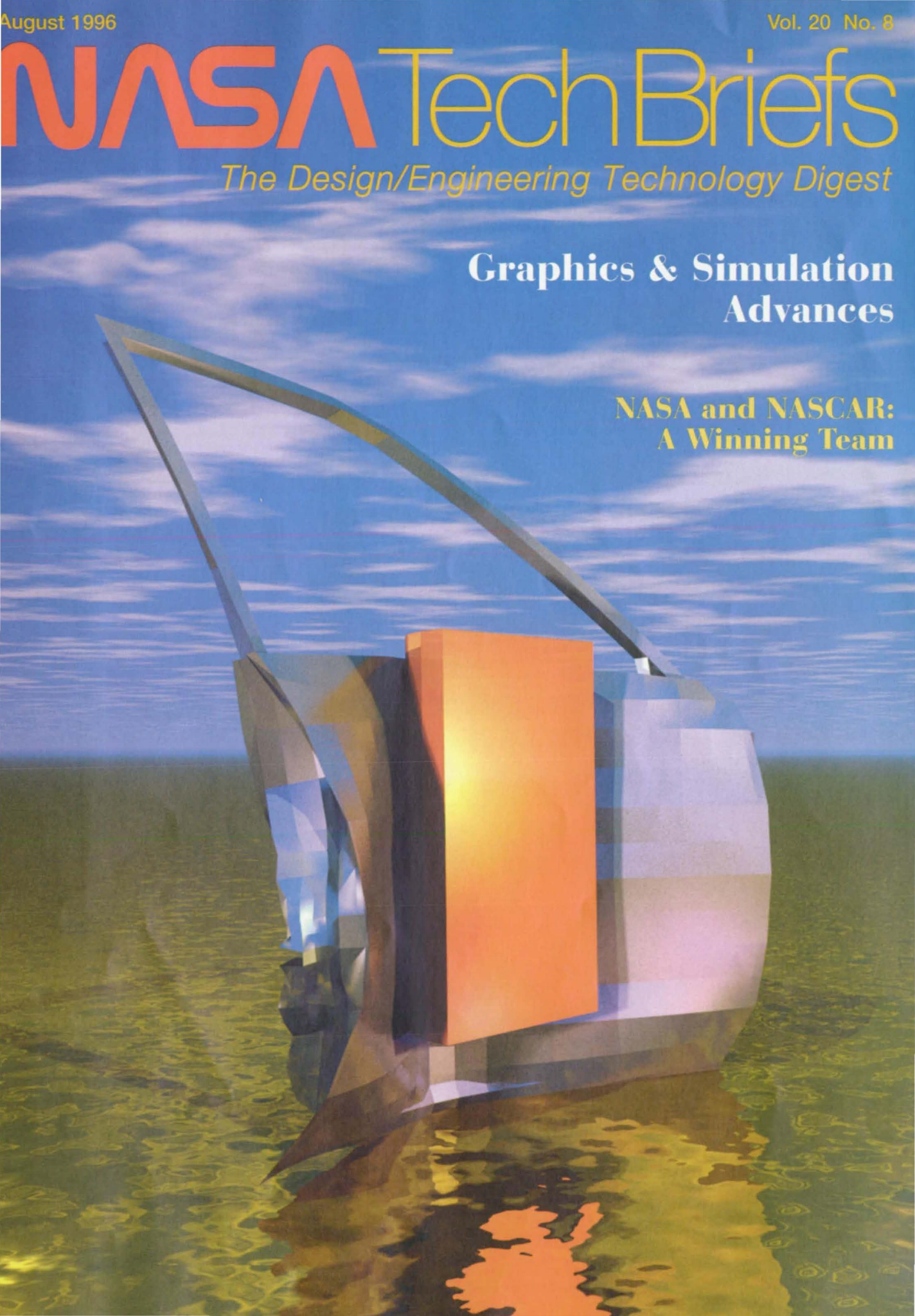
August 1996 Vol. 20 No. 8

NASA Tech Briefs

The Design/Engineering Technology Digest

Graphics & Simulation Advances

NASA and NASCAR: A Winning Team



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ComponentWorks is a new collection of ActiveX (OLE) controls and libraries for building virtual instruments in Visual Basic, Visual C++, and Borland Delphi. With ComponentWorks, you can acquire data from National Instruments DAQ products, control GPIB instruments with instrument drivers, perform advanced statistical analysis and signal processing routines, and build virtual instrument front panels in Visual Basic.

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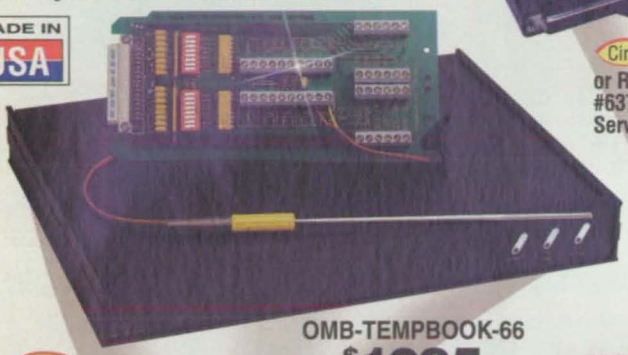

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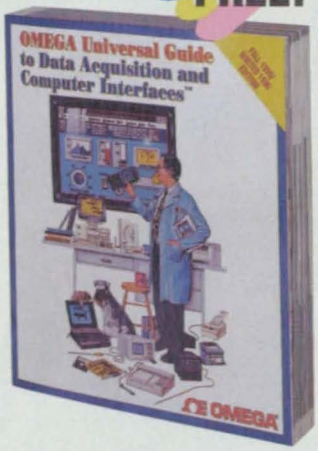

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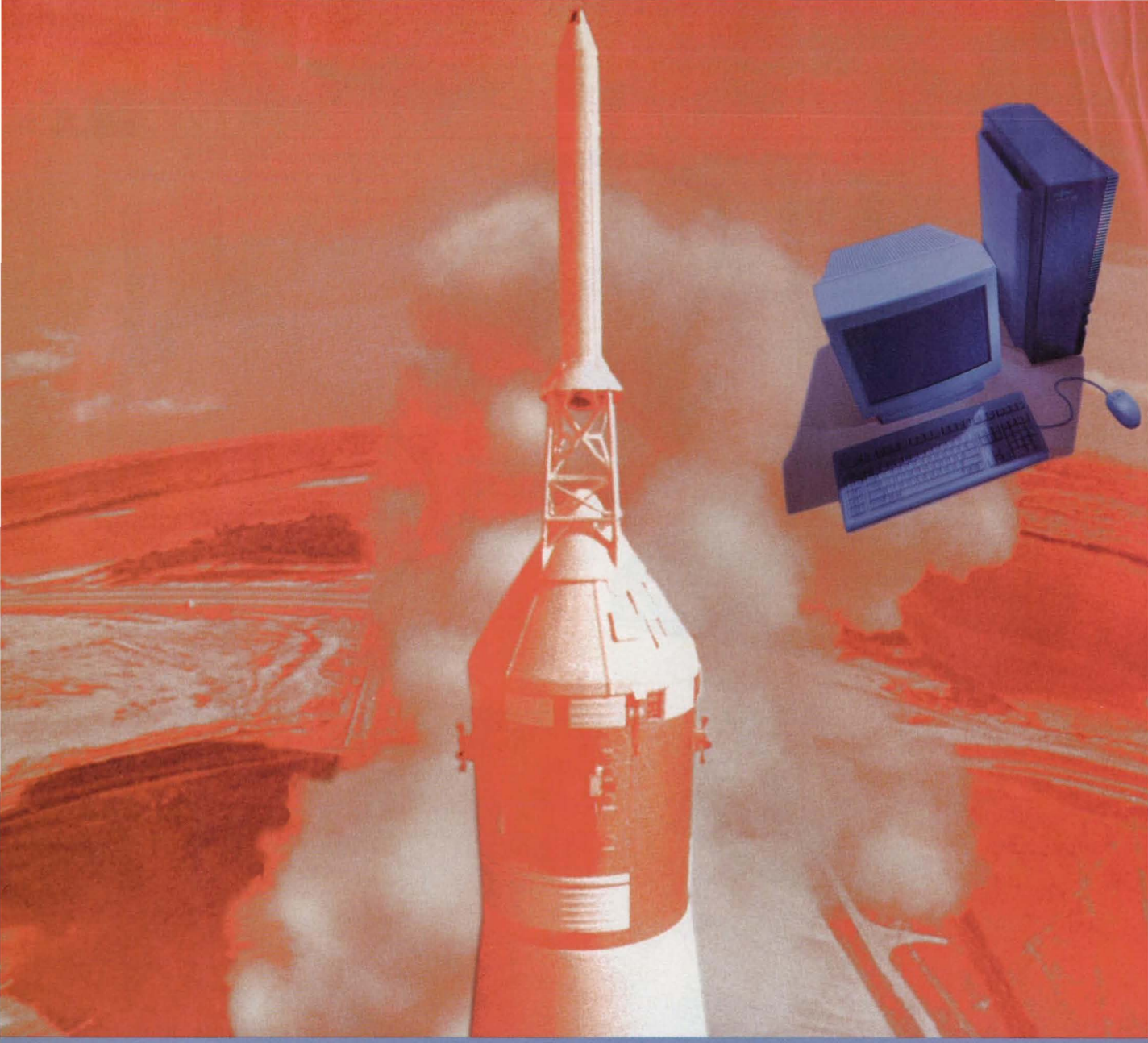

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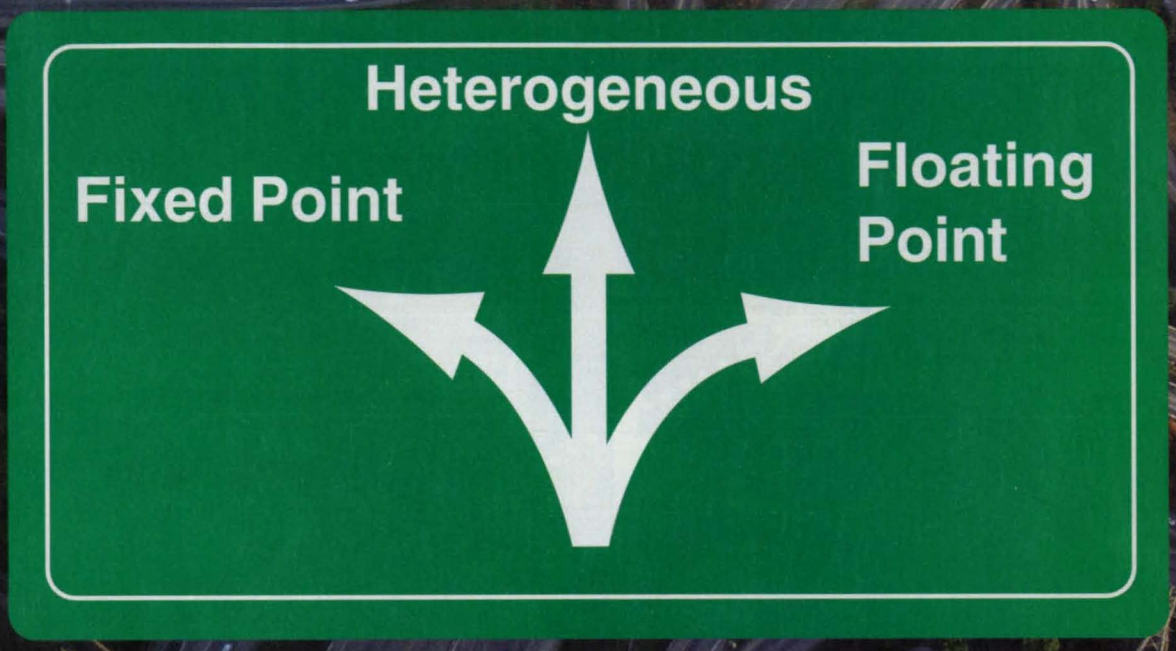

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TECHNICAL SECTION

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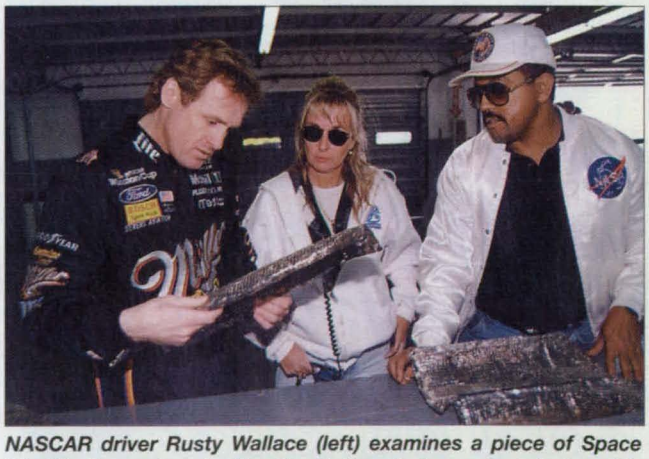
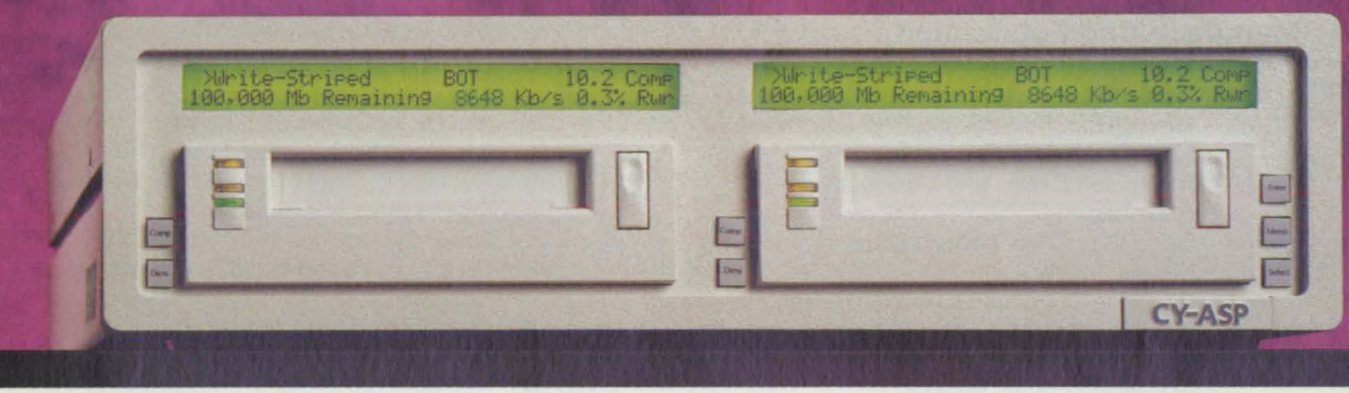


NASCAR driver Rusty Wallace (left) examines a piece of Space Shuttle thermal protection insulation that was installed on his Ford Thunderbird race car to reduce the excessive heat generated in the driver's compartment. The thermal barriers were designed and installed by a team of Kennedy Space Center (KSC) and Rockwell International personnel, led by NASA/KSC Thermal Protection System Facility manager, Bruce Lockley (right), and Rockwell's project engineer, Suzanne Hodge. For more information, see Mission Accomplished on page 20.

Photo courtesy of Kennedy Space Center

Write 200 GB At *18 MBS*



The CY-8900 8mm tape drive delivers a rare thing: a 185% increase in capacity, a 500% increase in speed, and backward read compatibility with earlier generations.

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Striping Write data to two or more tape drives at a time, to maximize throughput

Mirroring Write the same data to multiple tapes, to add fault tolerance or to make duplicate tapes

Cascade Data automatically writes to the next tape when the previous tape is full

Independent Write data to one drive while you restore with another

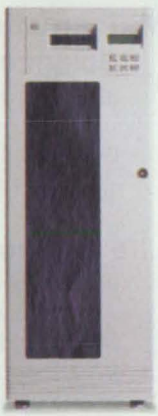
Offline Copy/Verify Make duplicate tapes without tying up the host

With the Advanced SCSI Processor, up to six drives can be configured in a powerful desktop tape array. Striping data, you can achieve an 18 MBS throughput uncompressed — up to 40 MBS with data compression.

No other tape drive can match it.

Other options include Accelerated File Access to speed file restore; Data Encryption to protect sensitive corporate data; and the Digital Data Recorder Interface, for data collection applications.

With a Fast SCSI interface, the CY-8900 is plug compatible with virtually every computer system and network running. It's available in a single or multi-drive desktop or rack mount configuration, or as part of an automated tape library with a capacity of up to ***12 terabytes***.



The CY-TL8-2020 features up to two drives and 20 tapes and can store between 400 GB and 2 TB.

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On the cover:

The deformation simulation of the side impact on a car door is depicted in a photorealistic image created by the MARC general-purpose analysis system from MARC Analysis Research Corp. of Palo Alto, CA. The image is one frame of an animation sequence created with the nonlinear structural analysis program. New advances in Graphics and Simulation are highlighted in the Special Focus beginning on page 29.

Image courtesy of MARC Analysis Research Corp.

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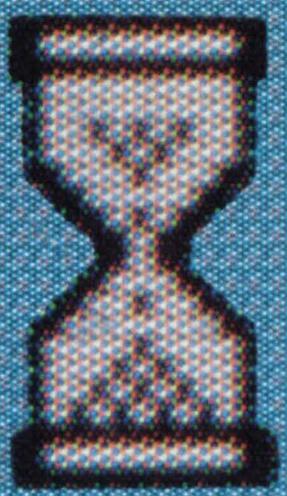

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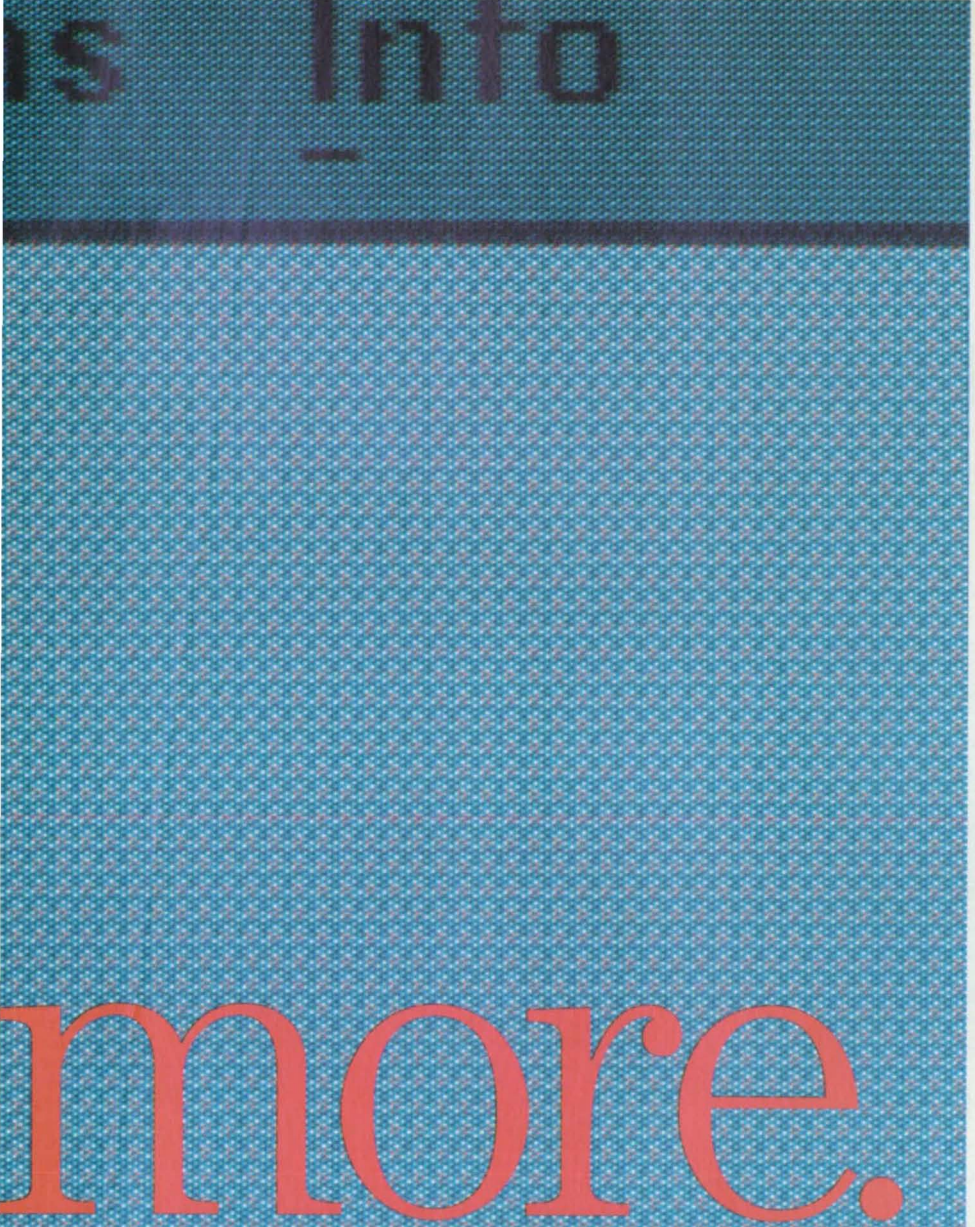

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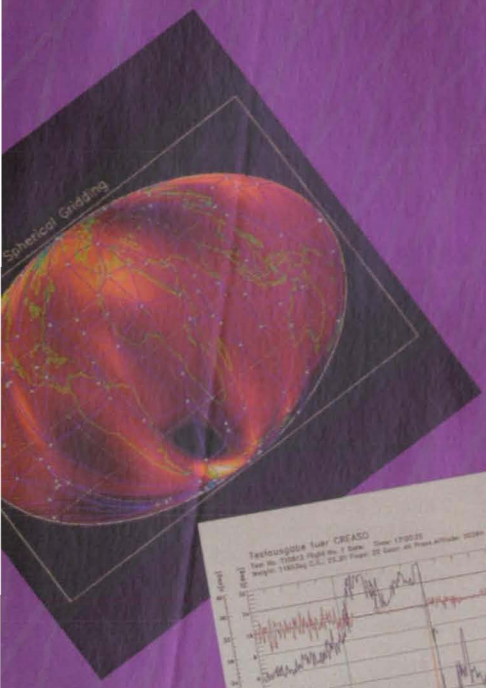

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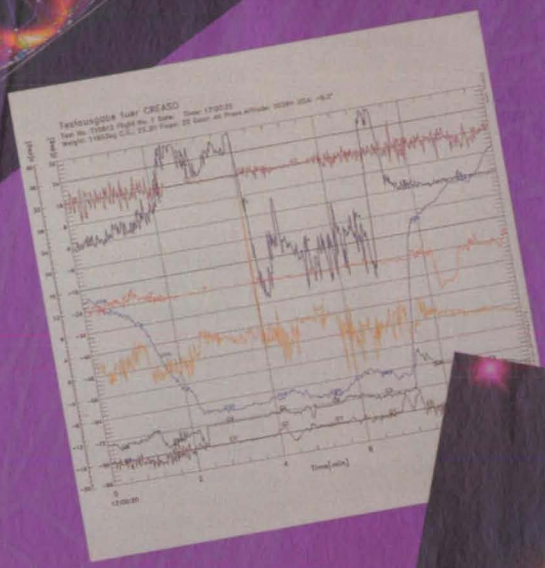

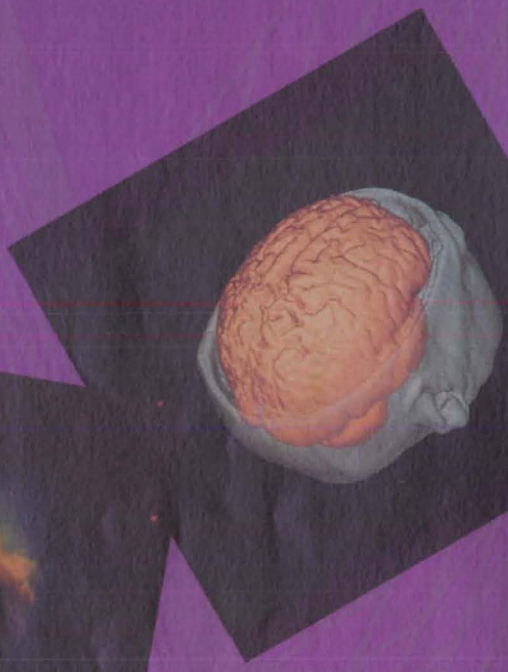

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If you are interested in information, applications, and services relating to satellite and aerial data for Earth resources, contact: Dr. Stan Morain, **Earth Analysis Center,** (505) 277-3622. For software developed with NASA funding, contact **NASA's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

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For More Information Write In No. 685

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:

Pipeline SAR Data Compression Utilizing Systolic Binary Tree-Searched Architecture for Vector Quantization

(U.S. Patent No. 5,477,221)

Inventors: Chi-Yung Chang, Wai-Chi Fang, and John C. Curlander, Jet Propulsion Laboratory

Among existing data compression algorithms, vector quantization (VQ) is an effective method of producing good reconstructed data quality at high compression ratios. VQ has been selected as the real-time downlink of the Earth Observing System on-board processor to ground data users. The present data compression system combines a real-time encoding rate with a low hardware cost by utilizing systolic array architecture for a tree-searched VQ algorithm. The array, consisting of a network of identical processing elements (PE) that rhythmically process and pass data among themselves, exploits design principles such as modularity, regular data flow, simple connectivity structure, localized communicating, simple global control, and parallel/pipeline processing functions. A fault-tolerant VQ encoder includes a spare PE and a means for detection and replacement of a faulty PE with the spare to enhance system reliability.

For More Information Write In No. 778

Multilayer Thin Film Hall Effect Device

(U.S. Patent 5,517,170)

Inventors: Palmer N. Peters and Robert C. Sisk, Marshall Space Flight Center

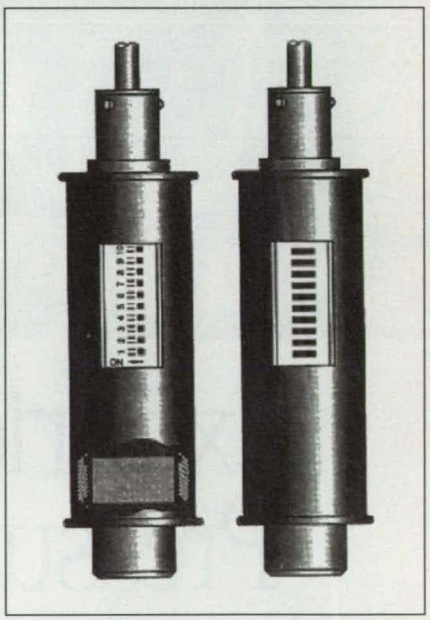
Hall effect measurements are indispensable to research on electric conduction and magnetic field properties, especially in semiconductors. One method of obtaining them is by means of a thin film of material that displays a high Hall coefficient and is deposited directly on the substrate. But the only such materials suitable for conventional thin-film deposition such as sputtering are bismuth and some high-T_c superconductors. The first is toxic, and the second group does not permit a wide range of adjustment in layer separation. The invention is the first to deposit on the substrate a duality of materials in thin films, one over the other, to produce a Hall effect device having a tunable Hall coefficient, the "third Hall coefficient." Creation of the latter coefficient by cooperation of the first and second layers allows use of materials for these layers that were previously ineffective because of their relatively weak Hall coefficient. The invention further posits a method of obtaining a magnetic field map of a magnetic body. By causing a bias current to flow in the first and second layers, and moving the magnetic body in a direction substantially transverse to these elongated layers, a voltage measured between predetermined points of the layers will indicate the strength of the magnetic field and thus produce a map of the magnetic body.

For More Information Write In No. 775

Accelerometer Method and Apparatus for Integral Display and Control Function

(U.S. Patent 5,517,183)

Inventor: Richard J. Bozeman, Johnson Space Center



The window in the accelerometer package at right shows bar graph elements such as light-emitting diodes. At left, the dip switch package has ten settings that can provide a digital trip signal. Cutaway at bottom shows position of "O" rings that shield electronics from vibration.

A need exists to improve electronic displays and control functions of accelerometers for operation directly on machines to measure their mechanical vibrations. The subject accelerometer package contains a transducer, display electronics, and a switch-selectable trip level for providing a fault signal. A bar graph display may be used to monitor machine conditions over time. In operation the apparatus outputs a broadband analog accelerometer signal and integrates it to produce a velocity signal that is calibrated and sent to the display driver. The package can be incorporated within an accelerometer case during the original manufacturing process or retrofitted into commercially available instruments. Micrologic and surface-mount technology can significantly reduce its size. Low cost, compactness, and simplicity are characteristic of a package that includes features normally provided only with more complex and expensive vibration monitoring equipment.

For More Information Write In No. 776

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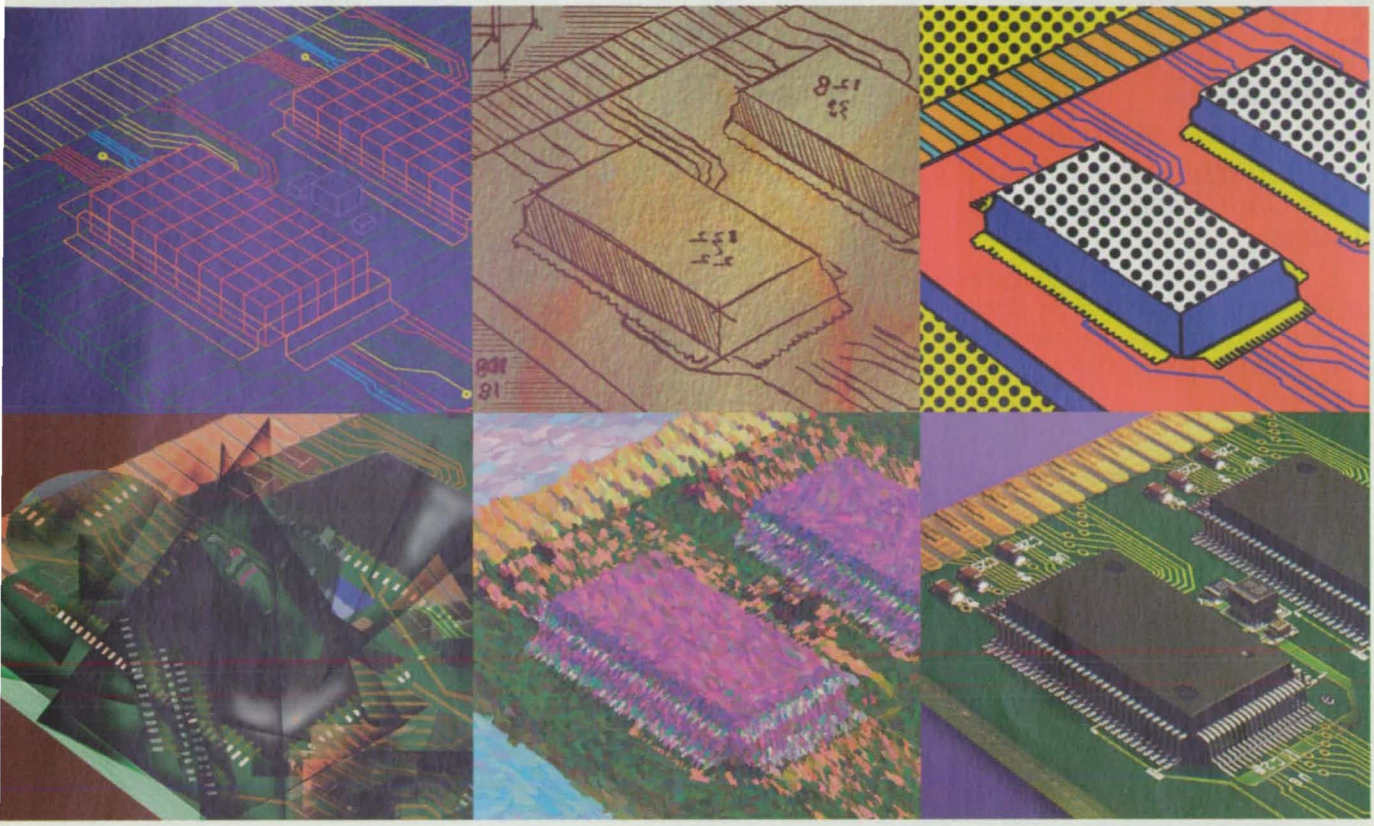

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For More Information Write In No. 686

New Product Ideas

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

Rechargeable Lithium-Ion Cells Containing Mg_2Si Anodes

A commercially available compound offers potential advantages of greater safety and longer cycle life over lithium itself or carbon-based lithium-intercalation materials.
(See page 50.)

Aircraft Maneuver-Envelope Warning System

A string of colored lights serves as an intuitive, easy-to-read indicator of the status of an aircraft relative to its maneuver envelope. Because of the arrangement of colors, the pilot can read the display with peripheral vision while attending to other things.
(See page 56.)

Advanced Microfabricated Hydrogen Sensors

Sensors of this type could be used, for example, at aerospace facilities that store and handle hydrogen as rocket fuel or at industrial facilities producing hydrogen. Broader use can be anticipated if hydrogen one day becomes practical for automobiles as a clean-burning fuel.
(See page 64.)

Deposition of Sapphire by Conversion Coating

Aluminum is deposited and immediately oxidized to convert the deposit to sapphire. The process can be used to form abrasion-resistant, clear protective coatings on polymeric windows, lenses, and face shields.
(See page 68.)

Filter Devices for Collection and Storage of Body-Fluid Samples

Use of these filter devices eliminates the need for centrifuges and freezers to separate and store blood and other biological fluid components. Dried acellular components can be stored inexpensively and analyzed up to six months later.
(See page 95.)

Production of Monoclonal Antibodies Specific to Hepatitis C

Antibodies specific to some peptides in hepatitis C viruses have been produced. With suitable modifications, these antibodies could become the basis for commercial products in immunotherapy and for use as controls in hepatitis C antibody assays.
(See page 97.)

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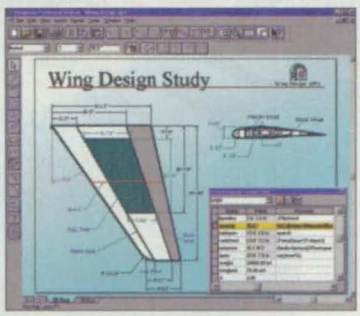

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For More Information Write In No. 660

Mission Accomplished

Former NASCAR racing champion Bobby Allison wasn't expecting to discover a way of revolutionizing Winston Cup racing when he toured NASA's Kennedy Space Center (KSC) last year, but that's exactly what happened. A tour with KSC Director Jay Honeycutt sparked Allison's idea of using thermal material from the space shuttle to insulate heat-generating areas of stock cars to protect drivers from exposure to excessive heat.

During NASCAR races, drivers often suffer burns and blisters due to the extreme heat transferred into the cockpit through the engine firewall, transmission tunnel, and floor. Exhaust pipes running under the driver's seat carry 600 to 800°F gases away from the engine. As a result, temperatures in the driver compartment often reach dangerous levels of between 140 and 160° F, causing some drivers to be pulled semi-conscious from their cars after a race. Drivers often rely on their own conditioning to be able to withstand temperatures hot enough to melt the soles of their right shoes (the ones pressing on the gas pedal). While cooling apparatus such as head gear and vests that run cold water or Freon are used to keep drivers from suffering heat exposure, the preferable alternative would be to stop heat at the source. That's where NASA came in.

Allison, who owns Ford cars driven by Derrike Cope, was encouraged by Honeycutt to work with KSC on installing scrap pieces of shuttle orbiter Thermal Protection System (TPS) blanket material in one of his cars. But due to a tight racing schedule, none of Allison's cars was available to ship to KSC. So, Allison contacted his racing rival Roger Penske of Penske Racing South, who had a car that could be loaned to KSC for a day to serve as the test bed for the new application. The Miller Ford Thunderbird driven by veteran racer Rusty Wallace was delivered to KSC on October 12 of last year. A team from Rockwell Space Systems Division's Thermal Protection System Facility (TPSF) worked with Wallace, crew chief Robin Pemberton, and a NASA team led by KSC's TPS Facility Manager Bruce Lockley, to design, build, and install the insulation system in about 12 hours.

Shown above are veteran NASCAR driver Rusty Wallace (left) and Kennedy Space Center Director Jay Honeycutt prior to testing the thermal blanket insulation in Wallace's car at Daytona International Speedway. At right, a Kennedy Space Center Thermal Protection System (TPS) employee fits the Penske Ford Thunderbird with space shuttle blanket material at the TPS facility in Florida.

A Patchwork Approach

The aluminus silicate material used had been graded as either scrap, obsolete, or generally not up to standards required for shuttle use. The material resembles house insulation; however, the shuttle material has a 1.3-micron diameter fiber, compared to the 30-micron diameter fiber used in commercial insulation. Thus, the TPS material allows more fiber per square inch than house insulation. Pemberton provided patterns for the material pieces, so the insulation blankets could be removed and installed in different cars.

The Penske team identified some of the car's hottest spots, and the Rockwell team fabricated two pieces of insulation to shield the driver. The first piece was two-inch-thick Flexible Insulation Blanket (FIB) material installed under the car's floorpan to run between the floor and the exhaust system and cover the area from the firewall back to behind the driver's seat. The second blanket, made of Thermal Control System (TCS) material, was placed under the driver's seat. Another three blankets of TCS and FIB material were used to insulate the transmission tunnel and floor next to the cockpit. TCS material was used to cover both the transmission gear shifter and the engine oil tank, which sits six to eight inches behind the driver. In the engine compartment, two blankets made of the material used on the shuttle orbiter's wing were installed in front of the firewall.

The insulation added less than four pounds to the 3400-pound car and cost NASA about $2000: $1000 for material and $1000 for labor. The material scraps were small; if they were whole, the cost would be about $6000. The cost could be reduced significantly if the material is mass-produced by a commercial company. Suzanne Hodge of Rockwell's Advanced Projects explained that the material was made available under a Space Act Agreement between KSC and Penske Racing that allows Rockwell to

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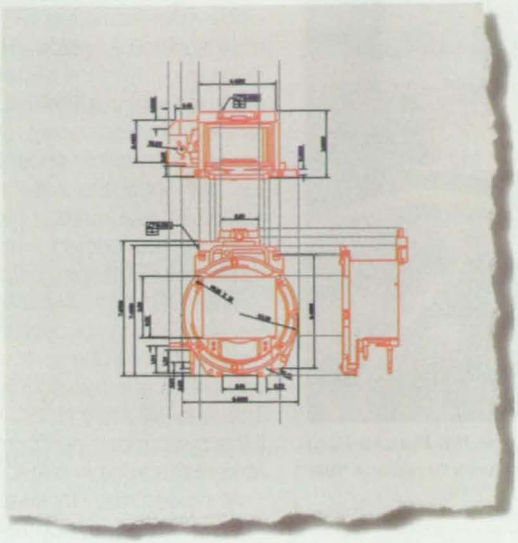

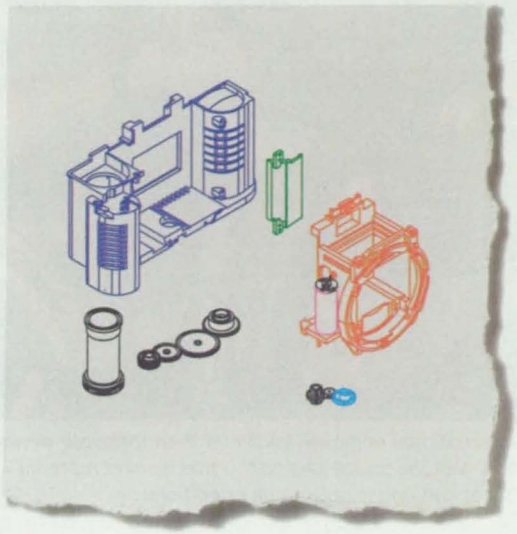

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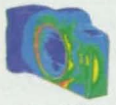

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A Rockwell International engineer installs a thermocouple device inside the Penske Ford to measure how well the space shuttle thermal blanket material would work to reduce heat in the driver's cockpit under race track conditions.

serve as an integrator to spin the technology off for commercial use. NASA agreed to work on the car with the understanding that other race teams will have access to the material. Said Pemberton: "We don't want to keep it to ourselves. You don't want something like this as an advantage over someone else. If my guy is racing side-by-side with someone else, I want both of them to have cool heads."

One of the most important considerations at the beginning of the project was whether the refurbishments would be approved by NASCAR. But since the insulation system does not enhance the performance of the car, it is not prohibited by NASCAR. Winston Cup director Gary Nelson explained that NASCAR wouldn't be involved unless it gets too expensive. "One of our questions is cost to competitors. Anything like that, which is within reason cost-wise and helps the driver, we don't get too involved in."

As for NASCAR approving the material pieces, Nelson said that it comes under the heading of driver performance, like "what kind of shoe he is going to wear." The team was not, however, able to insulate the car's exhaust system, due to NASCAR regulations on performance enhancements.

One Cool Car

Once installation of the TPS material was complete, the next step was to test the new insulation blankets. Would they cool the car's hot spots enough to reduce driver compartment temperatures to bearable levels? The first test was a preliminary session held last November, in which Wallace's car idled in the garage area until the oil temperature reached 165° F. The insulating material reduced the surface of the tank to 75° F. The 90-degree reduction in temperature is significant, given the fact that the oil cooler sits less than three inches from the driver's back.

Wallace pilots his Ford Thunderbird around the track at Daytona as part of a real-world test of the TPS material installed under the Space Act Agreement between KSC and Penske Racing.

On April 10, the first high-speed test was performed under race track conditions with full instrumentation to determine how well the thermal barrier system would reduce hot-spot heat. At the Daytona International Speedway in Florida, Wallace ran 20 2.5-mile laps in the Thunderbird with only the external elements of the TPS system in place to reach a constant temperature level. He then drove the same distance with the material removed. Computer-based sensors and data recorders measured temperatures in the car at the hot spots, including below Wallace's foot. With the insulation material in place, the temperature under Wallace's foot measured 108°F; with the material removed, the temperature was 145° F.

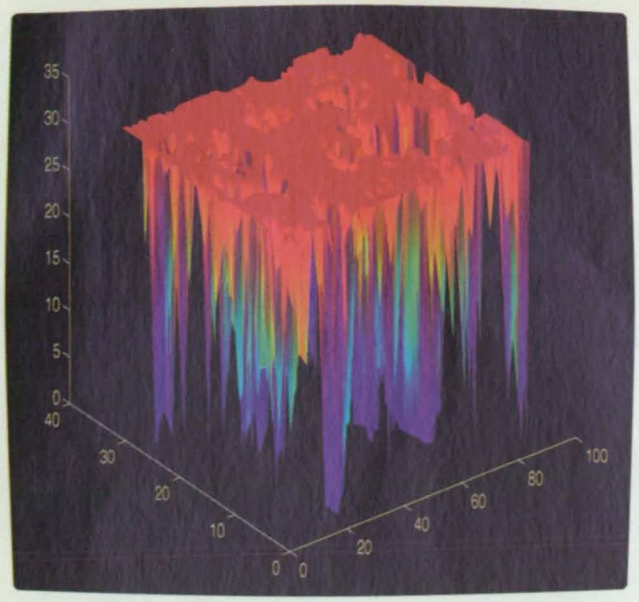
Another hot spot under Wallace's left elbow was measured with just the external insulation in place. The temperature measured 120°F; a blistering 260°F was recorded without the insulation. The difference in temperature of 140° is staggering, especially since the tests were run with only the external insulation in place. An even greater reduction in temperature is expected when the tests are run with the interior insulation in place.

The KSC team will continue testing with Penske Racing to develop an insulation system that can be switched quickly from one car to another, according to Lockley. The data will allow NASCAR to determine if the system can be approved for use on all cars that race in NASCAR events.

At press time, Rockwell was negotiating a business development contract with Penske Racing, which specifies a commercial manufacturer of the blanket material and other details. After the agreement is signed, Rockwell will release the name of the manufacturer, the details of the product, and its cost. The non-proprietary technology could be used by other companies to manufacture similar products. Rockwell hopes to have the commercial product available before the end of the NASCAR racing season in November.

Martin Wilson, Rockwell's TPS Facility project manager, is sure that "the system will significantly improve environmental conditions for race car drivers. This is another good example of how technology developed for the space program can be used for applications on Earth."

For more information, contact Bruce Lockley of Kennedy Space Center at 407-861-5381.



This surface plot shows impact damage to a rectangular section of helicopter laminate material. Algorithms developed with the MATLAB Neural Network Toolbox classify echoes from ultrasonic signals to automate non-destructive inspection. Data courtesy of McDonnell Douglas under an AATD contract.

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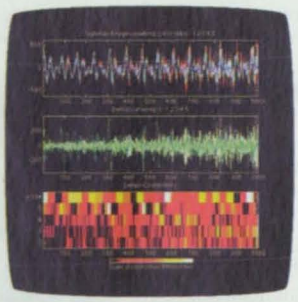

MATLAB Wavelet Toolbox algorithms perform a 5-level decomposition of a voice signal. Data courtesy U. S. Robotics Mobile Communications Corp.

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Dryden Celebrates 50 Years

Five aeronautical engineers from Langley Memorial Aeronautical Laboratory (now known as Langley Research Center) arrived from Hampton, VA at Edwards Air Force Base in Edwards, CA, on September 30, 1946 to set up the High Speed Flight Station in preparation for X-1 supersonic research test flights. The flights were part of a joint program between the Army Air Forces and NASA's predecessor, the National Advisory Committee for Aeronautics (NACA).

This operation marked the beginning of flight research at NASA's Dryden Flight Research Center, which celebrates its 50th anniversary next month. The center, renamed in 1976 in honor of Hugh L. Dryden, has ascended into flight research leadership over the past half-century, and now has nearly 900 NASA government and civilian contractor employees in flight research programs supporting U.S. industry and the military.

Located at Edwards Air Force Base—with which it has a partnership alliance—Dryden has access to more than 20,000 square miles of restricted air space over California's high desert and off the California coast. Dryden facilities include a high-temperature and loads-calibration lab to test aircraft and structural components on the ground for the effects of inertial and aerodynamic forces and heat. A flight systems lab provides for safe integration and testing of aircraft flight controls and other electronic and electrical systems before flights. Other facilities include a flow visualization facility for study of airflow patterns, and a flight research data processing facility.

Modified Boeing 747s are used as Space Shuttle Carrier Aircraft (SCA) to take the shuttle orbiters back to the launch site at Kennedy Space Center in Florida after landing or servicing at another site. The NASA 905, the first SCA in service, is shown leaving Dryden with the orbiter Atlantis.

The Advanced Control Technology for Integrated Vehicles (ACTIVE) program at Dryden uses specially modified F-15s to test how advanced thrust vectoring engine nozzle technology can improve the aircraft's performance during cruising flight or in maneuvering.

Aircraft Advances & the Space Age

Work at Dryden began with the early jet and continues with the space shuttle. But Dryden may be best-known for the historic breaking of the sound barrier in 1947. Flight research at and beyond the speed of sound during the late 1940s and 1950s included the first of the famous X-Planes, which pioneered supersonic flight, and the X-15 rocket planes, which brought pilots to the edge of space. This research provided important early verification of, and corrections to, the nation's wind tunnels; furnished significant information on previously unexplored aircraft characteristics that contributed to the controllability and maneuverability of planes; and proved the concepts of swept- and variable-speed wings, adjustable stabilizers, and reaction controls used on subsequent aircraft and space vehicles.

Dryden has pioneered in flight research through the use of modified, conventional aircraft such as the F-8, the F-111, and the F-15. Aircraft design has been profoundly changed as a result of aerodynamics and digital electronic flight control systems research performed in the 1970s on the F-series aircraft. For example, research on the F-8 Digital Fly-By-Wire (DFBW) aircraft resulted in effective use of DFBW technology in the space shuttle, the F-18, the B-2 Stealth Bomber, later models of the F-16, and the Boeing 777.

When NASA began the space program, research at Dryden focused on challenges of hypersonic (Mach 5+) speeds and piloted flight into space. The Lunar Landing Research Vehicle (LLRV) and the Lifting Body space research programs continued at Dryden in the 1960s and 1970s. The LLRV helped astronauts prepare for lunar landings, and the wingless Lifting Body research aircraft obtained data on controllable atmosphere reentry for development of the space shuttle. Dryden served as the shuttle's primary landing site for the first 12 years of the program.

The Next 50 Years

Incorporating technologies such as forward-swept wings, vectored thrust, and nose strakes, the F-18 HARV and F-15 ACTIVE programs have contributed to improved safety and controllability of high performance aircraft. Other research efforts contributing to future aircraft design include distributed systems that will substitute small, individual components for large, centralized systems to reduce weight and increase efficiency. The X-Planes currently under development at Dryden will help to advance aerospace vehicle designs and could make supersonic flight more economical in the 21st century.

Propulsion-controlled aircraft technology demonstrated in the F-15 in 1993 and in a wide-body MD-11 in 1995 showed that flight-control software can be used to land an aircraft using only the throttles for control. The Engines-Only Flight Control System, developed by Dryden's Frank W. Burcham, Joseph L. Conley, Charles G. Fullerton, Glenn B. Gilyard, and James F. Stewart was named NASA's nominee for the Intellectual Property Owners 1995 National Inventor of the Year Award. (See *NASA Tech Briefs*, April 1996, page 20.)

For more information, contact Dryden's Public Affairs Office at 805-258-3449, or visit the NASA Dryden World Wide Web Home Page at http://www.dfrc.nasa.gov/.

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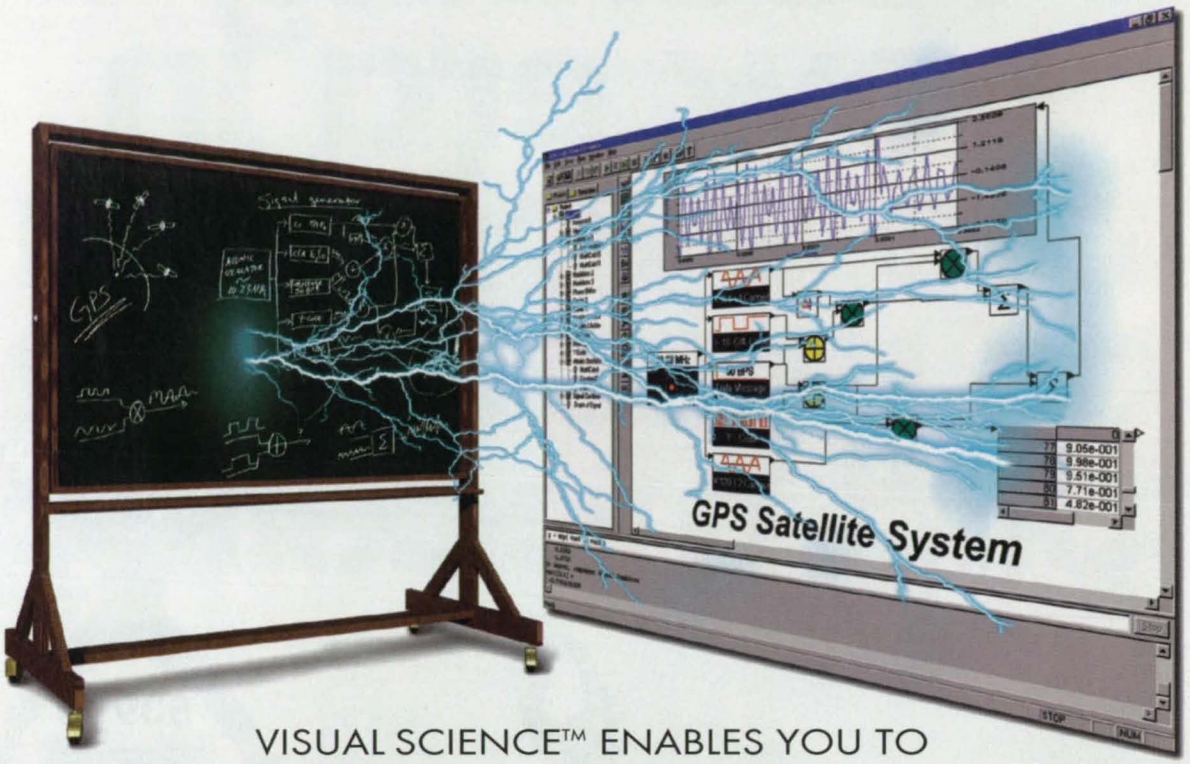

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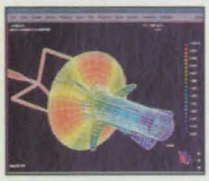
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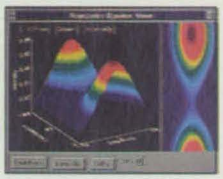

page 40

Remote Interactive Visualization of Planetary Image Data Using Parallel Supercomputers

This program could serve as a valuable tool for education in geology, geography, and space science.

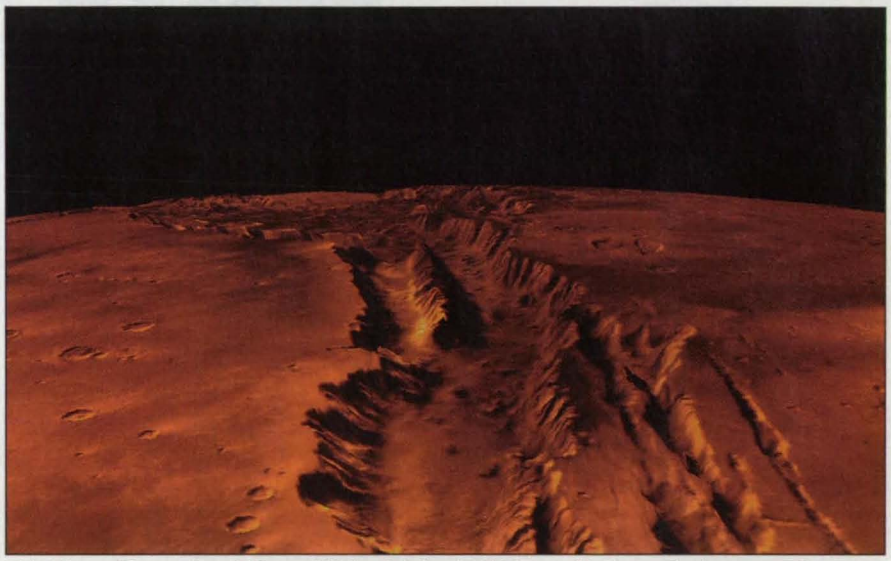
NASA's Jet Propulsion Laboratory, Pasadena, California

A parallel-processing computer program renders three-dimensional-appearing images of the Earth or other planet from any desired perspective. The program generates the images from satellite optical- and/or radar-image data registered with a digital elevation map of the planet. The data are referred globally to a spherical reference frame and can be presented by use of sinusoidal projected flat-surface mathematical models.

The program can handle tens of gigabytes of input image data and is scalable to very large, massively parallel processing computers. It can generate high-quality, high-resolution images in nearly real time when operating in a stand-alone or batch mode. Alternatively, an interactive interface in the program can be used to explore large volumes of remote-sensing image data in real time, or to simulate flight over planetary terrain.

This software can be run on a Cray T3D computer and an Intel Paragon computer (or equivalents), rendering images at a rate of 2 frames per second. For operation in the interactive mode, it is also necessary to use an SGI computer with texture-mapping and a HiPPI frame buffer connected to the parallel processing computer via a HiPPI network. It has been demonstrated by using it in interactive simulation of flight over the California and Nevada desert as rendered from 650MB Landsat imagery of that area, and in simulation of flight over Mars from an 860MB global set of Mars image data. The program could serve as a valuable tool for education in geology, geography, and space science.

This work was done by P. Peggy Li, Dave W. Curkendall, and William H. Duquette of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 65*** *on the TSP Request Card. NPO-19598*



This **Three-Dimensional View** of *Valles Marineris of Mars*, with 5 × vertical exaggeration, was rendered on the JPL Cray T3D using the parallel renderer described in the text.

Easy Plotter

Features include an easy-to-use data-entry format and automatic scaling.

Goddard Space Flight Center, Greenbelt, Maryland

The Easy PC Graphics (GFI) computer program provides for ease and flexibility in plotting of data. The program establishes a standard input-data format that eases the entry and evaluation of data. Multiple dependent axes are also supported. The program can be run either in a stand-alone mode or embedded in the user's own software.

Automatic scaling according to several logarithmic and decibel scales is built in. New scales, or other data transformations, are easily incorporated into the code through the use of object-oriented programming techniques. For the autoscale routines and the plotting code, data are not retrieved directly from a file, but a "method" delivers the data, performing scaling as appropriate. Each object (variable) has state information, which selects its own scaling.

GFI is written in version 6.0 of Turbo Pascal for IBM PC-compatible computers running MS-DOS. The source code can be compiled properly only with the version 6.0 and version 7.0 Turbo Pascal compilers. However, an executable code is provided on the distribution disk. This executable code requires at least 64K of random-access memory and DOS 3.1 or higher, as well as an HP LaserJet printer to print output plots. The standard medium for distribution of this program is one 5.25-in. (13.335-cm), 360K, MS-DOS-format diskette. The contents of the diskette have been compressed by use of the PKWARE archiving software tools. The utility software to unarchive the files, PKUNZIP.EXE, is included. An electronic copy of the documentation is provided on the distribution medium in ASCII format. GFI was developed in 1993.

This program was written by Rich Katz of **Goddard Space Flight Center** *and Ted Kopf of Caltech. For further information,* ***write in 4*** *on the TSP Request Card. GSC-13592*

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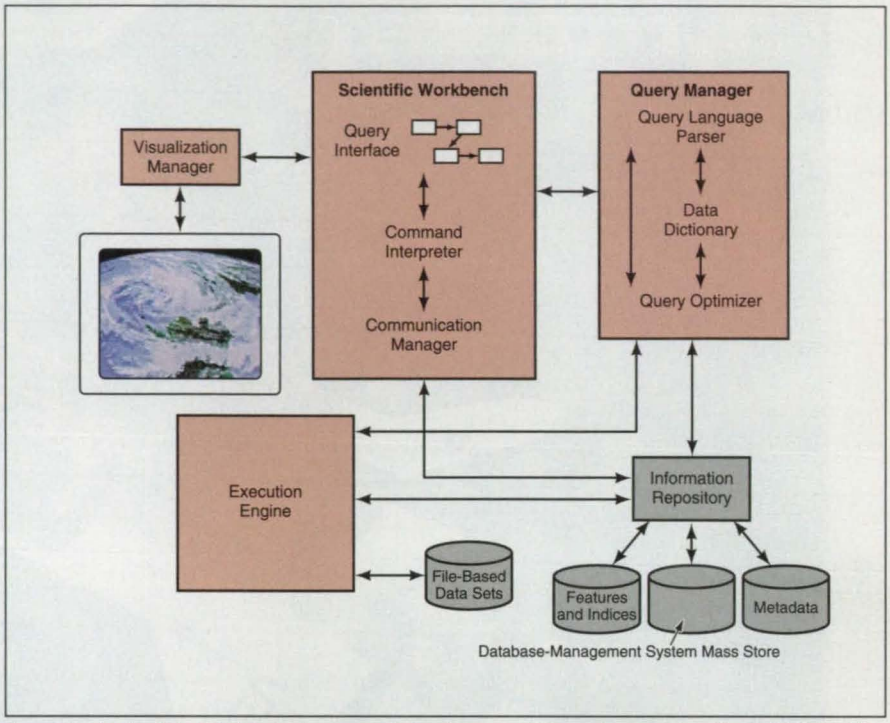
Mining Vast Sets of Geophysical Data

Features of interest can be extracted from temporal and spatial variations.

NASA's Jet Propulsion Laboratory, Pasadena, California

CONQUEST (for CONtent-based QUErying in Space and Time) is a system of computer software and hardware for "mining" vast sets of geophysical data, enabling scientists to extract features of interest from spatial and temporal variations of pertinent physical quantities included in the data. CONQUEST can be applied to data from diverse sources, including computational models of oceanic and atmospheric flows, multispectral imagery acquired from instruments aboard satellites, and synthetic-aperture radar images of terrain. CONQUEST has begun to be applied to meteorological data to study the long-term behaviors of the atmosphere and oceans. It is also being applied in the effort to understand and eventually predict such short-term meteorological phenomena as blocking events (associated with bifurcation of the basic westerly jet stream in mid latitudes) and cyclones.

The basic idea of CONQUEST is to provide a knowledge-discovery computing environment that enables geophysical scientists to do the following:



From the Scientific Workbench, a user formulates queries and interacts with CONQUEST to explore hypotheses. After extracting information from a vast repository, the system presents results graphically to the user.

1. Easily formulate queries — especially queries in the form of content-based indices that depend on both spatio-temporal patterns specified by the scientists and spatio-temporal patterns that emerge spontaneously from analysis of the data;
2. Execute these queries rapidly on massive data sets;
3. Make the results visible; and
4. Rapidly and interactively infer and explore new hypotheses by supporting complex compound queries (in general, these queries depend not only on the data but also on content-based indices supplied by the answers to previous queries).

CONQUEST exploits the distributed and parallel data-processing power afforded by a network of computer workstations and massively parallel processors. The system architecture (see figure) comprises five basic components; (1) the scientific workbench, (2) the query manager, (3) the visualization manager, (4) the execution engine, and (5) the information repository. The scientific workbench includes a graphical user interface that enables the formulation of queries in terms of imagery presented on the screen by the visualization manager. The execution engine is a subnet-

work that can be flexibly configured to include one or more workstations, serial supercomputers, and/or parallel supercomputers. The query manager accepts queries formulated on the workbench, parses them, and optimizes them for the applicable computer(s) in the execution engine, then passes them on to the execution engine.

The simplest queries involve the extraction of well-defined features from raw data, without reference to any other information. These features are registered with the information depository to act as indices for further queries. Salient information extracted by queries can also be displayed via the visualization manager. This information can be presented in the form of graphs of up to three dimensions, statistical parameters, contours, and/or animations.

This work was done by Paul Stolorz of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 71*** *on the TSP Request Card. NPO-19793*

Simulation of a Thermal System With Long Lags

A computational model of the system is used to generate analog temperature signals.

Goddard Space Flight Center, Greenbelt, Maryland

A digital/analog electronic system simulates the thermal and electrical responses of a thermal system that comprises a large structure with electric heaters and temperature sensors. "Large structure" here means a temperature-controlled instrument housing or other structure that is characterized by thermal-response times (lags) as long as several hours.

The digital/analog simulation system (see figure) was devised for use in testing engineering prototypes of temperature-control circuits when the thermal systems to be controlled are not yet available. The system can be characterized as analog in/analog out, with the relationships among inputs and outputs determined by software running in the digital part of the system. The digital/analog implementation was chosen because it is impractical to simulate lags of the order of tens of minutes or hours by use of simple analog circuitry in which the lags are established in the customary way by use of resistors and capacitors.

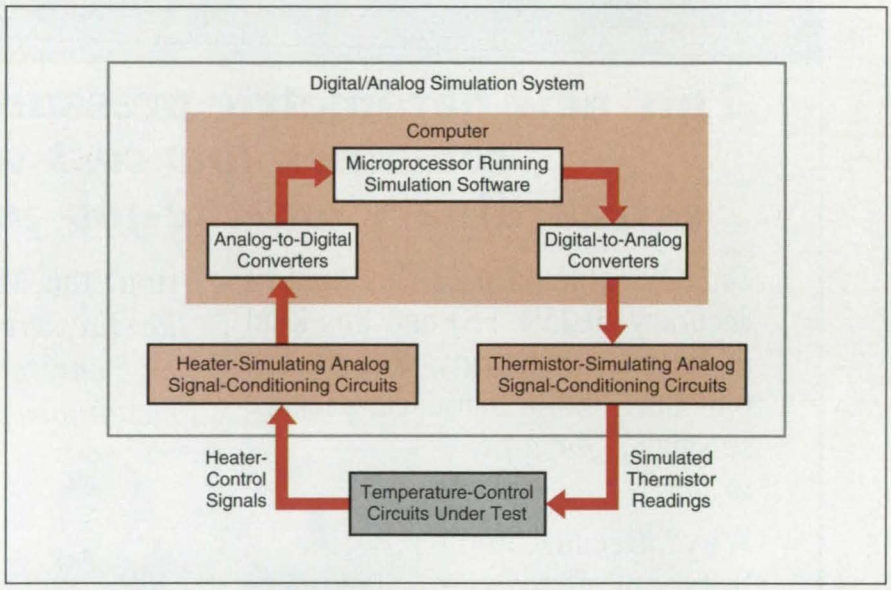
The thermal system to be simulated is represented by a conventional multinode resistance-and-capacitance thermal model that is implemented in software in a personal computer. In deriving the equations on which the software is based, the differential equations for the temperatures at the various nodes in the model are converted to a first-order matrix difference equation of the form

$$T_k = (C_\theta/\tau)(G_\theta + C_\theta/\tau)^{-1}T_{k-1} + (G_\theta + C_\theta/\tau)^{-1}(Q_f + Q_{hk}),$$

where T_k and T_{k-1} are the vectors of nodal temperatures at the kth and k–1st sampling intervals, respectively; C_θ is a matrix of thermal capacitances from the model; G_θ is a matrix of thermal conductances from the model; Q_f is a vector of environmental heat inputs from the model; Q_{hk} is a vector of heat inputs that represent the heater power levels commanded by the heater-control voltages; and τ is the sampling period.

The computer is equipped with an analog-to-digital circuit board, which receives the heater-control voltages from the temperature-control circuits under test and converts them into digital levels. The software uses these levels to compute the heater power that would be commanded by each heater-control voltage and thus computes the corresponding rate of heat input for the mathematical model.

The software then simulates the real-time response of the system to the heater-control voltages, such that the digital output of the software consists of real-time series of digital data that represent the sampled, digitized outputs of the temperature sensors in the simulated system. Digital-to-analog circuits in the computer convert these digital outputs to analog voltages like those that would be produced by thermistors or other suitable temperature sensors. These analog voltages are fed as temperature inputs to the temperature-control circuits under test.



The **Simulation System** produces thermistor outputs like those of a thermal system with long lags. It is used to test the temperature-control circuits in the absence of the thermal system. The simulation system can be characterized as analog in/analog out, with the relationships among inputs and outputs determined by software running in the digital part of the system.

Thermal and/or electrical disturbances and error signals can be incorporated into the response of the simulated system via software. For example, the digital voltages representative of the thermistor readings can be modified, thereby modifying the simulated analog thermistor readings to determine what effect erroneous thermistor readings would have on the behavior of the overall system comprising the thermal system and the temperature controllers.

This work was done by David I. Bergman of **Goddard Space Flight Center.** *For further information,* ***write in 33*** *on the TSP Request Card. GSC-13661*

"The Quiet Company" Continues to Sign Major New Business

CAD/CAM/CAE Master Model Approach and PDM Implementation Expertise Help Drive EDS Unigraphics Sales

Industry analysts, press representatives and even many of its own customers agree that EDS Unigraphics is a quiet company with remarkable technology and expertise. The company's vision of virtual product development represents the ultimate "build-it and break-it process" — the ability to design (or build), then analyze (or break) a digital model until it meet specifications. Today's manufacturers face critical issues, especially the paradox of mass customization and mass production. These manufacturers are partnering with EDS Unigraphics to manage this complexity through the intelligent use of information technology, turning hurdles into competitive advantage. Here is a sampling of companies that have recently employed the unique strengths of what insiders often describe as the industry's best kept secret.

Donaldson Company, headquartered in Bloomington, Minn., USA, has signed an agreement for the enterprise-wide global implementation of Unigraphics CAD/CAM technology with on-site support and services. Donaldson is a worldwide leader and manufacturer of filtration products for heavy-duty mobile and stationary equipment as well as specialized filters for applications like computer disk drives. Donaldson selected Unigraphics based on its flexible hybrid modeling approach to solving design problems, powerful assembly modeling capabilities and integrated manufacturing solution.

Pratt & Whitney of East Hartford, Conn., USA, continues its Unigraphics tradition, making UG the worldwide foundation of its computerized product development. All manufacturing facilities, partners and suppliers must now be capable of sending and receiving UG files electronically, producing the product in Unigraphics and assuring it meets P & W's specifications.

> ***"Perhaps because of the close association with GM, EDS Unigraphics does not seem to get the attention other CAD/CAM vendors do. Yet the company's worldwide software reveneues grew by nearly 20 percent in 1995 and were up over 35 percent in Europe."***
>
> Engineering Automation Report
> *EDS Unigraphics—A Quiet Success Story*
> February 1996

Philips Display Components—the world's largest manufacturer of color picture tubes—has signed a multiyear agreement for IMAN PDM software with implementation and customization services. The agreement spans five years with an initial purchase of 750 IMAN licenses. The selection of IMAN for Philips' Technical Product Information (TPI) project follows an extensive competitive evaluation and a worldwide "demonstrator" project centered in Eindhoven, Netherlands, and involving Philips' operations in France, USA, Taiwan and Brazil.

The Philips TPI project provides a long-term IT foundation for lowering costs and improving time to market. By providing true global access to engineering data and ongoing development through the implementation of an electronic PDM system, Philips will shorten the engineering cycle and increase the flexibility of its manufacturing operations.

Hyosung Motors and Machinery Inc. in Changwon, Korea, builds motorcycles for Suzuki in Korea as well as designs its own motorbikes, including small cc motorcycles and scooters. Hyosung will take advantage of UG's feature modeling for analytical components and freeform modeling for stylized components. The company will also develop virtual prototypes, further reducing lead times.

For More Information Write In No. 540

CFD Model of Flows in Turbopumps

The FDNS program has been extended to accommodate the complexities of turbopump flows.

Marshall Space Flight Center, Alabama

A computational fluid dynamics (CFD) model of flow has been developed for use in analyzing the performances of turbopumps. The model can be applied to single- and multicomponent flows in various turbopump components over a wide range of flow speeds. Although the model was originally intended for use in designing rocket-engine turbopumps, it can be used in the design and analysis of turbopumps in general.

In the past, preliminary designs of pump components have been based on potential-flow analyses and empirical data. Because of the ever-increasing performance requirements of rocket-engine turbopumps, designs of these pumps have been pushed beyond the limits of past experience. The present model satisfies the need for an enhanced analysis capability to enable progress beyond these limits. The greatest challenge in the development of this model was to obtain computational efficiency in the presence of complex geometries, terms that represent the effects of turbulence, and large source terms that represent the effects of Coriolis and centrifugal forces.

The present model and the computer program that implements it were developed by modification and extension of the Finite Difference Navier-Stokes (FDNS) computer program and model. As its name suggests, the FDNS program solves the applicable version of the Navier-Stokes equations of flow by a finite-difference method. The development included the incorporation of several submodels for simulation of flow fields in turbomachines. Because the centrifugal and Coriolis forces are very large in advanced pump designs, one of the submodels uses an implicit numerical-solution scheme to process the large source terms.

Another submodel implements a high-order upwind/central-difference numerical-solution scheme plus adaptive second- and fourth-order dissipation terms. The high-order numerical-solution scheme is necessary for accuracy of predictions of cross-stream secondary flows generated by curved blade passages, rotating blades, and the leakage past blade tips.

A third submodel is an extended k-ε turbulence model with a special near-wall function (k denotes the turbulence kinetic energy, while ε denotes the dissipation rate of turbulence kinetic energy). This model was incorporated not only to simulate separated turbulent flow (which commonly occurs in the turbopump flow environment), but also to enable the numerical calculation to be less sensitive to the numerical grid spacing near the wall and to reduce the amount of computer memory needed.

The complex geometry of turbopump components necessitates the use of grids that contain huge numbers of points. Accordingly, the present model incorporates a fourth submodel which utilizes a multiblock, multizone methodology to solve the grid-generation problem in the presence of complex geometries and moving interface boundaries. Finally, a pressure-based, predictor-plus-multicorrector solution algorithm was selected as another submodel to simulate the flow fields within the turbopump components, which flows are known to be influenced primarily by pressure and turbulence.

Because of its very compact numerical structure, short computation time, and versatility for different geometries, the present model is an efficient analytical tool for designing turbopumps. In a process of verification of the model as applied to various turbopump components, the model has proven to be very robust and capable of predicting the turbulent flow structure of each component. Proposals for modification of pump designs to improve performance have been derived from analyses conducted by use of the model. Moreover, experience gained from the extensive numerical investigations has led to recommendations for improving the present model.

This work was done by Gary C. Cheng of SECA, Inc., for **Marshall Space Flight Center.** *No further documentation is available.*

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-26329.

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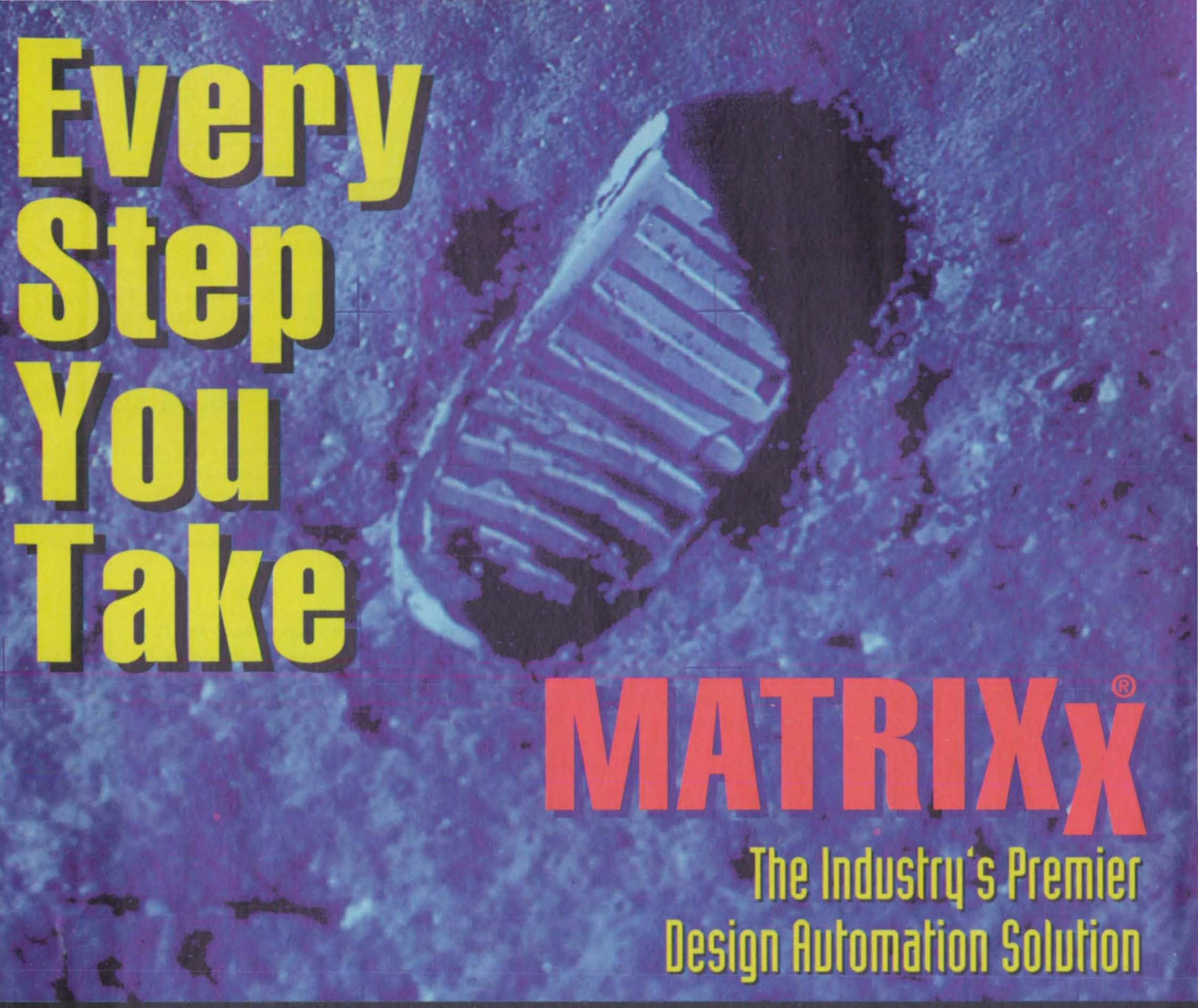

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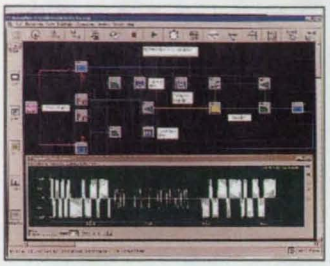
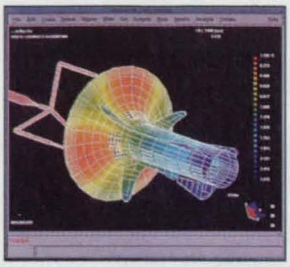


ELANIX, Westlake Village, CA, has introduced SystemView32™, a 32-bit version of its PC-based **dynamic system simulator** for communications, digital signal processing, and signal processing and control systems. The system combines memory management and processing capabilities of Windows 95 and Windows NT with Intel Pentium™ processors. The system features a Dynamic System Probe, which provides real-time signal analysis in the time and/or frequency domain. Using the probe, users can view the output waveform produced by any functional block in real time.

The simulator runs on 386 and higher IBM-compatible PCs with 8 MB RAM and 10 MB hard disk space. It features tools for analog, digital, and mixed-mode design and analysis and supports mixed-mode multi-rate systems, parallel simultaneous systems, and internal or external data sources. The system is available for $2950; optional communications, DSP, logic, and RF libraries start at $525.

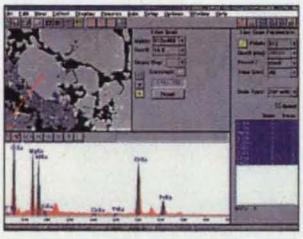
For More Information Write In No. 700



Dynamic Series Release 9.1 **parts design analysis and simulation software** from Moldflow, Shelton, CT, features enhancements such as improved data management and communications tools, more materials information, and stronger links to the production environment. The software is an integrated suite of CAE tools for simulating plastic flow, mold cooling, molding warpage, part stiffness and shrinkage, finished cavity size, fiver orientation, gas flow, and thermosets flow.

A new animation capability enables the system to graphically simulate various effects in real time or in slow motion. Models can be rotated and scaled up or down to achieve a particular viewing angle. With texture mapping, surface of the part can be visualized. Other features include translator enhancements to handle various CAD files, and a database of nearly 4000 materials.

For More Information Write In No. 701



EDAX International, Mahwah, NJ, has introduced iDX^{PRIME} **digital imaging and processing software** for collection of images and x-ray maps for microanalysis. Capabilities of the Windows-based program include spectra collection, editing and exporting data, and electron image acquisition at resolutions to 2048 x 1600 pixels. Users can raster an electron microscope beam in a selected area and position it along a line or in a spot mode within a field of view, allowing x-ray spectra to be collected from different areas of the image.

Image overlays; frame operations for adding, subtracting, multiplying, or dividing images; median and selected kernel filtering; and image enhancement through histogram manipulation can be performed. Image galleries can be created, saved, and imported. Using a file preview function, a thumbnail view of up to 144 saved images can be provided. Optional features include quantification of x-ray data for each pixel in a map, digital line scan, and fast x-ray mapping.

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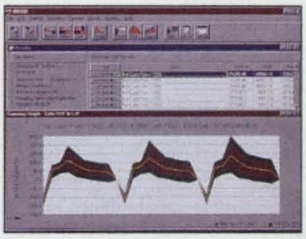
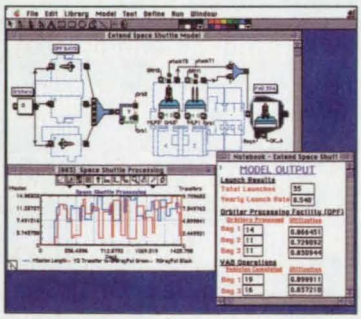


Palisade Corp., Newfield, NY, offers @RISK™ 3.5 **risk analysis and modeling software** for Excel 7, Windows 95, and Windows NT 32-bit applications. The software enables creation of large simulation models that may include thousands of uncertain factors, and tracks the effects of risk on thousands of results. Graphic overlays can be created in Excel format for results generated in different simulations, allowing users to compare trends in risk between simulations.

Other features include new probability distribution functions, an improved Windows 95 interface, and the addition of risk analysis to spreadsheets with versions available for Microsoft Excel and Lotus® 1-2-3® for Windows. Monte Carlo simulation is used to analyze the risk in any spreadsheet model. The software requires a 386 or higher IBM-compatible PC with Windows 95, Windows NT version 3.5 or higher, Excel 7.0, and 8 MB of RAM. The software is priced at $395; an upgrade from version 3.1 costs $99.

For More Information Write In No. 703



Extend™ for Power Macintosh **modeling simulation software** from Imagine That, San Jose, CA, enables modeling of scientific and engineering processes and systems, and simulates and validates ideas to resolve "what-if" questions. Drag-and-drop model building; statistical and sensitivity analysis; animation; sounds; top-down, bottom-up hierarchy; control panel interface; and user-definable modeling constructs for building libraries of blocks in any field are provided.

Before implementing changes, users model the existing process in Extend, then experiment with various scenarios on the model of the process, rather than the actual process. An open architecture allows sharing of data between Extend and other applications. Models involving hundreds to thousands of algebraic and differential equations simultaneously can be simulated in real time. Pricing starts at $695.

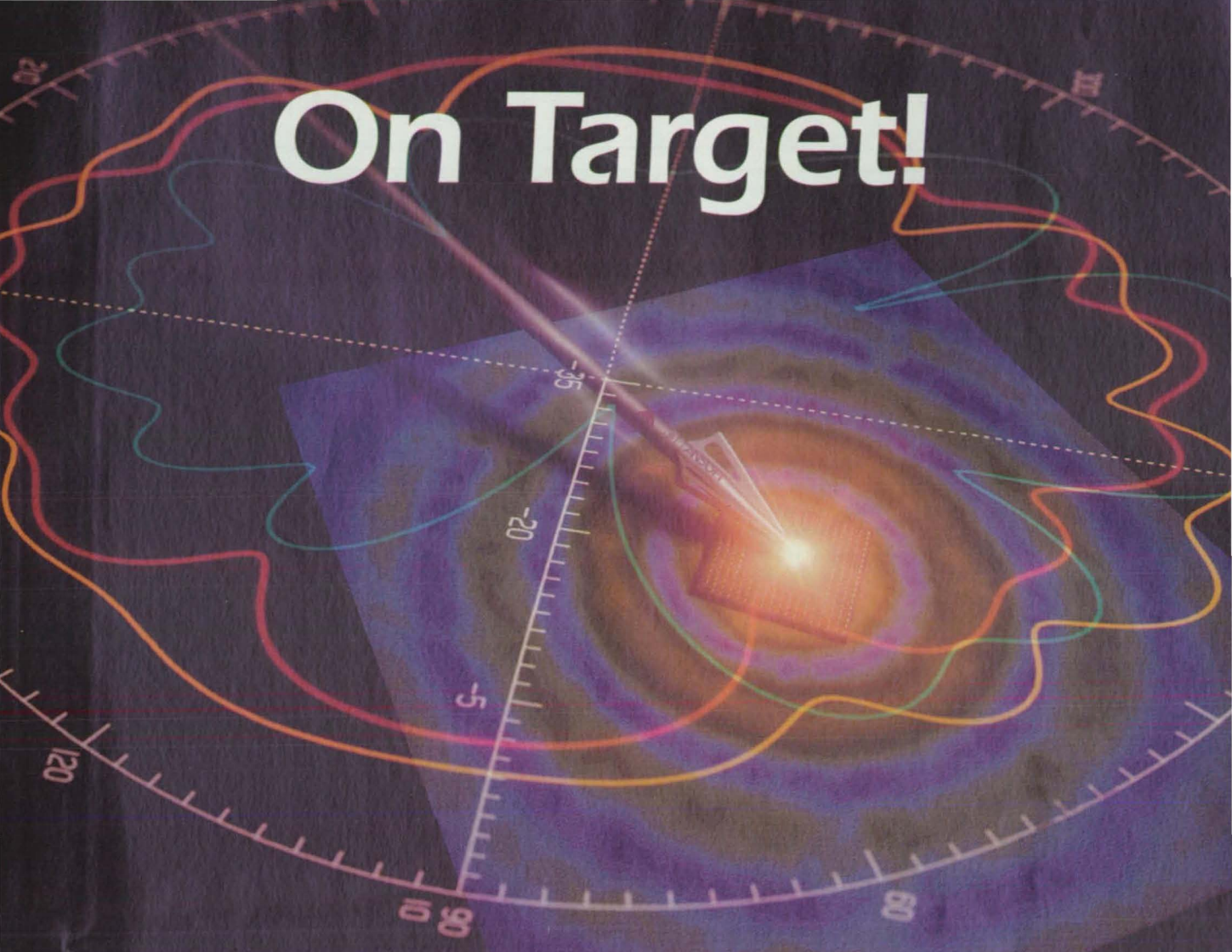
For More Information Write In No. 704

Intergraph Computer Systems, Huntsville, AL, has announced the TDZ-310, TDZ-410, and the TDZ-610 **3D graphics workstations** incorporating RealiZim 3D graphics. The systems achieve 1.2-million lit, Z-buffered, Gouraud-shaded, 50-pixel 3D triangles per second. RenderGL is an Intergraph-developed library of graphics extensions which work with the OpenGL graphics library to produce real-time, interactive 3D graphics. The Windows NT-based systems accelerate OpenGL, Heidi, and Direct3D graphics libraries and offer up to four 200-MHz Pentium Pro processors.

The RealiZim graphics are offered in three models to enable system users to render complex, realistic models and animation in true color at resolutions up to 1 million, 1.3 million, or 2.5 million pixels. Optional hardware texture memory in 4-, 8-, 16-, and 64-MB modules enables bitmaps to be applied to 3D surfaces. An optional geometry accelerator capable of up to 840 Mflops also is available. The systems can run CAD applications such as Pro/ENGINEER and animation packages such as 3D Studio MAX and LightWave 3D. Pricing for the TDZ-310 with one 200-MHz Pentium Pro processor, RealiZim Z-10 graphics, 32 MB of RAM, 1 GB hard disk, and the Windows NT operating system starts at $9995.

For More Information Write In No. 705

On Target!



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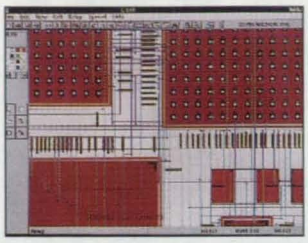
For More Information Write In No. 652

SmartScene™ **simulation interface** from MultiGen, San Jose, CA, eliminates the keyboard, mouse, trackball or other type of input device used to build 3D models and virtual environments. SmartScene users can pick up pre-rendered building blocks, stretch the objects to desired shapes and sizes, and place them in a virtual scene via the use of gloves equipped with sensors and a head-mounted display. Using immersive or non-immersive virtual reality, a 3D visual workspace is created.

The two-handed glove interface enables positioning, scaling, and rotating to be performed simultaneously with natural hand gestures. Fingertip touch pads provide the functionality of two four-button mouses. A 3D model browser and widget toolset lie in the palm of the hand, allowing rapid search and selection of modeling elements. ModelTime automated behaviors enable models to be snapped together, replicated, and scaled in size. The software operates on Silicon Graphics Impact and Onyx workstations and is priced at $30,000. The gloves and head-mounted display cost $2000 and $7900, respectively. Other required equipment includes a video splitter that ranges in cost from $8000 to $19,000 and a tracker priced at $7050.

For More Information Write In No. 706



Tanner Research, Pasadena, CA, offers Tanner Tools MCM Pro™ **multi-chip module design software** for schematic capture, simulation, layout, verification, and signal integrity analysis of MCMs. Features include automatic symbol creation for die elements, and a place and route tool which automatically places the die footprints, displays the connectivity via a rat's nest, and provides auto-routing of die and pad interconnects.

A 3D finite element thermal analysis solution enables optimal chip location prior to routing. Time domain simulation using transmission lines and vias extracted from layout, and model from electromagnetic analysis provide signal integrity analysis. IC backend tools perform design rule checking, netlist extraction, and layout versus schematic comparison. The program is available for PCs at a cost of $14,995; a Sun SPARCstation version also is available.

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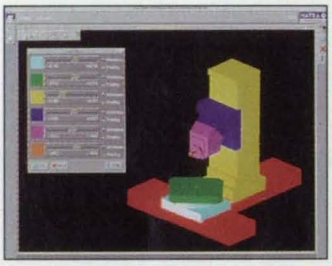
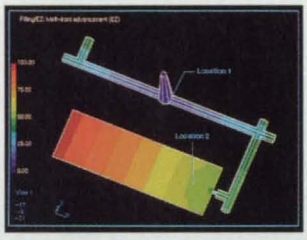


CAS.CADE Version 1.3 **object-oriented software application development platform** from Matra Datavision, Andover, MA, provides users in civil engineering, earth sciences, robotics, and automotive areas with a series of reusable software components and predefined object libraries. Enhancements include increased development tool productivity, extended coverage by the object libraries, and availability of data management functions.

New topology functions include local topological operations on shapes, creation of open solids, support of draft angles for faces, and a sewing algorithm for building a single topological entity from several shapes sharing common edges. Object libraries offer variational and parametric geometry and a new application prototyping tool provides testing of in-progress applications using a command interpreter, 3D viewer, and operational and geometric commands. The program runs on Windows NT, Windows 95, and UNIX workstations.

For More Information Write In No. 708



AC Technology North America, Louisville, KY, has introduced C-MOLD 96.7 **molding simulation software**. Enhancements include a Polymer Laboratory material database of more than 3400 thermoplastic resins with viscosity, thermal, and mechanical data; and the Rapid Designer suite of manufacturing process estimators for early-stage part and mold design decision-making before an actual simulation is launched. A process window estimator determines both feasible and optimal melt-temperature and fill-time combinations.

The Microchip Encapsulation add-on incorporates pre-conditioning and wire-sweep analyses to enhance the accuracy of reactive molding analyses for microchip encapsulation applications. The program is available for Hewlett-Packard, Digital Equipment, Silicon Graphics, and SUN workstations, as well as IBM-compatible PCs. The software also is available for Intel-based PCs running Windows NT.

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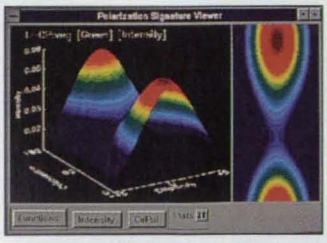
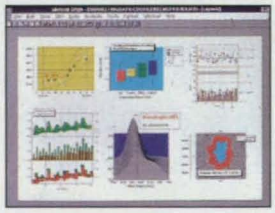


Version 2.5 of ENVI **image processing software** from Research Systems, Boulder, CO, is an image processing application program for analyzing remote sensing data. It includes traditional image processing tools and RADAR, spectral analysis, and file handling tools for environmental remote sensing. The program can be used to visualize and analyze satellite or aircraft digital imagery, including Landsat, AVIRIS, and ERS-1.

New features include state plane projections for GIS users, the ability to add customized annotation to images, input and output file formats, hyperspectral processing techniques, and data fusion capability, which allows merging of data from different sources. ENVI 2.5 is available for Windows 3.1, Windows 95, Windows NT, Macintosh, native Power Macintosh, UNIX, and Linux environments. Pricing for PC versions starts at $3350; workstation pricing starts at $5750.

For More Information Write In No. 710



Microcal Software, Northampton, MA, has introduced Origin 4.1 **technical graphics and data analysis software** for Windows, which includes new ternary diagram and bubble charts, a new calibration template, improved Sigmoidal Fit and FFT smoothing, and development support for LabTalk script users. The program is available in 16-bit and 32-bit formats; the 16-bit format supports large amounts of data and graphs, while the 32-bit format supports unrestricted data size and an unlimited number of graphs.

The data analysis and graphical presentation package allows users to enter, graph, analyze data, and present data in a variety of customizable visual graphs and plotting formats. A new calibration template allows engineers and technicians to directly obtain calibration curves from the instrumental data. Optional related products to enhance real-time data acquisition, 3D visualization, peak analysis, and other laboratory tasks are available. Origin 4.1 costs $495; $545 with the optional 3D & Contour Module.

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Fast-Response Driver for a Magnetic Bearing or a dc Motor

Features include efficiency and bidirectional current control from a single power supply.

Goddard Space Flight Center, Greenbelt, Maryland

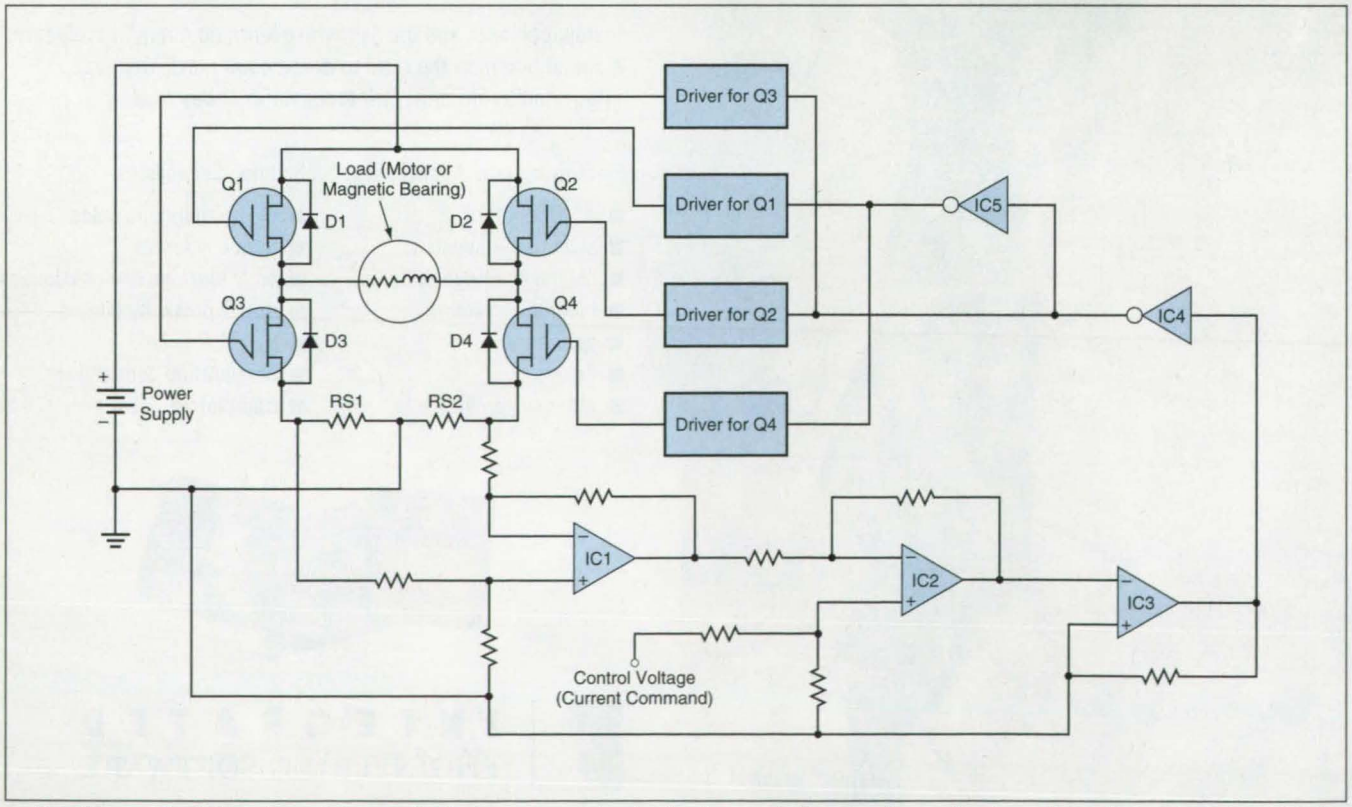
A fast-response, bidirectional current-control circuit has been designed as a prototype of improved drive circuits for inductive loads like magnetic bearings and dc motors. This circuit provides load current of the required magnitude in either polarity, as needed, from a single power supply of fixed polarity. Unlike some older magnetic-bearing drive circuits, this circuit does not maintain load current at a constant high level in the absence of control disturbances; instead, it provides load current only when required to counteract control disturbances. Thus, the present circuit consumes less power during nominal operation.

The figure is a simplified schematic diagram of the circuit. Bidirectionality of load current from a single power supply is achieved by use of an H-bridge, which comprises switching transistors Q1 through Q4, diodes D1 through D4, and resistors RS1 and RS2. The diodes help to commutate the inductive transients in the load current. The switching transistors are operated in a self-oscillating mode to achieve fast response and stability of control while providing load current only as required according to the power-saving scheme described above.

Each switching transistor is alternately driven fully "on" and fully "off." Resistors RS1 and RS2 serve as current-sensing shunts; the voltages across these resistors are fed to the input terminals of differential amplifier IC1. The output of IC1 is a voltage proportional to the sum of currents in the two branches of the H-bridge and thus proportional (in both sign and magnitude) to the actual load current. This voltage is fed to one of the two input terminals of differential amplifier IC2, while a control voltage proportional to the commanded current is fed to the other input terminal of IC2.

The output of IC2 is thus a voltage proportional to the difference between the commanded and actual load currents; in other words, an error signal that can be used to adjust the load current. This error signal is fed to one of the input terminals of IC3, which is configured as a Schmitt trigger with a built-in hysteresis. This hysteresis provides the mechanism for the self-oscillation, which produces an oscillation of the load current around the commanded value. The amount of hysteresis and thus the frequency of this oscillation is chosen according to the amount of ripple current desired, the effective inductance of the load, and the power-supply voltage.

The output of the Schmitt trigger is fed through inverters IC4 and IC5 to drivers for the switching transistors in the H-bridge. In the first half cycle of the oscillation, the input/output state of the Schmitt trigger and these inverters is



An **H-Bridge of Switching Transistors and Diodes** commutates the load current. The circuit operates in a self-oscillation mode in which the polarity of switching in the H-bridge is repeatedly reversed to make the load current oscillate about a commanded value.

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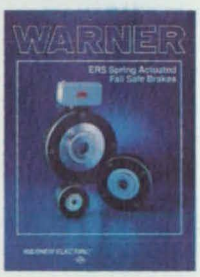

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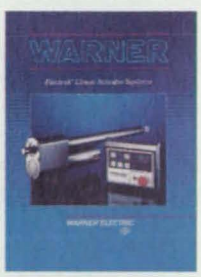

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such as to cause the switching transistors in the H-bridge to apply the power-supply voltage to the load in the appropriate direction (e.g., by switching Q1 and Q4 on while switching Q2 and Q3 off) such that the load current builds up to a threshold value equal to the commanded current plus the increment of current that corresponds to the hysteresis of the Schmitt trigger. When this threshold is reached, the Schmitt trigger reverses its state and the circuit goes into the second half cycle of the oscillation, in which the power-supply voltage is applied to the load in the opposite direction (e.g., by switching Q2 and Q3 on while switching Q1 and Q4 off), so that the load ramps down a threshold value equal to the commanded value minus the hysteresis increment. The cycle then repeats.

If the commanded current is changed, then the appropriate switching transistors are driven to apply the source voltage in the appropriate direction until the actual load current reaches the new commanded current plus or minus the hysteresis increment. Thereafter, the circuit oscillates about the new commanded load current.

This work was done by John Paulkovich and G. Ernest Rodriguez of **Goddard Space Flight Center.** *For further information,* ***write in 53*** *on the TSP Request Card. GSC-13717*

Synchronizing the CD4047B Monostable/Astable Multivibrator

Two techniques provide for synchronization with external oscillators.

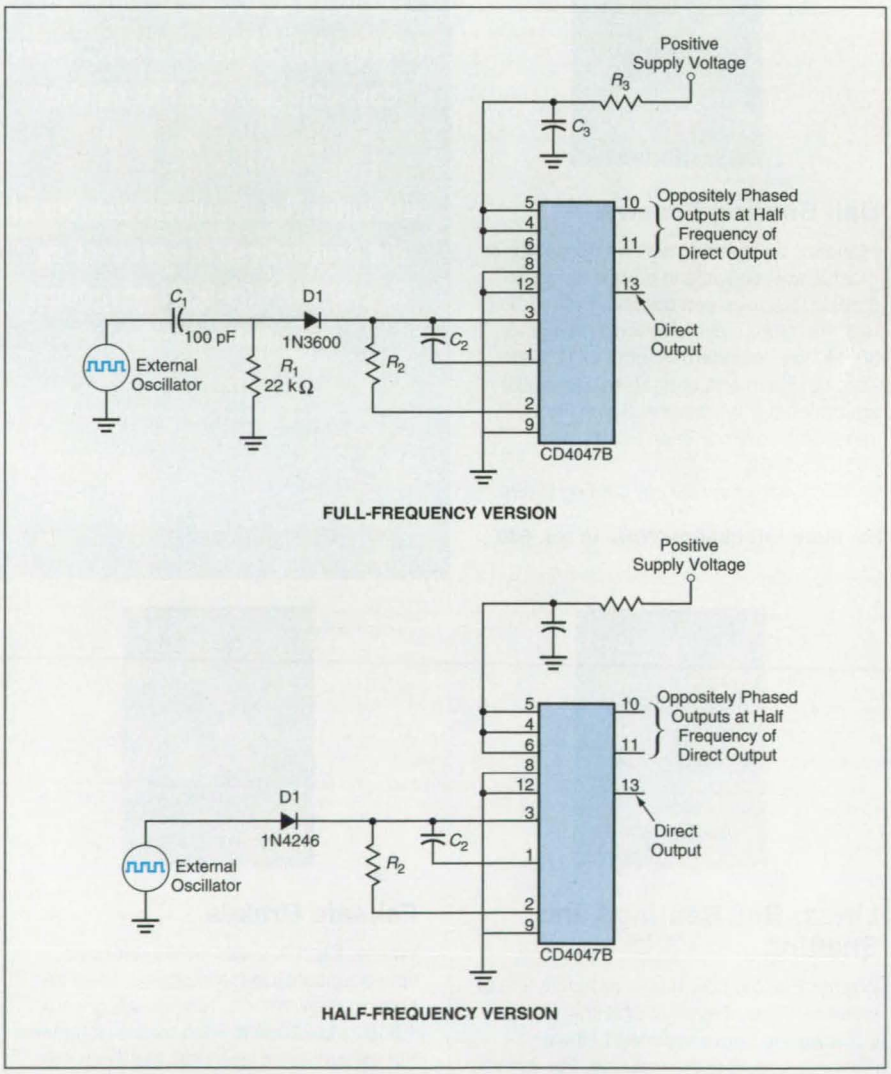
Goddard Space Flight Center, Greenbelt, Maryland

Two techniques for synchronizing the CD4047B integrated circuit with external oscillators have been devised. The CD4047B is a low-power complementary-metal-oxide/semiconductor (CMOS) circuit that can be configured, via external connections, to operate as an astable or as a monostable multivibrator. The two techniques apply to the astable mode of operation.

The top part of the figure illustrates one of the techniques for synchronization. The signal from an external square-wave oscillator is coupled through differentiator C_1, R_1 and switching diode D1 on the way to the CD4047B. To make synchronization possible, the external oscillator must oscillate at a frequency greater than the free-running frequency of oscillation of the CD4047B in the astable mode. When the external oscillator fails, the CD4047B reverts to the free-running frequency.

The bottom part of the figure illustrates the other technique for synchronization. This technique is suitable for use in conjunction with optional use of a divide-by-2 circuit that is part of the CD4047B. In this technique, the differentiator and switching diode of the preceding technique are replaced with a different diode. In this case, during synchronization, the external oscillator runs at twice the desired output frequency of the CD4047B and a D flip-flop that is part of the internal divide-by-2 circuit is triggered on the positive-going edges of the signal from the external oscillator. As before, the frequency of the external oscillator must exceed the free-running frequency (in this case, the free-running frequency before division by 2), and when the external oscillator fails, the circuit reverts to the free-running frequency with output at the free-running frequency divided by 2.

This work was done by David Galosky and Steven Scruggs of **Goddard Space Flight Center.** *For further information,* ***write in 29*** *on the TSP Request Card. GSC-13630*



The **Signal From an External Oscillator** used to synchronize the CD4047B can be fed through either of two input circuits, depending on whether a divide-by-2 circuit inside the CD4047B is used. While running freely (that is, without external synchronization), the CD4047B generates square-wave oscillations at a frequency determined by external capacitor C_2 and resistor R_2. C_2 must exceed 100 pF, while R_2 must be less than 10 kΩ.

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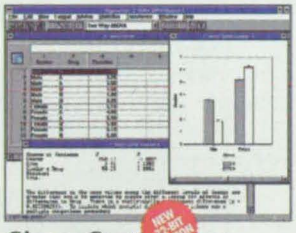

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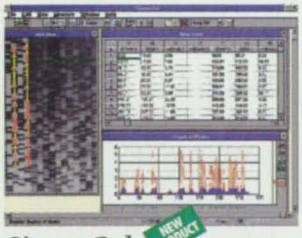

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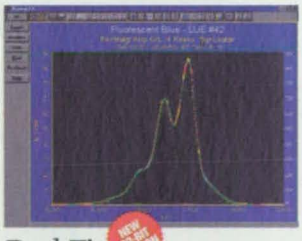

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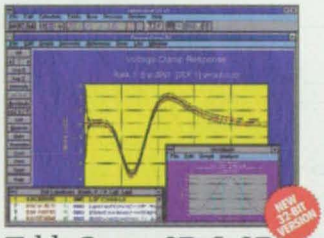

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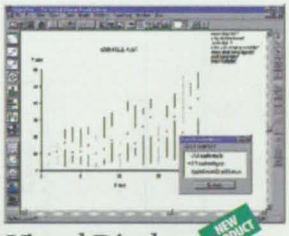

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Pulse Generator With Expanded Ranges of Adjustability

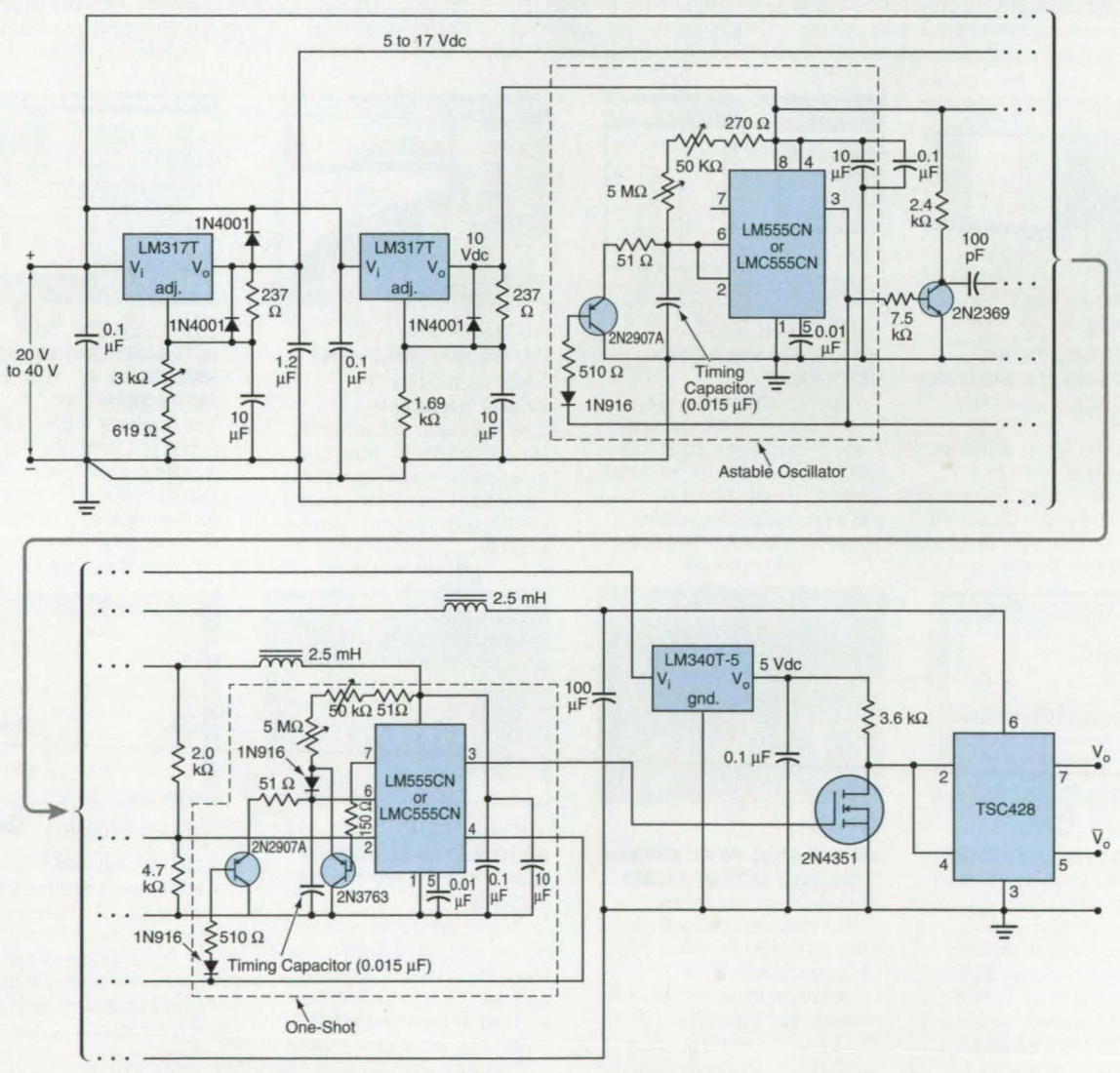
Adjustments are made by setting potentiometers and without switching capacitors.

Goddard Space Flight Center, Greenbelt, Maryland

A pulse generator has been developed to overcome some of the limitations of a commercial general-purpose laboratory pulse generator. This pulse generator is designed to supply short-rise-time and short-fall-time pulses simultaneously to a continuous load and to high-current power metal oxide/semiconductor field-effect transistors (MOSFETs) that have capacitive input impedances. Like the commercial unit, this pulse generator is also suitable for use as a laboratory instrument that provides periodic waveforms of adjustable repetition frequency, adjustable pulse duration, and adjustable amplitude with minimal output waveform jitter at low frequencies.

In the commercial unit, the frequencies and durations of pulses are adjusted by varying settings of potentiometers within frequency and duration ranges that are selected by switching capacitors of various values into and out of a timing circuit. The frequency- and duration-range switches are interlocked at coincident settings in a manner that is dictated by the fundamental limitations of the timing circuit and that imposes limits on the ranges of attainable combinations of frequency and duration settings.

The present pulse generator operates similarly, but the limits are less severe. Moreover, this pulse generator covers much wider frequency and duration ranges via potentiometer settings alone, without switching of capacitors; for



Pulse-repetition frequency: adjustable from 14.7 Hz to 167 kHz
Pulse duration: adjustable from 2 μs to 68 ms, with duty cycle from 20 to 80% at 100 kHz and with a nearly infinite duty cycle at low frequencies
Pulse amplitude: adjustable from 5 to 17 V

This **Pulse Generator Is Adjustable**, via potentiometer settings, over a relative-frequency range of more than 10,000:1, with no interaction between pulse-frequency and pulse-duration adjustments.

example, it can be set to pulse periods from 6 μs to 68 ms (pulse-repetition frequencies from 167 kHz to 14.7 Hz) and pulse durations from 2 μs to 68 ms, all with a single timing capacitance value, whereas it takes five switched-capacitor frequency settings and five switched-capacitor duration settings to cover the same ranges in the commercial unit.

The pulse generator is based on one of the versions of a popular integrated-circuit timer that is commonly denoted in the industry as "555" with various letter prefixes and suffixes. The design of the 555 timer, however, limits the magnitude of the timing-capacitor discharge current through an internal discharge transistor. In addition, one must limit the power dissipated within the timer circuit. For a complex of reasons that cannot be explained in the space available for this article, these limits on current and power give rise to similar frequency- and duration-range limitations described above for the commercial unit.

The present pulse generator is designed to circumvent these inherent discharge current and power limits. This circuit (see figure) contains two LM555CN or LMC555CN timers; one of them functions as an astable oscillator, the other as a variable-pulse-duration one-shot. A separate 2N2907A pnp transistor is connected to each timer to discharge the corresponding timing capacitor, instead of using the discharge transistor within the timer. This modification circumvents the discharge-current limit. Furthermore, because the external transistor also diverts the constant-load component of the current through the charging resistors away from the internal discharge transistor, this modification also reduces the power dissipated in the timer. The 2N3763 transistor prevents further charging and discharge of the one-shot timing capacitor until the proper time to prevent interaction between the pulse-frequency and pulse-duration adjustments and to eliminate an instability, also present in the commercial unit, where the output frequency suddenly halves while attempting to establish a relatively high duty cycle. The 2N4351 insulated-gate FET isolates the one-shot output from the TSC428 dual-MOSFET driver to minimize output waveform jitter and also acts as a step-down voltage-level shifter to meet the specified safe operating limit of the MOSFET-driver input.

Overcoming the current and power limits makes it possible to use discharge and timing resistances much lower, and capacitances much higher, than those recommended in the 555-timer literature for the desired pulse frequencies and

durations. Because the timing capacitors are now discharged much more rapidly, output pulse durations as short as 2 μs, much higher frequencies, and a broader frequency range can be obtained with only one timing capacitance value.

This work was done by George J. Stahl of **Goddard Space Flight Center.** *For further information,* ***write in 50*** *on the TSP Request Card. GSC-13650*

Noncontact Measurement of Stress on a Rotary Machine Part

A magnetic probe transduces stress via the magnetostrictive effect.

Lewis Research Center, Cleveland, Ohio

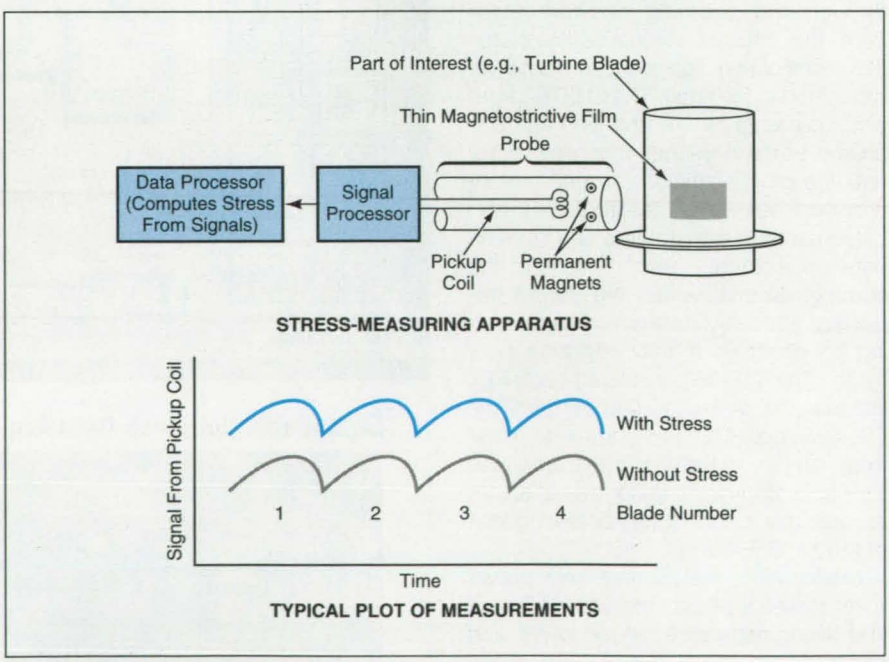
A simple magnetic probe exploits the magnetostrictive effect to take noncontact measurements indicative of stress on a turbine blade, impeller, or other part of a rotor in a rotary machine. A typical older stress sensor (e.g., an electrical-resistance strain gauge) is mounted on the part of interest, and either a radio transmitter powered by a battery or a combination of wires and sliprings must be used to transmit the measurement signal from the moving sensor to signal-processing circuitry outside the stationary machine housing. The present magnetic-probe technique can be implemented with smaller, more reliable, and cheaper equipment; in particular, it eliminates the need for radio transmitters and sliprings.

The probe is only 3/8 in. (9.5 mm) in diameter. It contains two permanent magnets and a pickup coil. As shown in the figure, the probe is positioned near the circular trajectory of the part of interest. The surface of the part of interest is covered with a lightweight film of magnetostrictive material only 0.001 in. (0.025 mm) thick.

The stress on the part of interest alters the magnetic properties of the film and thus alters the magnetic field that results from the interaction between the permanent magnets and the magnetostrictive material. The net effect of the alteration is a variation in the amplitude of the magnetic-field variation sensed by the probe.

This work was done by Sarkis Barkhoudarian of Rockwell International Corp. for **Lewis Research Center**. *No further documentation is available.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Lewis Research Center; (216) 433-2320. Refer to LEW-15721.



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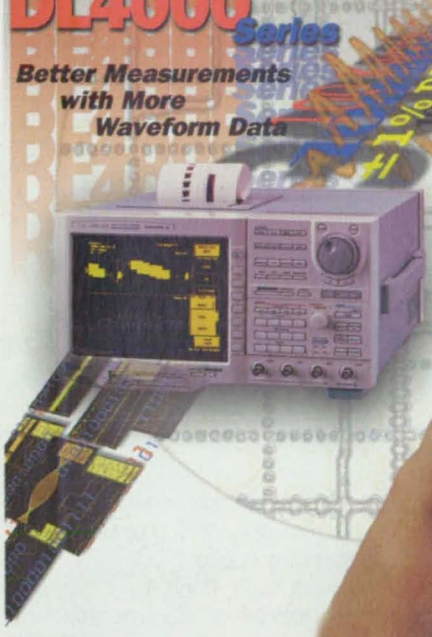

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Rechargeable Lithium-Ion Cells Containing Mg_2Si Anodes

Test data indicate retention of substantial capacity after 70 charge/discharge cycles.

NASA's Jet Propulsion Laboratory, Pasadena, California

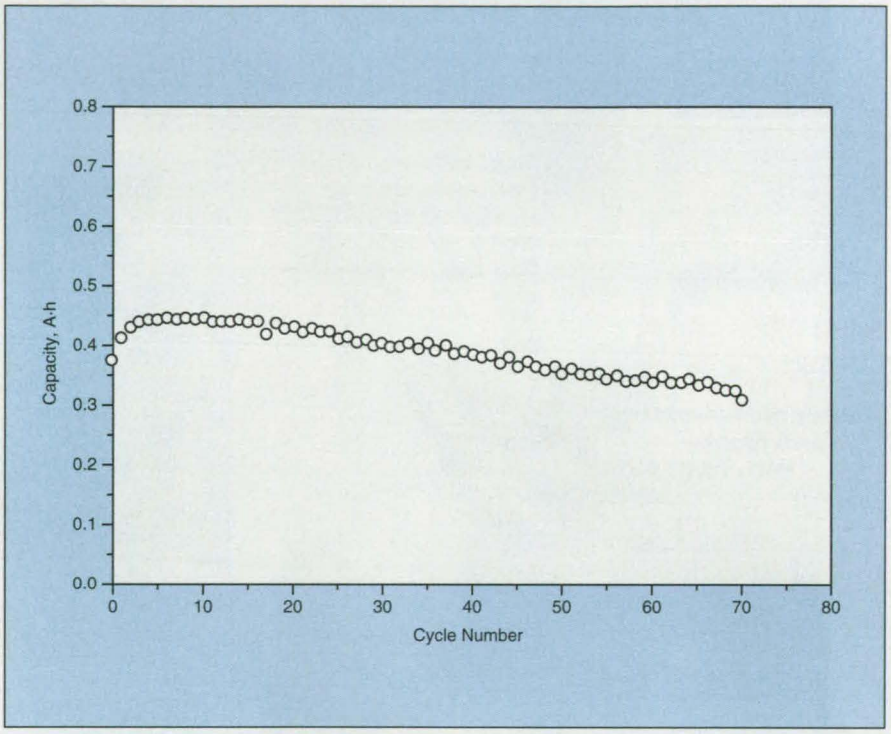
Ambient-temperature rechargeable lithium-ion electrochemical cells containing Mg_2Si anodes are undergoing development. Mg_2Si is a commercially available compound into which lithium can be intercalated. In comparison with lithium itself and with carbon-based lithium-intercalation materials that have been tried thus far, Mg_2Si as the anode material offers potential advantages of greater safety and longer cycle life.

The charge/discharge cycle lives of cells containing lithium anodes tend to be terminated prematurely by short-circuiting caused by the growth and penetration of lithium dendrites through the anode/cathode separators. The approach taken in recent developments (including the present development) to solve the safety and cycle-life problems has been to use lithium alloys and other lithium-intercalation materials that exhibit lithium activities lower than that of pure lithium.

Carbon-based materials have been investigated for use as lithium-intercalation anode materials because of their low equivalent weights, low voltages versus lithium, and chemical stability in the presence of various electrolytes. However, the carbon-based materials have exhibited various deficiencies: For example, graphite (which has twice the lithium capacity of coke) is vulnerable to short-circuiting by dendrites during charging because its potential is too close to that of elemental lithium. Moreover, development problems are complicated by the fact that the electrochemical properties of carbon-based materials depend strongly on which electrolytes are used.

Mg_2Si was selected as a candidate lithium-intercalation anode material because its electrochemical behavior is similar to that of carbon-based materials in some ways, yet advantageously different in other ways. The open-circuit potential of Li_xMg_2Si versus Li is greater than that of graphite. The intercalation of Li in Mg_2Si is highly reversible.

An experimental cell containing a Mg_2Si anode and a $LiCoO_2$ cathode was built and tested. In addition to yielding the capacity-vs.-cycle-life data presented in the figure, the tests showed that the cell exhibited a high degree of lithium reversibility, two major voltage plateaus, and specific capacity and potential similar to that of graphite.



Discharge Capacities were measured during 70 charge/discharge cycles of a Mg_2Si-anode/electrolyte/$LiCoO_2$-cathode cell at a current density of 0.362 mA/cm^2.

This work was done by Chen-Kuo Huang, Subbarao Surampudi, and Gerald Halpert of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 95*** *on the TSP Request Card. NPO-19561*

A Current-Control Circuit for an Inductive Load

Lyndon B. Johnson Space Center, Houston, Texas

A circuit that drives an inductive load includes a functional block that samples the load current and produces a dc voltage proportional to the sampled current. This voltage is compared to a command voltage and any error (difference between them) is integrated and converted to a voltage pulse train. The pulse train serves as input to a field-effect transistor that switches power to the load. The frequency of the pulse train is made as high as practical to minimize the size and weight of components needed to filter out electromagnetic interference.

This work was done by Carlisle Dolland of Allied Signal, Inc., for **Johnson Space Center**. *For further information,* ***write in 44*** *on the TSP Request Card. MSC-22507*

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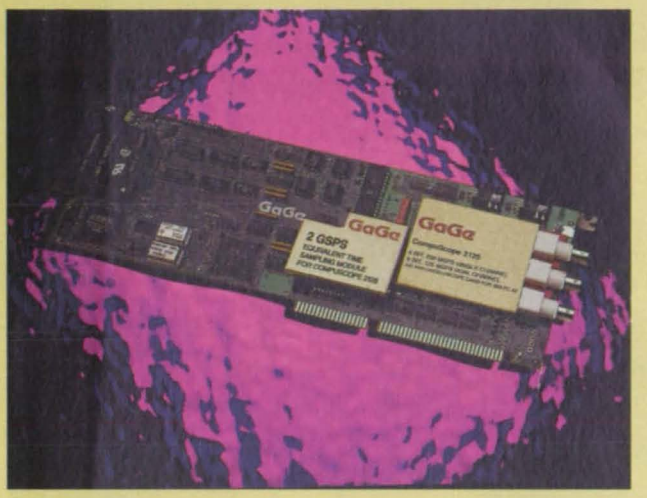

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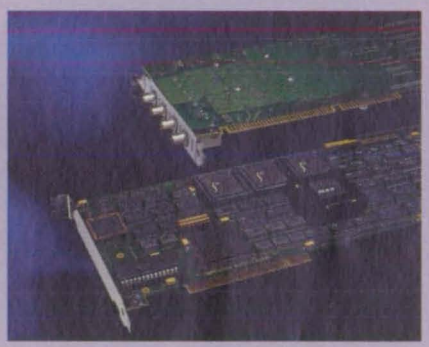

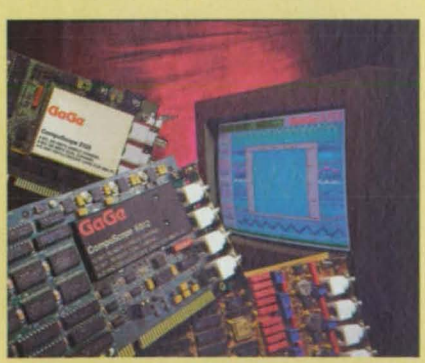

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Performance-Seeking Control System for Aircraft

Fuel efficiency, thrust, and other measures of performance are enhanced.

Dryden Flight Research Center, Edwards, California

Flight tests have been conducted on the NASA F-15 research aircraft equipped with a prototype performance-seeking control (PSC) system to demonstrate that optimal-control technology can be applied to an integrated airframe/propulsion system of an aircraft to improve the total performance of the aircraft. Further development of this technology can be

Figure 1. The **NASA F-15 Research Aircraft** is a high-speed, high-performance airplane that contains a highly integrated digital electronic control (HIDEC) system.

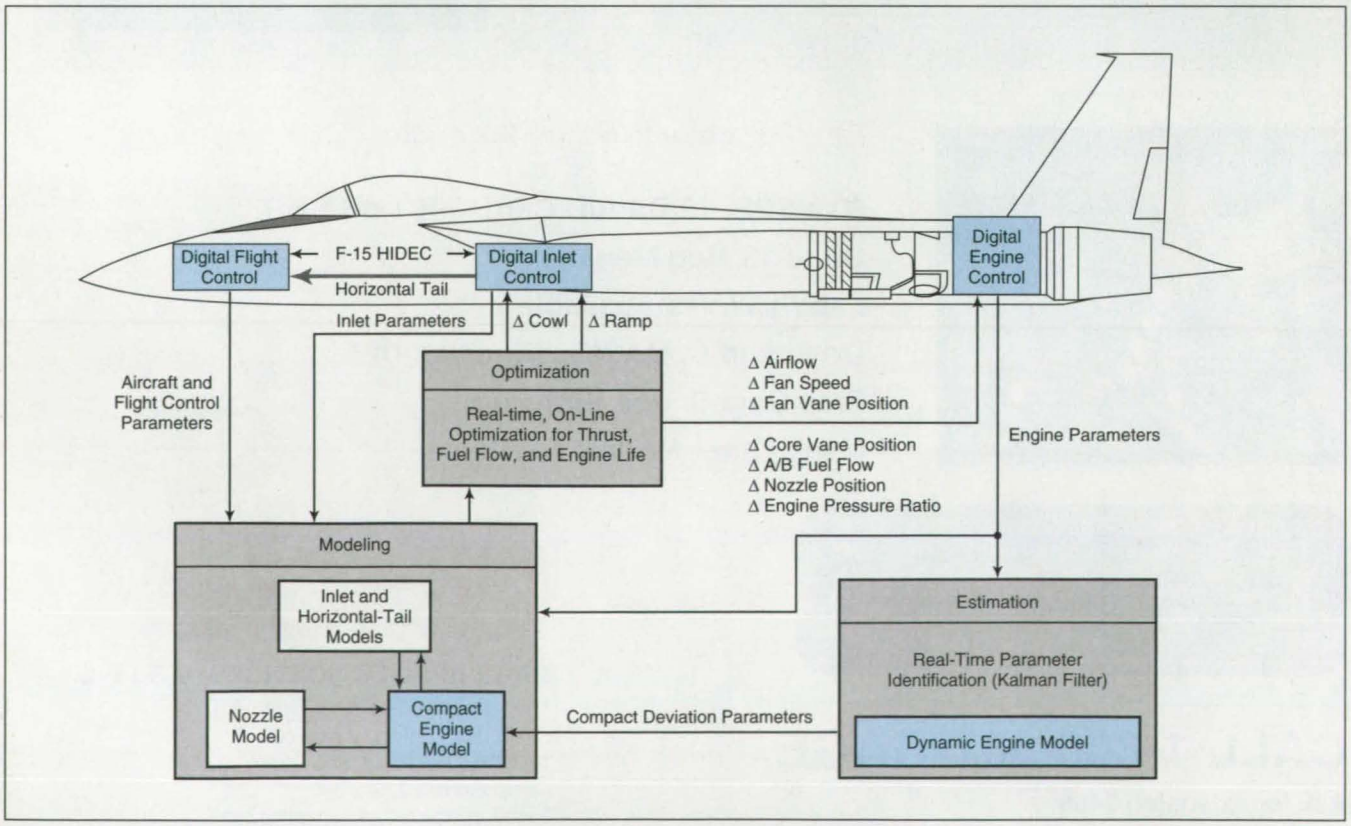

Figure 2. **Performance-Seeking Control** involves estimation, modeling, and optimization processes, which are implemented in the HIDEC system by the PSC algorithm.

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expected to prove beneficial in both civil and military aircraft by maximizing fuel efficiencies, maximizing thrusts, or prolonging the operational lives of engines.

The prototype PSC system resides in the digital electronic flight-control system of the NASA F-15 research aircraft (see Figure 1), which is a high-performance airplane capable of speeds in excess of mach 2. The F-15 is powered by two F100-derivative (PW1128) afterburning turbofan engines. The PSC system executes adaptive, model-based control algorithms formulated to optimize the quasi-steady-state performance of the F-15 propulsion system. The PSC system can function in any of three optimization modes:

- Minimum fuel flow at constant thrust,
- Minimum turbine temperature at constant thrust, and
- Maximum thrust at maximum dry and full afterburner throttle settings.

The PSC algorithm implements estimation, modeling, and optimization processes (see Figure 2). The estimation process involves a Kalman-filter estimation of five component deviation parameters designed to account for the off-nominal behavior of the engine during flight. The estimated component deviation parameters are used to update the compact engine model (CEM) (a mathematical model of engine and inlet flow conditions in response to control inputs) to reflect actual engine operation, which can vary from engine to engine; this is the adaptive feature of PSC. The modeling process starts with the CEM to estimate unmeasured engine outputs required to obtain an optimal solution.The CEM is then augmented with models of the inlet, nozzle, and horizontal tail to formulate a model of the complete aircraft. Flight measurements are used to look up model data and as direct inputs to the Kalman filter and the CEM. The optimization process then analyzes the augmented model (for one of the three modes of operation) and produces a set of optimal variables, which are sent to the inlet and engine controllers.

The flight tests were conducted at both subsonic and supersonic speeds. The results of the flight tests indicate that substantial benefits were obtained from the F-15 PSC algorithm. In the maximum-thrust mode, thrust levels were observed to increase as much as 15 percent at subsonic and 10 percent at supersonic speeds. In the minimum-turbine-inlet-temperature mode, temperatures were observed to be reduced by as much as 100 °F (56 °C) at high altitudes. In the minimum-fuel-flow mode, fuel-consumption rates were found to be reduced by as much as 2 percent in subsonic and 10 percent in supersonic flight. On the basis of these results, it appears that the initial objectives in developing PSC technology have been achieved and that PSC technology can provide significant benefits for the next generation of fighter airplanes or any other aircraft in which there is a high degree of integration between the airframe and the propulsion system.

This work was done by G. B. Gilyard and John S. Orme of **Dryden Flight Research Center**. *For further information,* ***write in 77*** *on the TSP Request Card. DRC-95-16*

Generating Widerange Linear Frequency Sweeps

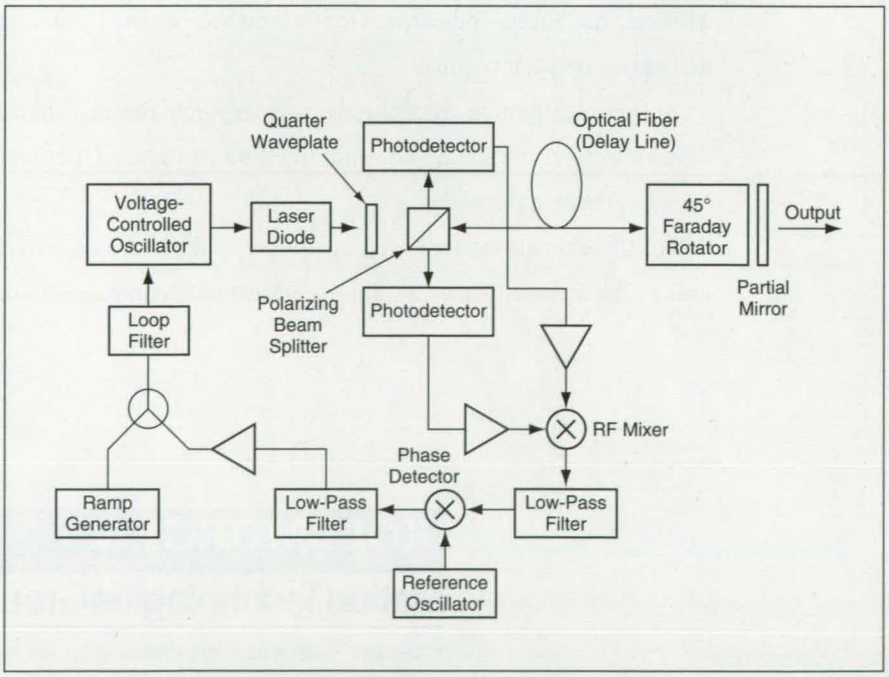
Sweeps at optical, microwave, and lower radio frequencies can be linearized.

NASA's Jet Propulsion Laboratory, Pasadena, California

A photonic/electronic apparatus has been devised for generating optical signals and/or electrical signals at microwave or longer wavelengths, with frequencies that are precisely linear functions of time over wide frequency ranges. The apparatus (see figure) is a prototype of signal generators that would produce the ultralinear, wideband swept-frequency signals that are needed for high performance in such applications as chirp radar and querying of multiple fiber-optic-coupled sensors.

In this apparatus, the frequency sweep rate of a radio-frequency sweep generator (a voltage-controlled oscillator controlled by a ramp signal) and a long fiber-optic delay line are used to generate another signal with a fixed low frequency that is directly related to the sweep rate and that can be locked to a stable, fixed-frequency reference. The swept-radio-frequency signal is amplitude-modulated onto an optical carrier generated by a laser, and the resulting optical signal is coupled into the near end of the fiber-optic delay line. The optical signal travels to the far end of the delay line, where it is reflected. Upon returning to the near end, the delayed (output) optical signal is coupled into a photodiode along with the nondelayed (input) optical signal.

The difference between the phases of the amplitude modulation on the input and output signals changes at a rate $\omega' =$



The **Frequency-Sweep Rate Is Stabilized** by using the fiber-optic delay line to convert the sweep rate to frequency ω' and locking ω' to the stable frequency reference.

$\alpha\tau$, where α is the frequency-sweep rate and τ is the delay. Therefore, the mixing of the input and output modulation signal in the photodiode introduces a component at a frequency of ω' into the photodiode output current. This frequency is forced to be constant by phase-locking it to the stable frequency reference. Then provided that the delay remains constant, the sweep rate is also forced to remain constant; in other words, the frequency sweep is forced to be linear.

The phase lock needed to stabilize ω' and α is accomplished as follows: The ω'-frequency component of the photodiode output is mixed with the signal from the stable frequency reference. The mixer output constitutes an error signal, which is added to the ramp signal to correct the sweep rate α. The correction of α is accompanied by a proportional correction in ω' and thus closure of the phase-lock loop.

This work was done by George F. Lutes of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 16*** *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-19722, volume and number of this NASA Tech Briefs *issue, and the page number.*

High-Resolution-Radar and Power-Transmission System

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed millimeter-wave radio system would provide high-resolution-radar for detecting debris as small as 1 mm orbiting the Earth and for mapping asteroids out to distances of Mars' closest approach. It would also provide a concentrated, sharply aimed beam for wireless transmission of propulsion power to place a 30-kg satellite in low orbit around the Earth or to a rectenna-equipped LEO spacecraft for battery recharging or supplementary dc power. The system would include a phased array of 3,000 dish antennas of 9-m diameter mounted on the ground. The transmitting equipment at each antenna would include a gyrotron operating at a peak power of 1 MW, average power of 10 kW, and carrier frequency of 245 GHz. The signals at the various antennas would be phase-locked via quasi-optical circulators. The receiver at each antenna would be cooled to a temperature of 200 K. The transmitter and receiver at each antenna would be diplexed by use of a flip mirror.

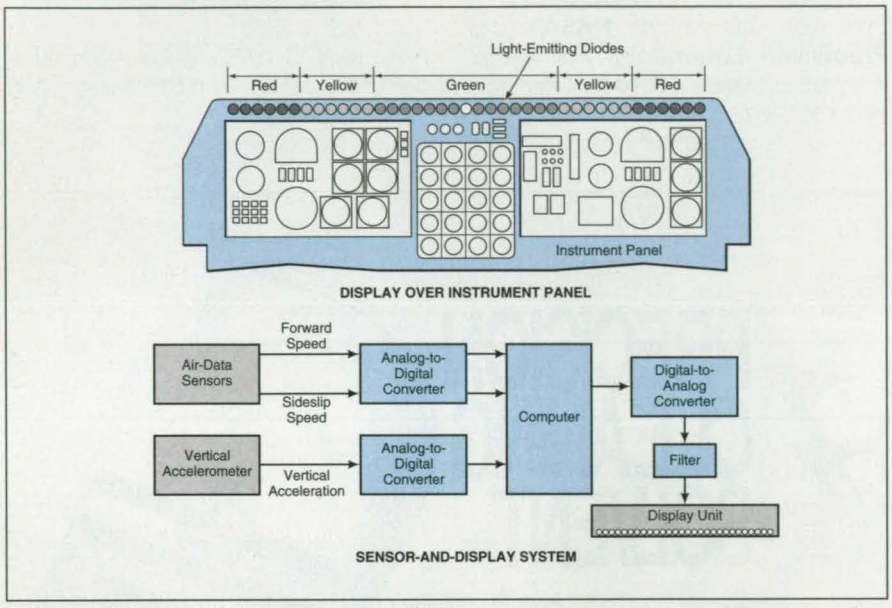
This work was done by Richard M. Dickinson of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 9*** *on the TSP Request Card.*
NPO-19791

Aircraft Maneuver-Envelope Warning System

A pilot obtains a rapid update on parameters relative to operational limits.

Ames Research Center, Moffett Field, California

An analog/digital electronic sensor-and-display system informs an aircraft pilot of the degree to which the aircraft is approaching or exceeding the operational limits. Such limits in combination (including, for example, the maximum allowable sideslip and the maximum allowable vertical acceleration or load for a given forward speed) are denoted collectively as the maneuver envelope of the aircraft. With the help of the present display system, a pilot is relieved of some of the burden of repeatedly interpreting the complex of readings of such instruments as the airspeed indicator, vertical-acceleration meter, and engine gauges to determine whether the aircraft remains within operational limits. Instead, the display system provides an easily and rapidly readable summary indication of status of the aircraft.



A **String of Colored Lights** serves as an intuitive, easy-to-read indicator of the status of an aircraft relative to its maneuver envelope. Because of the arrangement of colors, the pilot can read the display with peripheral vision while attending to other things.

The display consists of a horizontal row of colored lights over the aircraft instrument panel (see figure). Green lights in the center indicate that the aircraft is operating within the maneuver envelope. The green lights are flanked by yellow lights, which indicate the aircraft is approaching the limits of the envelope. At the outermost edges are red lights, which indicate that the aircraft is exceeding the limits.

The analog outputs of air-data sensors and a vertical accelerometer are digitized and fed to a random-access memory (RAM) in a computer. The sensors repeatedly update the RAM with fresh data. The central processing unit (CPU) in the computer compares the sensed forward speed, sideslip speed, and vertical acceleration with corresponding maneuver-envelope values. The software and the maneuver-envelope data needed for these computations are stored in a read-only memory. The digital output of the CPU is converted to an analog voltage indicative of the status of the sensed operating parameters relative to operational limits. This voltage controls the display of colored lights. Optionally, on its way to the display circuit, this voltage can be fed through a filter to prevent the display from changing too rapidly for the pilot to read.

This work was done by Courtland C. Bivens, Joel M. Rosado, and Burnett Lee of **Ames Research Center**. *For further information,* ***write in 84*** *on the TSP Request Card.*

This invention has been patented by NASA (U.S. Patent No. 5,359,326). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Ames Research Center; (415) 604-5104. Refer to ARC-13375.

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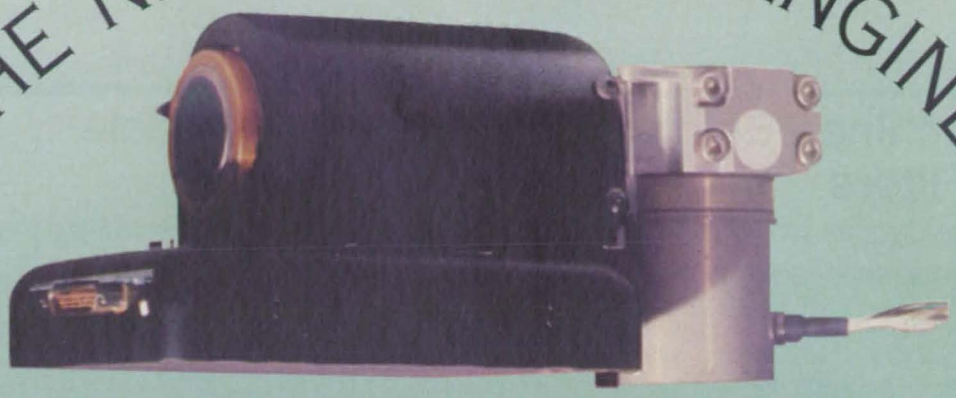

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Micromachined Electrostatic Charged-Particle Energy Filters

Arrays of these devices would perform equivalently to larger, heavier electrostatic lenses.

NASA's Jet Propulsion Laboratory, Pasadena, California

Micromachined electrostatic lenses of a type called "Bessel boxes" are being developed for use in compact, lightweight instruments for measuring the kinetic energies of electrically charged particles traveling in laboratory or outer-space vacuums. A planar $n \times n$ array of these devices could provide an acceptance area and thus a signal level equal to that of a conventional single-aperture electrostatic lens. However, because of the miniaturization of the devices, the weight and thickness of the array would be only about $1/n$ those of the conventional electrostatic lens.

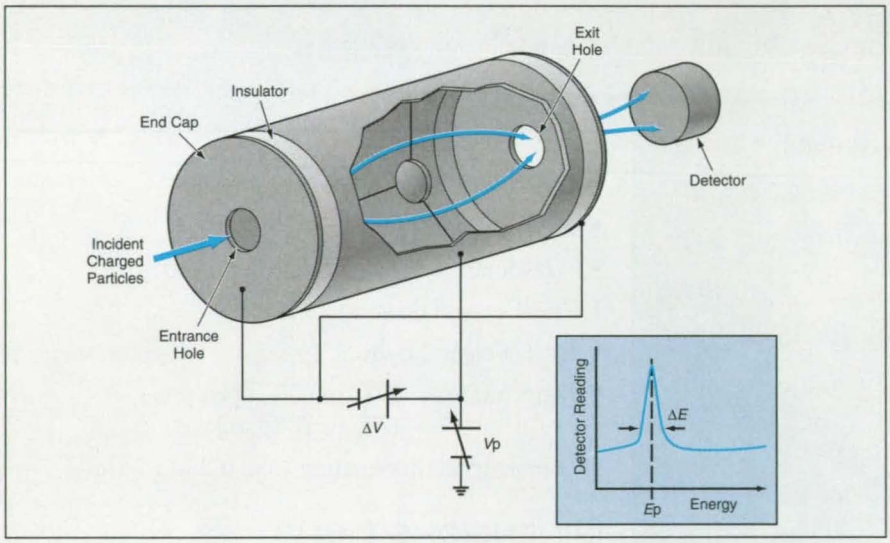

Figure 1. A **Bessel Box** is an electrostatic lens that can be used, in conjunction with a suitable detector, as an electrostatic analyzer (that is, as an electrostatic energy filter).

A Bessel box according to the original and basic concept (see Figure 1) includes a cylindrical metal can with holes in the end caps that are electrically insulated from the cylindrical side of the can. The straight axial path through the end holes and the center of the can is blocked by a beam stop — a small obstacle placed in the center. DC voltages are applied between the end caps and the cylindrical side to create an electrostatic potential barrier that defines the low-energy cutoff for the energy-filtering function in the center of the device: charged particles that enter the can through the hole at one

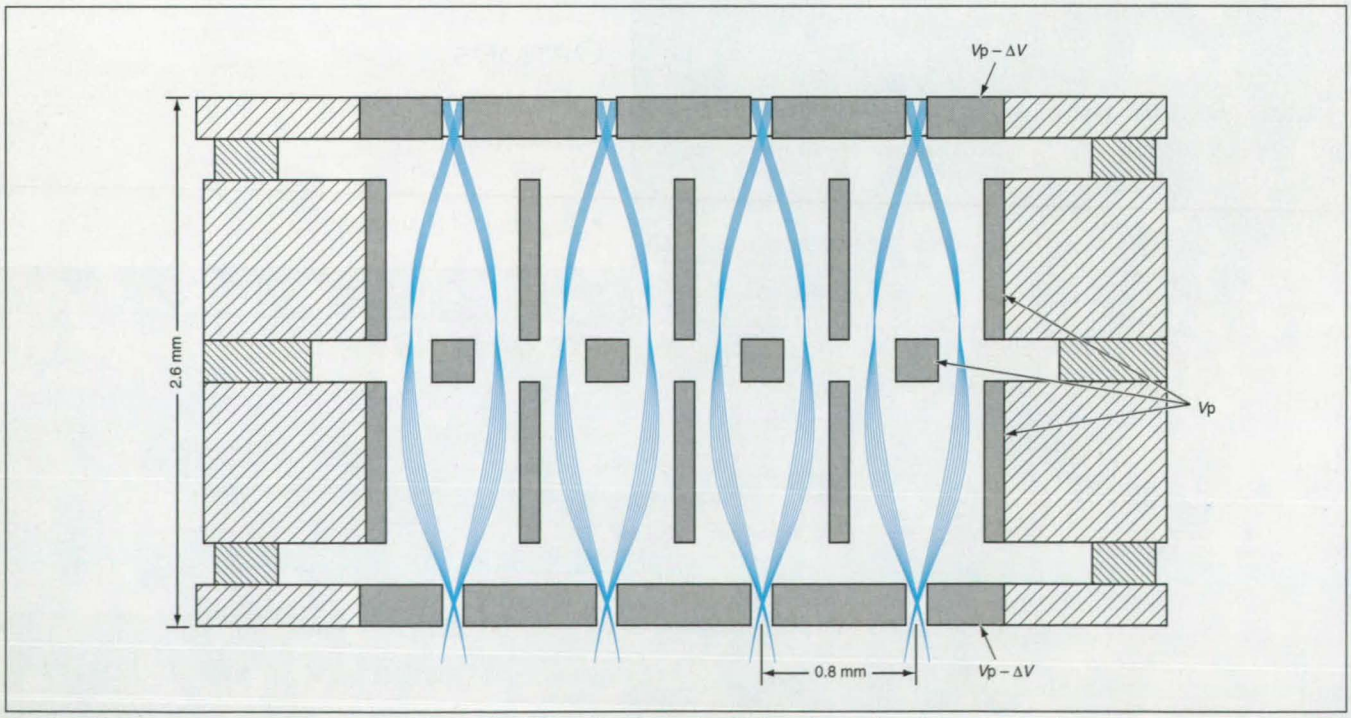

Figure 2. This **Linear Array of Micromachined Bessel Boxes** is an experimental version and prototype for development of much larger arrays.

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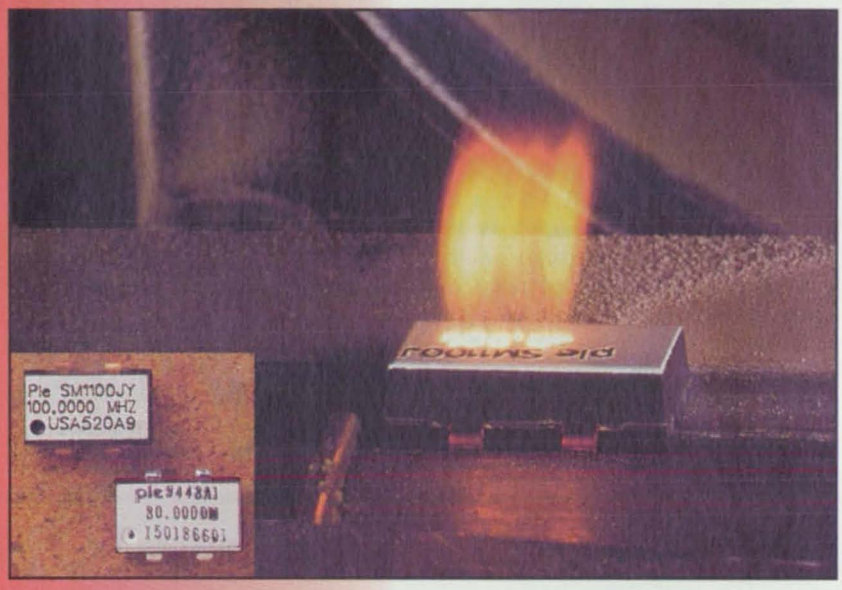

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end must possess enough kinetic energy to surmount this barrier, or else they cannot reach the exit hole at the other end.

The central beam stop establishes the high-energy cutoff of the energy-filtering function by virtue of the tendency of higher-energy particles to travel in more nearly straight lines. The electrostatic field from the applied voltages does not deflect the high-energy particles enough to bend their trajectories sufficiently around the beam stop to enable them to reach the exit hole. The band-pass energy (E_p) of the filter is centered just above the potential barrier (V_p). The energy resolution (ΔE) of the filter is a function of the dimensions of the can and is proportional to the difference, ΔV, between the voltage applied to the side and the voltage applied to the end caps. A typical Bessel box according to the original concept has a length of 10 cm and a diameter of 5 cm.

Figure 2 shows an experimental linear array of four micromachined Bessel boxes with rectangular, line-focus geometry instead of the cylindrical, point-focus geometry described above. The array was assembled as a stack of seven micromachined silicon wafers that were aligned within a few micrometers and bonded together. The choice of rectangular geometry was necessitated by the choice of micromachining technique and material; namely, anisotropic etching of <110>-oriented silicon crystal wafers with a KOH solution, using etching masks made of thermally grown SiO_2.

The electrodes were deposited by electron-beam evaporation of Ti, Pt, and Au. The distances between electrodes are maintained by silicon spacers, covered with thermally grown SiO_2 1 μm thick.

The performance of the array was tested in preliminary experiments, using Auger electrons from graphite and copper targets. The data from these experiments were found to agree well with those from computer simulations.

This work was done by Roland E. Stalder, Thomas R. VanZandt, Michael H. Hecht, and Frank J. Grunthaner of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 10*** *on the TSP Request Card.*

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

William T. Callaghan, Manager
Technology Commercialization
JPL-301-350
4800 Oak Grove Drive
Pasadena, CA 91109

Refer to NPO-19365, volume and number of this NASA Tech Briefs *issue, and the page number.*

Measuring Heat Flux via a Transparent/Opaque Surface Layer

Heat flux is measured radiatively, from a distance.

Lewis Research Center, Cleveland, Ohio

A technique for noncontact measurement of the flux of heat through a test surface incorporates elements of both (1) the basic contact-type heat-flux-measurement concept and (2) the basic spectral radiative temperature-measurement concept. The technique also exploits the unique optical properties of a layer of material that is applied to the test surface for the purpose of this measurement.

As in a contact-type measurement, the heat flux through the test surface is computed as the heat flux through a layer of material, one of the surfaces of which is in contact with the test surface. In Figure 1, the test surface is in contact with surface 2. The equation for this measurement is $\dot{q} = \kappa(T_2 - T_1)/t$, where $\dot{q}$ is the rate of flow of thermal energy per unit area conducted through the layer from surface 2 to surface 1, κ is the thermal conductivity of the layer, t is the thickness of the layer, and T_2 and T_1 are the temperatures of surfaces 2 and 1, respectively. In a contact-type measurement, T_2 and T_1 would be measured with thermocouples; in the present technique, T_2 and T_1 are measured radiatively as explained below.

Ideally, the material chosen for the applied layer would be (1) totally opaque and highly emissive in a range of wavelengths that would be used for spectral radiative measurement of T_1 and (2) totally transparent and nonemissive in another range of wavelengths that would be used for spectral radiative measurement of T_2. Thus, the thermal radiation from the two surfaces as viewed from a distance would be segregated into distinct spectral regions. Then T_2 and T_1 could be measured individually by use of a multiwavelength pyrometer, taking advantage of the spectral selectivity of this instrument

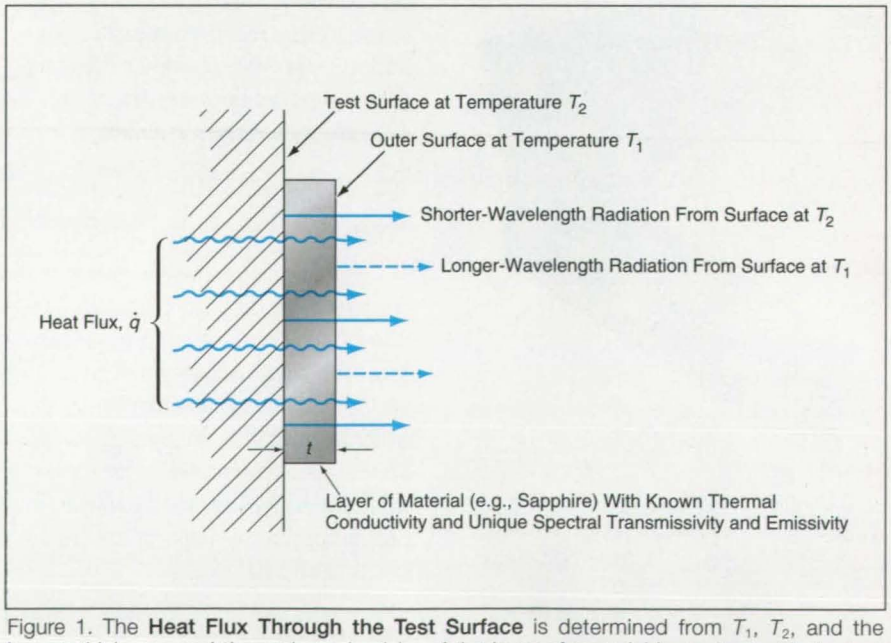


Figure 1. The **Heat Flux Through the Test Surface** is determined from T_1, T_2, and the known thickness and thermal conductivity of the layer of material in contact with the test surface. T_1 and T_2 are measured by multiwavelength pyrometry.

to distinguish between the T_2 and T_1 components of the spectrum.

In an initial experiment to demonstrate the technique, sapphire was chosen as the surface material because its spectral transmissivity and spectral emissivity approximate those

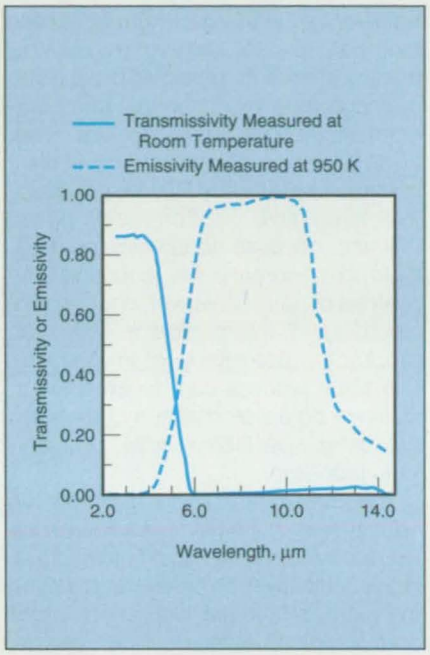


Figure 2. The **Measured Spectral Emissivity and Transmissivity** of an 8-mm-thick piece of sapphire used in an initial experiment approximate the ideal spectral characteristics needed in this technique.

of the ideal. At wavelengths < 4 μm, it exhibits high transmissivity and low emissivity, while at wavelengths > 6 μm, it exhibits high emissivity and low transmissivity (see Figure 2). Thus, a multiwavelength pyrometer observing at wavelengths < 4 μm or > 6 μm can measure T_2, or T_1, respectively.

In the ideal case, the emissivity and transmissivity would be independent of temperature. For a first approximation and simplicity one can assume this to be the case. However, in reality, the emissivity and transmissivity do vary with temperature, and this variation is a complication that one must address in future efforts to increase accuracy.

This work was done by Daniel Ng and Charles M. Spuckler of **Lewis Research Center.** *No further documentation is available.*

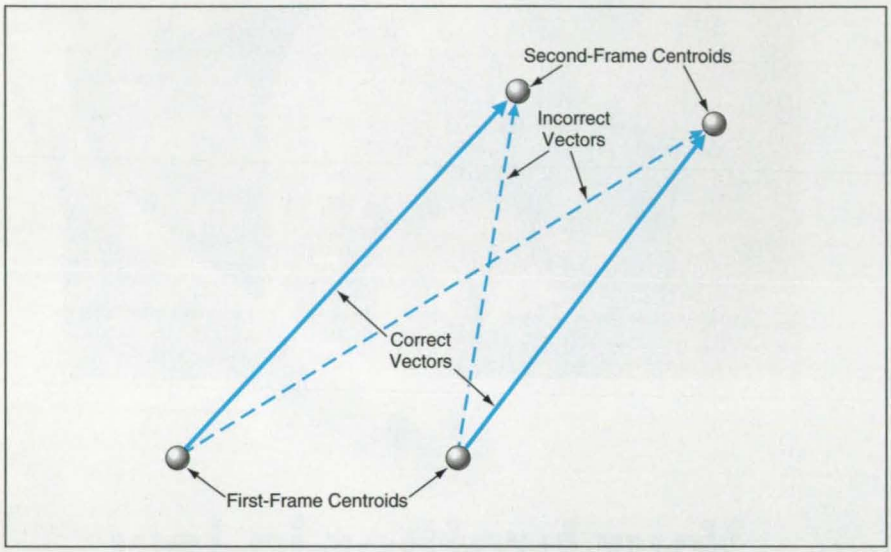
Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Lewis Research Center; (216) 433-2320. Refer to LEW-16000.

Particle-Tracking Velocimetry With Fuzzy Logic

Fuzzy logic is well-suited to tracking particle images according to loosely defined rules.

Lewis Research Center, Cleveland, Ohio

Fuzzy logic provides the mathematical basis for a computationally robust and economical method of particle-tracking velocimetry (PTV). Particle-tracking velocimetry is closely related to other velocimetric methods denoted by similar names like "particle-displacement tracking" (PDT) and "particle-image velocimetry" (PIV); these methods have been described in several previous articles in *NASA Tech Briefs*. These methods involve various degrees of manual intervention and/or processing of image data by hardware- and computation-intensive techniques like correlation of image densities. The present method, called "fuzzy PTV," is an attractive alternative to correlation-based methods because no specialized hardware is necessary for reduction and analysis of data. Moreover, direct digital recording of the particle images can simplify the processing of image data. The fuzzy process can be executed in software on a personal computer, without using specialized array or fuzzy-logic processors.



Two Pairs of Candidate Vectors are generated when two first-frame centroids are so close as to have overlapping search regions that contain the same two second-frame centroids. The correct pair of vectors is chosen under the assumption that the velocity vectors of two proximate particles are likely to be similar in magnitude and direction.

The overall task is to estimate the velocity field in one plane of a flowing liquid by seeding the liquid with small, highly reflective particles, illuminating the plane of interest with intense light from a pulsed laser or other source, recording a sequence of images of the illuminated particles over a short time, and processing the image data to determine local velocity vectors from displacements of particles. Some methods involve processing of data from multiple-exposure, single-frame photographs. Other methods involve sequences of two or more single-exposure photographic or video images on independent frames; fuzzy PTV is such a method, and requires only two single-exposure frames.

The image data from the two frames are acquired directly from a charge-coupled-device video camera. The data from each frame are processed independently to determine the particle-image centroids. The centroid locations are stored and used to determine candidate displacement vectors. Velocity vectors are calculated by dividing the displacement vectors by the interexposure time. Of course, the big problem in constructing the velocity vectors is to determine which particle-image centroids in the second frame represent the subsequent positions of which particle-image centroids in the first frame.

The centroids in the first frame are used as starting points for candidate particle displacements. The user specifies a search radius, typically between 10 and 20 pixels, that defines a circular region around each first-frame centroid, and a search for second-frame centroids

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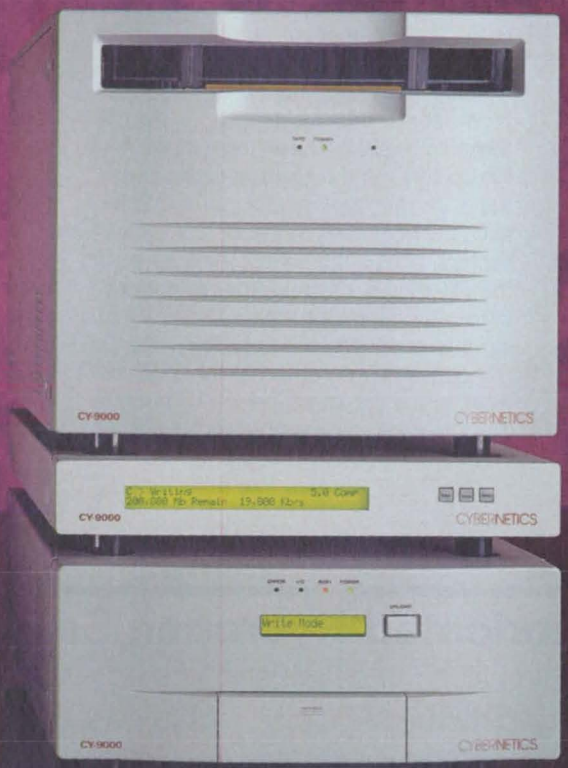

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is conducted within each such region. Each vector from a first-frame centroid to a second-frame centroid within its search region is a candidate displacement vector. In areas of high data density, search regions could overlap, so that many first-frame centroids could be found competing for the same second-frame centroids. All candidate displacements in each search region are recorded and stored as lists of candidate displacement vectors for the particle in question.

In fuzzy PTV, a fuzzy inference processor operates on the lists of candidate displacement vectors to determine the most likely displacement vector for each particle represented by a first-frame centroid. The list of vectors for each first-frame centroid is compared with the corresponding lists for all the other first-frame centroids. If two first-frame centroids claim the same second-frame centroid (see figure), then all possible vector pairs that involve these two first-frame centroids are compared. The main assumption is that if the particles represented by two first-frame centroids are close enough to claim the same second-frame centroid, then their velocities are probably almost the same, so that the pair of vectors that most resemble each other in direction and magnitude must be the correct pair of displacement vectors for the two particles.

Fuzzy logic is well-suited to this application for the same reason that has made it useful in controlling complex systems; it is capable of making control decisions from incomplete and imprecise input data according to imprecisely defined rules. In this application, it controls the selection of velocity vectors on the basis of fuzzily defined "common sense" rules that a human observer would use to identify particle tracks.

There are four inputs to the fuzzy processor for each vector pair: (1) the distance (in pixels) between the midpoints of the vectors, (2) the average of the magnitudes of the two vectors, (3) the difference between the magnitudes of the two vectors, and (4) the sum of the squares of the differences between the corresponding components of the two vectors. Each input is assigned to a fuzzy set, wherein the degree of membership for each element in the set varies between 0 and 1. The degrees of membership for each input are processed through a rule base of "IF...THEN" blocks. The rule base defines an output fuzzy set. For a given vector pair, up to 16 rules may fire, depending on the number of unique combinations of membership values. In lieu of a centroiding technique that is more common in fuzzy logic, this fuzzy processor computes its output via the singleton technique with a weighted average, which is computationally simpler.

An initial test of fuzzy PTV was performed on two PTV images of oil seeded with particles held in a transparent reservoir and convecting under the influence of a heater in the reservoir. The images contained 316 and 318 centroids, respectively. A total of 1141 candidate vectors were identified. From these vectors, the fuzzy processor produced a velocity-field map of 209 vectors in a processing time of 7.6 s.

This work was done by Mark P. Wernet of **Lewis Research 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, Lewis Research Center; (216) 433-2320. Refer to LEW-16205.

Advanced Microfabricated Hydrogen Sensors

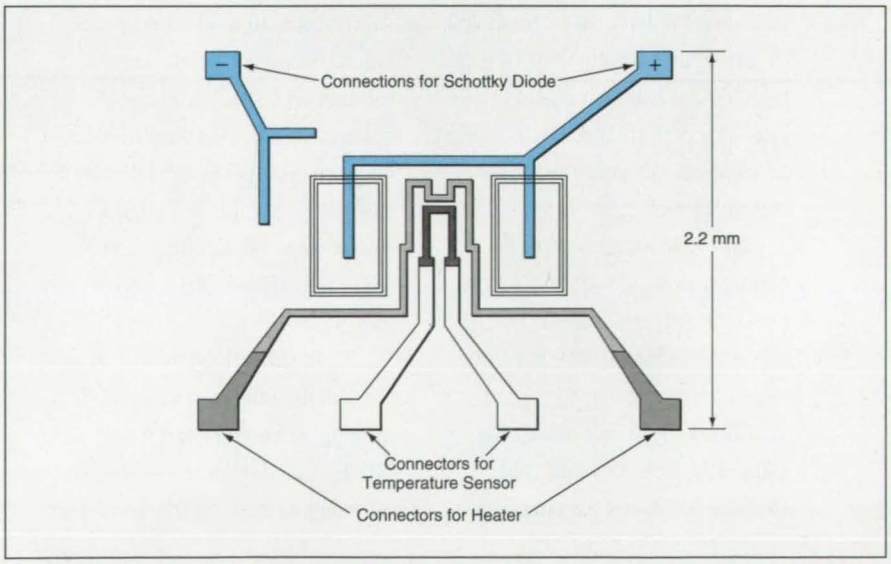
Multiple small sensors can be emplaced to detect and locate hydrogen leaks.

Lewis Research Center, Cleveland, Ohio

Advanced hydrogen sensors are being developed for detecting potentially dangerous leaks from tanks and plumbing that contain hydrogen. Sensors of this type could be used, for example, at aerospace facilities that store and handle hydrogen as a rocket fuel or at industrial facilities that will likely be constructed to satisfy demands for hydrogen as a clean-burning fuel. The sensors are made from silicon by the same metal oxide/semiconductor (MOS) technology and microfabrication techniques used in the semiconductor and electronics industries. The sensor structures are designed to minimize size, weight, and power consumption.

These sensors can measure low concentrations of hydrogen, both in atmospheres that do and atmospheres that do not contain oxygen. Because of their compactness and ability to operate without oxygen, these sensors can be used in applications in which the functioning of other leak-detection equipment would be problematic. For example, many sensors of this type can be placed in a region of potential hydrogen leaks. By monitoring the response of each sensor, the presence and location of a hydrogen leak can be determined.

The figure illustrates the sensor layout. The essential transducer component is a Schottky diode that comprises (1) an electrode made of a hydrogen-sensitive metal (an alloy of 87



A **Schottky Diode Containing a Pd/Ag Alloy Electrode** is the essential transducer component of the hydrogen sensor. The other components provide temperature control (which is necessary because the response of the sensor depends on temperature).

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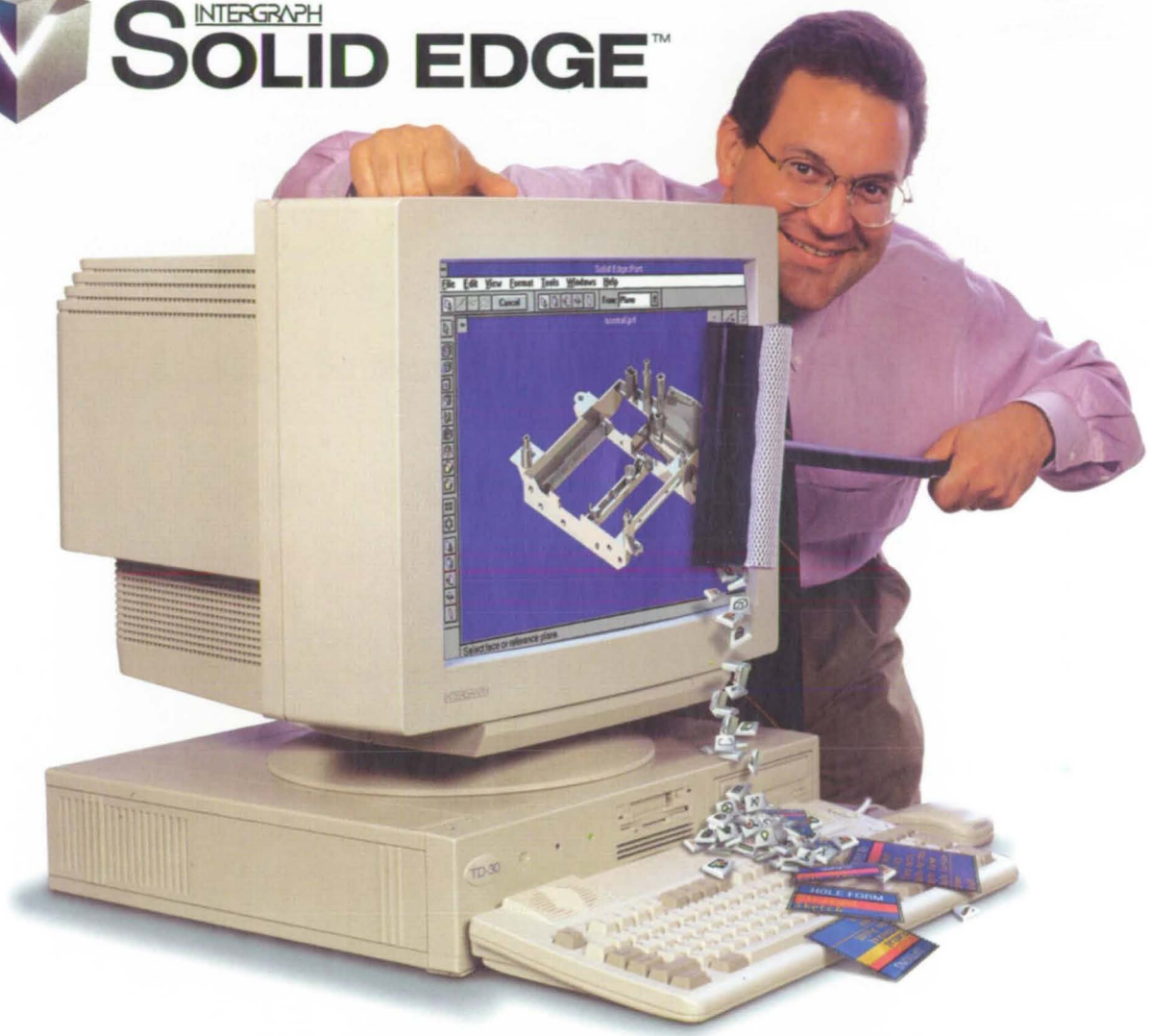

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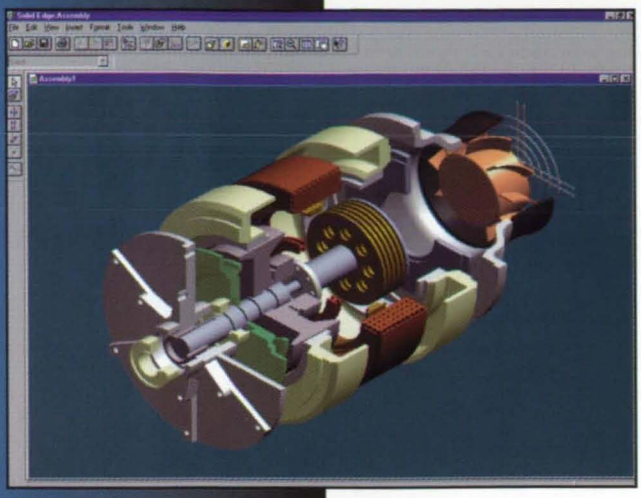

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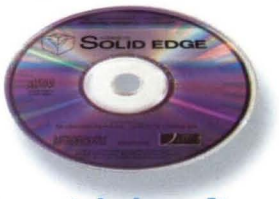

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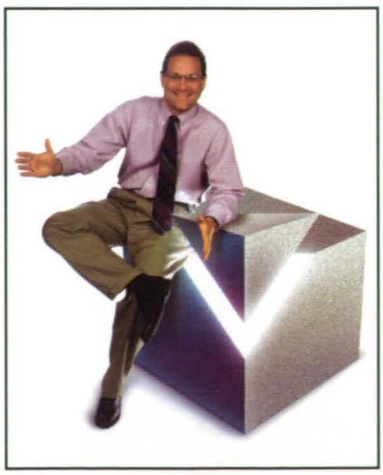

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percent palladium with 13 percent silver) on (2) a thin, electrically insulating layer of silicon dioxide on (3) a silicon substrate. Hydrogen dissociates on the surface of the Pd/Ag alloy and diffuses to the interface between the alloy and the SiO_2, where it affects the electronic properties of the MOS system and thereby provides an electronic signal indicative of the concentration of hydrogen.

The response of the sensor to a change in the concentration of hydrogen increases with temperature. Accordingly, a temperature sensor and heater are incorporated into the sensor to provide temperature control. The temperature of operation of the sensor is kept at or below 100 °C to prevent degradation of the sensor structure. The response of the sensor to hydrogen also depends on the concentration of oxygen: as the concentration of oxygen increases, the response to hydrogen decreases, and the recovery time decreases.

The minimum and maximum concentrations of hydrogen that the sensor can measure also depend on the temperature and the concentration of oxygen. The minimum measurable concentration of hydrogen is of the order of parts per million, while the maximum measurable concentration, above which saturation occurs, is less than two percent.

This work was done by Gary W. Hunter of **Lewis Research Center** *and C. C. Liu and Q. H. Wu of Case Western Reserve University. 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, Lewis Research Center; (216) 433-2320. Refer to LEW-16154.

Computing System for Calibration and Standards Laboratories

Calibration procedures are automated to save time and reduce data-entry and -processing errors.

John F. Kennedy Space Center, Florida

A local-area-network computing system has been established to automate much of the work performed in the calibration and standards laboratories at Kennedy Space Center. The system, called the "Calibration Support Network" (CSN), enables the calibration of a variety of instruments and tools with minimal human intervention. The CSN supports about 60 calibration programs of various degrees of complexity, and new programs are added from time to time to provide for the calibration of new equipment. The CSN hardware and software are designed so that once a technician sets up the equipment for a given calibration procedure, the CSN runs the procedure until calibration is complete.

An IBM-compatible 486 computer functions as a file server using local-area-network software. About 50 other computers are connected to the file server, using Ethernet topology. The CSN software includes a general program that contains commonly used subroutines and that serves as a base for developing new programs for specific calibration needs. All programs thus have a similar format and each calibration programmer can easily read software written by other programmers. Additional routines are stored in a library and can be loaded at the start of a program as needed.

All programs are written in-house expressly for specific applications. Each program is designed with the support of the metrologist in charge of the specific calibration discipline. If a global software change is needed, a programmer can easily make the change in the central library of commonly used subroutines.

Safety limits are built into the programs to protect technicians and equipment. Some programs also provide audible alarms that sound when hazardous conditions occur. Many programs stop and alert technicians when calibration setups have been performed incorrectly and/or when pieces of equipment approach maximum safe levels of specified physical quantities.

The following are a few of the CSN calibration programs and their functions:

- The Torque Wrench Calibration System eliminates the need for manual recording of torque-wrench-calibration data. This program reduces the measurement data statistically and produces a calibration data sheet.
- The Vacuum Gauge Calibration System tests instruments, corrects for thermal transpiration, and generates data sheets.
- The Temperature/Humidity Sensor Calibration Program is fully automated and controls up to three (3) environmental chambers at one time, each having the capability of controlling up to ten (10) sensors. The program automatically ramps the chambers, monitors the Standards via RS-232, reads the sensors via IEEE-488, reduces the data, and provides individual calibration data sheets.
- The Standard Torque Cell/Torque-Cell Calibration System eliminates the need for manually recording torque-cell calibration data. The system utilizes standard torque cells connected via an RS-232 interface to a 486 computer. This program contains a data base that stores the mass of four (4) sets of standard weights. When a torque cell is calibrated, the technician is prompted to use a predefined combination of weights and standard load arm that equal the desired torque. Readings from the torque cell are automatically read by the computer. The measured torque is compared with the actual computed torque and out-of-tolerance conditions are displayed in real time. A data sheet is printed at the end of the calibration.
- The Accelerometer Calibration System stores calibration points and compares them with output of a standard accelerometer to adjust a shaker table, and prints a calibration data sheet.

This work was done by James R. Lewis, William R. Frazier III, Robert H. McKay, Jr., Otto J. Fischer, Daniel D. Raymond, Lois E. Lewis, James H. Tidwell, Christopher M. Piehota, Perry C. King, Jeffrey A. Cheatham, Leonard Gaffney III, Todd E. Dayton, Joseph K. Cheatham, and Thomas C. Brown of EG&G of Florida for **Kennedy Space Center.** *For further information,* ***write in 7*** *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-11799.

Superalloy Matrices Compatible With Tungsten Wires

Improved composite materials resist interdiffusion of elements at high temperatures.

Marshall Space Flight Center, Alabama

A nickel-base superalloy has been found to exhibit potential as matrix material for improved superalloy-matrix/tungsten-wire composite materials. Such composite materials are needed for advanced gas turbine engines and other applications in which operating temperatures can rise as high as 2,000 °F (1,093 °C).

As indicated in the table, the composition of the present alloy differs somewhat from that of Waspaloy (or equivalent), which has been used previously as a refractory matrix material for tungsten-wire-reinforced composites. The present alloy is formulated to retard interfacial chemical reactions and interdiffusion of elements between matrices and reinforcing tungsten wires. The purpose of this formulation is to make composites more durable; specifically, to increase their high-temperature stability and their resistance to thermal fatigue.

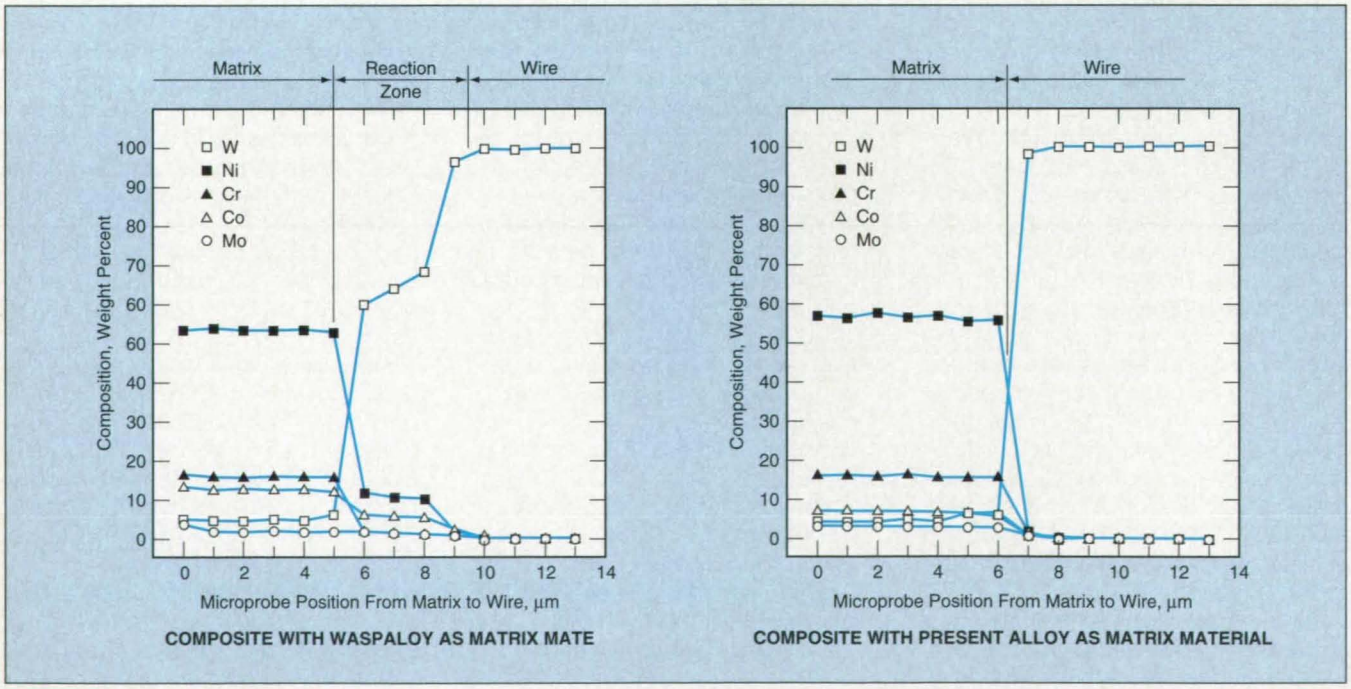
In preparation for experiments to demonstrate the retardation of interfacial reactions and diffusion, some specimens of tungsten-wire-reinforced composites were made with Waspaloy and some with the present alloy as the matrix material. The specimens of both types were fabricated by a process of vacuum melting and casting.

In the experiments, the specimens were annealed in vacuum at a temperature of 2,000 °F (1,093 °C) for times as long as 48 hours, then examined by scanning electron microscopy. The 48-hour specimen made with the present alloy as the matrix exhibited no apparent reaction zones around the tungsten fibers, whereas the 48-hour specimen made with Waspaloy as the matrix exhibited a 3.5-μm-thick reaction zone around each fiber (see figure).

This work was done by Jonathan A. Lee of **Marshall Space Flight Center** *and Po-Shou Chen and Pat Salvail, of IIT Research Institute. For further information,* ***write in 36*** *on the TSP Request Card. MFS-26302*

	Composition, Weight Percent of Elements							
	Fe	Ni	Cr	Mo	Ti	Al	Co	W
Waspaloy (or Equiv.)	1.3	Balance	19.3	4.3	2.9	1.3	14.3	0
Modified Alloy	1 to 2	Balance	18 to 20	4 to 5	2.7 to 3	1.1 to 1.5	8 to 13	2 to 4

The **Present Alloy** is a modified version of Waspaloy. The principal modification consists in the addition of tungsten to retard interdiffusion of elements between the alloy and tungsten wires embedded in the alloy.



The **Composition as a Function of Position** along a line perpendicular to a matrix/wire interface was determined by microprobe analysis. In the Waspaloy-matrix specimen, tungsten diffused from the wire into the matrix and the matrix ingredients diffused into the wire, forming a reaction zone. In contrast, a reaction zone is not evident in the specimen containing the present alloy.

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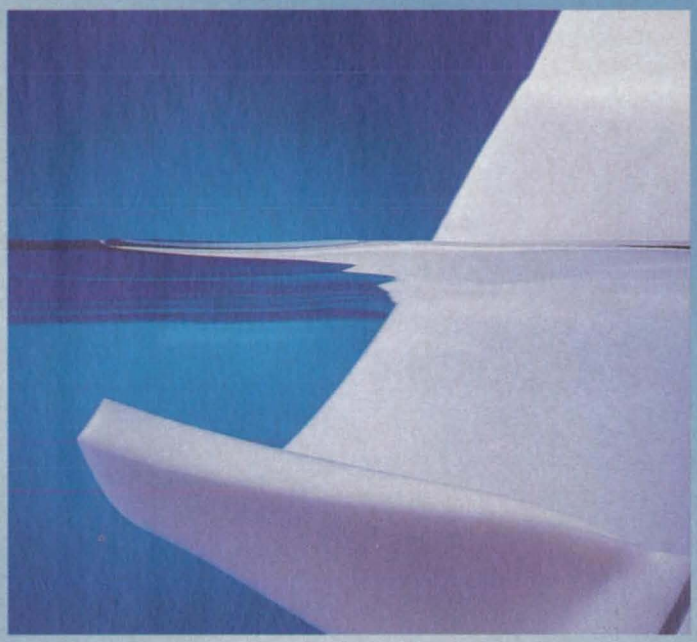

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Deposition of Sapphire by Conversion Coating

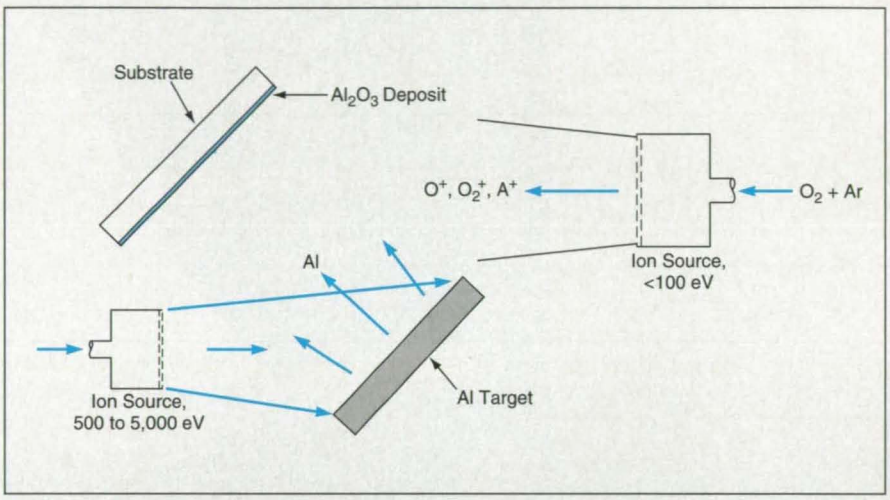
Aluminum is deposited and immediately oxidized to convert the deposit to sapphire.

Lewis Research Center, Cleveland, Ohio

Hard, transparent surface layers of sapphire can be deposited on solid substrates by a conversion coating method. The method can be used, for example, to form very clear protective surface coatings on polymeric windows, lenses, and face shields to resist abrasion and thereby help to maintain transparency. The essence of the method is to deposit aluminum atoms on a substrate while chemically active oxygen atoms and ions impinge, so that the aluminum deposit is immediately oxidized to form sapphire (Al_2O_3).

The method can be implemented by any of several processes. In one process, for example, the first step is to sputter-clean the substrate by use of a beam of oxygen and argon ions at kinetic energies between 200 and 500 eV. Then a beam of argon ions at kinetic energies between 500 and 5,000 eV is used to sputter-etch aluminum from an aluminum target that faces the substrate, causing aluminum to be deposited on the substrate (see figure). At the same time, chemically active monatomic and ionic oxygen is brought to the surface of the substrate by use of a beam of oxygen ions at kinetic energies less than 100 eV. A small amount of argon can be added to smooth the operation of the oxygen-ion source.

Techniques used in alternative deposition processes could include dc magnetron sputtering, electron-beam evaporation, thermal evaporation, and



Aluminum Is Sputtered onto the substrate in the presence of impinging oxygen ions, so that the deposited aluminum is oxidized into a hard, tenacious coat of sapphire.

vacuum arc deposition. Alternative techniques for converting aluminum deposits to sapphire could include use of radio-frequency or microwave oxygen plasmas or discharge-chamber plasmas.

This work was done by Bruce A. Banks and Sharon K. Rutledge of **Lewis Research Center.** *For further information,* ***write in 52*** *on the TSP Request Card. LEW-15638*

Nanostructured Flame Retardants

These materials can be blended with base materials on a near-molecular level.

Marshall Space Flight Center, Alabama

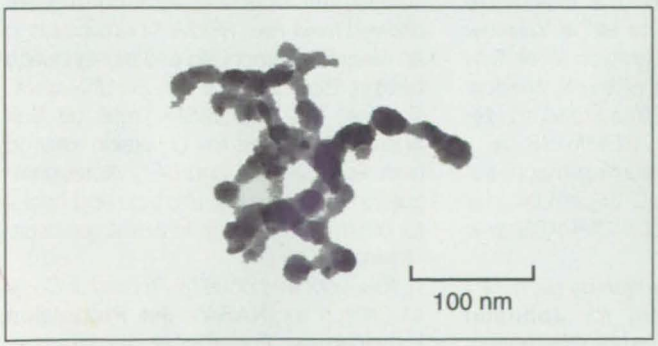
Improved flame-retardant additive powders with particle sizes < 100 nm are undergoing development. Called "nanostructured flame retardants," these powders can be used as ingredients of flame-retardant coatings or blended into composite polymeric materials to make fabrics and structural components that are flame-retardant throughout their thicknesses. The principal ingredient of nanostructured fire retardants tested in preliminary experiments was nanostructured antimony oxide (see figure), which was synthesized from micron-particle-size antimony oxide powder in a subatmospheric-pressure chamber by thermal evaporation and condensation onto a cooled surface.

Because of the high specific surface areas associated with their small particle sizes, nanostructured flame retardants are characterized by relatively high reactivity and correspondingly high effectiveness as flame retardants. The small particle sizes make it possible to blend these materials with other materials at a near-molecular level of fineness and interpenetration.

Unlike older flame-retardant additives with larger particle sizes, nanostructured flame retardants can be incorporated into micron- and submicron-sized fibers; this can be an important advantage in making clothing that stays flame-retardant, as contrasted with clothing made flame-retardant by coating materials that can come off with repeated washing. In another potential class of applications, nanostructured flame retardants could be incorporated into microelectronic devices, in which particles of excessive size could adversely affect performance.

This work was done by Shahid Pirzada and Tapesh Yadav of Nanomaterials Research Corp. for **Marshall Space Flight Center**. *For further information,* ***write in 70*** *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-26387.



This **Transmission Electron Micrograph** shows particles of nanostructured antimony oxide powder made in a thermal evaporation process.

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Mathematics and Information Sciences

General-Purpose Scheduling Program

Activities can be added to a schedule in nonchronological order.

Computer Aided Scheduling System (COMPASS) is a generic, nonchronological, interactive scheduling computer program. It is generic in the sense that it can be applied to any problem in which activities are placed on a time line while respecting a variety of constraints, including resource, temporal, and state constraints. It is nonchronological in the sense that schedules are built incrementally by placing activities on the time line, one at a time, and that the sequence in which activities are placed on the time line is not constrained by their order in time. High-priority activities and those that are time-constrained can be placed on the time line first, even though they may be scheduled to occur later than other low-priority activities.

In a nonchronological scheduling system, an activity is placed on a time line in roughly four steps: (1) Compute the intervals of time in which all of the requirements and constraints that pertain to that activity are satisfied, (2) Select one of these intervals, (3) Align the activity within the selected interval, and (4) Post reservations against the required resources during the chosen interval. COMPASS employs a general algorithm that computes the set of all satisfying intervals. This enables the system, or the interactive user, to employ sophisticated preference functions to choose the "best" interval and to align the activity at the "best" location in the chosen interval.

COMPASS enables the user to build schedules, one activity at a time, or to build schedules by use of automated methods. Once a schedule is created, the user can move the activities around, change resources or requirements, or create multiple schedules to reflect various scenarios. COMPASS ensures that constraints are not violated while the user manipulates the schedule. This enables the user to focus on the quality and overall look of the schedule while COMPASS maintains the validity of the schedule.

COMPASS comes in two versions. There is an ASCII-interface version, which requires only a terminal capable of ASCII input and output. Commands are entered in response to prompts and results are displayed as text. There is also a graphical version, which requires the appropriate windowing software for its graphical display. Both versions provide the same capabilities; however, the graphical version is intuitively easier to use.

COMPASS is written in Ada and C for Sun4-series computers running SunOS v4.1.3 and Solaris v2.3 and is available as executable code only. The required amount of random-access memory varies with the size of the problem being solved. This package of software includes sample executable codes that were compiled under SunAda and C on a Sparcstation running SunOS 5. Both X Window and command-line executable codes are included. The MIT X Window System, Version 11 Revision 4 or 5 is required for execution of the X Window version of COMPASS. The standard distribution medium for COMPASS is a 0.25-in. (6.35-mm) streaming-magnetic-tape cartridge (Sun QIC-24) in UNIX tar format. Version 2.0 of COMPASS was released in 1994.

This program was written by Barry Fox of McDonnell Douglas for **Johnson Space Center**. *For further information,* ***write in 46*** *on the TSP Request Card.*
MSC-22396

Software for Automated Detection of Anomalies in Real Time

The SELMON (SELective MONitoring) computer program monitors time-series engineering data from a complex equipment system (e.g., a chemical plant) to detect anomalies in the system in real time. To enable the detection of subtle or developing anomalies that are missed by older anomaly-detecting computer programs, SELMON goes beyond the traditional anomaly-detection techniques of comparing sensor readouts with predefined limits and/or with predictions of mathematical models. SELMON detects changes in the frequency distributions of sensor readings over time; it also detects changes in relationships among sensor readings to detect anomalies (e.g., breaks in causal dependencies) that could be indicated by relationships among system parameters. Thus, in comparison with older anomaly-detecting software, SELMON provides a more nearly complete anomaly-detection capability, removing more of the anomaly-detection burden from human operators. Once an anomaly has been detected, SELMON determines how much of the monitored system has been affected; this kind of information can be critical in the first few moments of an emergency, when several sensors reporting the same anomaly can confuse an operator, with consequent delayed response. SELMON is available in an Allegro CommonLisp and a C-language version. Both versions run on Unix workstations. The Lisp version runs on Sun Sparcstations, and the C version runs on both Sparcstations and DEC Alpha computers. A simple user interface and hooks for creating an interface to a data server are provided.

This work was done by Richard J. Doyle of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 93*** *on the TSP Request Card.*
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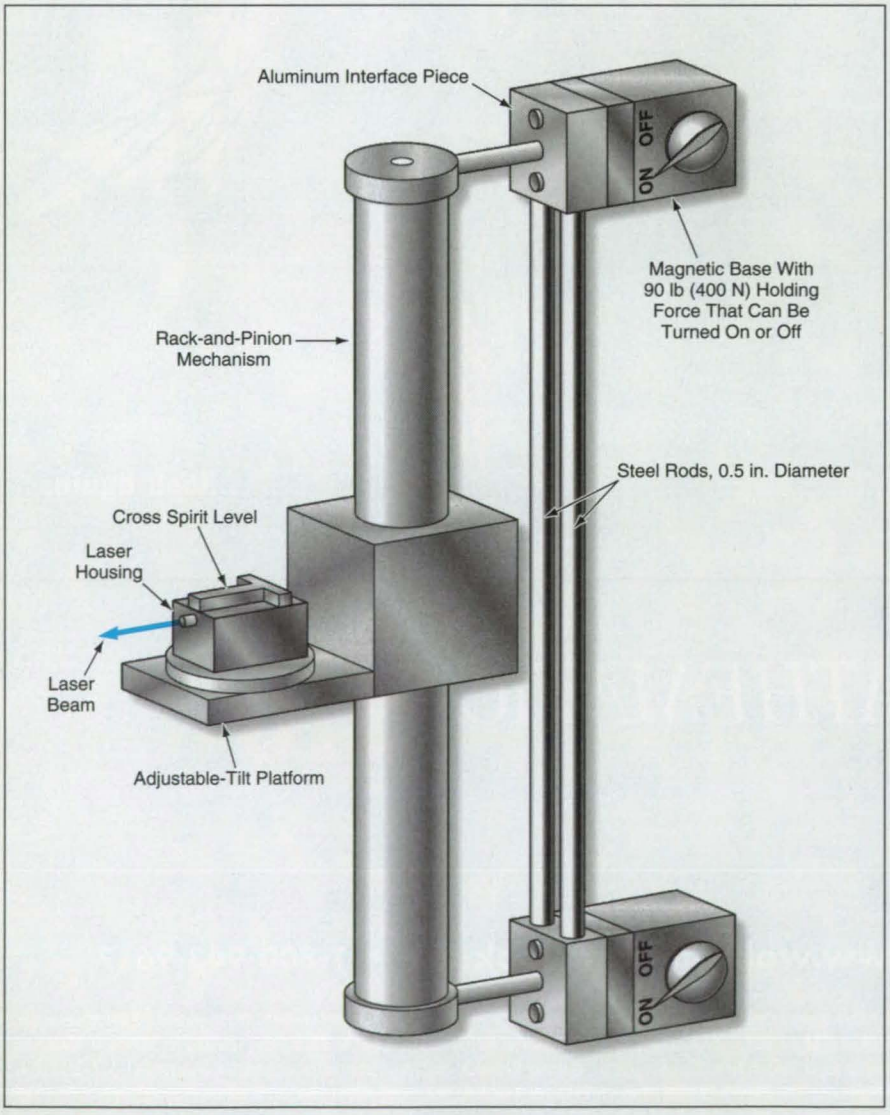
Relative-Height Monitor Aids Maneuvering of Large Objects

Relative heights can be determined before objects are brought together.

John F. Kennedy Space Center, Florida

An instrument provides measurements of the relative heights of objects within a tolerance of about 0.1 in. (2.5 mm) at a horizontal distance of 30 ft (9.1 m). In the original application, the instrument is needed to assure noninterference among payloads that are about to be installed in the space shuttle orbiter at precisely allocated vertical positions. The instrument could be readily modified for similar industrial assembly applications in which large and/or heavy objects are initially horizontally distant from each other and are required to be at specified height relative to each other before bringing them together.

The instrument is made largely of high-quality, commercially available optical-laboratory equipment. As shown in the figure, the instrument includes a framework of two steel rods with aluminum interface pieces at their ends. Magnetic bases bolted to the interface pieces are used to attach the instrument to a steel post or other convenient ferromagnetic structure in the workspace. A rack-and-pinion mechanism mounted on the framework provides for raising and lowering the optical assembly, with a total travel of 9 in. (23 cm). The relative height of the optical assembly is read from a ruler (not shown in the figure) mounted on the framework adjacent to the rack-and-pinion mechanism.



The **Relative-Height Monitor** is basically a laser-aided cathetometer.

The function of the optical assembly is to generate a well collimated, visible, horizontal laser beam that can be aimed at an object of interest by rotating the laser in a horizontal plane. The optical assembly includes a battery-powered eye-safe diode laser with a wavelength of 670 nm and an output power of 1 mW. The laser, its optics, and its battery are mounted on a rotary table on a platform equipped with a tilt adjustment for leveling the plane of rotation. A cross spirit level on top of the laser housing provides guidance for the tilt adjustment.

Once the instrument has been attached magnetically to a structure in the workspace, the rotary table is approximately leveled. The laser is switched on and is aimed at a first target by a combination of rotary-table (horizontal) and rack-and-pinion (vertical) motions. The relative vertical height of the first target is read from the ruler. Then without changing the tilt adjustment, the laser beam is aimed at a second target by a similar combination of motions, and the relative height of the second target is read from the ruler. Then the difference between the heights of the two targets is calculated by subtracting one reading from the other.

This work was done by Arne E. Aamodt and Ivan F. Velez of **Kennedy Space Center** *and Robert C. Youngquist, William D. Haskell, and Robert B. Cox of I-NET. For further information,* ***write in 38*** *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-11841.

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Conduit Clamp Is Easy To Use

This conduit clamp can be actuated by a single gloved hand or by a robot.

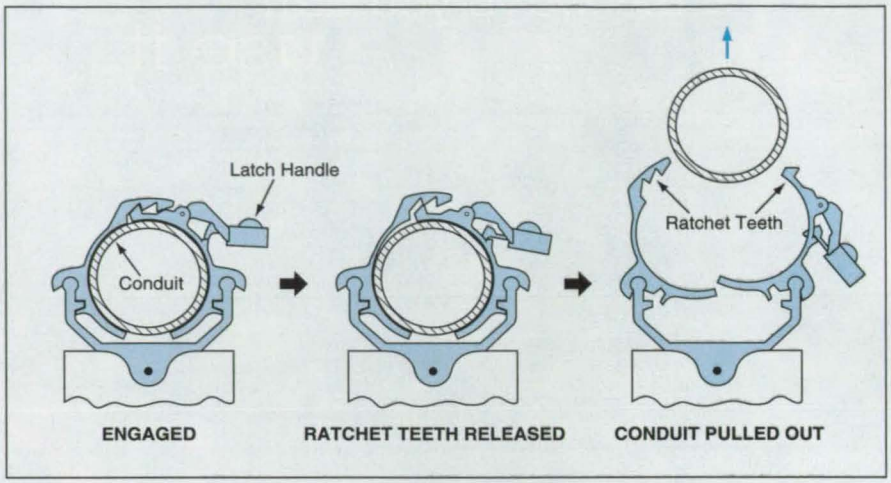
Lewis Research Center, Cleveland, Ohio

A multiple-piece metal conduit clamp has been designed to withstand extreme environments and to be operable by a robot or by a technician with a single gloved hand. This conduit clamp is similar to a commercial single-piece cast plastic conduit clamp, the flexing points of which fail over time, and which cannot be disengaged without a tool.

The conduit clamp includes clamping fingers with compound curvatures and varied lengths and thicknesses. The purpose and overall effect of these curvatures and variations in length and thickness are to ensure that the fingers fit snugly to the conduit and that the various faying surfaces come together and apart in the proper engagement and disengagement sequences.

The figure illustrates a disengagement sequence. The latch handle is pressed to release the ratchet teeth: this allows the fingers of the clamp to open. As the technician or robot pulls the conduit out, springs push the clamping fingers outward to provide a clear path for the conduit.

To install a conduit, the conduit is gripped away from the clamp and inserted in the opening between the outwardly sprung clamping fingers. As the conduit is pushed in, the fingers close into a soft-docking configuration in which the ratchet teeth become engaged in the looser of two ratchet positions. Further on, the conduit adjacent to the clamp causes the fingers to flex in such a way that the ratchet teeth become engaged in the tighter of the two ratchet positions.



The **Conduit Clamp** can be opened or closed easily, without special tools or training — even without looking.

This work was done by Clint A. Collins of Rockwell International Corp. for **Lewis Research Center.** *For further information,* ***write in 81*** *on the TSP Request Card. LEW-15618*

Docking Station and Replaceable Equipment Module

The module can be replaced by a technician or by a robot.

Lewis Research Center, Cleveland, Ohio

The figure illustrates an equipment module and a docking station that receives the module. The module and station are designed together with alignment features, coupling/uncoupling mechanisms and circuits, and a thermal interface. The integrated design accelerates and facilitates installation of the module in, or removal of the module from, the station by a technician or by a robot.

The thermal interface between the module and the station consists of two panels with mating parallel ridges and valleys. Heat from electronic or other equipment in the module is conducted across the ridged interface and carried away by a liquid coolant flowing in channels under the ridges on the station side. The mating ridges and valley surfaces also help to align the module with the station: Once the module and station are brought into initial alignment by pressing them together at these surfaces, the module is slid along these surfaces until spring-loaded alignment pins at the corners of the module fall into mating detent alignment holes in the station.

Once alignment is complete, the module is clamped to the station by use of two movable clamping wedges in the station that are pushed outward against mating fixed clamping wedges mounted in the module on opposite sides. The clamping wedges are attached to ball nuts that slide on linear bearings; they are driven by a ball screw that is, in turn, driven via miter gears by a pair of redundant dc motors. The motors are controlled and powered by compactly packaged external control and power circuits carried by the technician or robot. In the event of a failure in the power and/or control circuitry, the ball screw can be turned manually by use of a wrench inserted in a square drive socket at either end of the ball-screw shaft.

Connections with these external circuits are made via a multiple-pin plug that is inserted in a socket on the top of the module. The signals and power are carried from this socket to a specially designed multiple-contact-button electrical connector on the lower side of the module that mates with a specially-designed multiple-contact-button electrical connector in the station: the special design is such that the multiple-contact-button connectors do not prevent the sliding motion needed to effect alignment, and so that electrical contact between them is made via spring-detent action of mating convex and concave contact surfaces once alignment is complete.

A voltage proportional to the motor current is sent back to the external control circuitry. To a reasonable approximation, the motor current is proportional to the torque applied by the motor(s) and, thus, is proportional to the force of clamping between the two modules. This voltage

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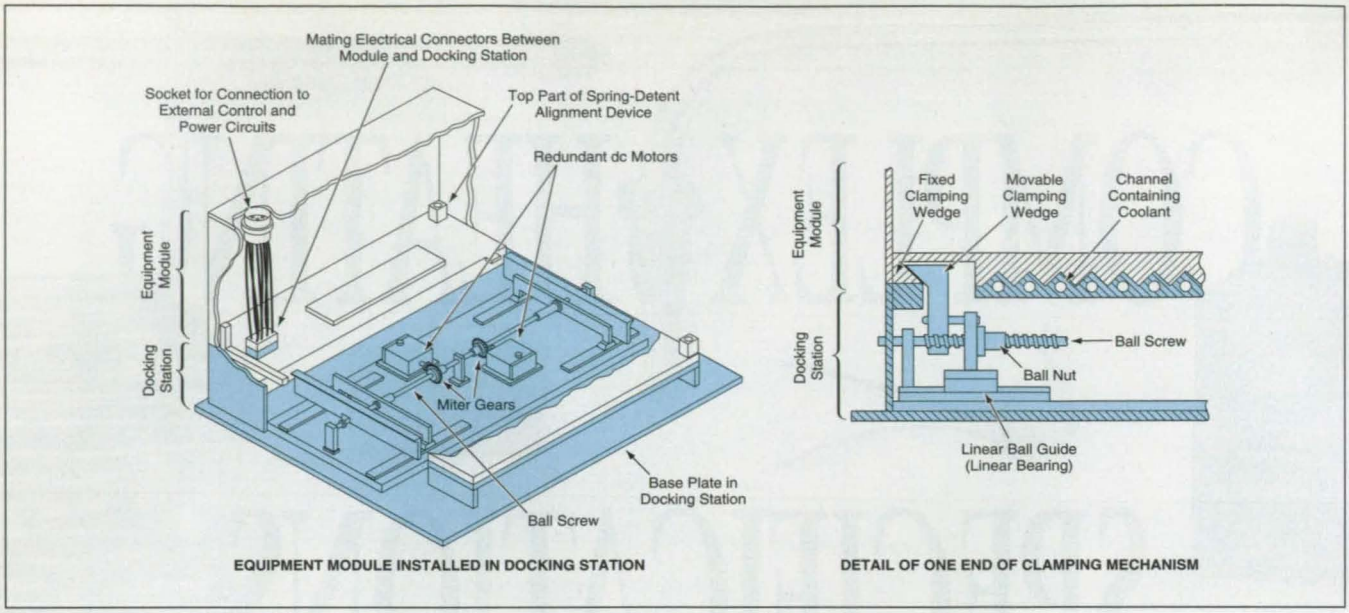


The **Equipment Module Can Be Installed** in the docking station or removed from the docking station quickly. The clamping mechanism in the docking station is operated via external power and control circuits carried by a technician or robot.

can thus be used to turn off the motor power and/or generate a visible display indicative of the clamping force.

The clamping mechanism as described thus far is part of a modular unit that can be installed in or removed from the docking station. This unit is held in the docking station by a specially designed Geneva mechanism that is actuated manually by use of a wrench.

This work was done by James L. Dolce of **Lewis Research Center** *and Andrew L. Gordan of Analytical Engineering Corp. For further information,* ***write in 55*** *on the TSP Request Card.*

This invention has been patented by NASA (U.S. Patent No. 5,290,121). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Lewis Research Center; (216) 433-2320. Refer to LEW-14906.

Magnetic Pressure-Relief Devices

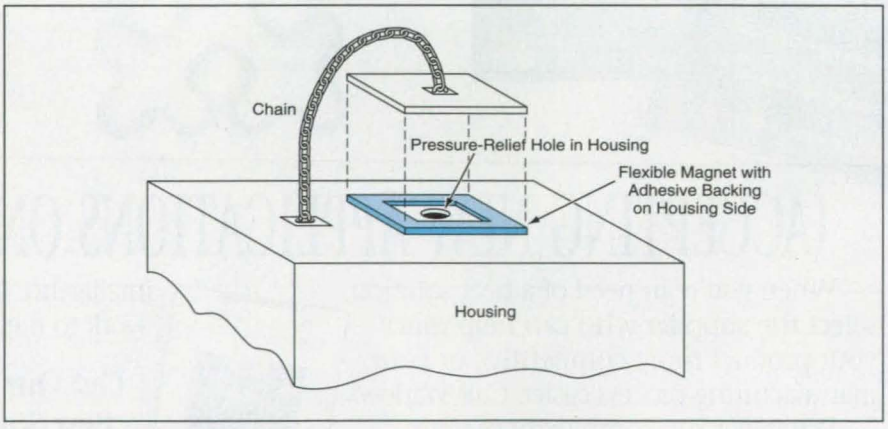
These devices are simple and can be reset easily.

Lewis Research Center, Cleveland, Ohio

The figure illustrates one of a number of reusable, low-profile, lightweight, devices that relieve excessive pressures in equipment housings. Unlike some more complex reusable pressure-relief valves, these devices present no permanent open cavities in which, for example, wasps can build nests.

These devices are simple in design and can be fabricated cheaply and easily. The one shown in the figure includes a magnetically restrained blowoff plate; in other devices of this type, the pressure-relief elements could be magnetically restrained flappers or poppets, for example.

A typical older nonreusable pressure-relief device contains a metal diaphragm (burst disk) that is scored to ensure breakage at a specified pressure limit, but there is no way to determine in advance whether it will give way at the specified limit. On the other hand, the present devices can be pressure-tested and reset as many times as necessary to measure and adjust the pressure limits.



This **Pressure-Relief Device** is cheap, simple, and reusable.

One of the advantages of a magnetic pressure-relief device of the present type is that it can be made to shift to the fully open position once the pressure limit is exceeded, and to remain fully open until manually reset. In contrast, a spring-loaded low-pressure-relief valve typically begins to leak at the pressure limit but opens fully only if the pressure continues to rise beyond the limit.

This work was done by Tyson Arthur Goudey and David Jonathan Chalk of General Dynamics for **Lewis Research Center**. *For further information,* ***write in 79*** *on the TSP Request Card. LEW-15558*

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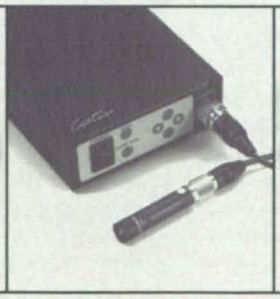

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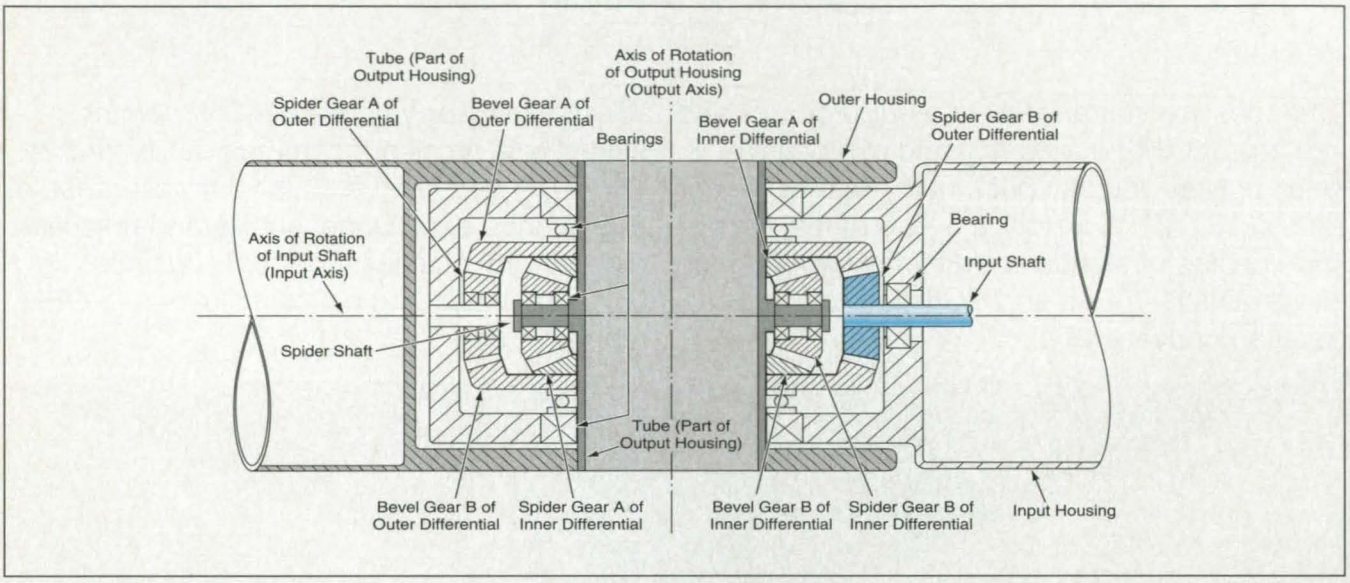
High-Torque Right-Angle Gearbox

The torque-to-weight ratio and output stiffness could be comparable to those of a harmonic drive.

NASA's Jet Propulsion Laboratory, Pasadena, California



The **Dual-Differential Mechanism** in this gearbox would be relatively compact and lightweight, with high output stiffness. It could be designed to provide an arbitrarily large speed-reduction ratio, without need for additional stages of gearing.

A conceptual right-angle gearbox could provide a large speed-reduction ratio (and corresponding multiplication of torque) in a relatively compact, lightweight package. Depending on the specific gear-tooth specifications and other design parameters, this gearbox could be made to provide any speed-reduction ratio from about 40 to infinity, without need for additional stages of gearing. The torque-to-weight ratio, output stiffness, and efficiency of this gearbox could be comparable to those of a harmonic drive. Harmonic drives are typically limited to speed-reduction ratios ≤ 320.

The gearbox would include an input housing that surrounds an input shaft, and an output housing that could rotate on bearings with respect to the input housing about an axis perpendicular to that of the input shaft (see figure). The output housing would be the output drive member; that is, the overall function of the gearbox would be to make the output housing rotate slowly, with high torque capacity, relative to the input housing, about an axis perpendicular to that of the input shaft. The input shaft could be turned by a motor or other actuator mounted coaxially in the input housing.

The gearbox would contain an outer and an inner differential. These differential mechanisms would be similar to those on the rear axles of most automobiles, but would contain gears cut with numbers of teeth somewhat different from those ordinarily used. The input shaft would turn spider gear B of the outer differential, thereby causing bevel gears A and B of the outer differential to rotate in opposite directions about the tube in the output housing. Bevel gears A and B would have the same pitch diameter, but may have a slight variation in the number of teeth, thus causing them to rotate at different velocities. The load would also be shared by spider gear A of the outer differential, which would rotate as an idler between bevel gears A and B of the outer differential. Each bevel gear of the inner differential would rotate with, and thus be driven by, the corresponding bevel gear of the outer differential. As in the outer differential, these bevel gears may also vary in number of teeth. In turn, the bevel gears of the inner differential would drive the spider gears; because the spider shafts would be rigidly attached to the tube in the outer housing, this action would cause the outer housing to turn about the output axis by an amount that would depend on the numbers of teeth in the various gears.

Because torque would be transmitted simultaneously through multiple gear teeth on large pitch diameters, the torque capacity of this gearbox would be very high in comparison with that of gearboxes of the same size and weight but older design. This same feature would impart very high output stiffness. Yet another advantage is that backlash could be reduced or eliminated in two ways: (1) Because the total number of gears would be kept small, even for high gear ratios, there would be fewer than the usual number of locations where backlash could enter. (2) The sandwich configuration of the differentials would make it possible to preload the differentials by incorporating springs to press the two sets of bevel gears inward against the spider gears.

This work was done by Timothy R. Ohm of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 19*** *on the TSP Request Card. NPO-19542*

Apparatus for Circumferential Sensor Scans

The principal advantage is reproducibility of circumferential position.

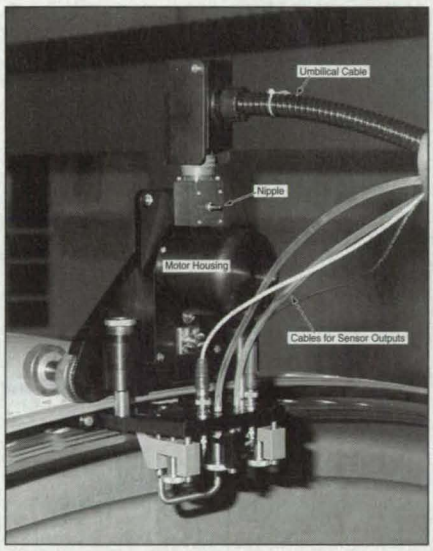
Marshall Space Flight Center, Alabama

An apparatus carries ultrasonic and/or other sensors in a scan along a circumferential track on a large cylindrical object. In the original application for which the apparatus was custom-designed, the circumferential track is part of a joint between two cylindrical sections of a large solid-fuel rocket motor, and the sensors are used to inspect the joint. The basic principle of the apparatus may be applicable to inspection of other large, round objects like tanks, pressure vessels, and pipeline sections.

The principal advantage of the apparatus is that it can be commanded to move to a specified circumferential position, repeatably and accurately. This not only helps to ensure accuracy of inspection data but also makes it possible to return to a previously identified defect for further inspection or repair.

The apparatus (see figure) is moved along the circumferential track by a drive mechanism actuated by a stepping motor with position feedback from a shaft-angle encoder. The kinematic relationships among the track, the apparatus, and the sensors are such that once mounted on the apparatus, the sensors are automatically maintained in the required alignment with respect to the part to be inspected.

The stepping motor is covered with an aluminum housing, which serves to contain any sparks that might be generated in the operation of the motor (sparks pose an obvious danger in proximity to the solid rocket fuel in the original application). Through a tube connected to a nipple, the interiors of the motor housing and shaft-angle encoder are purged with nitrogen.



Wheels Driven by a Stepping Motor with position feedback reproducibly position the apparatus and sensors along the circumferential track.

The main body of the apparatus is machined from aluminum stock and anodized for protection against corrosion. The apparatus is connected to a motion-control/data-acquisition electronic system via an umbilical cable. All drive and feedback information is transmitted via this cable. Separate cabling that piggybacks onto the umbilical cable is used to transmit data from the sensors to the data-acquisition subsystem.

This work was done by Paul W. Karner, Michael J. Mesick, Howard C. Morrill, William Chyr, and Gary Brochman of Thiokol Corp. for **Marshall Space Flight Center.** *For further information,* ***write in 72*** *on the TSP Request Card. MFS-31063*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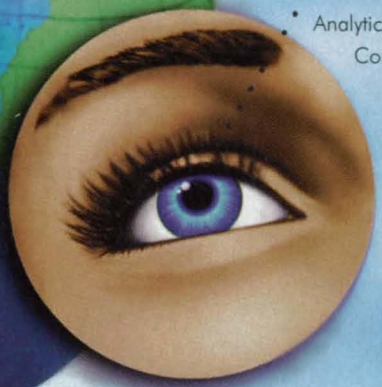

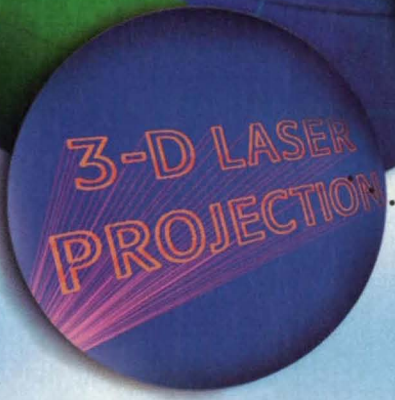

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LASER TECH BRIEFS

Laser Tech Briefs Supplement to *NASA Tech Briefs* August 1996 Issue Published by Associated Business Publications

LASER TECH BRIEFS

FEATURE

DEPARTMENTS

On the cover:
The photograph shows a selection of sapphire lenses offered by Meller Optics of Providence, RI. They are available in plano-convex and plano-concave configurations in sizes ranging from 1/2 inch to 2 inches. The company recommends the lenses for applications ranging from near-IR laser systems such as erbium and holmium medical lasers, UV excimer lasers, and other focusing and beam-steering applications in harsh environments. *Photo courtesy Meller Optics.*

NEWS BRIEFS

Notes on the Industry and Federal Labs

The already teeming diode-pumped solid-state (DPSS) laser marketplace has a new entrant: HMG Photonics. The company, a joint venture of Melles Griot Inc., Irvine, CA, and Hitachi Metals Ltd., Tokyo, Japan, introduced its first product at the Conference on Lasers and Electro-Optics (CLEO) in Anaheim in June. The Model ICD-430 (see "New Products") is a DPSS laser emitting a 10-mW single-spatial-mode blue beam that the company says is useful for reprographics, compact-disk manufacturing, and medical instrumentation. Melles Griot designs, manufactures, and distributes a wide variety of photonics products worldwide. Hitachi Metals, a leading manufacturer of specialty steels, automotive components, and magnetic and electronic materials, also develops new electronic and laser devices.

The Light Brigade, the supplier of fiber optic design, installation, and maintenance training, has moved to new and larger facilities. The new address is 7691 S. 180th St., Kent, WA 98032. Phone and fax numbers remain the same: (206) 251-1240 and (206) 251-1245 respectively.

Bell Laboratories researchers have demonstrated the world's first room-temperature and high-temperature semiconductor lasers that operate in the mid- and long-wavelength infrared regions. Quantum-cascade (QC) lasers, invented at Bell Labs' Murray Hill, NJ, site in 1994, initially operated at temperatures lower than -300 °F; the new lasers, at 5 microns, provide a pulsed peak power of about 200 mW at 77 °F and about 100 mW at 127 °F.

Federico Capasso, head of the quantum phenomena and device research department at Bell Labs (now the R&D arm of Lucent Technologies), says that the spectral ranges of the new lasers—3-5 μm and 8-13 μm—will be useful in pollution monitoring and industrial process control for environmentally safe manufacturing, because many hazardous and toxic chemicals have optical absorption "fingerprints" at these wavelengths. Among other uses foreseen are the detection of water and pollutants in the gases employed in semiconductor processing.

The Bell Labs team says the QC laser is the world's first whose emission wavelength can be tailored over a wide range in the infrared by varying the thickness of the material layers. They have demonstrated wavelengths ranging from 4 to 11 microns.

The Defense Sciences Office of the Defense Advanced Research Projects Agency (DARPA) awarded Bell Labs a two-year grant to develop continuous-wave QC lasers that can be cooled by thermoelectric coolers, *i.e.*, above -75 °C. Thermoelectric coolers typically cost no more than a few hundred dollars, while cryogenic coolers cost about $10,000.

Personnel of the Air Force Phillips Laboratory's Airborne Laser Technology Division registered the first successful use of a laser beam to illuminate and track a theater missile in its boost phase on June 3 at the Army's High Energy Laser System Test Facility, White Sands Missile Range, NM. The test, which involved a missile travelling at about one kilometer per second, was repeated successfully on June 16.

The researchers, a joint team from the Air Force, Army, Navy, Massachusetts Institute of Technology's Lincoln Laboratory, Hughes Aircraft, and Aerotherm Corp., initiated the test by locking the tracker onto the missile's bright exhaust plume. About 15 seconds and 23 kilometers into the launch, the laser was switched on to illuminate the missile's body. Technicians then used the reflected laser light to focus the tracker on the body, and the laser tracked it out to about 50 kilometers.

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NASA's Planetary Integrated Camera-Spectrometer

Behind the acronym PICS, for NASA's Planetary Integrated Camera-Spectrometer, with its seemingly fitting overtone of "pixels," actually lies a project that is innovative in both concept and execution, according to Jet Propulsion Laboratory researchers most closely involved with its development.

The integrated instrument, conceived for the Pluto Fast Flyby (PFF) mission, combines in one sensor system a near-IR spectrometer (256 spectral channels, 1300-2600 nm), a two-channel imaging camera (300-500 nm, 500-1000 nm), and a UV spectrometer (80 spectral channels, 70-150 nm). The great distance of the planet from Earth (30-50 AU) and budgetary constraints ruled out the use of any but the smallest reconnaissance spacecraft with currently available launch vehicles. In 1993 a NASA Research Announcement invited innovative designs to meet the objectives of the approximately 9-year-long mission to Pluto. Mission science requirements called for two spectrometers and two visible-light cameras in an instrument weighing less than 7 kg and consuming less than 6 W of power.

Since no previous instrument met the design constraints, or even came close, the JPL approach from the outset concentrated on three elements to reach the needed goals: system architecture, detector sensitivity and noise, and materials. The team strove first to maximize the commonality between the different channels of the unit. Thus, all of them use the same primary collecting mirror element, the heaviest mirror in the system. For detectors that require cooling, the heat radiator and the detector assembly form an integrated mechanical subassembly, so designed that the critical components will all run at their optimum temperatures. By sharing the set of foreoptics and a miniaturized, low-power set of electronics to drive the signal chain of all three PICS focal planes, the sensor system comes in weighing 5 kg, requiring 1.5 W of power, and fitting within a total volume of 30 X 30 X 40 cm.

Another pivotal issue considered very early in the design was the need to develop a self-sequencing instrument. That is, it would incorporate an integrated science data-gathering timeline in which the UV and IR spectrometers and the visible cameras would operate in complementary fashion to accumulate data as the spacecraft approaches and then passes Pluto and its satellite Charon. According to Gregg Vane, PICS Program Manager at JPL, earlier planetary missions such as Voyager were plagued with sequencing difficulties. Voyager, which required four optical sensors and a sophisticated scan platform to perform functions equivalent to those of PICS, en-countered such problems because all of those involved in the design "wanted to take data at the closest point of approach."

Sequenced Data-Gathering

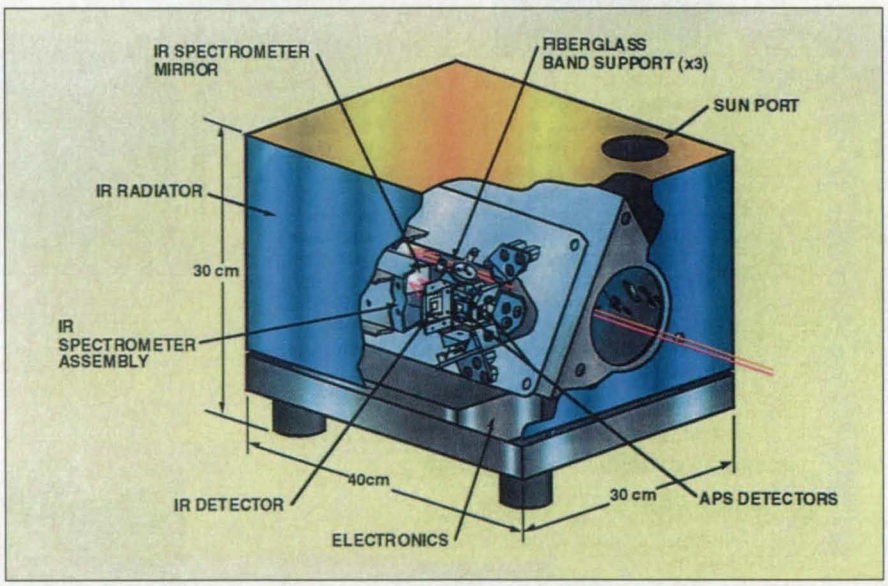
PICS's data, by contrast, will be acquired sequentially by the separate focal planes at times appropriate to provide correct spatial coverage in the respective channels. The integrated sensor system, configured as a long-focal-length instrument, enables data gathering from far out. Because the spatial resolution required for UV data is coarsest, it will be taken farthest from the target. The highest-resolution visible-image data will be taken closest to the planet, and the intermediate-resolution IR in between.

A further advantage is that this design feature eliminates the need for a scan platform, again reducing weight and power requirements. By contrast, Voyager's four-instrument optical remote sensing package, including its scan platform, weighed 200 kg, consumed some 75 W of power, and filled a total volume of close to a meter in both diameter and height. PICS is also expected to cost less than $20 million, whereas the Voyager equipment was more than $100 million.

The team's solution to the complex materials issue turned out to be simple. In addition to the question of mass, the instrument had to have long-term tolerance of a wide range of temperatures, from about 280K on Earth to 40-60K at Pluto. Thus the materials must be highly dimensionally stable, chemically nonreactive, and with good structural capabilities and manufacturability.

The result of this set of constraints was the decision to make the entire instrument, optical and structural, of silicon carbide (SiC). This in turn led to a new approach to the instrument's subsequent development. The JPL designers spent considerable effort in selecting industrial "teaming partners" to carry out the design to take advantage of SiC's strengths and to meet the other project constraints. "We don't think of anyone we worked with as vendors," Vane said. "This was truly a joint design effort. The revolution has really taken place." The PICS structural configuration was developed in collaboration with SSG Inc. of Waltham, MA. Others in the integrated team were Rockwell Science Center (the IR focal plane arrays), the University of Arizona (UV spectrometer), and the U.S. Geological Survey, which is the home institution of the PICS principal investigator, Dr. Laurence Soderblom.

All of PICS's data-gathering systems share a single off-axis Gregorian telescope. Both primary and secondary mirrors are off-axis sections of rotationally symmetric aspheres, enabling them to be fabricated by diamond turning with post-polishing. In the UV spectrometer channel, the primary mirror focuses the light directly through an entrance slit, and an aberration-corrected concave diffraction grating sends it to the UV detector.



Schematic of the Planetary Integrated Camera-Spectrometer. APS = active pixel sensor arrays.

The other instruments share the secondary mirror, an aluminum-coated concave mirror that picks up the fields reflected from a fold mirror. Another fold mirror directs the light to the focal plane assemblies of the two CCD cameras. A dichroic beamsplitter cube splits the light for the two. Diffraction-limited performance is achieved over both CCD fields of view.

Making the infrared imaging spectrometer slit off-axis from the CCD fields enabled the designers to use a small prism bonded to the dichroic cube to split off the light for it. The IR spectrometer had to be small enough to be cooled as part of the cold focal plane assembly to minimize thermal background. The team chose a design from the Czerny-Turner family with an overall focal length of just 7 cm. The field curvature was compensated for by an off-axis segment of a spherical field-flattening lens. The IR spectrometer also uses a plane grating with 110 grooves/mm.

The UV spectrometer uses a toroidal grating with 1400 grooves/mm that focuses the light onto an intensified CCD detector of the same type as that in the visible channel, to simplify data acquisition and control electronics. The grating is holographic to minimize stray light, and produces a flat image plane on the detector, which is a single microchannel plate coupled to a phosphor output.

Another aspect of commonality is that the electronics are integrated: that is, one signal chain serves all of the PICS's channels. State-of-the-art electronics packaging such as hybrids and gate arrays help to minimize mass and size.

Focal Plane Demands

The science requirements of the mission imposed some difficult demands on the design of the IR focal plane. Among them are a need for a very high signal-to-noise ratio of greater than 100 in all spectral channels; high spatial and spectral resolution, requiring at least a 256-X-256-pixel staring focal plane; radiation hardness, especially against the spacecraft's own plutonium-powered RTG power units; and modestly low operating temperature achievable with radiative cooling, obviating the deployment of active coolers.

A further consideration was to base the design on proven IR focal plane array technology. If none could be found to meet all of PICS's requirements, then the goal was to adopt an existing design and make as few modifications as possible to fulfill the design objectives. The PICS focal-plane readout thus represents an evolutionary advancement on the successful Near Infrared Camera and Multi-Object Spectrograph (NICMOS-3) readout developed by the Rockwell Science Center of Thousand Oaks, CA. The NICMOS-3, a Hubble Space Telescope second-generation replacement package, has also been utilized for several years in ground-based astronomical cameras at the world's leading observatories.

Meeting the demanding signal-to-noise ratio needed for high detectivity with the small optical system requires very low read noise. The team will improve on the NICMOS-3's already low noise—about 30 electrons input referred—by eliminating the earlier instrument's reset anomaly, bringing the read noise down to a predicted 10-15 electrons and resulting in greater operating efficiency and some reduction in data-storage requirements.

The JPL team is currently building a PICS flight model for the New Millennium Deep Space I solar electric propulsion asteriod mission, slated for launch in July of 1998. Though the Pluto mission has not yet been approved by Congress, the call for the payload was expected this summer, with a launch target of 2001, and the US Geological Survey will propose PICS for it.

For more information, contact Gregg Vane at (818) 354-2851; Fax (818) 393-4369.

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Army Research Laboratory, Adelphi, Maryland

The self-imaging effect in planar optical waveguides can be used to perform a variety of functions, such as beamsplitting and recombining, beam steering and switching, and signal multiplexing and demultiplexing. Several groups have demonstrated novel self-imaging-based devices in semiconductor waveguide systems.

Using reactive ion etching (RIE) to fabricate these devices produces deep recesses with vertical sidewalls in semiconductor materials. In important waveguide material systems such as $LiNbO_3$ and $LiTaO_3$, however, it is difficult to etch such deep recesses with vertical sidewalls. Researchers at the Army Research Laboratory (ARL) have demonstrated that a partial etch with sloping sidewalls is still sufficient to realize self-imaging. This fabrication technique eases manufacturability, increases applicability to diverse waveguide material systems, reduces insertion loss, and decreases polarization crosstalk.

1-X-N optical beamsplitting is a practicable application of the self-imaging effect in waveguides. Figure 1 illustrates the evolution of the guided field as it propagates through the multimode interference (MMI) region of a 1-X-4 beamsplitting device. The sidewalls of the device reflect the laterally diverging field, and a standing wave interference pattern is produced. An array of output ridge waveguides collects the light where four constructive interference nodes are formed.

To demonstrate self-imaging with the partial-etch technique, the ARL team fabricated 1-X-4 and 1-X-16 beamsplitters on an asymmetric air-GaAs/AlGaAs waveguide. A standard planar process of ion milling took place through a photoresist mask. A scanning electron micrograph of a ridge waveguide adjacent to the device is shown in Figure 2.

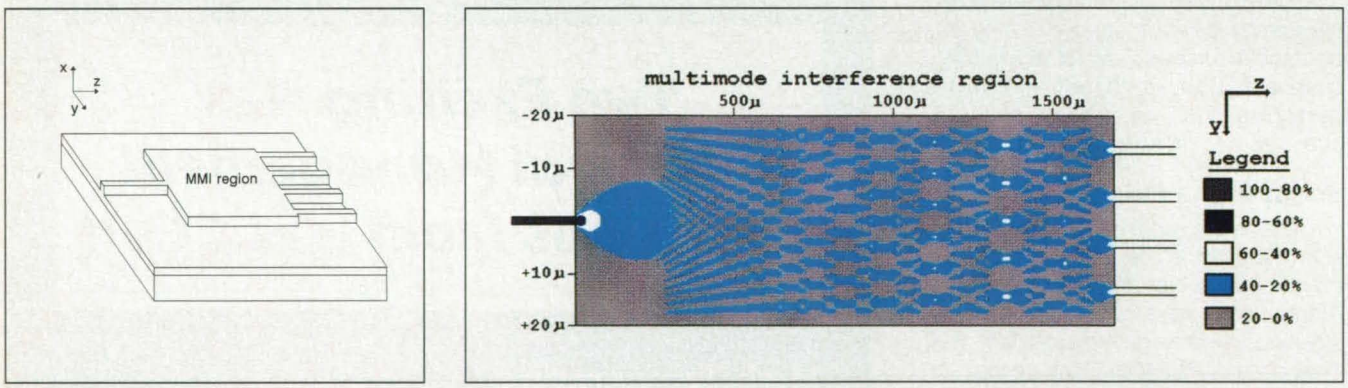

Figure 1. **1-X-4 self-imaging waveguide beamsplitter:** (a) perspective view of the device and (b) computer model of the electric field's evolution through the MMI region.

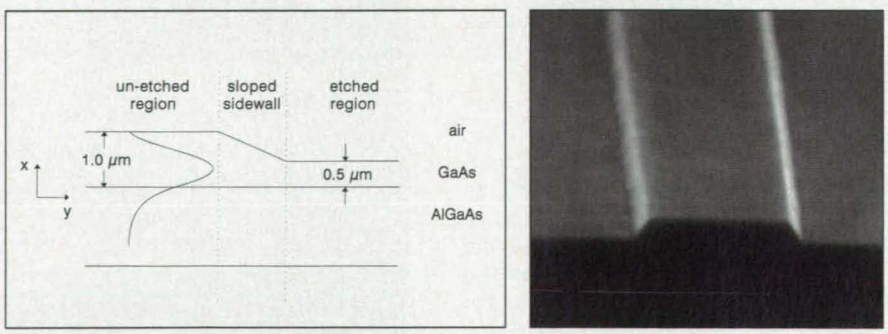

Figure 2. **Transverse waveguide structure:** (a) line drawing of the transverse waveguide and the device sidewall, and (b) scanning electron micrograph of the cleaved facet of a ridge waveguide adjacent to the device. The sidewall slant is 54° relative to the waveguide surface and the etch depth is 0.5 μm.

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Note that the etched recess extends only halfway through the guiding layer and that the sidewalls of the device are sloped at about 54° relative to the surface.

For self-imaging to be realized within a waveguide, the MMI region's sidewalls must form reflective surfaces that still maintain transverse confinement of the guided wave. The partially etched sidewalls form total-internal-reflection (TIR) interfaces for the waveguide modes if two conditions are met: (1) the sidewall profile is constant along the light-propagation direction, and (2) the input(s) to the device have the same transverse-waveguide structure as the MMI region. Under these conditions, the waveguide modes are totally internally reflected regardless of the slope of the sidewall.

The output facet of a 1-X-16 self-imaging waveguide beamsplitter is shown in Figure 3. The best uniformity measured in the 1-X-16 devices was ± 7.8%, and the polarization crosstalk was typically -25 dB for both the transverse-electric to transverse-magnetic (TE-to-TM) and the TM-to-TE conversions. Insertion-loss measurements are typically calibrated against an adjacent straight-through waveguide. In many of the devices fabricated at ARL, the insertion loss in the splitter was actually less than that in the adjacent straight-through ridge waveguide. This low insertion loss and the low polarization crosstalk are attributed to reduced scattering of the waveguide fields off device sidewalls.

A self-imaging waveguide device fabricated with a partial etch of the planar waveguide provides low insertion loss, low polarization crosstalk, ease in manufacture, and application to diverse material systems. These device characteristics lend themselves to integration with the modulators, amplifiers, sources, and detectors of a number of waveguide material systems. Sophisticated signal-processing devices such as wavelength division demultiplexers and optical signal routers are viable using the self-imaging effect.

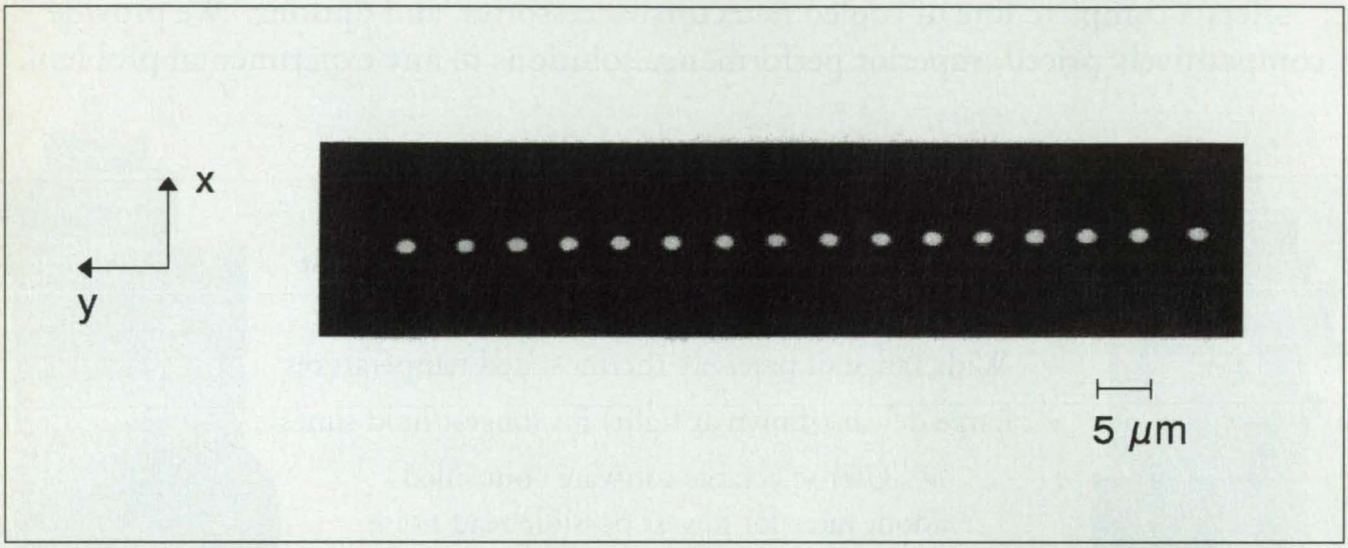

Figure 3. Imaged **output facet** of a 1 X-16 self-imaging waveguide beamsplitter. The output ridge waveguide array pitch is 5 μm.

This work was done by Dr. Tristan J. Tayag and Dr. David M. Mackie of the **Army Research Laboratory,** *Adelphi, MD. Inquiries concerning this technology should be addressed to Director, US Army Research Laboratory, Attn: AMSRL-TT-TA (Norma Vaught), 2800 Powder Mill Rd., Adelphi, MD 20783-1197; (301) 394-2952.*

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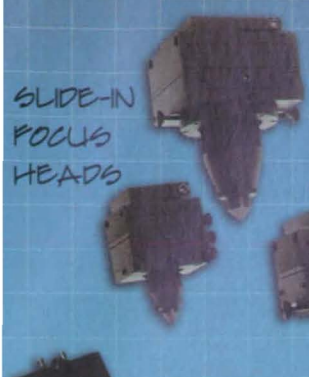
These devices could be useful in medical, automotive, aeronautical, and scientific applications.

NASA's Jet Propulsion Laboratory, Pasadena, California

Microlaser Doppler anemometers (μLDAs) consisting of distributed-feedback (DFB) lasers with integrated binary optics and avalanche photodiode detectors have been proposed. The laser Doppler anemometers now commercially available are large, fragile, power-hungry instruments made with gas or solid-state lasers, optics, and photodetectors as separate units that must be assembled and aligned with each other. The proposed μLDAs would be relatively inexpensive devices that would offer the advantages of low power consumption and compact, rugged, unitary construction that would maintain the alignment of the optics. Furthermore, unlike other miniature flow sensors based on measuring the loss of heat from hot wires and films, the proposed μLDAs would not be difficult to calibrate; the μLDAs would also be much less susceptible to errors induced by changes in temperature, and would not perturb the measured flows significantly. The compactness, ruggedness, and low power consumption of μLDAs would make them attractive for measuring a variety of flows, including (to name a few) flows of blood and/or air in the human body; winds; flows of air near aircraft-control surfaces; and flows of various gases and liquids in automotive engines.

Like older laser Doppler anemometers, a μLDA would measure a flow in a small, remote probe volume by measuring light scattered from particles entrained in the flow. In a basic laser Doppler anemometer, a laser beam is split into two beams that are focused and made to intersect, thereby defining the small probe volume at the intersec-



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COLLIMATORS

BEAM BENDERS

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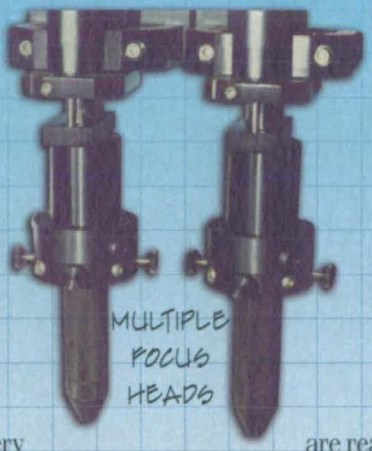

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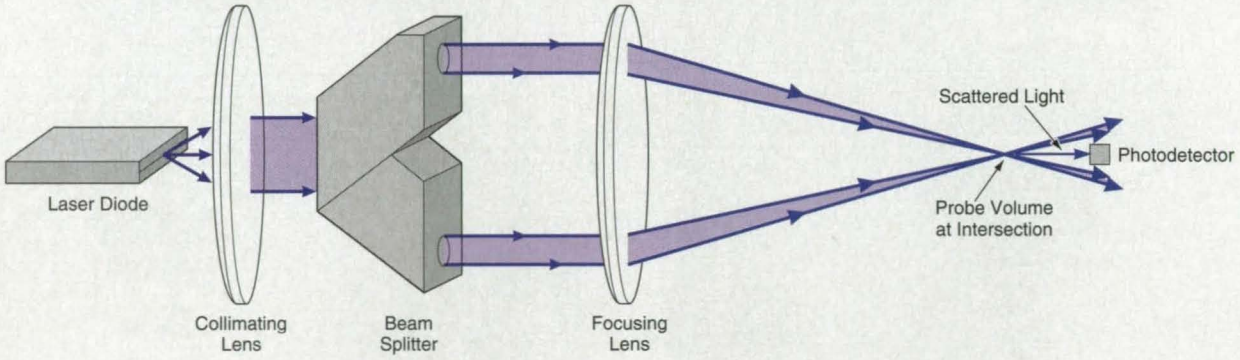
tion. The light scattered by particles passing through the two beams exhibits a slight difference in the Doppler-shifted frequency. This frequency difference, which is proportional to the particle velocity perpendicular to the optical axis in the plane of the beams, is detected as an intensity modulation of the scattered light in isolated "bursts" of light generated by particles passing through the measurement volume. Accordingly, the scattered light is continuously monitored, and the frequency content of these "Doppler bursts" is analyzed to determine particle speed.

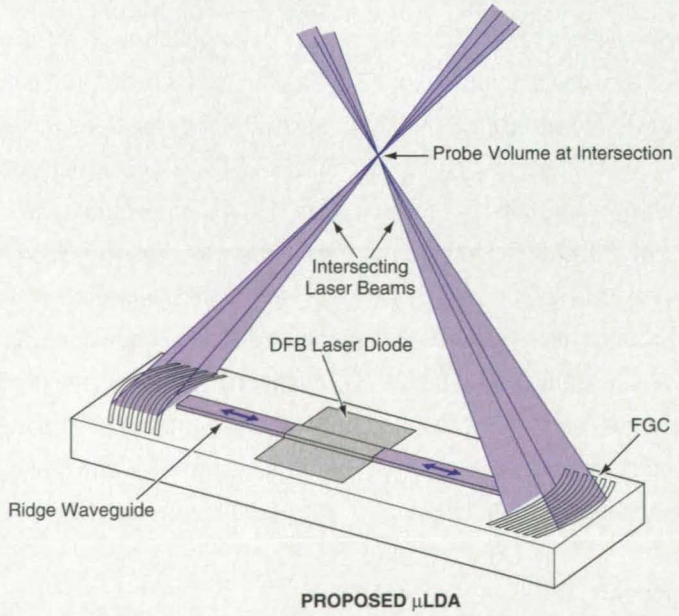
The top part of the figure illustrates a laser Doppler anemometer of typical older design, assembled from separate components. The bottom part of the figure illustrates a typical μLDA. The source of light would be a DFB laser diode with ridge waveguides on both ends. Two focusing grating couplers (FGCs) — on each end — would be connected to the DFB laser diode via the ridge waveguides. All of these components, plus a photodetector (not shown) to measure the scattered light, would be fabricated on one substrate as a unitary optoelectronic integrated circuit.

Instead of splitting a single laser beam as in an older laser Doppler anemometer, the μLDA would generate two coherent laser beams propagating in opposite directions, each traveling along one of the ridge waveguides toward the FGC. The FGCs would be curved, chirped gratings that would diffract the laser beams out of the plane of the substrate at the required angles and would focus the beams into the probe volume.

This work was done by Michael E. Hoenk, Richard D. Martin, and Siamak Forouhar of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 5*** *on the TSP Request Card. NPO-19538*



LASER DOPPLER ANEMOMETER (TYPICAL OLDER DESIGN) MADE FROM SEPARATE COMPONENTS



PROPOSED μLDA

A **Proposed μLDA** (not to scale as shown here) would be an optoelectronic integrated circuit. It would likely be fabricated by combination and extension of microfabrication techniques that have been used to make $AlGa_{1-x}As$-based DFB lasers and electron-beam direct-write techniques that have been used to make diffractive optics.

Thin-Film, Light-Energized Bimorph Micromechanical Actuators

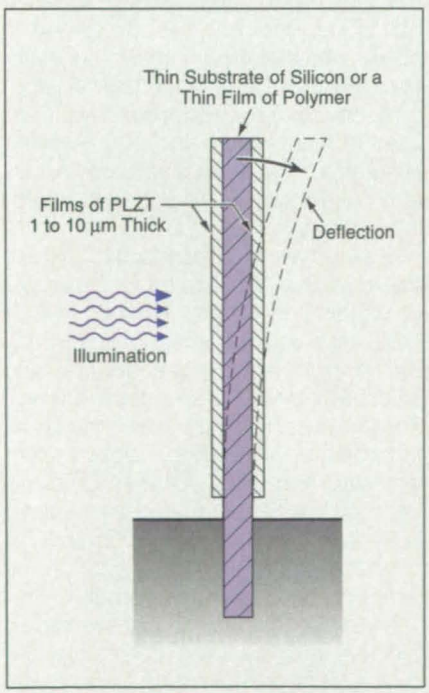
Efficiencies would exceed those of older bulk-piezoelectric devices.

NASA's Jet Propulsion Laboratory, Pasadena, California

Micromechanical actuators of a proposed type would be based on the bimorph concept, but would be energized by incident light instead of by applied voltages. In a given device, light could be supplied by a remote-controlled source or by a built-in semiconductor laser, for example. These devices offer the potential for contactless, precise actuation with tetherless control. They could prove useful in miniature walking, vibrating, or gripping mechanisms that could be used, for example, to power miniature motors, explore terrain, inspect narrow crevices, or hold tissues during microsurgical procedures.

Conventional, voltage-energized bimorphs contain relatively thick wafers of bulk piezoelectric materials. A typical proposed device would contain thin (1 to 10 μm thick) films of the ferroelectric/piezoelectric material lead lanthanum zirconate titanate (PLZT) deposited on opposite faces of a thin (25 to 35 μm thick), flexible substrate of silicon or perhaps a polyimide or other suitable polymer (see figure). The mass of the proposed device would be less than 10 mg — about 1/30 that of a conventional device of similar capability. The capacitance, and thus the response time of the proposed device would be of the order of 1/10 that of the conventional device. Moreover, the proposed device would be about 100 times as efficient.

When exposed to light, a sheet of PLZT exhibits a voltage attributable in part to the ferroelectric effect, and involving physical mechanisms quite distinct from those of semiconductor photovoltaic cells. By the reverse piezoelectric effect, this photovoltage causes the sheet to bend away from the source of light. Thus, a sheet of PLZT can function as a light-driven actuator. To enhance the deflection, two oppositely poled



Thin Films of PLZT on a thin, flexible substrate would constitute a bimorph that, when illuminated, would bend away from the source of light.

sheets can be bonded together on a suitable substrate, as in a conventional bimorph. The photovoltage is believed to be generated within an outer surface layer only 10 μm thick on the side facing the source of light; if true, this would make the proposed low-mass, thin-film design concept feasible.

The greater efficiencies of the proposed devices (in comparison with those of conventional bimorphs) would be obtained by exploiting the following effects:

- Losses caused by bonding processes would be eliminated.
- Losses of light by scattering would be reduced because the densities of defects in the thin films would be much smaller than in conventional piezoelectric ceramic wafers.
- The optical absorption coefficients of thin films can be tailored to be almost 20 percent greater than in the corresponding bulk materials.
- The crystalline structures of PLZT films can be oriented to match the polarization of the incident light.
- By appropriate doping, the response wavelength of the PLZT can be tailored for the visible part of the spectrum. Current materials are most responsive at 350 nm to 370 nm, and therefore, applications specifically in the biomedical arena which utilize near-UV irradiation in the chosen range will immediately exploit the potential of this effect.

This work was done by Sarita Thakoor of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 49*** *on the TSP Request Card.*
NPO-19607

Large-Area Avalanche Photodiodes for Oceanographic Lidar Systems

A laboratory-industry collaboration strives to develop devices to replace the photomultiplier tube.

Naval Air Warfare Center, Aircraft Division, Warminster, Pennsylvania

The Aircraft Division of NAWC and Advanced Photonix Inc. have been working to develop large-area (16-mm) avalanche photodiodes (APDs) for use in blue-green oceanographic pulsed laser radar (lidar) systems. Current lidar systems primarily use a photomultiplier tube (PMT) as a detector. Although the PMT has very low noise and very high gain (105-106), the PMT suffers from low quantum efficiency (QE of 5-20%), moderate dynamic range (3-5 orders of magnitude), and the fragility inherent to a vacuum tube. The large-area APD has a gain of 1000, a dynamic range of 8-9 orders of magnitude, and a QE of 70-80% for the blue-green sector of the spectrum. Also, since the APD is a solid-state device, it is much more robust and less liable to sustain physical damage, a plus for Navy systems. The bandwidth of the large area APD is currently 50 MHz; work is under way to increase this to 100 MHz.

One facet of this development program has been to develop a pixelated imaging APD from the large-area device. Imaging detectors allow lidar systems to do both target detection and target classification with the same receiver. Advanced Photonix has developed a novel reverse etching process that maintains the active area of the original large-area device. This technique has been used to manufacture an 8-X-8 pixelated large-area APD array, and work is currently under way to develop higher-resolution arrays.

Testing has been conducted on both the large-area APD and the 8-X-8 arrays. Measurements have included bandwidth, rise and fall times, quantum efficiency, gain, noise characteristics, and crosstalk between pixels (for the array). These measurements were made as functions of wavelength, optical input intensity, and bias voltage. Crosstalk between pixels was characterized under both continuous-wave and pulsed (3-ns) conditions. Effective pixel size of the array was also measured optically.

The pulse response was measured by injecting a 3-ns laser pulse into the device under test. Its output was amplified by an Analog Modules Inc. Model 382 log amp to increase the dynamic range of the measurement. The measured response of the large-area APD

decays 3 orders of magnitude in 150 ns. The long tail response is believed to be caused by surface defects on the face of the APD that create electron trapping centers, whose long lifetime causes such response to be increased. Work is under way to decrease tail response time. The rise time is 20 ns. The measured response of the array decays approximately 3 orders of magnitude in 60 ns. The rise time of the pixel is on the order of 5 ns.

The effective pixel size was measured by scanning a very small laser spot (0.25 mm) across the pixel under test. Output was monitored with a Keithley Inc. Model 617 electrometer. The measured pixel size was approximately 1 mm. This matched very well with the expected physical pixel size, which was 1 mm.

Crosstalk between pixels was measured by injecting an optical signal into a pixel and, as the power input was increased, noting the current output of an adjacent pixel. The crosstalk is on the order of 1000 to 1.

Testing continues to be conducted on the large-area APD and the pixelated APD array to evaluate their usefulness for lidar and other electro-optical systems. Future work will include forming an image from the array, optimization of the APD's structure for the blue-green spectrum, low-noise amplifier design, and integration of it with the device.

This work was done by David Allocca of AMPAC Inc. and Dr. V.M. Contarino at the **Naval Air Warfare Center, Aircraft Division**, *Warminster, PA. Inquiries about this work may be directed to Mr. Allocca at Ampac, 2640 Amy Dr., Norristown, PA 19403; (215) 441-1957; FAX (215) 441-3470. Alternative contacts are Dr. Contarino, M.F. Squicciarini, and R.I. Billmers at the NAWC, Aircraft Division, Code 5011, Warminster, PA 18974-5000; (215) 441-1569; FAX (215) 441-3470.*

Laser Velocimeter for Measurements Near a Wall

Crossflow velocity is measured more easily.

Ames Research Center, Moffett Field, California

The addition of a probe supporting a mirror at its end enables a laser velocimeter to measure the crossflow velocity directly in turbulent flow near the wall of a wind tunnel. This modification overcomes some of the limitations of prior laser velocimeters used to measure crossflows near a wall. These limitations include low signal-to-noise ratios, insufficient sensitivity to the crossflow velocity, and spurious signals from particles outside the intended small measurement volume in simultaneous multivelocity component measurement applications.

The laser beams enter the wind tunnel approximately perpendicularly to the wall. The probe can be introduced through the same or the opposite wall. The mirror on the probe turns the laser beams through a right angle to grazing incidence on the wall or on a plane near and parallel to the wall. The probe is mounted to move with the other laser velocimeter equipment in scanning the measurement region. Alternatively, the laser beams might be introduced through a fiber-optic head on the probe (see figure on next page).

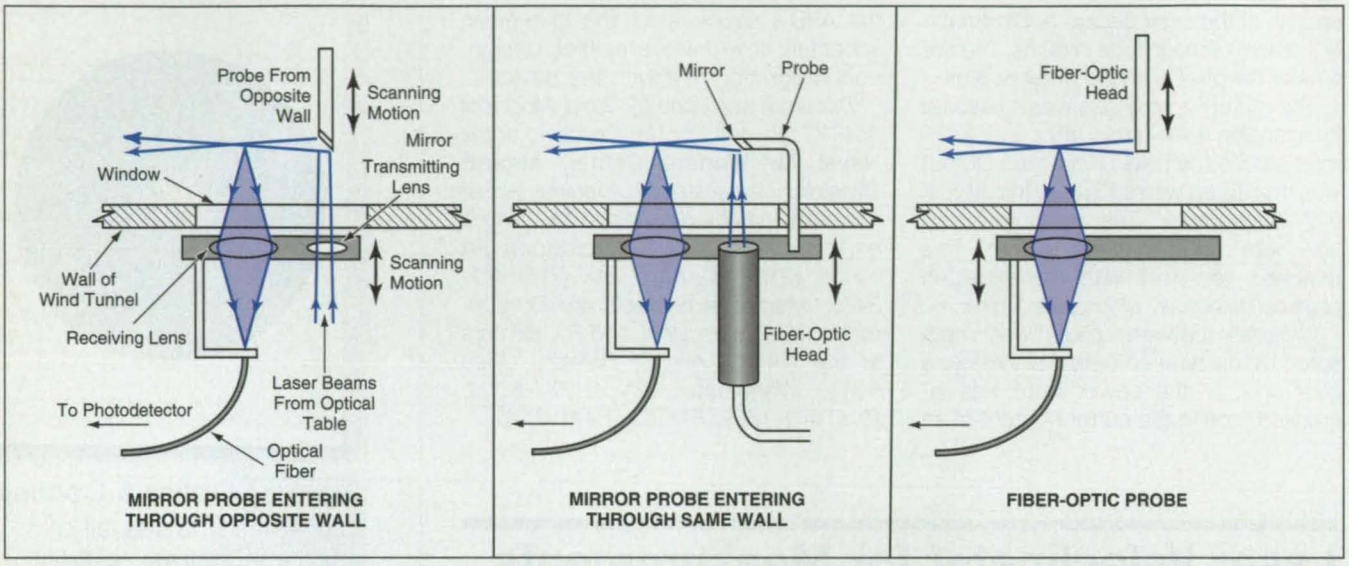
The use of the mirror probe involves three major disadvantages, but it offers several advantages in return. The first disadvantage is that with the introduction of the probe, the technique is no longer noninvasive. The second disadvantage is that one has to measure light scattered from the measurement volume perpendicularly to the optical axis, and this light is considerably less than is light scattered forward (along the optical axis). The third disadvantage is that to minimize spurious scattering of light by the wall and to enable measurements of perpendicularly scattered light, the wall in the measurement region has to be made transparent and optically smooth.

One of the advantages is that the perpendicular scattering provides for shorter sensing volumes (consequently, higher spatial resolution) and, perhaps, better isolation of the velocimetric photodetector from background light. One very important advantage is that the crossflow velocity can be measured directly at a grazing incidence, which allows for better spatial resolution normal to the wall and reduced background light. Another advantage is that the transmitting and receiving lenses can be placed close to the measurement region: this facilitates the use of a small measurement volume, and because the solid angle subtended by the receiving lens is relatively large, this lens can collect a relatively large amount of scattered light to provide a higher signal-to-

noise ratio. Yet another advantage is that measurements of turbulence are relatively free of spurious signals from particles outside the measurement volume in simultaneous multivelocity component measurement applications. Finally, the probe provides increased flexibility with regard to applications in different facilities.

This work was done by D. A. Johnson of **Ames Research Center** *and S. D. Abrahamson of the University of Minnesota. For further information,* ***write in 63*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Ames Research Center. Refer to ARC-12707.



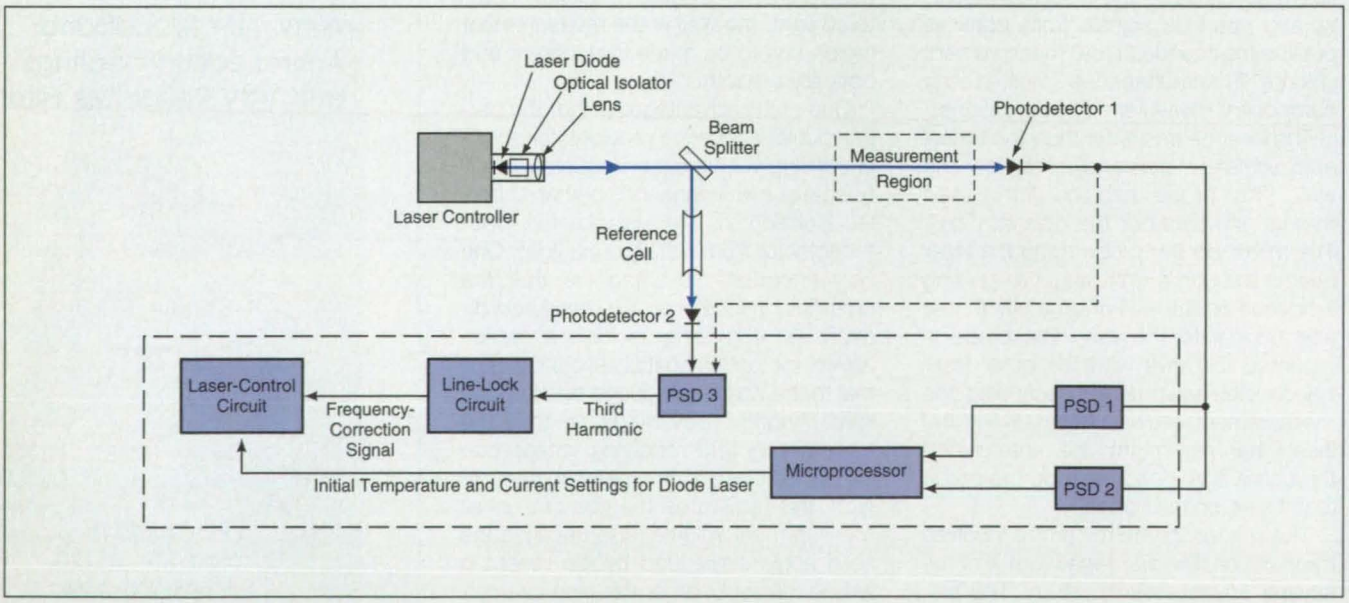
Velocimetric Laser Beams Are Turned to grazing incidence on or near the wall by a mirror on a probe or by a probe equipped with a fiber-optic head.

Off-Line-Locked Laser-Diode Chemical-Species Monitor

A reference gas species could reside outside a reference cell.

Marshall Space Flight Center, Alabama

The figure shows the major functional blocks of an improved tunable-laser-diode gaseous-chemical-species monitor. Like older instruments of the same general type, this one generates a laser beam at the wavelength of a characteristic absorption spectral line of a chemical species of interest, projects the beam through a gas (which could be air), and measures the absorption of the beam in the gas to determine the concentration of the species in question. Also like its predecessors, this instrument includes a reference cell plus a wavelength-dithering feedback control



The **Laser Wavelength Is Alternated** between that of an absorption spectral line of a reference species and that of an absorption spectral line of the species of interest. The reference species can be located in either the measurement volume or the reference cell.

system to lock its wavelength to an absorption spectral line of a known reference species. However, unlike in the older instruments, the reference species need not be the species of interest, and need not reside in the reference cell; these are important advantages when the species of interest is transient or unstable (e.g., a radical), too corrosive to be contained in a reference cell, or a stable species in an excited state that cannot be maintained in sufficient concentration in a reference cell.

These advantages are afforded by an off-line-locking scheme, in which the wavelength is locked to a reference spectral line at a known wavelength that differs from the wavelength of the spectral line of interest by a known amount. This scheme involves operation of the tunable laser diode in alternation between two wavelengths: First, the laser diode is locked to the reference spectral line during a short tuning period. Next, the line lock is temporarily disabled and the wavelength is abruptly shifted by the known wavelength difference to the absorption line of interest and held there during a short absorption-measurement period. The wavelength is then abruptly shifted back to the reference spectral line, the line lock is restored, and the cycle is repeated.

The abrupt shifts in wavelength and the rapid reference-line-locking adjustments of wavelength are effected by changing the laser-diode drive current according to the known dependence of the laser wavelength on the drive current as determined previously in calibration measurements. As part of an initial coarse setting of wavelength near the reference line, the current is initially set at a nominal value according to this known dependence. In addition, the temperature of the diode is maintained at a steady value, in coordination with the initial current setting, according to the known dependence of wavelength on temperature for a given drive current. The wavelength-vs.-temperature and wavelength-vs.-current information are contained in the memory of the microprocessor.

The beam from the laser diode strikes the beam splitter, which diverts a small part of the beam power through the reference cell. The rest of the beam power travels to the measurement region, which can be either an open region or a space inside a sensor head. After passing through the measurement region, the beam is received by photodetector 1, the output of which is fed to phase-sensitive detectors (PSD1, PSD2, and PSD3) in the control and measurement circuitry.

Depending on the chosen mode of operation, PSD1 puts out a signal proportional to either (a) the dc component of the output of photodetector 1 or (b) the first harmonic of the time-varying component of the electrical output of photodetector 1. The dc or first-harmonic signal provides an indication of the intensity of the laser beam in the measurement region. The output of PSD2 is the second harmonic (or a higher even harmonic), which provides an indication of absorption by the species of interest. The microprocessor divides the second-harmonic signal by the first-harmonic signal to obtain a normalized absorption signal that is independent of variations in the intensity of the laser beam or of partial obscuration of the optics by dirt.

If the reference species is located in the measurement region, then the off-line-locking scheme utilizes the output of photodetector 1. If the reference species is located in the reference cell, then the scheme utilizes the output of photodetector 2, which receives the small portion of the laser beam that has passed through the reference cell. In either case, the applicable photodetector output is fed to PSD3, which puts out a signal proportional to the third harmonic (or a higher odd harmonic). This signal constitutes an error signal, which is zero when the laser wavelength equals the reference wavelength. This error signal is supplied to the line-lock circuit, which generates a frequency-correction

signal for the laser-control circuit.

This work was done by Jamine Lee, Steven Richtsmeier, Neil Goldstein, Michael Gersh, and Fritz Bien of Spectral Sciences, Inc., for **Marshall Space Flight Center.** *For further information,* ***write in 94*** *on the TSP Request Card.*

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

Spectral Sciences, Inc.
99 South Bedford St., #7
Burlington, MA 01803-5169

Refer to MFS-26352, volume and number of this NASA Tech Briefs *issue, and the page number.*

Long-Trace Profiler for *In-Situ* and Vertical Scanning Applications

Precision metrology of x-ray mirror surfaces is available in harsh environments and over a 3-D area.

Brookhaven National Laboratory, Upton, New York

The long-trace profiler II (LTP II) is used to measure the shape of large flat and cylindrical aspheric mirrors used in synchrotron radiation (SR) beamlines. This instrument was originally developed at Brookhaven as part of a program funded by the US Dept. of Energy Office of Basic Energy Sciences in collaboration with Lawrence Berkeley Laboratory. A cooperative research and development agreement (CRADA) was established with Continental Optical Corp. to meet the demand from laboratories and institutions around the world for instrumentation to measure grazing-incidence mirrors, and to develop new applications for the instrument.

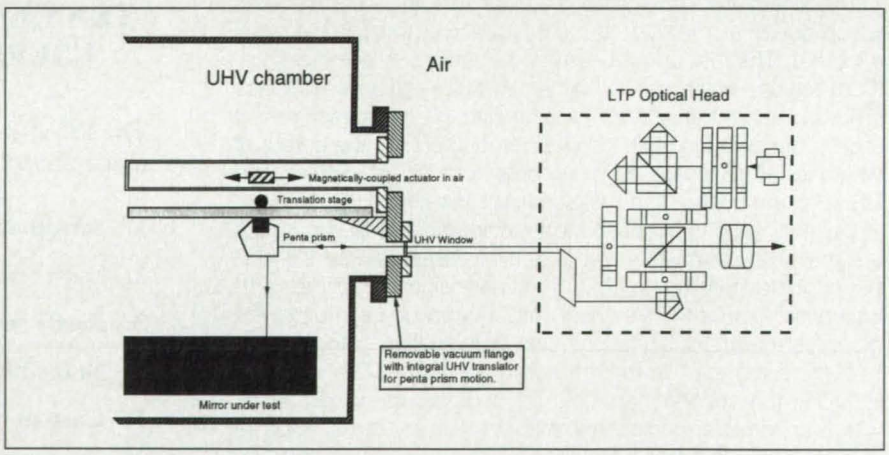
Continental Optical is developing an *in-situ* LTP (ISLTP) to be used to measure the shape and distortion of mirrors subjected to extremely high heat loads in the ultrahigh-vacuum environment of SR storage rings, and a vertical-scan LTP (VSLTP) to measure the three-dimensional shape of large x-ray telescope components.

The LTP is designed to measure the figure of large aspheric mirrors used to reflect x-rays at extreme grazing incidence angles. Mirrors used in grazing-incidence SR beamlines are often shaped like segments of cylinders or toroids, or far-off-axis conic sections such as paraboloids and ellipsoids. These mirrors are difficult to manufacture, since they require unconventional grinding and polishing techniques, and they are extremely difficult to measure by conventional optical testing techniques.

The LTP uses a noncontact optical probe mounted on a precision air bearing slide to scan down the length of the optical surface. The probe consists of a collimated laser beam split into two collinear beams separated by a distance of one millimeter. They are reflected off the test surface during the scan and are recombined and brought to a focus onto a linear-array detector. The position of the interference fringe on the detector records the local slope of the surface under test, and the height profile of the surface is computed by integrating the slope values. The intrinsic noise level of the system is less than 0.5 microradian per point, which permits measurement of slope errors in the range of 0.1 arc second with high precision and accuracy. The instrument is optimized to measure errors on the meter-long optics used in SR beamlines and for x-ray telescopes.

The ISLTP is being developed in collaboration with the Advanced Photon Source at Argonne National Laboratory and Sincrotrone Trieste in Italy. Because of the high-radiation environment and ultrahigh-vacuum compatibility requirements, the standard LTP configuration is modified so that the optical head remains stationary while the probe beam is scanned across the surface by a penta prism moving on a linear translation stage. Only the prism and translation stage are inside the vacuum chamber. The optical head can be easily shielded from stray x-ray radiation outside the chamber. The design goal for the ISLTP is to make the system portable by mounting the entire scanning system on a single UHV flange that can be easily removed from the mirror chamber and installed on another chamber as necessary.

The VSLTP incorporates a precision rotation stage for azimuthal scan capability and a vertical linear translation stage to move the scanning prism over the entire surface of x-ray telescope components. The system is designed to measure both the exterior surface of highly polished mandrels and the interior surface of replicated telescope cylinders. The vertical configuration minimizes the effects of gravity distortion on the measurement and permits accurate measurement of the true surface shape. The 3-D surface scan capability can also be applied to the standard LTP to measure the complete surface of large flats, long-radius spheres, and other cylinders in the horizontal scan configuration.



Schematic of the ***in-situ*** **long-trace** profiler for scanning surfaces in ultrahigh vacuum in high-radiation environments at synchrotron radiation light sources.

This work was done by Peter Z. Takacs at **Brookhaven National Laboratory.** *For information regarding the use of this technology, contact Dorry Tooker, Office of Technology Transfer, Brookhaven National Laboratory, Building 902C, PO Box 5000, Upton, NY 11973-5000; (516) 282 7338.*

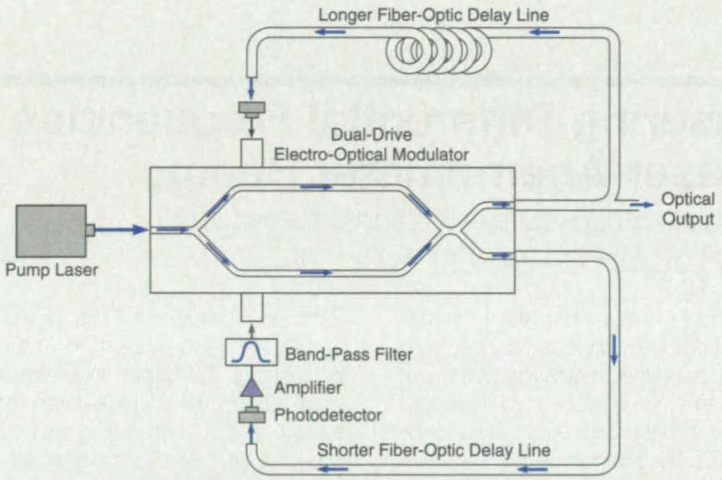
Self-Injection-Locked Electro-Optical Microwave Oscillator

Delayed feedback injection-locks the oscillator to its past output.

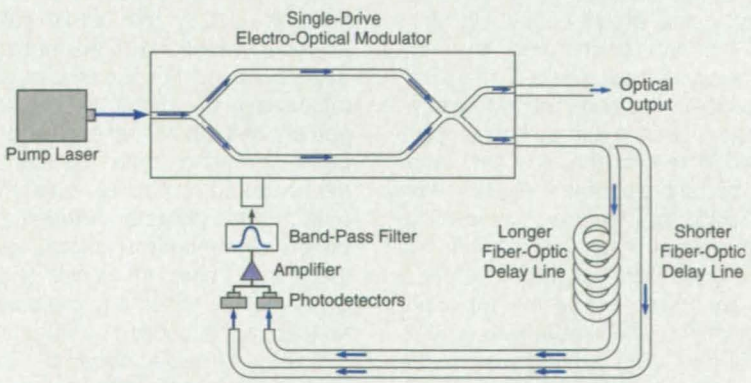
NASA's Jet Propulsion Laboratory, Pasadena, California

An experimental self-injection-locked electro-optical oscillator has been constructed as a prototype of hybrid photonic/electronic devices that would produce stable optical signals amplitude-modulated by microwave signals with frequencies up to 70 GHz, making those signals available as both optical and microwave outputs. These devices could be particularly useful in cellular telephone systems, where they could serve as photonic/electronic frequency converters (both up and down) that would be installed at antennas for fiber-optic communication between the antennas and remote base stations.

The injection-locking technique has been widely used to stabilize microwave oscillators. However, the success of this approach depends on the availability of low-noise, stable-frequency injection signals. Heretofore, the injection signals were generated by separate low-noise, stable-frequency oscillators. The present approach to injection locking eliminates the need for a separate injection-signal source. Instead, a delayed, attenuated sample of the output of the oscillator



CONFIGURATION WITH DUAL-DRIVE ELECTRO-OPTICAL MODULATOR



CONFIGURATION WITH SINGLE-DRIVE ELECTRO-OPTICAL MODULATOR

This **Electro-Optical Microwave Oscillator** features injection locking to a delayed replica of its own output via a fiber-optic delay-line discriminator.

itself is used as the injection signal, so that the oscillator becomes locked to its own past output; this inhibits the oscillation from changing its frequency and phase, reducing fluctuations in phase and frequency.

The figure illustrates two alternative configurations of the present self-injection-locked electro-optical oscillator. As in the previous apparatus, the feedback loop for radio-frequency oscillation in this apparatus includes a fiber-optic delay line coupled to a photodetector, an amplifier, and a radio-frequency bandpass filter, the output of which is applied to an input terminal of the electro-optical modulator. The present apparatus also includes a second feedback loop that serves as the injection-locking loop. The injection-locking loop is similar to the oscillation feedback loop except that its fiber-optic delay line is longer (e.g., as long as 12 km) to provide the necessary delay. Moreover, to prevent oscillations from starting in the injection-locking loop, the magnitude of its loop gain is set at much less than 1.

The remaining instability of the radio frequency is expected to be due largely to fluctuations in the lengths of the fiber-optic delay lines. Thus, further reductions in frequency and phase noise should be achievable by maintaining the delay lines at a constant temperature and isolating them from vibrations.

This work was done by Xiaotian Steve Yao and Lutfollah Maleki 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-19568, volume and number of this NASA Tech Briefs *issue, and the page number.*

Measuring Differential Frequencies of Laser-Anemometer Beams

Uncertainties caused by vibrations are reduced.

Lewis Research Center, Cleveland, Ohio

A method of measuring the instantaneous difference between the frequencies (the beat frequency) of two input laser beams in a fiber-optic-coupled laser-anemometer probe head has been developed. The instantaneous beat frequency of the laser beams must be measured because it must be subtracted from the corresponding beat frequency in the probe output signal to obtain the Doppler shift and, thus, the flow velocity that one seeks to measure.

A laser anemometer of the type in question is used in aerodynamic experiments. To reduce the size and complexity of the probe head, all laser-beam conditioning and electronic processing of signals are performed outside the aerodynamic test chamber. Optical fibers are used to transmit the input laser beams to the probe head, and to transmit the output beams from the probe head to the signal-processing circuits. Although the laser beams are generated with a preset beat frequency (usually 40 MHz), there is no assurance that the input laser beams are launched from the probe head into the flow with this same beat frequency; this is because vibrations of the probe head generate stress waves in the fibers, modulating the input laser beams in such a way as to cause random frequency shifts, thus giving rise to large uncertainties in instantaneous measured velocities.

Thus, it is necessary to measure the input-beam beat frequency in the probe head to obtain the actual value as altered by vibrations. In the method that was developed for this purpose, a prism mounted in the probe head extracts 1 percent of the power of each input laser beam and sends both 1-percent sample beams to a nonlinear detector. The output of the detector includes a component at the beat frequency, which is the preset beat frequency (e.g., 40 MHz) plus or minus any instantaneous frequency shift caused by vibrations.

This work was done by Dariush Modarress and Thomas Hoeft of Physical Research, Inc., and David F. Schaack, consultant, for **Lewis Research Center.** *No further documentation is available. LEW-15619*

Nonintrusive Stress Measurement System

A technology uses light probes to test stress on gas-engine rotor blades.

Engineering Development Center, Arnold Air Force Base, Tennessee

In the mid-Seventies AEDC personnel began developing a technique called the nonintrusive stress measurement system (NSMS) to help them test gas-turbine engines. The purpose was to develop an alternative to the traditional strain-gage method commonly used to make stress measurements on gas-turbine engine rotor blades during simulated altitude testing of aircraft engines.

Before NSMS was developed, engineers would attach strain gages directly to the blade surfaces with their signals exiting the engine through slip rings or by radio telemetry. These surface-mounted gages and the associated wiring would often interfere with the aerodynamic performance of the engine. Also, whether they lasted hours or failed within a matter of seconds, these traditional gages had a very limited life span because of the engine's extremely high temperatures. When the gages failed, replacing them was very expensive, because engineers would have to disassemble the engine to install new gages.

NSMS uses light probes to detect passing events on blade tips (Fig. 1). Engineers mount the probes (Fig. 2) through the engine's casing along the blade's rotation path. Light from a laser is transmitted through optical fibers (Fig. 3) and focused through a lens into the blade tip's path. As a blade passes, a portion of the light is reflected back through the lens into a receiving fiber optic photodetector. By timing and processing these events, engineers can determine blade-tip vibratory deflections.

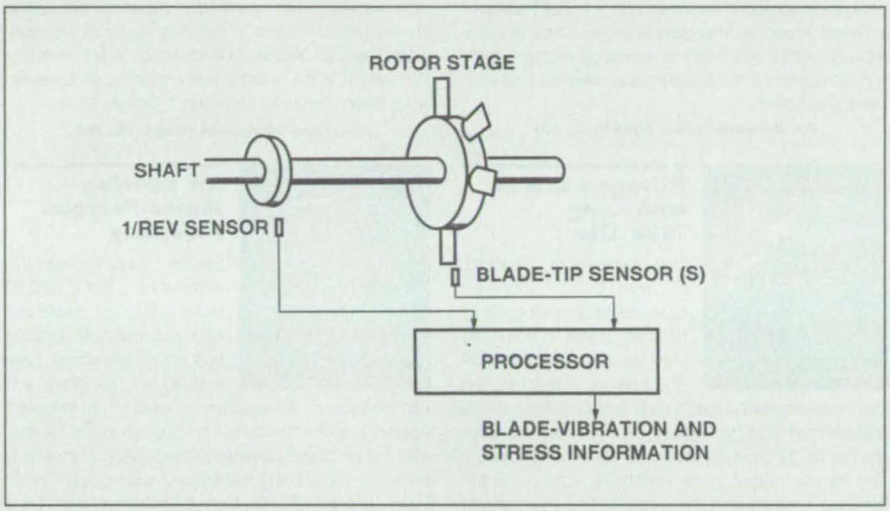


Figure 1. Conceptual configuration of **Nonintrusive Stress Measurement System.**

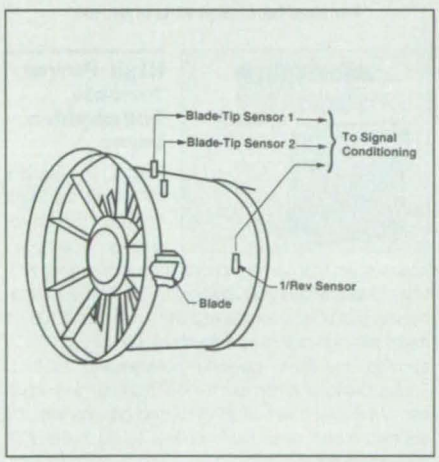


Figure 2. Arrangement of **Two Blade-Tip and 1/Rev Sensors.**

From one to four light probes are used for each rotor stage, depending on the measurement requirements. One probe can measure vibration amplitudes; two probes allow vibration phase and frequency to be determined. Four probes are needed to detect vibration frequencies that are integer multiples of the rotor speed. Probe separation angles around the case's circumference are determined by the blade's vibration frequency range or by the bladed-disk system-mode vibration pattern.

The AEDC NSMS can provide monitoring of selected or all blade rows simultaneously. Unprocessed digital data are continuously stored on optical disk. Processed data can be displayed in a variety of formats, including Campbell diagrams, FFTs, modal analyses, and vibrational amplitude presentations. Stress conversions are possible where the deflection-to-stress transfer functions have been entered into the database.

The advantages of using the NSMS to support engine testing are improved sensor reliability, increased measurement coverage to all blades in the instrument row, improved measurements in the hot sections of the engine, and minimized repair due to failed sensors. Potential additional applications of the NSMS technique are routine health monitoring of aircraft engines in flight and the monitoring of industrial machinery with rotor-blade assemblies.

Nonintrusive measurements of rotor blade vibrations using light probes are currently being applied and improved by major US engine manufacturers. The NSMS technique has proven to be a valuable supplement to the strain gage, and has replaced the latter in some engine tests.

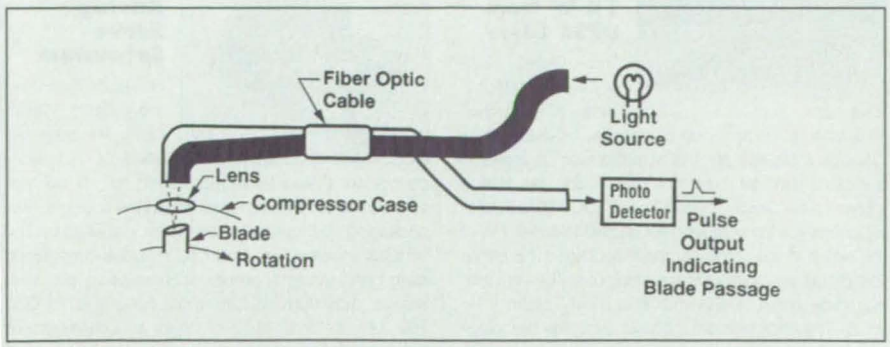


Figure 3. Functional schematic of the **Blade-Tip Sensor.**

This work was done by Sverdrup Technology, Inc., propulsion contractor for the US Air Force's **Arnold Engineering Development Center.** *Inquiries concerning rights for the commercial use of this invention should be directed to Henry Jones or Joe Babilon, AF/DOPT, Arnold Engineering Development Center, Arnold AFB, TN 37389-5050; (615) 454 4330.*

NEW PRODUCTS

Pentium-Based Laser Beam Analyzer

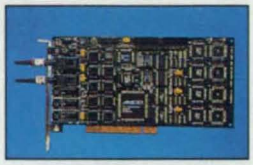
The LBA-300PC from Spiricon, Logan, UT, provides what the company calls the most advanced technology for laser beam analysis. The Spiricon framegrabber runs on the PCI bus of advanced PC computers. The LBA-300PC software runs under Windows 3.1 or Windows 95® to provide multiple new features, including 512 X 480 resolution and Ultracal® for more accurate spatial measurements.

For More Information Write In No. 800

Solid-State Single-Frequency Green Laser

The all-solid-state diode-pumped frequency-doubled Nd:YVO_4 laser called Verdi® by Coherent Inc., Santa Clara, CA, delivers more than 5 W of single-frequency continuous-wave green (532-nm) output. Noise (10 Hz-1 GHz) is less than 0.1% rms and the beam is near-diffraction-limited. The package is compact: the laser head is about the size of a typical shoebox. The company calls Verdi an ideal replacement for gas lasers in metrology, reprographics, and pumping of tunable continuous-wave and ultrafast Ti:sapphire lasers.

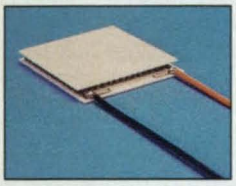
For More Information Write In No. 801



Multichannel PCI Frame-grabber

PixelVision Inc., Beaverton, OR, designed the Lynx™ multichannel PCI frame-grabber to capture 8, 12 and 16-bit output from scientific and nonstandard digital CCD cameras. It can accommodate fiber-optic or serial cable input from up to four cameras simultaneously. The bus data transfer rate of >55 Mbytes/s makes possible transfer of an unlimited number of consecutive frames across the bus in real time. Available with software drivers for Microsoft Windows 95, Windows NT, or Windows 3.1, the board is also offered as an accessory for PixelVision's SpectraVideo™ digital cameras.

For More Information Write In No. 802



Thermoelectric Cooling Above 200°C

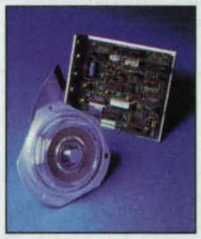
Melcor Corp., Trenton, NJ, designed the Therma-TEC™ family of thermoelectric coolers for cooling, packaging, and power-generation applications operating up to and beyond 200°C. First in the series is the HT6-12-40, with a heat-pumping capacity of 52 W and maximum values of 14.4 V and 6.0 A. The product targets cooling applications in biomedical equipment, high-temperature electro-optic packaging, and microprocessors and electronics operating in harsh thermal conditions.

For More Information Write In No. 803

Nitrogen Lasers with Long Tube Life

Oriel Instruments, Stratford, CT, says that a proprietary tube sealing technology for its nitrogen lasers yields long shelf life and more than 10^8 shots per fill. The lasers can generate ultraviolet pulses 5 ns in duration with energies greater than 300 microjoules. An optional dye laser module adds tunability over the 360-750-nm range, and its two output ports permit the user to switch between nitrogen and dye outputs. The dye module accepts a fiber optic focusing adapter for SMA-terminated high-power fibers 200 µm or larger in diameter.

For More Information Write In No. 804



Air Bearing Motor-Polygon Assembly

Lincoln Laser, Phoenix, AZ, introduces the SA24C motor-polygon assembly. This compact air bearing scanner is bidirectional, uses a brushless DC motor, and can operate in any position in which it is mounted. According to the company, it is the smallest and the lowest-cost air bearing device on the market, comparably priced to those using ball bearing technology. Lincoln Laser says the SA24C's high-speed mirror rotation and tight tracking accuracy make it a low-cost alternative for all high-speed scanning applications.

For More Information Write In No. 805

All-Solid-State OPA System

Spectra-Physics Lasers, Mountain View, CA, offers what it calls the first all-solid-state kHz femtosecond optical parametric amplifier (OPA) system. The system comprises the Tsunami mode-locked Ti:sapphire oscillator, the new-generation Spitfire II kHz regenerative amplifier, and the OPA-800. The latter's output pulses are <130 femtoseconds with up to 100 µJ power and wavelength coverage from 1.1 µm to 3.0 µm. Harmonic generation and difference-frequency-mixing options provide wavelength extension from <300 nm to >10 µm.

For More Information Write In No. 806

Desktop Vibration Isolation Unit

A line of desktop vibration isolation systems, called the Table-Topper™, for small-scale experiments from Melles Griot, Irvine, CA, comes in two versions, automatic- and manual-levelling. The rigid steel working surface, laminated with vibration retardant, can be supplied with drilled or tapped holes in standard 1/4-20-on-1-inch centers or M6-on-25-mm centers. The outer frame links all components and adds overall rigidity. The automatic version includes an air filter, auto-leveller sensors, and a regulator; the manual system comes with a hand pump and valve adjustment tool.

For More Information Write In No. 807

High-Power Tunable Ti:Sapphire Laser

Polytec PI, Auburn, MA, offers the Elight Ti:Flash flashlamp-pumped Ti:sapphire laser system that can be adapted or customized to provide pulse energies from 200 mJ to 2.5 J. The company says that pulse energies of 2 J at a rep rate of 100 Hz make this high-power version of the Ti:Flash, at 200 W average, the most powerful commercially available Ti:sapphire laser. It can reach the 2-3-µm range through use of the idler beam of an OPO, and can mix with the doubled output of an Nd:YAG laser to reach the 300-330-nm range.

For More Information Write In No. 808

Blue 10-mW DPSS Laser

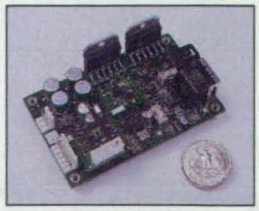
A diode-pumped solid-state (DPSS) laser, the ICD-430 from HMG Photonics, Auburn, MA, uses the doubled output of a new crystal, Cr:LiSrAlF (or Cr:LiSAF), to provide a 10-mW single-mode output beam in the blue at 430 nm. The company says it is ideal for compact-disk mastering, which requires a highly stable output, as well as data storage, biofluorescence, and lithographic applications. A high-speed feedback loop controls frequency instabilities, and a second loop at a lower frequency stabilizes the doubling crystal temperature to retain peak power.

For More Information Write In No. 809

More than 10 W from DPSS Laser

The Series 220 diode-pumped solid-state (DPSS) Nd:YAG laser from Lightwave Electronics, Mountain View, CA, is now capable of 11 W output power. Designed as a replacement for lamp-pumped lasers, the device incorporates "Direct-Coupled Pump" (DCP™) technology to increase the output power above the earlier 7 W of the series in the same compact package. The Series 220 produces continuous-wave output at 1064 nm with amplitude noise <0.2% rms in a TEM_{00} beam (M^2= <1.2). The microprocessor-based controller has diagnostics for performance monitoring.

For More Information Write In No. 811



Compact Analog Servo Subsystem

General Scanning Inc. (GSI), Watertown, MA, says the MiniSax, a credit-card-sized analog servo subsystem for the company's closed-loop galvanometric scanners, opens new packaging, performance, and price possibilities. The MiniSax enables easy mounting in space-constrained scan-head designs, where scanner/servo proximity insures maximum performance, according to GSI. The fully featured MiniSax offers a comprehensive command interface.

For More Information Write In No. 813

LITERATURE SPOTLIGHT

Free catalogs and literature for *Laser Tech Briefs*' readers. To order, write in the corresponding number on the Reader Information Request Form (opposite page 81).

IMPROVE ANY FUZZY PROBLEM WITH APART!

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Breault Research Organization Inc.

For More Information Write In No. 300

POLISHING EQUIPMENT FOR SMALL LENSES

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

Larsen Equipment Design

For More Information Write In No. 301

NEW INFRARED OPTICS CATALOG FOR RESEARCHERS, MANUFACTURERS, AND OPTICAL ENGINEERS

II-VI Incorporated, Saxonburg, PA, a worldwide leader in IR laser optics, is now offering a 48 page, full color optics catalog. This catalog is designed to assist researchers, manufacturers and users with the proper selection and specification of optics. It features detailed information on all significant aspects of infrared optics, including IR Materials.

II-VI Incorporated

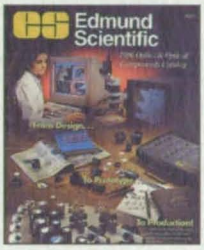
For More Information Write In No. 302

CCD CAMERA WITH MANY OPTIONS

A 128-page full-color catalog of "High-Performance Digital CCD Cameras" from Princeton Instruments outlines the company's line, with applications from microscopy to astronomy. The cooled slow-scan imaging CCD cameras have spectral response from x-ray to the near infrared. The catalog has specifications for the more than 30 CCD chips offered in the cameras, and application notes to help in selecting from the line. Princeton Instruments, Inc., 3660 Quakerbridge Road, Trenton, NJ 08619; (609) 587-9797; Fax: (609) 587-1970. **http://www.prinst.com**

Princeton Instruments

For More Information Write In No. 303



NEW! OPTICS & OPTICAL COMPONENTS CATALOG

Edmund Scientific provides technical design and production solutions with our extensive inventory of precision optics and optical components. 236-page color catalog features one of the largest selections of precision off-the-shelf optics and optical instruments. Over 8,000 hard-to-find items, including a large selection of magnifiers, magnets, microscopes, telescopes, and "machine vision" products. Tel: 609-573-6259; Fax: 609-573-6233.

Edmund Scientific Co.,
Industrial Optics Division Dept. 16B1, N948

For More Information Write In No. 304

NEW CROSSHAIR PROJECTOR

Lasiris introduces its new crosshair projector featuring the same high-quality, non-gaussian line as its single line projector. The patented crosshair uses a single laser and optical element to generate the crossed lines, thus avoiding the use of two lasers or a complex beamsplitter configuration. It is available in a wide range of fan angles, power outputs and wavelengths. Lasiris, Inc., 3549 Ashby, St. Laurent, Quebec, Canada H4R 2K3; Tel: 800-814-9552; 514- 335-1005; Fax 514-335-4576.

Lasiris, Inc.

For More Information Write In No. 305

THERMOELECTRIC COOLER SHORT-FORM CATALOG

Melcor Corp., Trenton, NJ, releases a new six-page shortform catalog design to give the engineer considering thermoelectric coolers (TEC) the information necessary for feasibility, selection, and performance modeling. Model numbers, performance values, physical characteristics, and options are provided for the company's standard product lines, including the CP series with moderate to high heat-pumping capacity; FC subminiature series with low current capacity; center-hole TECs; and multistage (cascaded) TECs. The catalog also features an introduction to TECs, their benefits and applications, and a "Frequently Asked Questions" section. Melcor Corp., 1040 Spruce St., Trenton, NJ 08648; Tel: (609) 393-4178; Fax (609) 393-9461.

Melcor Corp.

For More Information Write In No. 306

MOVING MAGNET GALVANOMETRIC SCANNER

The number of applications requiring fast and accurate placement of laser light or energy is growing at a very high rate. Cambridge Technology is a world leader in optical scanner technology, supplying key components to laser beam-steering systems. In response to industry trends, Cambridge Technology's new Model 6860 Moving Magnet Galvanometer-Based Optical Scanner is the latest addition to a series of high-performance mirror positioning optical scanners. For more information, contact Cambridge Technology, 23 Elm St., Watertown, MA 02172-2821; Tel: (617) 923-1181; Fax: (617) 924-8378.

Cambridge Technology Inc.

For More Information Write In No. 307

DPSS SLAB LASER BROCHURE

Descriptive literature is offered by the manufacturer of high-average-power diode-pumped solid-state (DPSS) slab lasers for commercial and industrial applications. Systems are available in quasi-CW configurations for operation to 2 kHz, and CW pumped to 20 kHz. Output powers in excess of 100 W and energy levels to 1 J are available. Cutting Edge Optronics Inc., PO Box 11621, St. Louis, MO 63105; Tel: (314) 895-4884; Fax: (314) 895-8833.

Cutting Edge Optronics Inc.

For More Information Write In No. 308

NEW LITERATURE

Off-Axis Parabolic Mirrors and Mounts

The 12-page color brochure from Space Optics Research Labs (SORL), Chelmsford, MA, contains detailed information about the company's line of off-axis parabolic mirrors (OAPs) and the MMOA Series mounts designed for stable, strain-free use with them. SORL OAPs are polished to precise surface figure tolerances on ceramic, glass, and metallic substrates for the UV, VIS, and IR. The brochure describes OAP production, mounting, alignment, and testing methods as well as specifying considerations, and gives technical data on both OAP and mount product lines. SORL provides OAPs on a standard and custom basis.

For More Information Write In No. 820

VUV-to-NIR Optics and Coatings

A 52-page "Optics and Coatings" catalog from Acton Research Corp., Acton, MA, contains all its standard optical components provided in single pieces as well as large OEM quantities. Products include excimer and UV laser optics, VUV and UV coatings for beamsplitters and mirrors, window and substrate materials, windows, curved and flat mirror blanks, cylindrical and spherical lenses, many kinds of filters, and monochromators and accessories.

For More Information Write In No. 823

Laser Diode Control Products

The "1996-7 Laser Diode Instrumentation Catalog" from ILX Lightwave, Bozeman, MT, contains full details and specifications of the company's lines of laser diode controllers, current sources, temperature controllers, laser diode analysis equipment, and laser diode mounts. Tech notes are interspersed throughout. A separate section details accessory products available, and there is a 24-page applications guide. The booklet concludes with descriptions of ILX Lightwave's other catalogs, "Laser Diode Instrumentation" and "Fiber Optic Test & Measurement Instrumentation."

For More Information Write In 826

Precision Measurement and Sensing Instruments

New from Automated Precision Inc., Gaithersburg, MD, is a 16-page brochure of its measurement and sensing instruments for the calibration and maintenance of machine tools, robots, and coordinate measuring machines, and for the measurement of machined parts. Among the products is a 6-D single-beam laser-tracking interferometer system for large dimensional measurements. Another is a complete metrology system for CNC machining-center performance evaluation.

For More Information Write In No. 829

Global Fiber Cable Solutions

The recently formed Optical Fiber Cable Division of AMP Inc., Harrisburg, PA, has issued a 20-page catalog showcasing fiber optic cable for the worldwide premises/networking, original equipment manufacturing, and telco/CATV industries. The color catalog expands on the earlier product line, adding low smoke zero halogen cable, and streamlines part numbers into one global set. Sections include interconnect, distribution, breakout, outdoor, and indoor/outdoor cable types, and provide basic specifications and construction details for all standard fiber cables.

For More Information Write In No. 821

Photonics Research Catalog Supplement

As an update of its 1995-96 main catalog, New Focus, Santa Clara, CA, has issued a 16-page color supplement. Featured are customer-inspired improvements to existing lasers and Picomotor positioners and drivers, the Nirvana DC autobalancing photoreceiver, fiber Bragg gratings (in cooperation with 3M), Models 5566-5569 broadband optical isolators, the Model 7711 Fizeau wavelength meter, a line of stainless steel "pint-sized" mounts, and the Model 6238 tunable diode laser with a center wavelength of 980 nm.

For More Information Write In No. 824

Broad Line of Optoelectronic Products

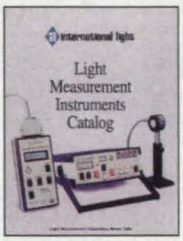
The 144-page 1996-7 catalog from Thorlabs Inc., Newton, NJ, features more than 480 new products. It is divided into three sections: Optomechanics, including optic and mirror mounts, translation stages and rails, micrometers, adjusters, piezoelectric actuators, and more; Optoelectronic Instruments, including high-speed detectors, optical power meters, lock-in amplifiers, and laser diodes; and Fiber Optics, including fibers, connectors, patch cords, and fiber launch systems. Specifications and prices are given for most items. The catalog's products are fully indexed.

For More Information Write In No. 827

Fiber Optic Components and Networks

The 144-page "Fiber Optic Product Catalog No. 1096" from Molex Fiber Optics, Lisle, IL, has performance information and technical specifications on connectors, adapters, cable assemblies, termination tooling, and fiber optic switches. Sections on the company's products for passive networks encompass network devices, distribution enclosures, frame systems and outside plant enclosures. The publication also includes a comprehensive glossary.

For More Information Write In No. 830



Light Measurement Resource

Available from International Light Inc., Newburyport, MA, is the "Light Measurement Instruments Catalog," a 36-page booklet featuring expanded tutorials about power measurements, wave effects, hardware, and other factors involved in light measurement. Organized by instruments and applications, the catalog describes turnkey system configurations for many uses. The IL1400A radiometer/photometer, which uses "smart" preprogrammed detectors, the IL1700 research radiometer, and the IL1800 lock-in radiometer for precise low-light-level measurements are featured.

For More Information Write In No. 822

Products for CATV and Telecommunications

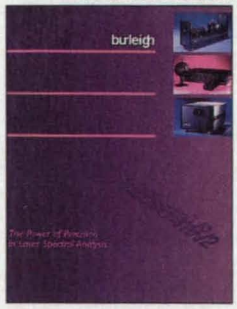
The 8-page full-color product catalog from Uniphase Telecommunications Products (UTP), Bloomfield, CT, outlines the company's capabilities and standard offerings. UTP manufactures high-performance $LiNbO_3$ waveguide modulators, fiber optic gyro circuits, and high-linearity integrated optic modules and subsystems used in CATV and digital communication systems, satellite receivers, antenna remoting subsystems, high-speed instrumentation and fiber optic gyroscopes. UTP fabricates its modulators using its patented annealed proton exchange process.

For More Information Write In No. 825

Piezoelectric and Optical Components

Valpey-Fisher, Hopkinton, MA, offers a 24-page "User's Guide to Ultrasound and Optical Products." The booklet's contents include technical notes and specifications on piezoelectric transducer crystals made from quartz, lithium niobate, and piezoceramic materials, surface acoustic wave substrates, and quartz and sapphire windows and substrates. Also described are the company's special services, including cutting, lapping, polishing, coating, and x-ray orientation.

For More Information Write In No. 828



Laser Spectrum Analyzer Reference

"The Power of Precision in Laser Spectral Analysis" is a 20-page color booklet from Burleigh Instruments, Fishers, NY, covering the company's family of laser spectrum analyzers. It has descriptive particulars of each model, together with specifications, details on accessories, and ordering instructions. The booklet also describes Burleigh's TrueView™ laser spectral analysis software.

For More Information Write In No. 831

Variable-Angle Alignment Fixture

Misaligned, egg-shaped, and oversized holes common in manual drilling can be eliminated.

Dryden Flight Research Center, Edwards, California

A lockable swivel fixture for use in drilling, tapping, or reaming can be aligned with a hole made previously, or with respect to a desired location on a flat or curved surface. The fixture was originally designed to chase existing airframe holes on an F-18 spin-chute-recovery system, but has since been adapted to a variety of uses in which there is a need for a fixture that can be easily aligned and locked at any desired angle.

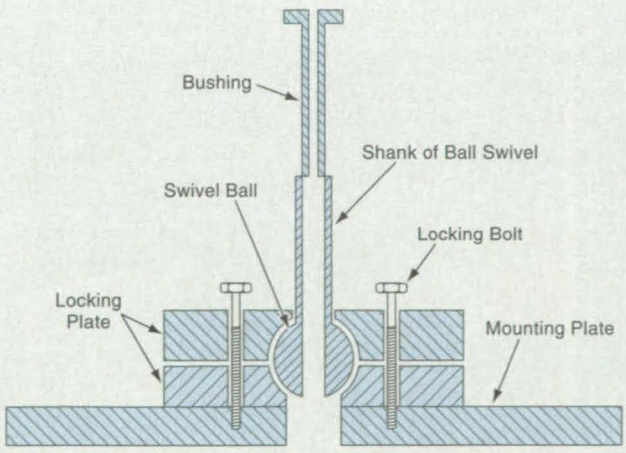
The fixture (see figure) includes a mounting plate, a two-piece locking plate, locking bolts, a ball swivel, and bushings. The mounting plate and the locking plate can be made of aluminum or any other suitable material. The ball swivel and bushings are preferably made of steel, and the bushings should be hardened, if possible. Protruding from the swivel ball is a shank that has been turned to a diameter large enough and cut to a length long enough to provide a stable bushing guide. The swivel and shank are bored along the centerline of the shank to accept the required bushings.

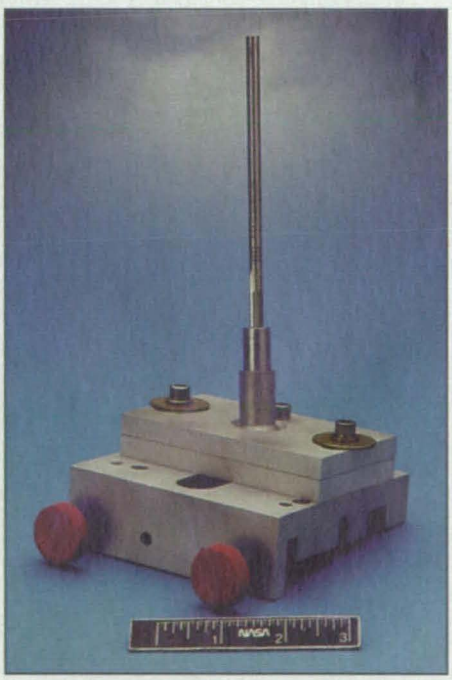
The mounting plate is configured with bolt holes and/or any other convenient features for attachment to a workpiece at a desired location. The top surface of the mounting plate is drilled and tapped to accept the locking bolts. The two pieces of the locking plate are top and bottom mating halves, each half milled with a female hemisphere having a 3/4-in. (19-mm) diameter matching the diameter of the swivel ball. The hemispheres are purposely cut 0.010 in. (0.25 mm) less than full depth to enable them to clamp the swivel ball tightly.

The pieces of the locking plate are brought together with the ball resting in the hemispheres, and the locking bolts are threaded into the mounting plate. Prior to tightening the locking bolts, the locking plates can be moved laterally to align the swivel fixture at the desired position. To enable such lateral movements, slots that accommodate the locking bolts with sufficient lateral clearance are milled into the two pieces of the locking plate. Once the swivel is aligned at the desired position and angle, the bolts are tightened to capture the swivel securely in that alignment.

In preparation for chasing a hole that was made previously, one first selects a pilot shaft with a diameter equal to that of the hole, then passes the shaft through a bushing into the hole. Then one tightens the locking screws. The ball swivel is now fixed in place, concentric to the hole, and the hole can be modified as required.

This work was done by Thomas W. McMullen of **Dryden Flight Research Center**. *No further documentation is available. DRC-95-10*





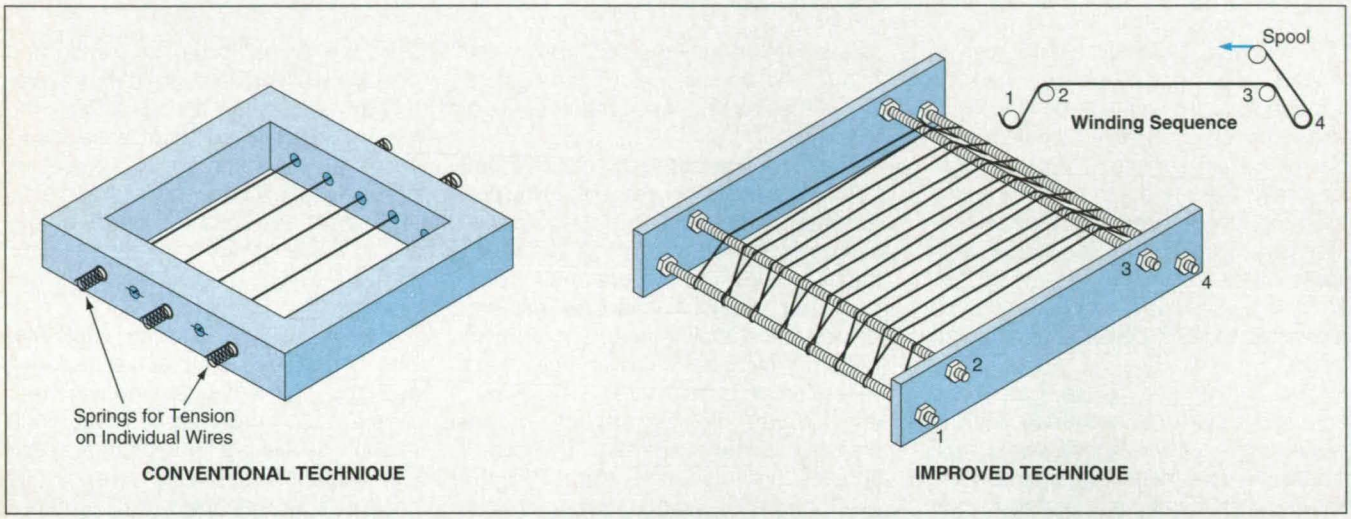
The **Swivel Becomes Locked** when the locking bolts are tightened to clamp the two pieces of the locking plate on the swivel ball.

Easier Fabrication of Polarizing Wire Grids

Time, cost, and difficulty of fabrication are reduced.

NASA's Jet Propulsion Laboratory, Pasadena, California

Framed parallel-wire grids that are used as microwave polarizers can be made by an improved technique that reduces the difficulty, time, and cost of fabrication. In the conventional technique for making such a grid (shown on the left side of the figure), grid wires are cut to length and threaded through holes or slots on opposite sides of a machined frame. The holes or slots establish the grid spacing. Each wire is then held in tension by a clamp and spring. This conventional fabrication technique is expensive and time consuming.



A **Grid Is Formed From a Single Wire** that is wound onto threaded rods in a frame in the improved technique. In contrast, the conventional technique involves cutting, inserting, and mounting multiple grid wires.

In the improved technique (illustrated on the right side of the figure), two opposite sides of the frame consist of pairs of identical threaded rods that support the grid wires in tension. The pitch of the threads on the rods establishes the grid spacing; the grid spacing can be any integer multiple of the thread pitch. If a standard thread pitch and diameter are not acceptable in a given application, then a nonstandard thread can be cut on a rod by use of a lathe.

What is new in this technique is (1) the specific arrangement of the four threaded rods in two pairs on opposite sides of the grid frame, (2) taking advantage of this arrangement to facilitate the placement of the grid wire on the frame, and (3) the continuous winding of a grid wire using wire dispensed from a spool rather than precut wires. In this technique, it is not necessary to cut, insert, and mount multiple grid wires as in the conventional technique. Instead, one continuous grid wire is simply unrolled from a spool and wound onto the threaded rods. Starting from the left side, the spool is passed around rod 1, over rods 2 and 3 in the first thread-pitch interval, and around rod 4. Then going back toward the left side, the spool is passed over rods 3 and 2 in the second thread-pitch interval. The cycle then repeats as the spool is passed around rod 1 and over rods 2 and 3 in the third thread-pitch interval. The tension is established by applying tension to the wire as it is unrolled from the spool.

This work was done by Raul M. Perez of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 43*** *on the TSP Request Card.*
NPO-19455

Moving-Temperature-Gradient Heat Pipe for Growing Crystals

Marshall Space Flight Center, Alabama

A directional-solidification furnace for growing crystals differs from other such furnaces in that neither the ampoule containing the material to be grown nor the furnace is translated. Instead, the ampoule is mounted in a fixed position in the central hollow of an annular heat pipe in which the thermal gradient is maintained with the help of a noncondensible gas that is deliberately put into the heat pipe along with the working fluid: the gradient forms at the boundary between the working-fluid vapor and the noncondensible gas, which collects in the heat-pipe condenser. The temperature gradient is made to translate along the heat pipe by feeding in additional noncondensible gas at a low rate. Because there are no moving mechanical parts, this design offers the advantages of simplicity, ruggedness, and very little vibration (vibration is undesirable because it can disturb the crystal-growth process).

This work was done by Donald Gillies

and Sandor L. Lehoczky of **Marshall Space Flight Center** *and Gregg J. Baldassarre and Nelson J. Gernert of Thermacore, Inc. For further information,* ***write in 18*** *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-26361.

Automated Design and Manufacture of Gloves

Techniques of computer-aided design and manufacturing are used extensively.

Lyndon B. Johnson Space Center, Houston, Texas

A partly automated process is being developed for manufacturing multilayer protective gloves (space-suit gloves in the original application). The process includes laser scanning of casts taken from hands, computer-aided design (CAD), computer-controlled generation of two-dimensional patterns from three-dimensional surfaces, rapid prototyping by stereolithography, and laser cutting of materials.

The process is intended to replace a time-consuming manual process for making custom-fitted gloves. In initial tests, the developmental automated process took about as much time and cost about as much as the manual process did, but reductions in manufacturing time and cost are anticipated as experience is gained and ways to realize the full potential of automation are found. The fit and comfort of gloves manufactured in the automated process are at least as good as, and often better than, those of gloves manufactured in the manual process. These observations suggest that the automated process could also be useful in the manufacture of other special-purpose or custom-fitted items of clothing.

As in the manual process, the developmental automated process begins with making a model hand from a mold cast from the hand. Then the model hand is scanned by a laser profilometer to obtain data on the size and shape of the hand. Scanning of models rather than direct scanning of hands was selected to eliminate errors caused by hand motions and to ensure that fine features like bumps are measured accurately. Models offer an additional important advantage in that they serve as permanent records of the sizes and shapes of hands to be fitted.

The data acquired in the scan are provided to a CAD program, which generates a mathematical wire model of the glove. Surface-design software in the CAD program then generates a mathematical surface model by interpolating and extrapolating from the wire model and incorporating features that promote comfort and freedom of movement and facilitate donning and doffing. Sections are taken through the surface model to check the design. Shaded images of the surface model are then displayed so that the model can be checked for geometry and aesthetics (see figure).

In the original space-suit application, the inner layer of a glove is a bladder that retains air or oxygen at an internal pressure of 8.3 psi (57 kPa). The bladder is made by use of a dip mold, which is a modified version of the original model cast from the hand. To begin fabrication of a dip mold, the CAD data are fed to a stereolithographic apparatus. In this apparatus, an ultraviolet laser beam is scanned to trace and cure a thin slice of material on a platen at the top of a vat filled with an ultraviolet-curable monomeric liquid. The ultraviolet laser light polymerizes the monomer, forming a thin slice of the dip mold. An ele-

vator in the vat lowers the platen and the laser traces another slice. This sequence is repeated until the complete dip mold has been formed. The dip mold is then removed from the vat and postprocessed into its final form.

In the original application, a glove also includes a fabric restraint layer that reinforces the bladder against the internal pressure, and an outer fabric layer, composed of multiple sublayers, that protects against extremes of temperature and impacts of high-velocity debris. The CAD system uses the data from the scan to generate two-dimensional patterns for the fabric pieces and to control laser cutting of these pieces. The pieces are then sewn together.

WIRE MODEL

SURFACE MODEL

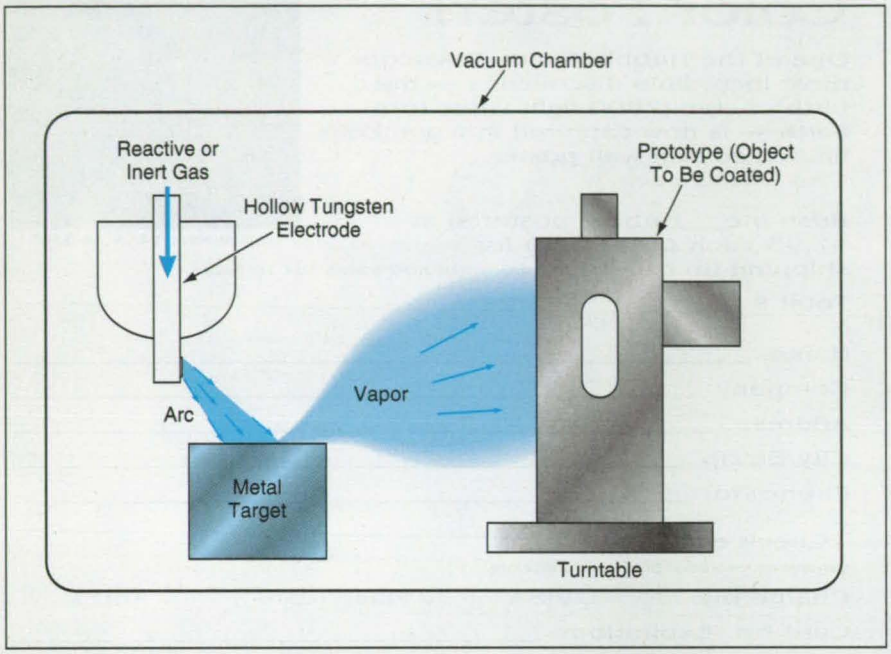
A **Computer-Aided-Design System** generates a mathematical wire model of a glove from data obtained in a laser scan of a model of a hand. The wire model is then processed into a surface model and rendered as a shaded image.

This work was done by Joseph Kosmo of **Johnson Space Center** *and David Cadogan, David Bradley, Philip Spampinato, and Tony McKee of ILC Dover, Inc. For further information,* ***write in 57*** *on the TSP Request Card.*
MSC-22508

Using Vapor Deposition in Forming Metallic Molds

Plastic and wax prototypes can readily be coated with thin metallic layers.

Marshall Space Flight Center, Alabama



In **Vacuum Arc Vapor Deposition**, a metal target is vaporized, and the vapor is directed onto the object to be coated. Contrary to intuitive expectation, the object to be coated is not exposed to a damaging amount of heat.

Vacuum arc vapor deposition (VAVD) has been shown to be useful in making metallic molds from relatively soft, low-melting-temperature prototypes of the objects to be molded. Such prototypes can be fabricated relatively quickly and easily from such materials as waxes and plastics, as an alternative to the more difficult and time-consuming procedure of machining prototypes or molds directly out of hard metals. The role of VAVD is to apply a thin coat of metal to a prototype. The metal coat can then serve as a base for deposition of more metal or other structural material (e.g., a polymer) to give the mold the strength and thermal stability necessary to withstand molding temperature and pressure. VAVD could also be used to form corrosion- or wear-resistant surfaces.

In such an application of VAVD, the soft prototype component is mounted on a turntable in a vacuum chamber, with a source of metal vapor facing the prototype. The source of metal vapor

includes an apparatus that generates an arc or an arc plasma in a chemically reactive or chemically inert gas appropriate to the specific application. The arc or arc plasma melts and vaporizes a metal target. Suitably biased electrodes direct the metal vapor toward the prototype.

Despite the relatively high melting and vaporization temperatures of the metal, this technique for deposition of metal from vapor does not deliver enough heat to damage the prototype. One of the advantages of VAVD is that it can be used to apply a variety of metallic and nonmetallic coats, depending on specific applications. For example, if one uses a reactive plasma containing nitrogen and the source metal is titanium, then one can deposit a coat of titanium nitride. Following VAVD to form the thin coat, metal can be added by thermal spraying and/or electrodeposition. Alternatively or in addition, a polymeric structural support can be added.

This work was done by Paul S. Gill of **Marshall Space Flight Center** *and Phillip D. Krotz, Douglas M. Todd, and Jack L. Weeks of Rockwell International Corp. For further information,* ***write in 39*** *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-30108.

Repairing Corroded Tubes With Swaged and Brazed Inserts

Marshall Space Flight Center, Alabama

A technique has been devised for repairing corrosion-induced leaks in metal tubes in the vicinity of joints where the tubes are brazed to a manifold. In an older repair technique, a "fish-mouth" section containing the defective portion of a tube was cut out of the tube and replaced by short tubular inserts that overlapped each other and extended beyond the cut opening. The inserts were then welded at their ends. In cutting the openings and in forming, positioning, and welding the inserts, it was necessary to ensure that welding did not occur closer than 0.25 in. (6.4 mm) from tube-to-manifold braze joint so as not to damage that joint. The present technique is similar to the older technique in that it also involves cutting out a fish-mouth section and using an insert. However, the insert in the present technique is longer; the insert is sized and shaped so that one end extends into the portion of the tube within the manifold and the other end extends along the tube, well beyond the defective region and into an intact adjacent region. The insert is swaged into the tube at the manifold end and brazed to the tube at the other end.

This work was done by Joseph W. Onstott, Christopher D. Maczuga, Steve A. Leonard, J. Gregory Somerville, and Jewell E. McCarroll of Rockwell International Corp. for **Marshall Space Flight Center**. *For further information,* ***write in 21*** *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-30114.

Making SiC Semiconductor Devices Containing Porous Regions

Controlled electrochemical etching imparts useful electronic and optoelectronic properties.

Lewis Research Center, Cleveland, Ohio

A method of controlled electrochemical etching provides for the formation of selected porous regions in silicon carbide wafers. The method is expected to contribute to the development of novel semiconductor devices that contain porous silicon carbide. Like porous silicon, on which considerable research effort has been focused in recent years, porous silicon carbide exhibits a variety of interesting electronic, optical, optoelectronic, and physicochemical properties that can be exploited in practical devices. For example, by suitable choice of the macrostructures, microstructures, and compositions of the porous regions, one can make SiC ultraviolet light-emitting diodes, ultraviolet lasers, blue electroluminescent devices, and filters for solid-state chemical sensors.

Figure 1 illustrates a basic version of the method of controlled electrochemical etching. The silicon carbide wafer to be processed is mounted in a carrier

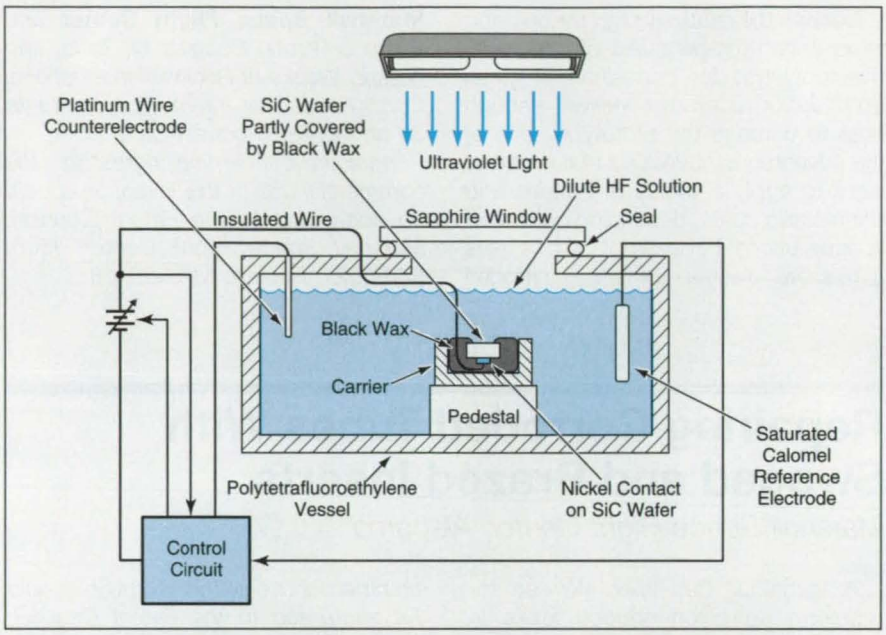


Figure 1. **A Masked Silicon Carbide Wafer Is Etched** in an electrochemical cell to make part of it porous.

with a nickel electrical contact and covered with black wax everywhere except for an opening at the designated surface location of the region to be made porous. The wax prevents etching everywhere except at the exposed area. The carrier is placed on a pedestal in a polytetrafluoroethylene vessel filled with an etching solution of dilute (typically, 2.5 percent) hydrofluoric acid.

A saturated calomel electrode and a platinum wire counter-electrode are immersed in the solution. Through the nickel contact, a variable-voltage dc power-supply circuit applies a bias voltage to the silicon carbide wafer. A control circuit maintains this bias at a prescribed voltage, V_{sce}, with respect to the saturated calomel electrode.

If, for example, the silicon carbide is of the 6H polytype and is doped with electron donor atoms (n-doped), then the exposed surface of the silicon carbide is illuminated through a sapphire window at the top of the vessel while the silicon carbide is maintained at an anodic potential (V_{sce} between 1.8 and 2.8 V) that promotes photoinduced corrosion. If the silicon carbide is of the 6H polytype and is doped with electron acceptors (p-doped), then it can be etched in the dark at V_{sce} between 0 and 2 V. The depth and structure of the porous region formed in the SiC is determined by a number of factors, including the anodization time, the applied potential, the intensity of ultraviolet light (if used), the pH of the solution, and the concentration of dopant in the silicon carbide.

By way of example, Figure 2 illustrates an application of this method to fabricate a silicon carbide p/n-junction diode supported by a broad, electrically insulating substrate. In this application, one takes advantage of the fact that porous SiC can be oxidized to SiO_2 at a rate much greater than that of solid SiC because the pores present much greater surface area for oxidation.

First, a wafer is fabricated by chemical-vapor deposition of a p-doped SiC epilayer and then an n-doped SiC epilayer on an n-doped SiC substrate. A mask is placed on the top n-doped epilayer, then patterned photolithographically. By use of the electrochemical etching method, the part of the n-doped epilayer not covered by the mask is made porous to make it highly susceptible to oxidation.

The resulting porous part of the layer is oxidized to SiO_2 to make it highly susceptible to etching by hydrofluoric acid, then it is so etched to strip it away, leaving a mesa of n-doped SiC. The electrochemical etching method is then used again, this time with process conditions selected to impart porosity to the exposed part of the p-doped SiC epilayer but not to the n-doped SiC. Then as before, the porous material is oxidized to SiO_2 and etched away, leaving a two-layer (n-doped/p-doped) mesa.

Next, the electrochemical-etching method is applied, this time with process conditions chosen to impart porosity to the n-doped SiC substrate only. Finally, the porous substrate is oxidized to SiO_2, which is electrically insulating.

This work was done by Joseph S. Shor and Anthony D. Kurtz of Kulite Semiconductor Products, Inc., for **Lewis Research Center**. *For further information,* ***write in 56*** *on the TSP Request Card. LEW-15755*

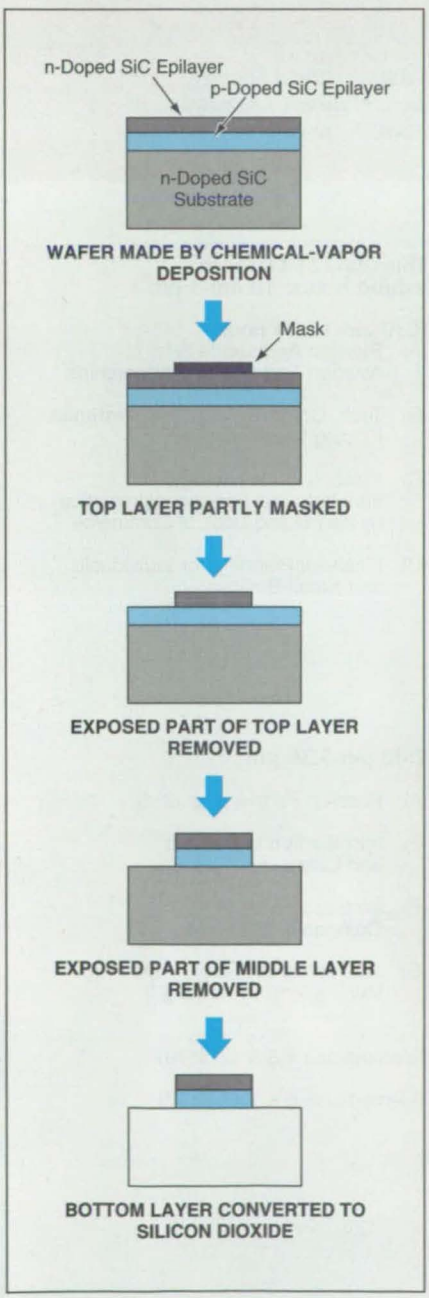


Figure 2. **A SiC p/n-Junction Diode** on a broad insulating substrate is fabricated with the help of the electrochemical-etching process.

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PROGRAM-AT-A-GLANCE

Tuesday, 29 October
exhibit hours: 9 am-4 pm*

9:00 am - 10:00 am
Exhibit Hall Opening Breakfast

9:00 am - 1:00 pm
Poster Presentation Showcase

10:30 am - 12:00 noon
Concurrent Sessions — T1
Advanced Manufacturing 1
Agriculture 1
Computers & Communications 1
Education 1
Environmental Technology 1
Materials 1
Medical & Rehabilitative Technology 1
Power & Energy 1

1:00 pm - 4:00 pm
Keynote Plenary Session
- Daniel Goldin, NASA Administrator
- James Barksdale, Pres. & CEO, Netscape Communications
- Glen Urban, Dean, Sloan School, MIT
- Ace Allen, Director, U Kansas Med Cntr
- Jay Sanders, Pres., Am. Telemed Assn

Note: Monday evening, 28 October
Reception at Richard Nixon Library

Wednesday, 30 October
exhibit hours: 10 am-4 pm*

8:30 am-10:00 am
Plenary: Innovative Agricultural Technology
Plenary: Growth Opportunities for Small Business/presented by the Small Business Administration

10:30 am-12:00 noon
Concurrent Sessions — W1
Advanced Manufacturing 2
Agriculture 2
Computers & Communications 2
Environmental Technology 2
Materials 2
Medical & Rehab. Technology 2
Physics 1
Power & Energy 2
Small Business 1

2:00 pm-3:30 pm
Concurrent Sessions — W2
Advanced Manufacturing 3
Computers & Communications 3
Environmental Technology 3
Materials 3
Medical & Rehab. Technology 3
Physics 2
Power & Energy 3
Small Business 2
Telemedicine 1

4:00 pm-5:30 pm
Concurrent Sessions — W3
Advanced Manufacturing 4
Environmental Technology 4
Materials 4
Physics 3
Power & Energy 4
Small Business 3
Telemedicine 2 & 3

7:00 pm — Seventh Annual Technology Transfer Awards Dinner

Thursday, 31 October**
exhibit hours: 10 am-3 pm*

8:30 am-12:00 noon
(A) Russian Aerospace & Aviation Technology Partnerships

(B) Tech. Commercialization Strategies/ Finding Niche Markets

(C) Protecting Technology from Industrial Espionage/presented by the FBI and Dept. of Commerce

(D) Financial Planning for Individuals and Small Business

2:00 pm-5:30 pm

(A) Russian Partnership (ct'd)

(E) Introduction to Patents and Licensing

(F) Setting up Your Company's INTRAnet

(G) Intellectual Property — Defining, Valuing, and Protecting It

Telemedicine 4 & 5 **(2-3:30)**

Telemedicine 6 & 7 **(4-5:30)**

* Lunch is available for purchase in the exhibit hall from 12:00 noon - 2:00 p.m.
** Short Courses A-G on Thursday require individual registration

Preregistration Form

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PLEASE REGISTER ME FOR THE FOLLOWING:

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Includes sessions & refreshment breaks on Tues., Oct. 29 & Wed., Oct. 30; 1 ticket to the opening reception on Mon., Oct. 28; exhibit hall opening breakfast on Tues., Oct. 29; 1 ticket to the Awards Dinner on Wed., Oct. 30 & entrance to the exhibits Oct. 29-31.
Thursday's Post-Conference Sessions ***are not*** *included.*

❒ **1-Day Conference Registration** **$160** **$185** $_____
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OPTIONAL SHORT COURSES ON THURSDAY, 31 OCTOBER

(Morning short courses include continental breakfast.)

	by 10/4	after 10/4	
Morning			
_____ (A) Russian Partnerships *(full day, incl. refreshments, lunch)*	$350	$400	$_____
_____ (B) Commercialization & Niche Markets	$100	$125	_____
_____ (C) Industrial Espionage	$100	$125	_____
_____ (D) Financial Planning	$100	$125	_____
Afternoon			
_____ (E) Patents & Licensing	$100	$125	_____
_____ (F) INTRAnet	$100	$125	_____
_____ (G) Intellectual Property	$100	$125	_____

❒ **Awards Dinner: _____tickets @** **$55** **$65** _____

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1 Which of the following best describes your industry or service? *(check one)*

1 ❒ Electronics
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5 ❒ Defense
6 ❒ Government
7 ❒ Materials/Chemicals
8 ❒ Industrial Equipment
9 ❒ Manufacturing
10 ❒ Power/Energy
11 ❒ Biomedicine
12 ❒ Transportation/Automotive
13 ❒ Research Lab
14 ❒ University
15 ❒ Agriculture
16 ❒ Environment
17 ❒ Other (specify) _____

2 Which of these products do you recommend, specify, or authorize the purchase of? *(check all that apply)*

18 ❒ Electronic Components & Systems
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20 ❒ Computers/Peripherals
21 ❒ CAD/CAE/CAM/CASE
22 ❒ Lasers/Optics
23 ❒ Materials
24 ❒ Mechanical Components
25 ❒ Positioning Equip./Motion Control
26 ❒ Test/Measurement Instruments
27 ❒ Sensors/Transducers
28 ❒ Data Acquisition
29 ❒ Video/Imaging Equipment
30 ❒ Industrial Controls/Systems
31 ❒ Communications Equipment
32 ❒ Laboratory Equipment

3 Your role in purchasing is:

33 ❒ Decision maker
34 ❒ Specify
35 ❒ Recommend

4 Your principal job function is: *(check one)*

36 ❒ General & Corporate Management
37 ❒ Design & Development Engineering
38 ❒ Engineering Services - Tests/Quality
39 ❒ Basic Research
40 ❒ Manufacturing/Production
41 ❒ Purchasing/Procurement
42 ❒ Other (specify) _____

If you require assistance to fully participate, call Wendy Corvi at 1-800-944-NASA.

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Software for Optimizing Maintenance Budgets

Cost effectiveness is maximized with optimal combinations of preventive and corrective maintenance.

Stennis Space Center, Mississippi

The Risk Constrained Optimized Planning (RCOMP) methodology has been developed to assist managers in analyzing and planning maintenance operations and, in particular, making rational decisions concerning maintenance-budget allocations. Incorporating selected techniques of operations research, RCOMP facilitates exploration of tradeoffs among various measures of availability of systems and subsystems to be maintained, costs of acquisition of maintenance packages, subsequent costs of maintenance, performance with regard to maintenance, equivalent uniform annual life-cycle costs, net investments, and total maintenance times. With respect to a given system to be maintained, RCOMP facilitates the selection of the optimal mix of preventive and corrective maintenance and the most cost-effective maintenance-acquisition strategy.

Several assumptions are made to simplify the basic equations of RCOMP. First, it is assumed that with respect to a given subsystem, actions associated with preventive maintenance and corrective maintenance (frequency and time to perform) remain constant for the time period between acquisition decisions. Second, it is assumed that the effectiveness of any given acquisition is instantaneously achieved; that is, no phase-in time is necessary to reflect changes in maintenance frequencies. Third, it is assumed that overall operational availability of the maintained system is maintained when acquisitions are made; this is the most critical assumption as it enables the initial examination of a system that is nearly 100 percent operational. This assumption also implies that acquisition of maintenance packages are not expected to increase failure rates or repair times. Fourth, the measure of equivalent uniform annual life-cycle cost incorporates the time value of money concepts and includes only the direct maintenance labor and materials costs as well as the hardware and software costs associated with the acquisition packages. Traditional life-cycle costs, such as retirement costs and software maintenance cost, are not included in this measure.

For each subsystem and component of a given maintained system, RCOMP maintains a data base of preventive and corrective maintenance frequencies, average time to perform each type of maintenance, labor rates associated with personnel performing both types of maintenance, and the costs of materials associated with both types of maintenance. RCOMP also maintains a data base on the acquisition of various maintenance packages; included in this data base are the costs of acquiring these packages, the components and subsystems that would be affected by the acquisition of each package, and the changes that would consequently be induced in the baseline parameters of the system.

The two basic equations in RCOMP are the following:

total maintenance time =

$$\sum_{i}^{ns}\sum_{i}^{na}\left[(1+{}_{\lambda}\Delta_p)(1+{}_{T}\Delta_p)\lambda_p T_{PM}\Delta t\right] + \left[(1+{}_{\lambda}\Delta_c)(1+{}_{T}\Delta_c)\lambda_c T_{CM}\Delta t\right]$$

and

$$\sum_{i}^{ns}\sum_{i}^{na}\left[\ (1+{}_{\lambda}\Delta_p)(1+{}_{T}\Delta_p)(1+{}_{c}\Delta_p)\ \lambda_p C_{PM} T_{PM}\Delta t\ \right] + \left[(1+{}_{\lambda}\Delta_p)(1+{}_{M}\Delta_p)\lambda_p C_{MPM}\Delta t\right] + \left[(1+{}_{\lambda}\Delta_c)(1+{}_{T}\Delta_c)(1+{}_{C}\Delta_c)\lambda_c C_{CM} T_{CM}\Delta t\right] + \left[(1+{}_{\lambda}\Delta_c)(1+{}_{M}\Delta_c)\lambda_c C_{MCM}\Delta t\right] + \left[C_{MW}+C_{SW}\right]$$

where

ns = the number of subsystems,

na = the number of acquisitions,

C_{MW} = the cost of hardware,

C_{SW} = the cost of software,

C_{CM} = the labor rate for corrective maintenance,

C_{PM} = the labor rate for preventive maintenance,

C_{MCM} = the cost of materials for corrective maintenance,

C_{MPM} = the cost of materials for preventive maintenance,

T_{CM} = time to perform corrective maintenance,

T_{PM} = time to perform preventive maintenance,

${}_{C}\Delta_c$ = change in labor rate for corrective maintenance,

${}_{C}\Delta_p$ = change in labor rate for preventive maintenance,

${}_{M}\Delta_c$ = change in cost of materials for corrective maintenance,

${}_{M}\Delta_p$ = change in cost of materials for preventive maintenance,

${}_{T}\Delta_c$ = change in corrective-maintenance time,

${}_{T}\Delta_p$ = change in preventive-maintenance time,

Δt = incremental planning horizon,

λ_c = frequency of corrective maintenance,

λ_p = frequency of preventive maintenance,

${}_{\lambda}\Delta_c$ = change in frequency of corrective maintenance, and

${}_{\lambda}\Delta_p$ = change in frequency of preventive maintenance.

With respect to a given system to be maintained, RCOMP searches for the optimal mix of preventive, corrective, and diagnostic system-maintenance strategies, given the data on measures of reliability, cost, and risk associated with the various subsystems and potential acquisitions of maintenance packages. In preparation for this search, a specification of the system and its subsystems, the baseline parameters of the system, and the parameters of maintenance packages that could be acquired are entered into the data base. RCOMP then calculates the total maintenance time and the total life-cycle cost for all acquisitions.

An optimal maintenance curve is established by computationally removing the acquisitions, one at a time: The acquisition that is removed each time is the one that contributes the least to the

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reduction in total maintenance time. When all acquisitions have been removed, the baseline parameters of the system have been achieved. Each point on the resulting curve (see Figure 1) represents an optimal combination of maintenance packages for the corresponding cost and total maintenance time. The curve does not indicate a single correct maintenance strategy; indeed, for organizational or cost-related reasons, the minimum point may not be achievable in a given system. In any event, RCOMP provides for exploration of each point on this curve, and of its associated maintenance packages.

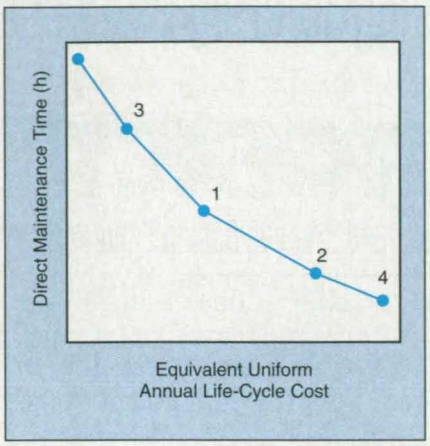


Figure 1. An **Optimal Maintenance Curve** of total maintenance time vs. equivalent uniform annual life-cycle cost is constructed by repeatedly simulating the effect of the removal of the remaining maintenance package that contributes least to the reduction in total maintenance time.

RCOMP also provides a measure of each acquisitions contribution to system availability (see Figure 2). This measure is the probability that a system will be available when it is required (PAR) given the acquisition package under analysis is in place. A minimum PAR value for acquisitions may be established and used to judge the expected effectiveness of each potential acquisition package.

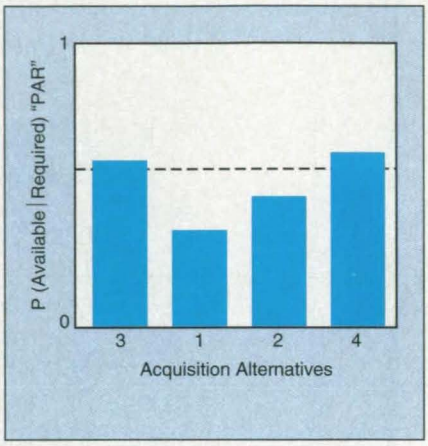


Figure 2. The **Minimal Acceptable Probability** that a system will be available when required is represented by the dotted line. The effectiveness of each acquisition package with respect to that standard is plotted as a histogram.

This work was done by Freddie Douglas III of **Stennis Space Center** *and A. Sean Williamson of Quantitech, Inc. For further information,* ***write in 58*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Stennis Space Center; (601) 688-1929. Refer to SSC-00038.

Iterative and Incremental Development of Software

Lyndon B. Johnson Space Center, Houston, Texas

A method for development of software has been named the "iterative/incremental software development methodology." This method governs a risk-driven, architecturally focused software-development process that reduces significantly the risk and cost of developing software in an environment of rapidly changing technology and evolving requirements. In contrast to the older "waterfall" software-development method, the present method incorporates the best of iterative and incremental development. To implement this method, a requirement analysis is done before the beginning of any programming. Next, a schedule of development milestones is created. By combining the iterative and incremental programming efforts, one can create a final software product that satisfies requirements on schedule.

This work was done by David Durand, George Heyworth, Ron Peugh, Dave Weller, and William Wessale of CAE-Link Corp. for **Johnson Space Center**. *For further information,* ***write in 34*** *on the TSP Request Card.*

MSC-22529

Filter Devices for Collection and Storage of Body-Fluid Samples

These devices are relatively easy to use and inexpensive.

Lyndon B. Johnson Space Center, Houston, Texas

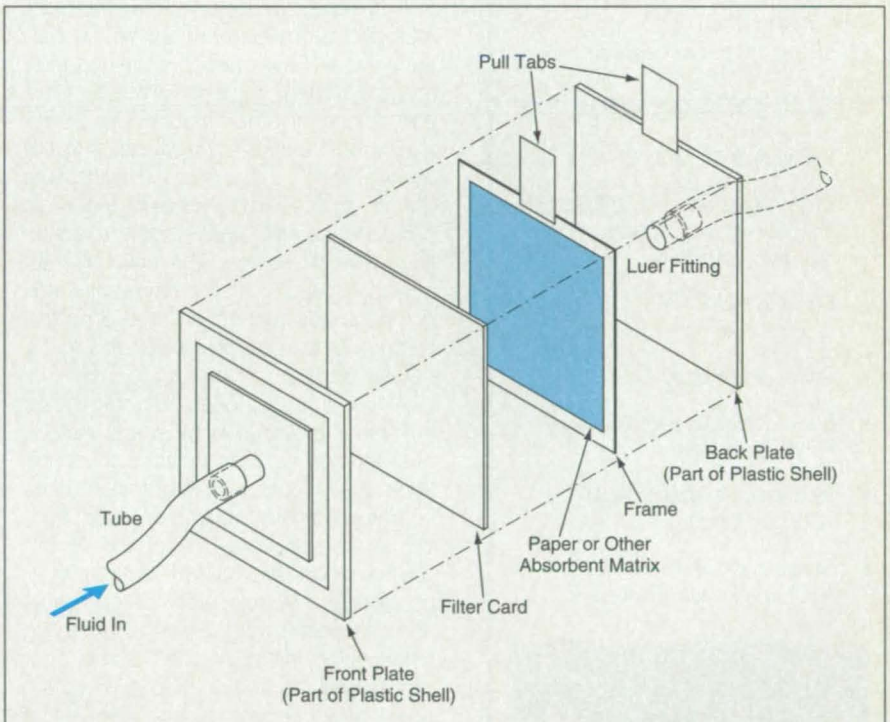
Scientists at NASA's Johnson Space Center have developed specialized disposable devices for use in filtering the cellular and acellular components of blood and other body-fluid samples. These devices contain filters that are treated with carbohydrate and protein compounds, which together with the physical characteristics of the filter act to retain the cellular components, allowing the acellular components (e.g., serum) to pass through and be absorbed onto another, untreated matrix, such as paper. The paper containing the serum is removed from the device, dried in air, and stored in an anaerobic, desiccated environment until analysis. The dried paper can be analyzed up to six months later by washing it with water and analyzing the effluent with conventional laboratory methods.

Previously, blood and other types of fluid samples were collected into evacuated glass or plastic tubes, which then had to be centrifuged immediately to separate the cellular and acellular phases. The acellular phases often had to be stored at –20° or –70°C in order to preserve the analytes of interest. Using the filter device obviates the need for centrifuges or freezers: All that is required to collect and store blood samples are a collection device, air to dry the serum fraction, and a bag containing an oxygen scavenger and a desiccant in which to store the dried paper.

The figure illustrates a typical blood-storage device of this type. The sample is passed into the device through a tube, and enters a chamber bound on the front side by a front plate (one of two parts of a plastic shell) and on the back side by a filter card. The volume of the chamber sets the upper limit of the volume of fluid that can be introduced into the chamber. The front plate includes a recess for this chamber, and a shallow depression into which the filter card is seated, with a watertight seal forming the chamber. The front plate also includes an outer flange that adheres to the back plate, the other part of the plastic shell, with an air-tight seal.

The sample is filtered first through the treated filter, and the acellular serum fraction is drawn onto the absorbent serum card. The first, treated filters consist mostly of glass fibers of 1-μm pore size. Before the units are assembled, these filters are dipped into a carbohydrate-and-protein solution and dried in air. The second, untreated filter is absorbent cellulose with a high Klemm factor, which acts to pull the acellular fraction onto this second filter card. The back plate is attached to the front plate with an adhesive on the flange, which makes an air-tight seal that also holds the second filter in its frame. A female Luer port is mounted on the back plate; this port is connected to an aspirating syringe that provides suction for collecting the specimen fluid. A second pull-tab is attached to the back plate, the two pull-tabs are used together to pull the device apart and remove the absorbing matrix once the collection process is complete.

A related device, containing two absorbent cellulose papers and no treated filter card, has been developed for drying and storing urine samples. Other modifications can make devices such as these useful for filtering and storing other types of body-fluid samples, such as saliva, tears, or peritoneal, synovial, or cerebrospinal fluids. Other modifications could involve using several reagents on the filters to allow several analytes to be assessed simultaneously. One practical example might be screening for several addictive drugs or for blood-borne viruses.



These **Parts Are Assembled** with adhesive around the edge to form air- and water-tight seals. Suction is applied to the Luer port at the back, drawing the specimen fluid in through the tube at the front. After the fluid is filtered, the device is pulled apart by use of the pull-tabs to extract the fluid-laden absorbent filter.

Because older collection devices did not allow immediate separation of cellular and acellular components of body-fluid samples, the analytes of interest often were affected by cell metabolism, cell lysis, or dilution during storage. The present device limits the potential for these effects by separating the cellular and acellular phases promptly. This advantage can be enhanced by chilling the devices before and after their use, which can further retard the chemical reactions that can destroy unstable analytes.

This work was done by Peggy A. Whitson of **Johnson Space Center** *and Vaughan L. Clift of Lockheed-Martin. For further information,* ***write in 54*** *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, Johnson Space Center; (713) 483-4871. Refer to MSC-22463.

Improved Hyperhydration Beverage

This beverage performs better than other rehydration beverages, including plain water.

Ames Research Center, Moffett Field, California

A beverage has been formulated for restoring hydration homeostasis in persons who have become dehydrated (hyperhydrated) through physical exertion, illness, or other causes. The beverage is also useful for counteracting the hypohydration that occurs in astronauts during space flight and in mountain climbers and airline passengers exposed to low air pressures. The beverage not only restores the overall volume of water, but also aids restoration of the normal balance between intracellular and extracellular fluids.

Why would one need to drink this or any other rehydration beverage instead of ordinary water? Under stressful conditions, the voluntary intake of fluids does not keep up with the loss of fluids, leading to dehydration. The cause of this phenomenon is unknown, but the temperature and composition of a beverage, and the gastric and intestinal emptying time (which influence the volume consumed and the rate of absorption by the body) play important roles. The rate of absorption of fluid from the intestinal lumen is maximal when the fluid has an osmolality of about 285 mOsmol/kg (the fluid is approximately isotonic). Moreover, drinking plain water does not replace sodium ions lost through sweating and urinary excretion.

Accordingly, the present beverage was formulated with an osmolality that optimizes absorption and aids retention of plasma water. It is also designed to avoid the disadvantages of traditional rehydration with salt tablets and water, which include the risk of hypernatremia (elevated levels of sodium in the blood). In addition, like commercial rehydration beverages, the present beverage includes a noncaloric sweetener (aspartame) that helps induce voluntary consumption.

The ingredients in this beverage are 9 g of sodium chloride, 15.44 g of sodium citrate, 0.72 g of aspartame, and the balance of water to a total volume of 2 L. The osmolality is 270 mOsmol/kg, which is close to the optimum fluid-absorption value.

The present beverage and five others with higher and lower osmolality were tested for hypervolemic response in human subjects under various conditions of rest and exercise. The other beverages were (a) water sweetened with aspartame (30 mOsmol/kg), (b) a sodium chloride solution sweetened with aspartame (70 mOsmol/kg), (c) a glucose/sodium citrate solution (650 mOsmol/kg), (d) a commercial rehydration beverage (380 mOsmol/kg), and (e) another commercial rehydration beverage (390 mOsmol/kg). From measures of plasma osmolality, plasma volume, and concentration of sodium and potassium in plasma, the present hyperhydration beverage performed better than the others during rest and performed comparably or better during exercise. Thus, the improved hyperhydration beverage should prove useful for increasing physical performance and to protect the body from excessive dehydration during stress situations.

This work was done by John E. Greenleaf of **Ames Research Center**. *For further information,* ***write in 96*** *on the TSP Request Card.*

This invention has been patented by NASA (U.S. Patent No. 5,447,730). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Ames Research Center; (415) 604-5104. Refer to ARC-13386.

Production of Monoclonal Antibodies Specific to Hepatitis C

There has been a need for these antibodies in medical research, testing, and treatment.

Lyndon B. Johnson Space Center, Houston, Texas

Antibodies specific to some peptides in hepatitis C viruses have been produced by hybridomas that were generated by electrofusion of human myeloma cells with lymphocytes from the peripheral blood of a human volunteer infected with hepatitis C. The production of monoclonal antibodies specific to hepatitis C is significant because heretofore, such antibodies have not been available, and there has been a growing need for them in medical research. With suitable modifications, these antibodies could become the basis of commercial products for immunotherapy and for use as controls in hepatitis C antibody assays.

The process for making the antibodies begins with the collection of samples of blood from volunteers known to be infected with hepatitis C. The mononuclear-cell fraction of the collected blood is prepared by density centrifugation on a Ficoll-Hypaque (or equivalent) cushion. ("Ficoll" is a trade name for a polymer, made by cross-linking of epichlorhydrin and sucrose, that is ordinarily used in motility studies to increase the viscosity of media and thereby temper rapidly motile organisms. "Hypaque" is a trade name for diatrizoate sodium and diatrizoate meglumine radiological-contrast media.) Once the mononuclear-cell fraction has been recovered, the NK cells are removed by incubation with leucyl-leucine methyl ester.

The remaining T and B cells are coactivated by use of a T-cell activator, including phytohemagglutinin, concanavalin A, or anti-CD3 monoclonal antibodies. Supplemental interleukins, including IL-2, IL-4, and IL-10 and/or concanavalin A supernatant are used as additional factors for stimulation of B-cells. After 48 hours, the B-cell blasts are harvested, washed, and suspended in a hypoosmolar electrofusion medium (75-milliosmolar sorbitol solution supplemented with calcium and magnesium acetate). These cells are mixed with equal numbers of similarly prepared H7 human myeloma cells, which serve as the electrofusion partners.

The cell mixture is transferred to an electrofusion chamber, where the cells are first aligned by a signal of 5-V amplitude at a frequency of 1.5 GHz for 30 seconds. At the end of the 30 seconds, the cells are fused with a single pulse of 45 to 60 V.

The electrofused cells are then grown in a medium supplemented with hypoxanthene aminopterine thymidine to select viable hybridomas. The resulting hybridomas are subcloned and their supernatants are screened, by use of standard enzyme-linked immunosorbent assay (ELISA) techniques, for production of antibodies specific to peptides of hepatitis C viruses.

This work was done by Garry A. Neil, Laurie Love-Homan, Deborah Clark, and Fred C. Johlin of the University of Iowa and Ulrich Zimmermann, Petra Gessner, Gerd Klock, and Reiner Schnettler of the University of Wurzburg, Germany, for **Johnson Space Center**. *For further information,* ***write in 90*** *on the TSP Request Card.*
MSC-22392

Books & Reports

These reports, studies, and handbooks are available from NASA as Technical Support Packages (TSPs) when a Request Card number is cited.

Physical Sciences

Thermal Conductances of Augmented Metal Contacts: Part I

A report describes experiments that were performed to determine the extent to which gold-coated aluminum washers squeezed between metal contacts can increase the thermal conductances of the contacts at liquid-helium temperatures (1.6 to 6.0 K). In the experiments, the thermal conductances of the contacts were measured while the contacts and washers were pressed together with various forces up to 661 N. The thermal conductances of contacts augmented with washers were not found to be significantly greater than those of bare contacts.

This work was done by L. J. Salerno and P. Kittel of **Ames Research Center** *and Alan L. Spivak of Trans-Bay Electronics. To obtain a copy of the report, "Thermal Conductance of Augmented Pressed Metallic Contacts at Liquid Helium Temperatures,"* ***write in 47*** *on the TSP Request Card.*
ARC-13387

Thermal Conductances of Augmented Metal Contacts: Part II

A report documents experiments, similar to those described in the preceding article, that were performed to determine the extent to which indium foil or a general-purpose laboratory grease can increase the thermal conductances of pressed metal contacts at liquid-helium temperatures (1.6 to 6.0 K). The specimens used in the experiments were pairs of copper, aluminum, brass, and stainless-steel rods of 12.7-mm and 10.2-mm diameter, with contact surfaces lapped to a finish of 0.8 μm. In the experiments, the thermal conductances of the contacts with indium or grease interfacial layers were measured while the contacts were pressed together with various forces up to 670 N. Thermal conductances were found to increase somewhat with contact forces, though not as much as in previous studies.

This work was done by Louis J. Salerno and Peter Kittel of **Ames Research Center** *and Alan L. Spivak of Trans-Bay Electronics. To obtain a copy of the report, "Thermal Conductance of Pressed Metallic Contacts Augmented with Indium Foil or Apiezon-N™ Grease at Liquid Helium Temperatures,"* ***write in 48*** *on the TSP Request Card.*
ARC-13388

Electronic Systems

Fault-Protection Architecture for the Cassini Spacecraft

A report discusses the fault-protection architecture for the command-and-data subsystem (CDS) of the Cassini spacecraft, which is scheduled for launch in October 1997 on a mission to Saturn. The fault-protection architecture chosen for this demanding application involves a highly modular system of hardware and software components, including a predominantly software-driven fault-diagnostic device in each module. With the intelligence of the designers embedded in the software, the system becomes autonomous in monitoring for, and responding to, faults.

This work was done by Thomas K. Brown and James A. Donaldson of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Fault Protection Design for the Command and Data Subsystem on the Cassini Spacecraft,"* ***write in 2*** *on the TSP Request Card.*
NPO-19747

Reusable Modular Architecture for Electronic Systems

A report proposes a modular architecture for spacecraft electronic systems, the modules of which would be standardized and reusable on different missions. Electronic architectures fitting this general description have been implemented commercially, but only in recent years has a concerted effort been made to apply this concept in the design of spacecraft electronic systems. A key feature of the proposed architecture would be a backbone parallel bus that could accommodate a variety of equipment through a series of input/output modules. Subsystems with different mass, power, performance, and other characteristics could be integrated into systems to satisfy the requirements of various missions without affecting the basic architecture of the systems.

This work was done by Kim R. Reh, Savio N. Chau, and Brian Cox of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "A Multimission Space Avionics Architecture,"* ***write in 64*** *on the TSP Request Card. NPO-19836*

Analysis of Carrier Tracking by Cascaded Phase-Locked Loops

A report presents an analysis of the performance of a carrier-aiding technique, which employs cascaded phase-locked loops (PLLs). This technique can be useful when two unequal antennas are required to coherently demodulate the received signal, but due to an extremely weak signal-to-noise ratio (SNR) level and high Doppler rates, the smaller antenna PLL is unable to lock on the carrier on its own. In this scheme, the carrier signal is assumed to be strong enough that the PLL in the receiver of the larger antenna can synchronize to the carrier and thereby provide a phase reference for down-conversion of the carrier in the receiver of the smaller antenna. Thus, the PLL in the receiver of the smaller antenna has only to coherently track the residual Doppler shift between the two antennas, and can use a narrower loop bandwidth than otherwise possible.

This work was done by Mazen M. Shihabi, Biren N. Shah, and Sami M. Hinedi of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Improved Carrier Tracking of Space Telemetry Signals Using Cascaded Phase-Locked Loops,"* ***write in 26*** *on the TSP Request Card.*
NPO-19612

Materials

Preceramic Organoboron/Silicon Polymers

A report describes the syntheses of preceramic polymers with Si-B bonds in their backbones. The syntheses were carried out by the Wurtz reaction of dialkyldichlorosilane and boron trichloride or methyl bromide, in some cases with and in some without methyl iodide. The polymers softened at temperatures between 40 and 180 °C, started to decompose at 200 to 450 °C, and yielded a 56-to-70-percent ceramic product in an inert atmosphere above 800 °C. The ceramics thus formed from the organoboron/silicon polymers can be in the form of fibers; alternatively, the polymers can serve as matrix resins for making composite materials for high-temperature applications.

This work was done by Salvatore R. Riccitiello of **Ames Research Center** *and Ming-ta S. Hsu and Timothy S. Chen of HC Chem Research & Services Corp. To obtain a copy of the report, "Preceramic Organoboron-Silicon Polymers,"* ***write in 76*** *on the TSP Request Card. ARC-12858*

Machinery/Automation

Development of a Solar Dynamic Power System

A report discusses the development of a proposed solar dynamic electric-power-generating system for the Space Station *Freedom*. The report includes results from the prime contractor as well as from in-house efforts, university grants, and other contracts. Also included are the writers' opinions, based on their experiences in the program, about the best technical and programmatic ways to proceed in future efforts to develop solar dynamic power systems.

This work was done by Thomas W. Kerslake, Kent S. Jefferies, Richard R. Secunde, Clinton B. Ensworth III, and Richard D. Corrigan of **Lewis Research Center**. *To obtain a copy of the report, "Solar Dynamic Power System Development for Space Station 'Freedom,'"* ***write in 66*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Lewis Research Center; (216) 433-2320. Refer to LEW-16223.

Centrifugal Instrument for Biotechnological Experiments

A report describes an instrument system for use in studying the effects of inertial acceleration (gravity) on cell biology, protein cell growth, and other phenomena of interest to the materials-science and biotechnologies communities. The instrument system is designed to produce inertial accelerations between 0 and 100 times the normal gravitational acceleration at the Earth's surface. By combining instrument automation with miniaturization, more data can be obtained in each experiment, either during space flight or in ground-based laboratories, than is possible with previous variable-gravity instrumentation.

This work was done by Steven L. Koontz of **Johnson Space Center** *and Ray Morales and Monty B. Carroll of Lockheed Engineering and Sciences Co. To obtain a copy of the report, "A Variable Gravity Instrument for Biotechnology Studies: Delta-G,"* ***write in 92*** *on the TSP Request Card. MSC-22577*

Development of an Advanced Helicopter Transmission

A report describes the engineering achievements of a program to develop an advanced helicopter transmission with less weight, less noise, and greater reliability in comparison with a baseline transmission in a three-engine army cargo helicopter that has a gross weight of 85,000 lb (38,600 kg). Some aspects of the advanced transmission were described in previous articles in *NASA Tech Briefs*; most notably, of the gearbox designs investigated, the one selected as most promising features a split-path drive configuration like that described in "Torque-Splitting Gear Drive" (LEW-14908), *NASA Tech Briefs*, Vol. 15, No. 4 (April 1991), page 90. A preliminary design analysis showed that in comparison with the baseline gear box, the particular split-path gearbox would weigh 23 percent less, its noise would be 10 dB lower, and its reliability would be nearly 4 times (in terms of mean time between replacements) as great. A half-scale version of the split-path gearbox was designed, fabricated, and tested; the results of the tests showed that most of the design assumptions were sound.

This work was done by Jules G. Kish of United Technologies Corp. and Timothy Krantz of the U. S. Army Research Laboratory for **Lewis Research Center**. *To obtain a copy of the report, "Sikorsky Aircraft Advanced Rotorcraft Transmission (ART) Program — Final Report,"* ***write in 3*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Lewis Research Center; (216) 433-2320. Refer to LEW-16278.

Electronic Components and Circuits

Wire Mesh for Protection Against Lightning

A report describes the choice of silver-plated wire to replace tin-plated beryllium copper strips that were previously used to provide grounding contacts for protecting a space shuttle umbilical disconnect against lightning strike. When they were used, the beryllium copper strips were bonded to foam insulating material and have come loose from the foam after thermal cycling between ambient temperature and –423 °F (–255 °C). The loose strips could become debris, which could not be tolerated in this application. The wire mesh is bonded (partially impregnated) to the foam with polyurethane adhesive. A portion of the wire mesh that overlaps the umbilical disconnect is impregnated with silver-filled epoxy. In comparison with the beryllium copper strips, the wire mesh has been found to be relatively insensitive to differential thermal shrinkage and to adhere better. The test demonstrated that the wire mesh does not disbond and maintains a low resistivity at the electrical bond surface before and after thermal aging in liquid hydrogen.

This work was done by Bernie Rosenbaum of **Johnson Space Center**; *Keith Y. Chong, Richard G. Jackson, Lee S. Durham, and Zenon Siminski of Rockwell International Corp.; and Benny Ewing of Lockheed-Martin. To obtain a copy of the report, "Wire Mesh for Disconnects Lightning Strike Protection,"* ***write in 11*** *on the TSP Request Card. MSC-22665*

(continued on page 116)

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Kollmorgen Motion Technologies Group is a leading international manufacturer of precision motion control products. Kollmorgen is traded publicly on the New York Stock Exchange (KOL).

For more information, contact Frank Locascio, product manager, at 540-633-4134 or Rory Falato, marketing communications director, at 540-633-5511.

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The National Technology Transfer Center (NTTC) enhances U.S. industry's economic competitiveness by linking it to the vast resources of federal technology.

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For more information on the National Gateway, Business Gold, *training courses, or other services, contact the NTTC via the Internet through World Wide Web URL http://www.nttc.edu or call 800-678-6882.*

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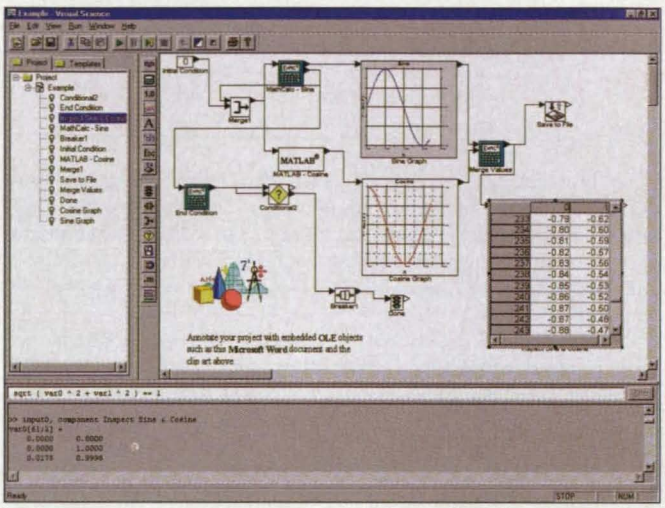


WARNER ELECTRIC

Offers Programmable Linear Actuators

Warner Electric, long a leading supplier of linear and rotary motion control devices, now offers an extensive line of programmable linear actuators that features greater service life and expanded load-carrying speeds, duty cycles, and accuracies. Named the *Electrak 2000*, this industry-leading line of linear actuators is available in both high-efficiency ball screw and economical Acme screw models.

All *Electrak 2000* actuators are engineered to operate for up to 50 million cycles. Operating speeds range from 20 inches/second for 40-lb. loads to 2 inches/second for 500-lb. loads, with repeatability of 0.0005 inches. Standard stroke lengths are 2, 4, 6, 8, 12, 18, and 24 inches. The maximum load capacity for parallel models with ball screw drive is 2000 lbs.

Ball screw models feature excellent speed, load, and duty-cycle capabilities with low power consumption. An electrically-released, spring-set brake mounted on the step motor controls back-driving of the ball screw actuator if power is interrupted.

Acme screw units offer an economical alternative for applications with lower load, speed, and duty-cycle requirements. The Acme screw models can hold vertical loads without back-driving in either a power-off or a stall mode.

Designed to be impervious to washdowns, *Electrak 2000* sealed step motors carry an IP-56 rating and are featured as standard equipment. Controls are supplied complete with I/O boards, input power cables, indexer, and drive.

All *Electrak 2000* Series actuators are available with a menu-driven software package that is specifically designed for linear motion/position applications. With terms expressed in linear units rather than in motor steps, the new software ensures simplified programming.

Mounting options include front flanges, trunnions, side-tapped holes, and mounting feet. Encoders, sensors, and brakes are offered as options. Both parallel and in-line actuator configurations are available.

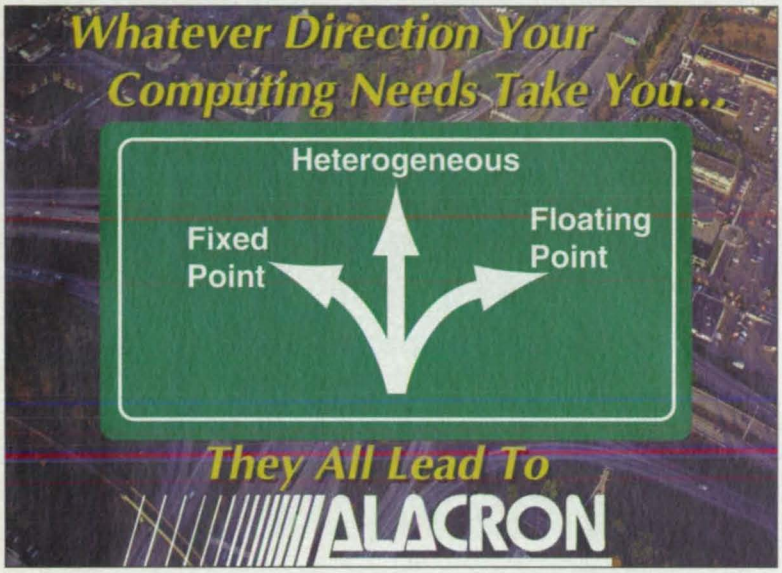
For additional technical information on any Warner Electric product, contact: Warner Electric Advertising Department, 449 Gardner Street, South Beloit, IL 61080; Tel: 815-389-3771; Fax: 815-389-2582.

For More Information Write In No. 853

ALACRON, INC.

The Total Imaging and Signal Processing Solution

Alacron provides total data acquisition and processing solutions for imaging and signal processing. Alacron offers a range of high-performance systems, based on Texas Instruments' TMS-320C80 processor, Analog Devices' ADI-2106x SHARC processors, and Intel's i860 RISC processors for PCI, PC/ISA, and VME buses.



New Products

Alacron's **FT-C80** subsystems, based on TI's TMS320C80 processor, are ideal for the most demanding real-time image processing and DSP applications. The FT-C80 provides 2 GigaOPS of processing power and can perform a 3x3 convolution on a 512 x 512 x 8 bit image in 6.6 msec.

Alacron's **FT SHARC** subsystems, based on an array of up to 24 ADI-2106x microprocessors, provide scaleable performance, up to 3 GigaFLOPs in a single slot! An eight-processor FT-SHARC can perform a 1K complex FFT in only 72 microseconds.

I/O and Expansion

Today's demanding real-world applications require not only processing power, but also efficient, balanced I/O. Each Alacron processor board is equipped with two 160 MB/sec. *FastTrack*™ expansion interfaces to which users can add one or several *FastTrack* modules. Our growing line of *FastTrack* modules includes a high-resolution graphic display, analog and digital frame grabbers, high-performance digital I/O, SCSI, and VSB. *FastTrack* connectors also support FT-SHARC and FT-C80 modules, providing heterogeneous processor environments.

For more information, contact Alacron, Inc. at 71 Spitbrook Rd., Nashua, NH 03060; Tel: 603-891-2750; Fax: 603-891-2745; E-mail: sales@alacron.com; URL: http://www.alacron.com.

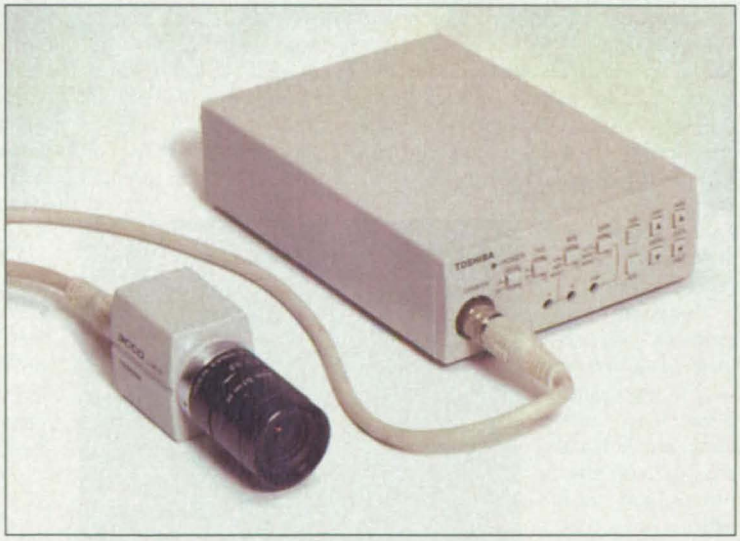
For More Information Write In No. 854

TOSHIBA AMERICA

In response to the growing demand for a more compact, broadcast-quality, point-of-view (POV) camera, Toshiba has introduced the world's smallest, most technologically advanced digital camera, the IK-TU40A.

Toshiba's IK-TU40A is the world's first three-chip, 10-bit remote head camera. It is specifically designed for remote broadcast use. The IK-TU40A can capture, up-close, all the excitement of fast-paced sports or other exotic applications. The camera head is about the size of an ice cube, allowing it to be mounted anywhere – from the driver's seat of an Indy car to the side of an in-line skate.

The IK-TU40A makes conventional one-chip POV cameras obsolete by utilizing revolutionary ten-bit DSP architecture developed exclusively by Toshiba, combined with three 410,000-pixel CCDs. The result is a breathtaking 750 horizontal lines of resolution and a 62dB signal-to-noise ratio for the brightest, sharpest color video in the industry.



Equipped with RS-232C interface and easy-to-read on-screen menus, the camera can be centrally controlled by way of a laptop computer. This provides the user with fingertip access to a wide range of functions and advanced image processing modes, including electronic shutter speed, integration time periods, AGC and white balance.

The IK-TU40A accepts most C-mount lenses and has video outputs for NTSC, S-VHS and RGB. A 10-, 18-, or 30-foot detachable cable is available for the camera.

For more information, contact Toshiba America Consumer Products, 1010 Johnson Dr., Buffalo Grove, IL 60089; Tel: 847-541-9400; Fax: 847-541-1927.

For More Information Write In No. 855

PLYMOUTH TUBE COMPANY

Plymouth Extruded Shapes — Near-Net Steel Extrusions

Original equipment manufacturers (OEMs) and parts suppliers in the automotive, aerospace, defense, machine tool, and industrial equipment manufacturing industries have found near-net extrusion of complex steel shapes to be a versatile, labor-saving, and cost-effective alternative to the welding, forging, casting, or machining of parts.

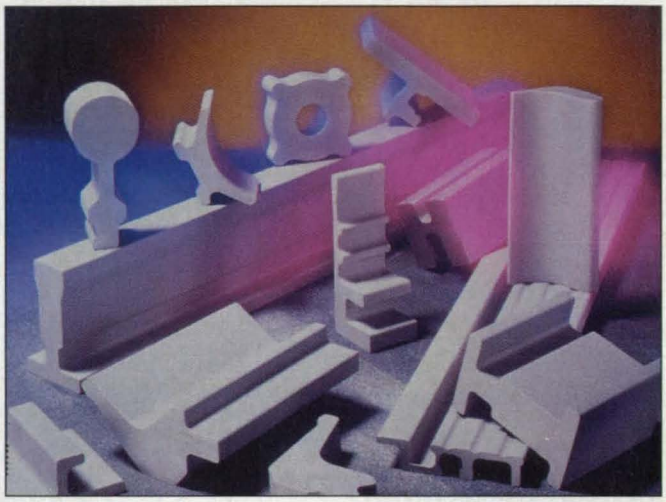
According to Don Ferguson, Plymouth Extruded Shapes's Marketing Manager, "Near-net extrusion technology gives product engineers the ability to achieve the desired shape, within close tolerances, in a single process. With this process, we can create a wide variety of solid or hollow shapes in various sizes using either carbon steel, alloy steel, stainless steel, nickel alloy, or titanium, with relatively low tooling costs – even for short runs. The technology not only reduces our customers' materials costs, but it also reduces downstream costs, since near-net parts require less machining and mechanical finishing than competitive technologies. Overall, the financial benefits of choosing near-net extrusion can be substantial."

The near-net extrusion operation begins with a solid round bar that is cut into shorter billets. Each billet is induction-heated to the correct extrusion temperature and is coated with a powdered glass during transfer to the extrusion chamber. The steel is forced through a die under high pressure at speeds up to 30 mph to provide the desired shape and is then air-cooled or rapidly water-quenched. After cooling, the extrusions are "stretch straightened" – an important step in controlling the bow and twist of the final product. Plymouth discards dies after each extrusion, minimizing an erosion process called "die wash." This is essential to achieving the consistent quality and close tolerances required by customers.

Plymouth's standard near-net stainless steel shapes include tees, equal and unequal leg angles, channels, and beams. Specialized, custom-order shapes may include cross-membered parts, as well as parts requiring varying degrees of angularity, transverse flatness, bows, or twists.

For more information on Plymouth's near-net extrusion process, contact Plymouth Extruded Shapes, Plymouth Tube Co., P.O. Box 768, Warrenville, IL 60555; Tel: 800-323-9506; Fax: 708-393-3552.

For More Information Write In No. 856



INTEGRATED ENGINEERING SOFTWARE

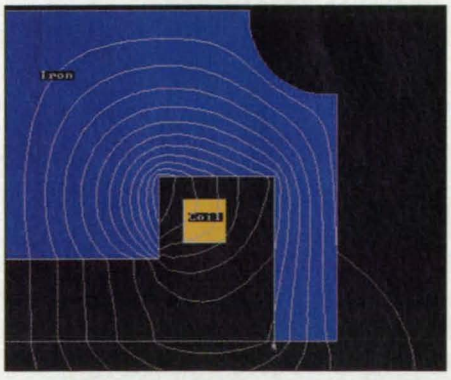
NEW Electromagnetic-Thermal Coupled CAE Software

Integrated Engineering Software has released the CAE industry's first coupled Electromagnetic-Thermal CAE solution based solely on the innovative Boundary Element Method (BEM) technology. Now designers searching for an alternative to complex electromagnetic-thermal FEM modeling can take advantage of BEM's superior ease of use, analysis speed, and accuracy. This coupled Electromagnetic-Thermal software solution enables designers to test various physical and material configurations, examine new design concepts, and optimize designs for a wide variety of Electromagnetic-Thermal applications prior to actually building a costly prototype.

Inductive/Conductive Heating Applications

Designers of induction heating/hardening systems or conductive heating designs are able to simulate coupled Electro-magnetic Thermal systems in one software environment. For inductive heating/hardening applications, designers can take advantage of Integrated's coupled Oersted and Kelvin software tools. Oersted is Integrated's two-dimensional time-harmonic field solver (shown) and Kelvin is the thermal analysis solver. And, for conductive heating applications, designers can effortlessly move between Integrated's coupled Electro and Kelvin. Electro is Integrated's two-dimensional electrostatic field solver.

Designers can examine electromagnetic properties such as capacitance, inductance, resistance, ohmic losses, eddy current, force, torque, and many other properties. And, with a simple menu selection, they can review the coupled thermal properties such as temperature, heat flow, temperature gradients, and other thermal properties.



Innovative CAE Technology - BEM

Integrated Engineering Software is the only provider of a full range of electromagnetic and thermal CAE products based on the Boundary Element Method (BEM). The Finite Element Method products require complex, full-region FEM meshing in contrast to the Boundary Element Method which requires only surface elements. BEM is not only easier to use and learn, but it also provides premium accuracy and analysis speed.

Integrated offers a 30-day free evaluation of all our software products to allow customers to assess the software's capability with no obligation to purchase.

For more information, contact Integrated Engineering Software at 46-1313 Border Place, Winnipeg, Canada R3H 0X4; Tel: 204-632-5636; Fax: 204-633-7780; E-mail: info@integrated.mb.ca; Internet:http://www.integrated.mb.ca/ies.

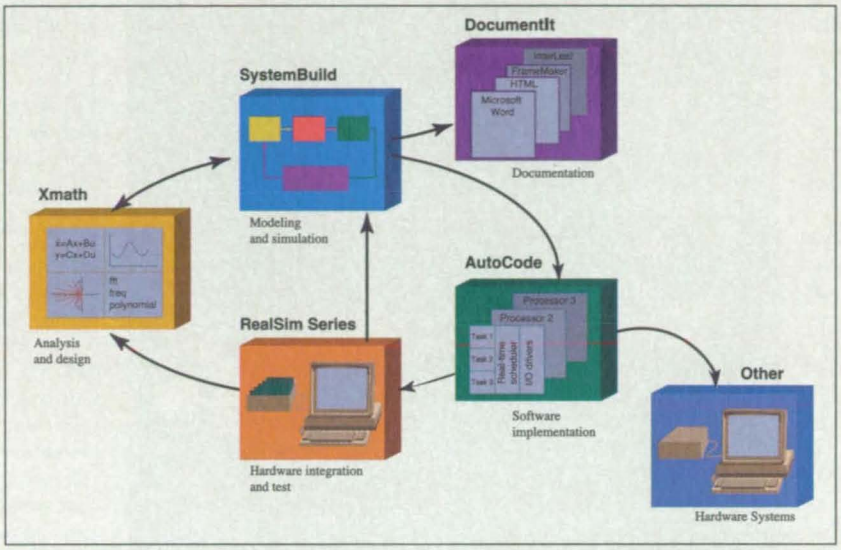
For More Information Write In No. 857

INTEGRATED SYSTEMS INC.

Headquartered in Santa Clara, CA, Integrated Systems Inc. (NASDAQ: INTS) is the leading worldwide provider of embedded solution tools for the telecommunication, automotive, multimedia/consumer electronics, office/retail automation, aerospace, and process control industries. Founded in 1981, Integrated Systems' worldwide presence includes sales and service offices throughout Asia/Pacific, Europe, Canada, and the United States. The company has over 450 employees worldwide. Revenue for the 1996 fiscal year was $84.4 million, an increase of 45 percent over the previous year's revenue.

MATRIX$_X$® from Integrated Systems

The MATRIX$_X$ Product Family is the first fully automated system that allows for the graphical design, simulation, automatic code and document generation, and real-time test for real time control systems. For over 10 years, the MATRIX$_X$ Family has proven its value in numerous control and embedded systems engineering programs worldwide. Users include 26 of the world's top 28 automotive manufacturers, as well as the top aerospace, industrial process control, computer manufacturing, and research organizations.



The MATRIX$_X$ product family features: *SystemBuild*™, the industry's leading graphical modeling and simulation environment; *Xmath*™, the first object-oriented mathematical analysis and visualization tool; *AutoCode*®, the first and the most sophisticated automatic C and Ada code generator; *DocumentIt*™, the first automatic documentation generator; and the *RealSim Series*™ of rapid prototyping computers.

For more information, contact Integrated Systems Inc. at 201 Moffett Park Drive, Sunnyvale, CA 94089; Tel: 408-542-1500; Fax: 408-542-1950; E-mail: info@isi.com.

For More Information Write In No. 858

DIGI-KEY CORPORATION

It started in 1972 – an idea – a new concept in distribution. Today, Digi-Key represents one of the fastest-growing electronic component distributors in the United States. At Digi-Key, service is the key! This customer-centered business philosophy has positioned Digi-Key as the industry-recognized leader among distributors when it comes to service.

Serving the customer ultimately begins with the Digi-Key catalog. It is updated and expanded every 60 days to accommodate constant product-line expansion and provide accurate, up-to-date pricing.

Complementing this printed catalog is an electronic media presence that will continue to make the customer's job more efficient. Digi-Key's World Wide Web site has earned recognition by *Electronic Business Today* as one of the best among distributors.

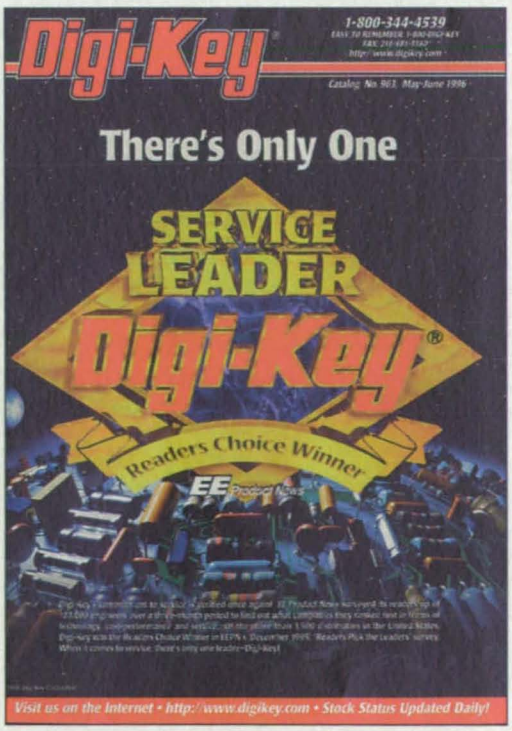
Digi-Key customers are provided with real-time stock status and order entry. An intelligent conveyer system is the basis for an order fulfillment system among the most efficient in the entire world. Fully supervised by Digi-Key's host computer, the conveyor flawlessly routes orders through more than a mile of conveyor.

This highly automated approach to order fulfillment allows orders to be processed in as little as 30 minutes! And, the entire process – from order entry to shipping – is ISO 9002 certified. Based on independent research conducted by several well-respected trade publications, Digi Key is the industry's consistent leader when it comes to service!

We believe Digi-Key provides the best service in the industry with a 30% compound annual rate of sales increase over the past 20 years – not as a result of acquisition – there is perhaps no greater testimony to the quality Digi-Key provides its customers. We feel it is this unparalleled level of service that differentiates Digi-Key from other distributors.

For your free catalog, call, write, fax, or visit us on the Internet: Digi-Key Corporation, 701 Brooks Ave. South, Thief River Falls, MN 56701; Tel: 800-344-4539; Fax: 218-681-3380; http://www.digikey.com.

For More Information Write In No. 859



ANALYTICAL GRAPHICS, INC.

Satellite Tool Kit (STK)®: The Leading Commercial Software For Space Mission Analysis

Analytical Graphics is the leading producer of commercial, off-the-shelf (COTS) satellite analysis software for the space industry. The company, headquartered in King of Prussia, PA, was founded in 1989 to produce graphical, interactive software analysis tools for space-related applications. Analytical Graphics' flagship product is called Satellite Tool Kit (STK).

STK is the space industry's market-leading analysis tool. It is a family of interactive, graphical software products that help analysts, developers, and operators of space systems easily access, manage, display, and manipulate data.

It is used to visualize and analyze the complex relationships involving satellites, orbits, launch vehicles, areas of sensor coverage, aircraft, ships, ground vehicles, ground stations, and targets. Much as charts and graphs enhance understanding of complex numerical relationships, STK's powerful representations of these relationships render them intuitively understandable and manageable. The software operates on all UNIX platforms and on personal computers using Windows® 95 or Windows NT™ operating systems.

A Tracking and Data Relay Satellite (TDRS) just after Inertial Upper Stage (IUS) separation.

The Satellite Tool Kit/Visualization Option (STK/VO)™ module provides a true three-dimensional, time-driven analysis environment. In addition, STK is available as a Programmer's Library (STK/PL)™, a complete set of astrodynamic, graphic, and user interface functions that are tested, documented, and available for custom use.

The third generation of STK – STK 3.0 – was released in June, significantly enhancing the software's power and functionality. STK has proven accurate and reliable in seven years of rigorous use by thousands of users worldwide in civil space, military, and commercial organizations.

For more information, contact Analytical Graphics at 800-220-4STK; E-mail: info@stk.com; Internet: http://www.stk.com.

For More Information Write In No. 860

ENDEVCO CORPORATION

Founded in 1947, Endevco Corp. is the world's leading supplier of dynamic instrumentation for vibration, shock, inertial motion, and dynamic pressure measurements. Endevco is a subsidiary of U.K.-based Meggitt PLC, an international group of companies renowned for its specialized engineering skills.

Endevco has 300 employees at its corporate headquarters in San Juan Capistrano in sales, marketing, manufacturing, and engineering functions. Endevco also operates a silicon research and fabrication center in Sunnyvale, CA, dedicated to new product development utilizing silicon micromachining technology. Endevco has European sales and marketing offices based in the U.K., France, and Germany, as well as an Asian sales and marketing office in China.

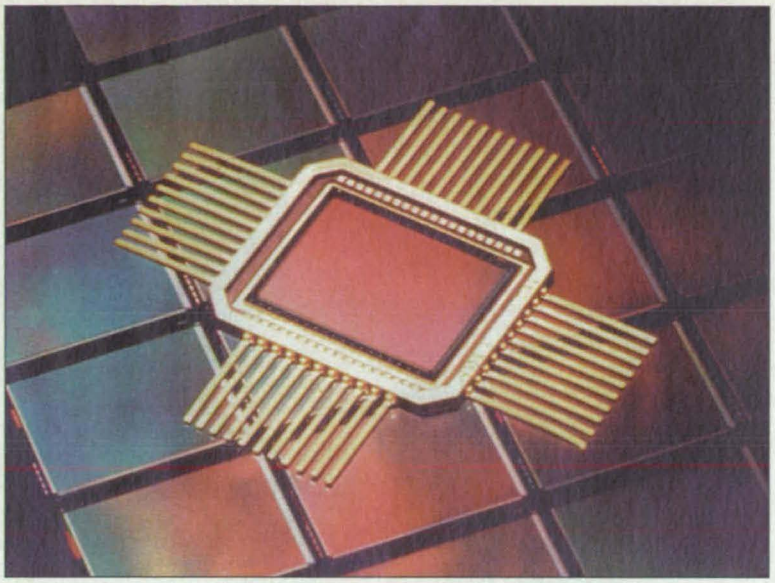
With more than 500 products, Endevco offers the industry's broadest product line. Endevco's product family includes piezoelectric, piezoresistive, and variable capacitance accelerometers; integrated electronic piezoelectric accelerometers (ISOTRON®); piezoresistive pressure transducers; signal conditioners and amplifiers; high-intensity microphones; measurement systems; fuses; accelerometers for guidance systems; accelerometers and tracking filters for engine vibration monitoring; calibration equipment and systems; cable assemblies and accessories; and engine balancing equipment.

Endevco's products are designed for laboratory, aerospace, defense, transportation, aviation, marine, industrial, and medical applications where obtaining accurate and reliable data is vital. Endevco provides solutions in critical applications such as spacecraft monitoring, automotive safety testing, in-flight gas turbine vibration monitoring systems, helicopter health and usage monitoring (HUMS), missile fusing systems, nuclear power plant monitoring, submarine silencing systems and activity monitoring in heart pacemakers. Endevco has also supplied standard and custom instrumentation for many international and most major United States aerospace programs.

For more information, contact Endevco at 30700 Rancho Viejo Rd., San Juan Capistrano, CA 92675-1789; Tel: 714-493-8181 or 800-982-6732; Fax: 714-661-7231.

For More Information Write In No. 861

DAVID SARNOFF RESEARCH CENTER



The mission of Sarnoff is the creation and commercialization of new technologies that change our world. To that end, it serves clients in both industry and government developing specific technologies for acquiring, processing, communicating, displaying, and using electronic information.

Building on more than 50 years of innovation that includes color television, the liquid crystal display, and the charge-coupled device (CCD) imager, Sarnoff today is at the leading edge of several key technical developments. These include a variety of advanced integrated circuits (ICs) that are used in infrared and visible focal-plane arrays.

In addition to designing, Sarnoff also manufactures high-performance mid-wave infrared and visible cameras for use in such specialized applications as in-flight tracking of missiles and transient analysis of other high-speed events.

Sarnoff's work is supported entirely by its clients, who are leading companies in the U.S., the Far East, and Europe, and various agencies of the U.S. government. Sarnoff participates in several programs of the National Institutes of Standards and Technology's Advanced Technology Program.

Established in 1942 in Princeton, NJ as the RCA Laboratories, the center was named after General David Sarnoff, chairman of RCA, in 1951. Following the GE acquisition of RCA, Sarnoff became a subsidiary of SRI International in 1987.

Operated for profit, Sarnoff's revenues and operating profit have increased each year since 1993. President and CEO Dr. James E. Carnes heads a staff of 750.

For more information, contact Business Development, David Sarnoff Research Center, CN 5300, Princeton, NJ 08543; Tel: 609-734-2553; Fax: 609-734-2443; E-mail: dzish@sarnoff.com; Internet: http://www.sarnoff.com.

For More Information Write In No. 862

ANSOFT CORPORATION

Ansoft Corporation develops, markets, and supports EDA software solutions that enable leading-edge performance and miniaturization of electronic, communication, and electromechanical systems. Ansoft products benefit users by enabling them to aggressively reduce time to market and maximize product performance. Significant savings are achieved by eliminating physical prototypes and optimizing size, material, and yield.

Ansoft delivers the best tool in its class because of its technology leadership. Ansoft has a history of creating significant technology breakthroughs. Zoltan Cendes, Ph.D., founder of Ansoft, conducted over 15 years of R&D prior to the company's inception in 1984. Since that time, over a decade of R&D by Ansoft research and development staff pioneered the notion of automatic and adaptive convergence to solutions, asymptotic waveform evaluation (AWE) for spectral domain solutions, transfinite elements, basis evaluation state space techniques, and fast multiple acceleration algorithms.

These advances meet the ever-growing needs of engineers as the market demands require smaller and faster devices with tighter design and compliance requirements. Ansoft continues to lead the technology in the industry with upgrades of its Maxwell products and the introduction of new products for both UNIX workstations and PCs.

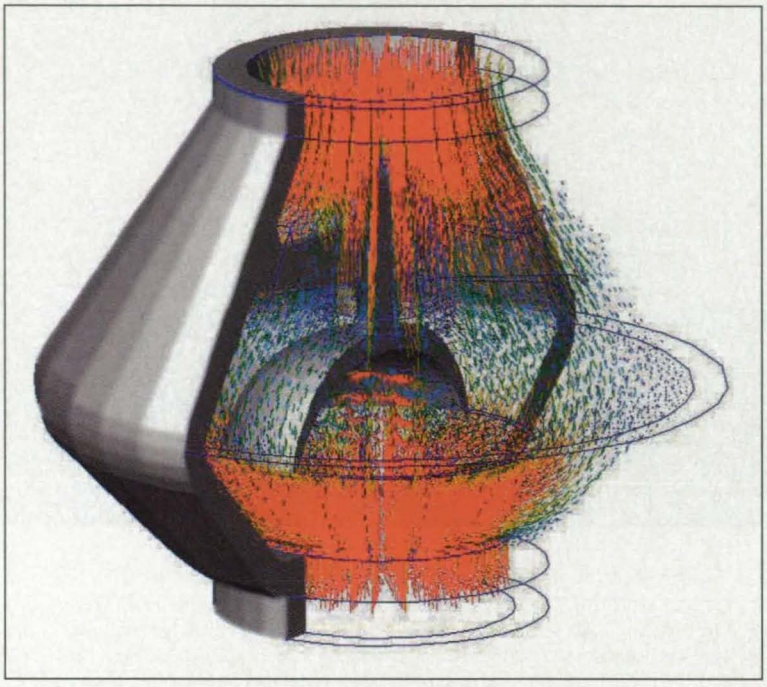
Ansoft directly markets its products worldwide with a sales force and a network of distributors. Customers include leading electronics, telecommunications, and automotive companies including Motorola, Intel, Texas Instruments, Samsung, Hitachi, SONY, Sharp, Ericsson, SGS Thomson, General Motors, Ford, and BMW.

For more information, contact Ansoft Corporation at Four Station Square, Ste. 660, Pittsburgh, PA 15219-1119; Tel: 412-261-3200; Fax: 412-471-9427; E-mail: info@ansoft.com.

For More Information Write In No. 863

ALGOR, INC.

When You're Serious About Engineering



Algor, Inc. is a leading maker of mechanical engineering analysis and design optimization software for UNIX, Windows NT, and Windows 95 operating systems. More than 12,000 engineers in more than 60 countries use Algor software.

At Algor, we emphasize serious, real-world engineering in everything we do. That's why Algor has led the market in recognizing the needs of engineering professionals and providing new technologies and innovative capabilities which meet those needs.

For example, engineers need better ways of optimizing designs which come into contact with fluids, such as air or water. This includes obvious applications like optimizing lift or drag characteristics in automotive and aerospace designs that involve turbulent flow. However, it also includes applications such as fluid product packaging, cooling systems, piping or pressure vessel components, and many others.

To meet these needs, Algor recently introduced advanced computational fluid dynamics (CFD) software which represents a new level of fluid flow analysis technology. Algor's steady state and unsteady fluid flow analysis software now provides advanced fluid-object interaction capabilities by linking with Algor's linear and nonlinear stress, vibration, and other analysis software. An all-new, easy-to-use turbulent flow analysis option is also available.

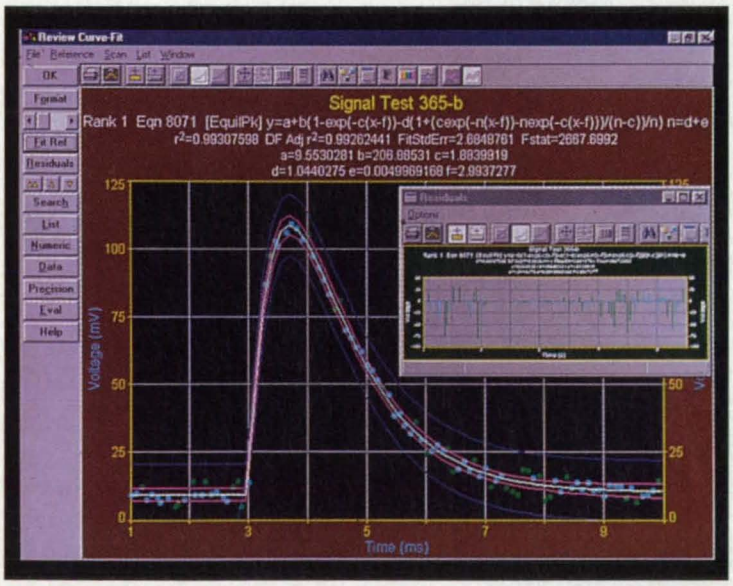
Other Algor innovations include Houdini, the first automatic CAD solid model to 8-node "brick" finite element mesh converter and the Integrated Plant Package (IPP), the most complete set of design and analysis tools available for the piping and pressure vessel industries.

For more information, visit Algor on the World Wide Web at: www.algor.com; Tel: 412-967-2700; Fax: 412-967-2781; E-mail: info@algor.com.

For More Information Write In No. 864

JANDEL SCIENTIFIC SOFTWARE

Jandel Scientific was established in 1982 to create microcomputer-based software tools for scientists. Jandel offers the widest selection of PC-based analytical and graphics software in the industry. Virtually all products have been redesigned to be optimized for the Windows 95 operating system, thus providing the latest technology platform for maximum performance.



Jandel products are the result of careful attention to customer input from telephone calls, letters, product evaluation cards, and scientific meetings. We are dedicated to offering products that meet the special needs of research scientists and engineers. Every product is supported by one of the strongest technical support staffs in the industry and a 90-day money-back guarantee.

Jandel's presentation and data analysis tools include SigmaSuite, SigmaPlot, SigmaStat, SigmaScan, SigmaScan Pro, TableCurve 2D, TableCurve 3D, SigmaGel, and Peakfit.

Jandel's Latest Release

Jandel Scientific just announced the release of TableCurve 2D version 4.0. TableCurve 2D, always a leader in curve-fitting technology, now includes 200 new equations, new non-parametric estimations, expanded graphing capabilities, more code generation options, improved smoothing capabilities, and more. In addition to new features, the overall functionality of the product has been significantly enhanced so version 4.0 is even more intuitive, easy to use, and remarkably simple to learn.

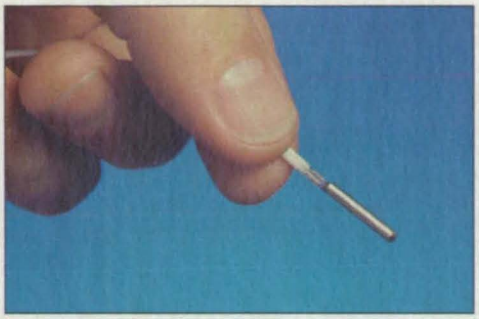
For more information, contact Jandel Scientific at 2591 Kerner Blvd., San Rafael, CA 94901; Tel: 415-453-6700 or 800-4-JANDEL; Fax: 415-453-7769. Visit our home page for the latest application briefs at: http://www.jandel.com.

For More Information Write In No. 865

WATLOW CORPORATION

Supplier Selection by Design Consideration: Your Guide to Selecting the Best Heat Solution Resource

There are as many ways to heat as there are products to process. Some approaches are just better than others. And some suppliers can provide better answers. Selecting a heater supplier should involve more than just "parts meet spec." You benefit when your supplier can also address these 12 design considerations:



1. *Simplifying the manufacturing process* can entail eliminating unnecessary complexity in the process itself or removing superfluous components from the product.

2. *Obtaining higher quality* can be defined as exceeding minimum specifications for demanding applications. This contributes to the product being more competitive in the market.

3. *Reliability* is an inherent part of a product's reputation. Often designs work well on paper, but don't take into account actual operating conditions or operator skill.

4. *Lowering costs* can result from lowering labor requirements, employing a more cost-effective approach, or exceeding break-even points in production. This applies to both processes and products.

5. *Increasing performance* makes a product or process achieve design or production goals faster or easier. Performance can be isolated to a single component, or involve how well components function together in a system.

6. *Increasing life* can result from many factors: a minor change in material, configuration, application, method, or component. Extending life improves productivity by increasing throughput and reducing downtime.

7. *Lowering maintenance* can be accomplished by increasing maintenance intervals, diminishing the level of service required, and making sure a component is well-matched to the application environment.

8. *Lowering parts count* will relieve procurement and production of added burden. Every part included in a design eventually requires making, handling, and assembling.

9. *Reducing size and weight* without decreasing power or performance. In effecting miniaturization, some technologies get pushed beyond practical limits.

10. *Producing a more saleable product* involves many considerations beyond engineering and production. An outside resource can bring new dimensions to developing a new product by seeing solutions that may not be obvious to the product class.

11. *Increasing energy efficiency* can be accomplished many ways: decrease heat loss, increase combustion efficiency, or more effectively transfer heat into the work. Monitoring a process to see where possible inefficiencies occur as well as employing new materials can help achieve unrealized improvements.

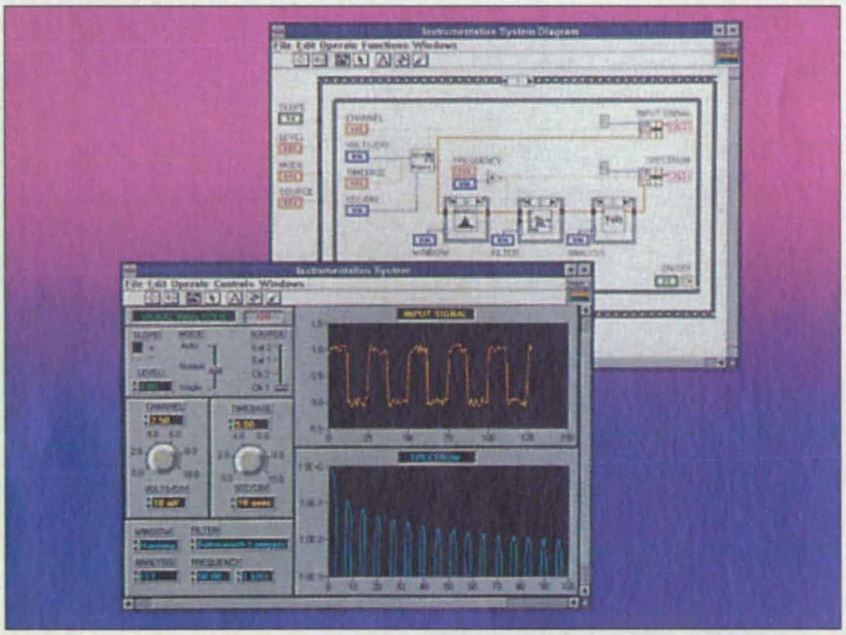
12. *Adding intelligence* can improve a product or process by automating many functions or more closely controlling operating parameters.

For more information, contact Watlow at 12001 Lackland Rd., St. Louis, MO 63146; Tel: 314-878-4600; Fax: 314-878-6814; Internet: http://www.watlow.com.

For More Information Write In No. 866

NATIONAL INSTRUMENTS

National Instruments is leading a revolution in instrumentation – the Virtual Instrumentation Revolution. With virtual instrumentation, personal computers and workstations are combined with software and hardware to build a powerful but low-cost instrumentation system. This complete system can consist of all the popular instrumentation alternatives, including plug-in data acquisition (DAQ) boards and GPIB, VXI, and RS-232 instruments.



Founded in 1976, National Instruments today is a leading manufacturer of IEEE-488 interfaces, plug-in DAQ boards, VXIbus controllers, and instrumentation software. National Instruments is dedicated to providing the highest quality products for data acquisition, data analysis, and instrument control. As part of our dedication to quality, in 1993 we announced a new organizational structure that is compatible with the guidelines from the ISO 9000 standards, ensuring that we deliver products and service of unequalled quality to our customers.

All of our products reflect the National Instruments commitment to high quality and innovation at a competitive price. We pledge to continue this commitment to you with investments in research and development that are well beyond industry norms. Likewise, our continued commitment to service will be demonstrated with a growing list of options for customer education and support.

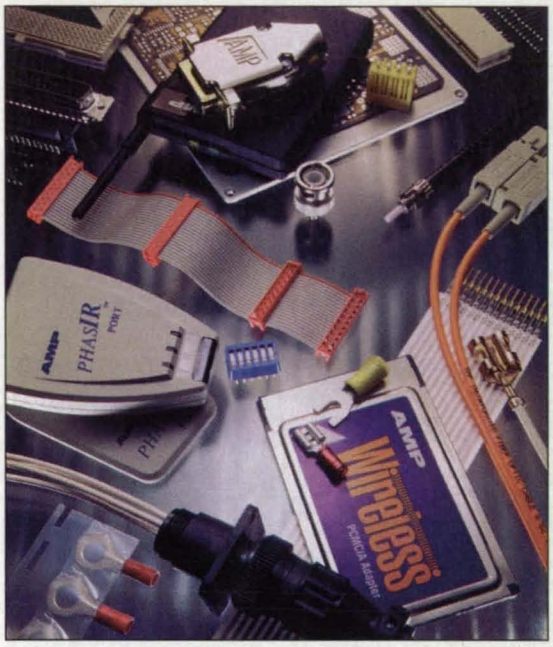
For More Information Write In No. 867

AMP

Interconnection From IC To I/O

For high-speed data, where every aspect of the circuit influences signal integrity, everything from the IC to the I/O is relevant to interconnect design. As the world leader in connection, AMP provides simulation and related engineering services in addition to components, subsystem fabrication, and support services for copper, fiber, wireless, and hybrid systems.

In the board-level simulation arena, the AMP capability combines SPICE and proprietary software with broad experience in a wide range of markets and applications. AMP simulation is available as a complete design and manufacturing resource or to verify developing designs. AMP also provides high-performance circuit boards, backplanes, card cages, enclosures, cables, and connector systems.



Standard products include more than 100,000 types and sizes of connectors, cables, terminals and splices, IC sockets, application tools and machines, and networking and premises wiring products. Markets served include aerospace, military and government systems, communication, computer/office systems, transportation, consumer goods, electrical, and construction.

The electronic catalog, accessible at www.amp.com, covers more than 70,000 products and is available in eight languages. Toll-free product information, at 1-800-522-6752, includes 24-hour, automated fax service that provides access to more than 70,000 technical documents, and a wide range of support services. CAD models, customer drawings, and technical documents that aid in system design are available on CD-ROM.

Founded in 1941, AMP employs 42,000 people in 45 nations and has sales exceeding $5 billion annually. A significant portion of sales dollars is devoted to research, development, and engineering, to anticipate changing technologies, and ensure state-of-the-art solutions to customer problems.

For more information, see AMP on the Internet at www.amp.com; Tel: 800-522-6752; or write: AMP, Harrisburg, PA 17105-3608.

For More Information Write In No. 868

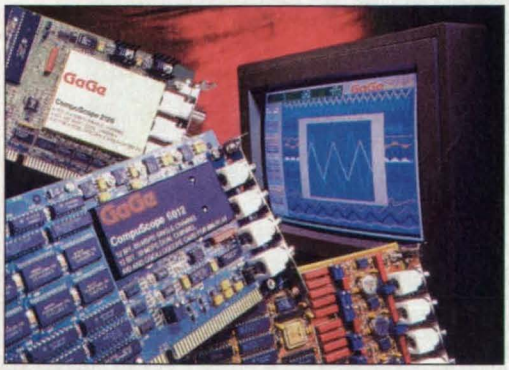
GAGE APPLIED SCIENCES, INC.

Manufacturer of the World's Fastest PC-Based Data Acquisition Products for ISA and PCI Bus

Gage Applied Sciences was founded in 1987 by a group of Canadian engineers and entrepreneurs with a mandate of designing, manufacturing, and marketing high-quality, high-speed data acquisition and instrumentation products based on the IBM PC platform.

Ultra-Fast A/D on the ISA and PCI Bus

Gage manufactures the world's fastest 8- and 12-bit A/D and D/A cards for the ISA and PCI bus. With speeds up to 500 MSPS for one-shot and 2GS/s for repetitive signals, these products provide performance better than any standalone instrument.

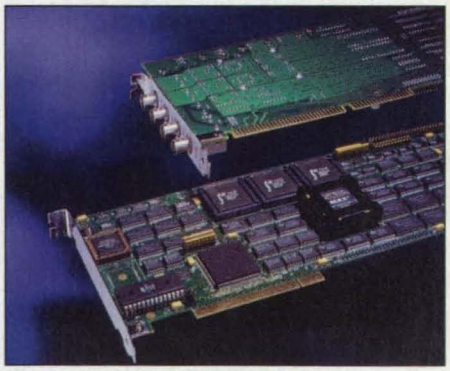


Very High Signal To Noise Ratio

Gage has developed the expertise of designing very low-noise, high-speed 12-bit A/D systems which can provide 60 dB and higher signal to noise ratio at sampling speeds up to 80 MSPS. This specification is very important for digitizing analog signals with high resolution.

Deep Memory

One of the most unique features of the CompuScope product line is the very deep data buffers it offers: up to 16 million samples. This allows the user to digitize an analog signal at very high speeds for a very long period of time.



Up to 16 Analog Inputs

Multiple CompuScope cards can be placed in the same system to digitize up to 16 inputs simultaneously.

Software Support

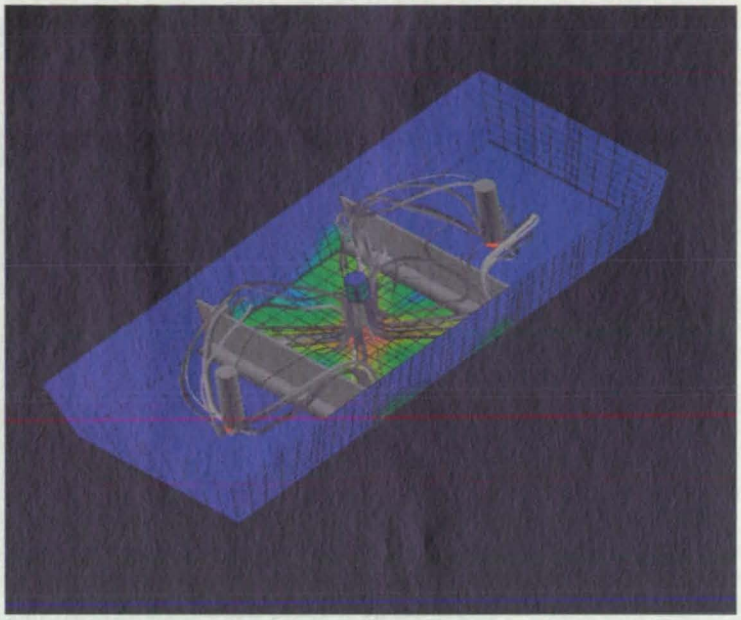
Award-winning GageScope scope-emulation software can be used to operate any CompuScope card without writing a single line of programming code! Drivers also are available for custom programming.

For more information, contact Gage Applied Sciences, Inc. at 5610 Bois Franc, Montreal, Quebec, Canada H4S 1A9; Tel: 800-567-GAGE or 514-337-6893; Fax: 800-780-8411 or 514-337-8411; Internet: http://www.gage-applied.com; E-mail: prodinfo @gage-applied.com.

For More Information Write In No. 869

ADAPTIVE RESEARCH

Computational Fluid Dynamics Specialists



Adaptive Research specializes in the design and development of CFD2000™ – a computational fluid dynamics software package for use in aerospace, architectural, automotive, biomedical, chemical process, electronics cooling, power generation, metallurgical, and other commercial and government applications.

CFD2000 helps engineers and scientists solve design problems cost-effectively by simulating fluid flow, heat and mass transfer, chemical reactions, and other physical phenomena – before product prototype stage.

The software is fully compatible across super computer, workstation, and PC platforms. Its fully integrated workflow guides the user through geometry input, computational grid definition, materials properties assignment, initial and boundary conditions set-up, solution control and monitoring, and finally, 3D visualization and animation of results.

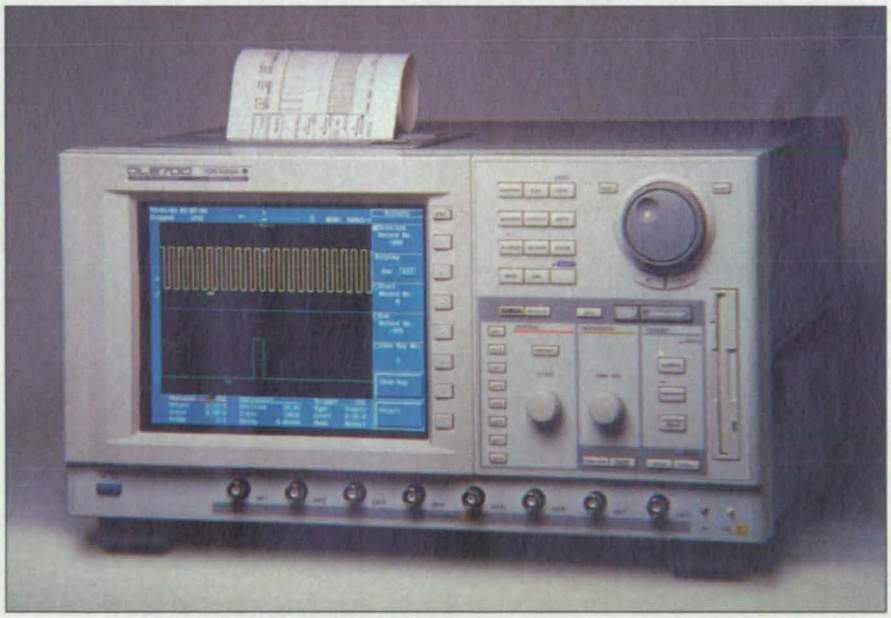
During its 20-year history in CFD research and development, Adaptive Research has established a large, worldwide customer base. Adaptive Research is a division of Pacific-Sierra Research Corporation, the California-based world leader in optimizing preprocessor technology. PSR is a $40 million company with a 25-year history of consecutive growth and sales and profit.

With seven offices nationwide, over 300 employees, and distribution channels in eight significant global markets, PSR and Adaptive Research stand postured to lead the global CFD marketplace.

For more information, contact Adaptive Research at 4960 Corporate Drive, Suite 100, Huntsville, AL 35805; Tel: 205-830-2620; Fax: 205-830-2628; E-mail: info@arc-cfd.com.

For More Information Write In No. 870

YOKOGAWA ELECTRIC CORPORATION



Yokogawa Electric Corporation has been in the business of designing, manufacturing, and supplying high-quality, leading-edge test and measurement equipment for more than 80 years. In that time, Yokogawa's enterprise has grown into a multibillion-dollar company with offices around the world. One of the most important contributing factors to Yokogawa's consistent, long-term growth has been its unwavering commitment to research and development

That commitment to R&D stems from Yokogawa's adherence to two fundamental principles: put quality first, and maintain a pioneering spirit. The high-tech equipment we develop to help our customers pursue their research and development goals enables them to test, measure, and record a wide variety of parameters. Our Digital Oscilloscopes, Power Meters, Recorders, and other products are designed with four key characteristics in mind – quality, reliability, accuracy, and flexibility.

In addition to test and measurement equipment, we design a wide range of instrumentation and field devices that are used by high-tech companies around the world. Our 132 manufacturing and service locations give us a presence on every major continent, which means we have the global resources to support all of your application needs. Yokogawa: we help invent the future every day.

For more information, contact Yokogawa Corporation of America at 2 Dart Rd., Newman, GA 30265; Tel: 800-258-2552 or 770-251-8700; Internet:http://www.yca.com.

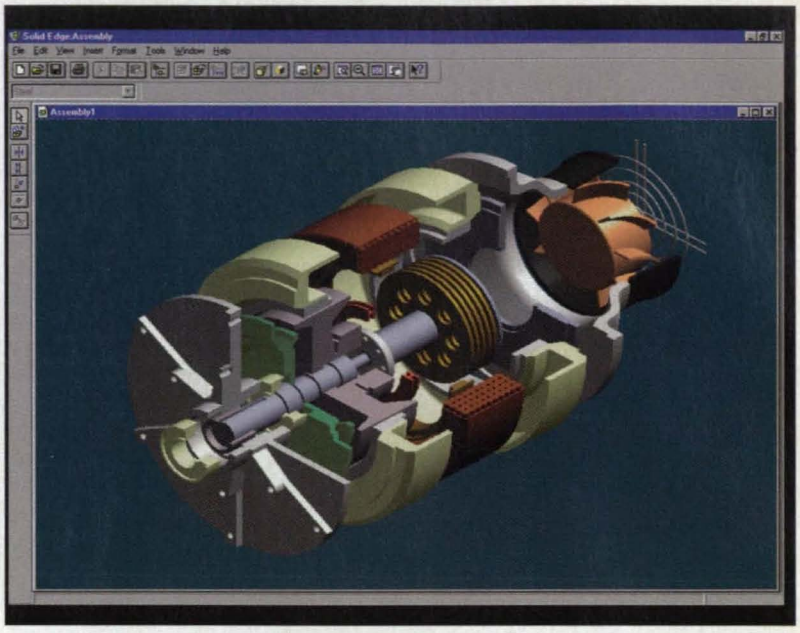
For More Information Write In No. 871

INTERGRAPH SOFTWARE SOLUTIONS

Leading-Edge Mechanical Design & Technical Drawing Tools for Engineering Professionals

Intergraph Software Solutions is leading a revolution in engineering automation with a new generation of computer-aided design and technical drawing software: Solid Edge™ and Imagineer™ Technical. Developed specifically for Microsoft Windows® 95 and Windows NT®, these innovative tools signal a new era in productivity, ease of use, and interoperation with other technical and business software applications.

Both Imagineer Technical and Solid Edge are Microsoft Office 95 compatible, allowing users to efficiently combine drawings with text, graphics, spreadsheets, and other OLE-enabled data. The intuitive Windows interface enables quick startup, streamlined operations, and day-to day ease of use. Both software packages remove the command clutter and complicated operating procedures of traditional CAD, so users can accomplish more, in less time, with fewer commands and mouse clicks.



Solid Edge: High-Performance Mechanical Design & Drafting

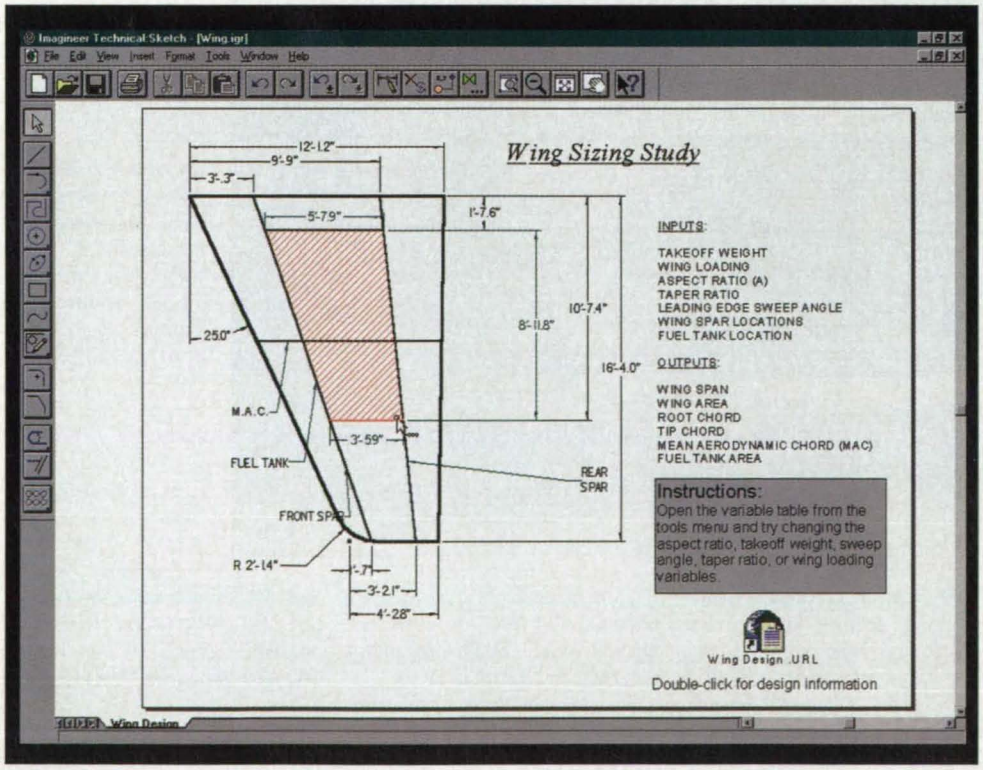
Solid Edge offers panametric, feature-based solid modeling with an easy-to-learn interface that emulates a natural mechanical design workflow, enabling engineering professionals to quickly develop designs in accurate, 3D solid geometry. Solid Edge goes beyond the part-oriented modeling approach of traditional CAD systems to improve assembly design productivity and quality. Assembly-specific tools address part-to-part interface, interference, and assembly structure problems. A complete drafting system streamlines the production of mechanical drawings that adhere to major international drafting standards.

Solid Edge is the first mechanical CAD system to feature OLE for Design and Modeling, which simplifies 3D data-sharing and interoperation with other CAD systems. Designers can view, manipulate, and assemble models from AutoCAD and MicroStation®, without data translation. In addition, Solid Edge can directly share solid models with any ACIS-based design, engineering, or manufacturing software program.

Imagineer Technical: Precision 2D Design

Imagineer is an affordable 2D precision design program that offers unique SmartSketch™ drawing, enabling users to capture ideas quickly and easily while doubling drawing productivity. From concept to final design, Imagineer is a companion to traditional workflows, with the ability to save files in AutoCAD .dwg, MicroStation .dgn, and DXF formats. Complete drawing manipulation tools – including variational dimensioning – make changes fast and easy. Symbol libraries for engineering, mapping, and architecture ensure conformance to departmental and industry standards. Imagineer is fully customizable using Visual Basic® or other OLE Automation-aware tools.

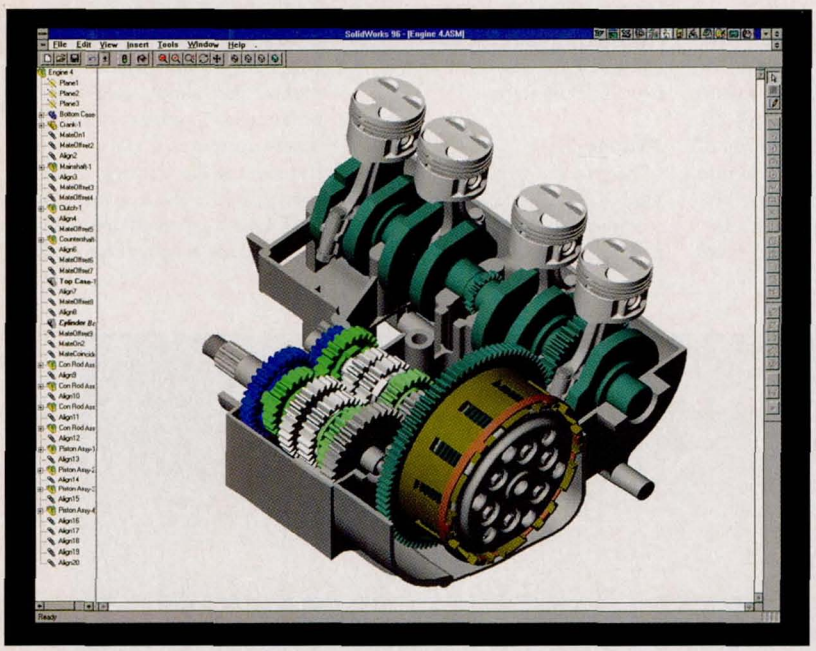
Imagineer was created for engineers, designers, scientists, inventors, and technicians as a cost-effective precision drawing tool. The product earned *CADALYST* magazine's Technology Leader award at the A/E/C Systems '96 Show in June. *CADALYST* Technical Editor Art Liddle cited Imagineer as "a very powerful, yet easy-to-use package that will change the way most of the world creates technical drawings...an extremely good example of what Windows-based programs can and should be."



For more information on Solid Edge or Imagineer Technical, contact Intergraph at 800-345-4856; Internet: http://www.intergraph.com.

For More Information Write In No. 873

SOLIDWORKS CORPORATION



SolidWorks Corporation is the leading developer of solid modeling mechanical design software products for Windows. The mission at SolidWorks is to bring production solid modeling to the desktop of every engineer, breaking the price/performance barriers. SolidWorks 96, the second major release of the company's Windows-based CAD system, is the first product of its class to put the power of production solid modeling into a native Windows environment at a price all engineers can afford – $3995 (USD). SolidWorks 96 offers significant enhancements in three major areas: assembly modeling, part modeling, and drawing generation.

SolidWorks 96 provides designers the ability to work the way they always wanted to work – completely within the context of an assembly – and SolidWorks 96 provides for 100% editability, meaning the design can be changed at any time. In addition, SolidWorks 96 provides simplification tools, including the Configuration Manager to access large assemblies quickly; the Feature Manager design tree, which records the sequence of steps taken to create a design; Dynamic Motion Visualization to view the motion of parts within an assembly; and full OLE 2.0 compliance to automate and customize the design process even further.

SolidWorks 96 is distributed in over 20 countries worldwide through a network of resellers and distributors who are trained to sell and support SolidWorks.

For more information on SolidWorks, or for a reseller or distributor in your area, call 800-693-9000; Internet:http://www.solidworks.com.

For More Information Write In No. 872

EDS UNIGRAPHICS

Building and Breaking Products – Digitally

EDS Unigraphics' vision of virtual product development represents the ultimate "build-it and break-it" process – the ability to design (or build), then analyze (or break) a completely digital model until it meets specifications.

This is critical to manufacturers because they now face the paradox of simultaneous mass customization and mass production. Most systems simply can't deliver the product development environment necessary to meet such unique new market requirements. But Unigraphics addresses these needs through its advanced master model infrastructure. Among strengths, Unigraphics leverages what it calls "process threads" – a connected series of activities performed on a part family or an assembly during the product development cycle. Creating such automated tools – i.e., that combine a series of processes into one – dramatically reduces time-to-market.

With its associative master model database, Unigraphics enables easy manipulation of complex assemblies in a concurrent environment. Components can be created separately or in the context of the product assembly in which they are used. Team members share the same product structure as it evolves. Division of work by zones – whether physical or logical – is overlaid on the common product structure and boosts response time. Convenient and high performance analysis tools for interference and clearance checking enable the use of the digital mockup for design reviews and evaluation instead of costly physical prototypes.

With UG/Manager, Unigraphics' engineering data management capability, engineers can easily access the correct revision or release version of information for even the most complex products. Moreover, anchored in the industry's most advanced master model approach, Unigraphics offers a natural progression to leveraging product data management technology, increasingly essential to turning information into knowledge for competitive edge.

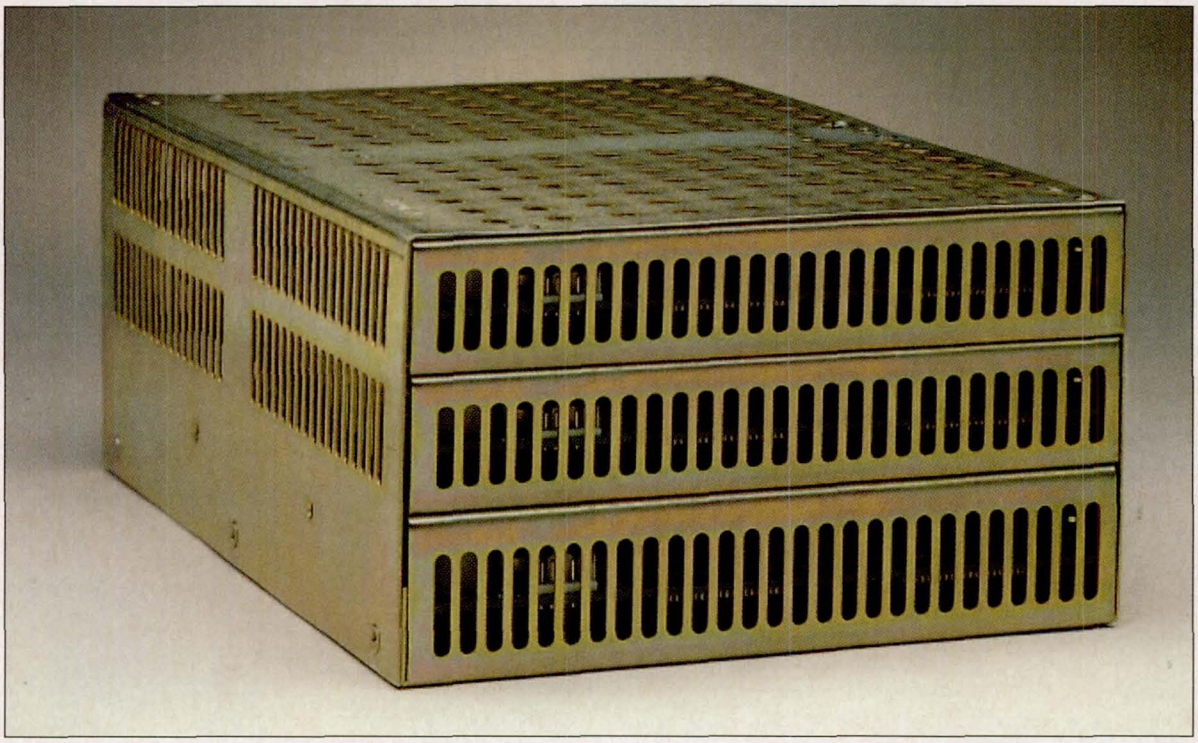
For more information, contact EDS Unigraphics at 314-344-2687.

For More Information Write In No. 874

CYBERNETICS

ESCON Interface Available for Cybernetics High-Performance Tape Subsystems

Cybernetics' high-performance data storage subsystems are now available with an ESCON interface for connection to IBM's high-end computer systems. The ESCON interface is a serial, fiber option connection which provides a 17 MBS throughput over distances of 37 miles.



The CY-9000 half-inch digital tape drive can store 42 GB on a single tape at 12 MBS, uncompressed. With optional data compression, tape capacity can reach 210 GB and speed can reach 40 MBS – allowing users to take full advantage of ESCON's performance. The drive is available in a single- or multi-drive desktop or rack-mount configuration or as part of an automated tape library solution capable of storing 7.35 TB.

The CY-8900 8mm tape drive can store 20 GB on a single tape, at 3 MBS. With optional data compression, each drive can store up to 100 GB at up to 9 MBS. Adding the Advanced SCSI Processor to a CY-8900 tape array (two drives with data compression) allows you to write as much as 200 GB at 18 MBS, taking full advantage of ESCON's 17 MBS speed.

Cybernetics subsystems feature the 2-line, 40-column status display, which shows command under execution, transfer rate, compression ratio, tape remaining, and ECC rate in clear, easy-to-read format. An Accelerated File Access option, for UNIX systems, allows you to locate a single file on a data cartridge in seconds. For data acquisition applications, Cybernetics offers an optional Digital Data Recorder Interface which allows you to write data to SCSI devices from Analog/Digital Converters of other instrument recorders, and provides an additional 128 MB or variable rate buffer. UNIX-compatible libraries can take advantage of Robotic Control Software that provides a complete command set for moving, loading, and unloading tapes, without manual tape handling.

Established in 1978 and based in Yorktown, VA, Cybernetics manufactures, sells, and services a complete family of tape and disk storage solutions that offers plug compatibility with virtually every computer system. Capacity ranges from 2.1 GB to over 12 TB.

Xtreme 5.1

Xtreme 5.1 is a 5.25" 5.1 GB hard disk drive with an average sustained transfer rate of 18 MB per second and an average seek time of 10 milliseconds. Featuring an Ultra SCSI or SCSI interface and a 4.5 MB data buffer, Xtreme is designed for integration into today's fastest workstations and servers and delivers almost instantaneous access to the largest files and databases. Host and operating system independent, the drive can be built into virtually any computer system.

Computer systems are only as fast as their weakest component, and that is usually the hard disk drive. With Xtreme, you can maximize CPU power and operating system performance. With four to five times the performance of existing hard disk drives, Xtreme can significantly increase execution speed in demanding applications like imaging, multimedia, video-on-demand, on-line transaction processing, scientific modeling, and more. Xtreme's performance also allows users to take advantage of today's leading tape drives, so users can save time and resources while working within an ever-shrinking backup window.

Cybernetics manufactures, sells, and services a complete family of disk and tape storage solutions for the widest range of computer systems. In addition to Xtreme and other hard disk drives, the company offers magneto-optical disk drives and libraries, as well as tape drives and libraries incorporating 8mm, half-inch, and 4mm technologies. Capacity ranges from 2.1 GB to over 12 TB.

For more information, contact Cybernetics at 111 Cybernetics Way, Yorktown, VA 23693; Tel: 757-833-9000.

For More Information Write In No. 876

HEWLETT-PACKARD

In June, Hewlett-Packard captured the attention of the computer industry by announcing hot new products that give customers unprecedented power in three areas: computing, visualization, and information access. This significant announcement is helping HP continue its lead in workstations and technical computing, as well as building additional momentum for HP in UNIX.

The news is the PA-8000, the HP VISUALIZE family of graphics workstations and an unprecedented level of information access. Taken together, they should leave no doubt about the value of HP to the Technical Computing Marketplace.

The new PA-8000-based HP VISUALIZE desktop systems triple the computational performance of their predecessors, HP's PA-7200-based C-class workstations. The systems are the first based on the breakthrough PA-8000 and represent huge gains in computing power. The numbers speak for themselves. This is the promise of 64-bit computing made good.

These graphics workstations shatter all industry benchmarks with the world's fastest compute performance of up to 20.2 SPECfp95 and 11.8 SPECint95. And the world's fastest 2D and 3D desktop graphics performance. For example, the HP VISUALIZE Model C180-XP, priced from $50,000, is the industry's premier 3D graphics desktop workstation, delivering industry-leading compute performance.

This system delivers 50 percent faster floating-point performance and 33 percent faster integer performance than Silicon Graphics' 200 MHz Indigo2 R10000, and more than three times the 3D graphics performance of SGI's Maximum IMPACT. And the HP system costs $2,000 less. The HP VISUALIZE Model C160, with a base price of only $24,000, is a clear price/performance leader for 2D graphics.

This system delivers 59 percent faster floating-point performance and 23 percent faster integer performance than Sun Microsystems' recently announced 200 MHz Ultra 2 Model 1200, and up to 176 percent faster 2D vector performance than Sun's Creator graphics and provides customers with a significant price/performance advantage.

Finally, compare the new K-class workstations, operating at 180 MHz, with the top-of-the-line technical systems from the competition: HP has 64 percent greater floating-point and 32 percent greater integer performance than the 200 MHz SGI R10000 Power Challenge systems.

Versus Digital's new 300 MHz Alpha Server 4100/300, the K Class has 60 percent greater floating-point and 45 percent greater integer performance, and benchmarked 131 percent greater floating-point and 88 percent better integer performance against Sun's new 167 MHz Ultra Enterprise Model 3000 server.

Of course, senior engineers and CIOs want more than performance, no matter how sizzling that performance might be. They are concerned about the future. And their assessment of HP's *commitment to them will be measured*, quite rightly, in terms of how well HP can provide for their future.

While these systems beat the competition, beating their competition isn't the real objective. HP is in business to help customers beat their competition, not only with shockingly impressive performance, but with the full breadth of solutions customers want in order to create competitive advantage.

As customers re-engineer to meet new demands, these are the systems that will enable them to work faster and more productively, and to handle much more analysis and simulation. Software prototyping. And knowledge sharing. Jobs they must be able to accomplish in this era of intense global competition. The real significance of this are the systems that will shorten customers' product development cycles, increase their product quality, and lower their manufacturing costs.

Engineers also want new ways to capture visual thoughts and make them real. HP's new VISUALIZE graphics provide faster, sharper, more intuitive ways to solve visual problems. Advanced graphics are an ongoing success story for HP. The new HP VISUALIZE *workstations represent* functionality that isn't just leading the industry, it's reinventing it.

The HP VISUALIZE-48XP delivers more than three times faster 3D graphics performance than SGI's Maximum IMPACT. In addition, the new HP VISUALIZE-EG – an entry-level 2D accelerator – delivers the world's fastest Xmark performance: 66 percent better than Sun's Creator.

Studies have shown engineers spend up to 70 percent of their time simply trying to find data – data from their suppliers, from existing designs, from test results, etc. HP has also made substantial investments in information access or connectivity for the technical enterprise, much of it based on corporate Intranets. This is where product developers are turning for greater access to data, knowledge, and a better way to manage the product development life cycle.

HP's Technical Enterprise Connectivity Solutions include a robust suite of knowledge, information access, and collaboration tools. These products, targeted at technical workstation, server, and X terminal users and delivered with HP's best-of-breed consulting services, address the critical issues that limit enterprise deployment of engineering applications.

HP has also announced improved collaboration with HP MPower Web – a desktop user environment that simplifies the large-scale technical data management in Internet and Intranet applications. HP MPower Web integrates Netscape Navigator with embedded Java for Internet/Intranet navigation, and supports standards-based multimedia data viewers.

Also announced was the HP Information Access Engine for accessing and managing data throughout the enterprise and translating legacy data to web-readable formats. HP will offer seamless integration throughout the enterprise, and even beyond the enterprise to suppliers and partners – the "extended enterprise" – giving users instant access to shared information, knowledge, and processes. Enterprise connectivity will be the domain of HP.

Unlike HP's competitors, who focus only on computing power or flashy graphics, HP has invested *heavily in all three areas* essential for your technical computing customers: computation, visualization, and information access.

HP's strategy for technical computing is to provide the technology customers need to do mind-blowing things better and faster than their competitors.

For More Information Write In No. 877

THE MATHWORKS, INC.

MATLAB® Technical Computing Environment

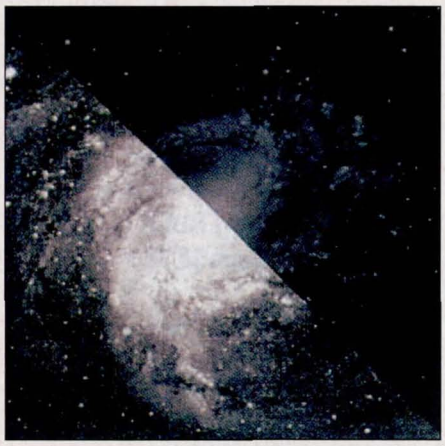
Now employing over 300 people, The MathWorks Inc. was founded in 1984 and is located in Natick, MA. The founders of The MathWorks recognized the need among engineers and scientists for more powerful computation environments beyond that represented by procedural languages such as Fortran.

In response to that need, they combined their expertise in mathematics, engineering, and computer science to develop MATLAB®, a high-performance technical computing environment that combines comprehensive math and graphics functionality with a powerful structured language.

The MathWorks has also developed SIMULINK® for simulating nonlinear dynamic systems, Real-Time Workshop™ for real-time C code generation, and an extensive family of add on products called toolboxes to meet the more specific needs of vertical-market scientific and engineering applications.

Over 300,000 technical professionals today use MATLAB to explore, analyze, simulate, design, and solve their most complex and challenging problems.

MATLAB, the underlying



numeric computation foundation for all of The MathWorks products, combines hundreds of built-in mathematical functions with powerful 2D and 3D graphing capabilities. In addition, the new MATLAB Compiler and C_c Math Library allow users to automatically convert their MATLAB programs into portable C code for standalone applications that run outside of the MATLAB environment. MATLAB offers the convenience of an application package and the flexibility of a language to customize and add new functions as needed. These unique features have made MATLAB the industry standard for technical computing.

MATLAB has found widespread acceptance in diverse application areas where matrix theory plays an important role, such as signal processing, control system design, process identification, image processing, neural network design, and numerical analysis. The MATLAB application toolboxes have been created by renowned experts in their respective fields and represent theory and algorithms at the cutting edge of scientific and engineering research. This solid algorithmic foundation assures maximum efficiency and reliable results.

NASA engineers and scientists nationwide have adopted the MATLAB Technical Computing Environment for several mission-critical research and design projects, including the next-generation High Speed Civil Transport. For researchers who require performance and cannot afford to be limited to "black box" functionality, The MathWorks continues to design and develop products based on an "open architecture." This approach enables users to extend MATLAB for custom applications and to meet their specific requirements.

For More Information Write In No. 875

(continued from page 100)

Life Sciences

Vascular Uptake of Six Rehydration Drinks at Rest and Exercise

A report presents data on the effectiveness of each of six rehydration fluids in restoring total body water and plasma volume in human subjects during rest and exercise. One of the six fluids was water sweetened with aspartame; the others were water containing various amounts of sodium chloride and/or sodium citrate, plus various amounts of aspartame and/or other carbohydrates. In one experiment, five men who had previously dehydrated themselves for 24 hours drank one of the rehydration fluids, then sat for 70 minutes. Pretest plasma volumes were measured and changes in plasma volumes were calculated. This procedure was repeated at weekly intervals until all six rehydration fluids had been tested. Another similar experiment involved four men who exercised on a cycle ergometer for 70 minutes in the supine position after drinking the fluids.

This work was done by J. E. Greenleaf, G. Geelen, C. G. R. Jackson, J.-L. Saumet, L. T. Juhos, L. C. Keil, D. Fegan-Meyer, A. Dearborn, and H. Hinghofer-Szalkay of **Ames Research Center** *and J. H. Whittam of Shaklee U.S., Inc. To obtain a copy of the report, "Vascular Uptake of Rehydration Fluids in Hypohydrated Men at Rest and Exercise,"* ***write in 67*** *on the TSP Request Card. ARC-13390*

Variable-Gravity Centrifuge/Laboratory

A report describes a study of the scientific uses and technical implementation of a 2.5-m-diameter centrifuge that would house a biological laboratory and would simulate variable gravitational acceleration aboard the International Space Station. This centrifuge facility will provide a spectrum of gravity levels from microgravity and partial Earth gravity up to 2 g to study biochemical and physiological changes in plants and animals from the cellular level to the whole-organism level. By using artificial gravity in outer space, it will be possible to separate the effects of weightlessness from other variables.

This work was done by C. C. Johnson and Alan Hargens of **Ames Research Center**. *To obtain a copy of the report, "Scientific Uses and Technical Implementation of a Variable Gravity Centrifuge on Space Station Freedom,"* ***write in 75*** *on the TSP Request Card. ARC-12962*

Mechanics

Algorithm for Targeting Spacecraft

A report describes a study of the problem of prescribing an initial velocity to a spacecraft, which is treated as a point mass at a known position with respect to a massive body, so that the craft will pass the body at a given distance in a given plane. A two-body solution is provided by an elementary geometric analysis. The solution has use in the guidance of a spacecraft into a specified orbital plane with a minimum of fuel consumption.

This work was done by Victor R. Bond, Robert G. Gottlieb, Michael F. Fraietta and Steven J. Sponaugle of McDonnell Douglas for **Johnson Space Center**. *To obtain a copy of the report, "Position to Minimum Wedge Angle Targeting,"* ***write in 78*** *on the TSP Request Card. MSC-21818*

New Literature

The STACIS 2000 stable active **control isolation system** from Barry Controls, Brighton, MA, is described in a four-page brochure. For use in stepper, inspection, grinding, and electronic manufacturing equipment, the system controls vibration in six degrees of freedom with isolation starting at 0.3 Hz.

For More Information Write In No. 743

Sonitech International, Wellesley, MA, offers a 124-page catalog of **digital signal processing equipment,** including DSP boards, development tools, software, and accessories. Applications include speech, audio, and acoustic processing; parallel processing; image processing; and acquisition and processing.

For More Information Write In No. 740

A 36-page catalog of **safety interlock switches** from Sentrol Industrial, Tualatin, OR, features Guard-Switches™, position switches, and surface-mount and miniature switches. The catalog also describes accessories and switch ratings. Most of the non-contact, sealed switches are UL-listed and CSA-certified.

For More Information Write In No. 741

Capitol Research Equipment, Chantilly, VA, offers literature describing rebuilding services for cryogenic, mechanical, and turbomolecular **pumps**. All makes and models of pumps, including Alcatel, Balzers, Edwards, Leybold, and Varian can be repaired or rebuilt and include a one-year warranty.

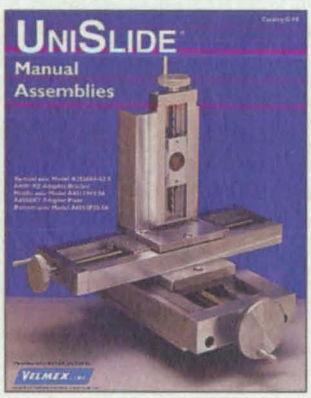
For More Information Write In No. 744

ABA of America, Rockford, IL, has released an eight-page catalog of **clamps and accessories,** including rubber clips and spring, exhaust, hose, and worm gear clamps. Clamp housings are pressed from one piece of steel tubing and have no rivets, welds, or other weak points. They can be used in high vibration, pressure, and corrosive environments.

For More Information Write In No. 742

Multi-axis motion control cards are described in a 116-page catalog from Precision MicroControl Corp., Carlsbad, CA. The catalog features motion control programming, utility software and tools, and the DCX 200 Series, DCX-PC Series, and DC2-PC Series motion control cards based on Distributed Process Control technology.

For More Information Write In No. 745



Velmex, Bloomfield, NY, offers a 40-page catalog describing UniSlide® **positioning slides and tables** for use where mechanical slide assemblies are required. Elevating tables, XY tables, adapter plates, screw motion assemblies, motor-driven assemblies, and custom construction systems are featured.

For More Information Write In No. 746

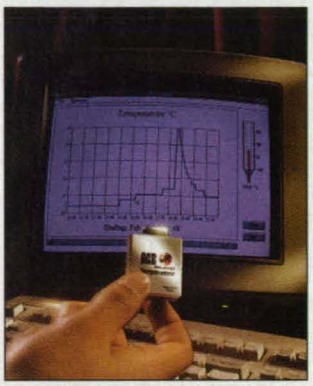
A 16-page guide of **touch screens and monitors** from CyberTouch, a division of Transparent Devices, Newbury Park, CA, features digital resistive screens for electronic, telecom, medical, aerospace, process control, and measurement equipment. More than 100 sizes and resolutions of screens and electronic interface scanners are included.

For More Information Write In No. 747

Switchcraft, Chicago, IL, has released a 345-page catalog of **electronic and electromechanical components,** including connectors, jacks and plugs, jack panels and jackfields, molded cable assemblies and patch cords, and switches. A 12-page section of switching and connecting terminology also is included.

For More Information Write In No. 748

New on the Market



ACR Systems, Surrey, BC, Canada, has introduced the ACR JR **temperature logger**, which continually records temperature versus time information and stores it to be graphed on a PC. The cordless unit has no switches, buttons, or set-up options and is used with JR. Graph software, which operates on any IBM compatible PC running Windows. The unit is plugged directly into the PC, and the software displays a time-based graph of more than 22 days of temperature readings.

For More Information Write In No. 715

The Active Matrix 10.4" LCD **touch screen monitor** from Datalux Corp., Winchester, VA, features a wide viewing angle, full-motion video capability, and VGA compatibility. The monitor is compatible with all PCs and can be wall-, desk-, panel-, or swivel-mounted. It weighs 4.8 pounds and measures one inch thick with a sealed housing. The display format is 640 x 480 pixels with a contrast ratio of 60:1. An optional touch screen is available in resistive or capacitive types.

For More Information Write In No. 716

M&M Precision Systems Corp., Dayton, OH, has announced the Type KBLS and KBL precision **linear slides** for positioning of medium loads in pre-engineered travel lengths from 4" to 40". The ball bushing slides are made from an aluminum extrusion with standard ball bearings traveling on round, hardened, and ground guide rods. Manual or motorized versions are available; options include bellow covers and pneumatic cylinders.

For More Information Write In No. 717

Master Bond, Hackensack, NJ, has introduced EP21TDC-7 two-component flexible **epoxy adhesive** for bonding most rubbers without surface preparation. The material adheres to natural rubber, neoprene, nitrile, and SBR rubber compounds, in addition to metals and most plastics. It cures at room temperature and releases no solvents or volatiles during the curing process. The cured system is chemical resistant and has a service operating temperature range from -73.3°C to +121°C.

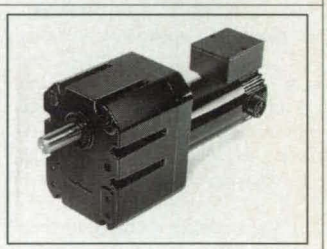
For More Information Write In No. 727

Custom Servo Motors, New Ulm, MN, offers the MaxPlus® multiple-winding **spindle motor**, which features three winding configurations—Y-Series, Y-Parallel, and Delta—that allow the spindle motor to achieve high torque without a gearbox. The permanent-magnet motor design requires less core material to reach high torque at low speeds, and generates less heat at high speeds.

For More Information Write In No. 723

POWERPAC™ **hybrid step motors** from Pacific Scientific, Motor Products Division, Rockford, IL, are available in NEMA 34 and 42 frames in two models: N Series motors, which feature holding torques to 272.8 lb-in.; and K Series motors with holding torques to 356 lb-in. Both feature large rotor diameters, a new rotor/stator design, and "housingless" frames. Various termination options are available, including MS connector, flying leads, or connection to a terminal board via a conduit connector.

For More Information Write In No. 719



Bison Gear and Engineering, Downers Grove, IL, has introduced an enhanced version of the Series 650 parallel shaft **gearmotors**, which feature a gearbox that measures 5" x 6.25" x 5.75" and torques to 720 in.-lbs. The five-stage motors are available in split phase, permanent split capacitor AC, and permanent magnet DC models. They have gear ratio ranges from 11:1 to 2206:1, speeds from 0.7 to 160 RPM, and horsepower ratings of 1/20, 1/6, or 1/2 HP. Special output shafts and liquid-tight junction boxes are optional.

For More Information Write In No. 720

The OPTOTRAK® portable **optical coordinate measurement machine** from Northern Digital, Waterloo, ON, Canada, uses active marker technology to measure rapid motions of objects in three-dimensional space. With a digitizing probe, the system provides digitized points for inspection or reverse engineering. Freeform data capture of parts at rates to 100 points per second is performed, enabling collection of dense point cloud descriptions of objects. Applications include motion capture for biomechanics analysis, medical device tracking, robotics, and aeronautics.

For More Information Write In No. 718

New on the Market

The "P" family of **pressure transducers** from Data Instruments, Acton, MA, is available in four package styles, and six portion options. The units provide calibration and temperature compensation in mV outputs and offer up to 0.5% accuracy in eight pressure ranges from 4" WC to 100 PSI Absolute. All styles are suitable for PC mounting; gauge and differential versions are available.

For More Information Write In No. 724

Servometer Corp., Cedar Grove, NJ, offers zero-backlash, bellows-type, flexible shaft **couplings** for critical positioning applications. The couplings can absorb parallel shaft misalignments up to 0.068", axial movements of 0.230", and angular misalignments to 31°. Torque ranges from 1.0 in-oz. to 4000 in-oz. are available. Outside diameters range from 0.250" to 2.40" and overall lengths range from 0.480" to 2.16".

For More Information Write In No. 729

The RG600 Series programmable regenerative DC **motor speed controller** is a full-wave, four-quadrant controller from Dart Controls, Zionsville, IN. It operates PM motors rated from 1/8 to 2 HP, in either a single or bidirectional mode with 120 or 240 VAC input voltage. The controller employs an 8/16-bit microprocessor and is field-programmable.

For More Information Write In No. 726

The SV-500 Series Surftest **surface testers** from Mitutoyo, Aurora, IL, feature Windows-based analysis software, built-in digital filter, and curvature compensation function. The units can perform more than 60 separate surface inspection parameters, including roughness and waviness motifs. Vertical recording magnifications of 100 to 500,000X and horizontal recording magnifications from 1 to 10,000X are provided. The SV-514 tabletop version and the SV-502 portable version use a 200 µinch radius diamond-tip stylus.

For More Information Write In No. 728

EPIX, Buffalo Grove, IL, has announced the PIXCI™ **imaging board** for the PCI bus that provides video rate capture from S-Video, NTSC, and PAL color video sources, as well as from RS-170 and CCIR monochrome video sources. The board provides full-frame, field, area-of-interest, scaled, and/or cropped image capture. Designed for machine vision and scientific applications, the board transfers data at rates to 132 MB/second.

For More Information Write In No. 725

Harris Computer Systems Corp., Fort Lauderdale, FL, has introduced the Night Hawk 6400 PowerPC-based, 6U VME **symmetric multiprocessing computer**, which supports from one to four PowerPC 604™ 150 MHz processors and cache, local, or global memory. Each board functions as a standalone computer system and contains real-time clocks, timers, and edge-triggered interrupts. The computer is available in commercial or rugged off-the-shelf configurations and includes the PowerUX™ operating system and the NightStar™ real-time development tool.

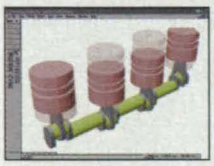
For More Information Write In No. 721

The Road Runner™ **digital camera interface** from BitFlow, Woburn, MA, connects industrial and scientific digital cameras to PCI-bus computers, regardless of the camera architecture. It places pixels directly into host memory and display in raster-scan order. A continuous burst capability of 132 MB/second minimizes time on the PCI bus, allowing virtually all host resources to remain available for processing. Applications include motion sequence capture and analysis, inspection of parts, noncontact measurement, and real-time thermal imaging.

For More Information Write In No. 722

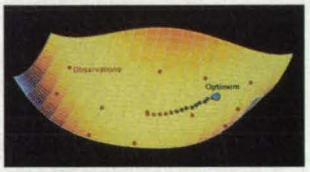
New on Disk

Product of the Month



Knowledge Revolution, San Mateo, CA, has introduced the 3D version of Working Model® **virtual prototyping and design software** for development and motion simulation of mechanical systems in Windows environments. Working Model 3D™ features a point-and-click user interface, seamless CAD integration, rapid simulation, and extends desktop engineering to both planar and spatial elements. Models can be created graphically, without specifying values or equations. The program integrates modeling, simulation, and analysis and offers an array of 3D joints and constraints such as motors, actuators, rods, and springs. An automatic collision detection and response feature in which solids interact, slide, and collide is provided, allowing users to model boxes moving over rollers or conveyors.

For More Information Write In No. 730



MATLAB Statistics Toolbox 2.0 **data analysis, algorithm development, and modeling software** from The MathWorks, Natick, MA, is integrated into the MATLAB technical computing environment to provide engineers with more than 200 statistics functions. Included are methods for probability distributions, parameter estimation, linear and nonlinear modeling, statistical plotting, and experiment design. The program can be used on any PC, Macintosh, UNIX, or VMS workstation supporting MATLAB. Prices start at $395.

For More Information Write In No. 735

Superconvergent Adaptive General Element (SAGE) **adaptive analysis software** from barnabei, Murrysville, PA, automatically determines optimum mesh with two analysis cycles: a simplified mesh for error measure and an extrapolated mesh that provides the final result to the specified error tolerance. Features include electromagnetics, computational fluid dynamics, and automated model building. The Windows program costs about $3000.

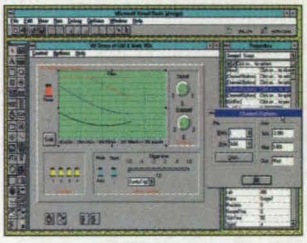
For More Information Write In No. 733

Minitab, State College, PA, has introduced MINITAB for Windows release 11 **statistical software**, which provides general statistics, quality control functions, designed experiment capabilities, and graphics features. Enhance-ments include a Design of Experi-ments interface and improved data handling. Gage linearity and accuracy, gage run chart, and two forms of gage R&R measurement systems analysis features, as well as data manipulation capabilities, are included. The program operates in Windows 3.1, Windows 95, and Windows NT and costs $895.

For More Information Write In No. 736

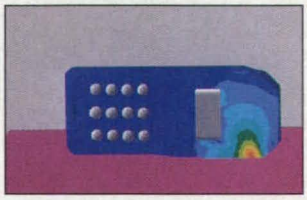
StatView® for Windows **statistical analysis software** from Abacus Concepts, Berkeley, CA, is a 32-bit application for Windows 3.1, Windows 95, and Windows NT that combines data management, statistical analysis, graphing, and presentation tools. A View window provides a drawing environment in which tables and graphs can be combined with drawn objects and text. The program is priced at $595.

For More Information Write In No. 731



ComputerBoards, Mansfield, MA, has introduced UniversalTools for Programmers, a suite of **data analysis and control software** tools for Visual Basic, Visual C++, C, and Borland Delphi programming languages. The package consists of graphical user interface custom controls and a library for real-time data analysis, manipulation, and control. The software costs $99.

For More Information Write In No. 732



ANSYS, Houston, PA, has introduced ANSYS 5.3 **multiphysics design analysis software**, which allows engineers to address real-world problems on the desktop in applications such as aerospace, automotive, electronics packaging, and biomedical. Included are a Fast Linear Solver and an Explicit Dynamics Solver that allows crash and product drop-test simulations. The program is available for UNIX, Windows NT, and Windows 95 and is priced from $8000.

For More Information Write In No. 737

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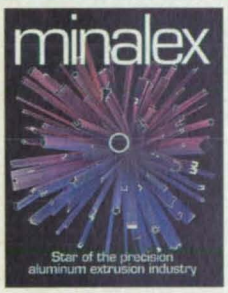

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Taber Industries

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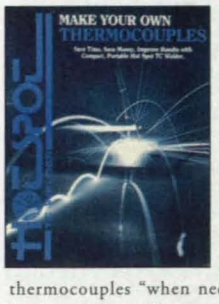

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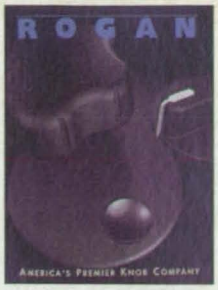

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Ball Screw & Actuators Co., Inc.

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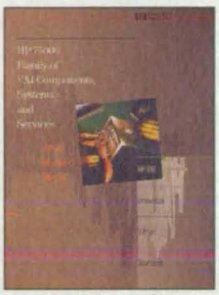

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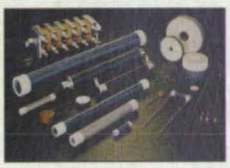

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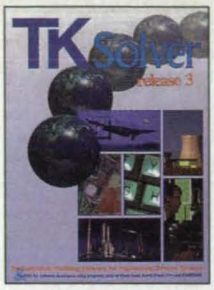

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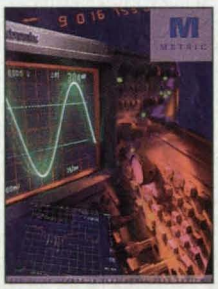

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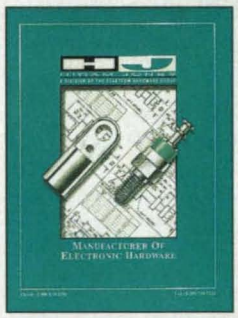

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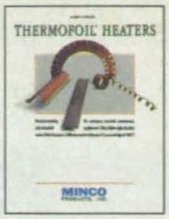

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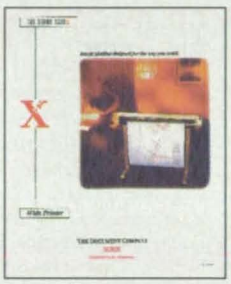

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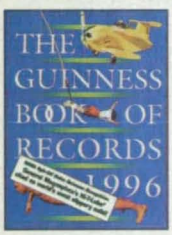

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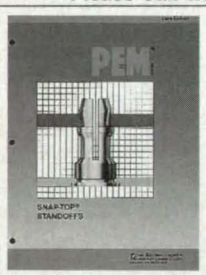

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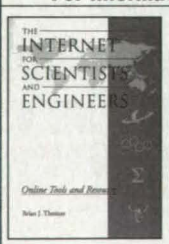

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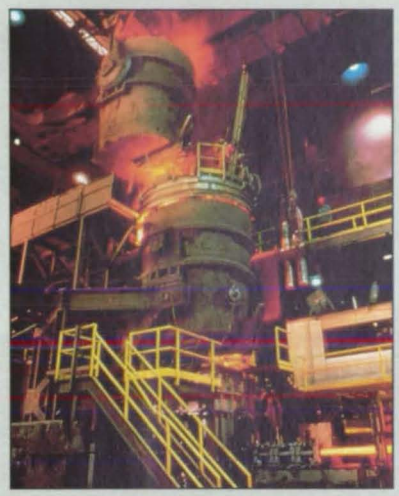
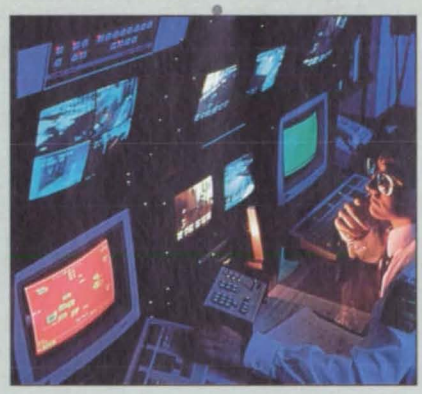


Security Systems Software CLIPS, a Johnson Space Center expert system program, enabled Software House to develop the *C.CURESystem 1 Plus*. This system allows users to manage large amounts of information, solve unique security problems and gain power over access control with time schedules, authorization levels and door entry with card validation.



Plasma Torch Using a plasma torch technology developed by Ames Research Center, Plasma Technology Corporation (PTC) has revived interest in a decade-old system for industrial heating. The *plasma torch* line developed by PTC far surpasses conventional methods. It offers greater temperature and processing control, faster reaction time, lower capital costs and a more efficient use of energy.

Environmental Seal Magnetizing fuel by dispersing finely ground particles of iron oxide through it – an idea developed by a Lewis Research Center scientist is the concept behind Ferrofluidic Corporation's *ferrofluids seal*. The initial use was in a zero leakage non-wearing seal for making semiconductor chips. The corporation now manufactures rotary feedthrough seals for the semiconductor industry.

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A/D D/A MATH $\sum_{n=0}^{N-1} x(n)W_N^{kn}$ IEEE-488 RS-232 Runtime

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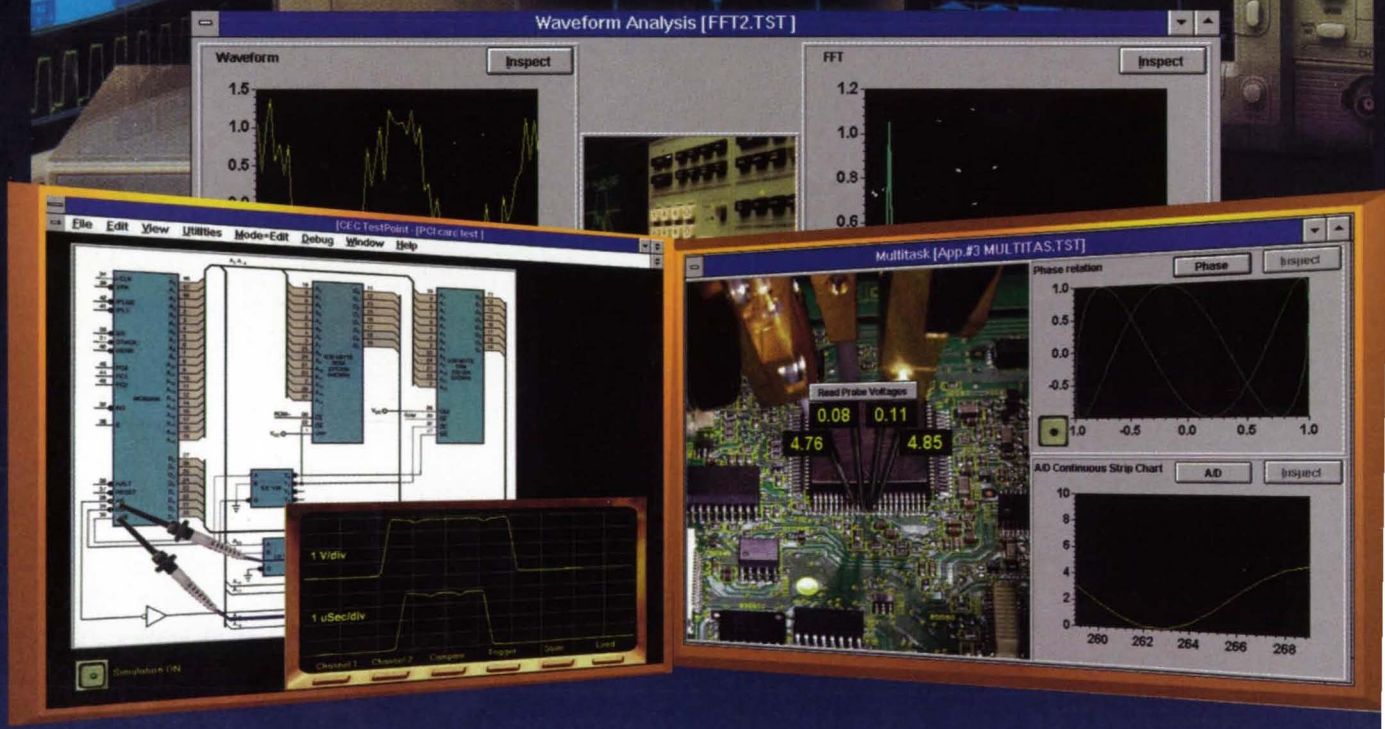

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