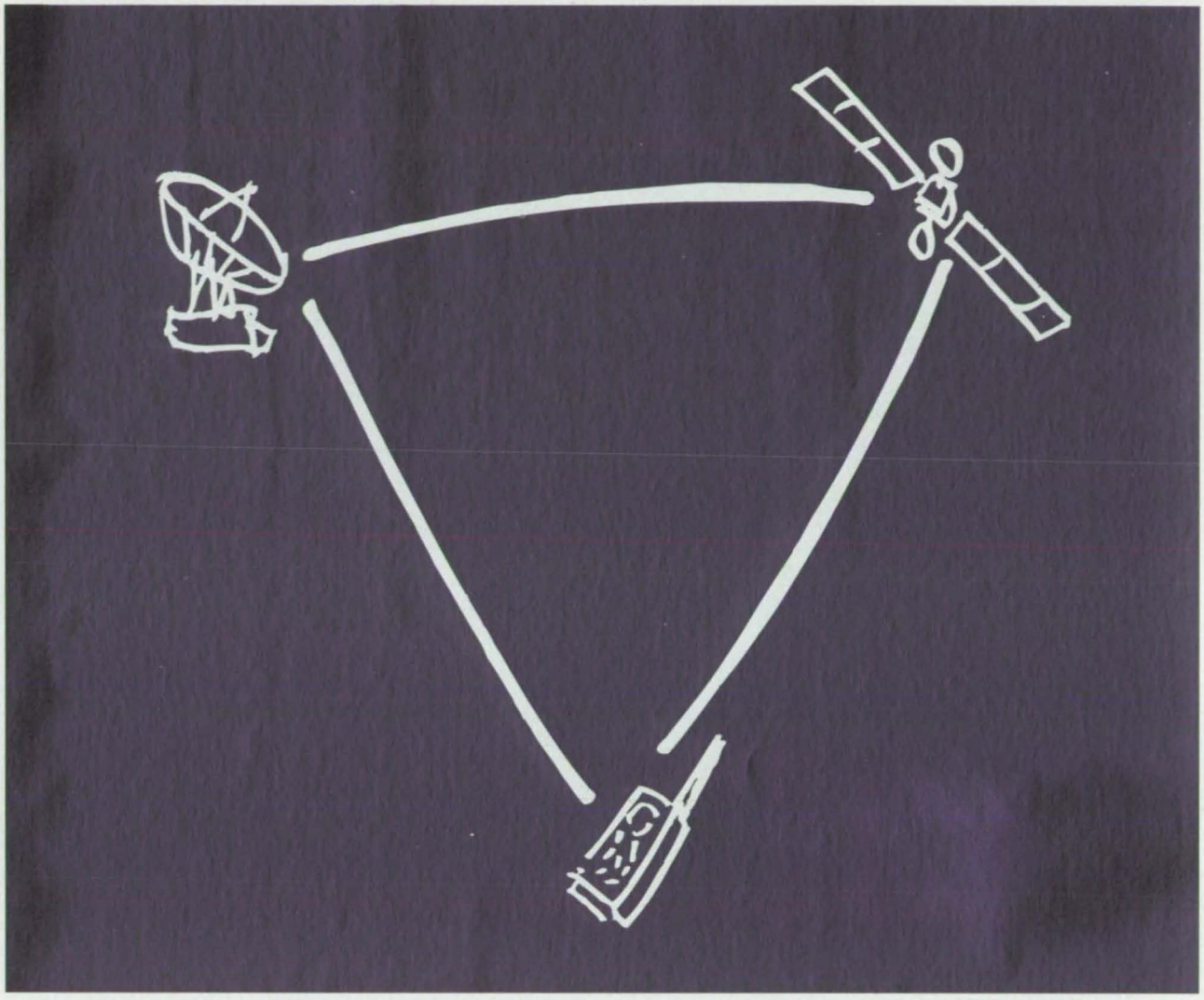
Alcatel Espace, with facilities in Paris and Toulouse, maintains the leading position among the Space Business Line companies with more than $500 million in sales and a staff of over 1,600. The company oversees the development and operation of communication satellite systems, a variety of payload subsystems and equipment, and ground control and communication units. Earth stations are provided by its relative, Alcatel Telspace, Europe's largest manufacturer of standard ground stations and VSATs. SAFT, another French Space Business Line company, specializes in satellite and launcher batteries.

Alcatel Bell, a Belgium-based company, is expert in on-board and ground communications, TCR ground stations, and frequency generators and converters. Another Belgian company, Alcatel ETCA, develops power supplies and subsystems for satellites and launchers, as well as launcher test benches.

In Madrid, Alcatel Espacio designs and manufactures data processing units, while in Denmark, Alcatel Kirk's area of expertise is power conversion and distribution units. Italy's Alcatel Telettra specializes in microwave modules and Norway's AME Space is a European authority on hybrid circuits, SAW devices, I.F. filtering, and processing units. The three German members of Alcatel's Space Business Line are Alcatel SEL AG, a specialist in military satellites; Alcatel ANS, experts in air navigation satellite systems; and Euteltracs, distinguished by its work in satellite truck fleet management.



The Globalstar Satellite, a product of Alcatel's Space Business Line.



Global Communication Satellite Systems: keep it in one hand.

Alcatel offers unrivaled expertise in providing the turnkey solutions that meet your exact telecom requirements. In fact, we are one of the first companies in the world to supply every link in the telecommunications chain, from definition of specifications and financial engineering to in-orbit delivery and operations. As supplier of both earth and space segment equipment, Alcatel delivers systems which are simpler, more reliable, more competitive. We have already been involved in more than 60 communication satellite systems and programs: civil and military, public and private, national and international. At Alcatel, we take pride in delivering a total system, ready to enter service from the word « go » – which means you can focus on your core business. If you're looking for a strategic partner, simply contact Alcatel on 33 (0)1 46 52 62 00 - fax 33 (0)1 46 52 62 50. **Alcatel, we help you grow.**

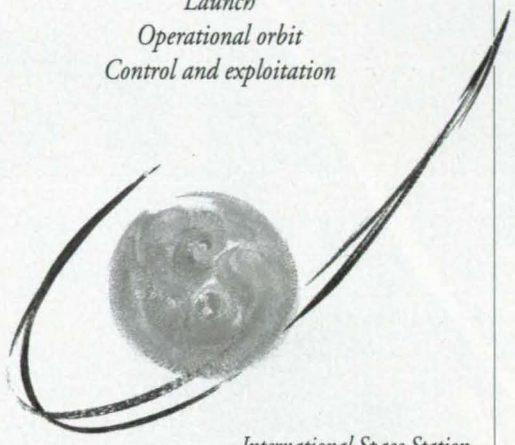
ALCATEL

5, rue Noël Pons 92737 Nanterre Cedex, France.

For More Information Write In No. 476

CNES pays tribute to the scientists, engineers and companies who have cooperated in the implementation of the space programs which have made France one of the major actors in the conquest of space to better serve the world.

Space policies
Aerospace industry
Launch
Operational orbit
Control and exploitation



	International Space Station
Altaïr	*Jason*
Antares	*LMS/STS missions*
Aragatz	*Metop*
Argos	*Polder*
Ariane	*Pronaos*
Cassiopée	*Proteus*
Cospas/Sarsat	*Scarab*
Cassini Huygens	*Sigma*
Columbus	*Soho*
Doris	*Spot*
Envisat	*Stella*
Gamma	*Stentor*
GNSS	*Télécom*
Helios	*Topex Poséidon*
Iso	*Vega...*

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CENTRE NATIONAL D'ETUDES SPATIALES

PARIS EVRY TOULOUSE KOUROU

F.R.I. Communication

Centre National d'Etudes Spatiales (France) - CNES

CNES is a government organization established in December 1961, responsible for developing French space activities. Its tasks are to propose a space policy to the French government and, in conjunction with its partners in industry, research, and defense, carry out its programs.

CNES implements the French space policy along two main lines, which complement each other:

- by participating in the programs of the European Space Agency (ESA) and playing a major role in this organization; and
- by conducting a dynamic national program which ensures a competitive French industry on a world level.

This policy operates in areas where the most important strategic and economic challenges are at stake:

- access to space with the Ariane program and a launch base in French Guiana (Centre Spatial Guyanais - CSG). This program is undertaken in the framework of ESA and launch services are marketed by Arianespace, a CNES subsidiary;
- manned space activities in cooperation with Russia and the United States, and a significant contribution, within ESA, to the International Space Station program;
- space applications such as telecommunications (Stentor), Earth observation (Spot, Topex-Poseidon, Envisat, and Polder), and development of new products in partnership with industry (the Proteus platform for small satellites); and
- scientific programs in conjunction with research organizations in European or international cooperation (Iso, Soho, Interball, etc.).

Over the years, the CNES has strengthened its links with its partners:

- with space users by finding the right compromises between their requirements and choices of space techniques;
- with French industry to which CNES gradually has transferred its know-how and project-management skills to support its competitiveness;
- with laboratories in industry and in large scientific organizations with which it works in numerous research programs;
- by supporting the developing countries in the use of space techniques for purposes of knowledge, economic growth, and resources management; and
- by participating in a defense program in partnership with the defense entity, thus generating synergy between civilian and military programs.

Today, the space sector is in a phase of major evolution. In particular, its activities and products gradually are taking on the dimensions of the commercial market, which demands innovation and a quest for new applications. In order to adapt to this new context, CNES has drawn up a strategic plan defining a framework for its activities in the next few years. CNES plans, in particular, to extend its partnership policy by enhancing the value of its potential for innovation in markets with a future.

The French space program, driven by strong political ambition for over 30 years and run by CNES, is an essential part of the European program and a reference in the world today.

Arianespace

Arianespace is the world's first commercial space transportation company, set up in 1980 by 36 leading European aerospace and electronics corporation, 13 major banks, and the French space agency CNES (Centre National d'Etudes Spatiales).

Arianespace is a European venture, the direct result of nations' commitment to bringing the Ariane family of launch vehicles from the drawing board to the launch pad. To meet this challenging goal, they turned to the European Space Agency (ESA) and mobilized the scientific and technological expertise of CNES.

The shareholding partners in Arianespace represent the scientific, technical, financial, and political capabilities of 12 countries: Belgium, Denmark, Germany, France, Ireland, Italy, the Netherlands, Norway, Spain, Switzerland, Sweden, and the United Kingdom.

To satisfy fast-changing market needs, Arianespace is directly present worldwide: in Europe, with its head office located near Paris, France, at Evry; in North America with its subsidiary in Washington, DC; in the Pacific Region, with a representative office in Tokyo, Japan; and the Arianespace ASEAN office in Singapore.

Arianespace has 320 employees and share capital of 270 million francs. As a space transportation company, Arianespace offers the following products and services:

- markets launch services for customers throughout the world;
- finances and supervises the construction of Ariane expendable launch vehicles;
- conducts launches from the Kourou space center in French Guiana;
- provides a launch insurance scheme; and
- offers partial financial loans for Ariane launches.

The Arianespace launch package is renowned for its highly reliable, personalized service. A team of experts is assigned to each mission, providing support throughout the launch campaign. Customers have come to rely on the savings in time and costs made possible by our operational efficiency and flexibility.

Most of the world's commercial satellite operators have contracted to launch at least one satellite with Arianespace, reflecting our pragmatic, cost-effective approach to getting satellites into orbit.

Novespace Celebrates 10 Years of Success

Novespace, the subsidiary of Centre National d'Etudes Spatiales (CNES) responsible for technology transfer and the promotion of microgravity, celebrated its tenth anniversary this past July. The small Paris-based company has a great deal to celebrate. Under the direction of President and CEO Jean-Pierre Fouquet, the company has seen turnover grow by 400% since its creation in 1986. In 1996 alone, Novespace earnings were over $3.5 million (FF 18m) — up 7.5% from those of 1995 — with profits of 6.6%.

In conjunction with its tenth anniversary celebrations, Novespace organized the Third Bi-Annual Microgravity and Parabolic Flight Colloquium in Bordeaux, attracting scientists and engineers from all over the world. At that time, Novespace unveiled the A300 ZERO-G, an airplane modified specifically for parabolic flight activity.

As organizer of parabolic flight since 1988 and the operator of the Caravelle ZERO-G from 1989 to 1995, Novespace has acquired extensive experience in the field of microgravity. Certain the A300 will enhance its parabolic flight activity and propagate continued interest in microgravity, Novespace anticipates 1997 to be an incredibly successful year.

Parabolic Flight and A300 ZERO-G

At present the world's largest parabolic aircraft, the A300 ZERO-G has an experiment cavity of 300 m^3. The aircraft can host as many as 20 different experiments and up to 40 passengers (not including crew). Outfitted with accelerator indicators, video screens, and a special gauge and measurement station, the A300 now can measure and display pertinent data specific to the execution of parabolic maneuvers. In addition, the 20-meter-long experimentation zone is equipped with 50 seats, ten electrical panels (20 kVA), an overboard venting system, attachment rails, foam padding, and special lighting.

Novespace executed 28 successful parabolic maneuvers for the A300's first commercial campaign on February 4 and 6, 1997. These flights were commissioned by the Japanese companies NEC and JGC, which tested the solar panel deployment of the NASDA experimental satellite, COMETS. COMETS, scheduled to be launched into geostationary orbit in August by the Japanese launcher H2, is a next-generation satellite that will serve as a test bench for many new technologies — notably inter-satellite communications. NEC and JGC used the A300's voluminous experiment zone to test the deployment and retraction of the satellite's 14-meter-long solar panels. Prior to the tests, similar panels had failed to retract during a satellite recovery mission by the space shuttle. The parabolic maneuvers provided an opportunity for real microgravity testing that demonstrated the effectiveness of NEC modifications and the necessity of parabolic flight for testing prototypes.

Technology Transfer

Novespace has been very busy on the technology transfer front, as well. In 1996, technology transfers rose 10% over those of 1995. Subscriptions for their technology catalogues, "Mutations" and "T.E.S.T.", have increased to more than 20,000 and 40,000, respectively. These catalogues serve to disseminate information about various technologies developed by European aerospace industries in hopes of finding applications for them in other industrial sectors. At present, Novespace is working on just over ten transfer projects.

In addition to distributing information regarding new technologies, Novespace conducts market studies and research for non-space-related companies with specific technological needs. As a member of an international technology transfer network, the Spacelink Group, Novespace works with technology transfer companies from the 14 countries represented in the European Space Agency. This tight and expansive network has enabled Novespace to provide its customers with the latest high-tech European developments. Novespace's international scope is best represented by its French, British, American, Irish, and German staff. Aside from clearly being an internationally staffed company, Novespace is always looking for opportunities to join forces with European, Japanese, Russian, and North American companies in order to expand and augment both its technology transfer and parabolic flight activities.

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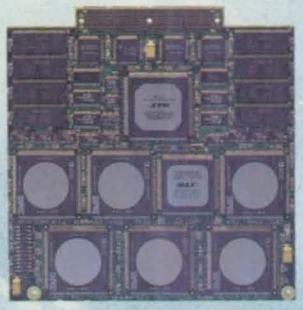

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Societe Anonyme Belge de Constructions Aeronautiques (S.A.B.C.A.)

S.A.B.C.A. is an innovative high-tech company that services the European aerospace and military community. Belgium's leading aeronautic construction company for over 75 years, it designs, develops, and manufactures a variety of space vehicles and hardware assemblies and components. In addition to manufacturing hardware, the company has facilities in Brussels, Gosselies, and Limburg with extensive analysis and testing capabilities. Headquartered in Brussels, S.A.B.C.A. is in a perfect position to design, develop, manufacture, and test a wide spectrum of space hardware, from launcher structures to thrust vector control systems, which can be either electrohydraulic or electromechanical in configuration.

S.A.B.C.A.

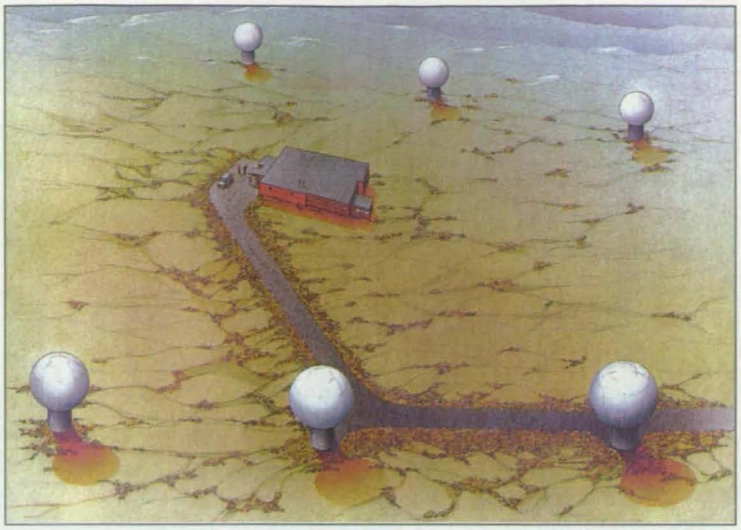
Responsible for the development of the cost-effective thermal protection procedure "PROSIAL" and of "DIAS," a laminated damping device that isolates the main body of a launcher from the boosters, S.A.B.C.A. has contributed enormously to the amelioration of numerous European launcher systems. In addition to these valuable developments, S.A.B.C.A. has worked closely with Aerospatiale (France) on the Ariane launcher programs. For both Ariane 4 and Ariane 5, the Belgian company designed, analyzed, developed, and manufactured electrohydraulic servoactuators including Direct Drive Valves (thrust vector control systems), and for Ariane 5, it designed and manufactured the lower booster skirt and booster nose cone.

Making strides in space vehicle technology, S.A.B.C.A. worked with Aerospatiale on the design, thermal analysis, and manufacture of internal and external structural assemblies for the Atmospheric Re-entry Demonstrator (ARD), a scaled-down version of a future manned capsule. At present, the company is working with Aerospatiale and MAN (Germany), and is conducting feasibility studies and design analysis of a Crew Rescue/Transfer Vehicle (CR/TV). S.A.B.C.A. also does a great deal of work in the space vehicle components domain, designing electronically controlled motorized pointing, deployment, and hold-on mechanisms.

The S.A.B.C.A. team is expert in robotics as well. The company designed and manufactured an integrated service tool and articulated joint service for the HERMES program, and continues to develop and test robotic technologies for future projects (ERA). In collaboration with SEP, S.A.B.C.A. realized a preliminary study and manufactured a motorized section of a valve allowing proportional control of cryogenic fluids for VULCAN MK2.

S.A.B.C.A.'s space flight proven technologies are being implemented in an active thermal control approach using loop heat pipes, two-phase capillary pumped loop and heat pipes for space vehicles.

SvalSat: Data Acquisition and Satellite Tracking From the Top of the World



An artist's rendering of the Svalbard Satellite Station (SvalSat), which will provide satellite tracking and data acquisition.

With strong support from the Norwegian government, the Norwegian Space Centre (NSC) is now establishing Svalbard Satellite Station (SvalSat). Located at approximately 80° N, it will offer full coverage; 14 out of 14 daily passes of polar orbiting satellites.

NASA will be the first user of the station for acquisition of data from the Earth Observing Satellites (EOS) and Landsat 7, both important parts of the Mission to Planet Earth program. NSC will operate the station on a NASA five-year contract of $6 million US. NASA primarily has requested backup service for data reception from the EOS-AM 1 satellite, which will be launched in 1998. The agreement is based on the existing Memorandum of Agreement between NASA and NSC and the details are described in a joint implementation plan. Norway will provide basic infrastructure such as access road, utilities, and a station building, while NASA is providing the technical infrastructure required. SvalSat also will be capable of tracking sounding rockets and Early Orbit Support for orbital launches.

NSC's goal is to make SvalSat a key station in the global MTPE ground station system and the facility will be proposed as a prime data reception station for the EOS follow-on satellites.

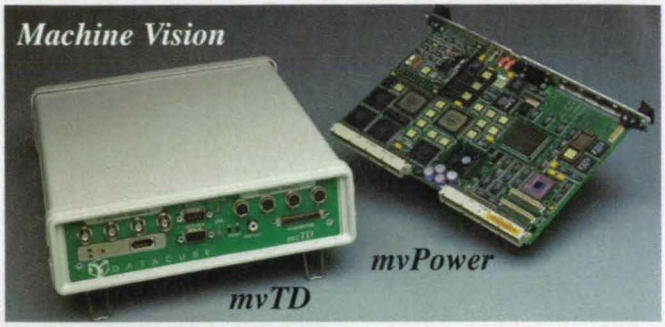
Discussions are being held between NSC and the Indian Space Research Organization (ISRO) about the possibilities to locate a control station for the Indian IRS C/D and related missions at SvalSat. The Indian Earth Observation satellite system is expected to grow significantly in size and complexity over the next years, and SvalSat will allow a 92% total coverage of seven Indian satellites. If the parties agree, NSC will provide ISRO with TT&C support 24 hours a day.

Imaging Solutions *for* Industry *from* Datacube

Image Processing Pioneer Now Offers Focused Products for Industrial Imaging

From our roots in the late 1970s as a pioneer of digital image processing technology for military, aerospace, and R&D applications, Datacube, Inc. of Danvers, MA, has evolved into a major supplier of focused solutions for commercial image processing markets.

In the early 1990s, our highly experienced image processing engineering staff was reorganized into vertical groups for machine vision, web inspection, and medical imaging.

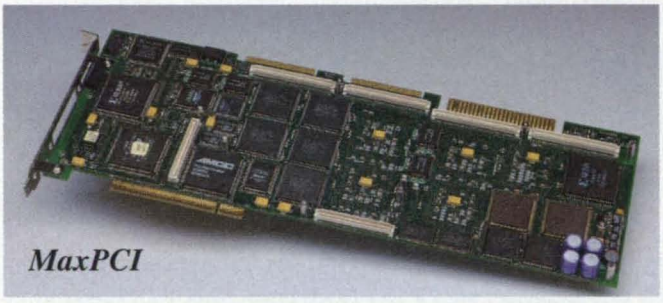


Over the past year, these groups have produced a steady stream of powerful and innovative new products for commercial imaging users. As a result, well over half of Datacube's sales are now to industrial vision OEMs.

mvPower® is a comprehensive single-slot solution for OEMs with an on-board PowerPC chip and a flexible camera interface.

mvTD™ is a fast, accurate, fully integrated solution in a compact unit with *mvPower*, Ethernet, the MaxVision Toolkit, and a remote procedure call facility for external control.

A comprehensive software suite for machine vision, the **MaxVision Toolkit**™ includes motion/robot guidance tools and metrology tools with sub-pixel accuracy. The **SMT Package** is a software extension for surface mount technology applications.



MaxPCI—The New Performance Leader

The MaxPCI® image processing engine for PCI-based systems has extended Datacube performance to a variety of new industrial and medical application areas.

Built exclusively with 40 MHz pipelines, MaxPCI features include dual acquisition, a massive non-blocking crosspoint, and 110 MB/sec. pipeline-to-PCI bus transfer. New MaxACQ acquisition modules, and PSMOD **P**rocessing and **S**torage **MOD**ules allow configuration for many different specific requirements.

For low-cost solutions to a variety of mid-to-high-end industrial and medical applications, MaxPCI is the ideal choice.

Rugged, Dependable VME Products

For those applications where the ruggedness and dependability of a VME architecture are appropriate, Datacube offers the **MaxVideo 250**®, our 4th generation, single-slot image processing subsystem that includes High Speed Image Access for frame-based processing.

Built around the MaxVideo 250 and Motorola's PowerPC®, the **PowerTD**™ system includes all the hardware and software for plug-and-play development, and allows seamless deployment of finished applications to multiple, low-cost target systems.

Powerful Solutions for Machine Vision

Datacube offers powerful, accurate, easily deployed, and competitively priced machine vision systems for integrators and OEMs.

Continuous Web Inspection Solutions

For challenging web inspection applications, Datacube offers **Black Widow**™, a powerful, easy-to-integrate systems solution.

With a scalable architecture, Black Widow can include cameras and lighting fully protected in factory-ready enclosures, an operator interface with an application-specific GUI, and a defect recorder. Based on open standards, Black Widow easily interfaces with existing web control systems.

For system specification, Datacube offers **Arachne**™—a pilot system that can be set up at the web, so the integrator and customer can quantify the task and specify exactly the right solution.

Focused Solution Products

coreDAP™ technology adapts Datacube hardware and software to the specific requirements of medical imaging OEMs, providing image processing, storage and retrieval, and networking for digital motion angiography applications. coreDAP incorporates Datacube's proprietary MD image recording/playback technology.

PowerTrack™ is a comprehensive tracking solution that streamlines development of surveillance, inspection, and factory automation applications. It includes automatic target acquisition, gate-sizing, full-edge tracking, and tracks two targets simultaneously.

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Kingston Mix and Match Flexible Storage Solutions

Kingston's storage products provide solutions specifically designed to reliably support increased storage capacity and system flexibility. Use the Kingston rugged Data Silo expansion chassis, available with up to nine bays, to accommodate fixed storage needs. Use the reliable Data Express enclosures for system internal removable storage.

Data Silo DS500 Chassis (9-bay Rackmount or Tower)

Our Data Silo DS500 is a steel rackmount or tower, RAID or JBOD (Just a Bunch of Disks) external expansion chassis designed to reliably house any combination of up to 9 half-height (or 4 full-height and 1 half-height) devices. Used in conjunction with our Data Express removable device enclosures, the DS500 can house up to 12 removable devices.

The Kingston DS500 can support up to 4 host systems. This enclosure comes standard with a power-on LED indicator, 1 or more highly rated, load-sharing, hot-swappable power supply(ies), and 2 quick-released, hot-swappable cooling fans. The DS500's front operator display panel provides a visual and audible warning alarm system that reports dangerous operating conditions.

Each DS500 unit is designed to support a variety of storage applications, from daisy chain configurations to high-performance RAID solutions. Prewired and custom-wired configurations are available with 50-pin SCSI 2 and 68-pin SCSI 3 I/O interfaces. The DS500 is compatible with all popular platforms.

Data Silo DS100 Chassis (1-, 2- & 4-bay)

The Kingston DS100 family of expansion chassis can house up to (4) 3.5" or 5.25" half-height, or (2) 5.25" full-height SCSI peripherals. Each DS100 is constructed of rugged steel and is designed to easily withstand the high temperatures generated by today's high-performance devices. These chassis are equipped with internal wiring, blank filler panel(s), and highly rated, auto-ranging, enhanced power supply(ies) and fan(s).

Data Silo DS90 Chassis (1 bay)

Our stackable DS90 1-bay expansion chassis is constructed of metal-shielded plastic. This lightweight, yet durable enclosure comes equipped with 4 stacking feet, 2 highly rated fans, auto-ranging power supply, internal wiring, a blank filler panel, industry-standard audio jacks, and a unique removable device installation sled. Various available versions of the Data Silo provide flexible options for storage expansion, making our Data Silo enclosures ideal for desktop, JBOD, and RAID, single and dual port disk arrays. Combine our Data Silo DS100 chassis with our Data Express subsystem units and enjoy the convenience of up to 6 removable devices in a small-footprint, desktop storage enclosure.

Data Express (Removable Device Enclosure)

The Kingston Data Express line of removable device enclosures can house 2.5" and/or 3.5" drives or 3.5" front-load type devices. Data Express subsystems are mountable into any internal or external 3.5" half-height and 5.25" half- or full-height peripheral expansion bay.

Kingston Data Express units are solidly constructed and employ highly reliable mating connectors that are rated as high as 25,000 insertion cycles for most models. An ID select indicator, device carrier key lock, device activity indicator light, and antistatic insertion guide rails are standard features.

Our Data Express modular subsystems are ideal for applications that require cold, warm, or hot swapping of devices. In addition, the Data Express is perfect for data transfer or transportation, data security, archiving large files, JBOD and RAID applications. "Mix and Match" with our Data Silo standalone expansion chassis with the Data Express for a custom, external removable solution.

Warranty & Testing

All Kingston storage products carry a 7-year warranty, the longest in our industry. We are so sure that our customers will be completely satisfied with our storage products, that in addition to our unbeatable 7-year warranty, we offer a 30-day, no-questions-asked, money-back guarantee. Every Kingston storage product is 100% tested and burned-in for 24 hours prior to shipment. All products are UL, CSA, and TuV approved and are designed to meet FCC class B and CE specifications. Kingston Storage Products Division is an active member of the RAID Advisory Board (RAB).

What Our Customers Say

Our most recent customer survey revealed the following quotes: "I like Kingston storage products because their high quality helps build customer loyalty." "As far as reliability goes, KTC is the Rolls-Royce of storage products." "I buy Kingston storage because I know that I am not going to have trouble connecting it up." "I can get delivery from Kingston in 2 or 3 days." "When a shipment comes into the port for repairs, we can count on Kingston to get the products we need right away." "I do not have the room to carry inventory, so fast shipping is necessary for me to please my customer, and so far Kingston has not let me down." "Whenever I call Kingston for anything, I always get a helpful person on the line, not just someone trying to sell me something."

Where to Find Our Products

With approximately 700,000 Kingston storage products shipped around the world, often we are asked where our products actually are used. Because we sell through distribution and integrators, applications are difficult to track and often are not reported to us. However, we do know that some of our products have found their way into the White House, aboard Woods Hole's submersible "Alvin" for exploration of the Titanic, into Army bunkers in the Middle East, onto a few of NASA's shuttles, onboard large numbers of Navy ships, on Air Force C130 aircraft, and most recently, dropped from pods into Bosnia for information retrieval purposes. Whether it's RAID or JBOD configurations for graphics, multimedia, design, file servers, CAD/CAM, engineering security or government applications, Kingston's storage products are rugged and flexible enough to suit most needs.

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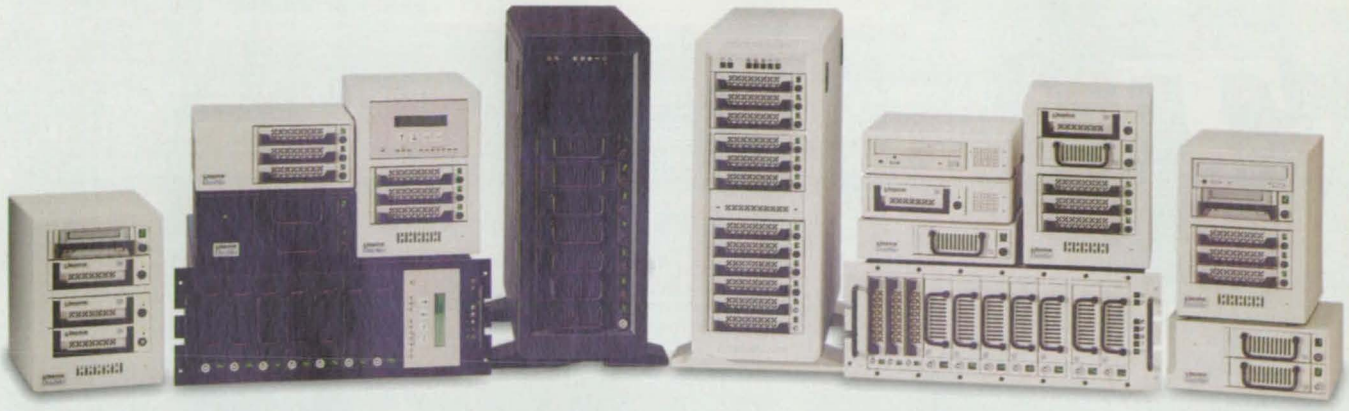

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Best of all, you can integrate a variety of Data Express models into a stand-alone Data Silo and create your own custom removable solution. Plus, all Kingston storage enclosures are backed with Kingston's superior service and support, including a generous 7-year warranty. Kingston Storage enclosures—proof that you can be both tough and flexible at the same time.

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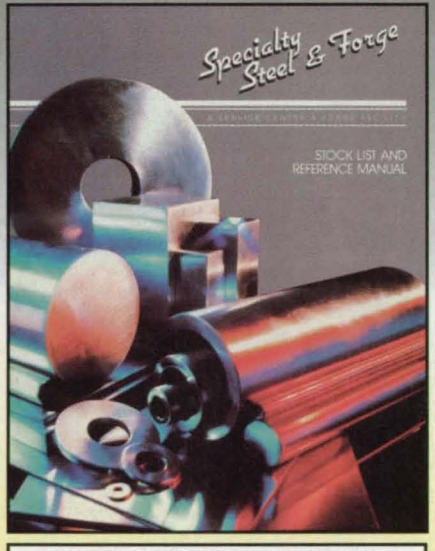

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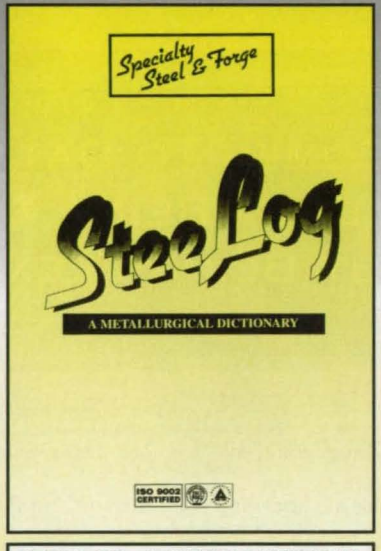

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Faugère & Jutheau: Insuring Progress

The French insurance and re-insurance broker, Faugère & Jutheau, has been insuring Europe's space, aviation, and high-tech aerospace industries for over 20 years. Presently under the direction of Chief Executive Officer Mohammed B. Dahbi, Faugère & Jutheau provides a spectrum of financial protection from launcher insurance or ground facilities coverage, to in-orbit life insurance.

The firm furnishes ESA with launch insurance for a number of its space programs (OTS-1,2; METEOSAT; ECS-1,2,3,4,5; MARECS-A,B,B2; and OLYMPUS F1) and in-orbit life insurance for the ECS-1,2,4,5 programs and the MARECS-A and B2 programs. For CNES, Faugère & Jutheau provides launch insurance for SYMPHONIE, pre-launch coverage for Ariane launches and SPOT satellites, as well as coverage for ground facilities and space activity liabilities.

In addition, Faugère & Jutheau provides insurance for EUTELSAT, Arianespace (Ariane launchers), France Telecom (Telecom 1 and 2 families), Aerospatiale (ARABSAT, TURKSAT, NAHUEL, THAICOM, AGILA), TéléDiffusion de France, Spot Image, CLS, ARABSAT, NAHUELSAT, DASA, and the European Southern Observatory.

Intespace

Intespace is a limited company specializing in environmental testing services and engineering (with an average annual turnover of 110 MFF), running a 20,000 m^2 environmental test center located within CNES Space Centre of Toulouse.

Environmental Tests (from space to industrial applications)

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- Climatic tests: hot, cold, humidity
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- Test center engineering
- Test facilities engineering
- Training

Data Processing

- Design and industrialization of information systems for test and simulation data management analysis (DynaWorks®)

IMEC: a Dynamic Microelectronics Resource

Established by the Government of Flanders in 1984, IMEC is located in Leuven, Belgium. Now the largest independent microelectronics center in the world, it currently employs about 700 mostly scientific and technical professionals, while working with a large number of collaborators, approximately 365 companies and research organizations worldwide.

As Europe's leading laboratory in microelectronics, it is participating in close to 90 R&D projects cofunded by the CEC. IMEC is also strongly involved in the various JESSI projects, including the common JESSI/ESPRIT ADEQUAT project on 0.25-micron CMOS, for which IMEC was project coordinator. IMEC is involved in many R&D projects for ESA.

Scientific research, which runs 3-10 years ahead of industrial needs, is concentrated on: digital telecom systems, broadband and high-speed communications, design methods, submicron process technology, nonvolatile memories, microsystems, multichip modules, compound materials, electronics, and optoelectronics, broadband and personnel communication, physico-chemical analysis, and solar cells. Besides these research activities, IMEC makes an appreciable contribution to the training of microelectronics specialists of tomorrow.

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Software for Internet Distribution of Oceanographic Data

The DODS HDF Data Server and Client Library computer program facilitates distribution, via the Internet, of oceanographic data that reside on servers in the Distributed Ocean Data System (DODS). This software extends the suite of DODS data formats to include Hierarchical Data Format (HDF), which is the primary format for dissemination of data from NASA's Earth Observing System (EOS). With the help of this software, an application program that utilizes the HDF application programmer interface (API) can gain direct access to data on a remote DODS server; the access and the concomitant translation of data between formats are both automatic and transparent to the application program. Users can develop programs that perform such operations as extracting subsets and conducting searches as though the data to be examined resided in their own local computer files. The DODS and this software work under UNIX. At the time of receipt of information for this article, the server component of the software was undergoing beta testing, and the client component was still undergoing development. It is planned to release the client and server components together in a single package. This work was sponsored by NASA's Earth Science Data and Information System (ESDIS) Prototyping effort. It is intended that this software will be incorporated into the EOSDIS (EOS Data and Information System) core system to provide remote access to EOS data sets.

This program was written by Todd Karakashian of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 98*** *on the TSP Request Card.*
NPO-20020

MOO Web Core

The MOO Web Core computer program implements an interface between the MOO multiple-user database computer system and the World Wide Web, enabling any Web user to obtain information from a MOO server. At the time of reporting information for this article, there were about 100 MOO servers at industrial, university, and government sites, and the number of them is expected to grow. The nature of the MOO system and its software can be understood partly in terms of the history of its name: "MOO" stands for "MUD, Object Oriented", while "MUD" originally stood for "Multi-User Dungeon," (an Internet adventure game with a large number of simultaneous players), which then evolved into self-explanatorily-named software called "Multi-User Data base." MOO has evolved in conjunction with a collaborative project called "AstroVR," wherein MOO and MOO Web Core have been used to make images of celestial objects available on the Internet. MOO Web Core creates a set of MOO objects designed to provide an http interface to a MOO server running a LambdaCore-derived data base. By use of MOO Web Core, any standard World Wide Web client can connect to a MOO server and request data. MOO Web Core implements the http "GET" and "POST" commands, supporting html document delivery, search services, and fill-in form queries. MOO Web Core is designed to fit into any LambdaCore-based MOO data base.

This work was done by David Van Buren of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 9*** *on the TSP Request Card.*
NPO-19642

Software for Evaluation of Data-Compression Algorithms

The Advanced End-to-end Simulation for On-board Processing (AESOP) program facilitates computational simulations of the performances of data-compression and -decompression algorithms in the presence of noise. AESOP satisfies a need for a single program that can be used to evaluate, compare, and build on data-compression algorithms developed by different scientists and engineers. AESOP provides a graphical interface to an extensible set of data-compression algorithms, interfacing with both complied code and stand-alone programs. Most interactions between AESOP and the user take place via a mouse. Once compressed, data can be fed through simulated transmission and decompression to evaluate the effects of compression parameters, noise, and error-correction subalgorithms. The user can predict the ultimate data quality attainable via different compression methods and compression ratios, and evaluate data compression in the larger context of packeting and noisy transmission. Written in C and C++, AESOP currently runs on Sun SPARCstation computers using SunOS 4.1.3 and Motif. Operating-system dependences are minimal.

This work was done by Alan Mazer, Roberto Mendoza, and Andy Boden of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 45*** *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

Larry Gilbert, Director
Technology Transfer
California Institute of Technology
Mail Code 315 - 6
Pasadena, CA 91125
(818) 395-3288

Refer to NPO-19673, volume and number of this NASA Tech Briefs *issue, and the page number.*

Algorithms for Selection of Scheduling Heuristics

A computer program incorporates the STOP1, STOP2, EL1, and EL2 algorithms, which implement different versions of a statistical approach to choosing one out of a number of alternative heuristic strategies for scheduling. The basic rules for making this choice are that (a) the chosen scheduling strategy should be the one that allocates resources most efficiently, (b) the choice must be made on the basis of incomplete information, and (c) excessive information-gathering cost must not be incurred in making this choice. Each algorithm tests the performance of each strategy on a randomly selected sample of scheduling problems, then uses parameter-estimation techniques to infer statistical models of performance on the general population of scheduling problems. These models are then used to estimate (a) the utility and cost of acquiring additional information and (b) the desirability of selecting a particular strategy. Each algorithm implements a different method of balancing the expected utility of additional information against the cost of acquiring that information. The pro-

gram can be executed on Sun SPARCstations running common LISP. In computational experiments on representative sets of scheduling data, all four algorithms were found to outperform both the benchmark COMPOSER algorithm and the traditional manual selection procedure.

This work was done by Steven A. Chien and Jonathan Gratch of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, **write in 33** on the TSP Request Card.*
NPO-19766

Software for Managing SAR Systems

The Data Acquisition and Production Planning System (DAPPS) computer program assists in the management of synthetic-aperture-radar (SAR) equipment and data. DAPPS incorporates three subsystems; the Flight Agency Interface Subsystem (FAIF), the Acquisition Planning Subsystem (APS), and the Production Planning Subsystem (PPS). The FAIF manages interfaces with the Canadian, European, and Japanese space agencies. Satellite planning and scheduling files received from the various flight agencies are used to plan the acquisition of raw signal data transmitted from the satellites to the McMurdo (in Antarctica) and Alaska SAR Facility (ASF) ground stations. Users can submit data-acquisition requests. The APS uses the satellite planning and scheduling files to incorporate data-acquisition requests into satellite schedules. When final flight-agency schedules are received, the APS generates an antenna schedule file for the appropriate antenna at ASF or McMurdo. The PPS manages the production of SAR imagery and other data products; in so doing, it also provides an interface for operators to queue various product requests, modify their priorities, and provide a central control mechanism for the generation of SAR data products at ASF. DAPPS runs on two SUN SPARCstation 20/71 computers with 96 MB of memory and 9 GB of disk space. Each computer includes two Ethernet connection cards.

This work was done by Navid Dehghani, Quentin Sun, Sally Chou, Richard Norman, Philip Yurchuk, Rodney Hoffman, Miguel Siu, Teresa McKillop and Larry Stevens of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, **write in 10** on the TSP Request Card.*
NPO-19995

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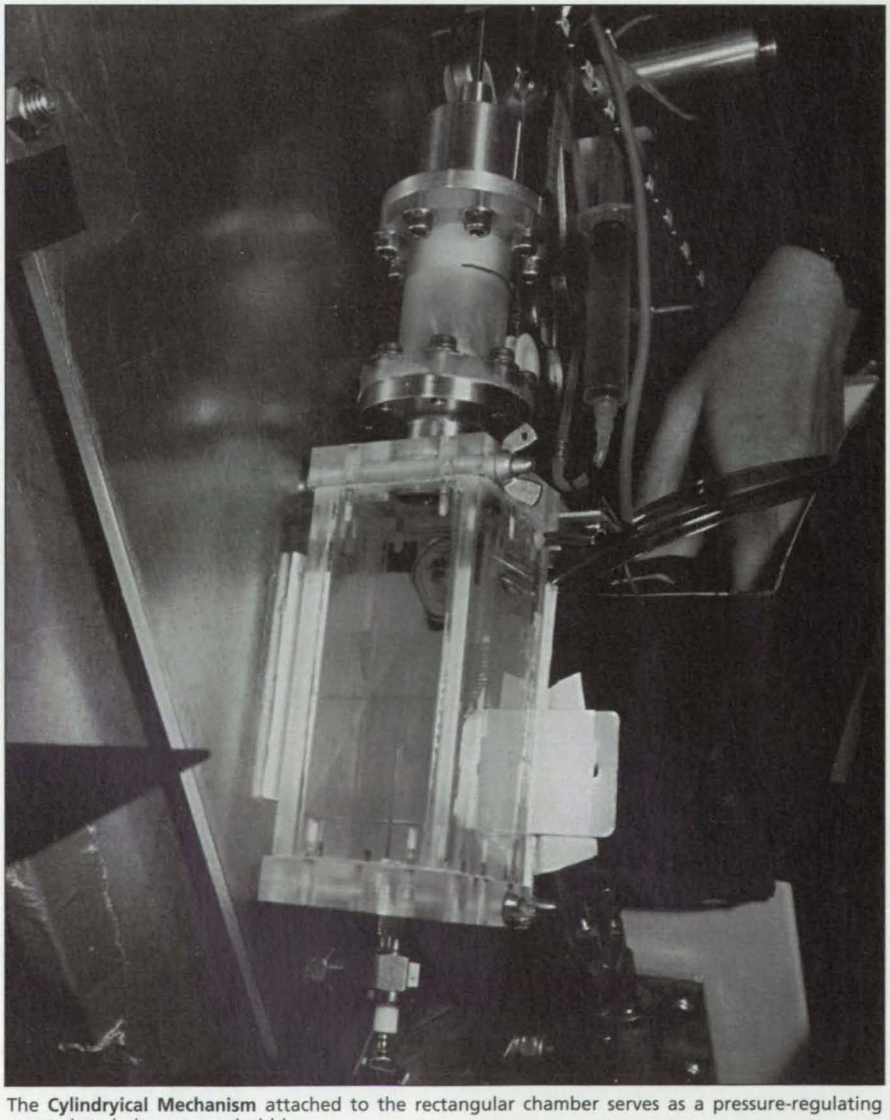
Fluid Reservoir Maintains Constant Back-Pressure During Addition and Removal of Liquid

A piston moves to accommodate addition or removal of liquid from a completely filled reservoir.

Marshall Space Flight Center, Alabama

The figure shows a chamber completely filled with liquid. The chamber is equipped with a mechanism, a free-floating piston at one end, that can be attached to a spring-driven lever-arm of variable mechanical advantage, to help prevent the introduction of bubbles of gas during liquid addition or removal. Originally developed for use in the microgravity environment of space, where lack of hydrostatic pressure and buoyancy can cause problems with unwanted bubbles during liquid-filling, this apparatus can also be used on Earth in any situation in which a constant back-pressure would be desirable. A syringe needle is inserted into the reservoir through a septum port on the end opposite to the piston for liquid transfer, and a pressure transducer is mounted within the reservoir to allow pressure monitoring during liquid transfer.



The **Cylindryical Mechanism** attached to the rectangular chamber serves as a pressure-regulating reservoir to help suppress bubbles.

The overall function of the apparatus is to maintain a nearly constant back-pressure (including zero pressure) on the liquid in the reservoir while providing a storage volume that can expand or contract just enough to match the volume of additional liquid being injected or withdrawn from the reservoir, thereby minimizing bubble formation. This apparatus has been test-flown aboard the NASA KC-135 low-gravity aircraft to test liquid handling during low gravity, for applications such as solution crystal growth and cavitation tests.

The apparatus includes a piston-cylinder assembly attached to one end of the reservoir. The piston is held centered in the cylinder and guided by a linear ball bushing to minimize pressure error due to friction. Instead of piston rings, sealing between the cylinder wall and piston is accomplished by a very thin flexible latex rubber bladder which unrolls from the cylinder wall as the piston moves outward, to provide additional liquid volume. Pressure is applied to the back of the piston through a linkage mechanism by a constant-force spring motor — that is, a spring which does not change force as it winds or unwinds. This spring motor maintains a constant force on the piston as the piston moves in or out to accommodate changes in the volume of the liquid, and this force may be set to any desired level by changing the mechanical advantage lever in the linkage mechanism.

This work was done by Dale M. Kornfeld of **Marshall Space Flight Center** *and Raymond H. Moore, Mark Wells, and Byron Burden of Teledyne Brown Engineering. For further information,* ***write in 80*** *on the TSP Request Card.*

MFS-31081

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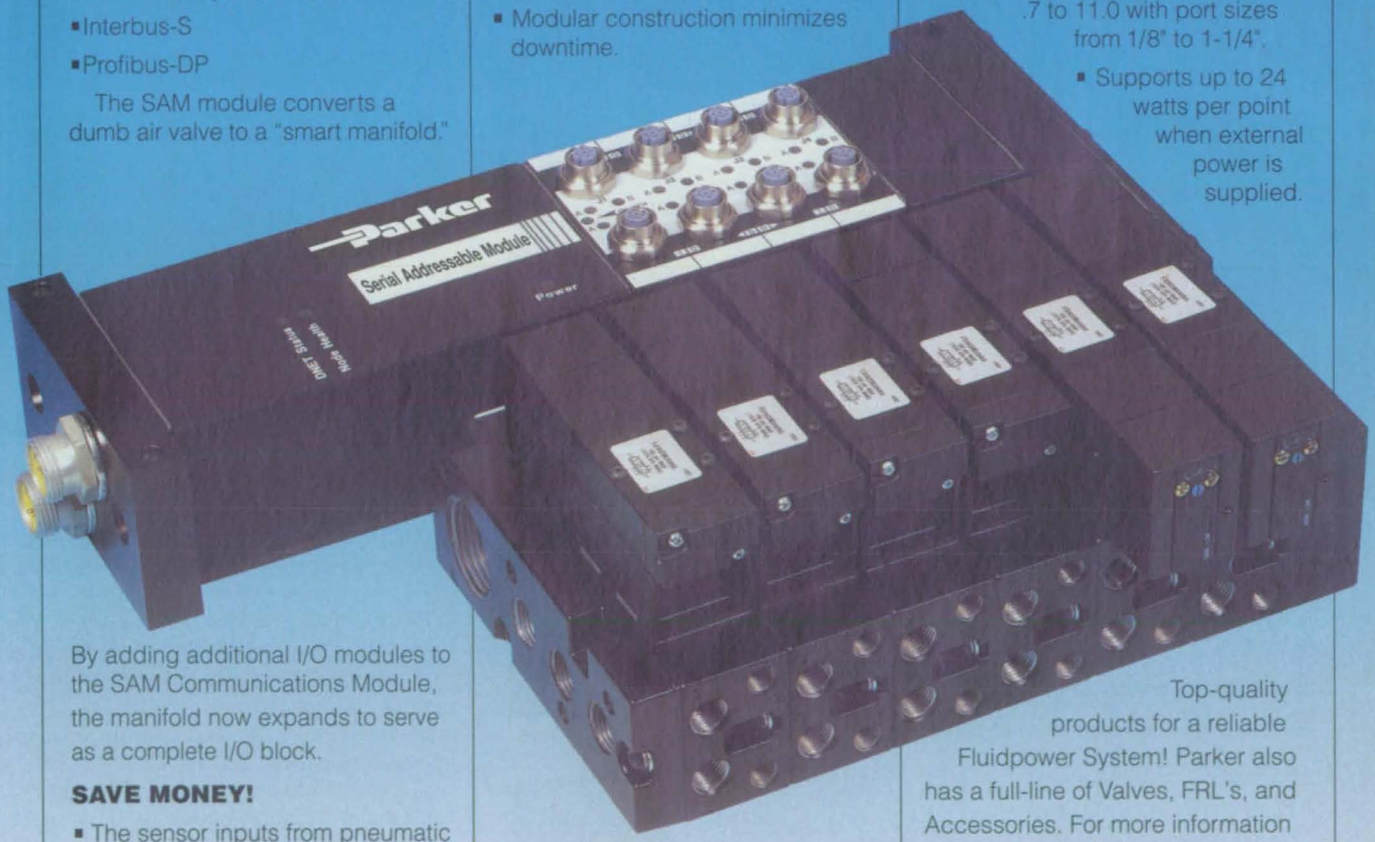

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Low-Differential-Pressure Test Apparatus

Differential-pressure transducers can be tested and calibrated more easily and cheaply.

John F. Kennedy Space Center, Florida

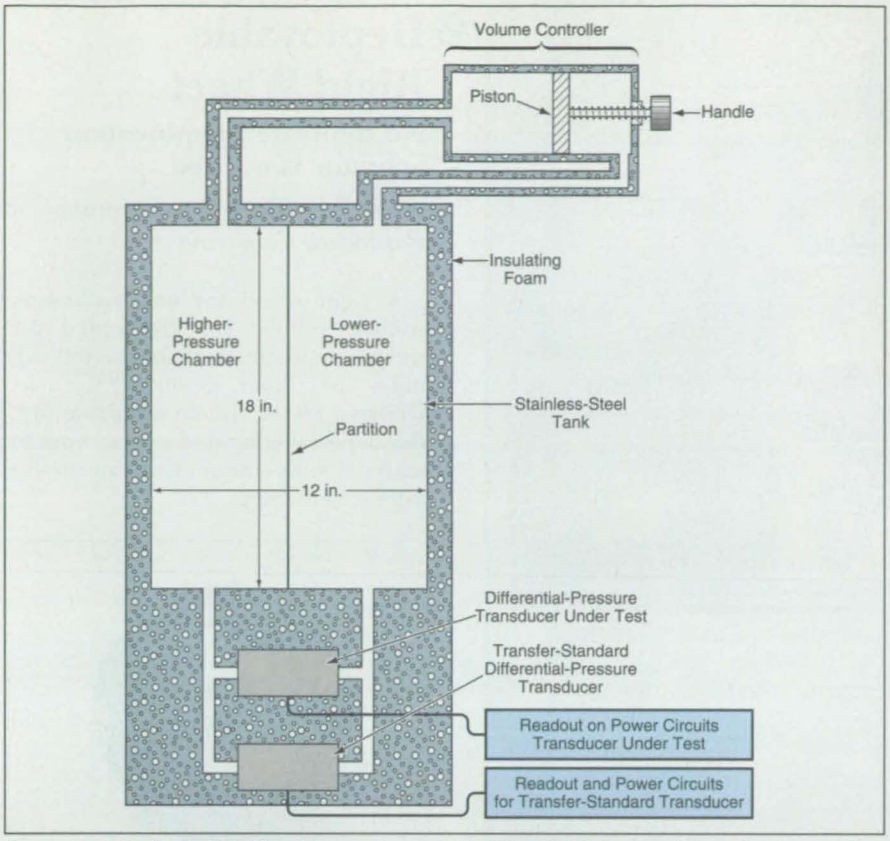
An apparatus for testing and calibrating low-differential-pressure transducers can be used under various conditions in the laboratory or in the field. The apparatus is designed especially for use on clean-room-air-conditioner differential-pressure transducers with typical full-scale ranges of about 0.1 in. of water (about 25 Pa).

Previously, it was necessary to test and calibrate such transducers in the laboratory by use of expensive and cumbersome dead-weight testers, with strict control of room temperatures and long waiting times for equalization of temperatures. The present apparatus costs about one-third as much as a dead-weight tester does, is portable, does not depend on strict control of room temperature, and can be operated easily by a technician with minimal training.

The apparatus (see figure) comprises a differential-pressure generator, a standard differential-pressure gauge with electronic output that can be displayed and recorded by a computer, and associated plumbing. The differential-pressure generator includes a stainless-steel tank partitioned into two approximately equal volumes. A tube connects each volume to one of two ports of a precise volume controller based on a threaded piston with an operating handle. Other tubes connect the two volumes to the ports of the transfer-standard differential-pressure gauge and to the ports of the differential-pressure gauge to be tested or calibrated. The two gauges are connected in parallel; that is, they are exposed to the same differential pressure between the two volumes.

When the operator turns the handle of the volume controller, the volume on one side of the controller decreases, causing an increase in the gas pressure on that side. On the other side of the controller the volume increases, causing a decrease in the gas pressure on the associated side. The technician turns the handle on the volume controller until the transfer-standard gauge indicates the desired differential pressure; when this point is reached, the technician causes the computer to record the readings of the transfer-standard gauge and the gauge under test.

While the decreasing volume (compression) caused an increase in pressure, there was an increase in the temperature. A corresponding decrease in temperature accompanied the decrease in pressure on the other side. In order to determine the value of the pressure he/she has just set, the technician normally has to wait until the temperature differences dissipate. The metal divider in the tank allows this temperature differential to mix at approximately the speed of sound, therefore dissipating the temperature difference during the volume controller adjustment. However, the heat-transfer processes in this apparatus are slow enough that the technician can easily maintain a desired pressure setting by manual adjustment. Moreover,



Pressures of Gas in the Two Chambers can be made to differ slightly by use of the volume controller, which contains a manually adjustable piston that increases the volume of the gas on one side while decreasing the volume of gas on the other side by an equal amount.

the apparatus is insulated to prevent room air currents and other ambient phenomena from differentially heating or cooling the gases in the two volumes.

The standard differential-pressure gauge is a commercial unit that has been calibrated by use of primary standards that have, in turn, been calibrated by the National Institute of Standards and Technology (NIST). The full-scale reading of this unit is 0.53579 in. of water (about 133 Pa). Tests have shown that with manual adjustment, differential pressure can be regulated to within 5×10^{-5} in. (0.012 Pa), exceeding a design requirement for an accuracy and resolution of 2.5×10^{-4} in. (0.062 Pa).

This work was done by Gregory A. Hall of **Kennedy Space Center** *and Stephen J. Stout, Richard T. Deyoe, James E. Meeks, and Harold E. Crain of I-NET. For further information,* ***write in 75*** *on the TSP Request Card.*

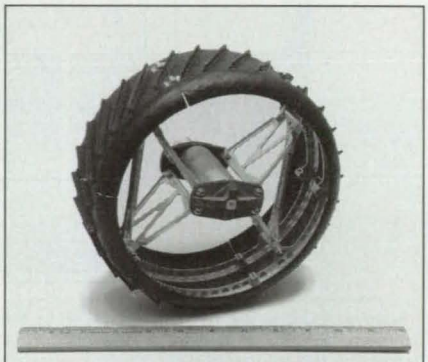
This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Kennedy Space Center; (407) 867-2544. Refer to KSC-11804.

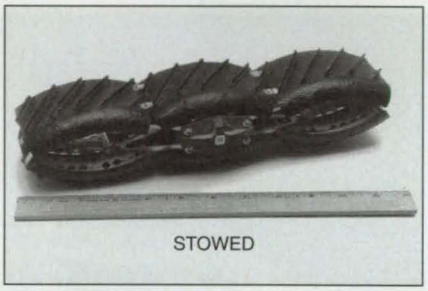
Deployable Rigid Wheel

No dedicated deployment actuator is needed.

NASA's Jet Propulsion Laboratory, Pasadena, California

A rigid wheel for an exploratory robotic vehicle can be folded for stowage at about one-third its full volume, then later deployed for use. Unlike a wheel with an inflatable tire, this deployable rigid wheel can work in extreme temperatures and can survive intense radiation.





The **Deployable Rigid Wheel** can be stowed at about one-third its full volume. When released from stowage, it extends itself, then locks itself at full extension.

The wheel (see figure) includes six rigid outer segments that are hinged together and connected to a hub via pin-ended spokes. No dedicated actuator is needed for deployment; instead, to initiate deployment, one simply releases some restraints. Deployment force and locking are derived from pin-ended extension springs. When deployment is complete, the spokes rest on mechanical stops at the hub; this establishes the load path for transmission of torque.

This work was done by Lee F. Sword, Geoffrey D. Harvey, and Jack A. Frazier II of Caltech for **NASA's Jet Propulsion Laboratory**. *No further documentation is available. NPO-19982*

Procedure for Quick Calculations of Hydroelastic Loads

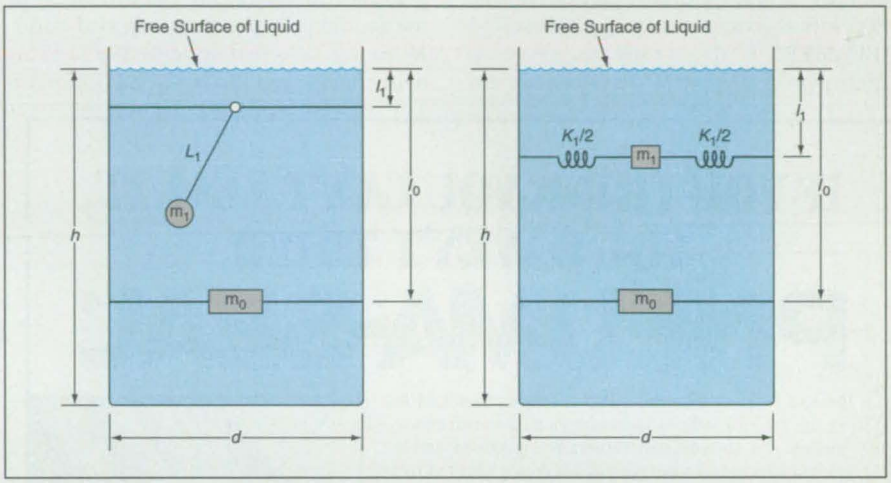
Effects of sloshing can be estimated faster by use of a simplified mathematical model.

Marshall Space Flight Center, Alabama

A procedure for calculating hydroelastic loads associated with sloshing of liquid in a tank involves the use of (1) a computer code developed previously for finite-element mathematical modeling of hydroelasticity and (2) a finite-element mathematical model of the dynamics of the tank to obtain (3) a simplified (one-degree-of-freedom) approximate mathematical model of sloshing. In comparison with other, more complex mathematical models of sloshing, this approximate model can be implemented more rapidly and easily and thus more cheaply. The capability afforded by this procedure can be beneficial in analyzing and designing tanks in which sloshing can adversely affect safety and controllability; potential applications include ballast and liquid-transport tanks in ships, fuel tanks in aircraft, and liquid-transport tanks on land vehicles.

The previously developed HYDRO computer program implements the finite-element model of the liquid. This model is based partly on the simplifying assumptions that the liquid is inviscid, incompressible, and irrotational, and that it undergoes only small displacements. The principal unknown quantities that one seeks to compute in HYDRO are pressures in the liquid as functions of position and time. One important consequence of the simplifying assumptions is that one can compute these pressures from displacements of the boundary of the liquid.

In the finite-element modeling of the



A **Pendulum or Spring-and-Mass Model** approximates the effects of sloshing of liquid in a tank. Masses m_0 and m_1 represent the nonsloshing and sloshing parts, respectively, of the mass of the liquid. The spring stiffness K_1 or the pendulum length L_1 represents the slosh stiffness.

tank, one seeks to compute the displacements (elastic deflections) of the tank as functions of position and time. Wherever the liquid wets a wall of the tank, the pressure in the fluid and the displacement of the wall affect each other, and the dynamic response of the tank is affected by its elasticity and its distribution of mass.

In the present procedure, HYDRO is used to calculate the slosh frequencies under the initial simplifying assumption that the tank is rigid. Another previously developed computer program called "BEAMER" is then used to obtain a transformation matrix that couples the HYDRO model of the liquid with the finite-element structural model of the tank. The resulting system of equations for the coupled models is solved by use of a third previously developed computer code; namely, MSC/NASTRAN.

The last step in the procedure is to generate the approximate single-degree-of-freedom model of sloshing (see figure). Such models have traditionally been used in analyzing control systems that interact with sloshing liquids. To generate data to determine the values of the model parameters m_0, m_1, and either K_1 or L_1, one first models the tank as being subjected to a lateral enforced acceleration. One then finds the values of these parameters that make the oscillations of the model produce net lateral forces and moments equal to those of the first lateral slosh mode. A HYDRO-post-processing code called "SLOSH" has been written for this purpose. SLOSH reads in the results from HYDRO, performs a frequency-response analysis, and solves for parameters of the approximate model.

This work was done by Joseph Brunty and Frank Bugg of **Marshall Space Flight Center** *and Eric R. Christensen of Sverdrup Technology, Inc. For further information,* ***write in 87*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center; (205) 544–0021. Refer to MFS-31134.

Turbine-Blade Radial Damper With Offset Center of Gravity

Marshall Space Flight Center, Alabama

A device suppresses radial vibrations of a turbine blade, thereby helping to reduce fatigue and prolong the life of the blade. The device is a damper that is pressed outward against the turbine-blade platform by centrifugal force. The damper is shaped and positioned with its center of gravity offset from the radial line through the point of contact with the blade platform, so that centrifugal force applies a torque about this point. The torque is reacted by contact between a radial leg of the damper and the sides of a radial slot into which the leg extends. The circumferential force of contact gives rise to a radial frictional force whenever the blade platform and thus the damper move radially. Thus, kinetic energy of radial vibrations is damped by friction, with consequent reduction of the amplitudes of the vibrations. The heat generated by the frictional dissipation of energy is removed by the turbine flow.

This work was done by Charles A. Bulgrin and John O. Struthers of United Technologies Pratt & Whitney for **Marshall Space Flight Center**. *For further information,* ***write in 83*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center; (205) 544-0021. Refer to MFS-31177.

Apparatus for Access to a Confined Space From Above

Telescoping tubes, a ladder, and platforms would fit through a narrow opening.

John F. Kennedy Space Center, Florida

A proposed apparatus called an "access kit" would enable technicians and equipment to enter and leave a confined space through a relatively narrow opening in the ceiling. The apparatus is undergoing development; its original intended application is in the installation and removal of refrigerator and freezer components in a spacecraft module through a 50-in. (126-cm) square hatch on top of the module. Similar apparatuses could be designed to provide access to other confined spaces through narrow top openings for purposes of manufacturing, maintenance, and rescue. Large confined spaces such as chemical tanks, vats, and silos could be easily accessed from above. The access kit is unique in that it does not touch the room interior and is entirely supported from above.

The apparatus (see figure) would include three rectangular-cross-section telescoping tubes, a ladder, platforms, and hoists. For compactness, the telescoping motions of the tubes would be actuated by a single wire-rope-drive hoisting mechanism. This mechanism would be strong enough to raise and lower not only the platforms, tubes, and ladder, but also the technicians.

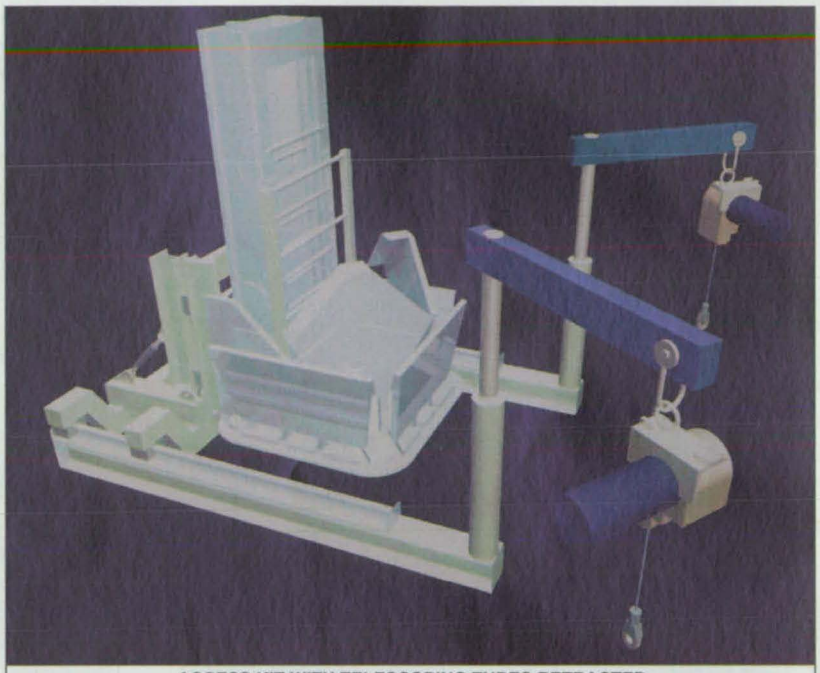
Initially, the apparatus would be maneuvered into position above, and aligned with, the hatch. The telescoping tubes would then be extended by a single actuator down through the hatch into the room below. The telescoping tubes would provide support for the platforms as they were lowered through the hatch and set up for use.

The platforms would include a fixed access platform and several flip platforms, all combined into an assembly at the bottom of the telescoping tube assembly. Once the platform assembly was lowered to the desired position, a technician would climb down the ladder to the platform assembly, then deploy the flip platforms to cover the entire open area and thereby provide a safe work platform. Other technicians, if needed, would then climb down the ladder to the work platform.

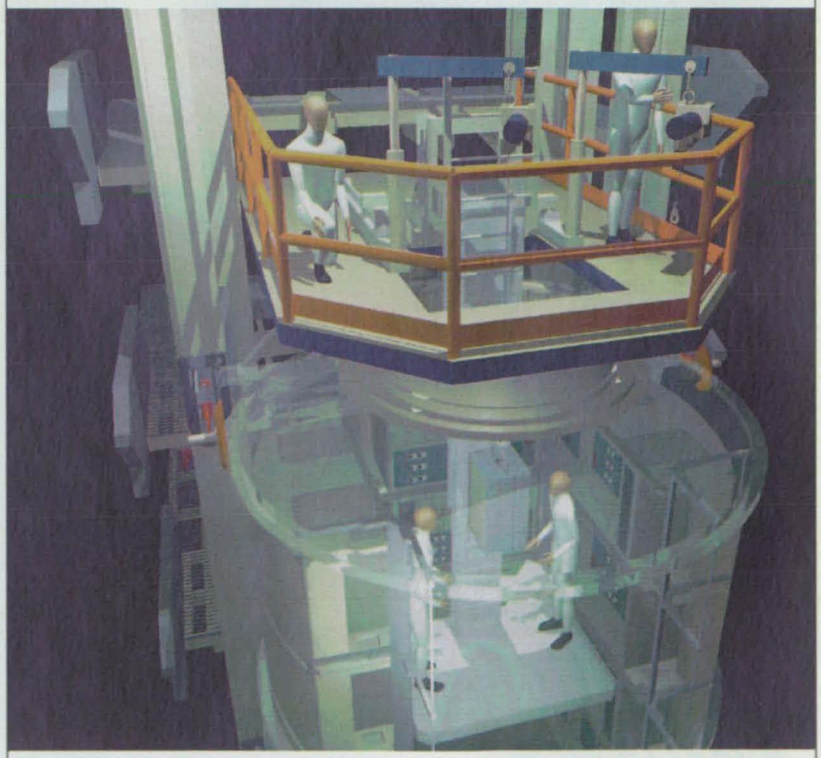
Two small jib hoists would be available for lowering and raising components and other equipment and, if necessary, for raising injured technicians.

This work was done by Scott T. Colloredo and Alan C. Littlefield of **Kennedy Space Center** *and Scott Strickland of McDonnell Douglas Corp. For further information,* ***write in 65*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Kennedy Space Center; (407) 867-2544. Refer to KSC-11848.



ACCESS KIT WITH TELESCOPING TUBES RETRACTED



ACCESS KIT IN USE

The **Access Kit Would Be Fairly Compact** when the flip platforms were folded inward and the telescoping tubes retracted for assembly. In use, the telescoping tubes would be extended downward and the flip platforms deployed to form a work platform.

Reducing Gear-Mesh Vibrations With Piezoelectric Actuators

Opposing vibrations are introduced in a feedforward control scheme.

Lewis Research Center, Cleveland, Ohio

Experiments have demonstrated the feasibility of a feedforward scheme for reducing gearbox vibrations by introducing opposing forces at the gear-mesh frequency, using piezoelectric actuators coupled to the outer races of some of the gear-shaft bearings. The need to consider the introduction of opposing vibrations arises because even in the presence of the most careful design and precise fabrication, the variation in gear-tooth stiffness with motion of the meshing point along the gear-tooth profile makes it impossible to eliminate gear-mesh vibrations completely. The vibrations are transmitted through the gear shafts and bearings to the gearbox housing.

The basic concept of reducing vibrations in the gear box housing by use of opposing, piezoelectrically actuated vibrations has been investigated previously, but with a view toward suppressing synchronous, subsynchronous, and transient vibrations of rotors. In engineering disciplines concerned with vibrations of rotating machine elements, "synchronous" means at the frequency of rotation. Typically, frequencies of rotation are of the order of tens to hundreds of hertz. One of the novel aspects of the present development is the choice of the gear-mesh frequency (typically of the order of several kilohertz) rather than the lower frequencies addressed previously. Another novel aspect is the particular design for coupling between the actuators and the bearing races.

Figure 1 illustrates the arrangement of gears, bearings, and piezoelectric actuators in a test rig used in the experiments. The actuators at an angle that is collinear with the gear-tooth contact force; in the particular gear design, this angle is 20° off the centerlines of the shafts. Cone washers and a threaded plug preload a push rod between each actuator and its respective bearing race. A small accelerometer is mounted on each

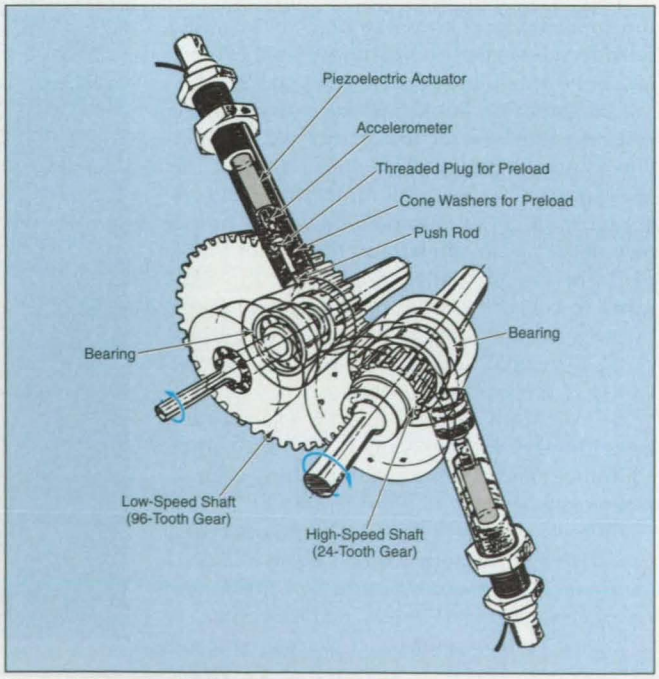


Figure 1. **Piezoelectric Actuators Generate Forces** to counteract gear-mesh vibrations. The off-center mounting scheme makes the actuator force collinear with the gear-mesh force.

actuator. Not shown in Figure 1 are a mechanism for applying a static preload torque to the low-speed shaft, four accelerometers mounted on the gearbox housing to measure vibrations.

Figure 2 shows the major functional blocks of the feedforward control scheme to illustrate the principle of operation. An eddy-current displacement sensor is mounted to detect the passage of the teeth of one of the gears. As the gear rotates, this probe produces a pulse wave at the gear-mesh frequency. A feedforward circuit converts the pulse wave to a sinusoid of equal frequency. The phase of the sinusoid for each actuator can be adjusted manually, by use of a phase shifter and an inverter, over the full range of 360°. The feedforward circuit has a separate manual control to adjust the amplitude of the sinusoid.

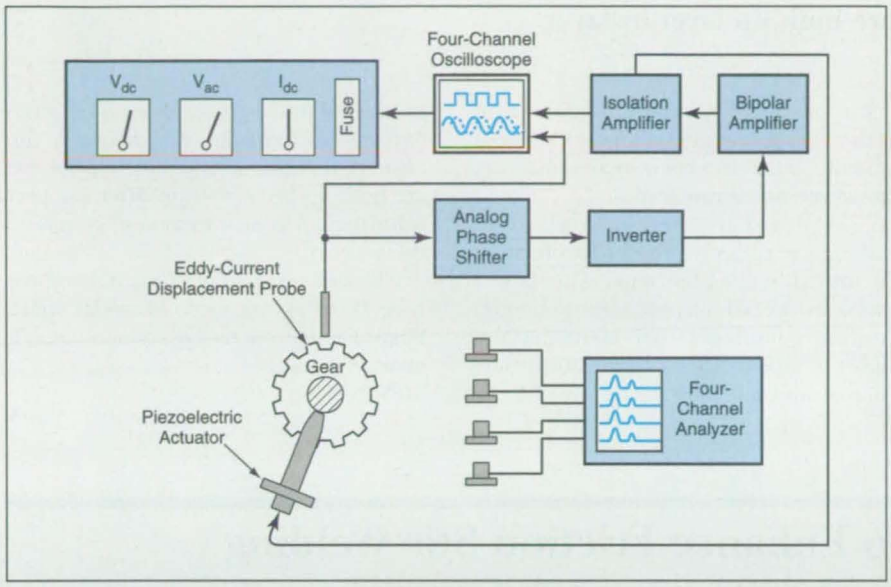


Figure 2. **Feedforward Excitation for the Piezoelectric Actuators** is generated from the displacement-probe output, which is a pulse wave synchronous with the meshing of the gear teeth.

An oscilloscope is used to monitor the gear-tooth pulse wave and the amplified feedforward sinusoid for each actuator. The voltage and current of the feedforward sinusoid is monitored by analog meters. A four-channel dynamic signal analyzer monitors the frequency responses of four accelerometers. In operation, the phase and amplitude of the feedforward sinusoid(s) are adjusted manually to minimize the amplitude of the gear-mesh-frequency component of the vibration amplitudes indicated by the signal analyzer.

This work was done by Albert F. Kascak and Gerald T. Montague of the Vehicle Propulsion Directorate of the U. S. Army Research Laboratory and Alan Palazzolo, Daniel Manchala, and Erwin Thomas of Texas A&M University for **Lewis Research Center**. *For further information,* ***write in 13*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Lewis Research Center, Commercial Technology Office, Attn: Tech Brief Patent Status, Mail Stop 7–3, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16070.

Desktop Manufacturing of Silicon Nitride Components

Three-dimensional components are built up layer-by-layer.

Marshall Space Flight Center, Alabama

A proprietary "desktop" laminated-object-manufacturing process has been used to rapidly fabricate silicon nitride components. The finished components are based on a computer-generated model and built without any mold or dies, so the design can be easily changed, providing engineers and designers with a very flexible and rapid prototyping process. The process has been used previously for rapid fabrication of prototype components from other ceramic materials besides silicon nitride. It has also been successfully used to create metal prototypes.

The first step in the process involves taking the ceramic powder and forming it into thin, flexible tape. The tape is used in special-purpose, computer-controlled equipment that laminates one layer of tape to a stack of previously laminated and cut layers. The new layer is then cut to form one cross-section of the part being built. In this manner, the desired three-dimensional components are built up layer-by-layer. After the part is finished, it is heat treated to complete the process.

This work was done by Curtis W. Griffin of Lone Peak Engineering for **Marshall Space Flight Center.** *No further documentation is available.*

MFS-26467

Back-Surface Relief To Enhance Friction Stir Welding

Sensitivity to depth of penetration is reduced, and strength is increased.

Marshall Space Flight Center, Alabama

An improved version of friction stir welding (FSW) incorporates a weld-preparation step in which a groove of suitable cross section is machined into the back surface, straddling the weld line between two workpieces to be joined (see Figure 1). This groove, known in the art as back-surface relief, offers two advantages: (1) it makes the overall FSW process more controllable by decreasing the sensitivity of the resulting weld quality to variations in the depth of penetration of the welding tool into the workpieces, and (2) the fracture strength and toughness of the weld exceed those of a similar weld made without back-surface relief.

The tool used in FSW comprises a shoulder and a probe. The tool is rotated, moved along the weld line, and pushed into the workpieces with considerable force. The force and motion plasticize and forge the parent material under the tool. The quality of the resulting weld is highly dependent on the depth of penetration of the probe, making it necessary to control the depth of penetration precisely by use of rigid structures to support the tool and the workpieces. In principle, the depth could be measured and controlled actively, but this would entail great expense.

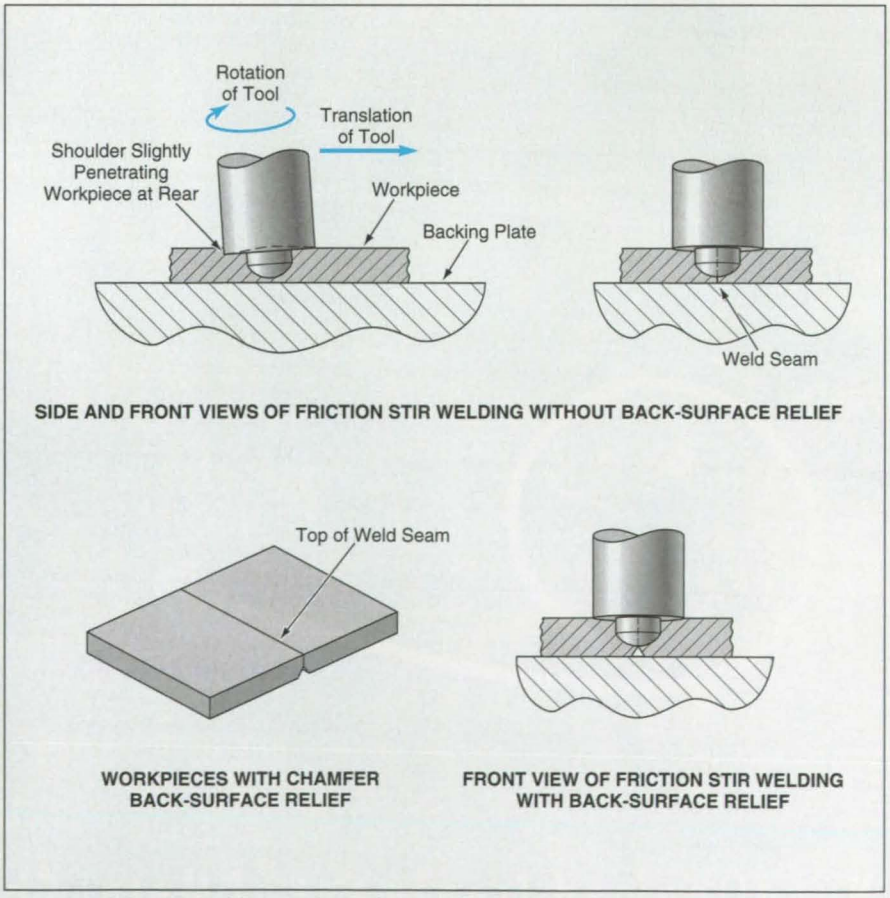
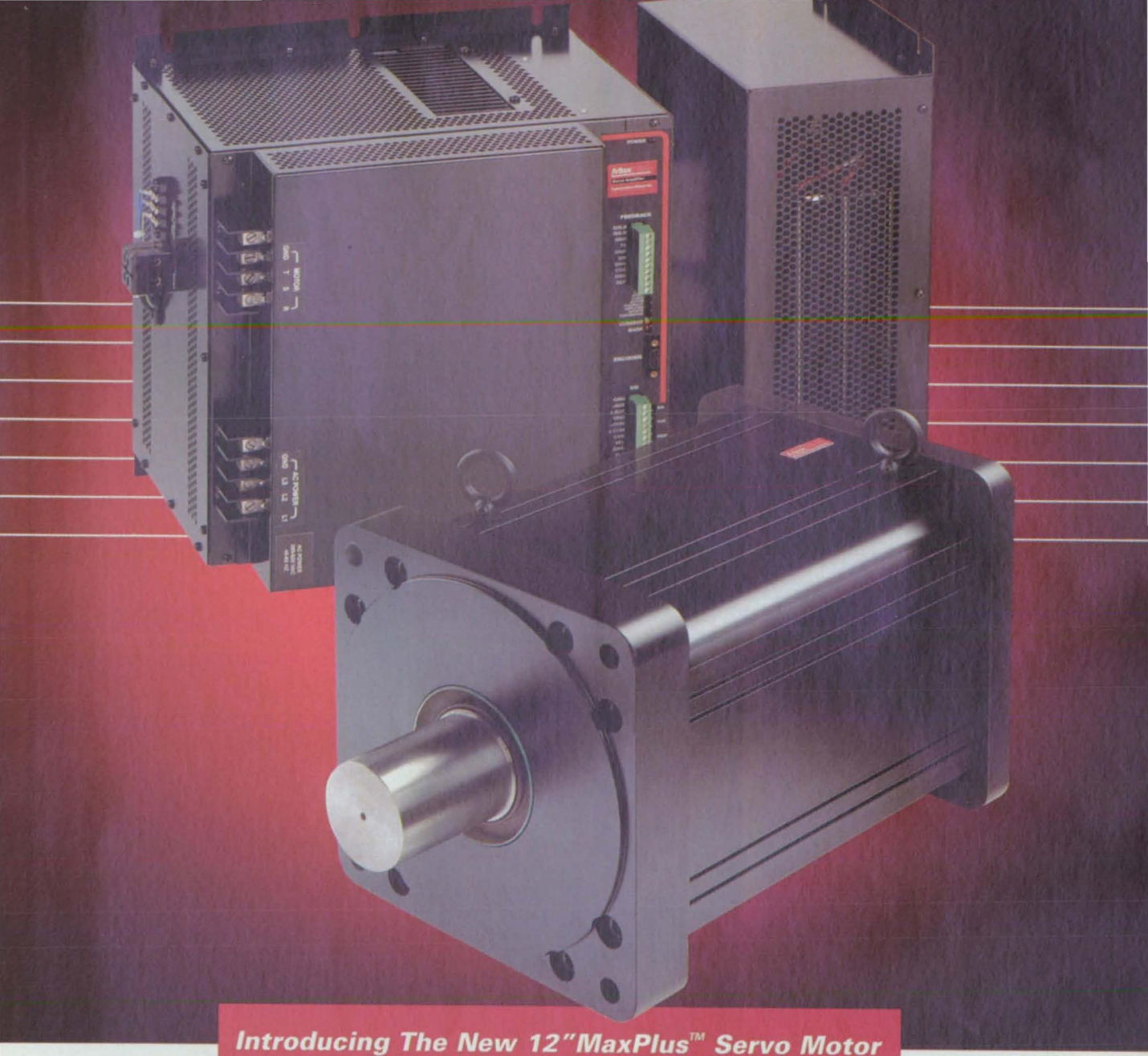


Figure 1. **Friction Stir Welding** can be performed without or with back-surface relief. Although the back-surface relief shown here is in the form of an inverted V groove, other relief cross sections could also be used.



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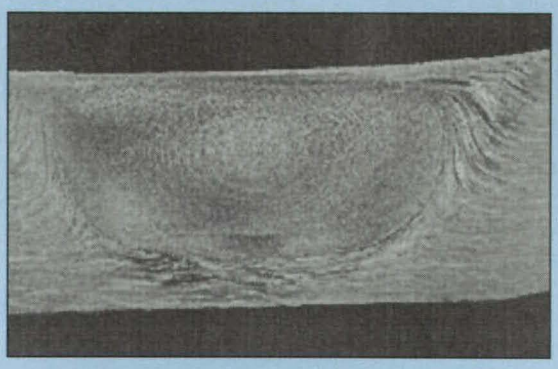
In the absence of back-surface relief, plasticized material is forged between the probe tip and the bottom of the parent material. In the presence of back-surface relief, forging occurs between the probe tip and the backing plate, so that forged material is pushed into the relief volume. Back-surface relief thus redefines the nature of the FSW process. Though the precise physics of the improvement may be difficult to explain, it is apparent that back-surface relief makes the depth of penetration of the tool less critical, and there is apparently some optimal relationship between the geometry of the relief and the amount of parent metal pushed into the relief volume.

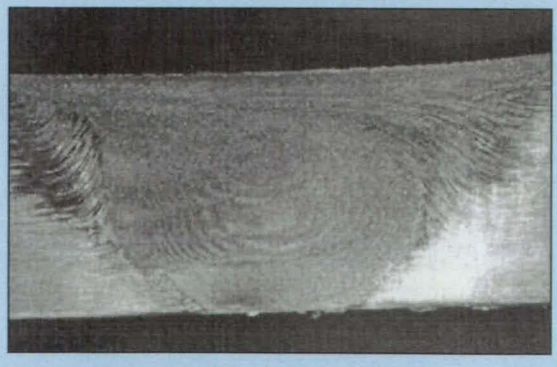
In an experiment to demonstrate this concept, 0.250-in. (6.35-mm)-thick workpieces of Al/Li alloy 2195 were joined by FSW, both with and without back-surface relief (see Figure 2). The specimens made with back-surface relief exhibited higher fracture strengths and greater elongations than did the specimens made without back-surface relief. Moreover, the standard deviations of the fracture strengths of the specimens made with back-surface relief were an order of magnitude smaller than those of the other specimens. These data indicate that back-surface relief results in stronger, more consistent welds.

This work was done by Jeff Ding of **Marshall Space Flight Center,** *Peter Oelgoetz of Boeing North American, Rocketdyne Division, Peter Romine of Florida International University, and Glynn Adams of the University of Arkansas. For further information,* ***write in 56*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center; (205) 544-0021. Refer to MFS-30134.



FRICTION STIR WELD WITHOUT BACK-SURFACE RELIEF



FRICTION STIR WELD WITH BACK-SURFACE RELIEF

Figure 2. These **Cross Sections of FSW Specimens** exhibit different distributions of fine-grain structure. In the specimen made with back-surface relief, the distribution extends to the bottom and is more nearly even. These differences are associated with differences in mechanical properties.

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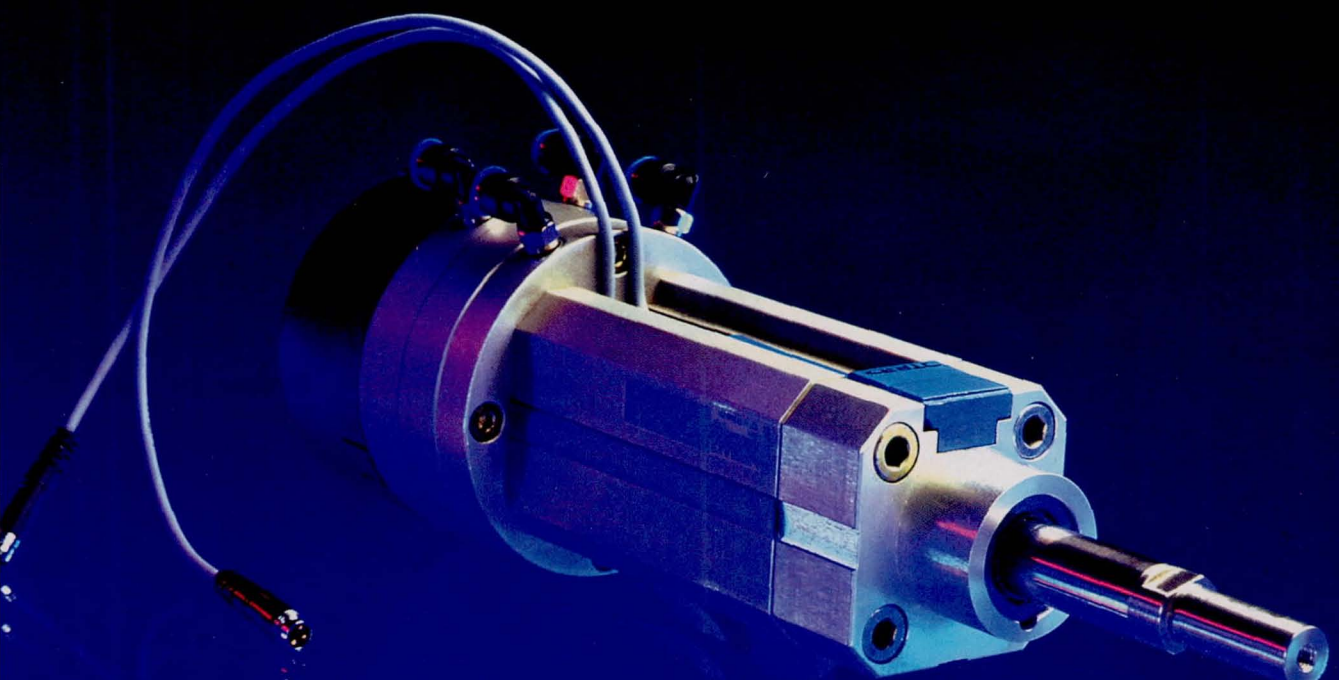

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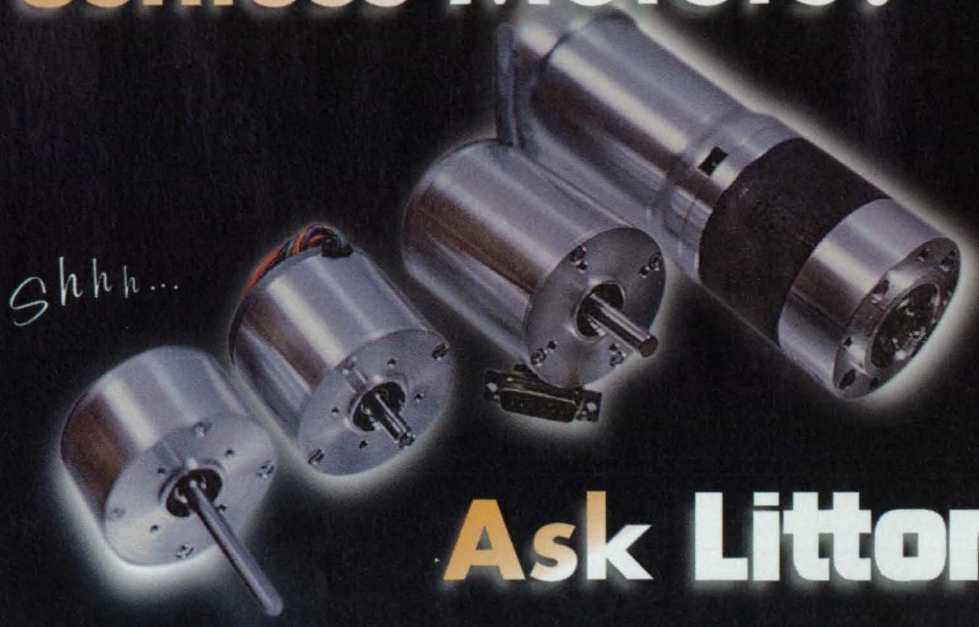

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Motion Control Tech Briefs Supplement to *NASA Tech Briefs* June 1997 Issue Published by Associated Business Publications

MOTION CONTROL TECH BRIEFS

On the cover:
The DSL series of actuators from Festo Corp., Hauppauge, NY, features rotary, linear, and simultaneous rotary/linear actuation in one compact module. An extruded aluminum profile design makes it possible to mount the actuator on a wide range of Festo's pneumatic slide units via standard transition plates to build modular devices for pick-and-place, capping, and packaging.
Photo courtesy Festo Corporation.

Novel Air Spring Design Uses Fiber-Reinforced Plastic

Finite element analysis helped designers minimize stress on the piston.

Firestone Industrial Products Company, Carmel, Indiana

Firestone has produced a novel design for an air spring whose piston can be made from fiber-reinforced plastic (FRP) to reduce weight and eliminate corrosion. The earliest of these pistons were compression-molded from 50-percent glass-reinforced polyester and were somewhat lighter than aluminum counterparts. Applications were fully supported across the base.

In the late 1980s, injection-molded designs were developed that utilized 33-percent glass-filled nylon, with emphasis on applications that only partially supported the piston base with the spring beam's trailing arm. These pistons were lighter in weight while still maintaining the necessary design criteria.

Currently Firestone engineers have developed designs that are supported only in the center of the piston and that use a portion of it as an air reservoir. This design further complicates the structure, since the load must be transferred through the outside of the piston to the central support.

The initial design process began by using commercial and proprietary finite element analysis (FEA) programs. The piston's shape was developed (see figure) and a loading scheme was applied to determine high-stress locations. The geometry was altered in the model until stress predictions were at an acceptable level.

The design team produced drawings from the model to release the production injection mold for fabrication. Initial samples from the production tool passed load deflection testing and fatigue testing on a flat-plate center support. Fatigue testing on the customer's spring beam, however, resulted in failure due to small cracks on the internal rib structure of the piston.

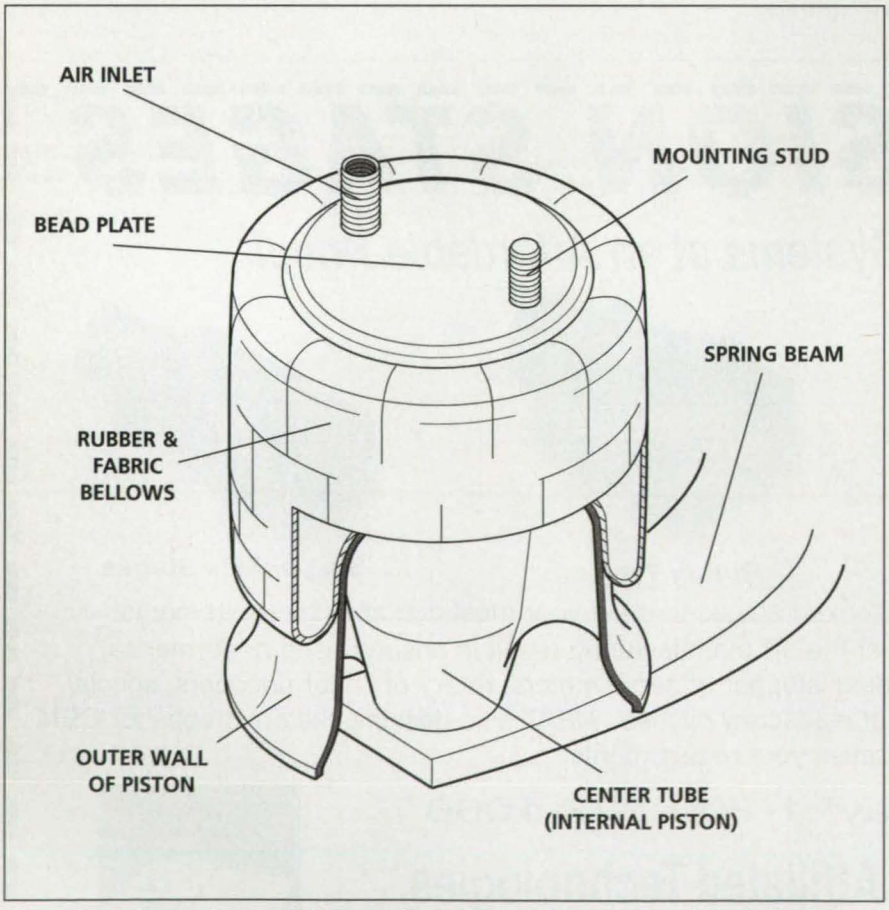
Shown at right is Firestone's FRP piston, with the full air spring assembly at left.

Analysis of the spring beam revealed a rough convex surface because of its manufacture as a forging. A footprint analysis was performed on the beam. The team mounted the air spring piston assembly, fully torqued, onto the beam with pressure-sensitive Mylar installed as an interface. The assembly was then pressurized to various loading conditions and the resulting contact areas obtained.

By analyzing the footprint of the piston on the beam, a special contour was developed on the bottom piston surface to maximize contact area and minimize stress. Additionally, with the help of the FEA model, the team revised the internal rib structure to further lower stresses caused by the irregular mounting surface. These low-stress predictions were verified by utilizing strain gauges during both static burst and dynamic fatigue testing. The piston was then released for testing on a truck.

Test track results concluded the design was capable of more than 500,000 kilometers, based on previous test track experience. The resultant piston, when compared to the production aluminum design, provided a weight saving of 3.4 lbs. and a 40-percent reduction in cost.

This work was done by Daniel J. Leonard, technical director of **Firestone Industrial Products Co.,** *Carmel, IN, and colleagues. For more information, contact Leonard at 1-800-247-4337; fax (317) 776-5116; E-mail: http://support @firestoneindustrial.com*



Schematic of Firestone's **Reversible-Sleeve Air Spring with Fiber-Reinforced Plastic (FRP) Piston.** During travel, the bellows (inflated to a maximum of 100 psi) rolls down and over the outer wall of the piston. In some air spring designs, as shown here, the center tube is the only part of the piston that interfaces with the spring beam. The fiber-reinforced plastic piston has the strength to withstand pressures up to 150 psi in jounce, while providing weight and cost reductions.

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Mechanisms for Fine Adjustment of Radio-Frequency Reflectors

Differentially pitched inner and outer threads on bushings would produce small differential displacements.

NASA's Jet Propulsion Laboratory, Pasadena, California

A class of simple mechanisms for fine adjustment of the panels of radio-frequency reflectors is based on the use of two sets of screw threads at slightly different pitches to obtain small differential axial displacements for relatively large rotations. In the original application for which these fine-adjustment mechanisms were devised, reflector panels were adjusted by use of singly threaded adjusters of 20 threads per inch (pitch of 0.05 in. = 1.27 mm). To displace a panel 0.001 in. (0.0254 mm), one would turn one of the older singly-threaded adjusters through an angle of 7.2°. This is too small a turn to control easily by hand, and a slight rotation error could lead to an unacceptably large displacement error; a mechanism with a much larger rotation for the same displacement would make it easier to perform fine adjustments.

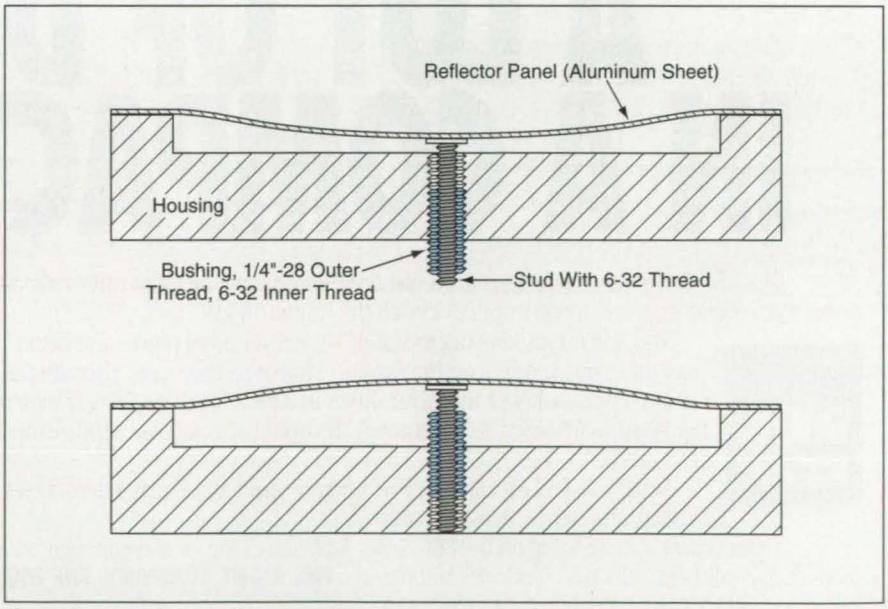
A mechanism of the present doubly threaded type provides the desired larger rotation for a given displacement. The figure illustrates a prototype of this type of mechanism installed behind a simple aluminum sheet, which serves as a model of a reflector panel. The edges of the aluminum sheet are bonded to a housing, in which the mechanism is mounted.

The heart of the mechanism is a hollow bushing with an outer thread pitched at 28 per inch (pitch of about 0.0357 in ≈ 0.907 mm) and an inner thread pitched at 32 per inch (pitch of 0.03125 in. = 0.79375 mm). The inner thread of the bushing engages a stud connected to the center of the aluminum sheet, while the outer thread of the bushing engages a threaded hole in the housing behind the sheet.

Turning the bushing to pull down (or to push up) on the stud causes the bushing to ride upward (or downward, respectively) in the threaded hole in the housing, so that the net upward or downward movement of the stud and reflector is the difference between these two displacements. The net displacement equals the difference between the two pitches multiplied by the number of turns of the bushing. For example, one full turn of the bushing produces a net displacement of about 0.00446 in. (≈ 0.113 mm). For another example, to obtain a displacement of 0.001 in. (0.0254 mm), one would turn the bushing about 80°; this is ten times the rotation and thus easier to control and less subject to error than is the original single-thread design.

This work was done by Michael P. Moore of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 32*** *on the TSP Request Card.*

NPO-19457



The **Deflection of the Reflector Panel** in this prototype is adjusted by turning the bushing. A practical reflector structure would include many (48 in the original intended application) such adjustment mechanisms.

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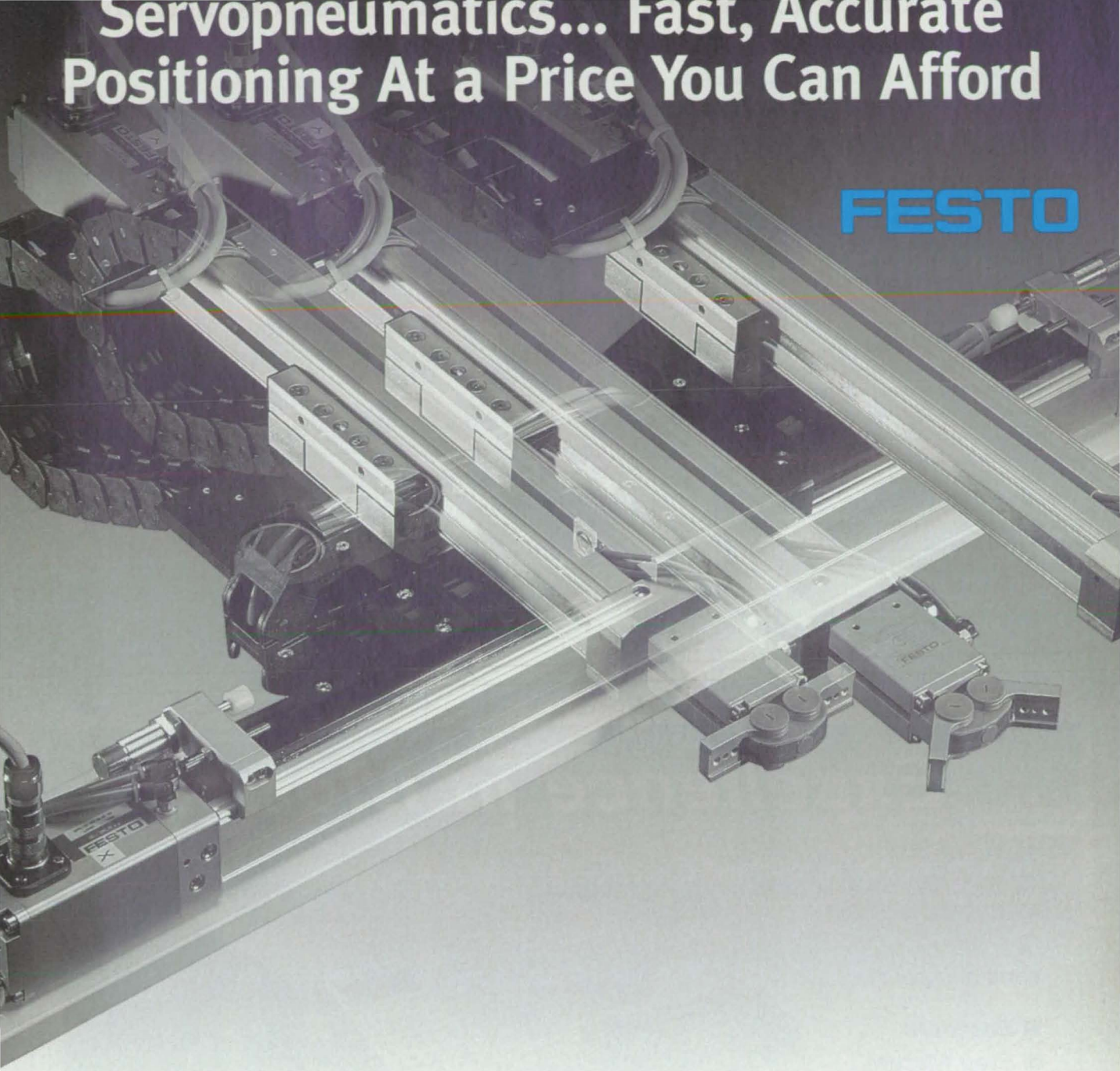

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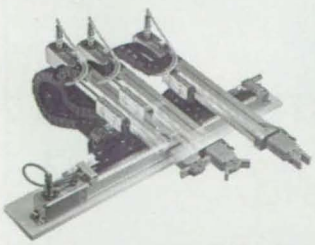

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Fixture Holds Flexible Waveguide Rigidly After Installation

Spherical ferrules can be clamped in somewhat different orientations.

NASA's Jet Propulsion Laboratory, Pasadena, California

A fixture called a "lockout device" rigidly holds the ends of a bellowslike flexible section of a waveguide after installation. The flexible section is needed during installation to accommodate small misalignments of the interfacing end flanges (see figure). After installation, the waveguide is required to be rigid to prevent excessive displacements in the flexible section and, ultimately, fatigue failure; this requirement is satisfied by use of the lockout device, which fixes the positions and orientations of the ends of the flexible section with respect to each other while also accommodating misalignments.

The lockout device includes a split tube with bolted frictional clamps at the ends. The clamps engage flangelike ferrules at the ends of the flexible section of the waveguide. The outermost surfaces of these ferrules are spherical, while the inner contact surfaces of the clamps are cylindrical; thus, each clamp can engage a ferrule at any orientation within the range provided by the spherical surface.

This work was done by David J. Levitt and Wesley P. Schmitigal of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 50*** *on the TSP Request Card.*

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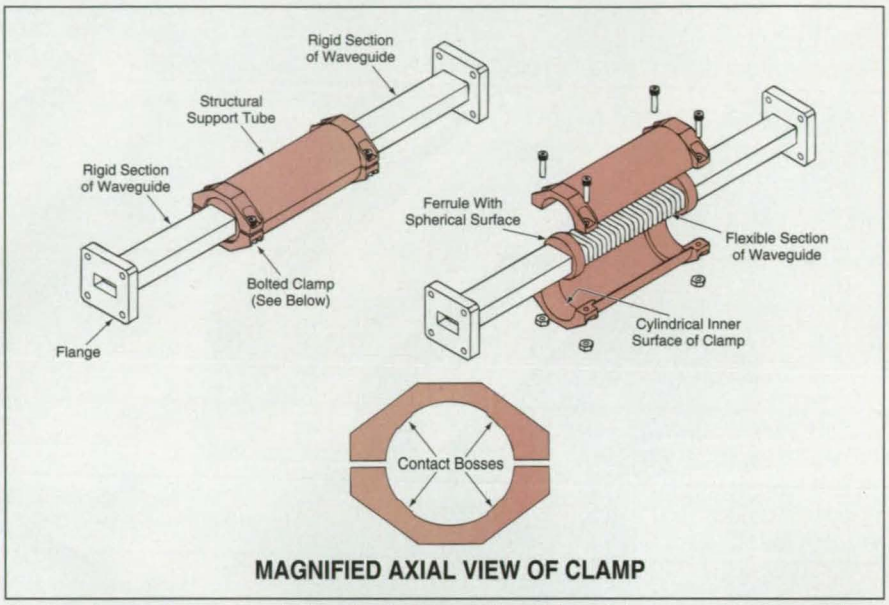

The **Ferrules Are Clamped** to rigidize the flexible middle section of the waveguide. Contact bosses on the inner cylindrical surfaces of the clamps accommodate manufacturing tolerances.

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F464

Dropped Devices Would Penetrate Ground to Regulated Depths

Instruments would be set up at prescribed heights in inaccessible locations.

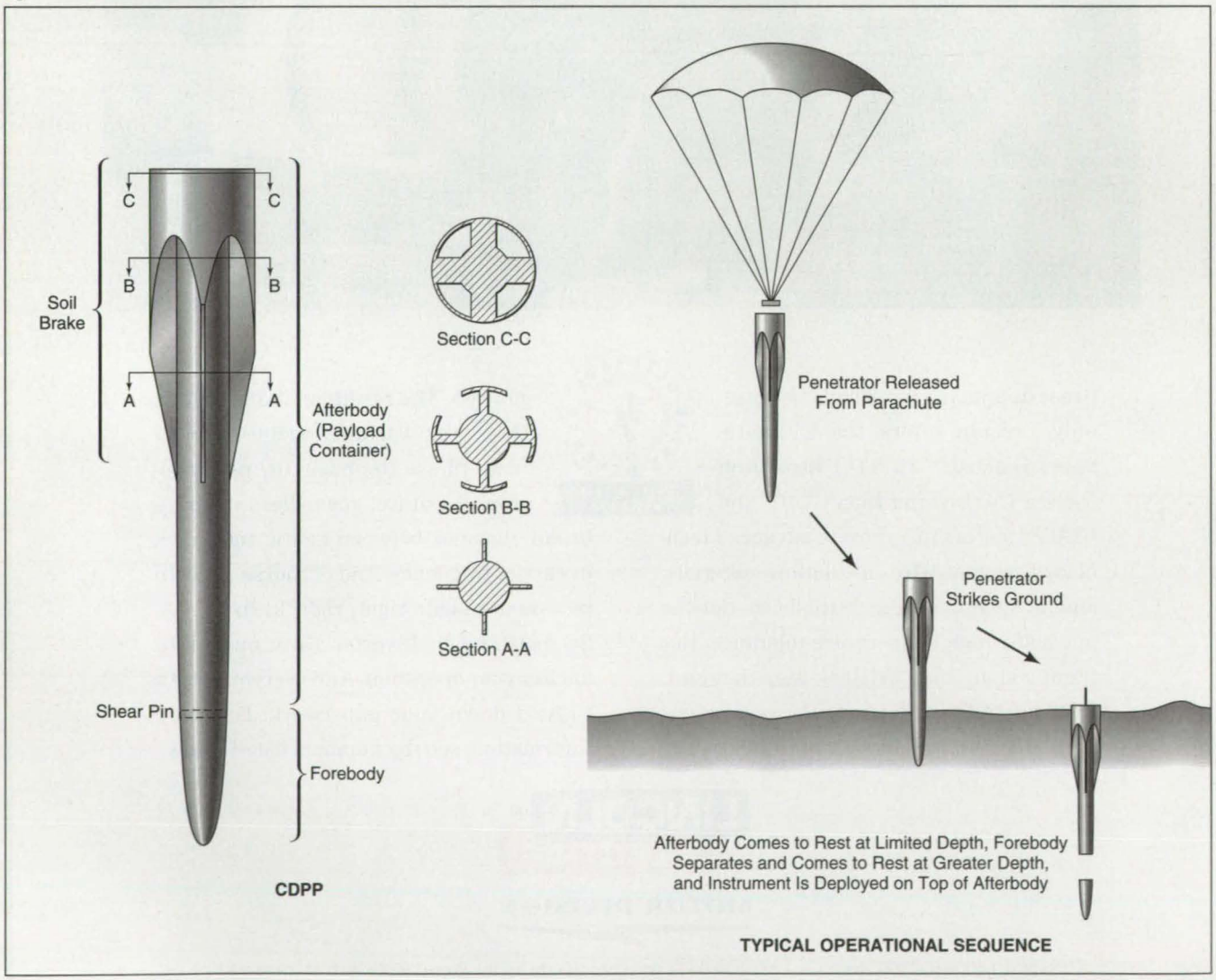
NASA's Jet Propulsion Laboratory, Pasadena, California

Devices that would penetrate the ground to regulated depths after being dropped from heights are undergoing development. These devices — known as controlled-depth-of-penetration penetrators (CDPPs) — would be used to carry cameras and/or other instruments, which, after impact, would be deployed at predetermined heights above the ground. CDPPs could be dropped from aircraft or balloons, for example, to install instruments in locations not readily accessible by travel along the ground. CDPPs would minimize impact forces so that high-resolution optical components, scanning mechanisms, and other delicate instrument components would not be damaged. CDPPs would function in soils of various types and over a wide range of impact velocities.

Each CDPP would comprise two sections: a heavy ogive forebody and a relatively light afterbody, which would be a payload container with exterior fins shaped to act as a soil brake (see figure). The forebody would have the shape and mass needed to penetrate the soil to an acceptable depth. The soil brake would be designed to decelerate the payload at a rate small enough to prevent damage to the instrumentation, yet large enough to limit penetration to no more than a prescribed depth. The forebody and afterbody would be connected by a shear pin.

Upon impact, the forebody would penetrate the soil, carrying the payload with it until the drag of the soil brake exceeded the design strength of the shear pin. The shear pin would then break, releasing the forebody from the payload. The forebody would continue into the ground until its kinetic energy was spent, while the soil brake would cause the afterbody to come to rest at no more than the prescribed depth, with its upper end at approximately the prescribed height above the surface. The instrument(s) would then be deployed.

This work was done by David W. Juergens of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 18*** *on the TSP Request Card.*
NPO-19846



The **Forebody and Afterbody** would separate after impact, after the relatively heavy forebody had dragged the relatively lightweight afterbody to a prescribed limited depth.

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Active Suppression of Vibrations in Automobile Drive Trains

Vibrations were reduced substantially in experiments.

NASA's Jet Propulsion Laboratory, Pasadena, California

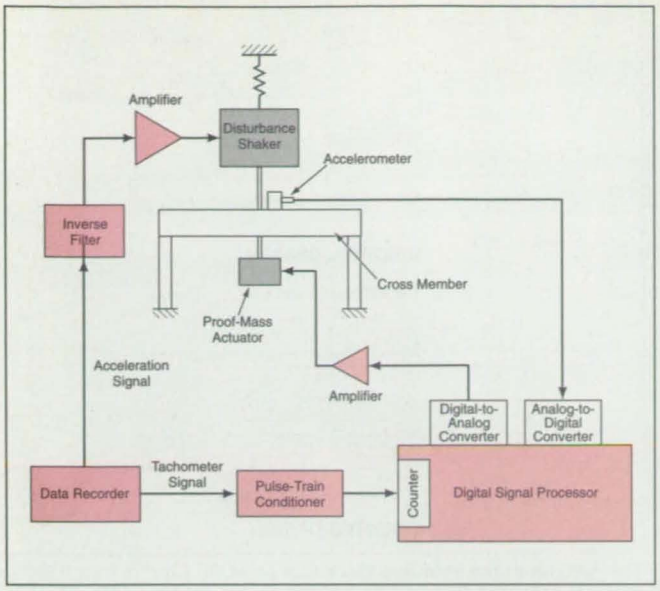
Feedback control systems for suppression of vibrations in automobile drive trains are undergoing development. Like typical active vibration-suppressing systems designed for other purposes, a system of this type would be based on the general concept of measuring vibrations with an accelerometer, processing the accelerometer output via a suitable compensator to generate a command signal representative of opposing vibrations, and applying an amplified version of the command signal to an electromechanical actuator to generate the opposing vibrations. With proper design of the compensator, actuator, and associated circuitry, the net vibration level could be reduced substantially.

A broadband control system would not perform adequately because it would not focus its energy at the disturbance frequencies, where it would be most needed. Most of the energy of vibrations in an automobile drive train is concentrated at the first few harmonic and subharmonic frequencies of the rotational speed of the engine. Accordingly, the approach followed in the present development is to design a compensator such that the overall effect of the system is that of a self-tuning bank of notch filters, with notch center frequencies that are adjusted to track the varying engine speed.

In a vibration-suppression system of this type, the basic engine-rotation signal would be provided by a magnetic pickup device, mounted near the flywheel, that senses the passage of the flywheel teeth. The accelerometer would be affixed to a drive-train-mounting cross member. The electromechanical actuator would also be mounted on the cross member near the actuator. The output of the magnetic pickup device would be digitized and fed to a counter for determination of the number of flywheel teeth that have passed at any given instant of time. The output of the accelerometer would be digitized and fed to a digital signal processor (DSP), along with the digital tooth-count signal.

The DSP would use the tooth-count signal to determine the instantaneous engine shaft angle and generate in-phase and quadrature reference signals — synchronized with the engine rotation — for all the harmonic and subharmonic frequencies at which vibrations are to be suppressed. All the reference signals would be generated with little computation, by use of only one lookup table. The DSP would implement the compensator from the reference and acceleration signals by use of a modified version of the Least Mean Squares algorithm. The output of the DSP would be fed through a digital-to-analog converter, then amplified, then applied to the actuator.

The figure schematically illustrates a prototype system in a laboratory setup. The electromechanical actuator used in this setup was of the proof-mass type, with a mass of about 1 kg and the capability to generate forces as large as 40 N at frequencies above 40 Hz. The compensator was implemented in a commercial DSP, which was programmed to suppress vibrations at nine frequencies; namely, the first five harmonics and the



This **Laboratory Setup** was used to demonstrate the present concept for active suppression of vibrations in an automobile drive train. In a real application, the tachometer signal would be a flywheel-tooth-passage signal from a magnetic pickup device, and the shaker would be replaced by an engine and drive train.

four integer-and-a-half harmonics between them. A real engine was not used in this setup: Instead, engine vibrations were synthesized by driving a shaker, via an inverse filter, with a previously recorded vibration signal from a real engine; and flywheel-tooth-passage pulses recorded along with the vibration signal were substituted for the output of a real magnetic pickup device. In experiments on this setup, the vibrations at the nine selected frequencies were attenuated by more than 20 dB when the system was operating.

This work was done by Zahidul H. Rahman and John T. Spanos of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 64*** *on the TSP Request Card.*
NPO-20026

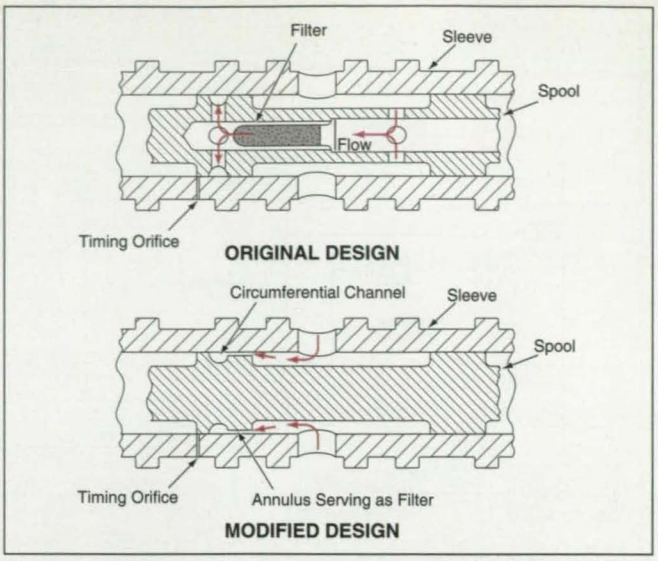
Self-Cleaning Spool Valve

Controlled leakage for gradual shutdown is combined with self-cleaning.

Marshall Space Flight Center, Alabama

A spool that places the main actuator in the pneumatic shutdown position and is used to control the rate of shutdown has been modified by the incorporation of a self-cleaning curtain orifice. Helium gas applied to the pneumatic end of the spool places the valve in the pneumatic shutdown position. In this position, the opening cylinder of the main actuator is communicated to the hydraulic return system via a timing orifice in the spool valve sleeve. The shutdown rate is regulated by a sized timing orifice of rectangular cross section. Helium gas, which is also applied to the closing piston of the main actuator (the closing piston is in a push-push configuration with the opening piston), provides the necessary closing force to the main actuator. The hydraulic fluid in the opening cylinder is forced through the timing orifice, therefore controlling the closing rate of the main actuator.

The top part of the figure shows the unmodified version of the valve, without the self-cleaning curtain orifice. In this version, debris is trapped by a filter inside the spool. The oil flows only one way through the filter and only during the shutdown sequence; as a result, there is no convenient way to remove accumulated debris



The **Annulus in the Modified Valve Acts as an Oil Filter** in that it blocks particles too large to travel easily through the timing orifice. The flow of oil through the annulus keeps the annulus clean by sweeping away smaller particles that can travel easily through the timing orifice.

from the filter.

The bottom part of the figure shows the modified version. An annular gap around part of the spool allows some leakage and acts as an oil filter. The radial gap of the annulus is chosen small enough (smaller than the smallest dimension of the timing orifice) to prevent debris from reaching and blocking the timing orifice. The length of the annulus is then chosen so that the rate of leakage through the annulus can be an order of magnitude greater than that through the timing orifice. The annulus is cleaned by the scavenging effect of the normal flow of oil through the valve. The leakage past the annulus is collected by a circumferential channel, which provides for unrestricted flow to the timing orifice.

This work was done by Mario Padilla of Rockwell International Corp. for **Marshall Space Flight Center.** *For further information,* ***write in 73*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center; (205) 544-0021. Refer to MFS-30042.

Air-Slide Powder Preblender and Gas Seal

One powder is shaped to block a flow of gas into another powder.

Marshall Space Flight Center, Alabama

The figure illustrates an air-slide apparatus that combines precisely controlled flows of aluminum and iron oxide powders. The apparatus is part of a facility that manufactures solid rocket propellant containing these powders plus other ingredients, but the technological significance of the apparatus goes beyond the rocket propellant application. Apparatuses of this type can be used in processes for making such diverse products as foods, fertilizers, and plastics.

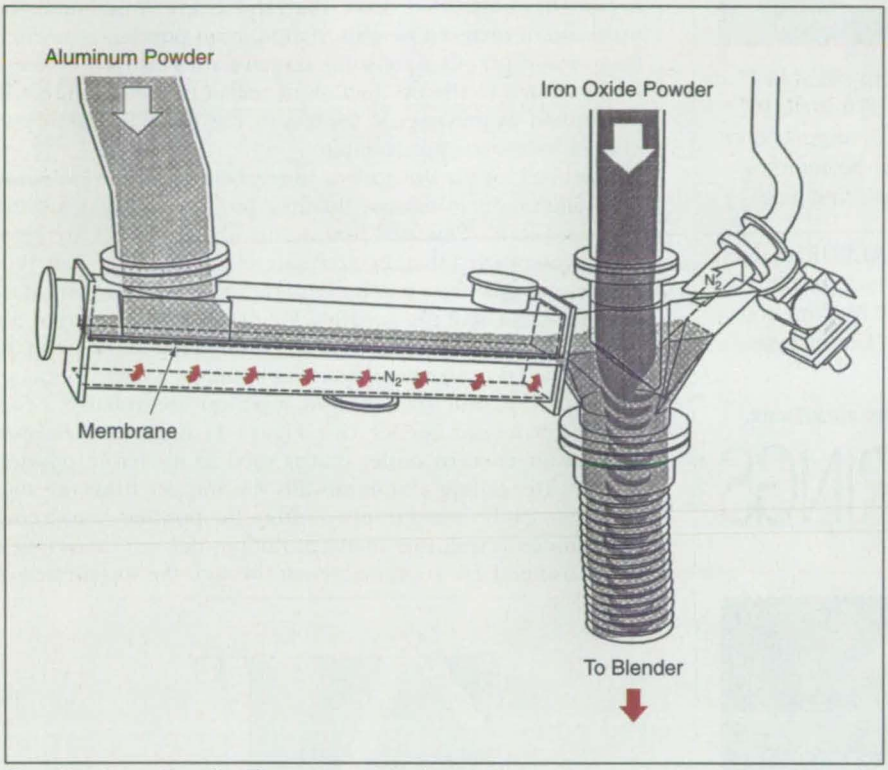
The basic task is to combine and preblend two or more weighed quantities of powder in a closed system without degrading their weighment accuracies. Care must be taken to ensure that accuracy is not decreased by either allowing gas pressures to alter precision of upstream weighing equipment or altering the weight of powder that is delivered at the end of

the process, by allowing some of it to adhere to interior surfaces of the pipe and process equipment. In designing the apparatus to satisfy these requirements, it was necessary to pay special attention to the unique properties of the aluminum and iron oxide powders:

- To prevent ignition of the highly explosive aluminum powder, it is necessary to maintain an inert (nitrogen) atmosphere in the ducts.
- Iron oxide powder is very adhesive, tending to accumulate on some duct surfaces. To ensure the integrity of the weighment, the accumulation of iron oxide powder on surfaces must be minimized.
- Iron oxide powder comprises submicron-sized particles that could easily be blown away by excessive flows of nitrogen in the ducts, with consequent loss of weighment precision.

In the present apparatus, the accumulation of iron oxide powder on surfaces is prevented by making the powder fall through the center of an oversized vertical duct. The air-slide part of the apparatus is used to convey the aluminum powder across a 4-ft (1.2-m) horizontal distance from the outlet of an aluminum-powder feeder to the inlet of the blender, wherein the two powders are mixed. The slide path has a slight downhill tilt from the aluminum-feeder outlet to the blender inlet. "Air slide" is something of a misnomer in that nitrogen is the gas used in this slide. The upper and lower halves of the slide are separated by a gas-permeable membrane. Compressed nitrogen is introduced below the membrane, and flows up through the membrane, fluidizing the aluminum powder, which is fed in on top of the membrane. Fluidization enables the aluminum to flow down very slight inclines, much like a fluid.

Iron oxide and aluminum powder merge and are preblended inside the air slide. The iron oxide inlet to the air slide extends vertically into the aluminum powder discharge. The annulus that forms between the outside diameter of the pipe and the air slide was carefully sized to flood and fill with aluminum powder. Thus, the aluminum powder acts as something of a seal, suppressing pressure fluctuations from the upstream weighing equipment and thus preventing the loss of the smaller iron oxide particles as nitrogen vents from the process. Finally, the adhesive iron oxide becomes encapsulated in aluminum powder, which flushes it through the system.



The **Aluminum Powder Flows** around the iron oxide powder, up to a level above the outlet of the vertical iron oxide duct. The aluminum powder thus blocks any flow of nitrogen through the iron oxide powder, and the iron is encapsulated in the aluminum flow.

This work was done by Joel Crook of Thiokol Corp. for **Marshall Space Flight Center.** *For further information, write in 77 on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center; (205) 544-0021. Refer to MFS-31129.

Discharge Valve for Gravimetric Feeder

This valve prevents leakage of fluidized powder during filling of a hopper.

Marshall Space Flight Center, Alabama

A computer-controlled, pneumatically actuated valve blocks incidental discharge of aluminum powder from the outlet of a gravimetric feeder during batch refills. The feeder is part of a facility that manufactures solid rocket propellant. By preventing small, unintended flows, the valve helps to maintain the precision of metered weights of aluminum powder, as needed for mixing with other constituent materials. This valve concept is not limited to the production of rocket propellant; it could be applied to gravimetric feeders in the food, fertilizer, and plastics industries, for example.

The need for the valve arises largely because of the propensity of aluminum to assume fluidlike properties, when moving (fluidized flow). Fluidized flow occurs when particles are separated from each other by cushions of gas. Contact bed flow occurs when particles touch each other and gas is present only in the interstices of the particles. Fluidized flow is preferred for moving powder, within a process, from point A to point B. Contact bed flow is preferable for metering the powder because, in comparison with fluidized flow, it is more controllable.

The gravimetric feeder (see Figure 1) includes a hopper with an auger at its outlet that is used to discharge powder. Initially, free-falling aluminum fills the hopper from the top, and some gas becomes trapped within the powder. After a couple minutes at rest, the weight of the powder will cause much of the trapped gas to permeate out through the top surface of

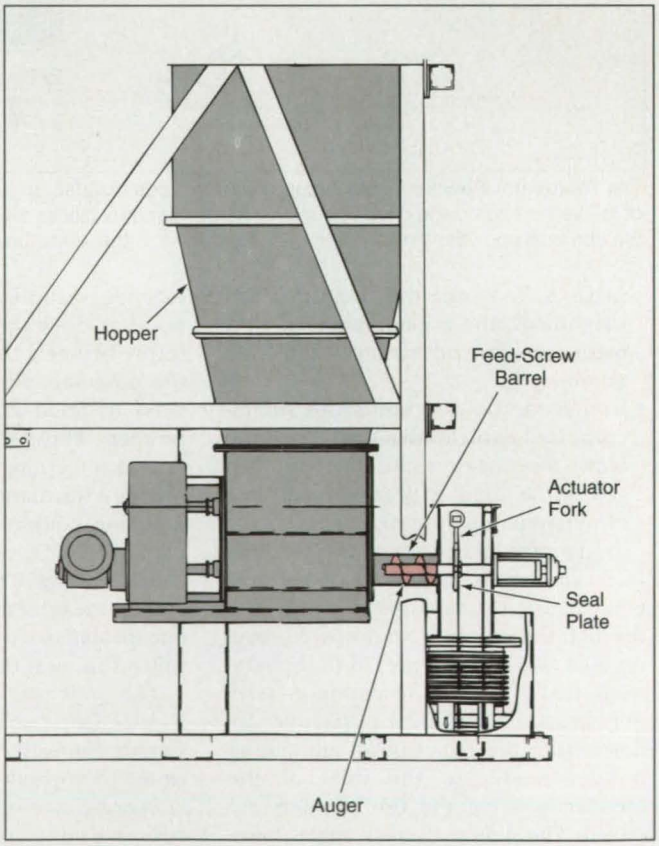


Figure 1. **Leakage Occurs** as fluidized aluminum flows around the auger helix and through the clearance between the auger (feed screw) and the auger barrel, when the auger is not turning. The valve blocks this leakage during times when powder feed is not desired.

the powder. As aluminum is dropped into the hoper, during refills, the fluidized powder spreads outward as it hits the hopper bottom, rather than forming a pile. Under these conditions, some of the powder spirals through the auger helix and drops into the discharge. Powder following this path is unaccounted for in the batch weighment; this is the unintended flow that the valve is designed to block.

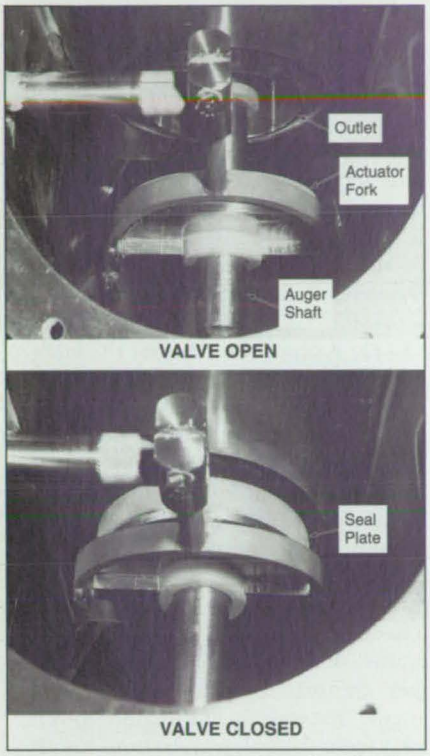


Figure 2. The **Actuator Fork Pushes the Seal Plate** along the auger shaft between "open" and "closed" positions. The auger shaft runs through the center of the seal plate when the valve is open. The seal occurs around the shaft and also around the auger barrel. The shaft to which the actuator fork is connected is driven by an external pneumatic actuator.

The auger discharge is blocked within a seal plate that slides along the auger shaft. The seal plate is an elastomer covered disk. During hopper refills, the seal plate is pushed against the outlet of the auger barrel ("closed" position), blocking unintended flow of aluminum powder. The seal plate is moved along the shaft, between the "open" and "closed" positions, by an actuator fork (as shown in more detail in Figure 2), which is connected to an external pneumatic actuator. Under computer control, the actuator closes the valve immediately before the hopper is filled, and opens it immediately before the auger is started to feed powder.

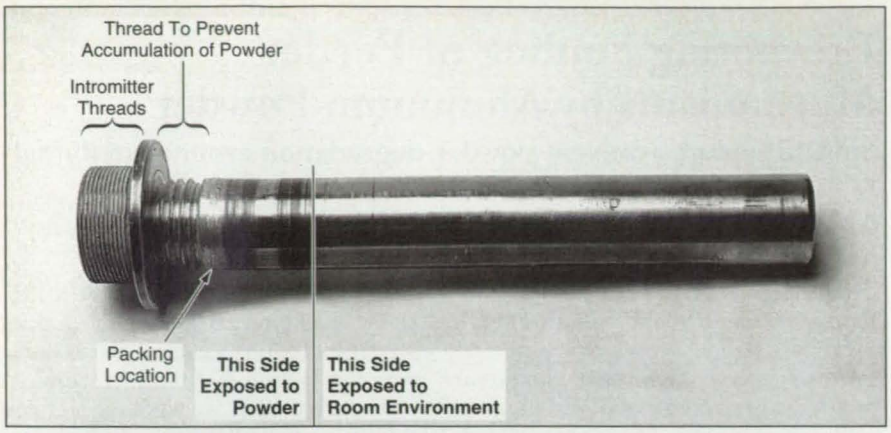
This work was done by Joel Crook of Thiokol Corp. for **Marshall Space Flight Center.** *For further information, write in 82 on the TSP Request Card.*
MFS-31120

Preventing Fouling of Feeder Mechanisms by Aluminum Powder

Several features prevent powder degradation around rotational components of process equipment.

Marshall Space Flight Center, Alabama

The design of the gravimetric aluminum-powder feeder mentioned in the preceding article incorporates several features to prevent fouling by aluminum powder, an essential ingredient in many solid rocket motors. The particular fouling problem arises because aluminum powder is so soft and fine that it infiltrates small internal openings within the feeder and forms hard foil pieces under very low pressures. Around rotating or sliding parts, such foil pieces accumulate rapidly, so that clearances close and the affected parts seize. The antifouling fea-



The **Deep Thread** just to the right of the flange acts as an auger to prevent the accumulation of powder inside the hopper near the packing seal.

tures prevent the formation of foil by creating a gas pocket around regions where clearances between moving and stationary parts are very small. Similar features might also be useful in gravimetric feeders like those used in the food and chemical industries, where fouling could cause contamination, frictional heating (leading to fire hazards), and possibly other adverse effects, depending on the material(s) being fed.

In the gravimetric feeder, aluminum powder will typically foul where rotating auger and intromitter shafts penetrate the wall of an aluminum-powder-filled hopper. At the wall penetration of each shaft, the interior of the hopper is sealed with graphite packing, a brass lantern ring, and a packing gland, to prevent leakage of aluminum powder. Because of the explosive nature of aluminum powder, an oxygen-free gas (nitrogen) at a pressure of 2 psig (gauge pressure of 14 kPa) is piped directly over the lantern ring. This pressurizes the packing with respect to the environment in the hopper, thereby preventing the flow of aluminum powder into the packing.

Additional antifouling features help to prevent the accumulation of aluminum powder around each shaft near the wall penetration. In the case of the intromitter shaft, one of these features is a deep thread, which is cut into the end of the shaft near the wall penetration (see figure). This thread acts as an auger, moving accumulated powder away from the wall penetration. Another antifouling feature is a chamfer around the inside edge of each shaft hole in the hopper wall. The chamfers eliminate what were previously blind holes that trapped powder. A third antifouling feature is a radiused shield that is welded in place on the wall of the hopper just above each shaft. The design of the shield is based on the bulk properties of aluminum powder. A horizontal projection into any vertically flowing powder will create a powder-free area underneath it. The size of this area depends on the physical properties of the material and the geometry of the shield. These antifouling features allow for the shafts to turn inside the powder-filled hopper with little or no powder present in the tight clearances between the shafts and the stationary parts.

This work was done by Joel Crook and Charles D. Fuller of Thiokol Corp. for **Marshall Space Flight Center.** *For further information,* ***write in 42*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center; (205) 544-0021. Refer to MFS-31128.

Inlet Gas Distributor for Pneumatic Powder-Conveying Vessel

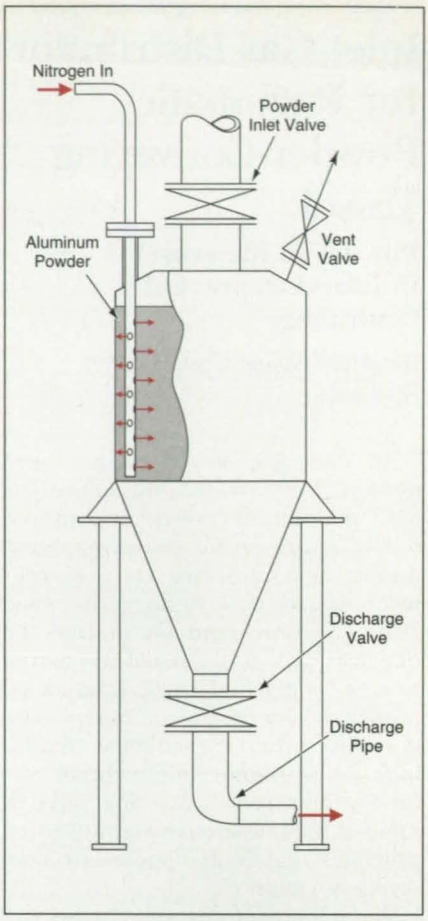
Powder in the vessel is fluidized to prevent "ratholing."

Marshall Space Flight Center, Alabama

An inlet gas distributor has been devised to ensure that the entire volume of aluminum powder is conveyed out of a pneumatic conveying vessel during each conveying cycle, thereby increasing the time-averaged conveying rate. The vessel and the rest of the pneumatic conveying system are part of a facility that manufactures solid rocket propellant containing aluminum powder plus other ingredients. Similar inlet gas distributors might also be useful for increasing conveying rates in some of the numerous other industrial processes that utilize pneumatic conveying of materials.

The pneumatic conveying vessel is a hopperlike pressure vessel with a discharge valve connected to a discharge pipe at the bottom (see figure). Each batch of powder is conveyed in the following way: First, the vessel is filled with powder. Next, the powder-inlet valve is closed and the interior of the vessel is pressurized with nitrogen. Once the pressure has risen to a predetermined level, the discharge valve is opened, allowing the pressurized nitrogen to push the powder out through the discharge pipe. During this discharge, pressurized nitrogen continues to flow into the vessel. When the discharge is complete, pressurized nitrogen is supplied for a little while longer to blow the discharge pipe clear.

A phenomenon called "ratholing" occurs during the discharge as a result of the tendency of aluminum powder to settle and consolidate into a weak mass, with just enough strength to hold its shape against gravity. When the discharge valve is opened, only the powder immediately above it is discharged, leaving a thick layer of powder around the periphery of the vessel and a vertical hole (the "rathole") in the middle. Thus, a significant portion of the original powder filling remains in the vessel after discharge. This decreases the effective volume of the vessel, and the time-averaged conveying rate is reduced correspondingly. This prob-



The **Pneumatic Conveying Vessel** is modified from its original design by substitution of the inlet gas distributor for a nozzle.

lem is further exacerbated when pressure is applied above the powder, just prior to opening the discharge valve. The resultant force from this pressure causes further powder consolidation, which increases the strength of the rathole.

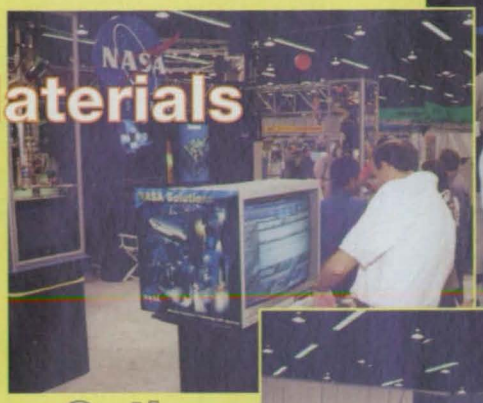
The inlet gas distributor is a capped, perforated pipe that extends along the vertical wall of the vessel. Pressurized nitrogen is fed into the vessel through this distributor. The purpose of the inlet gas distributor is twofold: First, nitrogen pressure is no longer applied directly above the powder. The gas distributor pressurizes the vessel from within the powder mass. This eliminates the differential pressure that can consolidate the material. Second, nitrogen flowing from the distributor fluidizes some of the powder in the vessel along a line that extends vertically through the consolidated ring of powder. The fluidized powder falls out, thereby destabilizing the remaining powder mass enough to make it fall into the discharge pipe.

This work was done by Joel Crook of Thiokol Corp. for **Marshall Space Flight Center.** *For further information, write in 78 on the TSP Request Card.*
MFS-31121

Biomedicine

Manufacturing

Materials



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Liners for Inlet Bellows of Gravimetric Feeders

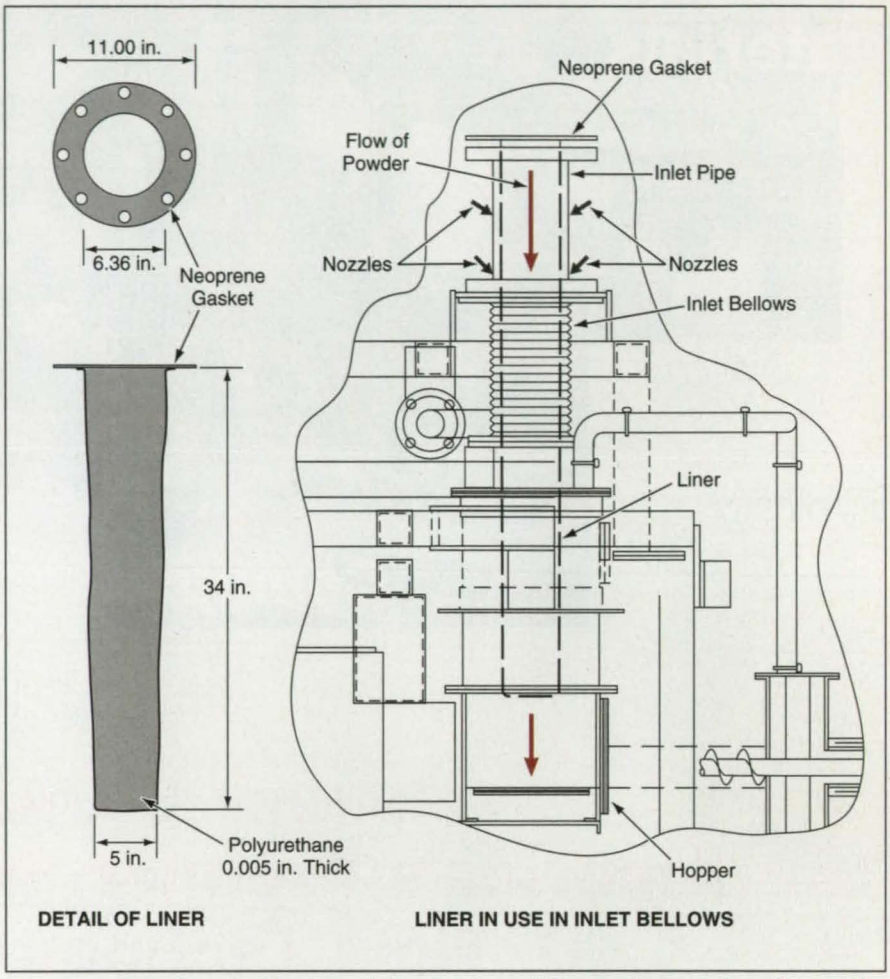
Liners increase weighment accuracy by preventing powder accumulation.

Marshall Space Flight Center, Alabama

Flexible liners have been incorporated into the inlet bellows of gravimetric feeders that are used to meter precise amounts of powders for making solid rocket propellants. The bellows provide freedom of movement between the scale portion of the feeder and the rigid pipe connections at the feeder inlet/outlet. The liners prevent accumulation of powder in the convolutions of the bellows. Before the liners were developed, powders tended to accumulate in the bellows convolutions, causing their stiffness to change. These variations in bellows stiffness degraded metering accuracies.

Each liner is made from a sheet of 5-mil (0.13-mm) thick polyurethane that is cut in a pattern, rolled up, and stitched to form a long, flexible cone that resembles a wind sock (see figure). A neoprene gasket is sewn in place around the hole at the wide end. To install the liner, the gasket is bolted between flanges at the top of the inlet bellows. The liner hangs down from these flanges, extending below the lower end of the bellows and into a hopper that is part of the feeder.

The conical taper prevents the liner from dragging on the inner surface of the bellows and thereby affecting the weight measurement of the feeder. The polyurethane liner material is so slick that even relatively sticky powders like iron oxide do not adhere to it. In operation, the hopper is filled by dropping powder in through the inlet pipe and liner. After the refill is complete, an automatic valve opens, causing compressed nitrogen to flow through four nozzles that penetrate the wall of the inlet pipe, directly beneath the neoprene gasket of the sock. The nozzles sweep the inlet pipe, while vigorously shaking the bellows sock, to remove fugitive dust and powder agglomerations that may be trapped within wrinkles in the sock. Powder that is shaken loose during the compressed-nitrogen sweep falls into the hopper, as desired.



The Liner Is Basically a Flexible, Tapered Pipe that keeps falling powder away from the convolutions of the bellows.

This work was done by Joel Crook of Thiokol Corp. for **Marshall Space Flight Center.** *For further information, **write in 39** on the TSP Request Card.*
MFS-31122

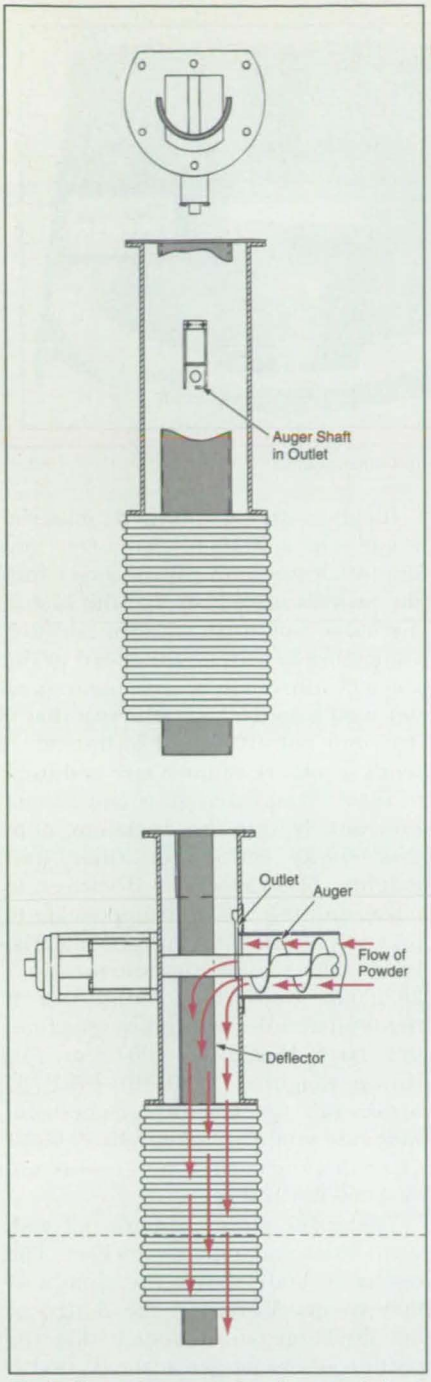
Deflectors for Outlet Bellows of Gravimetric Feeders

These deflectors serve the same purpose as that of inlet-bellows liners.

Marshall Space Flight Center, Alabama

Deflectors have been placed inside the outlet bellows of bulk-powder gravimetric feeders that are used to meter precise weights of powders. Like the inlet-bellows liners described in the preceding article, the outlet-bellows deflectors are used to prevent accumulation of powders in the convolutions of the bellows in order to keep the bellows flexible, as necessary for precise metering of powders by weight.

When powder is discharged from the feed auger, it has a small but significant horizontal velocity. This velocity causes the powder to strike the bellows at some point below and opposite the outlet. The outlet-bellows deflector is a half-cylindrical aluminum shield supported by a flange above the feeder outlet. It hangs down past the outlet and through the bellows to a point somewhat below the lower end of the bellows (see figure). The con-



The **Deflector Intercepts Powder** extruded out by the auger, preventing the powder from striking and getting stuck in the convolutions of the bellows on the opposite side.

Discharge Knife for a Gravimetric Feeder

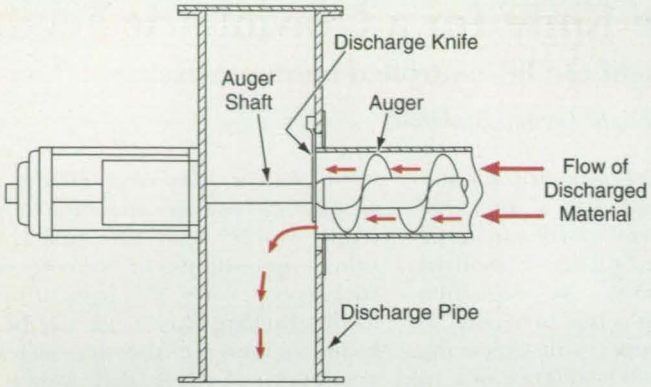
Discharge weight can be controlled more precisely.

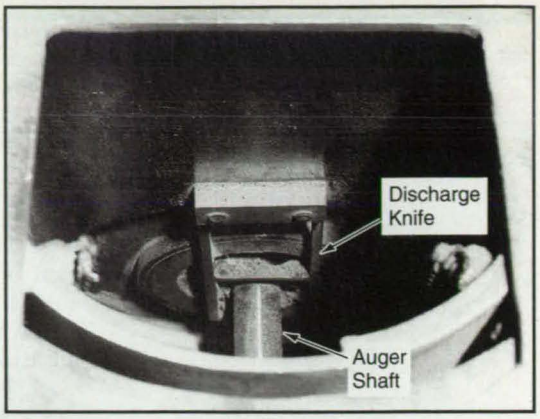
Marshall Space Flight Center, Alabama

The outlet of a gravimetric powder feeder is equipped with a discharge knife that shaves and cuts the material as it is discharged off the end of its auger (see figure). As explained below, the shaving action is needed to increase the accuracy with which the discharged material is weighed out. In this case, the discharged material is iron oxide powder, and the gravimetric feeder is part of a facility that weighs out precise amounts of iron oxide powder that are mixed with other ingredients in making solid rocket propellants. The basic principle of the discharge knife can also be utilized to improve the accuracies of gravimetric feeders that weigh out other materials in the food and chemical industries.

cave side of the deflector faces the outlet-bellows liner, its horizontal velocity goes to zero, and the powder drops vertically through the center of an oversized pipe. Conductive Teflon (or equivalent) is bonded to the surface of the liner to prevent powder adherence and buildup of electrostatic energy.

This work was done by Joel Crook of Thiokol Corp. for **Marshall Space Flight Center.** *For further information,* ***write in 71*** *on the TSP Request Card.*
MFS-31124





The **Discharge Knife Shaves Material** drawn out by the auger, making the material fall off the auger in smaller clumps.

Ideally, the discharged material would not adhere to the auger and would fall smoothly off the auger into the process stream, so that the rate of discharge would be uniform and well controlled by varying the speed of the auger. Unfortunately, iron oxide powder is so cohesive and adhesive that it does not fall off smoothly; instead, it tends to adhere to the auger and itself to form clumps that grow and extend horizontally, into the discharge, until they break off under their own weights. This causes the discharge to pulse, and this makes it impossible to precisely weigh a discharged material batch. For example, suppose that the a 20.000-lb (9,071.8-g) batch size is required and the amount weighed out thus far is 19.990 lb (9,067.3 g). If a clump weighing 0.070 lb (31.8 g) breaks off, the amount weighed out suddenly jumps to 20.060 lb (9,099.1 g), so that the batch is now overweight by 0.060 lb (27.2 g).

The auger pushes clumps out with small axial and radial velocities. The discharge knife shaves the clumps as they rotate. Moreover, the design of the discharge knife is such that the portion of discharged material that is not shaved is cut into five roughly equal parts. Thus, the net effect of the discharge knife is to make the discharged material fall off in smaller clumps. This makes it possible to approach the required weight of delivered material in smaller increments, stopping the discharge within a smaller undershoot or overshoot of the required discharge weight.

This work was done by Joel Crook of Thiokol Corp. for **Marshall Space Flight Center.** *For further information,* ***write in 84*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial or noncommercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center; (205) 544-0021. Refer to MFS-31123.

Double-Difference Precoding and Postdecoding

This method improves data-compression performance for multiple and time-shifted sets of data.

Goddard Space Flight Center, Greenbelt, Maryland

A method of increasing the efficiency of data-compression coding involves precoding and postdecoding via double-difference computations. The method is particularly suitable for data from multiple and/or time-shifted sources; for example, image data from the same scene observed in different spectral bands and/or observed at different times.

The precoding and postdecoding amount to additional stages of compression and decompression, respectively. Like other data-compression schemes, this one reduces the volume of data to be transmitted by removing some of the correlated and redundant components of successive original data, so that successive transmitted data samples contain a higher proportion of uncorrelated and nonredundant data. Also as in other schemes, the redundant and correlated components are reconstructed, during decoding, from information contained in both current and previously transmitted coded data samples.

Of the various types of double-difference schemes that could be used, the one preferred in the present method is called "cross-adjacent" and is illustrated schematically in Figure 1. This scheme applies to two original sets of data; $\{a_i\} = (a_1, a_2, a_3, \ldots)$

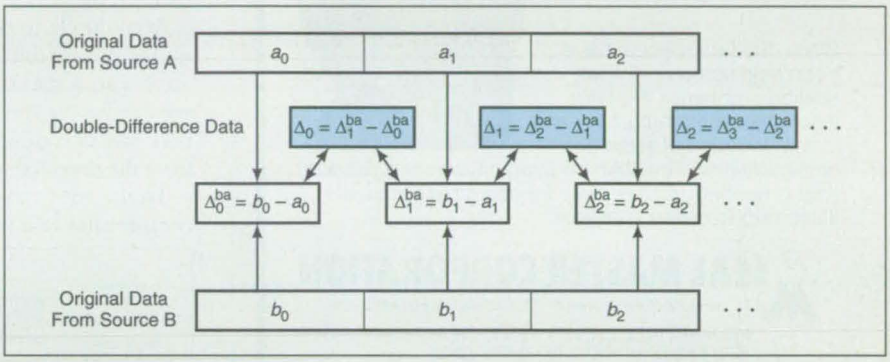


Figure 1. **Cross-Adjacent Double Differences** $\{\Delta_i\}$ are computed from sequences of corresponding original data $\{a_i\}$ and $\{b_i\}$.

and $\{b_i\}$, = (b_1, b_2, b_3, ...) where successive subscripts denote successive original data and where a_i corresponds to b_i. For example, a_i and b_i could represent original spectral intensities from the same location (the ith pixel) in the same image at two different wavelengths. First, for each (ith) pair of original data, one computes the cross-difference

$$\Delta_i^{ba} = b_i - a_i.$$

Next, one computes the differences between successive (adjacent) cross-differences; that is,

$$\Delta_i = \Delta_{i+1}^{ba} - \Delta_i^{ba}.$$

This is the desired set of double differences.

Straightforward algebraic manipulation of the double-difference equations yields recursive equations for reconstruction of one of the original sets of data from the other original set of data, the double differences, and the zeroth cross-difference term. That is, one obtains equations for reconstructing $\{b_i\}$ from $\{a_i\}$, $\{\Delta_i\}$, and Δ_0^{ba}. Thus, it suffices to transmit the precompressed set of data ($\{a_i\}$,$\{\Delta_i\}$, Δ_0^{ba}).

Accordingly, in operation, the original data are precompressed via the double-difference equations, and the precompressed data are fed to a standard lossless or lossy data-compression encoder suitable for the specific application. Following transmission, reception, and decoding, the complete original data are reconstructed from the decoded precompressed data via the recursive equations.

Typical electronic hardware for double-difference precoding compression and postdecoding reconstruction consists of several

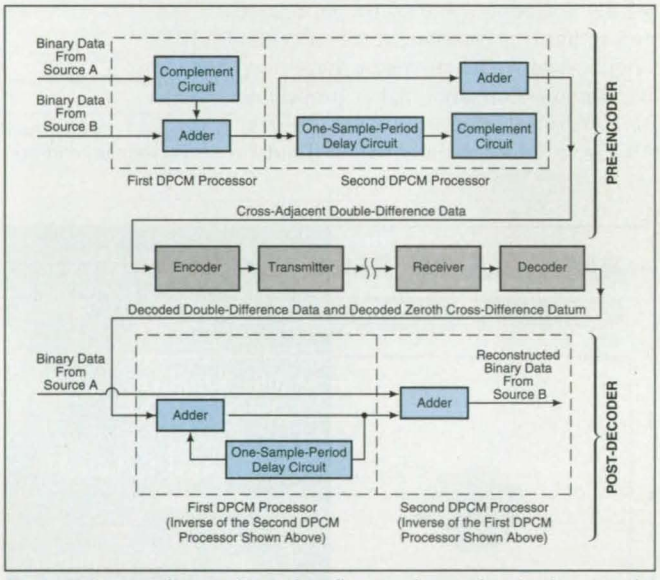


Figure 2. **Preencoding and Postdecoding Hardware** that implements the cross-adjacent double-difference scheme consists of DPCM functional blocks.

differential pulse code modulation (DPCM) processors (see Figure 2.) In precoding, binary data $\{a_i\}$ from source A are fed to an arithmetic-complement circuit, while binary data $\{b_i\}$ from source B are fed to one of the two input terminals of an adder. The output of the arithmetic-complement circuit is fed to the other input terminal of the adder. The output of the adder is the cross-difference data $\{\Delta_i^{ba}\}$. This output is fed directly to one of the input terminals of a second adder; it is also delayed by one data-sample period, then complemented, then fed to the other input of the second adder. Thus, the output of the second adder computes differences between successive cross-differences, yielding the stream of double-difference data, $\{\Delta_i\}$.

The postdecoding hardware, shown at the bottom of Figure 2, includes logic circuitry similar to that of the precoding hardware, except that it does not include a complement circuit. The decoded binary data $\{a_i\}$ from source A are fed to one of two inputs of the right adder. The decoded double-difference data $\{\Delta_i\}$ and the

zeroth cross-difference ($\Delta_0^{b\,a}$) are fed to one of the two input terminals of the left adder. The output of the left adder is delayed by one data-sample period and fed back to the other input terminal of the left adder. The output of the left adder is also fed to the other input terminal of the right adder. The output of the right adder is the stream of reconstructed data $\{b_i\}$ from source B.

This work was done by Pen-Shu Yeh of **Goddard Space Flight Center.** *For further information,* ***write in 72*** *on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Goddard Space Flight Center; (301) 286-7351. Refer to GSC-13552.

Flexible Software Processes Telemetric Data

This software provides a less-expensive alternative to ASIC telemetry-processing hardware.

Goddard Space Flight Center, Greenbelt, Maryland

The Software Telemetry Processing System (STPS) is a computer program that performs telemetric-data-processing functions that, heretofore, have been performed by custom-designed application-specific integrated circuits (ASICs). The cost of using the STPS in a given application ranges between one-tenth and one-fifth that of using ASICs. Originally designed to process data from spacecraft telemetry as specified by the Consultive Committee for Space Data Standards (CCSDS), the STPS can also be used, with little or no modification, to process non-CCSDS data.

In comparison with older telemetric-data-processing hardware and software, the STPS offers greater portability, scaleability, and flexibility. Portability is achieved by use of the C language, which can be compiled and installed on most computers. Scaleability is a consequence of portability in the sense that one can take advantage of portability to select a computer capable of handling data at the required rate for a specific application. Flexibility is achieved by incorporating the main data-processing capabilities into three software modules that can readily be customized for specific applications; an additional degree of flexibility is the possibility of using the computer for other tasks when there is no need to process telemetry.

The STPS performs the functions of a traditional frame synchronizer with an embedded Reed-Solomon Decoder and service processor. The first of the three software modules is functionally equivalent to an ASIC frame synchronizer that follows a "search, check, lock, and flywheel" synchronization strategy. It features programmable frame length, synchronization pattern, and tolerance settings. When executed on a Sun Microsystems Ultra 1-170 (or equivalent) computer with 32MB of random-access memory, this module can process data at a rate up to 18 Mb/s.

The second software module is functionally equivalent to an ASIC Reed-Solomon decoder. High-speed operation is achieved by clever use of registers and pointers in a highly optimized version of the Reed-Solomon decoding algorithm. This module features programmable virtual fill and interleaving settings. It can decode any Reed-Solomon code with a symbol length up to eight bits. When executed on a computer like the one mentioned above, this module can function at a data rate up to 2.55 Mb/s for data with a bit-error rate < 10–9, or at a somewhat lower data rate for data with a higher bit-error rate.

The third software module — functionally equivalent to an ASIC service processor — accepts a stream of synchronized, decoded data from the preceding modules in a CCSDS format called "Channel Access Data Units" (CADUs). The data are subjected to either of two CCSDS processes called "Virtual Channel Data Unit Service" ("VCDU Service" for short) and "Path Service," respectively. The output of this module is in the form of data packets or VCDUs that do not include synchronization markers but do include headers that describe the processing that was performed and, optionally, descriptions of the data. The performance of this module depends on the lengths of packets; typical rates for execution on the previously mentioned computer are 10 Mb/s or 4×10^4 packets per second.

This work was done by Steve Duran, Chris Wilkinson, Tom Grubb, Karen Michael, Alex Krimchansky, John Park, and Greg Henegar of **Goddard Space Flight Center,** *and Jay Masino of Lockheed Martin. For further information,* ***write in 27*** *on the TSP Request Card.*

GSC-13826

Books & Reports

Coupled Fluid-Dynamic and Thermal Effects in a Turbomachine

A report summarizes a study of coupled fluid-dynamic and thermal effects that affect the performance and longevity of the fuel turbine of the Space Transportation main engine. The fuel turbine is a two-stage transonic turbine designed to produce a power of approximately 60,000 hp (≈45 MW) and drive a three-stage turbopump that pumps cold hydrogen. A method called "conjugate heat transfer analysis" was used to solve equations for the conduction of heat in each disk. The goal of this and similar studies is to design a disk-cooling scheme that yields an acceptable thermal environment throughout the turbine.

This work was done by George Bache, Richard Swaim, and Robert Blumenthal of Gencorp Aerojet for **Marshall Space Flight Center.** *To obtain a copy of the report, "A Numerical Procedure for Coupled CFD/Thermal Conduction Analysis of Turbine Disks and Disk Cavities," **write in 20** on the TSP Request Card.*

MFS-28935

Crack-Propagation Studies of Failure Modes in Thin-Rim Gears

A report describes theoretical and experimental studies of the effects of rim thicknesses on the propagation of cracks in thin-rim gears, which are used in advanced aircraft because they weigh less than conventional gears do. The goal of the studies was to determine whether cracks grow through gear teeth (a relatively benign failure mode) or through the rims (a catastrophic failure mode) at various rim thicknesses. The theoretical studies included finite-element computer simulations of gear-tooth bending, fatigue, and propagation of cracks based on linear elastic fracture mechanics. In both the theoretical and experimental studies, it was found that tooth fractures occurred in gears with backup ratios of 3.3 and 1.0, and rim fractures occurred in gears with a backup ratio of 0.3. For gears with a backup ratio of 0.5, the experiments revealed rim fractures, whereas the theoretical study showed instability; that is, the possibility of either tooth or rim fracture, depending on initial conditions.

This work was done by David G. Lewicki of the Vehicle Propulsion Directorate of the U.S. Army Research Laboratory for **Lewis Research Center.** *To obtain a copy of the report, "Crack Propagation Studies to Determine Benign or Catastrophic Failure Modes for Aerospace Thin-Rim Gears," **write in 79** on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Lewis Research Center, Commercial Technology Office, Attn: Tech Brief Patent Status, Mail Stop 7–3, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16436.

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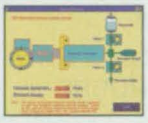

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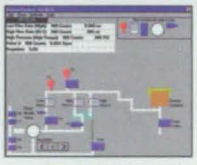

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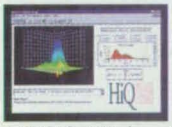

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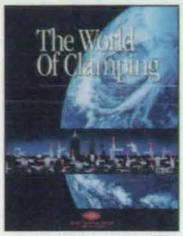

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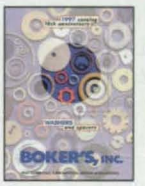

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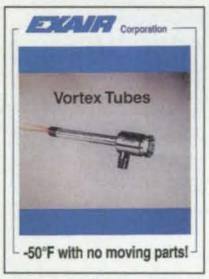

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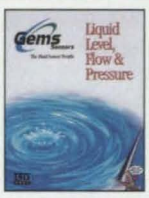

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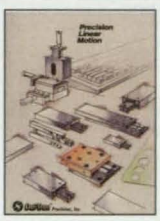

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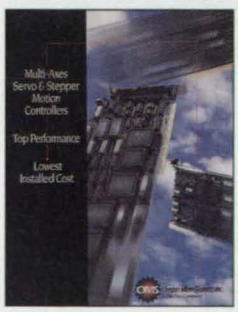

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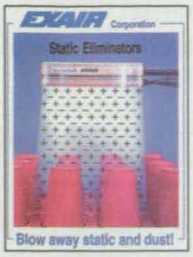

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Lambdachrome® quality laser dyes from Lambda Physik, the leader in the excimer/dye laser industry with over 25 years of experience. This complete compendium includes information on the most frequently asked questions, lasing wavelengths, solvents, and pump sources. Available at no charge with your first dye order. Overnight delivery available. Lambda Physik, Inc., 3201 W. Commercial Blvd., Fort Lauderdale, FL 33309; Tel: 800-EXCIMER or 954-486-1500; Fax: 954-486-1501.

Lambda Physik, Inc.

For More Information Write In No. 325

SOLIDSTATE BACKLIGHTING

SolidState Backlighting that provides brighter, more uniform light at lower power is described in a new data sheet. These molded backlighting panels feature an ultra-thin design and are ideal for applications where power, brightness, and cost are prime design considerations. Panels as large as 3.5 × 5" can be backlit with as few as five LEDs. SolidState Backlighting is appropriate for use in a variety of electronic products, as well as automotive applications. LUMITEX, Inc., 8443 Dow Circle, Strongsville, OH 44136; Tel: 216-243-8401 or 800-969-5483; Fax: 216-243-8402.

LUMITEX, Inc.

For More Information Write In No. 326

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

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

Algor, Inc.

For More Information Write In No. 327

NEW INTERACTIVE CD-ROM BASED ON ENGINEERING "BEST-SELLER"

A comprehensive FEA CD-ROM/textbook that blends theory & real-world engineering examples. Dr. Constantine Spyrakos, well-known finite element stress and vibration analysis expert, has created a reference for all engineers from designers to "gurus." CD-ROM includes search capabilities, Internet-type browser & 3D, full-color graphics. Hard- and soft-cover books include every example problem on disk. APD; Tel: 800-482-5467; URL: http://www.algor.com/apd; E-mail: apd@algor.com.

APD

For More Information Write In No. 328

NEW KIND OF MULTIMEDIA VIDEO TEACHES FEA LESSONS

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

APD

For More Information Write In No. 329

MAGNETIC SHIELDING CABLE, CONDUIT SLEEVING & WIRE

This literature details applications for Magnetic Shield's Inter-8 Weave cable, Spira-Shield Flexible conduit, CO-NETIC Braided Sleeving, and CO-NETIC AA Wire. Each product's specifications are described. All materials are in stock. Custom variations are also available. Magnetic Shield Corp., 740 N. Thomas Drive, Bensenville, IL 60106; Tel: 630-766-7800; Fax: 630-766-2813.

Magnetic Shield Corp.

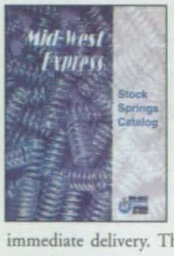
For More Information Write In No. 330

BORESCOPIC VIDEO SYSTEM

The MCV-8000 borescopic video system couples any Machida borescope to a miniature, high-quality color camera to create the clearest images for review on a monitor screen. The portable MCV-8000 is a quick set-up unit protected in a rugged, shock-mounted, shippable carrying case. The 1/2" VHS record/playback unit with microphone allows inspections to be recorded easily with narration. Machida's MCV-8000 borescope video system is the professional choice for high-resolution video inspection. Machida, Inc., 40 Ramland Road South, Orangeburg, NY 10962; Tel: 800-431-5420 or 914-365-0600; Fax: 914-365-0620.

Machida, Inc.

For More Information Write In No. 331



MID-WEST EXPRESS STOCK SPRINGS CATALOG

New, 56-page Mid-West Express Stock Springs Catalog describes over 4,500 different stock springs and spring kits available for immediate delivery. The catalog contains specifications, price list, order form and other helpful information. Describes compression, extension, torsion, die springs and Belleville washers. Mid-West Express, Div. of Mid-West Spring Mfg. Co., 1404 Joliet Road, Unit C, Romeoville, IL 60446; Tel: 800-346-1400; Fax: 888-466-1400.

Mid-West Express, Div. of Mid-West Spring Mfg.

For More Information Write In No. 332

PREMIER TO THE 21ST CENTURY™

OMEGA Engineering is proud to announce the release of its latest Data Acquisition Handbook, "The Universal Guide to Data Acquisition and Computer Interfaces - Premier to the 21st Century™ Edition." This new handbook contains 600-plus pages of products and valuable technical information. Over 140 pages are dedicated to new and unique products. OMEGA Engineering; Tel: 800-TC-OMEGA or 203-359-1660; E-mail: info@omega.com; http://www.omega.com.

OMEGA Engineering

For More Information Write In No. 333

CALIBRATOR OFFERS EXCEPTIONAL VERSATILITY

The CL328 calibrator offers exceptional versatility and laboratory performance with a portable construction for field use. Model CL328 signal simulator/analyzer simultaneously will read and source any combination of process milliamp and voltage signals. Calibrate state-of-the-art equipment such as smart transmitters and indicators with your Model CL328, and a full, five-digit resolution lets you check any type of process control equipment. Priced at $1,295. For more information, use OMEGAfax and request Document #1690 by calling 800-848-4271; E-mail: info@omega.com; http://www.omega.com.

OMEGA Engineering

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AVIONICS COMMUNICATIONS SOLUTIONS

Request your FREE info-pack on Systran's complete line of avionics communications solutions. Board-level products include replicated shared-memory network interfaces, Fibre Channel host bus adapters and switches, I/O IP modules, and 1553 products. Support is available for various buses such as VMEbus, VXIbus, Sbus, GIO, EISA, ISA, PCI, PMC, and PCMCIA. Systran Corp.; Tel: 937-252-5601 or 800-252-5601; Fax: 937-258-2729; E-mail: info@systran.com; http://www.systran.com.

Systran Corp.

For More Information Write In No. 335

FREE DEMO CD-ROM

Now you can tap into concise, validated, and accurately presented data for design and performance analysis. Provided on CD-ROM are ESDU Fluid Mechanics, Internal Flow Data Items, and computer programs. These tools enable the engineer quickly to optimize compressible and incompressible flow system designs based upon independently validated methods and procedures. Call today for more information and your FREE DEMO CD-ROM. ESDU International plc, London; Tel: +44 (0) 171 490 5151.

ESDU International, plc

For More Information Write In No. 336

SENTRY™ SERIES BRUSHLESS SERVOMOTORS

New selection guide provides detailed specifications and selection information for these high-performance servomotors. SENTRY servomotors feature the industry's highest torque per frame size. Available in NEMA 23 and 34 frame sizes, SENTRY servomotors meet the most demanding torque, velocity, and/or positioning applications with a medium inertia design for improved load matching. Pacific Scientific, Motor Products Div., Rockford, IL; Tel: 815-226-3100; Fax: 815-226-3080.

Pacific Scientific, Motor Products Div.

For More Information Write In No. 337

POWERPAC™ HYBRID STEP MOTORS

Four-color brochure details Pacific Scientific's powerful new line of hybrid step motors. Brochure reviews product options and benefits for N and K series steppers, which are available in NEMA 34 and 42 frame sizes. POWERPAC has the highest torque per frame size in the industry, up to 5,700 oz-in. (356 lb-in.). These motors meet demanding motion requirements and are a cost-effective alternative to servo motors in applications with moderate speed requirements. Pacific Scientific, Motor Products Div., Rockford, IL; Tel: 815-226-3100; Fax: 815-226-3080.

Pacific Scientific, Motor Products Div.

For More Information Write In No. 338

GILMONT FLOWMETERS FROM BARNANT

Gilmont flowmeters can be used for all critical flow monitoring applications. These flowmeters are excellent for high temperatures, pressures, and specialty gases. Fluid contacts only glass flow tube, glass or SS float, and Teflon stops, ideal for high-purity and superb chemical resistance. Gilmont flowmeters can be calibrated for most liquids and gases. Computerized flow tables are available. Calibrated/correlated and compact direct reading flowmeters are offered. Barnant Company, 28W092 Commercial Ave., Barrington, IL 60010; Tel: 800-637-3739 or 847-381-7050; Fax: 847-381-7053.

Barnant Company

For More Information Write In No. 339

'97 ELECTRONIC HARDWARE

New from Globe Electronic Hardware comes the 1997 revised 240-page catalog, which provides complete engineering dimensions and specs for our precision electronic hardware. Products include standoffs, spacers, captive panel screws, retainers, handles, ferrules, thumb screws, shoulder screws, washers, and other components in American and metric standards. Materials include aluminum, brass, steel, stainless steel, nylon, phenolic, and Teflon. Globe Electronic Hardware; Tel: 800-221-1505 or 718-457-0303; Fax: 718-457-7493; http://www.globe-elec-hdwe.com.

Globe Electronic Hardware

For More Information Write In No. 340

AUTOMATION CONTROLS & COMPONENTS

New Automation Controls & Components Selector Guide provides overview of pneumatic and electronic industrial automation components and controls available from Festo. Over 90 product categories in 24-page brochure, covering control systems, PLCs, Fieldbus manifolds, sensors, pneumatic cylinders, valves and accessories. Education/Training programs in automation control technologies described. Contact: Festo Corporation, 395 Moreland Road, Hauppauge, NY 11788; Tel: 516-435-0800.

Festo Corporation

For More Information Write In No. 341

POWDER METALLURGY DESIGN SOLUTIONS

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

Metal Powder Industries Federation

For More Information Write In No. 342

1997 PCMCIA PRODUCTS CATALOG

The new PCMCIA-PC CARD standard has been incorporated into many new applications such as: Datalogging, agriculture, digital film, and wireless communications. Envoy Data has just released its new catalog for these new applications plus many other products like: memory, I/O (serial, parallel, SCSI, A/D, etc.) cards; PC card drives for ISA, IDE, SCSI, etc.; along with industrial card and drives, multimedia, industrial, and engineering tools for PCMCIA applications. Envoy Data Corporation, 6 E. Palo Verde, #3, Gilbert, AZ 85296; Tel: 602-892 0954; Fax: 602-892-0029; E-mail: info@envoydata.com; http://www.envoydata.com.

Envoy Data Corporation

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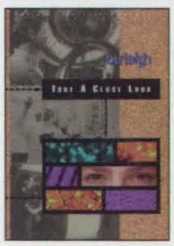


BURLEIGH'S SURFACE TOPOGRAPHY DIVISION

Burleigh Instruments manufactures scanning probe microscopes and interferometric optical profilers. This family of products can scan atoms and up to 1.75 mm in X and Y. Z resolution is accurate to a fraction of an Angstrom while maximum Z range is 100µm. Burleigh Instruments, Burleigh Park, PO Box E, Fishers, NY 14453-0755; Tel: 716-924-9355; Fax: 716-924-9072; E-mail: spm@burleigh.com; http://www.burleigh.com.

Burleigh Instruments

For More Information Write In No. 344

EMI/RFI SHIELDING PRODUCTS

New catalog details hundreds of standard gaskets and grounding strip variations, engineered to meet the most common shielding applications. Standard as well as custom designed shields are manufactured from Beryllium, Copper, and other High-performance materials. Special finishes and a variety of mounting methods are offered. For World Class quality and service call 201-890-7455 or visit our Web Site at: HTTP://WWW.OMEGASHIELDING.COM; E-mail: SALES@OMEGASHIELDING.COM.

Omega Shielding Products Inc.

For More Information Write In No. 345

1997 CALIBRATION STANDARDS CATALOG

All new free 1997 catalog of metrology calibration standards for surface contamination, critical dimensions, film thickness, surface profiling, roughness, resistivity, and much more. All important for ISO 9000 certification. Also, valuable information on calibration science and services. VLSI Standards, 3087 North First St., San Jose, CA 95134; Tel: 408-428-1800; Fax: 408-428-9555.

VLSI Standards

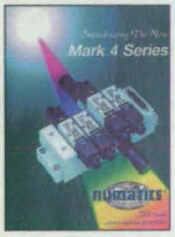
For More Information Write In No. 346

FREE PC & PCMCIA SOLUTIONS HANDBOOK

Quatech's detailed handbook covers our extensive line of quality communication, data acquisition, and industrial control products for PCMCIA and desktop PCs. New for 1997 are a unique 4-port RS-232 PC Card, 12- & 16-bit PCMCIA data acquisition systems, and a custom configurable Industrial Test & Measurement System. Product overviews, photos, and complete technical specifications are provided. For a free copy, call 800-553-1170; E-mail: sales@quatech.com; or visit our web site at: http://www.quatech.com.

Quatech, Inc.

For More Information Write In No. 347



NUMATICS MARK 4 SERIES

Numatics introduces the MARK 4 Series directional control valves, which are miniature direct solenoid and solenoid air pilot actuated valves in which all internal wiring has been eliminated. MARK 4 offers true plug-together flexibility and expandability to meet design requirements and serial/bus communication interface options. Features include: Z-board™ electrical interface that eliminates wiring within the manifold; plug-together modular discrete inputs/outputs; plug-in speed control sandwich; and meets NEMA 4 specifications. Numatics; Tel: 810-887-4111; http://www.numatics.com (reference catalog #LTMK4-1).

Numatics

For More Information Write In No. 348

ACCELEROMETERS

New 108-page catalog of Entran's Accelerometers with associated power supplies, amplifiers & signal conditioning. A broad selection: miniature to rugged, low and high ranges, wide frequency response for static and dynamic. Both damping and overrange stops available. Ideal for acceleration, vibration & shock testing in aerospace, industrial, automotive, military & research applications. Many items in "Off-the-Shelf" stock. Entran Devices, Inc., 10 Washington Ave., Fairfield, NJ 07004; Tel: 888-8-ENTRAN; Fax: 201-227-6865; E-mail: sales@entran.com; http://www.entran.com.

Entran Devices, Inc.

For More Information Write In No. 349

OLYMPUS HIGH-SPEED VIDEO CAMERA

New Olympus Encore™ video camera lets you pinpoint problems in high-speed industrial equipment. It digitally records up to 2,000 frames per second and provides instant, variable-speed slow-motion replay for analysis. Ideal for manufacturing, testing, QC, and research applications. Compatible with Olympus fiberscopes and borescopes. Olympus America, Inc., Industrial Products Group, Two Corporate Center Drive, Melville, NY 11747-3157; Tel: 800-446-5260; http://www.olympusipg.com.

Olympus America, Inc.

For More Information Write In No. 350

INSTRUMENT DATA ACQUISITION

The SoftwareWedge™ directs serial (RS232, RS485, RS422) data from any instrument into any Windows 3.x, 95, or NT applications such as Excel, HMIs, statistical, and control applications. Collect data from and control PLCs, bar code scanners, laboratory, process and quality control instruments, etc. If you would like information or have any questions, please contact TAL Technologies, Inc., 2027 Wallace Street, Philadelphia, PA 19130; Tel: 800-722-6004 or 215-763-7900; Fax: 215-763-9711; http://www.taltech.com.

TAL Technologies, Inc.

For More Information Write In No. 351

AIR KNIFE FOR BLOWOFF

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

EXAIR Corporation

For More Information Write In No. 352

PRECISION COMPONENTS CATALOG

PIC Design's comprehensive Catalog 43 is bigger and better than ever – 288 pages including precision Gears, Modular Framing Elements, Linear Motion Systems & Positioning Tables, and expanded lines of Lead Screws & Nuts, Belts & Pulleys, Ball Slides, Shoulder Screws, Bearings, Shafting, Couplings, and more, all in inch and metric sizes. Ordering from the catalog is easy – major credit cards now accepted. PIC Design, PO Box 1004, Middlebury, CT 06762; Tel: 800-243-6125; Fax: 203-758-8271; E-mail: info@pic-design.com.

PIC Design

For More Information Write In No. 353

FREE DRIVE COMPONENT LIBRARY

Features over 52,400 off-the-shelf inch and metric, commercial and precision small drive components. These five new catalogs include technical specifications for over 13,000 gears (D190); 7,900 shafts, bearings, and couplings (D200); 18,300 timing belt drives (D210); 9,400 design components (D220); and Fairloc® hub fastening components (D240). Stock Drive Products/Sterling Instrument, New Hyde Park, NY; Tel: 516-328-3300; Fax: 800-737-7436; http://www.sdp-si.com.

Stock Drive Products/ Sterling Instrument

For More Information Write In No. 354

RUGGED MINIATURE SWITCH

The Series 70 is an environmentally rugged line of lighted and unlighted switches. Wet, dusty or oily duty. DPDT MOM or ALT switch actions. Mounts on 0.700" centers with 0.880" depth. Lighted pushbuttons use T-1 MFB lamps. Variety of display types, colors, and styles. StacoSwitch, 1139 Baker St., Costa Mesa, CA 92627; Tel: 714-549-3041; Fax: 714-549-0930.

StacoSwitch

For More Information Write In No. 355

MONITOR, RECORD & ANALYZE

Astro-Med's 32-channel recorder with built-in monitor, 170 Mbyte internal hard drive and front-panel floppy drive is described in this illustrated 20-page brochure. The unit, called the MT95K2, features extraordinary capabilities including three on-board analysis programs, Windows host control, Windows data analysis, and a wide variety of sophisticated data capture options. Tel: 800-343-4039; Fax: 401-822-2430.

Astro-Med Inc.

For More Information Write In No. 356

OPTICAL LIQUIDS

R. P. Cargille's Specialty Optical Liquids catalog features high-transmission, safe-handling laser liquids plus fused silica matching liquids and specific refractive-index liquids (1.300 to 2.11 n_D). The catalog now includes comparative diagrams of glasses and optical liquids. R. P. Cargille Laboratories, Inc., 55 Commerce Road, Cedar Grove, NJ 07009-1289; (201) 239-6633; (201) 239-6096.

R. P. Cargille Laboratories

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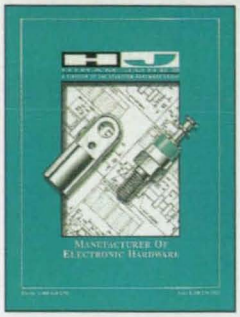

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Hiram Jones Electronics, Inc./A Division of the Seastrom Hardware Group manufactures a complete line of standard miniature and subminiature terminals including: insulated test jacks, assembled standoffs and press-type terminals. All standard catalog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

Hiram Jones Electronics, Inc.

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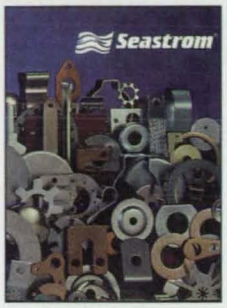

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Seastrom Manufacturing Co. Inc.

For More Information Write In No. 359

VACUUM VALVES

VAT's 192-page catalog contains detailed information on the widest selection of quality vacuum valves in the industry: Gate, angle, fast closing, throttle, pressure control, retrofit, and customized valves. Using innovative sealing technology, both elastomer and all-metal, they are ideal for applications such as pump isolation, load locks, beam lines, and other vacuum applications. VAT, Inc., 500 W. Cummings Pk., Woburn, MA 01801; Tel: 617-935-1446; Fax: 617-935-3940; E-mail: usa@vatvalve.com; http://www.vatvalve.com.

VAT, Inc.

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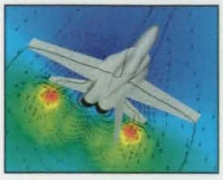

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Intelligent Light

For More Information Write In No. 361

NEW SENSORS CATALOG

New catalog describes load, force, and torque sensors. Gram Sensors: from 10 to 1K grams; Load Cells: to 400K lbs.; Load Buttons: to 50K lbs.; Thru Hole Load Cells: to 30K lbs.; Torque Sensors: to 50K in/lbs.; and Load Pins. Transducer Techniques Inc., 43178 Business Park Dr., Temecula, CA 92590; Tel: 909-676-3965; Fax: 909-676-1200; E-mail: tti@ttloadcells.com; http://www.ttloadcells.com.

Transducer Techniques Inc.

For More Information Write In No. 362

CUSTOM PRECISION POTENTIOMETERS

FREE, all-new 1997 Betatronix Custom Precision Potentiometers Catalog provides background on industry-leading design and manufacturing capabilities. Betatronix has manufactured conductive plastic and wirewound potentiometers for 30 years. Catalog covers linear & rotary motion, aerospace & missile, outer space, and robotics & animatronics applications. Full-color photos and mechanical parameters are featured. Betatronix, Inc., 110 Nicon Court, Hauppauge, NY 11788; Tel: 516-582-6740; Fax: 516-582-6038.

Betatronix, Inc.

For More Information Write In No. 363

ESCAPEMENTS FOR COST-EFFECTIVE PARTS FEEDING

Series 160 Escapements are ideal for isolating and feeding individual parts from vibratory feeders, magazines, or hoppers. Internal interlocking pin ensures that both rods are extended before either rod can retract. Available in standard and heavy-duty versions. Send for a free catalog today. PHD, Inc., PO Box 9070, Fort Wayne, IN 46899; Tel: 800-624-8511; Fax: 219-747-6754; http://www.phdinc.com.

PHD, Inc.

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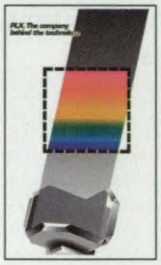

PLX HOLLOW RETROREFLECTOR BROCHURE

Pioneers in the development of hollow retroreflector technology, PLX can provide solutions where great optical stability and high-quality wave fronts are essential. The brochure features products designed for a variety of military, aerospace, industrial, and medical applications involving boresighting, interferometry, and spectroscopy. For a free copy, contact Jack Lipkins at: PLX, 40 Jeffryn Blvd., Deer Park, NY 11729; Tel: 516-586-4190; Fax: 516-586-4196; E-mail: plx@netusa.net.

PLX

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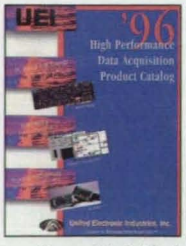

FREE DATA ACQUISITION CATALOG

UEI's catalog gives you full specs for data acquisition boards which are DSP-enhanced and provide 16 channels at 1 MHz continuous A/D. Options include on-board simultaneous sampling and individual programmable gain amplifiers for all channels. Also available: 16 bits at 200,000 samples/sec. Describes UEI's new PowerDAQ™ boards for the PCI bus, to be released July '97. UEI, 10 Dexter Ave., Watertown, MA 02172; Tel: 800-829-4632; Fax: 617-924-1441; http://www.ueidaq.com.

United Electronic Industries

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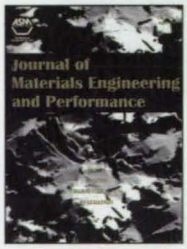

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ASM International

For More Information Write In No. 367

NEW MEGAPIXEL CAMERAS

Hitachi Denshi has introduced two new monochrome video cameras, each providing over one million pixels of information. Designed using Hitachi's experience in machine vision, medical and scientific imaging, the cameras are provided with both analog and digital outputs. Hitachi Denshi America, Ltd., 150 Crossways Park Drive, Woodbury, NY; Fax: 516-496-3718.

Hitachi Denshi America Ltd.

For More Information Write In No. 368

New on the Market

Product of the Month

Keyence Corp. of America, Woodcliff Lake, NJ, has introduced the CV Series Compact Vision System, a **handheld machine vision system** that provides a processing time of 1/60 sec., resolution of 240,000 pixels, 1/10,000 sec. synchronizing shutter, illumination adjustment, auto tracking, pattern matching, and gray search. Four image processing modes are available: area detection, pattern matching, absolute position detection, and relative position detection. The CCD camera is the same size as a sensor; the controller is the size of a micro PLC. The system does not require the use of a PC, and sensitivity and position do not need adjustment once the system is set up.

For More Information Write In No. 743

Kestrel VWF350 multi-output switchmode **power supplies** from Advance Power, Solon, OH, deliver 350 watts of continuous output power. The units feature universal input of 85 to 264 VAC and power factor correction at 0.99. They are available in a standard three-output version, or optional four- and five-output versions.

For More Information Write In No. 740

Columbia Research Laboratories, Woodlyn, PA, offers the VM-103-MI-8 **vibration monitoring system,** which uses piezoelectric accelerometers as vibration sensors for monitoring rotating or reciprocating machinery. Up to eight accelerometers can be located up to 200 feet from the readout module. The system supplies a readout calibrated in velocity and measures over a frequency range from 2 to 200 Hz.

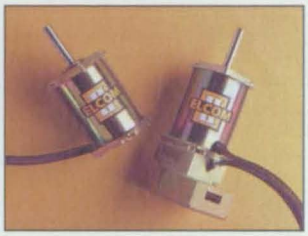
For More Information Write In No. 741

GE Plastics, Pittsfield, MA, has announced MD133 ULTEM® **resin** and polyphenylene oxide resin blend that provides heat and chemical resistance, and dimensional stability. Designed for use by molders, OEMs, and designers in the manufacture of automotive switches, sensors, and bulb sockets, the material is based on ULTEM polyetherimide resin, an amorphous polymer.

For More Information Write In No. 742

Schaevitz Sensors PS-10,000 **silicon pressure transducer** from Lucas Control Systems Products, Hampton, VA, features a pressure range to 10,000 psi and digital compensation. The unit's signal conditioner compensates for linearity and thermal error, and each unit enables a frequency response of 3,000 Hz.

For More Information Write In No. 745



Pittman, Harleysville, PA, has introduced ELCOM® II 3400 slotless **brushless DC motors** that can be configured for back EMF, Hall sensor, or optical encoder commutation applications. Features include gearheads, timing-belt pulleys, cables and connectors, modified shafts, and special configurations.

For More Information Write In No. 747

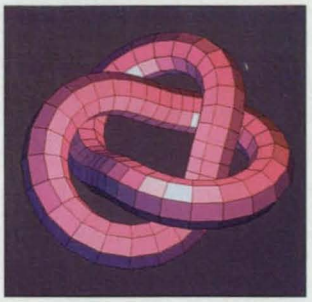
Associated Spring-Raymond, Maumee, OH, offers Raymond **threaded inserts** for thread repair and reinforcement. They are available in thread sizes of 2/56 to 1-1/2" in UNC and UNF categories. Inserts are made of 18-8 stainless steel, and are offered in phosphor bronze. They are used to replace existing threads, as a bolt-locking mechanism in high-vibration applications, or to reinforce threads in soft metals such as aluminum or magnesium.

For More Information Write In No. 746

LeCroy, Chestnut Ridge, NY, has introduced the LC374A color **oscilloscope,** which features four input channels with 500 MHz bandwidth and 1 GS/s sampling on each channel. It offers a record length of 100 Kpoints per channel and comes with 8 Mb of processing RAM, upgradeable to 64 Mb. The unit is supplied with the ProBus™ Intelligent Probe Interface that enables use with a range of FET probes.

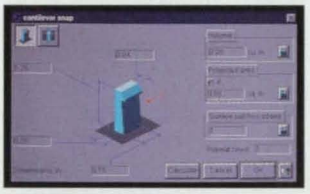
For more information Write In No. 744

New on Disk



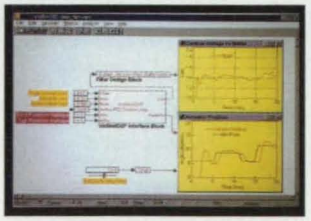
Research Systems, Boulder, CO, has introduced IDL Version 5.0 **visualization and programming software** for engineers, scientists, and software developers building data analysis and data visualization applications. It includes mathematics, statistics, graphics, image processing, mapping, and data manipulation tools, as well as IDL Insight, a pre-built graphical user interface. The software is available for Windows 3.1, 95, NT, Macintosh, Power Macintosh, UNIX, Linux, and Open VMS.

For More Information Write In No. 732



Early Cost Estimating for Injection Molding version 2.0 Windows-based **injection molding analysis software** from Boothroyd Dewhurst, Wakefield, RI, provides cost estimates at any point in the product development process. Design engineers can obtain estimates for process parameters such as set-up time and cost, and mold time, allowing them to see the cost impact of material choice, wall thickness values, tolerance specifications, and other molding elements.

For More Information Write In No. 727

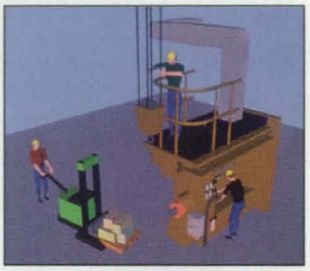


VisSim/DSP **modeling and simulation software** from Visual Solutions, Westford, MA, integrates DSP algorithm design/simulation with automatic code generation for development of DSP products and embedded systems. The Windows 95-based program is an add-on module to VisSim dynamic system modeling software, and features mathematical, engineering, and scientific functions.

For More Information Write In No. 733

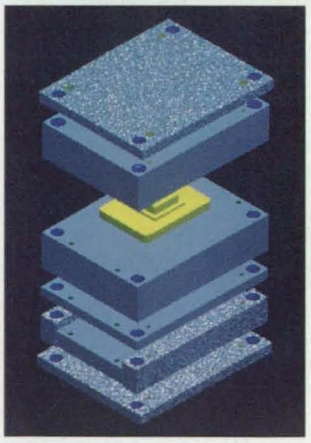
Autodesk, San Rafael, CA, has introduced Mechanical Desktop™ Release 1.2 **solid and surface modeling software** for mechanical design on a Windows 95/NT PC. The program includes an Express User Interface with a context-sensitive menu structure; Edit-in-Place assembly functionality; and enhanced ordinate dimensioning, editing, and displaying of crosshatch patterns, surface sealing, section views, and BOM generation.

For More Information Write In No. 725



Transom Technologies, Ann Arbor, MI, offers Transom Jack V1.1 real-time **human modeling and simulation software,** which provides a 3D graphical environment enabling users to create or import graphics of objects and environments; populate the environment with a human figure or figures; and interact with the virtual scene. Users can walk or fly through digital mock-ups of products, perfect product ergonomics, plan product assembly and maintenance procedures, and train operators. It runs on Silicon Graphics workstations.

For More Information Write In No. 737



Bentley Systems, Exton, PA, offers MoldDesign™ **mold design software** that generates designs from 3D solid model parts, automating the process of designing plastic and high-pressure aluminum injection molds. Users can choose from various components such as plates, leader pins, bushings, and ejectors for use in generating the mold. The software provides tools for designing the mold-cooling system and for generating a bill of materials.

For More Information Write In No. 726

New on Disk

Galactic Industries Corp., Salem, NH, offers GRAMS/32 Version 5 **data analysis and management software** for Windows NT and 95. Enhancements include Spectral Workbooks, which provide a custom environment for processing and viewing data; network administration tools; and features such as improved printing options, an Array Basic Debugger for programming; and the ability to preview data files and open multiple files simultaneously.

For More Information Write In No. 729

Brady USA, Identification Solutions Div., Milwaukee, WI, has released BradyTRAXX™ **data management software** to help users track, store, and manage information about assets, tools, and supplies. The software is based on Microsoft® Access™ and is available in single-user and network versions. It runs on Windows™ 3.1, 95, NT, or Windows for Workgroups and allows users to print bar code labels for item identification.

For More Information Write In No. 728

Matra Datavision, Andover, MA, offers Euclid 3 Version 2 **design software** that enables designs involving large or complex models and assemblies, as well as import/export of large files from other CAD systems. Tools include mechanism design, animation of 3D assemblies, multiple collision detection, interference control, and multi-scenario/multi-group simulations. It is available on UNIX platforms from Digital Equipment, Hewlett-Packard, Silicon Graphics, and Sun.

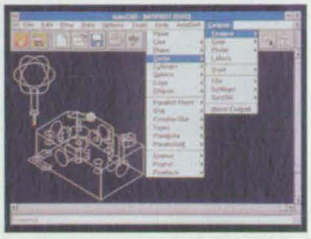
For More Information Write In No. 730

Continuum Builder Software from Continuum Engineering, Canoga Park, CA, is a **motion programming software** program that includes direct visual screen representations in three dimensions. Multiple changes in velocity, acceleration, and motor run current levels; input and output initialization values; x, y, and z motion programming; time delays; and other parameters can be performed through a touchscreen feature. It is compatible with Windows 3.xx, 95, and NT.

For More Information Write In No. 736

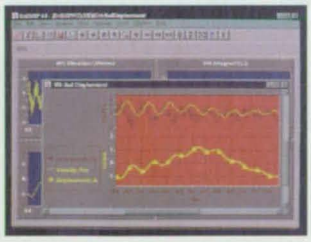
Verbal Control Suite **voice control software** from Voisys International, Nutting Lake, MA, provides complete voice control of any Windows 95-based PC, PC-based product, or software package by using voice commands. It can be embedded into PC-based hardware and software, enabling selective verbal control, hands-free operation, and system security. The software suite includes Verbal Mouse, Verbal Keyboard, Verbal Navigator, and Verbal Explorer. The four functions are speaker-independent and allow use of a PC without the need for a manual mouse or keyboard.

For More Information Write In No. 738



CADMeasure™ 6000 **CMM programming software** from Mitutoyo, Aurora, IL, is a Windows NT system that provides multi-tasking and 32-bit operation for graphical on-line/off-line part programming for coordinate measuring machines (CMMs). It supports measurement of non-prismatic and prismatic geometry and can be combined with AutoCAD® to perform reverse engineering and other CAD functions. Features include automatic probe calibration, modeless operation, and user-selectable tolerances.

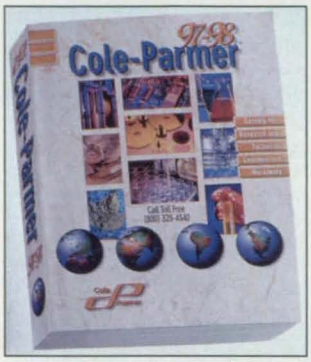
For More Information Write In No. 731



DSP Development Corp., Cambridge, MA, has released a native version of DADiSP 4.0 **data analysis and signal processing software** for Windows NT and 95. The software allows users to work with data series, matrices, images, waveforms, and signals to perform graphical data analysis, mathematical and statistical analysis, data management, and FFT analysis. It includes the Series Processing Language, a programming language for additional customization. Enhancements include message logging, dynamic linked libraries, and a menu-driven import generator.

For More Information Write In No. 735

New Literature



A 1997-98 catalog of **scientific instruments, equipment, and supplies** is available from Cole-Parmer Instrument, Vernon Hills, IL. Included are more than 30,000 products, including a new line of polarimeters, laser equipment, and the MASTERFLEX® series of pumps.

For More Information Write In No. 722

LaVezzi Precision, Glendale Heights, IL, offers a 32-page selection guide of more than 80 **sprockets and rollers** in rectangular tooth and round tooth configurations. The sprockets are machined in stainless, hardened steel, aluminum, engineering plastics, or other specified material.

For More Information Write In No. 721

Bishop-Wisecarver Corp., Pittsburg, CA, has released a 24-page catalog describing LoPro **linear motion systems** in four sizes and with drive options including belt, chain, lead screw, and pneumatic cylinder actuator. Designed to minimize installation, the systems are available with three different wheel plate assemblies.

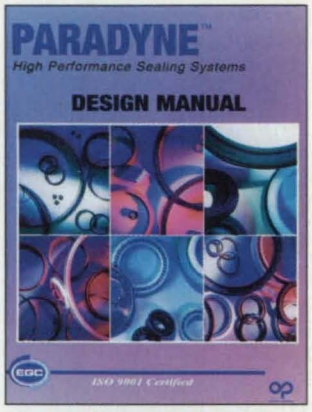
For More Information Write In No. 718

Non-Linear Systems, San Diego, CA, has released a six-page brochure describing the Series 8000 **signal conditioners**, including transmitters, isolators, and converters. The signal conditioners use PIN configuration and allow input, output, and special function selectability and interchangeability.

For More Information Write In No. 720

Superior Tube, Collegeville, PA, offers a 10-page brochure describing small-diameter **metal tubing** available in a variety of stainless steels, nickel, and nickel alloys. Applications include aerospace, medical, nuclear, instrumentation, automotive, and fabricated parts.

For More Information Write In No. 715



Paradyne™ **sealing systems** are described in a 72-page design manual from EGC Corp., Houston, TX. Metallic spring energized seals, rotary lip seals, and elastomer energized seals are used as rod, piston, face, and flange seals in applications requiring resistance to extreme temperatures, chemicals, corrosion, wear, and pressure.

For More Information Write In No. 717

A 50-page catalog of industrial **I/O products** is available from Acromag, Wixom, MA. Featured are VMEbus boards, ISA bus cards, and IP mezzanine modules for analog I/O, digital I/O, and communication functions. Accessories described include signal conditioning systems, termination panels, cables, adapters, and software.

For More Information Write In No. 716

Data loggers are described in a 28-page brochure from ACR Systems, Surrey, BC, Canada. Products include self-powered and pocket-sized devices that measure and record temperature, relative humidity, electric current, pressure, process signals, pulse frequency, and power quality.

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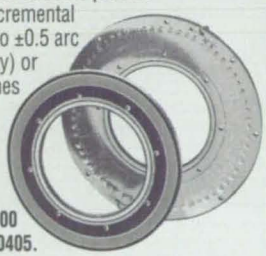

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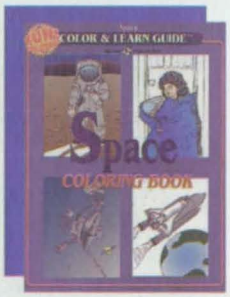

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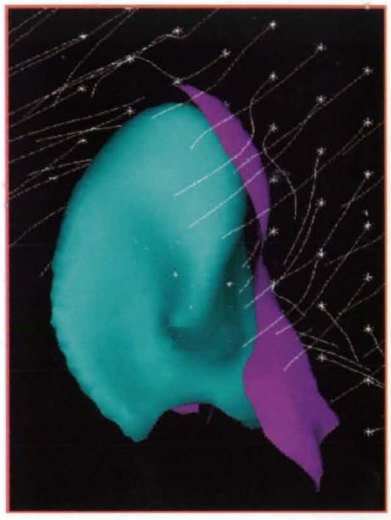

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