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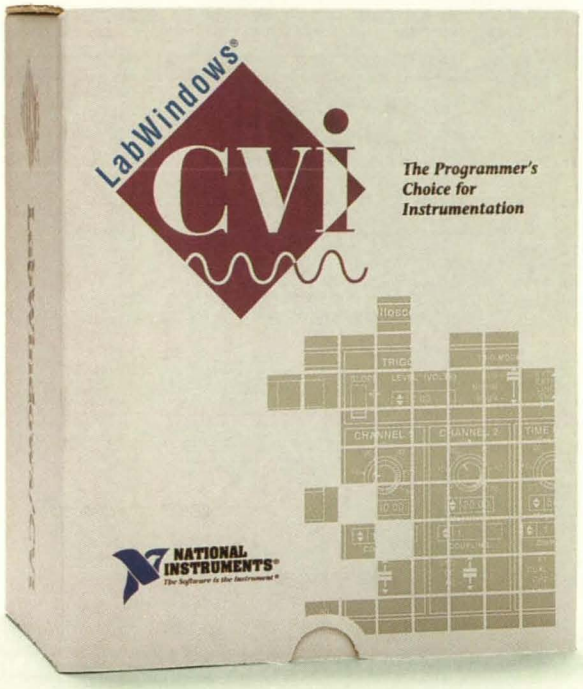

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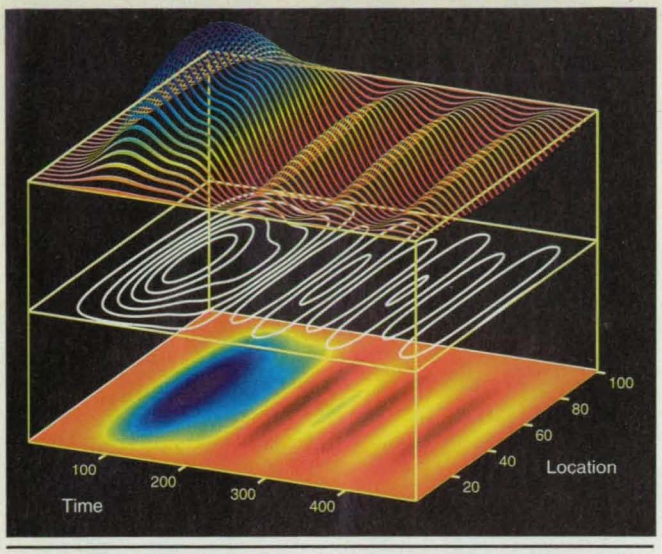

Three views of bending forces on a magnetic levitation train guideway. Analysis was one part of an 80th-order differential equation modeled with MATLAB. Data courtesy of Grumman Corp.

Add it all up – nothing else equals MATLAB® for technical computing.

When you need to solve tough technical problems, math is only part of the equation.

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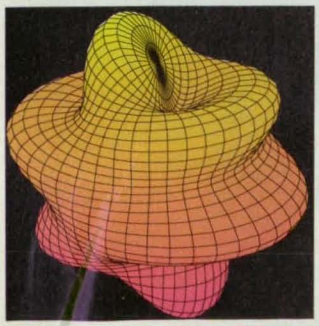

Visualization of a spherical harmonic function, created with the new Symbolic Math Toolbox.

High-performance numeric computation.

MATLAB puts over 500 math, scientific, and engineering functions at your fingertips, all designed to deliver high-performance numeric computation to your desktop. With MATLAB, you can quickly and easily crunch huge data sets and evaluate complex models.

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MATLAB is the natural language to express technical concepts, design algorithms, and prototype solutions. An elegant language, rich with built-in functionality, MATLAB enables you to develop technical applications in a fraction of the time it takes with Fortran, Basic or C.

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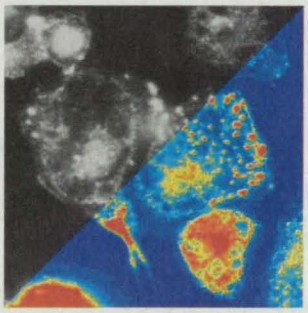
With MATLAB's open approach, you can inspect source code and algorithms, change existing functions, or create your own. You can also link MATLAB with your C or Fortran programs, exchange data with other applications, and share work across systems.



Enhancement of a cell micrograph using density slicing with the new Image Processing Toolbox.

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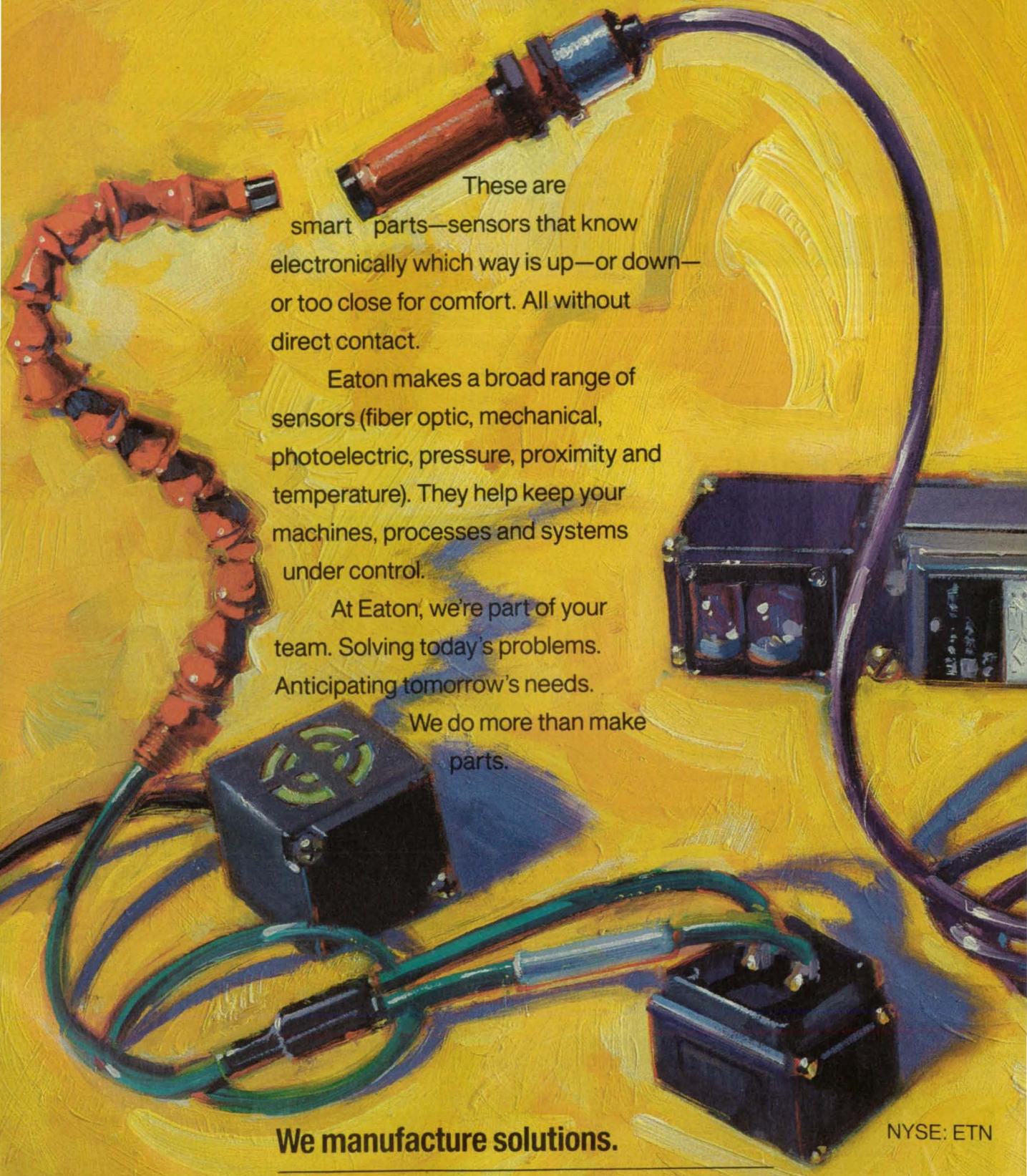

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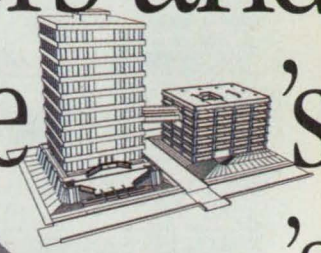
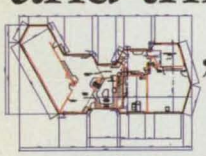
you can do Windows™ and walls and doors and floors, ceilings, whole  's,  's, trains, boats,  's, chains,  's, diamond rings,  's and things,  's, power plants, topo maps,  's, helicopters, roads and bridges, circuit boards,  's power lines,  's, airports, furniture,  , digital terrain models,  's, skateboards, the  's, chemical plants,  's, golf courses, anything you can think of ... even the kitchen  .

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An Engineer's Spreadsheet Under Windows?

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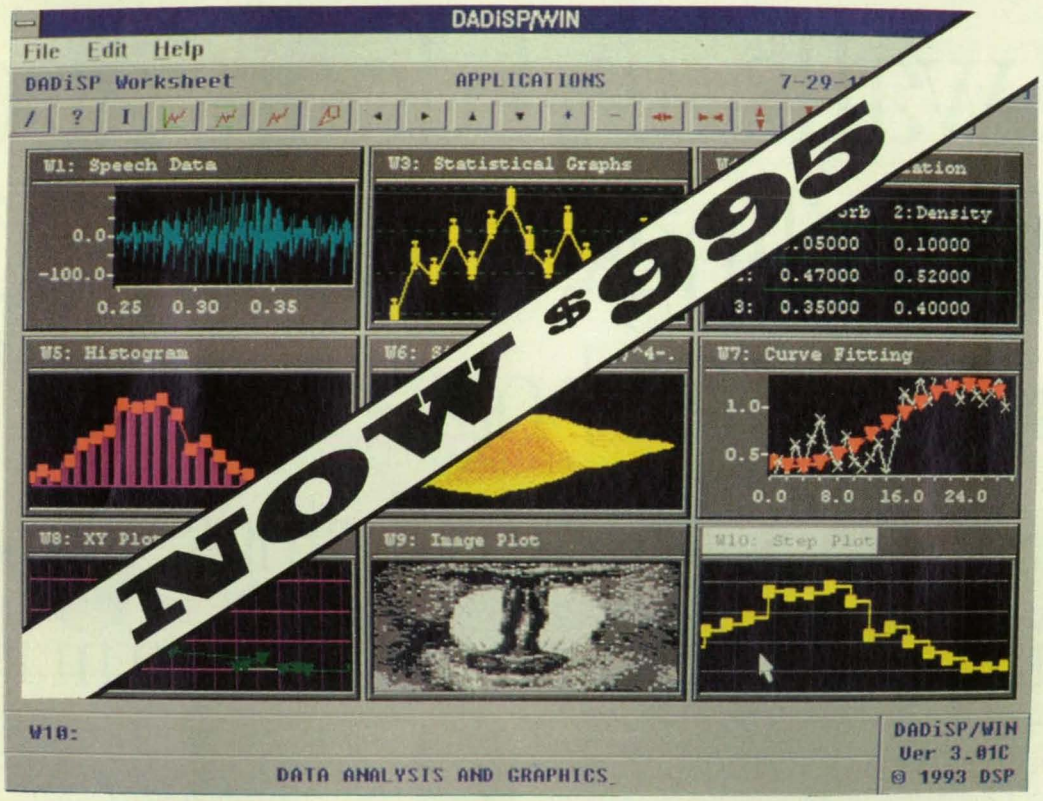

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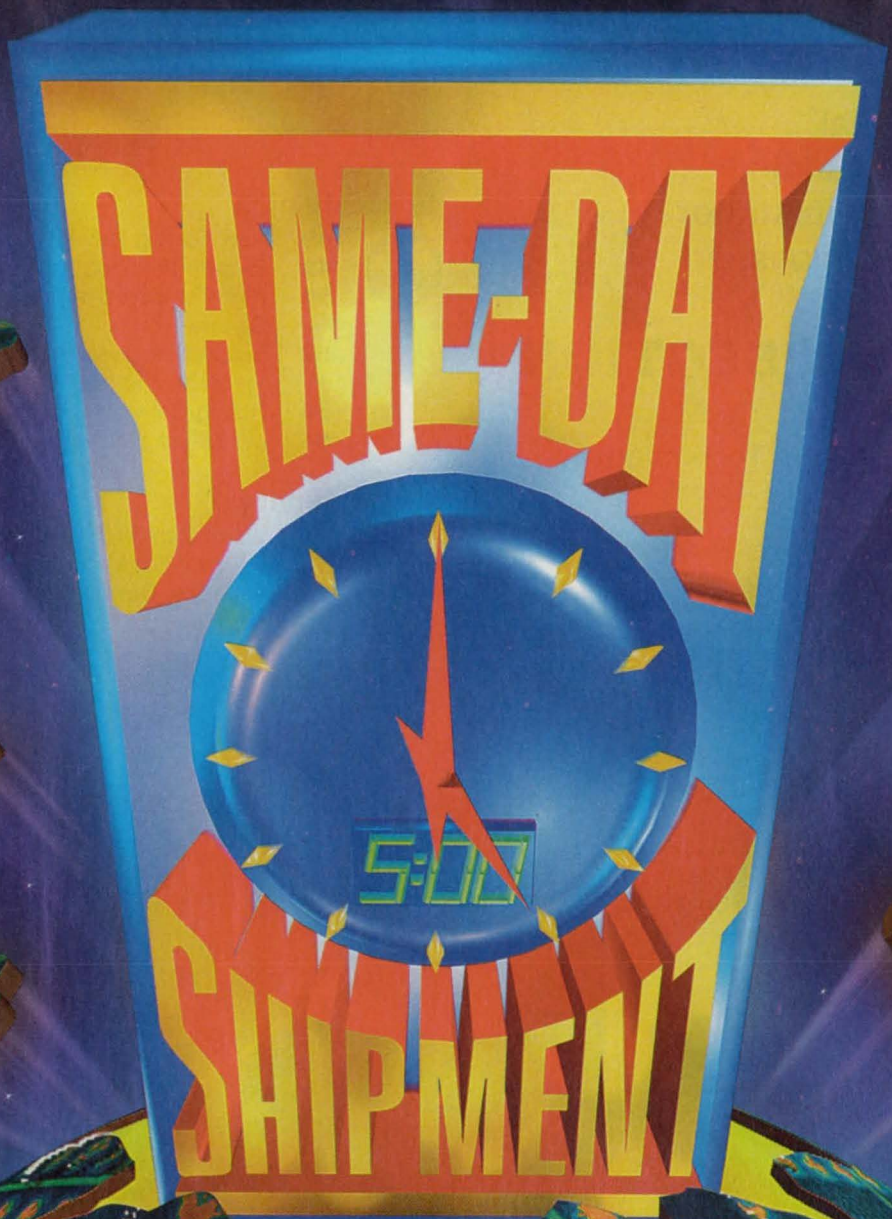

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TECHNICAL SECTION

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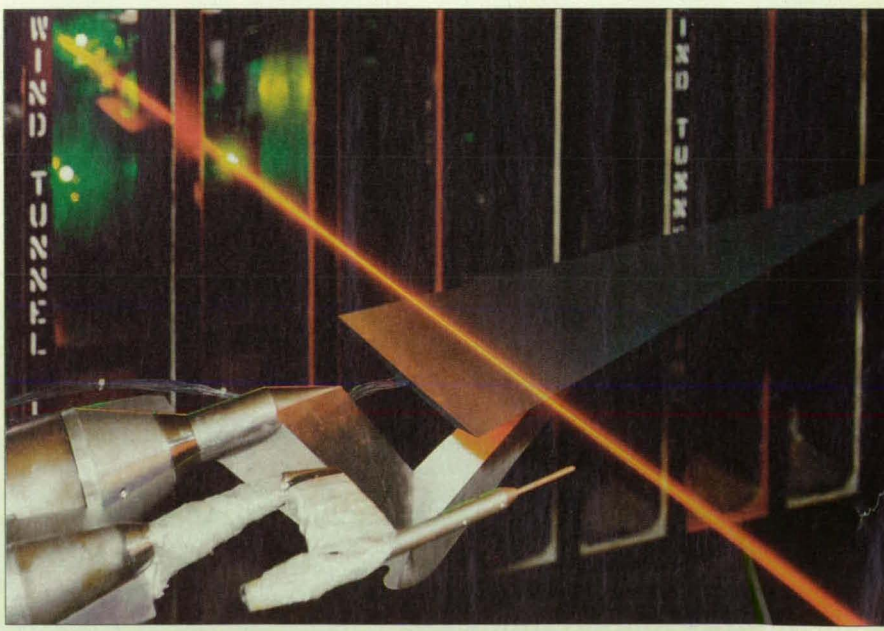

An optomechanical device developed at Langley Research Center translates the probe volume of a crossed-beam laser velocimeter while maintaining the beams' optical alignment. It measures the velocity, pressure, and temperature of a flowing gas at several locations within a supersonic wind tunnel, without requiring tedious realignments of its optical train at each site. See the tech brief on page 41.

Photo courtesy Langley Research Center

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

Single:
Drives can operate independently.

Cascade:
Data automatically writes to the second tape when the first tape is full.

Mirroring:
Writes the same data to both tapes simultaneously.

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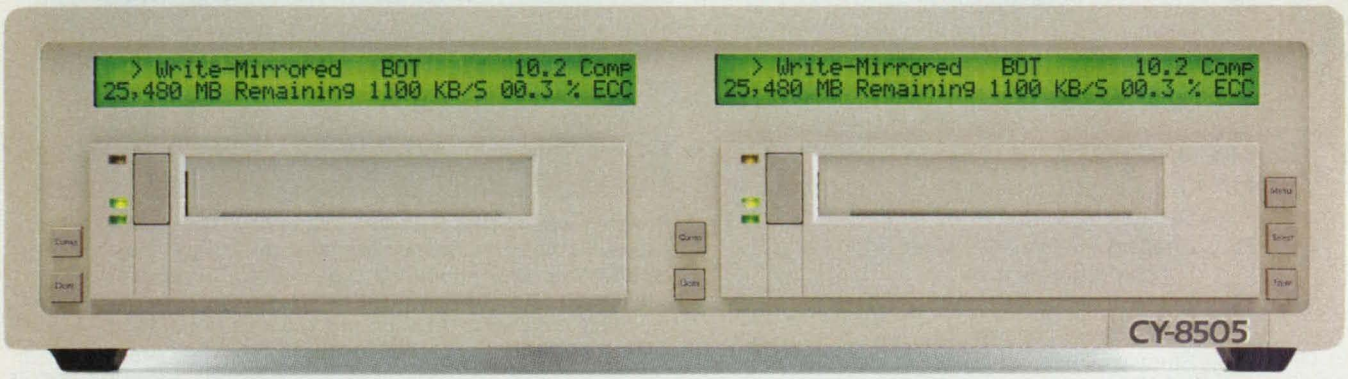

Introducing the dual drive CY-8505 with the Advanced SCSI Processor.

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Contents *(continued)*

On the cover:

A robot developed with NASA's aid assists physicians performing minimally-invasive surgery. The mechanical arm holds the laparoscope, a tiny camera inserted into the patient's abdomen to provide visual feedback. Manipulated by the surgeon via a foot or hand controller, the arm can help reduce the time, expense, and complications associated with laparoscopic procedures. Turn to Mission Accomplished on page 16. Photo Quinn Michael Farley

Researchers at Lewis Research Center have designed a tool to gauge the fiber/matrix interface strength in lightweight, high-temperature, fiber-reinforced composites. The device uses a small pushrod to displace a thin slice of the material, recording the loads required to displace and to continue moving the fiber against frictional resistance. See the tech brief on page 49.

Photo courtesy Lewis Research Center

DEPARTMENTS

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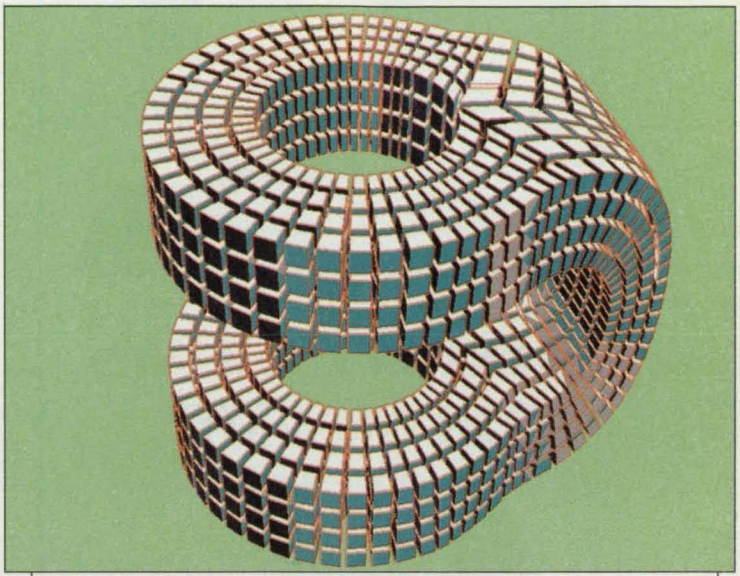

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Guest Editorial

FROM WIDGETS TO DATA STREAMS

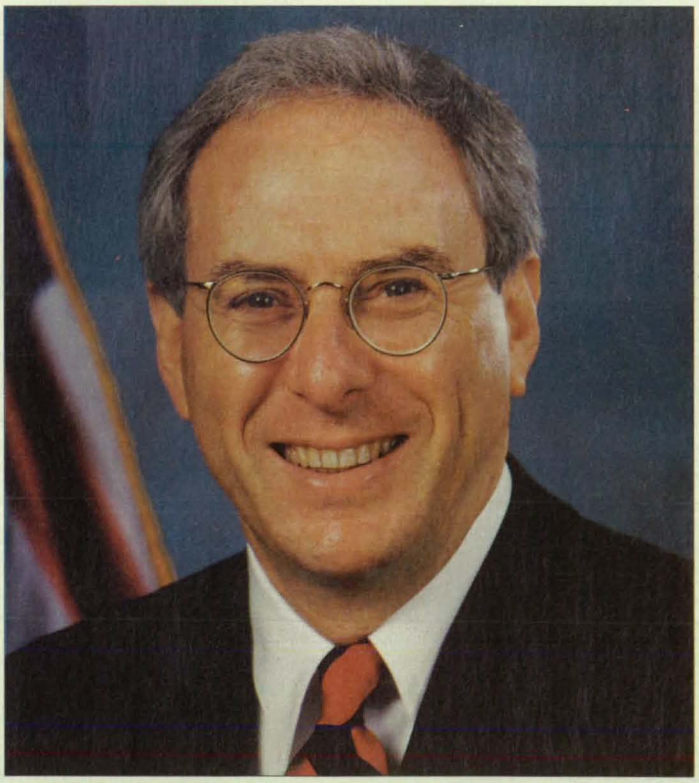
PROMOTING DUAL-USE TECHNOLOGY FOR AMERICA'S FUTURE

by DANIEL S. GOLDIN, Administrator
National Aeronautics and Space Administration

For 35 years, NASA research in air and space exploration has resulted in a steady stream of new ideas and products for America and the world. Some, such as the micro-miniaturized electronics that grew out of Project Apollo, have changed the face of our society.

But now, at the threshold of a new era in air and space development, NASA's transfer of technology is undergoing a radical change of its own. Gone are the days when technology transfer was seen as a secondary mission, governed by the relaxed rules of serendipity.

Today the space agency is stressing technology as one its primary means to make the space program relevant and meaningful to a cost-conscious nation. Under the leadership of President Clinton and Vice President Gore, we are leveraging America's federal research and development investment for the practical gain of all Americans. If there is a peace dividend from the end of the Cold War, the Clinton administration's multi-billion-dollar technology reinvestment program is it.



Daniel S. Goldin, NASA Administrator

The need to leverage that national investment is the reason I have directed the NASA team to move from a reactive to a proactive program of technology transfer, one that makes a real difference to the American people. As we boldly explore the realms of air and space, we make technology transfer an intrinsic part of our programs. Our goal will be to weave dual-use technology and commercialization into the very fabric of NASA by ensuring that our research is focused not just on the agency's needs, but also on national needs.

We have put into place several initiatives to improve and streamline NASA's technology transfer processes to be more responsive to the needs of the private sector. We intend to build upon and continually improve our current network for transferring technology. At NASA, the determination to move in this direction is more than just the latest fashion. It represents the realization that in order to effectively meet the challenges of the next century, we have to respond to powerful trends in the genesis and use of technology.

After two centuries, the Industrial Revolution is giving way to the Information Age, and it is happening on a global basis. More and more, fortunes will be based not on the manufacture of widgets, but on the harnessing of information. In order to build the vast new digital systems of the future, systems management skills will be crucial, as will mastery of the technology that makes it possible.

All over the planet, corporations and nations are racing to take advantage of the new possibilities inherent in the Information Age. Already, telecommunications provides more than five percent of the Gross Domestic Product of the industrialized nations, according to the International Telecommunication Union. In the future, that percentage will only increase.

From fax machines and beepers to laptop computers and optical disks, we already have seen the advent of the digital revolution. Now the trend is to combine those and other technologies into one box—but that will be only the beginning. The even greater challenge, and one that will define the Information Age, is construction of the vast planet-girdling systems necessary to feed data into those boxes and enable them to interact.

In the near future, the personal computer will combine the features of a tele-

The Delta Clipper Experimental DC-X.

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For More Information Write In No. 632

vision, a telephone, a communications link, a banking and shopping tool, and, just as likely, a constantly evolving digital laboratory. Futurists predict widespread use of devices that can access unlimited amounts of information, store digitized photos, send faxes around the world, and tap into fiber-optic networks with the speed of light. It is truly a brave new world on the horizon.

The skills defining success in that new world will include not just mastery of building the interactive black boxes destined to populate office desks and homes all over the world, but also the vast infrastructure and databases supporting them. From low-orbiting satellites for mobile radio frequency links to the construction of colossal data-networks on a global scale, feeding millions of access points at the speed of light, the size of things to come will be nothing short of revolutionary.

That's where the space program comes in. As Presidential Science Advisor Dr. John Gibbons has said, "The whole idea of systems design and integration in which NASA and the aeronautics people have more experience than anyone else has relevance in other sectors of our economy." The space station program is one example of how NASA's future missions will require exactly that kind of global systems integration and management know-how—to bring together components from all over the world, launch them into orbit, and assemble the pieces into a functioning space laboratory.

The experience gained in systems management of such a complex orbital laboratory, working with many nations, could offer a number of insights and new techniques even as the digital revolution changes our daily lives. Computerized tracking of design changes, information retrieval from vast data repositories, complex schedule administration, and other management tools already are being developed by the space station program. Other technologies that play into this digital future are expert systems, fuzzy logic, neural networks, automation of operations, and human-computer interactions—all areas where the space program is at the cutting edge.

The space program has been a key contributor to the information revolution from the very beginning. From the earliest communications satellites to the most recent supercomputers, NASA's unique requirements have helped to push the state of the art in information processing. Now another wave of developments is on the horizon, and what better way to prepare for it than by working at the cutting edge and cycling the new knowledge and techniques back into the national mainstream?

It is an exciting future ahead, a future that in many ways will be defined by the frontiers of technology. And working on the frontiers of knowledge, the people of NASA will tell you, is what America's space agency does best. ❑

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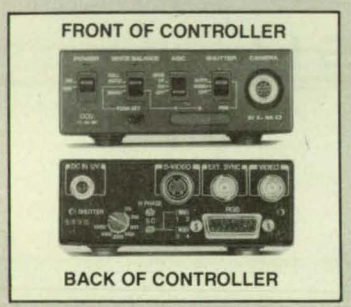

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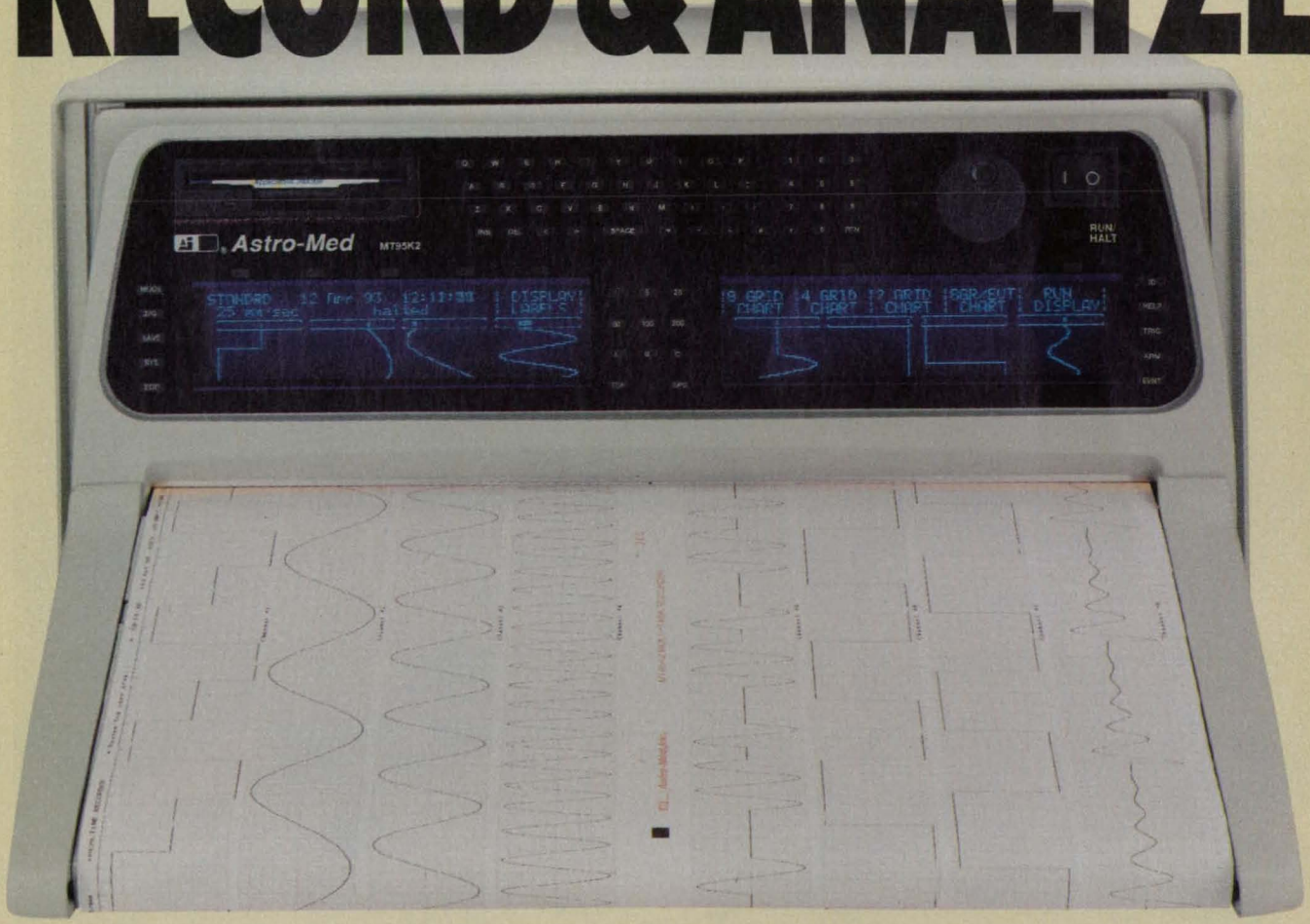

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Mission Accomplished

Through the technology transfer process, many of the systems, methods, and products pioneered by NASA are reapplied in the private sector, obviating duplicate research and making a broad range of new products and services available to the public.

Photo courtesy Computer Motion Inc.

A new robot from Computer Motion Inc. assists surgeons during minimally-invasive surgery, significantly reducing time, costs, and risks.

Ever wish for a third arm while performing a demanding or delicate task? Thanks to a mechanical arm developed by Computer Motion Inc. (CMI), Goleta, CA, physicians performing laparoscopic surgery can operate three instruments simultaneously, reducing the time, costs, and risks associated with the procedure.

Laparoscopy, which employs an optical tube with a miniature camera at its tip that can be inserted into a patient's abdomen, is gaining in popularity because it does much less damage to the patient than traditional surgery. The camera permits the surgeon to view the procedure on a video monitor, eliminating the need for a large incision. The method is used in more than one million operations a year nationwide, including gallbladder removal, hernia repair, hysterectomies, urological surgery, and infertility treatment.

"The conversion in recent years to laparoscopy has been a patient-driven phenomenon," said Yulun Wang, CMI's president and one of the robot's inventors. "It's actually harder for the surgeon to do and so takes longer in the operating room—but the patient often can leave the same day."

The traditional gallbladder removal surgery, for example, requires a six-inch incision across the abdomen, resulting in a five-day hospital stay followed by a six-week recovery period. With laparoscopy, three one-inch cuts are made, one for the laparoscope and two for surgical instruments. Such minimally-invasive surgery means the patient spends less time under anesthesia—20 percent less in recent trials—and recovers much more quickly. After a laparoscopic gallbladder removal, the patient probably will go home the next day and recover in a week.

Until now, however, a medical assistant was needed for the tedious job of

holding and maneuvering the laparoscope to the surgeon's instruction. "Surgeons didn't like not being able to control their visual feedback," said Wang.

The new robot, AESOP, short for Automated Endoscopic System for Optimal Positioning, holds the laparoscope and moves in response to a foot controller operated by the surgeon. Mounted on the edge of the surgical table, it provides a stable image for delicate work and thereby reduces the risk of error and postoperative complications. Pedals on the foot controller enable the surgeon to pan smoothly backwards and forwards as well as safely view the introduction and exit of instruments from the abdomen. The robot also reduces the tendency to touch internal tissues during a procedure, which necessitates cleaning the lens.

Eliminating an assistant reduces both the crowding in the sterile field and personnel costs, which represent 70-80 percent of hospital costs. "You might think that surgical assistants would be angry at losing this position, but everyone attests that it's a thankless job because you get yelled at all the time," said Wang. Frustration results on both sides because no human assistant can precisely interpret the surgeon's constant commands to "move a little to the left, now a little up."

AESOP's ReView™ feature enables it to remember key operative sites and tool insertion points. The surgeon can press one of six programmable buttons to lock a position in memory, touching the button anytime during the procedure to return automatically to the programmed location. Each button can be reprogrammed as many times as necessary during the procedure.

The robot also solves the problem of counter-intuitive view adjustments. Traditionally, shifting the view to the right required the operator to move the laparoscope to the left; panning up meant moving the instrument down. Because AESOP's motion is screen-based, the robot moves in accordance with the image on the monitor.

"I can go measurably faster with AESOP because the procedure is more efficient," said Dr. Jonathan Sackier, a surgeon at the University of California at San Diego Medical Center who performed the first surgical trials and is heading a ten-hospital study of the robot. Used to date in 25 cases at six institutions nationwide, AESOP recently received Food and Drug Administration approval.

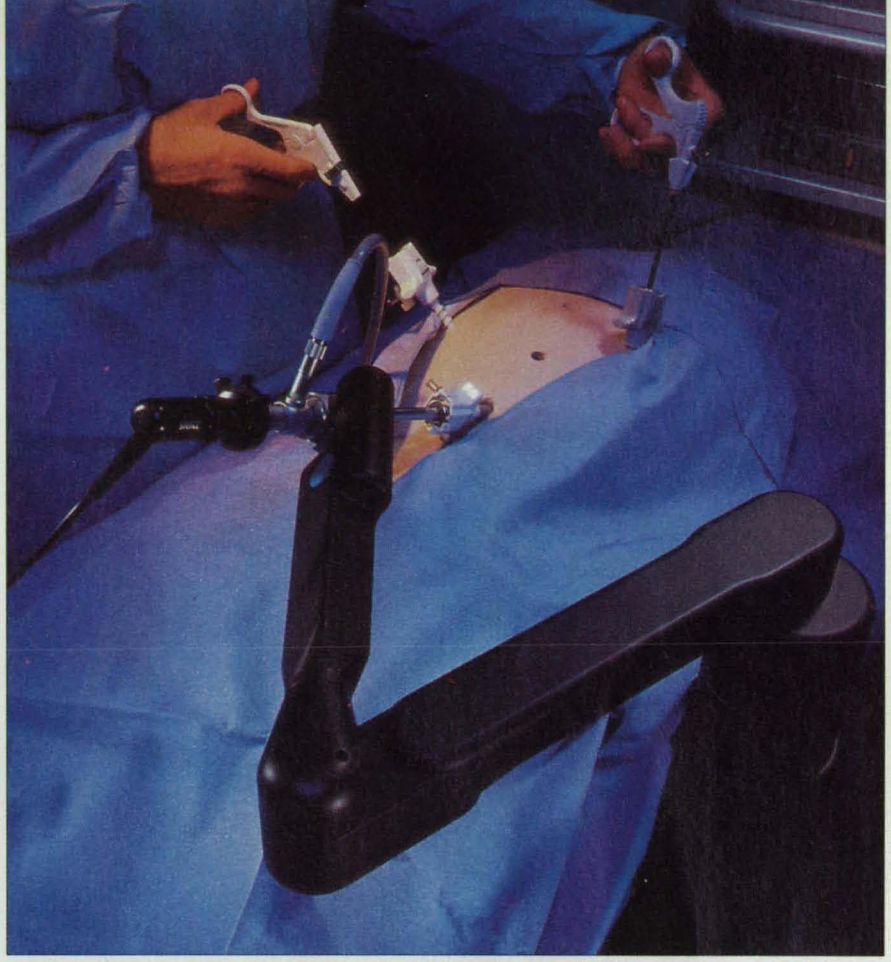

Photo Quinn Michael Farley

Mounted to the surgical table, AESOP requires little space and assumes the tedious task of holding steady and manipulating the laparoscope, a tiny camera inserted into the patient's abdomen.

AESOP is the first commercial application of technology developed through a Small Business Innovation Research grant from NASA's Jet Propulsion Laboratory. Computer Motion's task was to develop a low-cost robot capable of delicate force control for precise tasks such as polishing, finishing, cleaning, and deburring. "With the JPL funding, we built a core team of robotics experts and developed from the ground up all the subcomponents that go into any robotic system," said Wang. "Consequently, we were able to build our first prototype of AESOP in three months."

AESOP doesn't fit into either of the two classes of robots common today. One type is the usually large and expensive industrial robots programmed for specific high-speed movements such as parts assembly or welding. Teleoperated robots, on the other hand, mimic the movements of a human operator at a remote location where it is unsafe for humans to go, such as a hazardous waste site. By contrast, AESOP offers robotic enhancement technology (RET™), which combines a man and a machine to perform tasks neither could perform alone. AESOP melds the precision of robotics with the memory of a computer and the intelligence of a doctor.

The robot utilizes a unique macro/micro design—coupling a large robot to a smaller and more accurate manipulator—to control costs. "In this particular application, the robot doesn't have to move very quickly or accurately, compared to industrial robots, because there's a man in the loop constantly making adjustments," said Wang. "As a result, we'll be able to sell it for around $20,000."

CMI continues to conduct research to create a more seamless man-machine interface. Current efforts are focused on incorporating voice-activation and eye tracking, by which the robot would move in response to a surgeon's eye movements. Such enhancements, according to Wang, could enable the surgeon to operate more than one robot and, thereby, several different surgical instruments for even more efficient surgery. ❑

For more information on the technology described above, contact James W. Wright, Director of Marketing, Computer Motion Inc., 250 Storke Road, Suite A,

New Product Ideas

New Product Ideas are just a few of the many innovations described in this issue of *NASA Tech Briefs* and having promising commercial applications. Each is discussed further on the referenced page in the appropriate section in this issue. If you are interested in developing a product from these or other NASA innovations, you can receive further technical information by requesting the TSP referenced at the end of the full-length article or by writing the Technology Utilization Office of the sponsoring NASA center (see page 20). NASA's patent-licensing program to encourage commercial development is described on page 20.

Enhanced Cultivation of Stimulated Murine B Cells

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(See page 68.)

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Piezoelectric Motor in Robot Finger Joint

This robotic finger contains an integral piezoelectric motor. The finger is simpler to assemble and disassemble and to repair.
(See page 57.)

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(See page 62.)

Two-Stage Series-Resonant Inverter

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(See page 34.)

Making $CoSi_2$ Layers by Ion Implantation

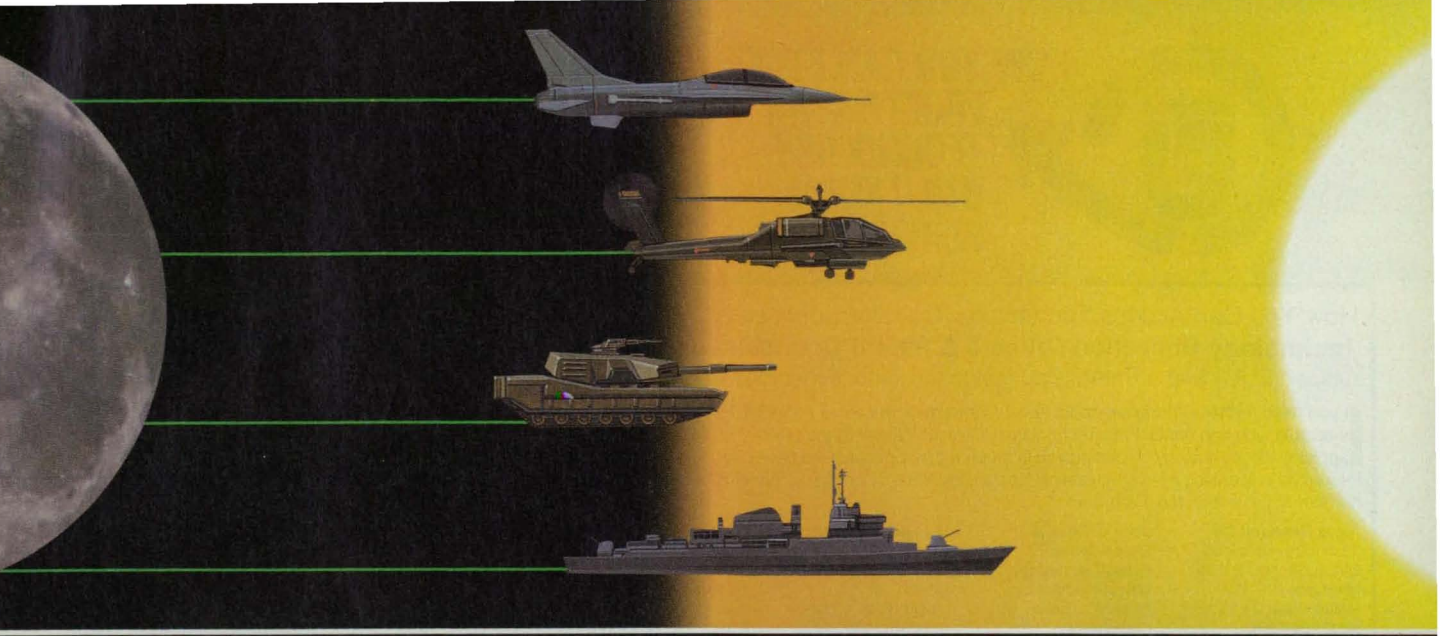
Vertical-junction photovoltaic cells in series would be fabricated in a monolithic structure. Such cells offer potential advantages of high power density and low series resistance.
(See page 35.)

Pyrolle-Based Conductive Polymers for Capacitors

Polypyrolle films that contain various dopant anions exhibit superior capacitance characteristics. Sample films have demonstrated volumetric capacitance of about 300 F/cm^3.
(See page 43.)

Guanidine Soaps as Vehicles for Coating Ceramic Fibers

Such soaps serve as vehicles and binders for coating ceramic fibers, various smooth substrates, and other problematic surfaces with thin precious-metal or metal-oxide films. The soaps are entirely organic and can be burned off, leaving no residue.
(See page 45.)



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

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

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

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

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

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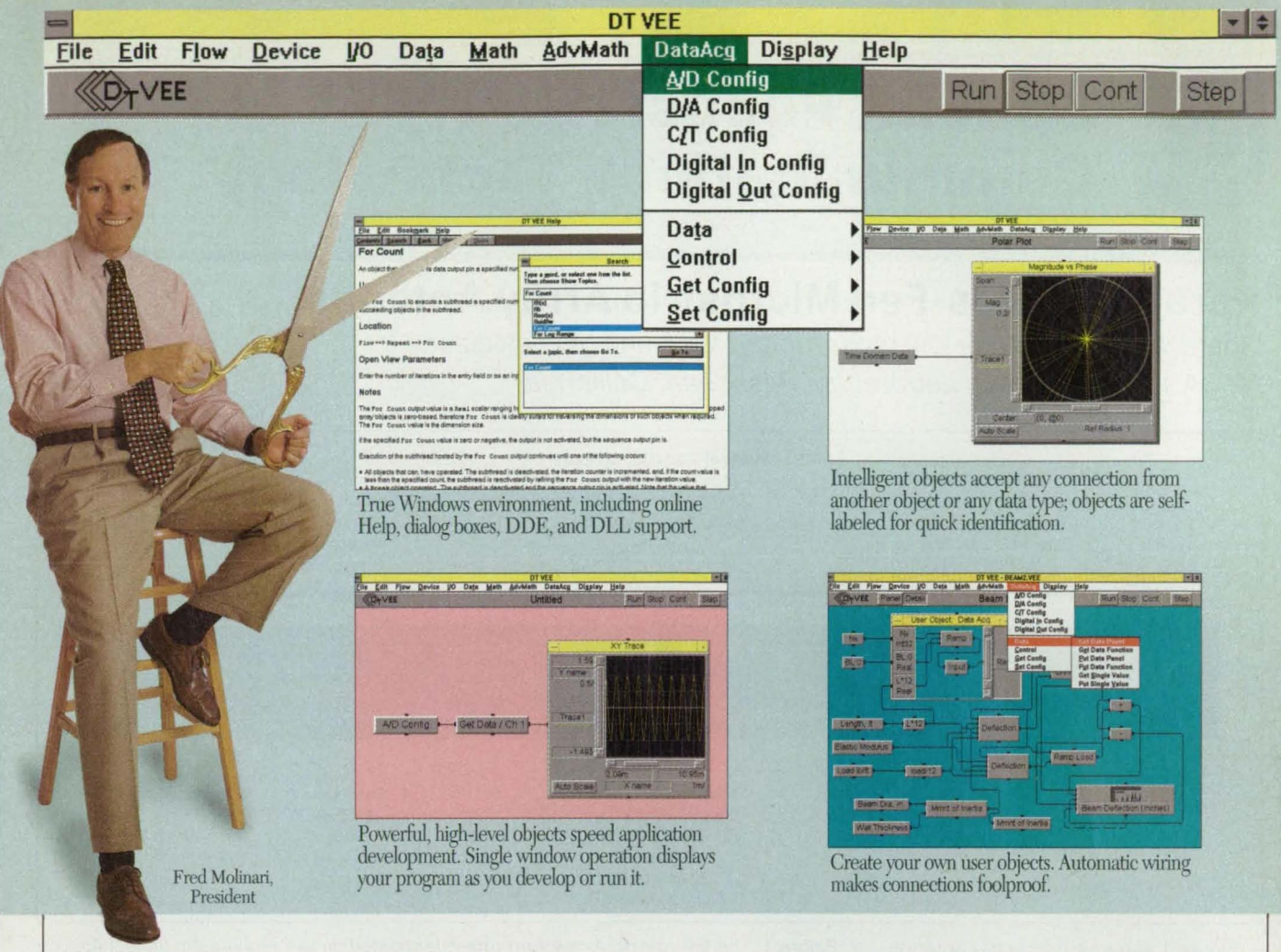

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For More Information Write In No. 558

Special Focus: Communications Technology

Parallel/Series-Fed Microstrip Array Antenna

Characteristics include low cross-polarization and high efficiency.

NASA's Jet Propulsion Laboratory, Pasadena, California

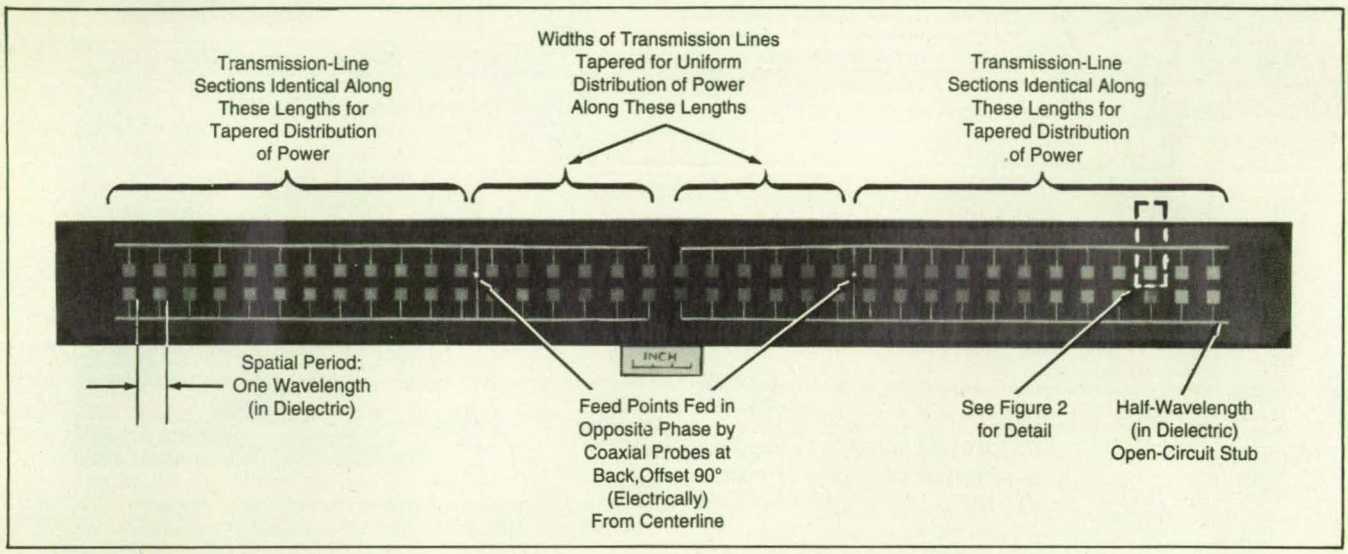

Figure 1. The **Microstrip Array Antenna** is fabricated on two rectangular dielectric substrates.

Figure 1 shows a microstrip antenna that produces a fan-shaped beam polarized parallel to its short axis. The design of the antenna optimizes its performance at a frequency of 5.3 GHz, minimizes cross-polarization and insertion loss, and suppresses the beam squint or change in beam squint that would otherwise occur when the operating frequency is changed to another, nearby value. This antenna, fabricated on two thin dielectric substrates, is meant to be mounted conformally on the outside surface of an aircraft for use in synthetic-aperture radar. Other antennas of similar design could be mounted, for example, on the roofs or sides of buildings, ships, or land vehicles for use in radar or communications.

The antenna contains a total of 72 microstrip-patch radiating elements connected to 2 coaxial feed probes via microstrip transmission lines. To minimize cross-polarization, the two feed points are located electrically 90° off center and are excited in opposite phase; this combination of features results in cancellation of both spurious radiation from higher-order electromagnetic modes of the patches and leakage radiation from the microstrip transmission lines, and the net result is that the radiated beam is nearly purely polarized along the desired direction.

Beam squint is suppressed and insertion loss is minimized by a combination of parallel and traveling-wave series feed configurations. As shown in more detail in Figure 2, the microstrip transmission lines contain sections of various lengths and widths chosen to produce the desired amplitude and phase relationships among the radiating elements. In this approach to traveling-wave series feed, the impedances are matched not only at the feed points but also at the power-division points and at the radiating elements. For example, the outer parts of the array are designed so that each element radiates one-sixth of the traveling-wave power that reaches it.

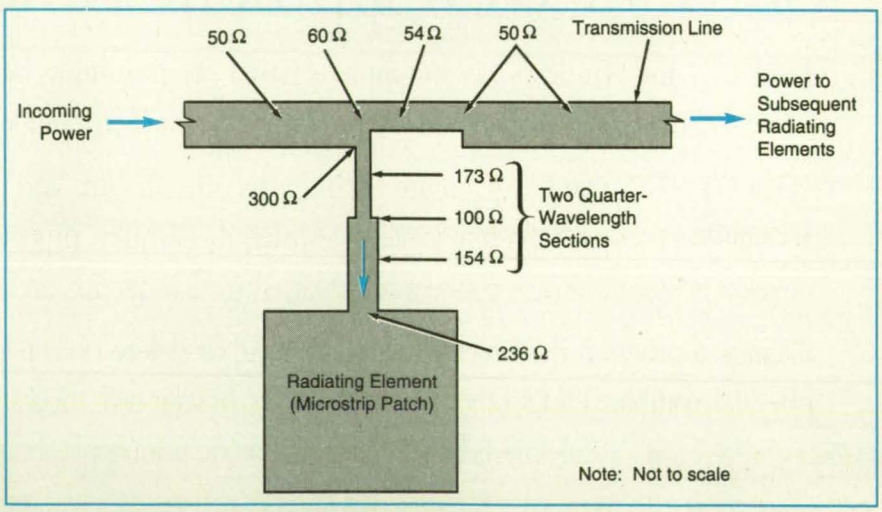

Figure 2. **Impedance-Matching Sections of Microstrip Transmission Lines** apportion power to the various radiating elements. The radiating element shown here is the one denoted by the dashed outline in Figure 1.

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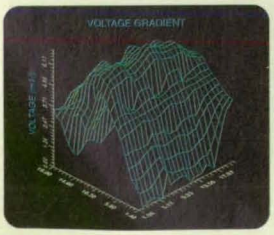
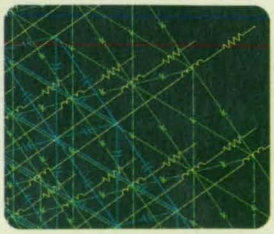
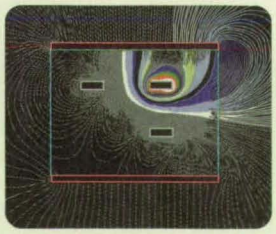


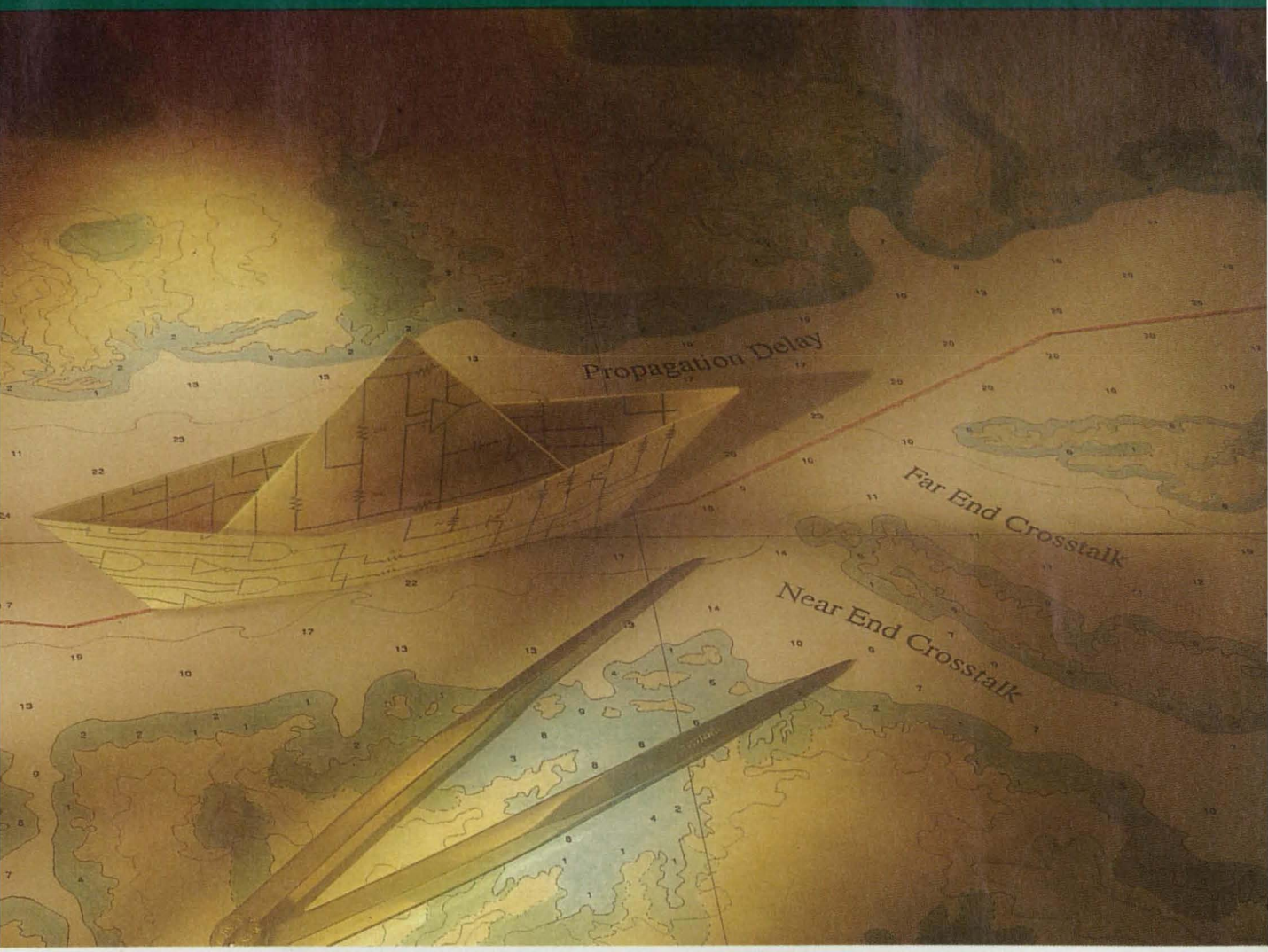
3D voltage drop analysis.



3D matrix model improves CAE simulation.



*2D, 3D electromagnetic analysis of interconnects.**



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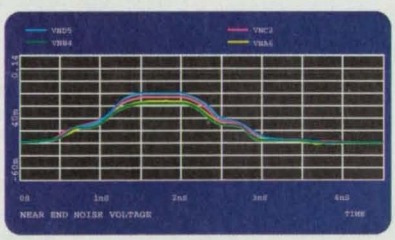
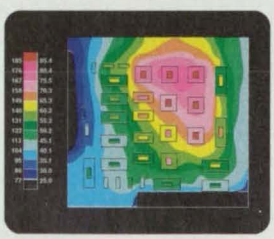


Noise voltage analysis predicts performance.



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The distance along the transmission lines between radiating elements is one wavelength in the dielectric substrate, so that the radiating elements are fed in phase and the main lobe of the radiated beam is broadside. Half wavelength open-circuit stubs at the outer ends of the array reflect the remaining power back along the transmission lines. The reflected traveling waves are in phase with the incoming traveling waves at the feed points of the radiating elements: consequently, the reflected power is utilized as fully as possible, and very little power is wasted.

The particular off-centerline, off-midlength feed configuration is such that the middle part of the antenna array is effectively parallel-fed even though each half of the array is series fed. Under this condition, although the beam from each half of the array would squint away from broadside with a change in frequency, the combined beam produced by the whole array remains broadside. Of course, the gain in the broadside direction is reduced when this happens.

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

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Resident Office–JPL [see page 20]. Refer to NPO-18678.

Dual-Beam Microstrip Array Antenna

One array produces two off-broadside beams with no additional complication of feeds.

NASA's Jet Propulsion Laboratory, Pasadena, California

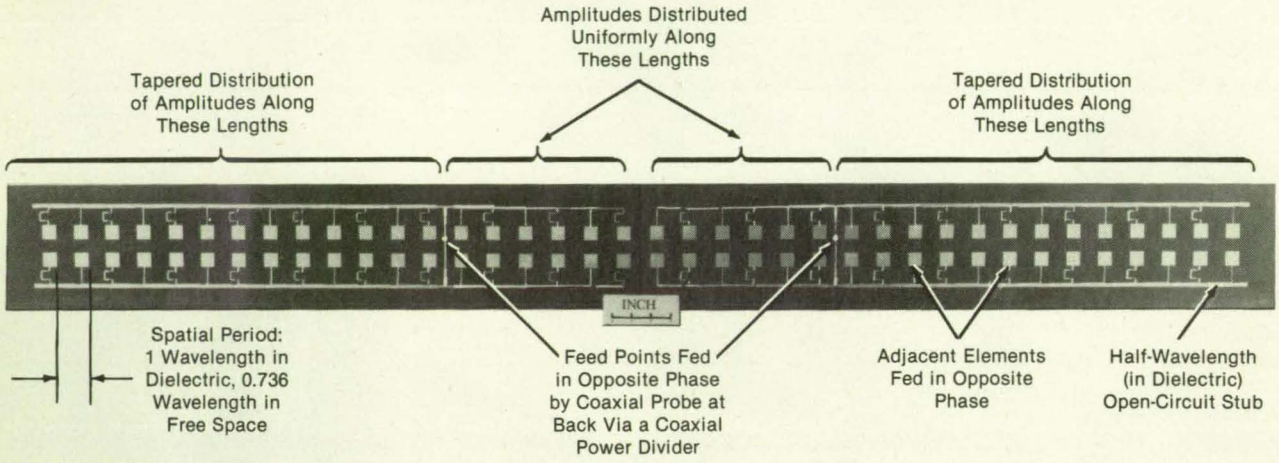
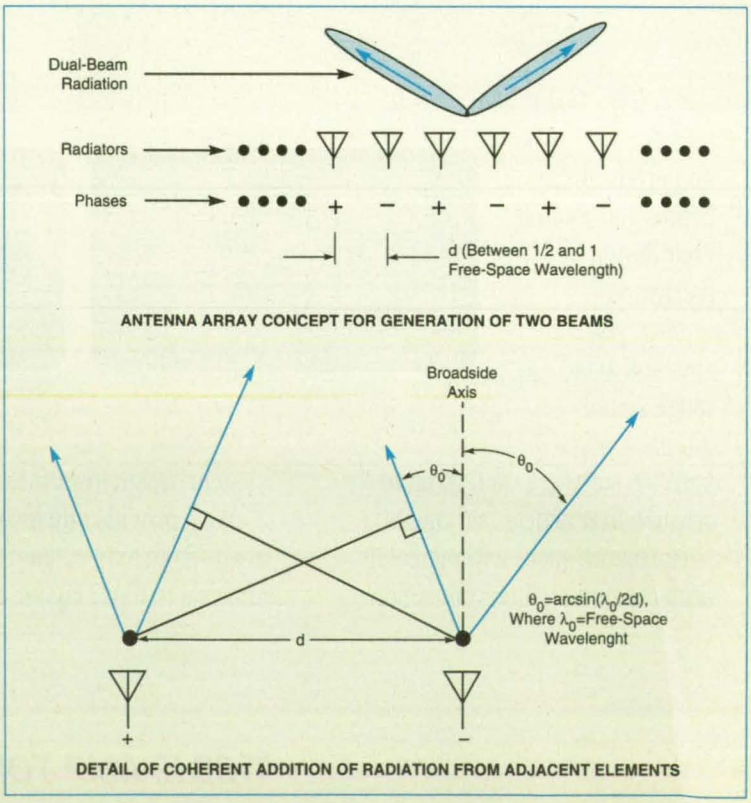


Figure 1. This **Microstrip Array Antenna** is similar to the one described in the preceding article, except that it produces two off-broadside beams instead of one broadside beam.

The microstrip array antenna shown in Figure 1 produces two squinted beams at angles of ±41.5° off broadside, at a frequency of 5.29 GHz. This antenna is similar, in many respects, to the antenna described in the preceding article, "Parallel/Series-Fed Microstrip Array Antenna" (NPO-18678). Like that antenna, this one is designed with offset, opposite-phase feed points in a combined parallel and traveling-wave series feed configuration that minimizes (1) cross-polarization, (2) the change in beam squint with a change in frequency, and (3) insertion loss. In the original application, the two beams are to be used in an airborne synthetic-aperture interferometric radar to measure along-track and cross-track velocities simultaneously. Other potential applications include multiple-beam communications and tracking of aircraft at airports.

Two of the differences between this antenna and the previous one lie in the free-space distance between the radiating elements and the phasing of the element feeds. The elements are spaced a full wavelength (in the dielectric) apart

Figure 2. **Adjacent Elements Are Spaced and Phased** to radiate coherently in the desired beam squint directions.



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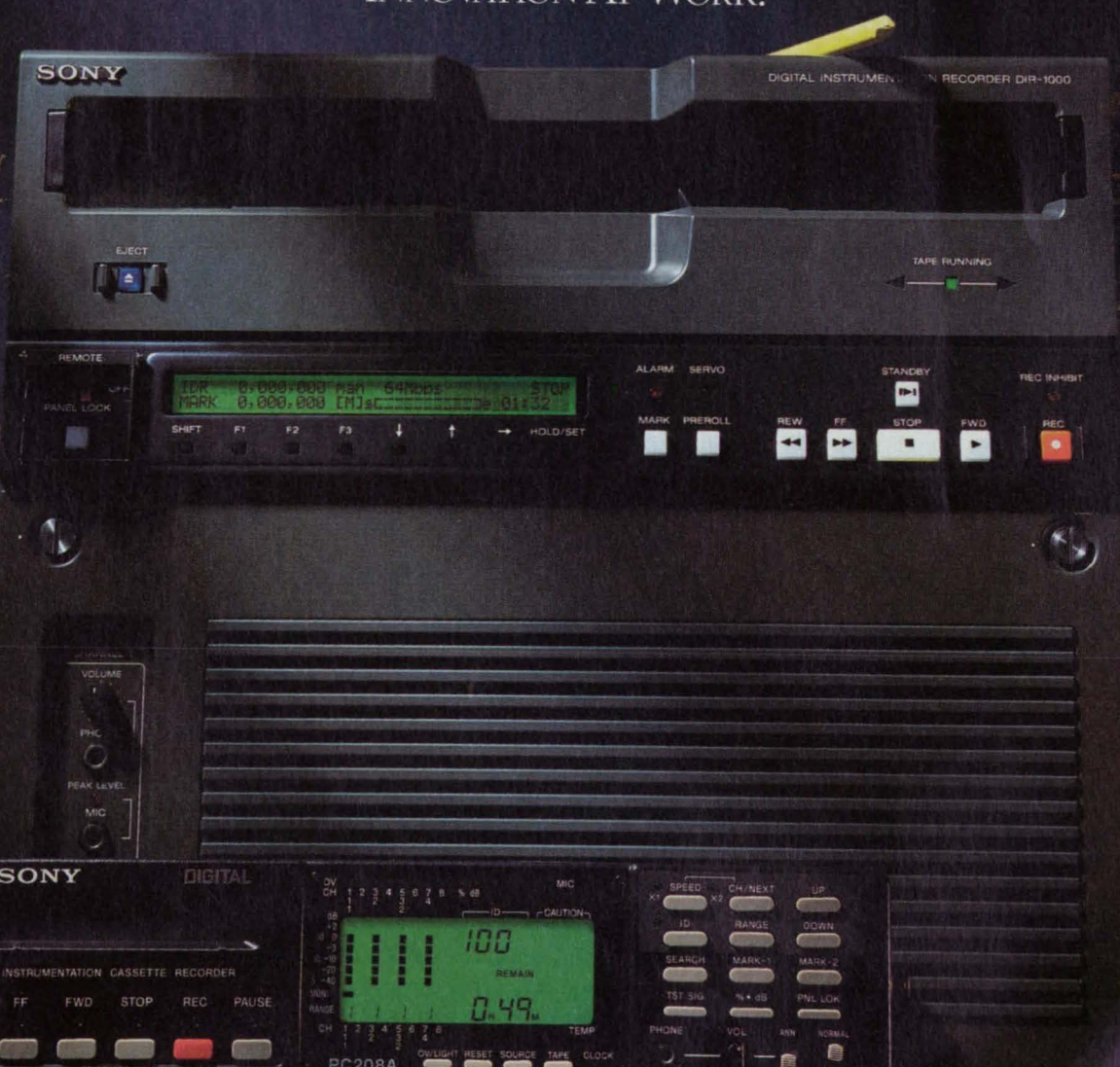

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in the long dimension, corresponding to a 0.736 free-space wavelength. The impedance-matching transmission line sections that feed adjacent elements differ in electrical length by 180°, so that adjacent elements are fed in opposite phase. Thus, the antenna can be regarded as consisting of two interleaved subarrays excited in opposite phase.

The combined effect of interferences among the electromagnetic fields radiated by the various elements in like and opposite phases is to suppress the net radiation in the broadside direction and add coherently to produce the two off-broadside beams at ±41.5°. These two off-broadside beams are the results of grating lobe radiation. The 3-dB width of each beam is 2.7°; the peak sidelobes are 15 dB below the main-beam peaks. In practice, imperfections of design and fabrication prevent exact cancellation of the broadside beam, which remains about 18 dB below either main beam. The measured peak gain at 5.29 GHz is 20 dB with respect to an isotropic antenna. The coaxial power divider and coaxial cables that feed the antenna account for about 1.5 dB of insertion loss.

This work was done by John Huang and Soren N. Madsen of Caltech for **NASA's Jet Propulsion Laboratory.**

For further information, ***write in 83*** *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
Jet Propulsion Laboratory
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4800 Oak Grove Drive
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Refer to NPO-18810, volume and number of this NASA Tech Briefs *issue, and the page number.*

Steerable K/Ka-band Antenna for Land-Mobile Satellite Applications

This antenna tracks and communicates with a geostationary satellite from the roof of a moving vehicle.

NASA's Jet Propulsion Laboratory, Pasadena, California

A prototype steerable microwave antenna tracks and communicates with a geostationary satellite. It is designed to be mounted on the roof of a vehicle (car, truck or van) and is only 10 cm tall. Together with a stationary ground terminal, the vehicle and satellite are parts of an experimental mobile-satellite communication system using NASA's Advanced Communications Technology Satellite (see Figure 1).

The antenna includes a feedhorn and an offset reflector mounted on a rotary table driven by a stepping motor. A layered dielectric radome protects these components (see Figure 2). The antenna handles both the 20 GHz, vertically polarized, received (downlink) beam and the 30 GHz, horizontally polarized, transmitted (uplink) beam, both with a 300 MHz bandwidth. It provides a peak receive sensitivity of –3 dB/K (gain to noise temperature ratio) and a peak transmit isotropic gain of 24 dB, while supporting transmit power levels up to 10 W. The transmitted and received beams are routed between the antenna and the equipment inside the vehicle via a coaxial rotary joint and a diplexer.

The position and orientation of the feedhorn on the rotary table are fixed, but the elevation angle of the reflector can be adjusted manually so that it matches that of the satellite in the geographical region in which the vehicle operates. The radiation patterns of the antenna at the two frequencies are broad enough to accommodate the typical tilting experienced by vehicles while traveling along paved roads.

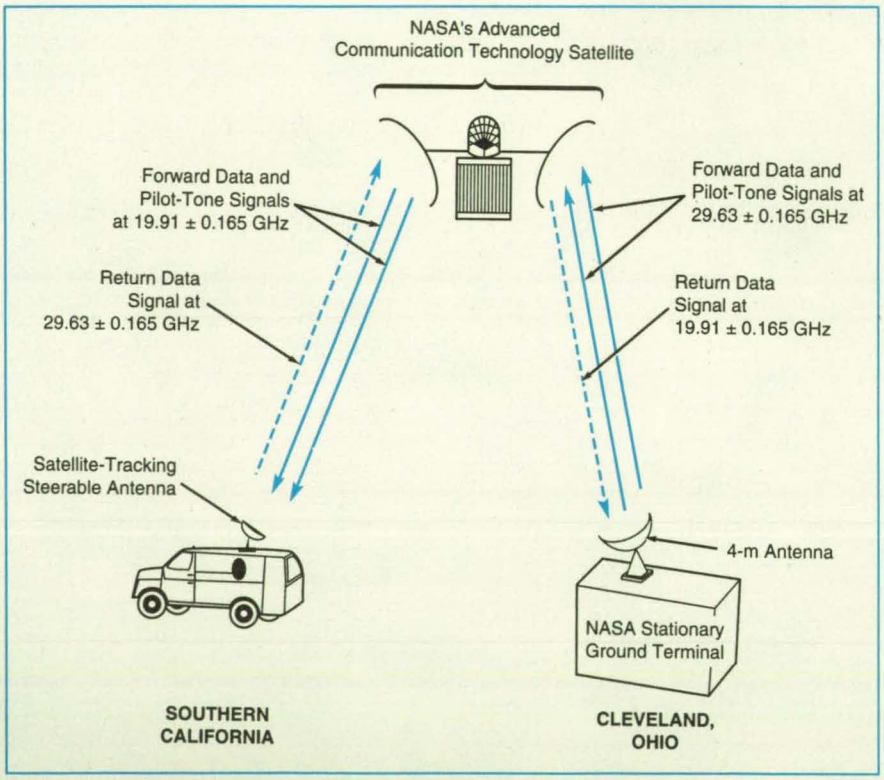

Figure 1. This **Experimental Communications System** is designed to demonstrate and test various aspects of mobile satellite communications. A principal subsystem — the subject of this article — is the steerable microwave antenna mounted on the roof of a van.

Under control of a computer mounted in the vehicle, the rotary table is turned so that the antenna acquires a pilot-tone signal that the satellite relays to the van from the stationary ground terminal. Once the pilot tone is acquired, an inertial turn-rate sensor mounted to the vehicle provides most of the information needed to keep the antenna pointed toward the satellite as the vehicle moves about, so that communications are sustained while traveling. Any residual azimuthal-angle pointing error that develops is detected by sinusoidally dithering the rotary table ±1° at a frequency of 2 Hz while monitoring the signal strength of the pilot

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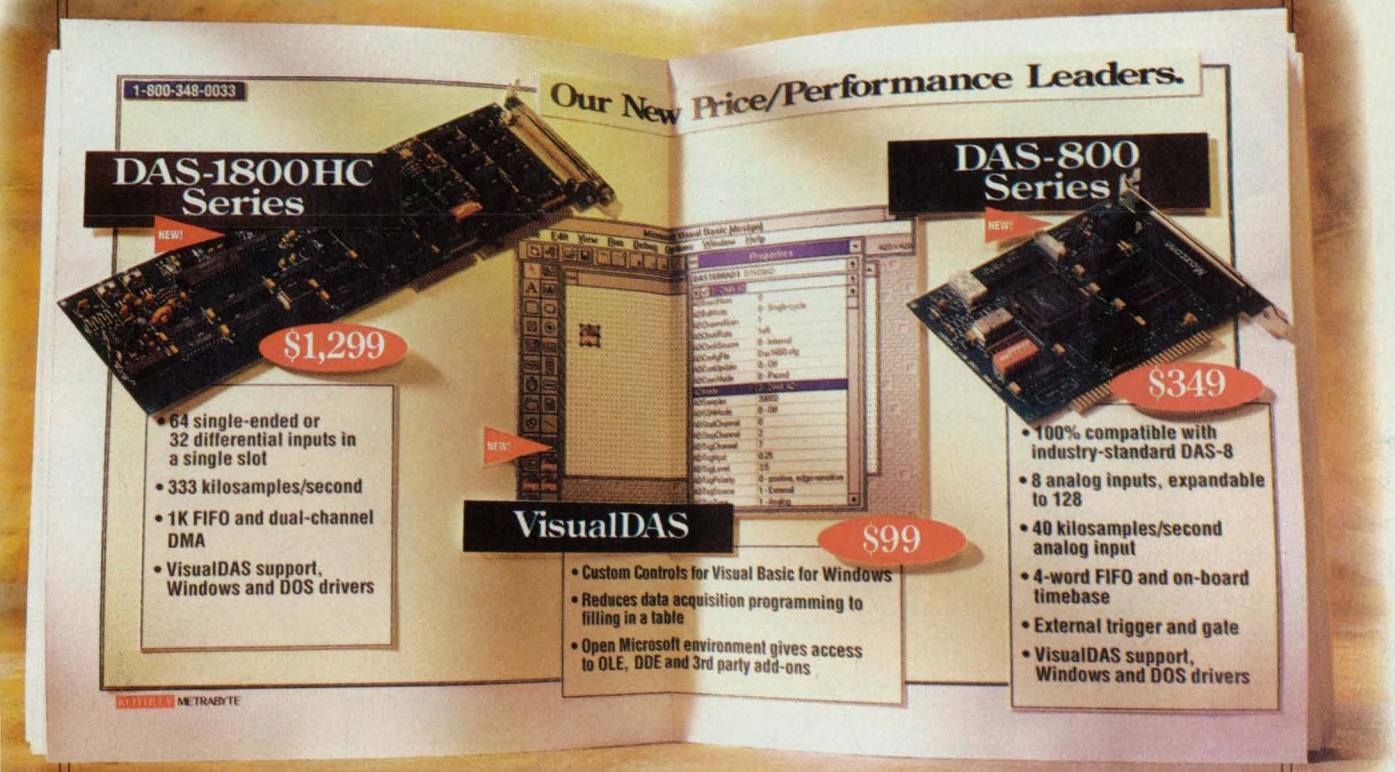

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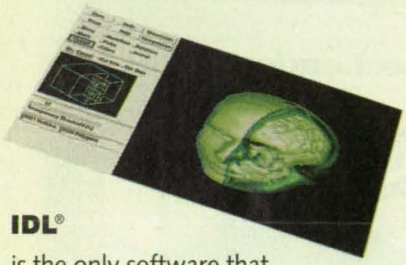

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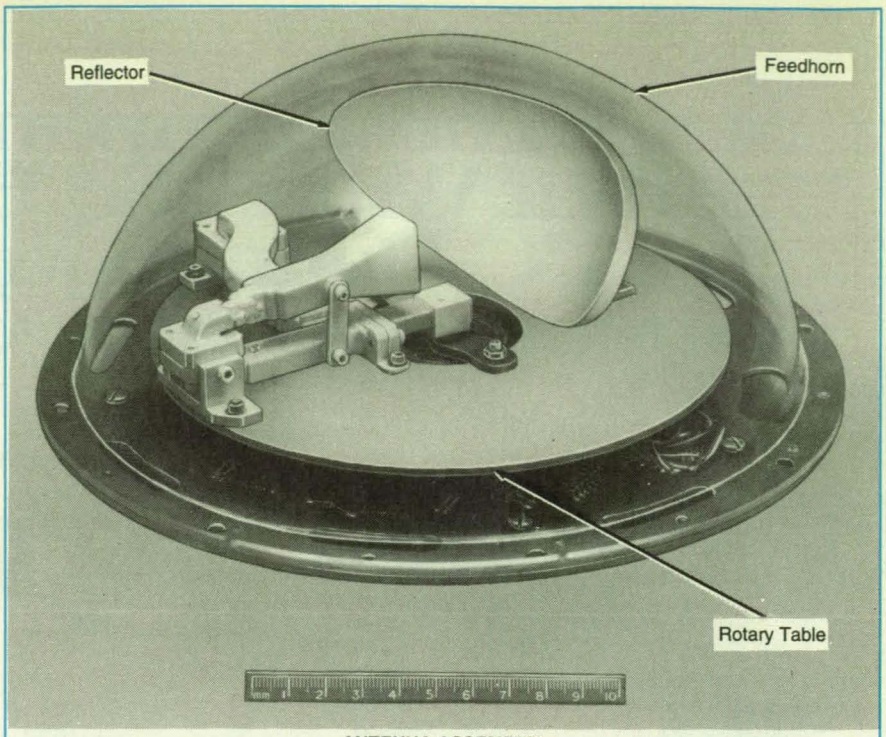

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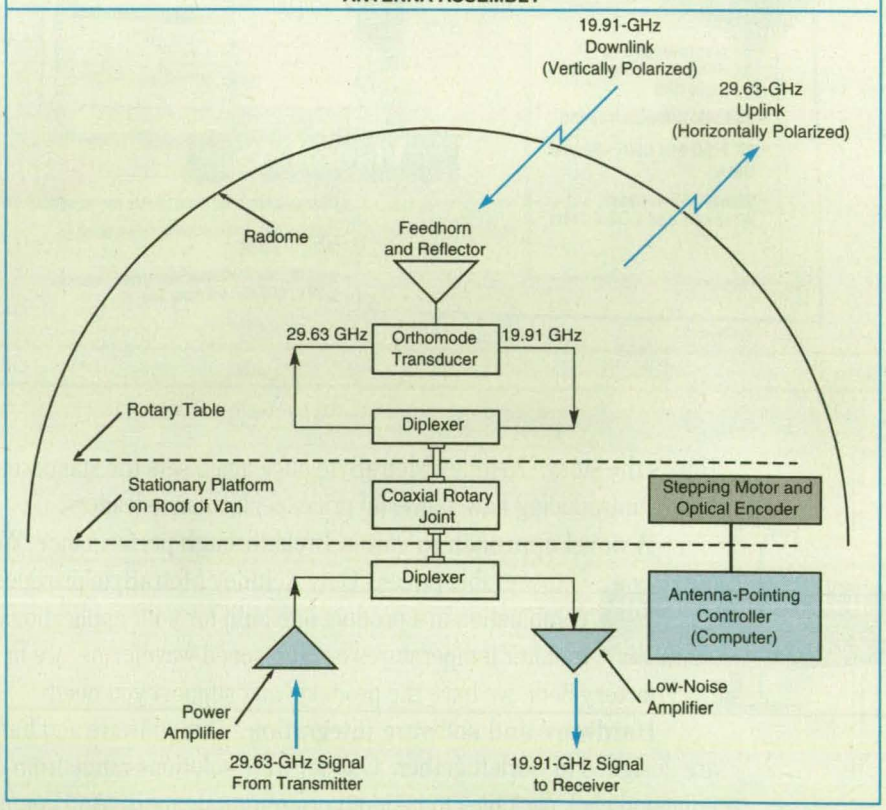

Figure 2. The **Steerable K/Ka-band Antenna** is made rugged and compact to suit the rooftop mobile operating environment. The more-delicate signal-processing and control equipment is located inside the vehicle.

tone received through the antenna. The resulting estimate of pointing error is the source of feedback for the antenna pointing subsystem.

The antenna system completes a full azimuthal scan and acquires the pilot tone in about 6 seconds. After acquisition and during tracking, the root-mean-square pointing error is only a small fraction of a degree. The system can compensate for vehicle turn rates up to 60°/s. If the pilot tone is temporarily lost (e.g., when the vehicle passes under a bridge) the inertial part of the antenna pointing subsystem continues to function, thereby facilitating immediate reacquisition.

This work was done by Arthur Densmore, Vahraz Jamnejad, and Kenneth

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Frequency-Selective Microwave Reflectors

Multiple double-loop patch elements reflect at some frequencies and transmit at others.

NASA's Jet Propulsion Laboratory, Pasadena, California

Lightweight dichroic reflector panels are being developed for use in multiplexing electromagnetic waves at three or four microwave frequencies. The basic requirement is that the panels be highly reflective in the X and K_a bands and highly transmissive in the K_u and S bands. The original intended application is in the subreflector of a main paraboloidal reflector to enable simultaneous operation in both a prime-focus configuration in the K_u and S bands and a Cassegrain configuration in the X and K_a bands, as shown in Figure 1.

The reflector panels are being designed according to two alternative approaches — add-on and integrated. In the add-on approach, each panel includes a lightweight dielectric (e.g., plastic foam or honeycomb) core that supports dichroic arrays of double-loop array elements on its front and back surfaces. The front-surface array is highly reflective in the K_a band and highly transmissive in the S, X, and K_u bands; the back-surface array is highly reflective in the X band but highly transmissive in the S and K_u bands. In the integrated approach, only one surface of the dielectric panel core supports an array of double-loop array elements that satisfies the basic frequency-selective reflection and transmission requirement.

The subreflector panels for the intended application will have to be curved, but for the sake of simplicity, the prototype panels that have been built and tested thus far have been made flat. Both square and circular double-loop antenna elements have been designed and have been fabricated by depositing patches of copper on thin dielectric sheets. The sheets have then been attached to the dielectric cores to form unitary sandwich structures. For example, Figure 2 shows a panel according to the add-on approach, with arrays of square double-loop array elements on polyimide sheets bonded to a foam core.

This work was done by Te-Kao Wu of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 4*** *on the TSP Request Card.*

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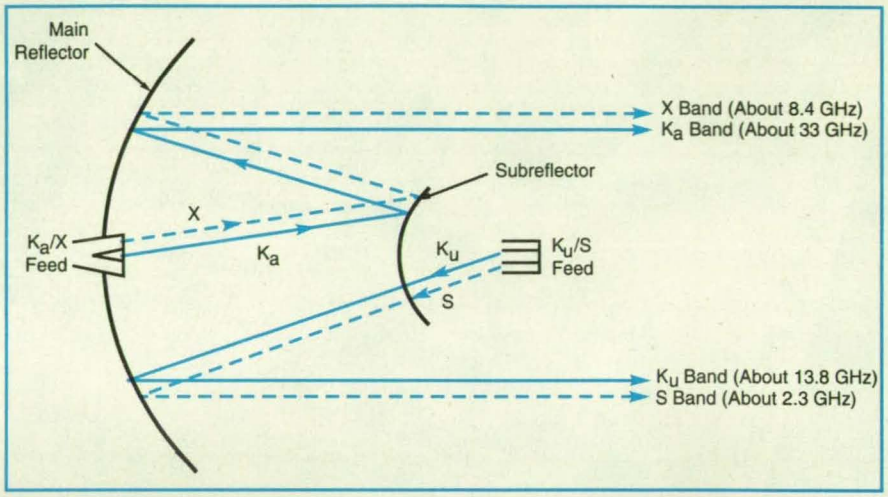


Figure 1. **Reflector Panels** are being developed for use in the subreflector of the dual reflector system. The subreflector is required to be highly reflective in the X and K_a bands and highly transmissive in the S and K_u bands.

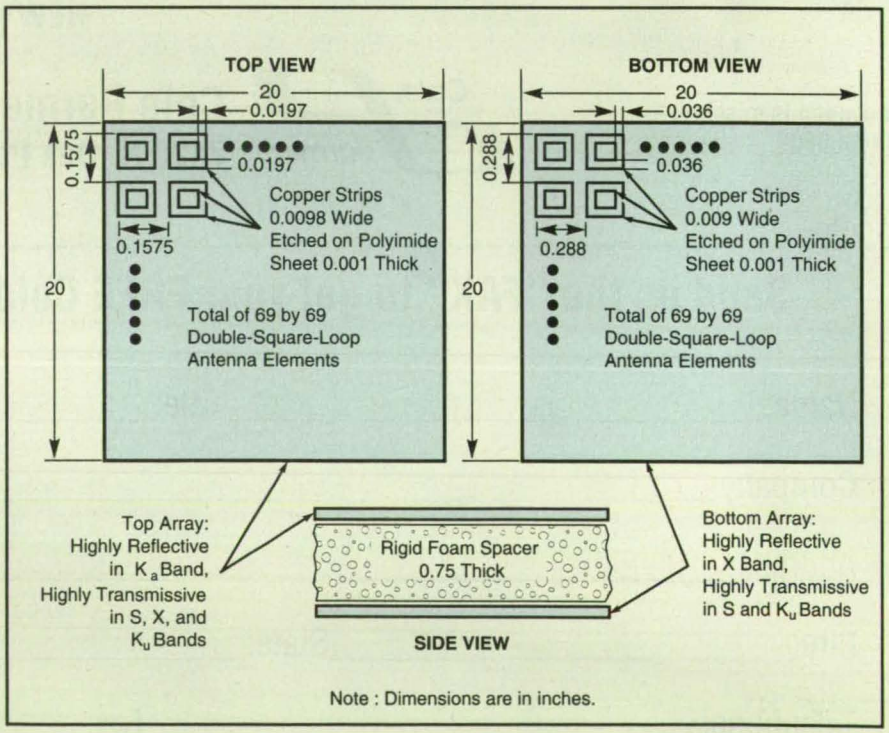


Figure 2. This **Flat Reflector Panel** of the add-on type includes two surface arrays of double-square-loop patch elements. This panel is one of several prototypes of the curved subreflector of Figure 1.

Dual-Anode Nickel/Hydrogen Cell

As expected, resistance is about half that of a single-anode cell.

Lewis Research Center, Cleveland, Ohio

The use of two hydrogen anodes — one on each side of the nickel cathode — in an experimental nickel/hydrogen cell reduces the ohmic and concentration polarizations that contribute to the internal resistance of the cell, yielding a cell with improved discharging performance compared to that of a single-anode cell. It is anticipated that the dual-anode concept could be incorporated into nickel/hydrogen cells of both the individual pressure-vessel type (for use aboard spacecraft) and the common pressure-vessel type, which could be used on Earth to store electrical energy from photovoltaic sources, in "uninterruptible" power supplies of computer and telephone systems, in electric vehicles, and for load leveling on power lines. The dual-anode concept should also be applicable to silver/hydrogen and other metal/gas batteries.

A standard nickel/hydrogen cell (see Figure 1) includes a nickel hydroxide/nickel oxyhydroxide cathode in which the reactants are supported on a metallic nickel matrix, and a hydrogen-gas/water anode in which the oxidation and reduction reactions occur on a platinized surface. The electrodes are separated by an ionically conductive material that is saturated with an alkaline hydroxide electrolyte solution.

At the cathode, the active nickel species is oxidized to the +3 oxidation state during charging and reduced to the +2 state during discharge; at the anode, water is reduced to hydrogen gas during charging, and hydrogen is oxidized to form water during discharge. A potential of 1.5 to 1.6 Vdc is used to charge the cell, and the typical discharge potential is between 1.2 and 1.3 V.

A dual-anode cell includes hydrogen

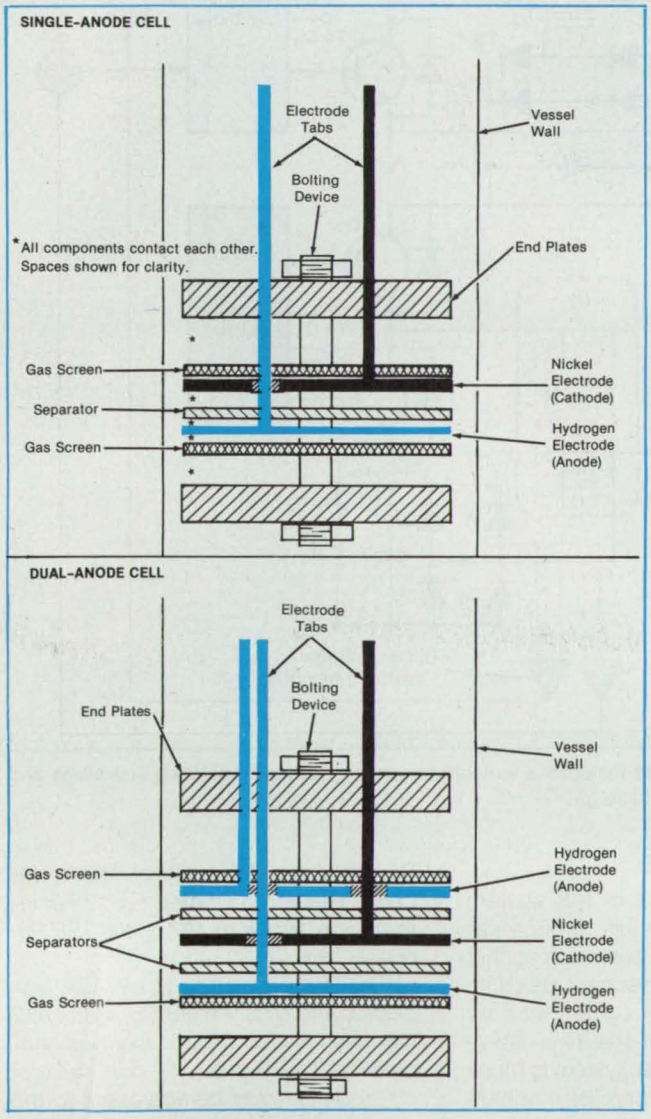


Figure 1. The **Nickel/Hydrogen Cells** have been made in single-cathode/single-anode and single-cathode/dual-anode versions.

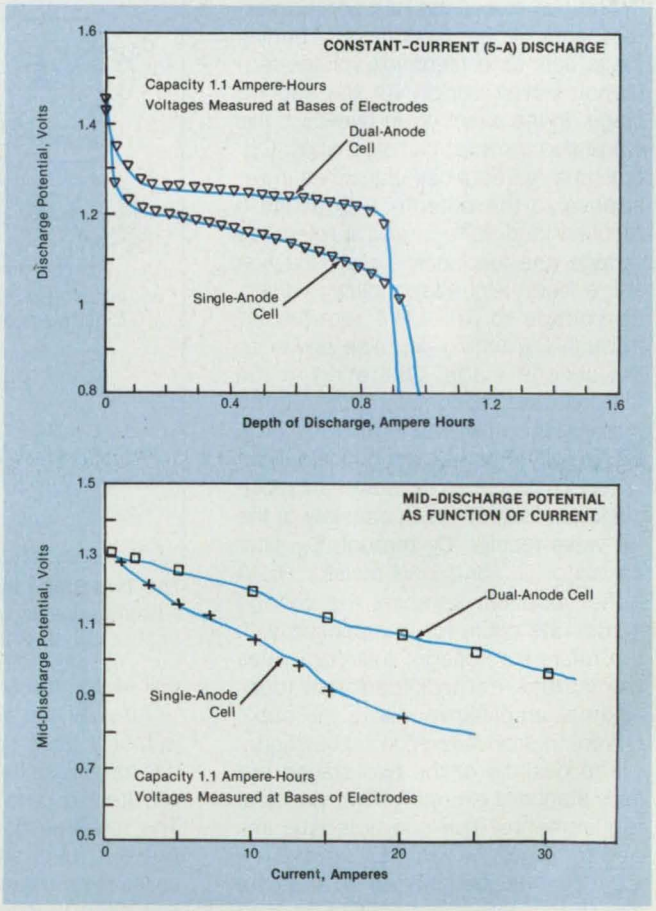


Figure 2. **Comparisons of the Outputs** of a dual-anode and a single-anode nickel/hydrogen cell show that the dual-anode version performs better during discharge.

anodes on both sides of the nickel cathode, plus an electrolyte-saturated separator between each hydrogen anode and the single nickel cathode. The polarization effects in the experimental dual-anode cell were smaller than in the single-anode version of the cell. The top part of Figure 2 shows the comparison of voltages of the single- and dual-anode versions during discharge at currents of 5 A. At a depth of discharge of 50 percent (0.55 A-h), the potential of the dual-anode cell was about 100 mV higher than that of the single-anode cell; at a depth of discharge of 75 percent (0.83 A-h), the potential of the dual-anode cell voltage was about 130 mV higher than that of the single-anode cell.

The bottom part of Figure 2 shows the potentials of the dual- and single-anode cells as functions of the discharge current. These potentials were measured in a test in which each cell was first charged fully, then discharged at constant current until its potential reached 0.1 V; the voltage at the midpoint of the discharge was then plotted against the current for that particular discharge. The slopes of the two lines show that the apparent resistance of the dual-anode cell is about half that of the single-anode cell (0.012 Ω vs. 0.024 Ω).

This work was done by Randall F. Gahn and Timothy P. Ryan of **Lewis Research Center**. *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, Lewis Research Center [see page 20]. Refer to LEW-15212.

Two-Stage Series-Resonant Inverter

A lightweight circuit provides regulated power and is invulnerable to output short circuits.

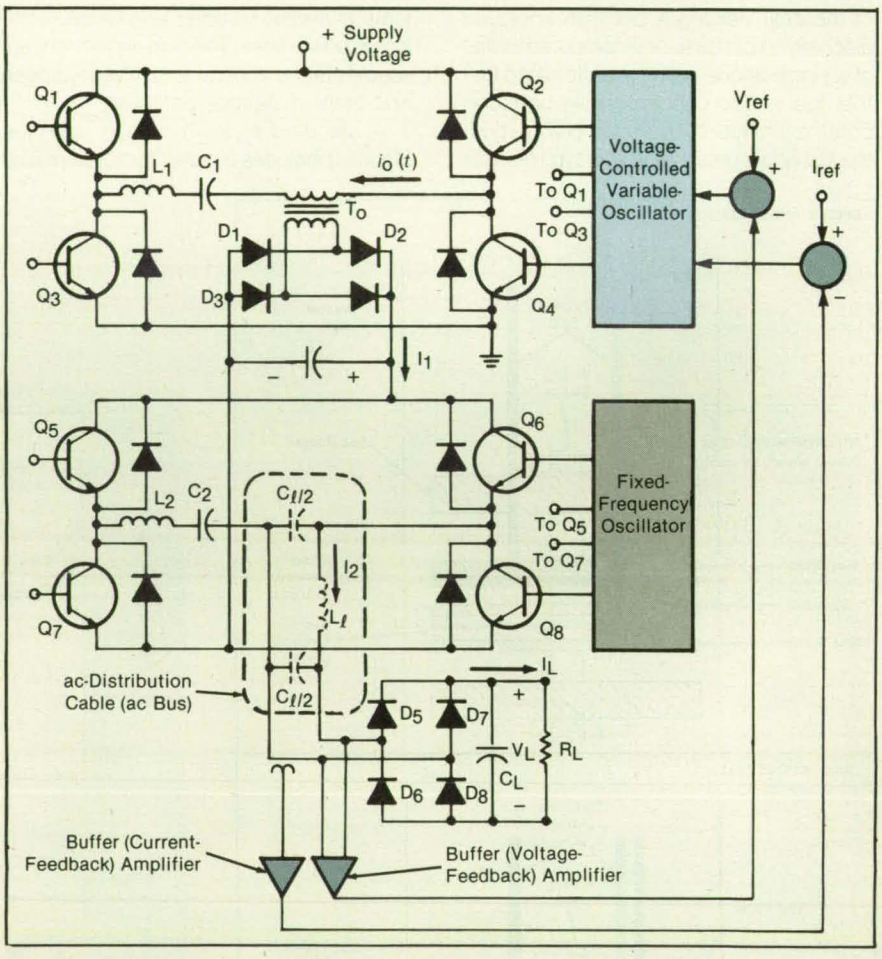
Lewis Research Center, Cleveland, Ohio

A two-stage inverter circuit provides well-regulated alternating voltage at a fixed frequency. Current limiting, in conjunction with the internal impedance of the inverter, provides short circuit protection. Another desirable feature is low-loss commutation. Also, like other resonant-inverter power supplies, this one is light in weight. This combination of features makes the inverter particularly suitable for use in the ac-power-distribution system of an aircraft.

The two stages are cascaded series-resonant inverters (see figure). The first stage acts as a feedback voltage-regulating power supply for the second stage. In the event of an overload, this stage also provides current limiting. Operating at a frequency that varies in response to the difference between a rectified load voltage and a reference voltage (the feedback signal), the first stage feeds a correspondingly varying ac voltage to full-wave rectifier D_1 through D_4, which supplies power to the second stage. Operating at the fixed output frequency, the second stage generates the output voltage that is fed to the ac-distribution cable.

The cable transmits power to multiple loads, one of which consists of the full-wave rectifier D_5 through D_8, filter capacitor C_L, and load resistor R_L. A buffer amplifier samples the voltage across the cable for comparison with the reference voltage; this completes the voltage-control feedback loop. Another amplifier monitors the cable current to provide overload protection.

The designs of the two stages are fairly standard except for two principal requirements. The characteristic impedances $Z_1 = \sqrt{L_1/C_1}$ and $Z_2 = \sqrt{L_2/C_2}$ must be chosen so that the circuit can deliver a specified ac load current, I_2, and the load current I_2 is momentarily limited to a specified safe value in the event of a short circuit across the bus.



The **Two-Stage Inverter** includes a variable-frequency, voltage-regulating first stage and a fixed-frequency second stage.

Another advantage of this system is that it does not require a large capacitor across the ac bus, such as that required in parallel resonant designs. The result is that the current load on the output stage of the two-stage series resonant inverter system is much less than that for a parallel resonant inverter system with equivalent power rating.

This work was done by Thomas A. Stuart of the University of Toledo for **Lewis Research Center**. *For further information,* ***write in 107*** *on the TSP Request Card.*

This is the invention of a NASA employee, and U. S. Patent No. 4,853,832 has been issued to him. Inquiries concerning license for its commercial development may be addressed to the inventor, Mr. Thomas A. Stuart, 924 W. Wayne, Maumee, Ohio 43537. Refer to LEW-14916.

Making $CoSi_2$ Layers by Ion Implantation

Monolithic photovoltaic batteries containing vertical cells would include buried $CoSi_2$ contact layers.

Langley Research Center, Hampton, Virginia

Layers of single-crystal $CoSi_2$ with low resistivities (about 1.2×10^{-5} Ω•cm) can be formed by implantation of energetic Co^+ ions into Si substrates followed by annealing. The layers of $CoSi_2$ can then be buried by subsequent epitaxial deposition. The resulting heteroepitaxial Si/$CoSi_2$/Si structure would be the fundamental structural unit in a proposed monolithic photovoltaic battery in which cells with vertical junctions would be connected in series (see figure).

Series-connected, vertical-junction photovoltaic cells offer potential advantages of high power density and low series resistance. Heretofore, such batteries were fabricated by soldering together the metal contacts of individual cells. Soldering yields good connections but entails wide junction spacings and relatively thick metal contacts, with consequent loss of efficiency. To make the cells thin enough (10 to 20 μm thick) to minimize the effects of damage by radiation and to obtain the desired high efficiency, it would be necessary to fabricate a battery with the proposed monolithic structure.

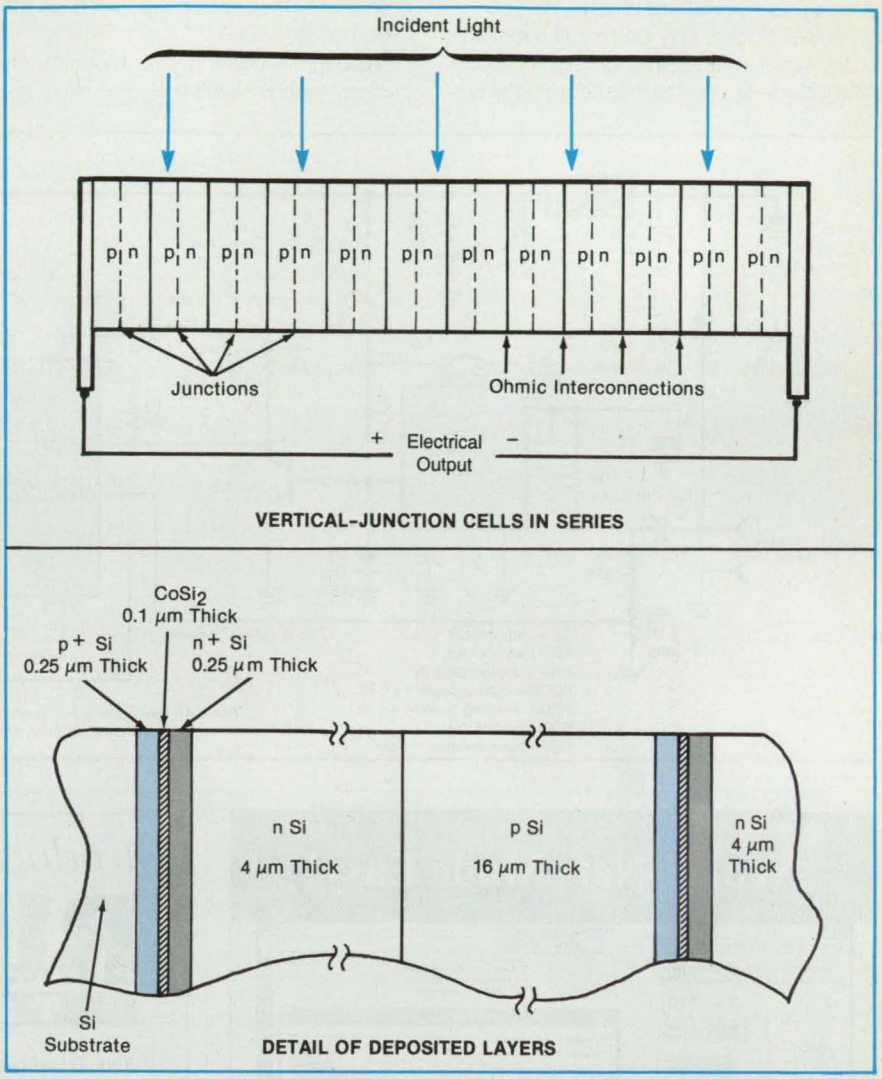
The optimum conditions for formation of high-quality, low-resistivity $CoSi_2$ layers were investigated in experiments in which Co^+ ions were implanted at various kinetic energies and dosages, the Si substrates were heated to various temperatures during deposition, and post-implantation annealing was performed at various temperatures for various times. The thickness of an implanted layer increases with the kinetic energy; for example, a kinetic energy between 150 and 200 keV yields a layer 600 to 1,000 Å thick. Typical doses are the order of 2×10^{17} cm^{-3}. For best results, implantation should be performed at a temperature of 350 to 400 °C. A typical anneal involves heating for 1 to 2 hours at a temperature of 700 to 1,000 °C.

This work was done by Fereydoon Namavar of Spire Corp. for **Langley Research Center**. *For further information,* ***write in 73*** *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

Michael W. O'Dougherty
Spire Corporation
One Patriots Park
Bedford, MA 01730-2396

Refer to LAR-14604, volume and number of this NASA Tech Briefs issue, and the page number.



Vertical-Junction Photovoltaic Cells in Series would be fabricated in a monolithic structure. The n- and p-doped silicon layers would be deposited epitaxially. The $CoSi_2$ layers, formed by ion implantation and annealing, would serve as thin, low-resistance ohmic contacts between cells.

Instrument Records and Plays Back Acceleration Signals

Principal advantages are compactness, portability, and low cost.

Lyndon B. Johnson Space Center, Houston, Texas

The figure illustrates the electronic circuitry of a small, battery-powered, hand-held instrument that feeds power to an accelerometer and records the time-varying component of the output of the accelerometer for 15 seconds in analog form. In comparison with instruments that record analog signals on magnetic tape, this one is mechanically simpler and costs less.

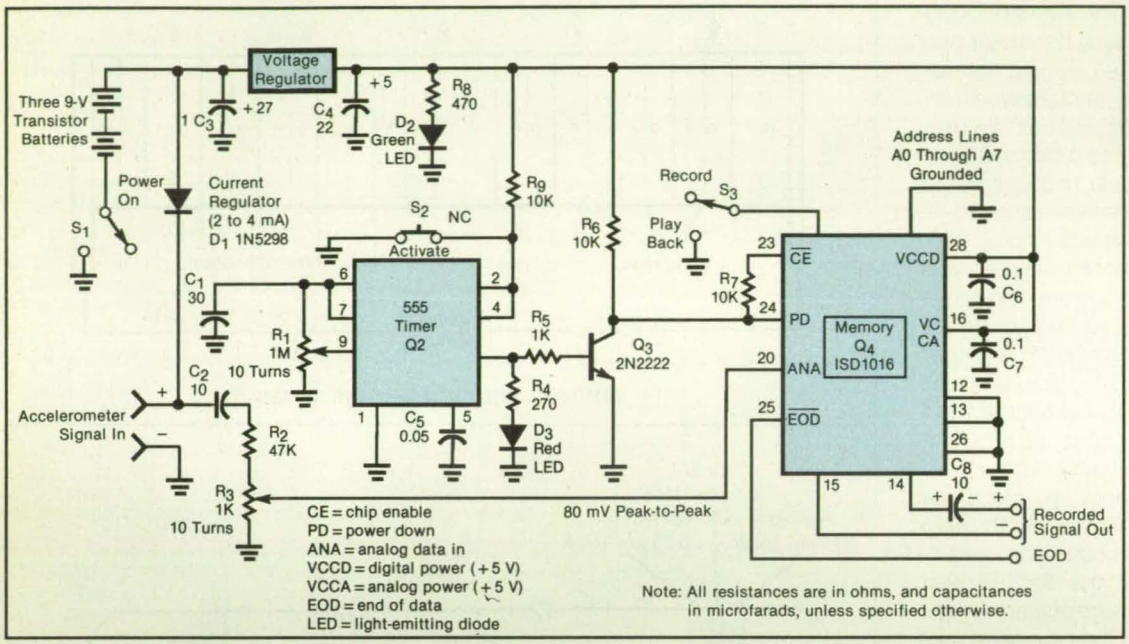
The heart of the circuit is an analog electrically programmable read-only memory contained on a single complementary

metal oxide/semiconductor integrated-circuit chip in a 28-pin package. No power is needed to maintain the content of the memory; the memory chip can be removed after recording and stored indefinitely. The recorded signal can be played back at any time up to several years later.

Power from a 27-V battery is supplied to the accelerometer through current-regulating diode D_1, and to the recording/playback circuitry through voltage regulator Q_1. The dynamic output of the accelerometer is coupled through capacitor C_2, attenuated by resistors R_2 and R_3, then fed to the memory-input terminal (pin 20 of Q_4). To enable the recording of the accelerometer signal, switch S_3 must be in the "record" position.

To begin recording, one momentarily pushes (opens) switch S_2, causing the output voltage of the timer (pin 3 of Q_2) to go high and to remain high during a recording interval that depends on the values of R_1 and C_1. These values are chosen to make the interval 15 seconds long, thereby allowing a 1-second margin because the memory overflows at 16 seconds.

The output of Q_2 is fed to transistor Q_3, and the output of Q_3 is fed to terminals 23 and 24 of Q_4, through which the se-



This **Simple, Compact Circuit** records and plays back accelerometer signals on a 3.4-kHz passband for 15 s.

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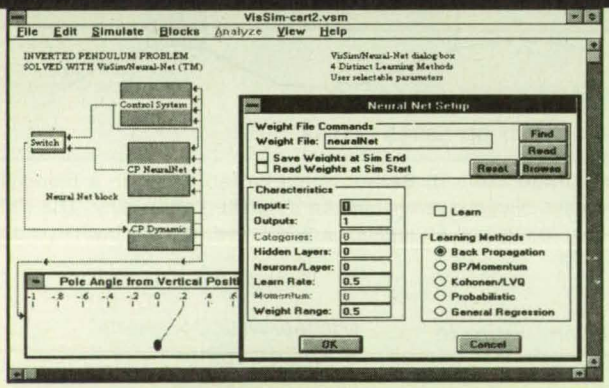

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lected recording or playback function is controlled. While the output of Q_2 remains high, the output of Q_3 remains low, in which condition the memory records the incoming signal. When Q_2 reaches the end of its 15-second interval, output returns to the low state, causing the output of Q_3 to go high and the memory to return to a standby mode, in which it retains the recorded signal.

For playback, S_3 must be placed in the "playback" position. As in the case of recording, playback is initiated by opening S_2 momentarily. The timing functions are the same as in recording. At the end of playback, the voltage on the EOD (end-of-data) line goes low; this transition serves as an EOD mark for the signal-processing equipment to which the playback is coupled.

The ISD1016 memory chip in this circuit can record and play back signals within a 3.4-kHz passband. Similar memory chips with narrower passband and longer recording interval, or wider passband and shorter recording interval, are also available. Chips can also be cascaded for longer record interval.

This work was done by Richard J. Bozeman of **Johnson Space Center**. *For further information,* ***write in 2*** *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 [see page 20]. Refer to MSC-22008

Optically Addressable Spatial Light Modulators

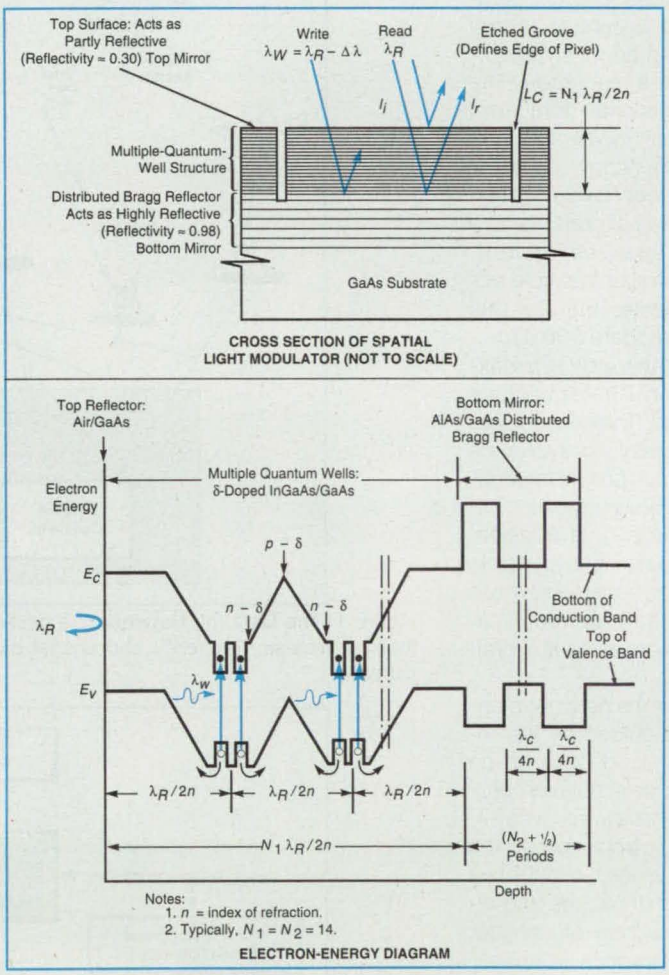
Multiple-quantum-well structures are integrated with asymmetric Fabry–Perot etalons.

NASA's Jet Propulsion Laboratory, Pasadena, California

Optically addressable spatial light modulators are being developed with molecular-beam-epitaxy engineered III–V material and structures. Strong photo-optic effects are achieved from exciton quenching with periodically doped multiple-quantum-well structures. These photo-optic layers are integrated with an asymmetric Fabry–Perot cavity to achieve an optically addressed modulator, which operates at normal incidence in the normally-off reflection mode. The read-beam wavelength λ_R must be close to the exciton resonant wavelength (for maximum photo-optic effect), and the write wavelength λ_W, shorter by some Δ_λ but still larger than the host-material (GaAs) absorption edge.

The figure shows a typical device of this type. A distributed Bragg reflector in the form of alternating layers of AlAs and GaAs is deposited on a GaAs substrate, and constitutes the highly reflective bottom mirror of the asymmetric Fabry–Perot etalon. A multiple-quantum-well structure in the form of alternating layers of InGaAs and GaAs with n and p δ-doped layers (doping at extremely high concentrations in extremely thin layers) is formed atop the distributed Bragg reflector. The interface between air and GaAs at the top surface of the device constitutes the partly reflective top mirror of the asymmetric Fabry–Perot etalon.

The parameters of the device are chosen so that when absorption of light in the intervening layers is taken into account, interference between reading-beam light reflected from the top mirror and reading-beam light reflected from the bottom mirror results in zero net reflection of the reading beam in the absence of the writing beam. The parameters of the device are also chosen so that the writing beam can cause a change in the absorption of the reading beam through enhanced photo-optical effects in the multiple-quantum-well structure. This change upsets the balance between the interfering reflected portions of the reading beam, effectively turning on an output beam in the form of a net reflection of the reading beam.



The **Integrated Multiple-Quantum-Well/Fabry-Perot** structure provides for high-contrast variation of the reflection of the reading beam, under the control of the writing beam. The periodic potential barriers of the quantum-well structure separate photogenerated electrons from holes, leading to long recombination lifetimes and large concentrations of free charge carries. These concentrations quench excitons or fill energy bands in the quantum wells, thereby altering the absorption of the reading beam.

A prototype of the device was fabricated and tested. It included a 14½-period distributed Bragg reflector designed for a center wavelength (λ_C) of 1,020 nm, and a 14-period quantum-well structure. A monochromator generated reading beam ($\lambda_R \approx$ 1,018 nm) and a laser-write beam ($\lambda_W \approx$ 920 nm) were used. In the absence of the write beam, the read beam was reflected 0.5 percent; when the flux density of the writing beam was about 100 mW/cm^2, the reading beam was reflected 34.3 percent. These figures indicate an insertion loss of 4.6 dB when the writing beam is on and an on/off contrast ratio > 60.

This work was done by Joseph Maserjian and Anders G. Larsson of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 70*** *on the TSP Request Card.*
NPO-18689

Software for Management of a Packet-Radio Network

Techniques of simulation, artificial intelligence, and computer graphics are utilized.

NASA's Jet Propulsion Laboratory, Pasadena, California

Computer programs are being developed to assist technical personnel in planning, monitoring, and controlling the resources of the Range Applications Joint Program Office (RAJPO) Datalink network, which is a developmental L-band packet-radio network for communication between a central control station on the ground and instrumented aircraft flying over a test range. The aircraft derive navigational data from satellites of the Global Positioning System, and the primary function of the Datalink network is to feed GPS position data from participating aircraft into the control center in real time (see Figure 1).

By use of a time-division multiple-access allocation scheme, the Datalink network can accommodate 200 participating aircraft simultaneously at a maximum data rate of ten 736-bit packets per aircraft per second. The network features frequency diversity (to overcome multipath interference) and spatial diversity (to overcome blocking of line-of-sight reception by terrain). In addition, each aircraft participates in a dynamic tree-structured routing scheme in which it occasionally acts as a communication relay between more-distant aircraft and the control station.

The development of the network-management software is guided by the results of simulations conducted on an older Datalink-network-simulation program. That program answers "what-if" questions about the behavior of the network but offers limited capabilities for real-time analysis of causes and effects or for the prediction of network routing behavior. Utilizing a combination of simulation, artificial-intelligence, and computer-graphical techniques, the developmental software is being designed to overcome these limitations so that it can assist a network planner or analyst in answering hypothetical questions and analyze the performance of the network in real time.

The network-management activities of the developmental software can be divided into three basic categories: fault management, performance management,

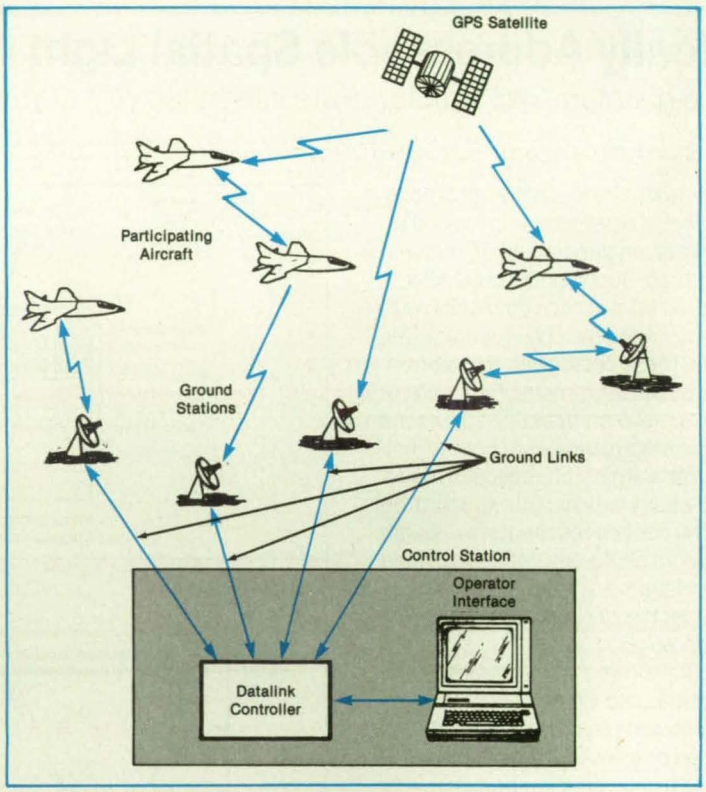


Figure 1. The **Datalink Network** is a packet-message network that features time-division multiple access, frequency and spatial diversity, and a dynamic tree-structured routing scheme.

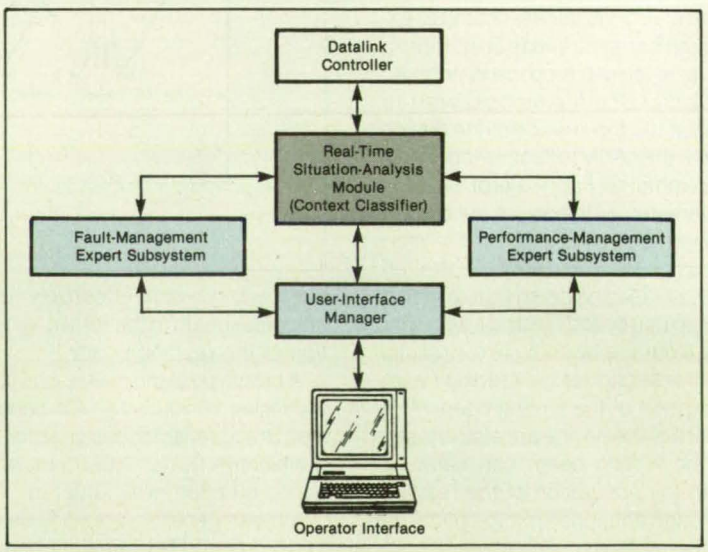


Figure 2. The **Network-Management Software** is being developed to assist in planning, monitoring, and controlling the resources of the Datalink network.

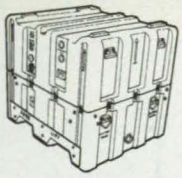
and operator-interface management. The software is divided into corresponding modules. In addition, the software includes a module that performs real-time situation analysis (see Figure 2). The real-time situation-analysis module serves a dual purpose. Firstly, it serves as a buffer to isolate the real-time system (the Datalink network) from the network-management software so that the various analysis modules can operate by continuously looking at prioritized agendas without the need for concern about the time dependencies involved. Secondly, and more importantly, the situation-analysis module translates the raw data into higher-level representations. In particular, three useful levels have been identified: (i) the low-level network information (packet headers and the like), (ii) quantitative summaries of network behavior (traffic statistics, routing trees, and the like), and (iii) a qualitative context level of representation. This identification of different levels of representation is the key component in developing a complex network-management system.

The three other modules operate off the real-time situation-analysis module. The fault-diagnosis module uses a set of rules written at the context level to monitor network events and determine whether there are any potential faults. Potential faults are then examined in more detail to determine likely causes. At this point, many false alarms can be expected to be eliminated; e.g., losses of packets because of normal network operations. Remaining faults can be correlated and prioritized prior to being handed over to the operator-interface module. The performance module is primarily algorithmic, monitoring network-traffic statistics at the qualitative level. However, once adverse performance is detected, context-level rules can be used to represent constraints and provide advice to the operator, via the operator-interface module.

The operator-interface module uses a mix of context-level and quantitative summary information to provide a real-time "snapshot" of network activities to the operator via graphical displays. The interface also uses context-based rules to represent constraints that filter the operator keyboard input and provide feedback as to whether a particular command may or may not be appropriate.

The operator-interface module uses some context-level rules to control the nature of the display shown to the operator. For example, a mission goes through various sequential phases such as startup, initialize, shutdown, and the like. It is clearly inappropriate to display the same information (such as traffic statistics) during these various phases; hence, the display is actively changed in response to the context. This is the key factor in the design of the system; namely, that the system operates in a context-dependent manner, in which the system actively tracks the context of the network in real time.

This work was done by Patrick J. Smyth, Todd H. Chauvin, Gordon P. Oliver, and Joseph I. Statman of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 7*** *on the TSP Request Card.*
NPO-18646



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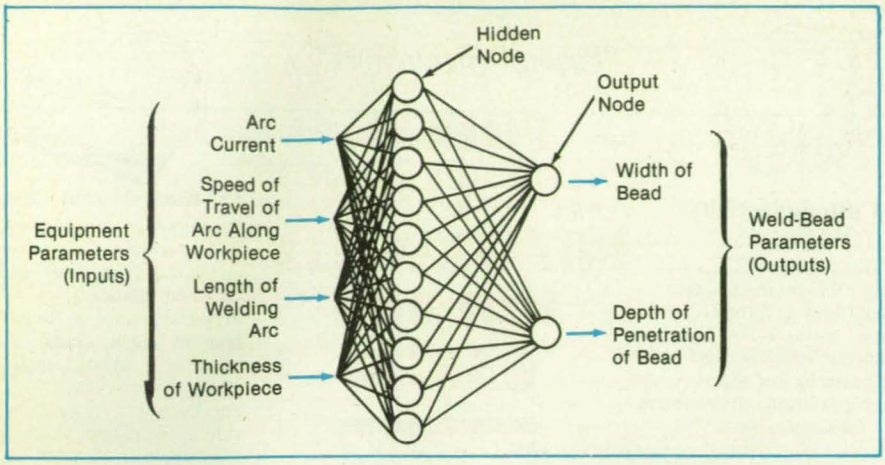
Neural-Network Modeling of Arc Welding

Weld-bead parameters can be estimated from equipment parameters and vice versa.

Marshall Space Flight Center, Alabama

Artificial neural networks are being considered for use in monitoring and controlling gas/tungsten arc-welding processes. In a typical application, a neural network would implement a mathematical model that would estimate principal parameters of the weld bead (e.g., width and depth of penetration), given such equipment parameters as the thickness of the workpiece, arc current, arc length, voltage, and speed of travel of the arc along the workpiece. Alternatively, a neural network would implement an inverse mathematical model that would estimate the equipment parameters needed to obtain the desired weld-bead parameters.

The advantage afforded by neural networks is computational efficiency; a neural network of relatively few nodes can be made to implement a highly nonlinear or even unknown approximate mathematical model, provided that enough input/output pairs of training data and a suitable training algorithm are available. In principle, a neural network of modest complexity that is implemented on a personal computer could set equipment parameters from a given set of weld-bead parameters,



A **Relatively Simple Artificial Neural Network**, using 4 welding equipment parameters as inputs, can estimate 2 critical weld-bead parameters within 5 percent.

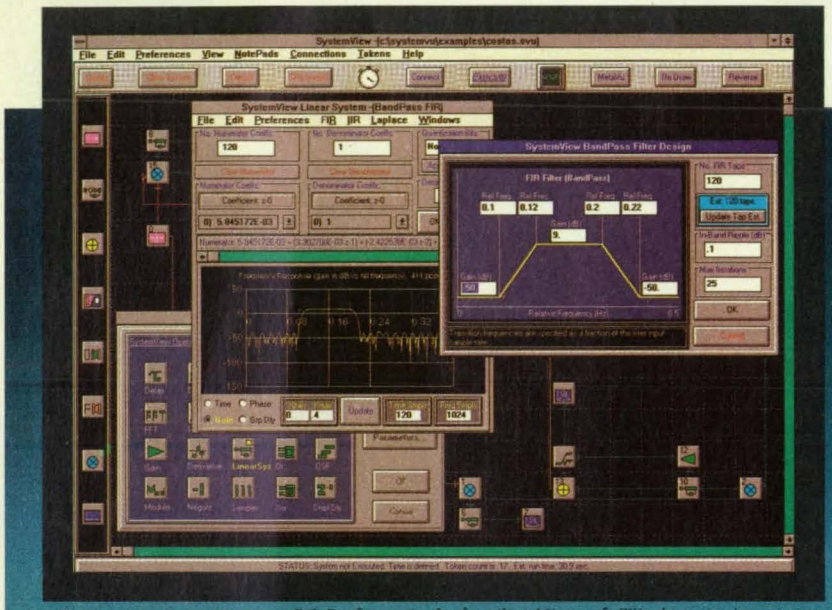
with accuracy and speed greater than those of other computing systems.

An artificial neural network includes a number of input terminals, a layer of output nodes (analogous to output neurons), and one or more "hidden" layers of nodes (analogous to neurons) between the inputs and the output nodes. Each node in each layer is connected to one or more nodes in the preceding or following layer, possibly to an output terminal, and possibly to one or more input terminals. The connections are via adjustable-weight links analogous to variable-coupling-strength neurons. The output of each node is a sigmoid function of a thresholded or offset sum of its inputs. Before being placed in operation, the neural network must be trained by iteratively adjusting the connection weights and offsets, using pairs of known input and output data, until the errors between the actual and known outputs are acceptably small.

The figure illustrates a 4-input, 2-output neural network with a single 10-node hidden layer that was implemented by computer simulation to demonstrate the feasibility of a neural network for estimating weld-bead parameters from equipment parameters. The network was trained with equipment and weld-bead parameters obtained empirically from 10 argon/tungsten arc welds on 2 mild-steel plates of different thicknesses. The network was then tested by using input (equipment) parameters that had not been presented to it during training, and found to estimate weld-bead parameters within 5 percent of their correct values. In another simulation, a similar three-input, three-output network was trained to estimate the required travel speed arc current and arc length given the thickness of the workpiece and the width and depth of penetration of the weld bead. In this case, the estimated equipment parameters deviated from the correct values by less than or approximately equal to 20 percent.

This work was done by Kristinn Anderson, Robert J. Barnett, James F. Springfield, George E. Cook, Alvin M. Strauss, and Jon B. Bjorgvinsson of Mid-South Engineering Inc., for **Marshall Space Flight Center**. *For further information,* ***write in 82*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 20]. Refer to MFS-26209



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For More Information Write In No. 623

Apparatus Translates Crossed-Laser-Beam Probe Volume

Repeated tedious realignments are no longer necessary.

Langley Research Center, Hampton, Virginia

An optomechanical apparatus translates the probe volume of a crossed-beam laser velocimeter or similar instrument while maintaining the optical alignment of the beams. The instrument can thus be used to measure the velocity, pressure, and temperature of a flowing gas at several locations, without having to perform time-consuming realignment of its optical train at each location.

The optomechanical apparatus was designed to accommodate a stimulated-Raman-gain spectrometer for noninvasive measurement of local conditions in the flowing gas in a supersonic wind tunnel. The apparatus can also be adapted to other techniques, like coherent anti-Stokes Raman spectroscopy, that involve the use of laser beams crossed at small angles (10° or less).

In stimulated-Raman-gain spectroscopy, two separate laser beams — the pump beam and the probe beam — are made to intersect in a small probe volume, where a measurement is to be made. The two beams interact via the probed gas in such a manner that energy is transferred from one beam to the other. The exact nature of the interaction depends on the conditions of the gas in the probe volume: the spectrum of the return Raman signal depends on the pressure, temperature, and velocity in the probe volume.

The pump and probe beams are generated by lasers and aimed in parallel at fixed mirror 1, which reflects them to mirror 2 on translating platform 1 (see figure). The parallel beams are separated by about one beam diameter (1 cm).

Lens 1 on translating platform 1 focuses the beams so that they cross in the desired probe volume, which is about 1 cm long and 100 μm in diameter. Lens 2 on translating platform 2 recollimates the beams. A beam dump absorbs the pump beam. A corner-cube retroreflector returns the probe beam through the probe volume and the rest of the optical train to mirror 1. Mir-

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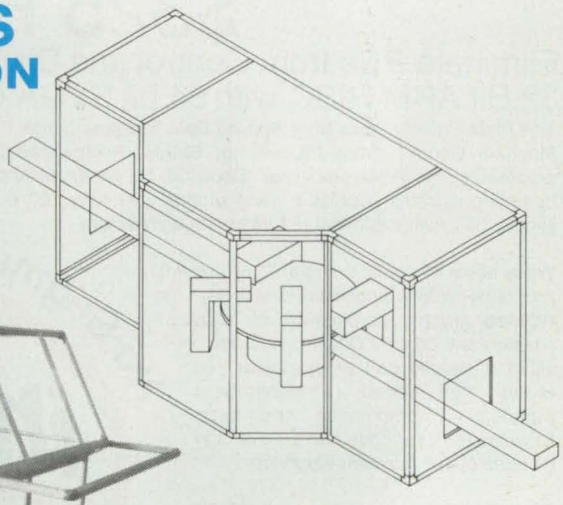

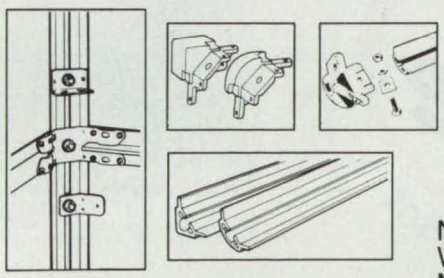

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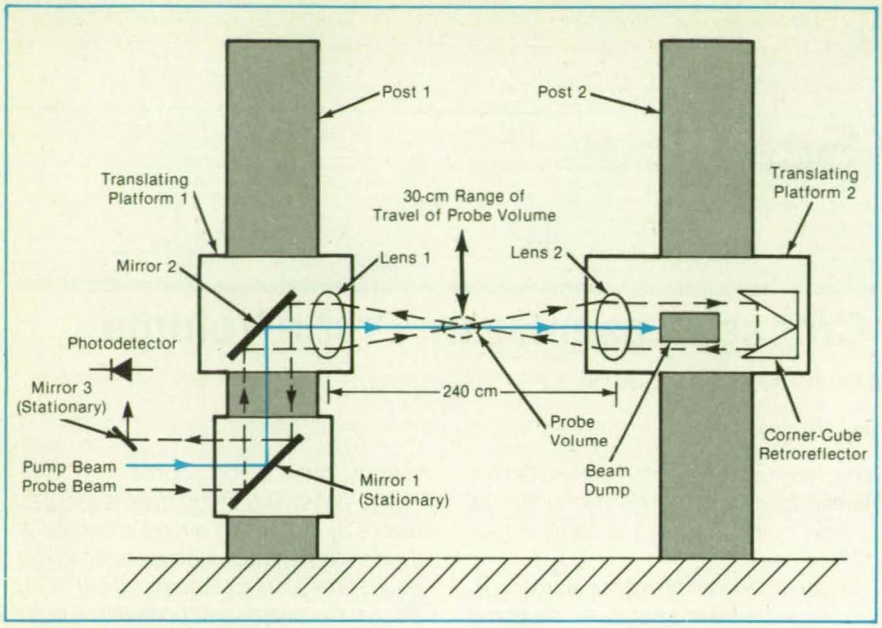

To Move the Probe Volume up or down, the translating platforms are moved equal distances on their posts. When the apparatus is properly aligned and conditions in the probe volume are constant, no change is detectable in the Raman signal when the probe is translated to a new position within an overall range of 30 cm.

ror 3 picks off this return probe beam, directing it to a photodetector.

The optical system is initially aligned with the translating platforms in a reference position. Thereafter, the probe volume can be translated vertically by simply moving both translating platforms identical distances up or down on the posts. The platform-and-post subassemblies are commercial linear translators that can be set to an accuracy of ± 1 μm per cm of travel.

For proper operation, it is essential that the posts be accurately parallel and that the probe and pump beams also be accurately parallel to each other and to post 1 after initial reflection from mirror 1. The incoming probe and pump beams must be nearly collimated, with the same divergence and diameter. Finally, the distance between lens 1 and lens 2 must be carefully adjusted to ensure that the retroreflected probe beam is focused at the sample volume.

This work was done by Gregory C. Herring, Bruce W. South, and Reginald J. Exton of **Langley Research Center**. *No further documentation is available. LAR-14833*

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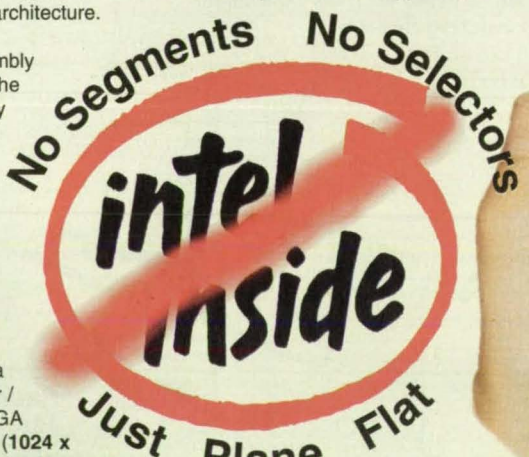

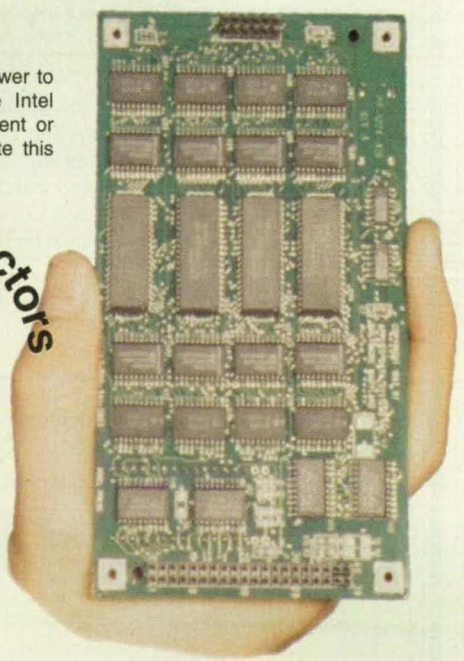

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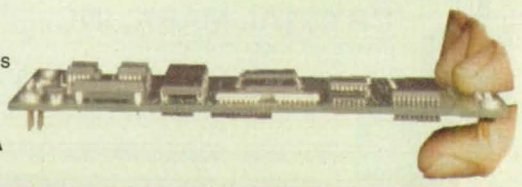

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Insulating Blankets Withstand Higher Temperatures

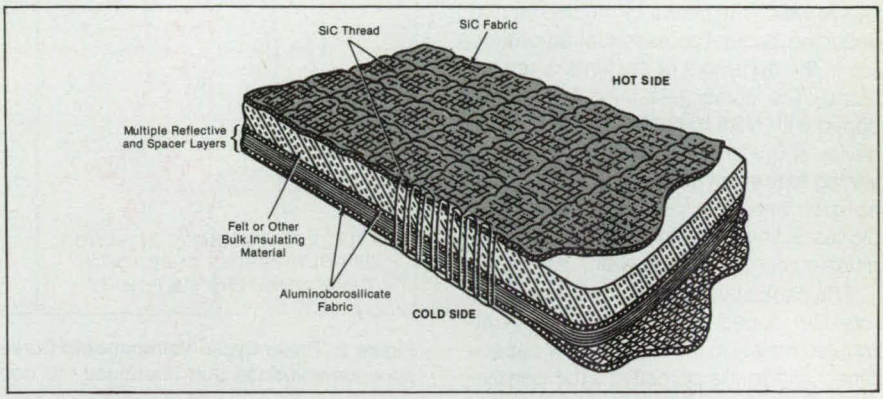
Refractory threads help quilted blankets survive temperatures up to 2,000 °C.

Ames Research Center, Moffett Field, California

Thermal-insulation blankets of an advanced type can withstand repeated exposure to temperatures up to 2,000 °C. The blankets are thin, light in weight, and flexible. They were developed to protect proposed aerospacecraft like the Aeroassisted Space Transfer Vehicle and the National Aerospace Plane, which are expected to be exposed to temperatures higher than those on the surface of the Space Shuttle during reentry into the atmosphere of the Earth. These blankets may also prove useful as furnace insulation and in firefighters' clothing.

Sewing threads made of silicon carbide yarn are essential components of the blankets. These threads resist temperatures greater than those resisted by the silica threads used previously, and can readily be sewn by machine to quilt the many layers of the blanket. The thread withstands heat fluxes up to 37 W/cm^2 without breaking, kinking, doubling, or twisting.

A typical blanket of this type contains between 9 and 30 reflective layers of aluminum foil or aluminum film deposited on polyimide film, alternating with separating layers of aluminoborosilicate scrim cloth, aluminoborosilicate felt, or polyimide. A typical blanket also contains a layer of silica felt or aluminoborosilicate insulation. All of the aforementioned layers are quilted together between silicon carbide fabric (for the hotter side) and aluminoborosilicate fabric (for the cooler side) (see figure).



Silicon Carbide Threads are stitched from opposite sides of the blanket in a quilt pattern. The overall thickness of a typical blanket is only about 2.3 centimeters.

This work was done by D. A. Kourtides, W. C. Pitts, H. E. Goldstein, and P. M. Sawko of **Ames Research Center**. *For further information,* ***write in 28*** *on the TSP Request Card.*

This invention has been patented by NASA (U.S. Patent No. 5,038,693). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Ames Research Center [see page 20]. Refer to ARC-11907

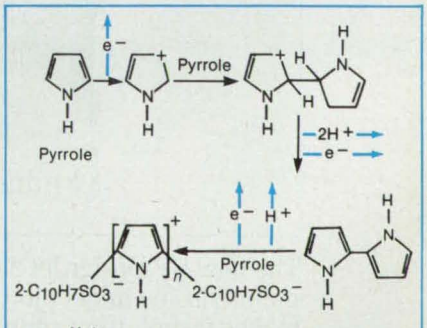
Pyrrole-Based Conductive Polymers for Capacitors

Thin films of large area and high volumetric capacitance have been prepared.

NASA's Jet Propulsion Laboratory, Pasadena, California

Polypyrrole films that contain various dopant anions have been found to exhibit superior capacitance characteristics. Together with the ability to be used with nonaqueous electrolytes, these characteristics make polypyrrole a candidate for use in advanced electrochemical double-layer capacitors that would be capable of storing electrical energy at high densities. (As used here, "double layer" denotes the two oppositely electrically charged layers that can be formed at the interface between an electrical conductor and an electrolyte.) In particular, mechanically robust polypyrrole films with areas up to 50 cm^2, containing 2-naphthalene sulfonate (NSA) negative counterions, have been prepared galvanostatically (see Figure 1) and found to have a volumetric capacitance of about 300 F/cm^3. Capacitors made of films of this type could be used, for example, in automobiles and pulsed power supplies.

The galvanostatic procedure for the deposition of polypyrrole films was demonstrated in several experiments, each of which was performed in 700 mL of an aqueous solution that contained 0.02 M sodium salt of the desired counteranion and 0.1 M pyrrole. The counterions included sodium 2-naphthalene sulfonate (NaNSA), sodium poly(p-styrenesulfonate) (NaPSS), and sodium dodecyl benzene sulfonate (NaDBS).



Notes:
1. The negative 2-naphthalene sulfonate (NSA) ion, (also denoted as 2-$C_{10}H_7SO_3^-$) is contained in the pores of the polymer film but not attached to the polymer.
2. *n* is an integer.

Figure 1. **Polypyrrole Film Doped With NSA** is formed galvanostatically in this sequence of oxidative polymerization reactions.

In each experiment, a well-polished stainless steel, glassy carbon, or platinum working electrode was used, and nickel gauze (symmetrically positioned about the working electrode) was used as the counterelectrode. The films were grown at a current density of 45 $\mu A/cm^2$.

The cyclic voltammetric behaviors of the films on 0.01 cm^2 glassy carbon and platinum electrodes were studied in aqueous solutions that contained the dopants. Particularly noteworthy are the differences between the cyclic voltammetric behaviors of films doped with NSA and DBS (see Figure 2). Apart from the potentials at which the peaks for the doping and undoping occur, the essential difference lies in the behaviors of the films when oxidized. The curve pertaining to the film doped with NSA indicates capacitive behavior at 0.5 to 0.6 V, but the curve pertaining to the film doped with DBS shows no such behavior: instead, the curve includes a linear portion characteristic of diffusion-controlled behavior.

The capacitive behavior of the polypyrrole film doped with NSA has been attributed mainly to the double-layer capacitance and to the porosity of the polypyrrole. The absence of any capacitive behavior of DBS-doped polypyrrole film in aqueous solutions may be due to the blockage of the pores of the polypyrrole by the bulky negative DBS counterions.

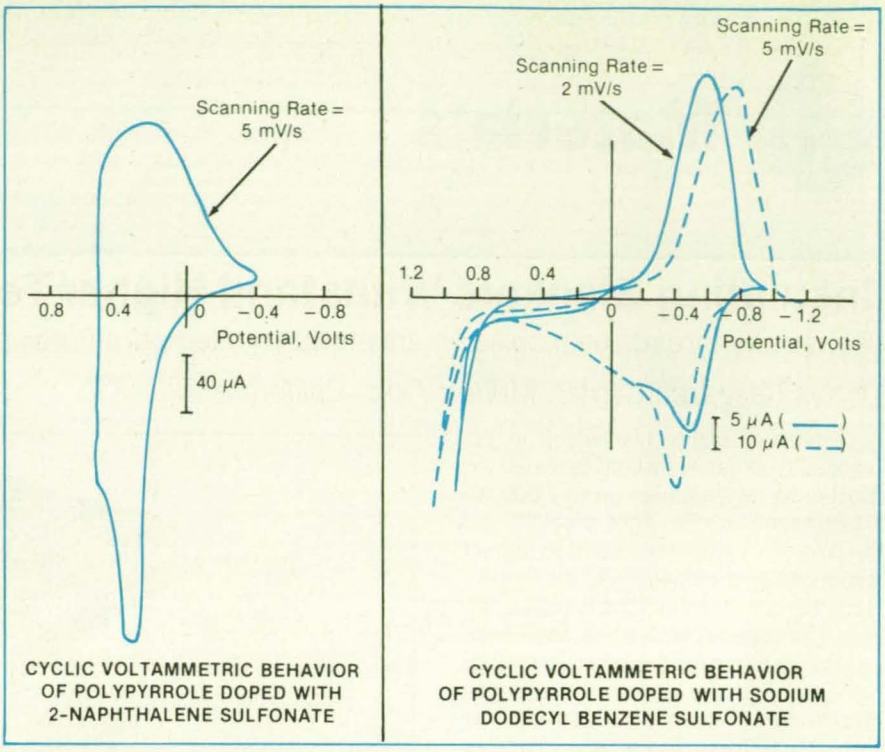
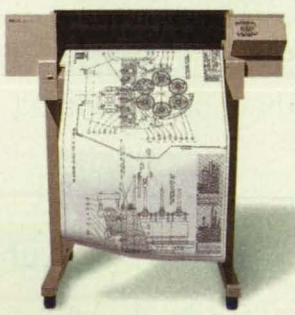


Figure 2. These **Cyclic Voltammetric Curves** of doped polypyrrole films were measured in aqueous solutions that contained the dopant ions.

This work was done by Ganesan Nagasubramanian and Salvador Di Stefano of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 23*** *on the TSP Request Card.* *NPO-18582*

Power.



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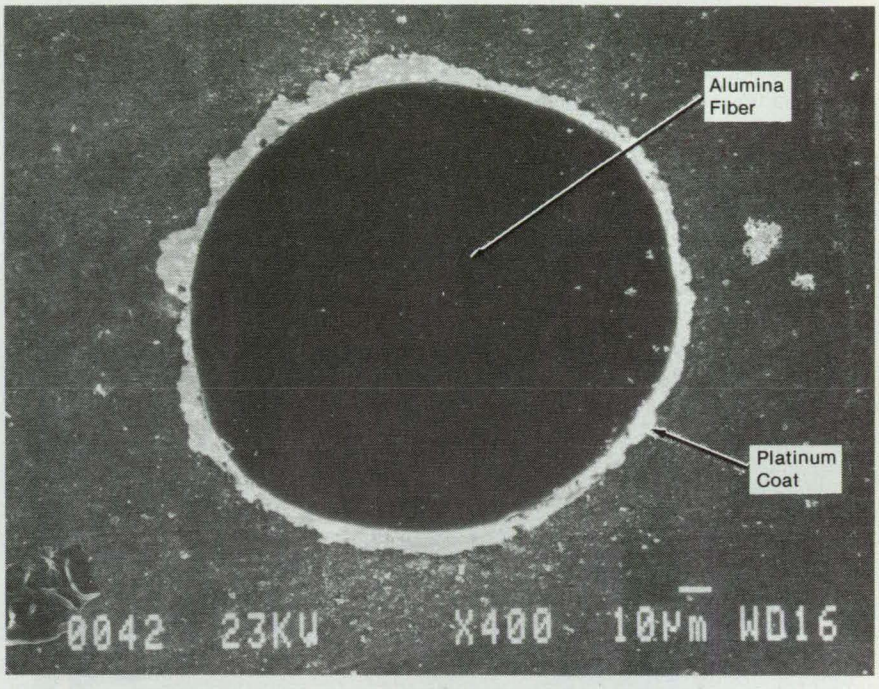
Guanidine Soaps as Vehicles for Coating Ceramic Fibers

Metal or oxide films can be deposited on smooth surfaces.

Lewis Research Center, Cleveland, Ohio

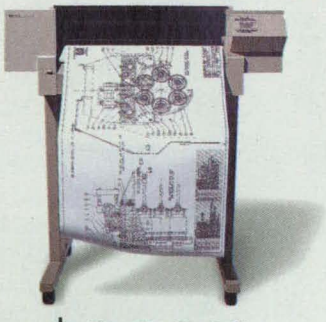
Soaps made from the strong organic base guanidine [$(NH_2)_2C{:}NH$] and organic fatty acids serve as vehicles and binders for coating ceramic fibers, various smooth substrates, and other problematic surfaces with thin precious-metal or metal-oxide films. Such films are needed, for example, to serve as barriers to diffusion in fiber/matrix ceramic composite materials. Sodium soaps are not suitable for the deposition of such films because they leave sodium-ash residues after firing. Sodium ash and other metal residues are undesirable because they degrade the strengths of many ceramics at high temperatures. However, guanidine soaps are entirely organic and can be burned off, leaving no residues.

In one example of this method of coating, a layer of platinum 3 μm thick was applied to a single-crystal alumina fiber of 0.005 in. (0.13 mm) diameter. First, the bare fiber was pulled through a molten mixture that consisted of the vehicle, guanidine 2-ethyl hexanoate, and a platinum precursor, guanidine hexachloroplatinate. After the fiber had been pulled through melt, the solidified mixture bonded to the fiber. The fiber thus coated was then fired at a tem-



The **Alumina Fiber Was Coated With Platinum** by first coating the alumina fiber with a mixture of guanidine 2-ethyl hexanoate and guanidine hexachloroplatinate, then heating the coated fiber at 1,200 °C to burn off organic material.

To the people.



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perature of 1,200 °C to burn off the organic materials, leaving the platinum coat on the fiber (see figure). If a thicker coat had been desired, the process could have been repeated.

In another example, a single-crystal alumina fiber was coated with the refractory oxide zirconia. In this case, the fiber was first passed through a slurry of zirconium dioxide particles suspended in the molten vehicle, guanidine 2-ethyl hexanoate. After the fiber was removed from the melt, it was fired at a temperature of 1,500 °C to burn off organic material and densify the zirconia coat.

This work was done by Warren H. Philipp, Lisa C. Veitch, and Martha H. Jaskowiak of **Lewis Research Center**. *For further information,* ***write in 50*** *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 [see page 20]. Refer to LEW-15314

TECH BRIEF INDEXES

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Making Diamondlike Films More Transparent

A dual-ion-beam process produces hard, adherent films.

Lewis Research Center, Cleveland, Ohio

Diamondlike carbon films that are highly transparent to visible light (wavelengths from 0.38 to 0.7 μm) can be made by a dual-ion-beam deposition process. The films are hard, resistant to scratching, and hermetic. They could be used as protective coatings on eyeglasses, magnetic recording heads, computer hard disks, and windows in bar-code scanners. Amorphous diamondlike carbon films are preferable to polycrystalline diamond films in these and other applications: unlike polycrystalline films, they are smooth and adherent and can be deposited at room temperature.

In the dual-ion-beam process, two sources generate ion beams of different ion-beam energies and current densities. Methane is introduced into the discharge chamber of the primary source, and the ionized fragments of the methane molecules are accelerated to a kinetic energy of 125 eV. Hydrogen is introduced into the secondary discharge chamber, and the hydrogen ions generated there are accelerated to a kinetic energy ≤ 125 eV. The two species react in vacuum to deposit amorphous diamondlike carbon on a substrate.

The film thus produced exhibits a visible-light transmittance greater than those of diamondlike carbon films produced by plasma or other ion-beam single-source deposition techniques. A film 1,000 Å thick produced by this technique was found to have a transmittance of 0.85 at a wavelength of 0.5 μm, while the best transmittance of any film of the same thickness made by any of the other techniques was found to be 0.64.

This work was done by Michael J. Mirtich, Michael T. Kussmaul, James S. Sovey, and Bruce A. Banks of **Lewis Research Center**. *For further information,* ***write in 9*** *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 [see page 20]. Refer to LEW-15322.

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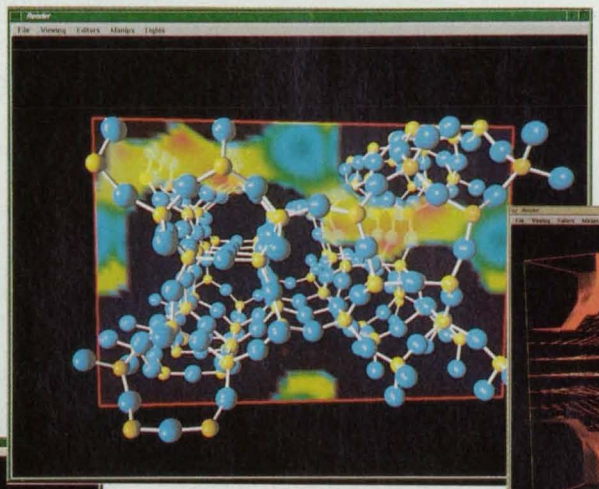

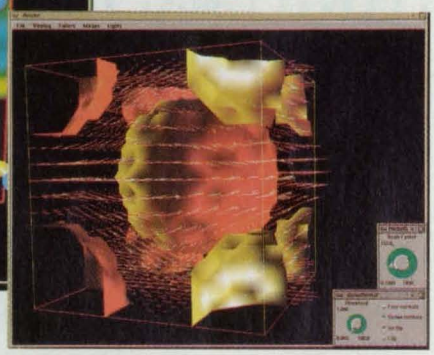

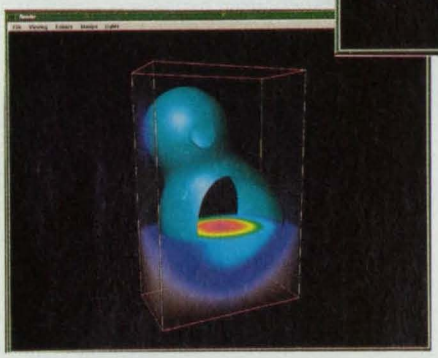

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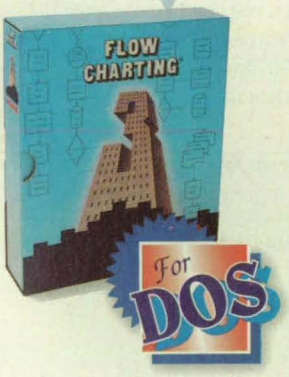

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Mathematics and Information Sciences

Image-Processing Program

IMAGEP manipulates digital image data to effect various processing, analysis, and enhancement functions.

IMAGEP is a FORTRAN computer program that performs various image-processing, -analysis, and -enhancement functions. It is a keyboard-driven program organized into nine subroutines. Within the subroutines are sub-subroutines that are also selected via keyboard.

Some of the functions performed by IMAGEP include digitization, storage, and retrieval of images; enhancement of images by contrast expansion, addition and subtraction, magnification, inversion, and bit shifting; display and movement of cursor; display of gray-level histogram of image; and display of the variation of gray-level intensity as a function of position in the image. This algorithm has possible scientific, industrial, and biomedical applications in the study of flows in materials, analysis of steels and ores, and pathology, respectively.

IMAGEP is written in VAX FORTRAN for DEC VAX-series computers running VMS. The program requires the use of a Grinnell 274 image processor, which can be obtained from Mark McCloud Associates, Campbell, CA. An object library of the required GMR-series software is included on the distribution medium. IMAGEP requires 1 Mb of random-access memory for execution. The standard distribution medium for this program is a 1,600-bit/in. (630-bit/cm), 9-track magnetic tape in VAX FILES-11 format. It is also available on a TK50 tape cartridge in VAX FILES-11 format. This program was developed in 1991.

DEC, VAX, VMS, and TK50 are trademarks of Digital Equipment Corp.

This program was written by D. J. Roth and D. R. Hull of **Lewis Research Center**. *For further information,* ***write in 13*** *on the TSP Request Card.*
LEW-15370

New Testing Tool for Composite Interfaces

Strength of fiber/matrix interface is key factor.

Lewis Research Center, Cleveland, Ohio

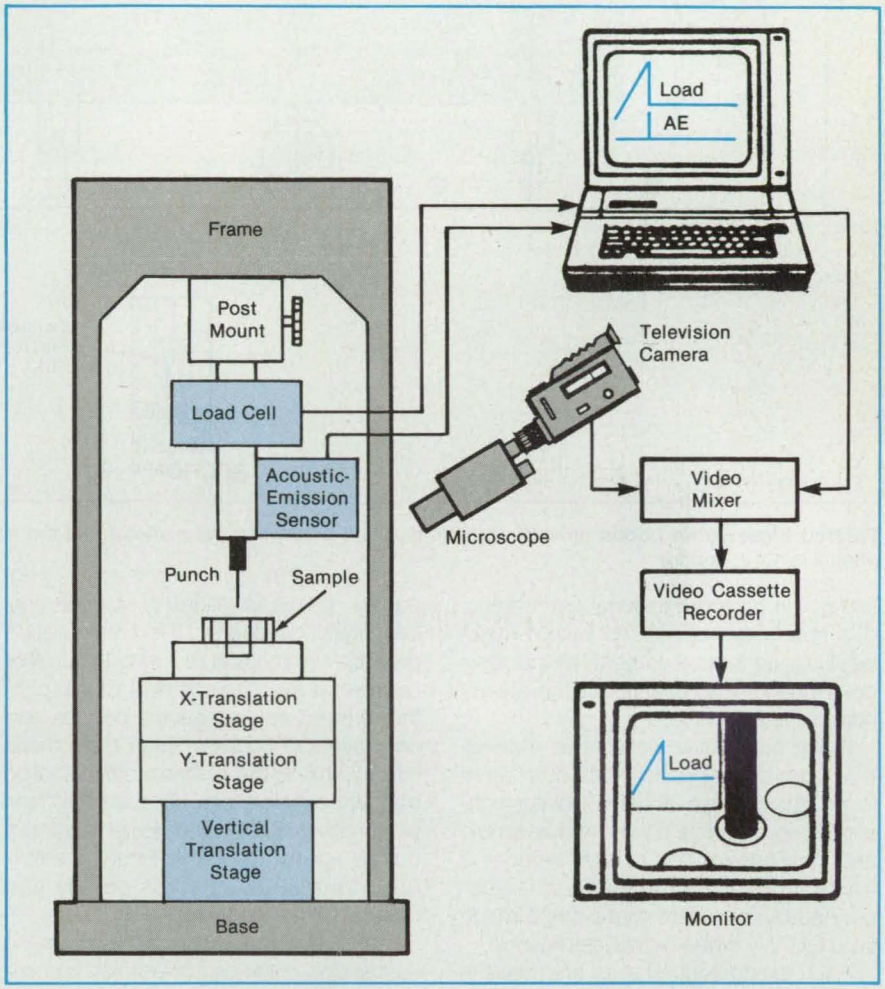
Researchers at NASA Lewis Research Center are developing new lightweight, high-temperature, fiber-reinforced composite materials for use in future generations of jet engines. These new materials will lead to lighter, cleaner-burning engines. While much of the development effort is focused on independently improving the properties of the reinforcing fibers and the surrounding matrix, it turns out that the mechanical strength of the interface between the fibers and matrix is a key factor in the overall strength and toughness of the composite material. This dependence on interfacial properties opens the opportunity for interfacial engineering to optimize the composite properties.

Any attempt to tailor the strength of the fiber/matrix interface requires a micromechanical test, which evaluates that strength. To fulfill this need, a desktop fiber-pushout apparatus was developed. A schematic of the apparatus is shown in the accompanying figure.

The simple concept behind the test is to use a small-diameter pushrod (typically, 100-μm diameter) to displace an individual fiber in a thin slice of composite material. A channel in the sample-support plate allows the other end of the fiber to exit the material without resistance. The force required to displace the fiber and the force required to continue moving the fiber against frictional resistance are recorded; these values are important to composite designers.

In addition to recording fiber debonding and sliding loads, a microscope and video camera provide real-time observations of the motions of the pushrod and fiber. Additional characterization of the fiber debonding is performed by analyzing the acoustic (sound) waves generated as the fiber/matrix interface is fractured.

The apparatus is compact, easy to operate, and inexpensive. This test has been applied to, and found appropriate for a wide range of composites, including metal, intermetallic, and ceramic matrix composites, and is not restricted to aerospace/aeronautics applications.



The **Desktop Fiber Pushout Apparatus** generates load and acoustic-emission (sound-wave) data as a function of translation-table displacement. The video camera gives a view of the specimen.

This work was done by Jeffrey I. Eldridge of **Lewis Research Center**. *For further information* ***write in 104*** *on the TSP Request Card.*

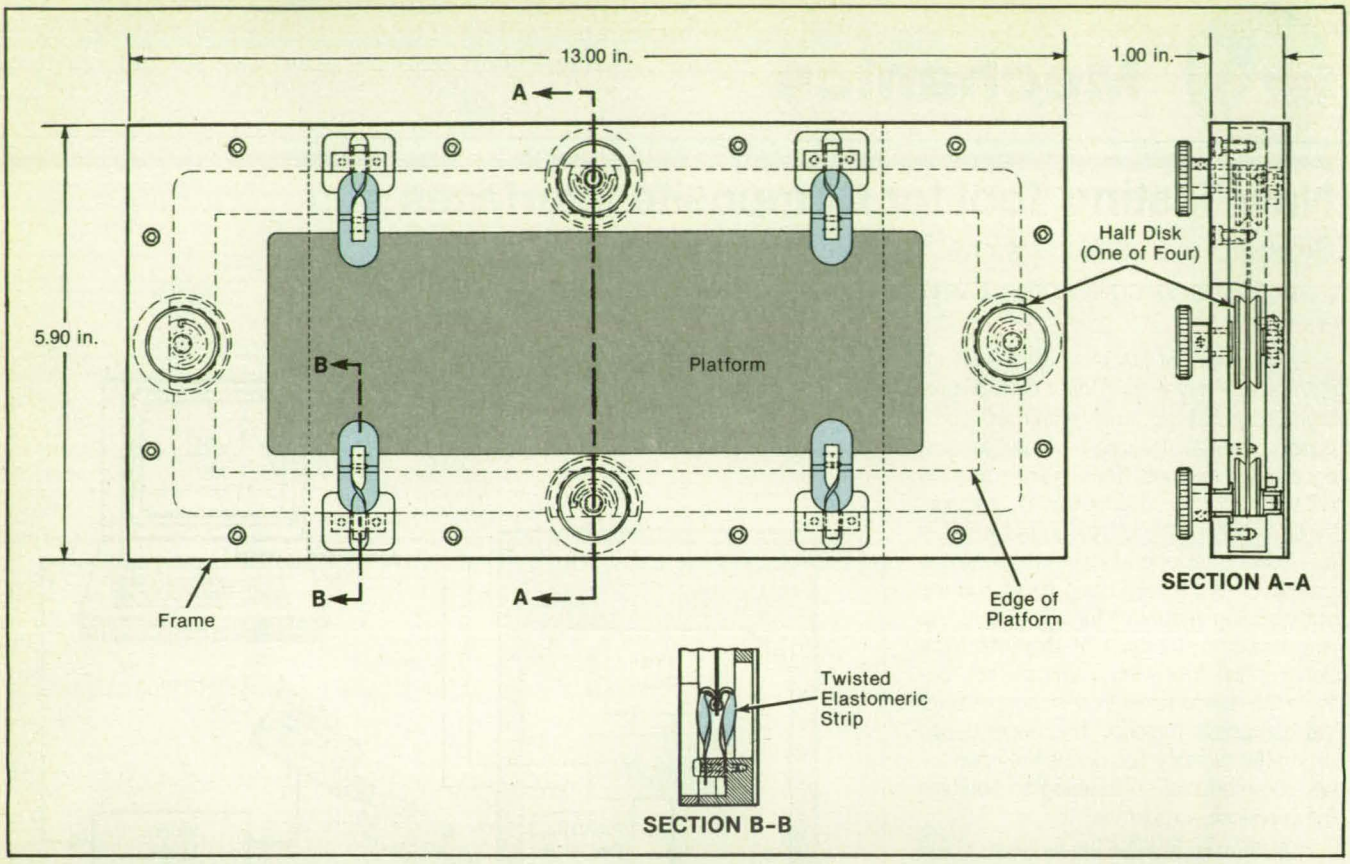
Inquires concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Lewis Research Center [see page 20]. Refer to LEW-15297.

Passive Vibration Isolator for Experiments

Elastomeric suspension suppresses low-frequency vibrations.

Marshall Space Flight Center, Alabama

A passive isolator reduces the natural vibrational frequency of a platform to less than 1 Hz — well below the frequenciesof vibration induced by human activity (about 3 Hz). Biological, crystal-growth, and other experiments mounted on the platform are therefore protected against disturbances by technicians working in the vicinity. The passive vibration isolator is designed for



Twisted Elastomeric Loops provide vibration isolation b between the platform and the frame. Half disks lock the platform to the frame when it is not in service.

use in the microgravitational environment of a spacecraft; a modified version might be designed for use on Earth by including components that counteract the steady normal Earth gravitation.

Unlike such active isolators as systems that employ magnetic fields and servo loops, this passive vibration isolator consumes no electrical power and is simple and inexpensive. This isolator includes a frame from which the platform is suspended by four elastomeric strips made from ordinary rubberbands (see figure).

Each elastomeric strip is anchored in the frame, twisted, and pinned to the platform in a configuration that ensures that the strip (1) flexes, rather than stretches, and (2) isolates the platform approximately equally against vibrations in all three perpendicular directions. The configuration provides symmetrical restoring forces that counteract the displacement of the platform from a nominal central position and orientation. In addition, each elastomeric strip cushions the platform against large transient accelerations because it stiffens when either its upper or lower segment bumps against the frame. Finally, the flexure of the strips absorbs energy and quickly damps vibration.

The overall stiffness of the elastomeric suspension at the central position and orientation is about 8,000 dyn/m. For a 1-kg load, this stiffness results in a natural vibrational frequency of about 0.5 Hz.

The platform can be locked to the frame for loading, unloading, maintenance, adjustment, and other purposes. To lock the platform, four grooved half disks on the frame are rotated so that the grooves in their circular edges engage the edge of the platform. To release the platform, the disks are rotated so that their flat edges face the edge of the platform.

This work was done by Robert J. Naumann of the University of Alabama for **Marshall Space Flight Center.** *For further information,* ***write in 41*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 20]. Refer to MFS-26208.

High-Temperature Resistance Strain Gauges

Apparent strain (attributable to temperature) is low and highly reproducible.

Lewis Research Center, Cleveland, Ohio

Resistance strain gauges have been developed for use at high temperatures in such demanding applications as testing aircraft engines and structures. Whereas prior commercial resistance strain gauges could not operate at temperatures beyond 400 °C, the new gauges measure static strains at temperatures up to 800 °C. Moreover, whereas the apparent strains (spurious gauge outputs attributable to changes in temperature rather than strains) of the prior gauges included large components that were not reproducible from cycle to cycle, the apparent strains of the new gauges are small and highly reproducible; consequently, the readings of the new gauges can be corrected for temperature within small tolerances, provided that temperatures are measured simultaneously by thermocouples or other suitable devices.

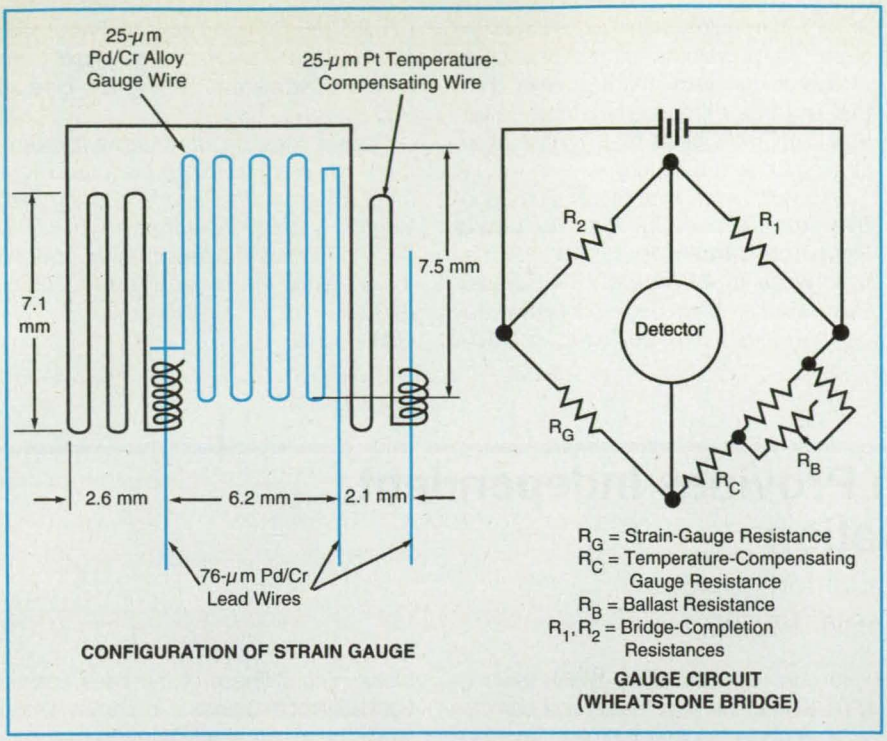


Figure 1. This **Temperature-Compensated Pd/Cr Strain Gauge** is connected in a wheatstone bridge. The bridge is balanced at room temperature by appropriate adjustments of R_B, R_1, and R_2.

Figure 1 shows a representative gauge of the new type, along with a wheatstone bridge circuit in which it is used. The gauge wire, made of an alloy of 87 weight percent palladium and 13 weight percent chromium, has a diameter of 25 μm and a nominal resistance of 120 Ω. Because the Pd/Cr alloy has a high temperature coefficient of resistance, a temperature-compensating wire of Pt with a diameter of 25 μm and a nominal resistance of 15 Ω is included. Lead wires of the Pd/Cr alloy, 76 μm in diameter, are spot-welded to the gauge and compensating wires.

Prototype gauges were mounted on nickel-base high-temperature-alloy coupons and test beams. Some gauges were held in place with high-temperature ceramic cements and coated with alumina-based mixtures, which protect against oxidation and shorting to ground at temperatures up to 600 °C. Other gauges were not cemented but instead were coated with flame-spray powders to prevent oxidation of the fine gauge wires at temperatures up to 800 °C. First, an alumina base coat was flame-sprayed onto each bare gauge. Then a

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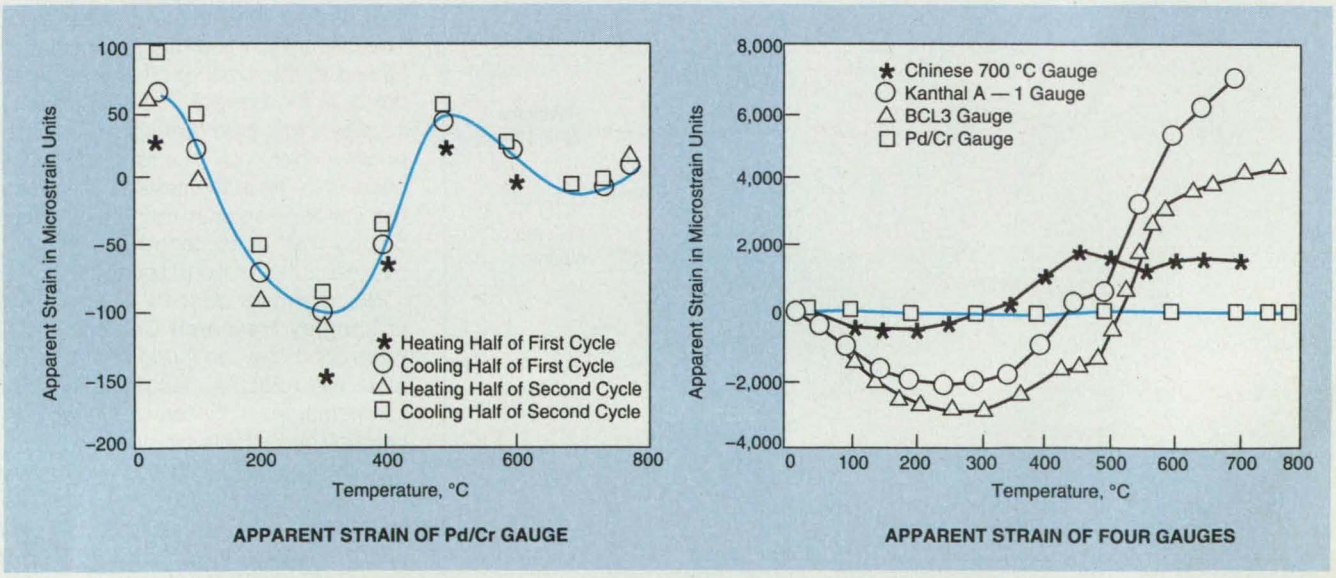

Figure 2. The **Apparent Strain** of a temperature-compensated Pd/Cr strain gauge was measured in two thermal cycles. As shown in the right plot, the apparent strain of this gauge is much smaller than that of three other high-temperature strain gauges.

powder mixture of alumina with 4 weight percent zirconia was flame-sprayed to form a protective overcoat.

In preparation for a test, a gauge of the new type was mounted on a test beam and prestabilized by maintaining the gauge and beam at a temperature of 800 °C for 50 hours. During the test, which involved two thermal cycles, the range of variation of the apparent strain was found to be less than 250 microstrain, and the apparent strain was found to be reproducible within 50 microstrain at each temperature. The apparent strain of this gauge was much smaller than that of three other, commercially available Fe/Cr/Al-based high-temperature strain gauges (see Figure 2).

This work was done by Jih-Fen Lei of Sverdrup Technology, Inc., for **Lewis Research Center**. *For further information,* ***write in 43*** *on the TSP Request Card. Further information containing additional details may be found in NASA CR-185256 [N90-26063], "A Resistance Strain Gage With Repeatable and Cancellable Apparent Strain for Use to 800 °C."*

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LEW-15379.

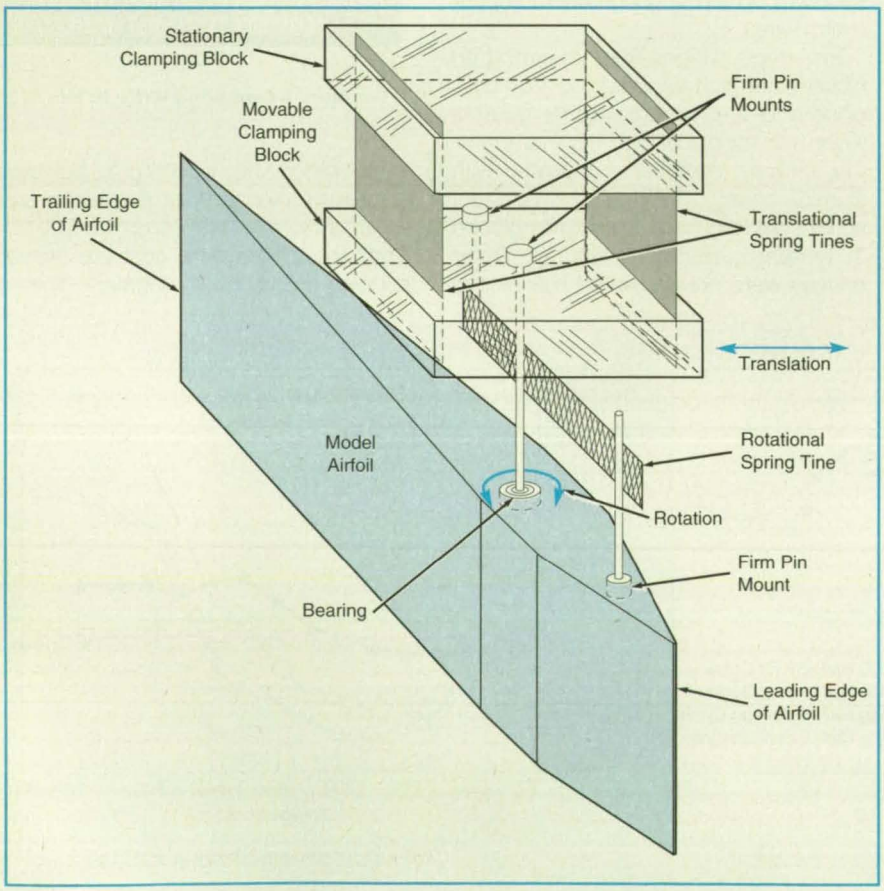
Suspension System Provides Independent Translation and Rotation

Spring tines govern motion of mounted object.

Langley Research Center, Hampton, Virginia

A spring suspension provides one translational and one rotational degree of freedom. The suspension can be used, for example, to provide for pitching and plunging movements of an airfoil in a wind tunnel.

The translational freedom is provided by two thin, flat steel spring tines, clamped at one end to a stationary block fixed to the ceiling of the wind tunnel, and clamped to a movable block at the other end (see figure). This combination of spring tines and blocks constitutes a spring analog of a parallelogram linkage, in which the bending of the tines allows only translation (but not rotation) of the movable block. The stiffness of the tines against translation of their ends is four times what it would be in the purely cantilevered state (movable ends not clamped to the block). The tines are also very stiff against twisting, which would interfere with the rotational degree of freedom if it were allowed to occur.



The **Upper Pair of Spring Tines** clamped at both ends give the model airfoil its translational degree of freedom, while the single lower spring tine gives the airfoil its independent rotational degree of freedom.

The stiffness of a tine depends on its thickness, length, width, and material. The effective stiffness of the tines and, consequently, the resonant frequency of vibration of the movable block and whatever is mounted on it can be varied over a moderate range by adjusting the position of the movable plate on the tines with the help of the setscrews.

The rotational degree of freedom is governed by a single tine attached to a set of three pins. The aft and middle pins are attached firmly to the movable block. The forward pin and middle pins are attached to the airfoil or other suspended object — the former by a bearing and the latter by a firm, fixed connection. The airfoil or other object can thus rotate about the middle pin. As in the case of translation, the stiffness against rotation depends on the thickness, length, width, and material of the rotational spring tine.

This work was done by Jennifer Heeg of **Langley Research Center**. *Further information may be found in NASA TP-3241 (N93-20584), "Analytical and Experimental Investigation of Flutter Suppression by Piezoelectric Actuation."*

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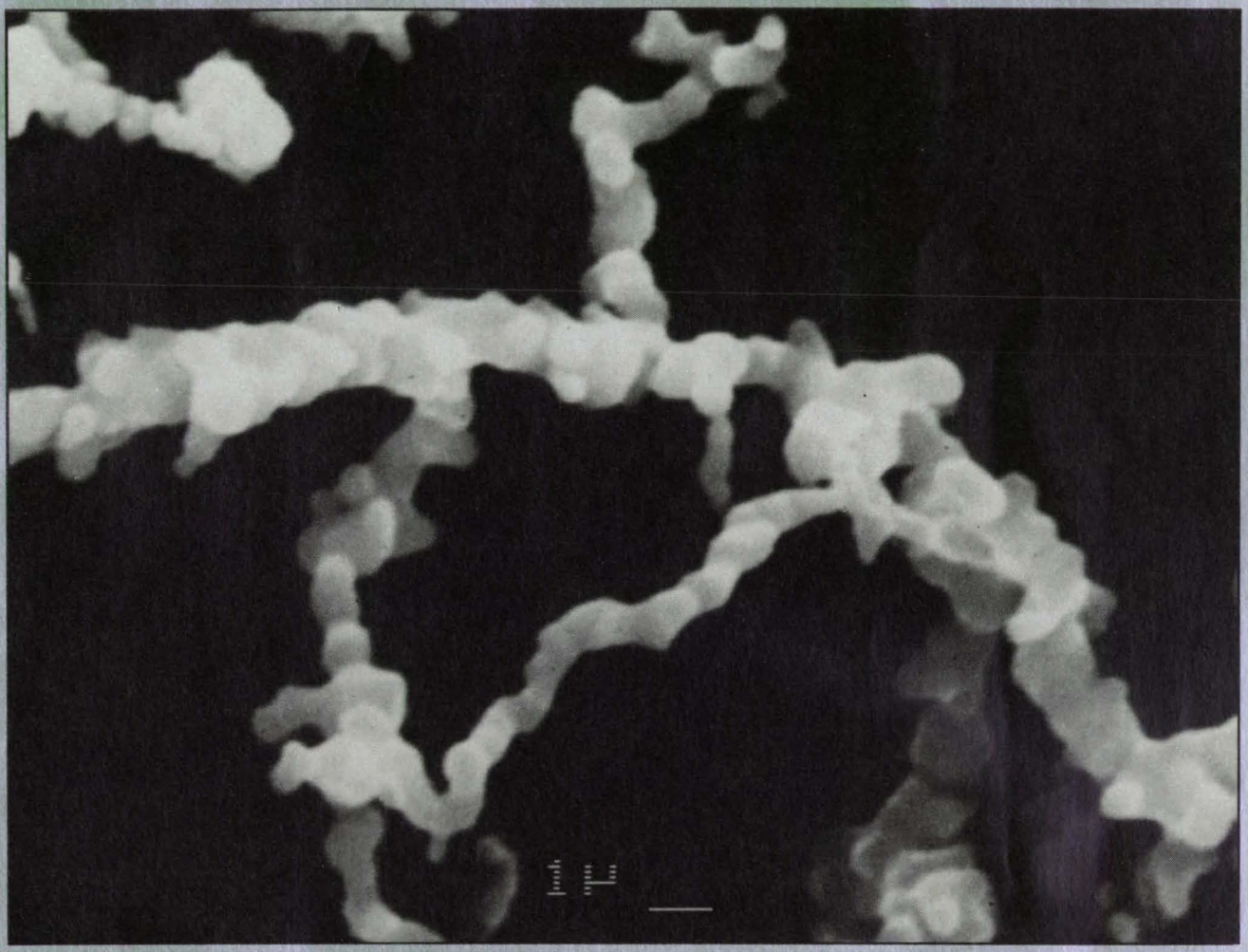

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Rolling-Convolute Joint for Pressurized Glove

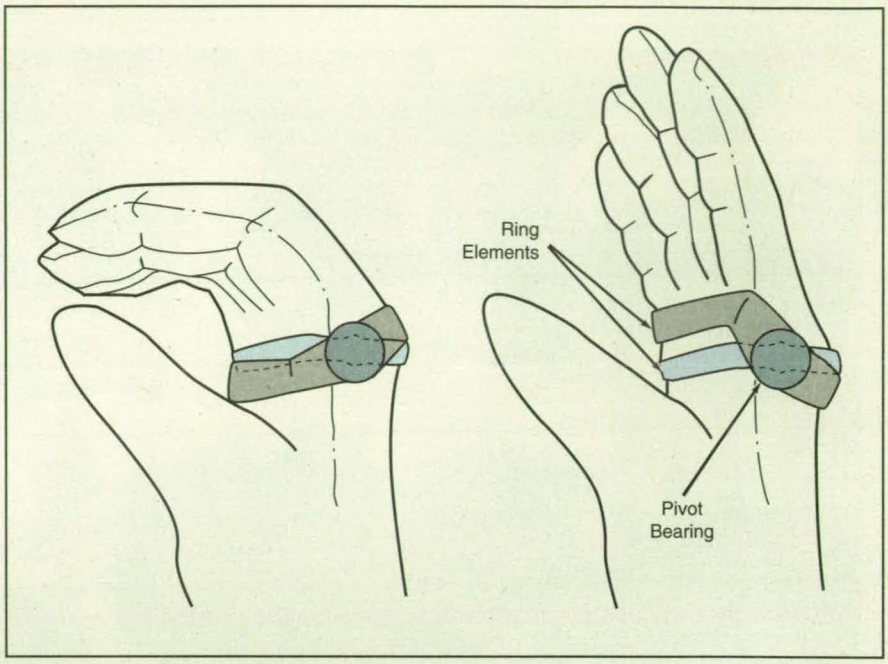
Mobility and flexibility are enhanced.

Lyndon B. Johnson Space Center, Houston, Texas

A rolling-convolute metacarpal/finger joint enhances the mobility and flexibility of a pressurized glove. Intended for use in a space suit to increase dexterity and decrease the wearer's fatigue, such a joint might also be useful in diving suits and other pressurized protective garments.

The joint is designed to counteract the stiffening effects of internal pressurization. Two ring elements are linked together on opposite sides of the glove through a pair of externally located pivot bearings (see figure). A conformal urethane bladder with a separate fabric restraining layer retains the internal glove pressure and allows the relatively mobile outer ring to roll over the relatively immobile inner ring. Expansion (or compression) of the bladder and restraining fabric on the dorsal (knuckle) surface of the hand is compensated by the contraction (or compression) of the bladder and restraining material on the palmar surface of the hand. This constant-volume feature balances the torques exerted on the joint by the internal pressure. Therefore, the weaver need exert minimal torques and forces to flex the joint or to maintain fingers at any point in a wide range of neutrally stable angular positions.

The glove, equipped with the rolling-convolute joint, was tested at an internal gauge pressure of 8 psi (55 kPa). It was found to allow for a range of motion of 30° to 45° with extremely low hand forces. It also provided a comfortable grasp of various pieces of equipment.



The **Two Ring Elements** shown here plus a bladder (omitted for clarity) constitute a rolling-convolute joint that balances torques caused by internal pressurization of the glove.

This work was done by Joseph J. Kosmo of **Johnson Space Center** *and John W. Bassick of David Clark Co. For further information,* ***write in 8*** *on the TSP Request Card.*

MSC-21628

Liquid/Gas Flow Mixers

Small bubbles are distributed uniformly.

NASA's Jet Propulsion Laboratory, Pasadena, California

Improved devices that mix gases and liquids into bubbly or foamy flows are being developed. These mixers generate flowing, homogeneous foams or homogeneous dispersions of small, noncoalescing bubbles entrained in flowing liquids. Such mixers could be useful in a liquid-metal magnetohydrodynamic electric-power generator, for example: bubbles of metal vapor are present, and the velocity slip between the bubbles and liquid causes significant energy-conversion loss. The coefficient of drag of bubbles per unit volume of gas increases with decreasing size of the bubbles; that is, smaller bubbles are entrained in the flow more effectively, with consequent decrease in velocity slip and in the attendant loss of energy. The improved mixers might also be useful in froth flotation in the mining industry, wastewater treatment, aerobic digestion, and stripping hydrocarbon contaminants from ground water.

In designing and constructing the improved mixers, care must be taken to avoid the flow conditions that lead to the generation of large bubbles at gas-injection surfaces. It is also necessary to prevent separation of flow, which can lead to agglomeration of small bubbles into large ones at locations downstream from gas-injection surfaces.

The improved mixer concept has been tested in air/water-mixing experiments using the air-injection device shown in Figure 1. The air-injection surfaces of this device are two stainless-steel plates. The water flows parallel to the surfaces of these plates, and a multitude of small bubbles is created as air is injected into the flow through many 0.5-μm pores in the plates. The large size of the injection surfaces makes it possible to inject a significant flow of air at a low injection velocity — only 0.1 ft/s (3 cm/s). The use of a low injection velocity helps to prevent the formation of large bubbles at the injection surface.

Figure 2 illustrates one way of preventing the formation of a gas-filled region of separated flow at the trailing edge of the injection device, thereby preventing the coalescence of small bubbles into

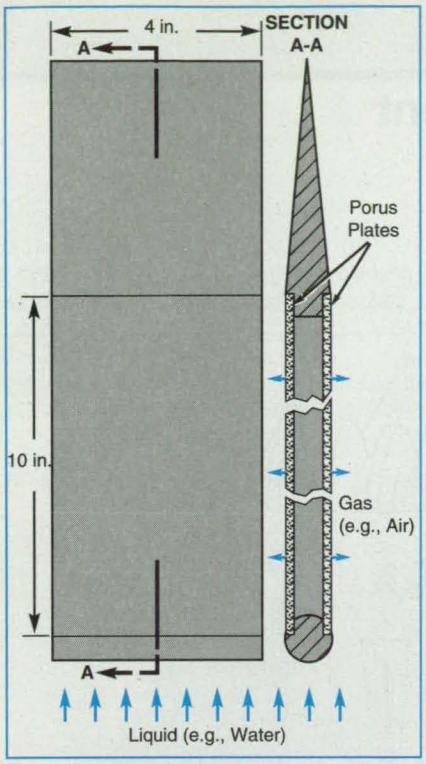


Figure 1. **Many Small Bubbles Are Formed** by injection of air through porous plates into flowing water.

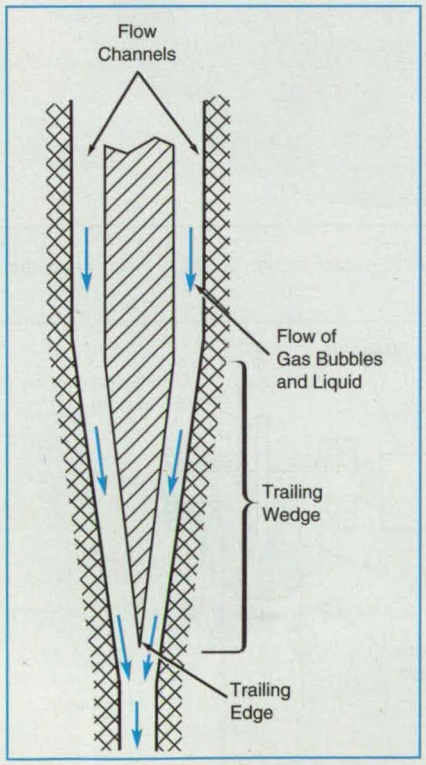
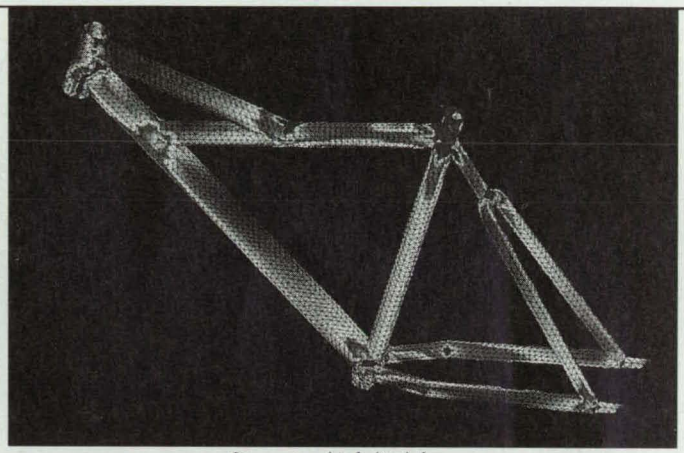


Figure 2. The **Flow Channel Can Be Tapered** in such a way as to prevent the separation of flow at the trailing edge, thereby preventing the coalescence of small bubbles into larger ones.

large ones downstream from the injection surfaces. The cross section of the flow channel is made to decrease continuously with position along the flow channel from a position upstream of the thick end of the trailing wedge to a position downstream of the pointed end of the trailing wedge. This taper ensures moderate acceleration of the flow with a favorable (negative) gradient of pressure along the flow. This favorable gradient of pressure ensures thin boundary layers and prevents separation of flow from the trailing wedge.

This work was done by Gracio Fabris of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 106*** *on the TSP Request Card.*
NPO-18681



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Worm Gear With Hydrostatic Engagement

Friction would be reduced greatly.

Lewis Research Center, Cleveland, Ohio

In a proposed worm-gear transmission, oil would be pumped at high pressure through the meshes between the teeth of the gear and the worm coil (see Figure 1). The pressure in the oil would separate the meshing surfaces slightly, and the oil would reduce the friction between these surfaces. Each of the separating forces in the several meshes would contribute to the torque on the gear and to an axial force on the worm. To counteract this axial force and to reduce the friction that it would otherwise cause, oil would also be pumped under pressure into a counterforce hydrostatic bearing at one end of the worm shaft.

This type of worm-gear transmission was conceived for use in the drive train between the gas-turbine engine and the rotor of a helicopter and might be useful in other applications in which weight is critical. Worm gear is attractive for such weight-critical applications because (1) it can transmit torque from a horizontal engine (or other input) shaft to a vertical rotor (or other perpendicular output) shaft, reducing the speed by the desired ratio in one stage, and (2) in principle, a one-stage design can be implemented in a gearbox that weighs less than does a conventional helicopter gearbox.

Heretofore, the high sliding friction between the worm coils and the gear teeth of worm-gear transmissions has reduced efficiency so much that such transmissions could not be used in helicopters. The efficiency of the proposed worm-gear transmission with hydrostatic engagement would depend partly on the remaining friction in the hydrostatic meshes and on the power required to pump the oil. Preliminary calculations show that the efficiency of the proposed transmission could be the same as that of a conventional helicopter gear train.

Figure 2 shows an apparatus that is being used to gather experimental data pertaining to the efficiency of a worm gear with hydrostatic engagement. Two stationary disk sectors with oil pockets represent the gear teeth and are installed in a caliper frame. A disk that represents the worm coil is placed between the disk sectors in the caliper and is rotated rapidly by a motor and gearbox. Oil is pumped at high pressure through the clearances between the rotating disk and the stationary disk sectors. The apparatus is instrumented to measure the frictional force of meshing and the load force.

The stationary disk sectors can be installed with various clearances and at various angles to the rotating disk. The

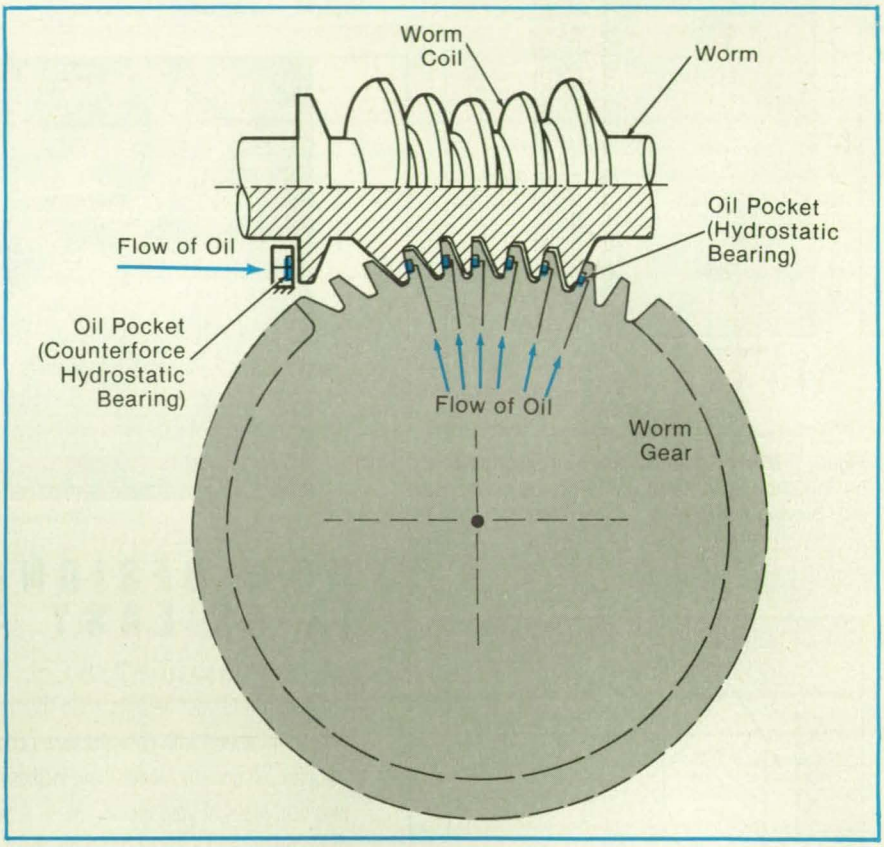

Figure 1. **Oil Would Be Injected** at high pressure to reduce friction in critical areas of contact.

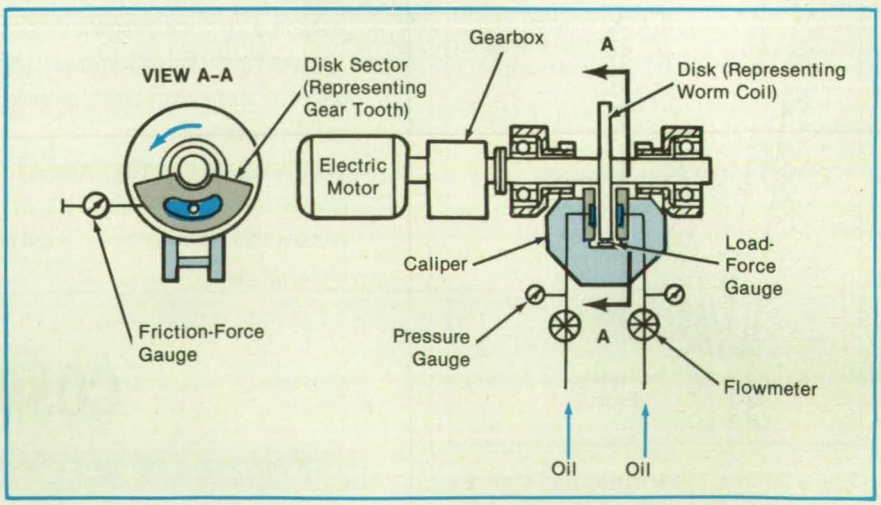

Figure 2. This **Test Apparatus** simulates and measures some of the loading conditions of the proposed worm gear with hydrostatic engagement. The test data will be used to design efficient worm-gear transmissions.

stationary disk sectors can be made in various shapes and with oil pockets at various positions. A flowmeter and pressure gauge will measure the pump power. Oils of various viscosities can be used. The results of the tests are expected to show the experimental dependences of the efficiency of transmission on these factors.

It has been estimated that future research and development will make it possible to make worm-gear helicopter transmissions that weigh half as much as conventional helicopter transmissions do. In addition, the new hydrostatic meshes would offer longer service life and less noise. It might even be possible to make the meshing worms and gears, or at least parts of them, out of such lightweight materials as titanium, aluminum, and composites.

This work was done by Lev I. Chalko of the U.S. Army Propulsion Directorate (AVSCOM) for **Lewis Research Center.**

Further information may be found in NASA TM-102441 (AVSCOM TM-89-C-010) [N90-15923], "Assessment of Worm Gearing for Helicopter Transmission."

Copies may be purchased (prepayment required) from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700. LEW-15092

Piezoelectric Motor in Robot Finger Joint

A direct drive unit replaces remote electromagnetic motor.

Marshall Space Flight Center, Alabama

A robotic finger contains an integral piezoelectric motor. In comparison with a robotic finger actuated by remote motors via tendonlike cables, this robotic finger is simpler and can therefore be assembled, disassembled, and repaired more easily. It is also more reliable and contains more internal space that can be allocated to sensors and control circuitry.

The finger (see figure) includes two piezoelectric clamps and a piezoelectric-rotator subassembly. Each clamp is composed of a piezoelectric actuator, a concave shoe, and a thin bushing with an axial slit. A finger-joint shaft fits in the bushing. When the actuator in a clamp is unenergized, the shaft is free to rotate in the bushing. When the same actuator is energized, it expands and pushes the shoe against the bushing. This action clamps the shaft. (The slit in the bushing allows it to flex so that more actuator force acts on the shaft and is not wasted in deforming the bushing.)

The piezoelectric-rotor subassembly includes a pair of piezoelectric actuators and a component denoted, simply, as the rotator, which is attached to the bushing in clamp 2. The upper rotator actuator, when energized, pushes the rotator a fraction of a degree clockwise. Similarly, when the lower rotator is energized, it pushes the rotator a fraction of a degree counterclockwise. The finger-joint shaft extends through the rotator. The two clamps are also mounted on the same shaft, on opposite sides of the rotator. The rotator actuators are energized alternately to impart a small back-

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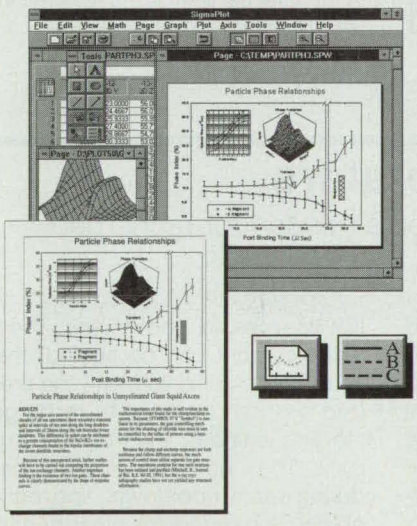

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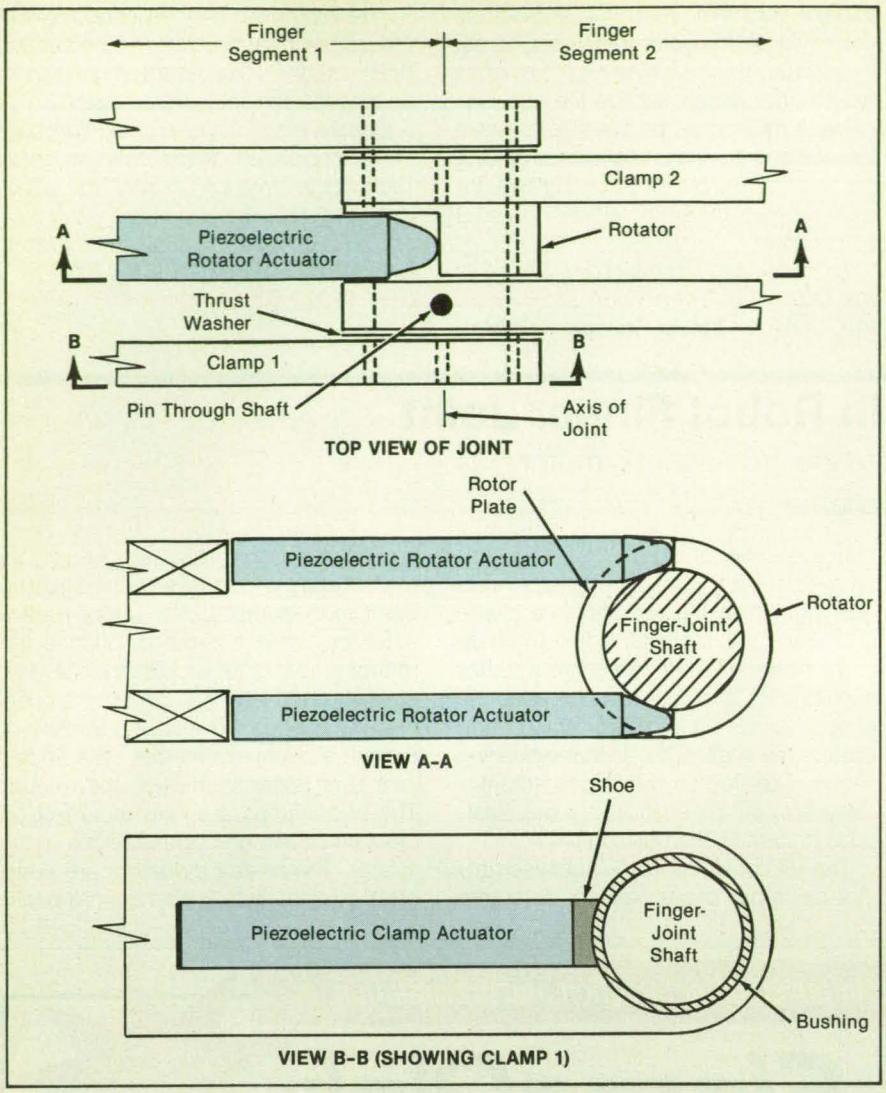

and-forth motion to the rotator. At the same time, the clamp actuators are energized alternately in such a sequence that the small oscillations of the rotator accumulate into a net motion of the shaft (and the finger segment attached to it), clockwise or counterclockwise, depending on whether the shaft is clamped during clockwise or counterclockwise movement of the rotator.

The piezoelectric motor, including lead wires, rotator-actuator supports, and actuator retainers, adds a mass less than 10 grams to the joint. The power density of the piezoelectric motor is much greater than that of the electromagnetic motor that would be needed to effect similar motion. The piezoelectric motor operates at low speed and high torque — characteristics that are especially suitable for robots.

This work was done by Allen R. Grahn of Bonneville Scientific, Inc., for Marshall Space Flight Center. For further information, ***write in 75*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial of this invention should be addressed to the Patent Counsel, **Marshall Space Flight Center** *[see page 20].*
Refer to MFS-26198.

Each **Piezoelectric Clamp Grasps** a shaft when energized. The piezoelectric rotor turns the shaft in small increments as it is alternately clamped and unclamped.

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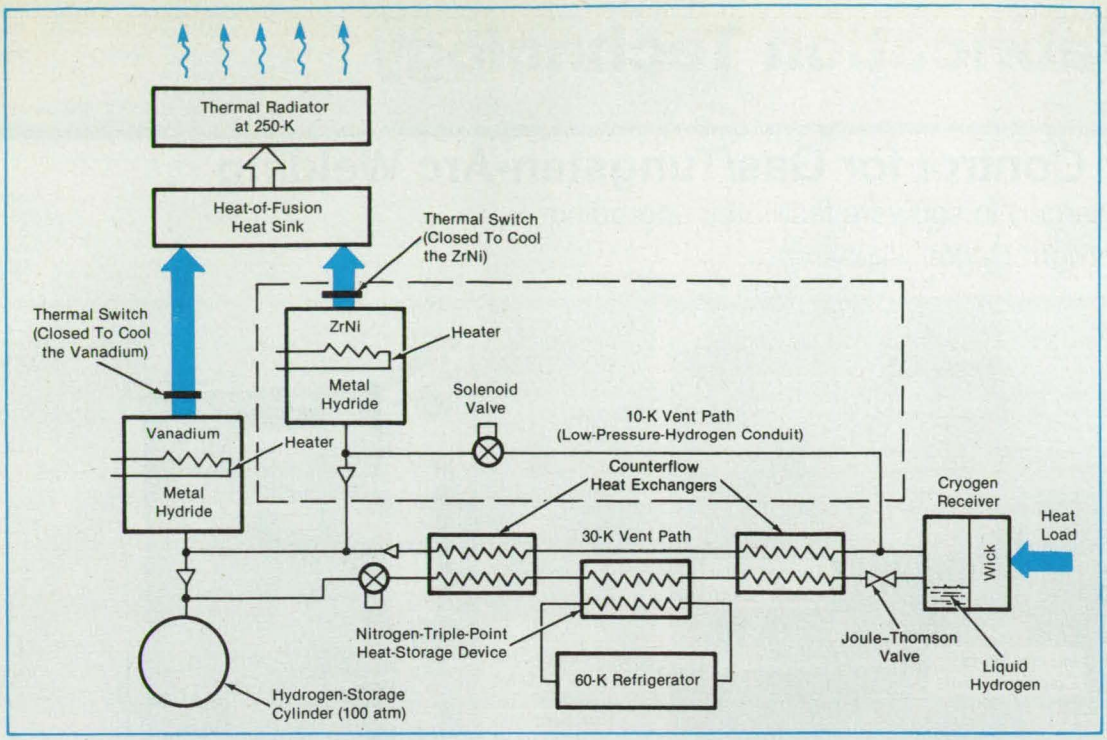
NASA's Jet Propulsion Laboratory, Pasadena, California

Metal hydride/hydrogen-sorption refrigerators are being developed to provide rapid, intermittent cooling at temperatures between 30 and 10 K. In the original intended application, these refrigerators would cool infrared detectors aboard spacecraft, exhausting heat to outer space via radiators at 250 K. A refrigerator of this type could be modified to cool scientific instrumentation on Earth, albeit with some loss of efficiency, by raising the design exhaust temperature to a typical ambient temperature of 300 K.

The development sorption refrigerators are solutions of the specific problem to design a lightweight, low-power, low-vibration cooling system that provides 1.5 W of cooling for 30 min daily at 30 K and 0.15 W of cooling for 30 min daily at 10 K. Only 30 s are allowed to cool from 60 K to 30 K, and only 120 s are permitted to cool from 60 K to 10 K. No known conventional mechanical cooling system can satisfy these requirements.

The designs of these sorption refrigerators are based on the fact that the only known way to obtain the desired rapid cooling is to expand gas (in this case, hydrogen) from a pressurized storage cylinder through heat exchangers and a Joule-Thomson valve. The expanded gas is not vented but instead is recycled by storing it in a sorbent (in this case, a hydride-forming metal powder) and providing for quick transfer of the heat of absorption from the sorbent to the environment. Later, during the long interval between rapid cooldowns, the gas-laden sorbent can be heated, thereby causing pressurization, and the pressurized gas can be used to recharge the storage cylinder, thus completing the cycle. Thus, no power supply is needed during rapid cooldown, and only low power is needed for slow heating to recharge the storage cylinder.

The figure is a schematic diagram of two of the developmental quick-cooldown sorption refrigerators. In the one that does not include the parts within the dashed outline, a canister that contains vanadium hydride is heated to about 403 K, causing hydrogen to fill a storage cylinder at a pressure of 100 atm (about 10 MPa). When cooling at 30 K is desired, a solenoid valve is activat-



These Quick-Cooldown Sorption Refrigerators require no power during quick cooldown and low heating power during relatively long recharge periods. One refrigerator includes the parts within dashed lines; the other does not.

ed, permitting gas to flow through a counterflow heat exchanger and to be cooled to 63 K by a nitrogen-triple-point (containing solid, liquid, and gaseous nitrogen) heat-storage device. The high-pressure hydrogen then proceeds through another counterflow heat exchanger and is expanded to 8 atm (about 0.8 MPa) when it passes through a Joule-Thomson valve. The resulting liquid hydrogen is boiled at 30 K when a heat load is applied, and the returning low-pressure hydrogen precools the high-pressure hydrogen gas in the counterflow heat exchangers. The low-pressure hydrogen gas finally returns to the vanadium in the canister, which is maintained at about 333 K by contact with a heat-of-fusion heat sink.

In the apparatus that includes the parts shown within the dashed outline, the parts outside the dashed outline are used first to provide liquid hydrogen quickly at 30 K. Then a solenoid valve is opened to admit hydrogen gas to a lower-pressure hydride material (e.g., zirconia-nickel hydride) that is maintained at about 373 K, thus absorbing the hydrogen at about 0.001 atm (100 Pa). Assuming that the pressure drop in the low-pressure-hydrogen conduit to this ZrNi sorbent is about 0.001 atm, the resulting pressure on the liquid hydrogen becomes 0.002 atm (200 Pa). At this pressure, the hydrogen freezes at 14 K, then sublimes at 10 K. During the "off" interval, the low-pressure-hydrogen cycle is completed by heating the zirconia-nickel hydride to about 543 K, causing the hydrogen to vent to the vanadium hydride canister, which is cooled to about 293 K while absorbing the hydrogen at about 1 atm (0.1 MPa). The vanadium hydride is then heated to about 403 K, recharging the 100-atm hydrogen-storage cylinder.

This work was done by Al Johnson of Aerospace Corp. and Jack A. Jones of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 51*** *on the TSP Request Card.*
NPO-18631

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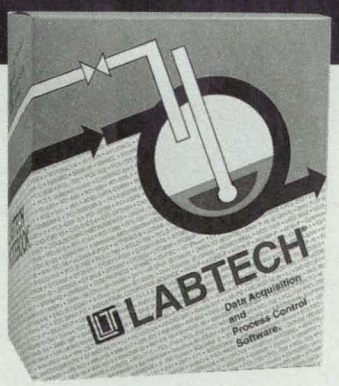

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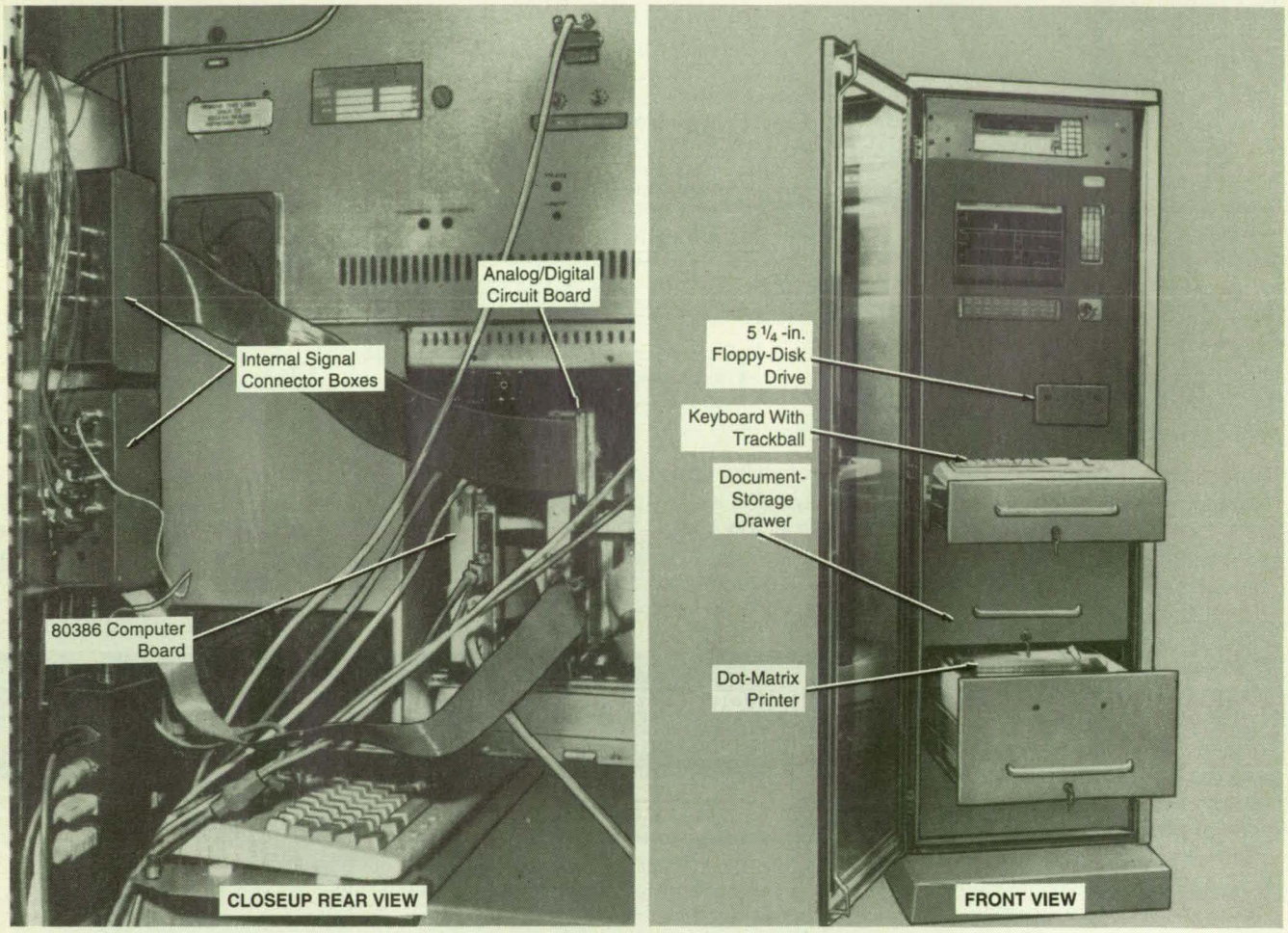
Computer Control for Gas/Tungsten-Arc Welding

Implementation largely in software facilitates upgrading.

Marshall Space Flight Center, Alabama



The **Prototype Control Hardware** is designed to be modular for ease of reconfiguration and upgrading. This same modularity is also reflected in the software.

A prototype computer-based feedback control system has been developed for use in gas/tungsten arc welding. Beyond improving the welding technician's moment-to-moment general control of the welding process, the control system is designed to satisfy two important additional requirements: to assist the technician in selecting the appropriate welding-process parameters (e.g., voltage, current, and rate of travel of the welding head) and to provide better automatic voltage control.

The development included an investigation of mathematical models of the welding process — both prior models based on the physics of the weld pool and an innovative neural-network empirical model. In experiments to measure shapes of weld pools for calibration of mathematical models, explosive charges were used to blow molten metal out of the weld pools (this technique has been called "impulse decanting") and snuff out the welding arcs, and the resulting craters were then measured.

The automatic voltage-control subsystem was singled out for special attention because of the deficiencies of prior analog automatic voltage-control subsystems. These systems could not provide the requisite control when the welding-process parameters — especially current — varied over wide ranges. In particular, the poor control of voltage during the decrease of current toward the end of a weld typically resulted in cracking of the workpiece.

The digital automatic voltage-control feedback loop of the prototype control system incorporates a sophisticated mathematical model of the time-dependent relationship between the voltage and the length of the welding arc, which is adjusted by a servo-motor that raises or lowers the torch over the workpiece. The implementation of the control system as a whole in software confers a special benefit in the case of automatic voltage control, because experience shows that much is yet to be learned about this topic, and future upgrades in the light of new knowledge can be implemented much more easily and quickly in software than in hardware.

The prototype control hardware (see figure) includes a rack-mounted comput-

er, based on the VME bus, that contains Intel 80286 and 80386 processors. The bus is connected via analog-to-digital and digital-to-analog converters to input and output ports, respectively, to enable monitoring and control of the welding-process parameters. The hardware is designed to be as modular as possible. The analog input and output lines are routed through signal-connector boxes mounted inside the rack cabinet, and this provides easy access to all signals for testing, expansion, and re-routing of the individual signal channels.

The software is designed with modularity in mind, as well. The various software tools implemented under the Windows program — this includes a data base and the digital automatic-voltage-control software — are essentially individual, self-supporting programs that can be replaced with future versions or modified for other welding processes. This modularity is especially important in the case of the weld-modeling programs, which almost surely will have to be modified to some extent when other welding processes are considered.

This work was done by Kristinn Andersen, James F. Springfield, Robert J. Barnett, and George E. Cook of Mid-South Engineering, Inc., for **Marshall Space Flight Center.** *For further information,* ***write in 100*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 20].

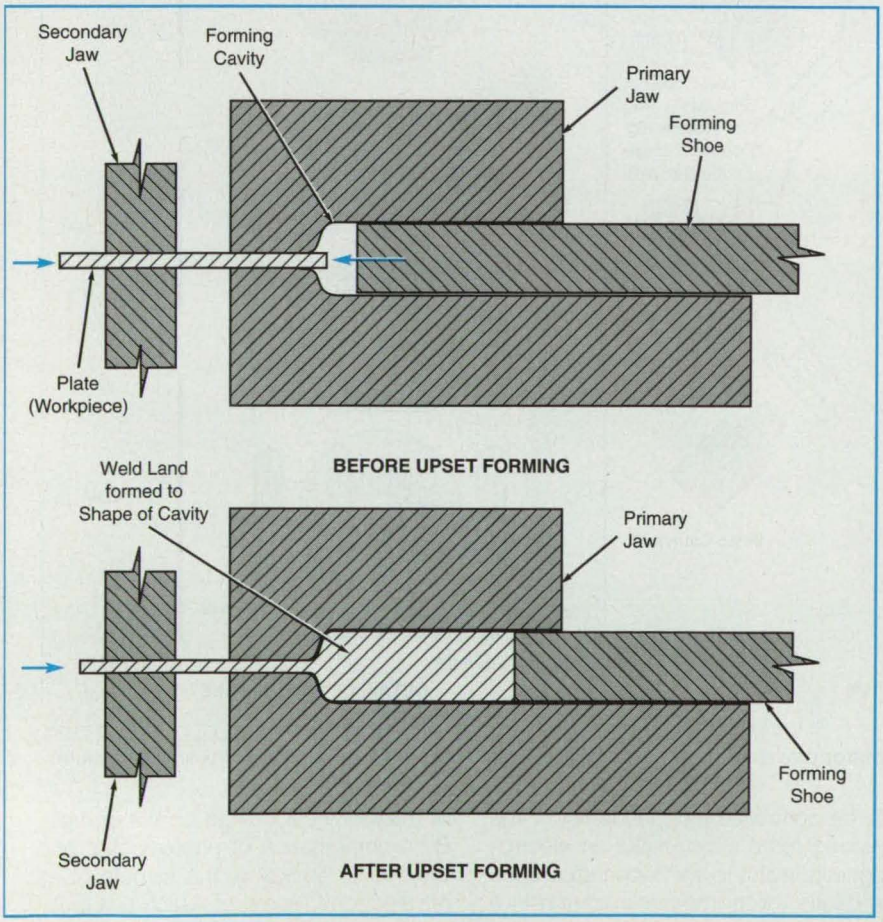
Refer to MFS-26183.

Forming Weld Lands on Metal Plates

Edges would be thickened in an upsetting process.

Marshall Space Flight Center, Alabama

Weld lands on thin metal plates like those used to make pressure vessels would be formed in a proposed upset-forming process. Weld lands — thickened areas at the edges of the plates — are needed so that the heat-affected re-



The **Forming Shoe Would Pound the Edge** of a newly inserted plate workpiece (top). After many passes of the shoe and advances of the plate, a thick land would be built up at the edge. The workpiece could be heated to enable the metal to flow without strain hardening.

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gions near the weld joints can withstand the anticipated tensile stresses. The proposed upset-forming process would replace a relatively expensive, time-consuming, and wasteful process in which integral weld lands are created by machining metal away from the plates everywhere except at the lands.

The proposed process would be carried out in a machine in which the edge of a plate would be advanced in increments into a forming cavity. After each advance, a forming shoe would pound the edge to thicken it. The plate would be inserted into the machine through two sets of jaws (see figure) so that the edge of the plate would protrude into the cavity. The primary jaws would clamp the panel, and the shoe would be driven into the cavity with enough force to deform the edge.

Then the shoe would be withdrawn. The primary jaws would release their grip as the secondary jaws grasped the plate, and advanced it slightly farther into the cavity. Once again, the primary jaws would grip the plate, and the shoe would form the edge, forcing it to take the shape of the forming cavity.

This forming cycle would be repeated until a land of sufficient width for welding was built up on the edge. The plate would then be removed and reinserted on another edge to be formed into a weld land.

This work was done by Bruce Weddendorf of **Marshall Space Flight Center.** *For further information,* ***write in 37*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 20].

Refer to MFS-28743.

High-Temperature Electrostatic Levitator

Heating and levitation can be controlled independently.

NASA's Jet Propulsion Laboratory, Pasadena, California

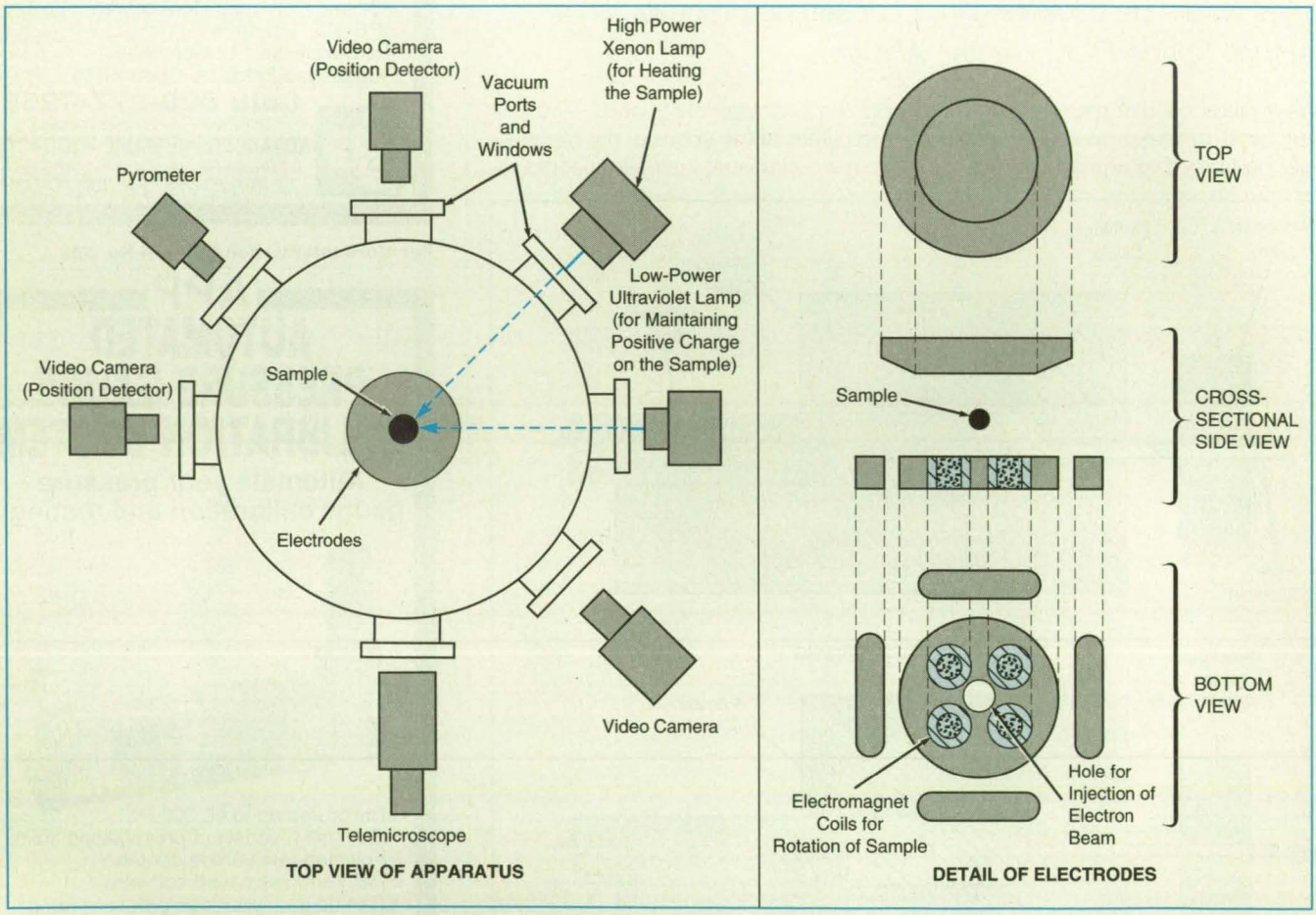
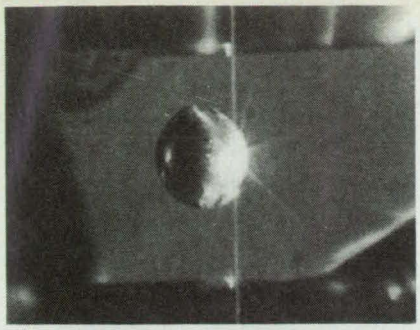


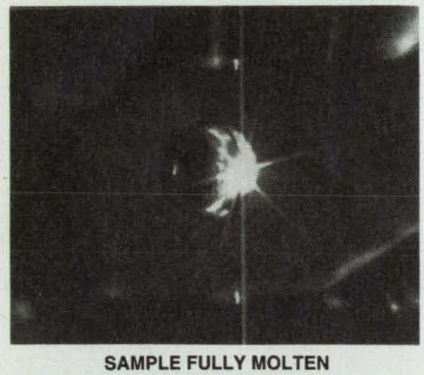
Figure 1. The **High-Temperature Electrostatic Levitator** provides independent control of levitation and heating of the sample in a vacuum.

The apparatus illustrated schematically in Figure 1 provides electrostatic levitation and radiant heating of a small sample of material in a vacuum. Unlike in an electromagnetic levitator (in which the sample must be a conductor), the sample can be an electrical insulator or semiconductor. and the rate of heating can be controlled independently of the levitating force. Also unlike an electromagnetic levitator, this apparatus does not cause electromagnetic stirring in a molten sample (such stirring can cause early nucleation in undercooling).

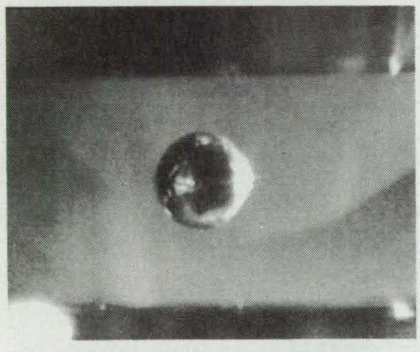
Maintenance of the levitating force entails control of the electrostatic field and of the electrical charge on the sample. By a combination of photoelectric and thermionic emission, the sample gives off electrons, some of which are reabsorbed and some of which are swept away by the levitating electrostatic field. In general, the charge on the sample tends to equilibrate to a positive value



SAMPLE DURING HEATING



SAMPLE FULLY MOLTEN



SAMPLE SOLIDIFIED FROM MELT

Figure 2. A **Sample of Aluminum** is shown at three stages of processing in the high-temperature electrostatic levitator. The diameter of the sample is about 4 mm.

that increases with the electric field. The design of the levitating apparatus exploits the following two electron-emission mechanisms to produce and maintain required sample changes:

1. At a temperature ≤1,200 °C, the sample can be irradiated with ultraviolet light to induce photoemission and thereby impart a positive charge.
2. At a temperature ≥1,200 °C, thermionic emission defeats the attempt to charge the specimen negatively with an electron beam, but it can be used alone or in combination with photoemission to maintain a positive charge.

The main vertical electrostatic force is generated by applying a dc voltage between the central top and bottom electrodes. Four smaller electrodes that surround the central bottom electrode provide horizontal electrostatic control force, if needed. Two position-detecting cameras monitor the position of the levitated sample; a microprocessor converts the position error into feedback control signals, which are amplified and applied to the electrodes to correct the vertical and horizontal excursions of the sample from the desired position. If the sample material is an electric conductor, then four electromagnet coils under the central bottom electrode can be used to generate a rotating magnetic field to induce sample rotation.

The sample is heated by a high-power xenon lamp. The temperature of the sample is monitored by a pyrometer. The surface of the specimen can be observed through a telemicroscope (see Figure 2).

This work was done by Won-Kyu Rhim and Sang K. Chung of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 36*** *on the TSP Request Card. NPO-18716*

Muffling Hammer Blows in a Workshop

Sound-deadening bags would be placed on hammered workpieces.

Marshall Space Flight Center, Alabama

Sound-deadening bags would be placed on hammered workpieces to muffle the load hammering sounds, according to a proposal. This concept should prove useful in many workshop situations

In the original situation for which the proposal was made, the workpiece is a rocket-engine nozzle in which coolant tubes are "booked" (deformed to bring the intertube gaps to the specified width) by use of a manual or pneumatic ballpeen hammer and polytetrafluoroethylene pad inside the nozzle and wooden backup blocks held between hatbands outside the nozzle. The nozzle structure itself acts as an acoustic coupler, giving the impression that it amplifies the hammering sound, thus making it uncomfortable and distracting to "book" the nozzle in an indoor workspace.

Sound-deadening bags for this or other situations could be fabricated easily and inexpensively. The bags would be filled with particles (for example, sand, metal shot, plastic, or glass), then sewn or molded shut. Bags could be tailored to fit the special configurations of some workpieces. They could also be equipped with hook-and-pile or other fasteners and strung together, if necessary, to obtain

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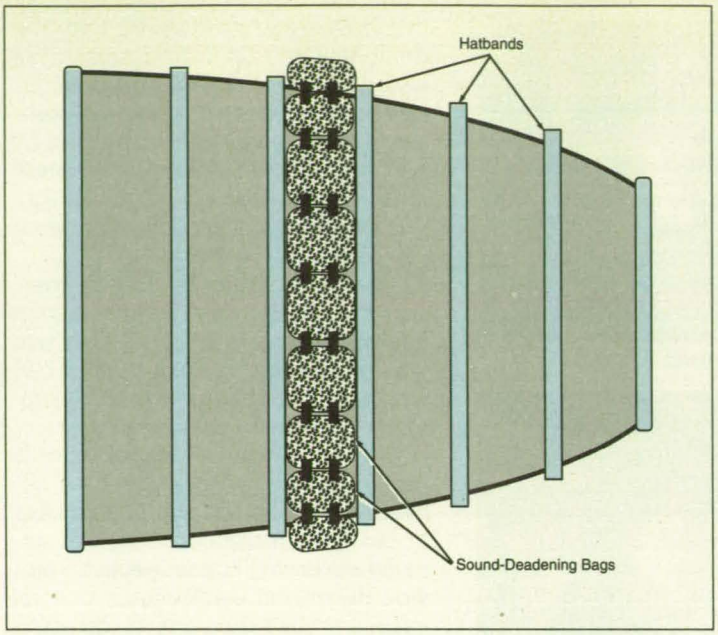
the desired configuration (see figure).

In many situations, fairly crude bag materials and fillings (e.g., sandbags) would probably suffice. In special situations, more-sophisticated bags might be needed; these might be designed according to the principles of particle-filled vibration-damping devices. Such devices have been used to deaden print rollers and to reduce vibrations in the main-injector inlet manifold of a rocket engine.

This work was done by Alfred W. Thiele, Jeffrey L. Gilbert, and David A. Gutow of Rockwell International Corp. for **Marshall Space Flight Center.** *No further documentation is available.*
MFS-29937



A **String of Sound-Deadening Bags** would be wrapped around a large workpiece (in this case, a rocket-engine nozzle) to muffle hammer blows transmitted through the workpiece.

Reinsertable Captive Bolt

The bolt engages either a housing or a mating part.

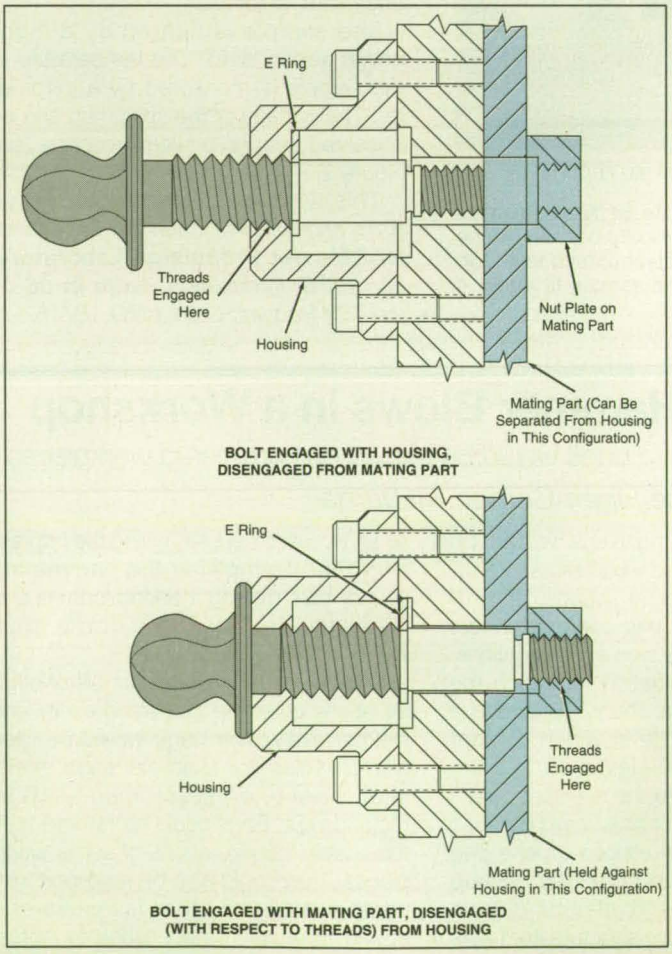
Lyndon B. Johnson Space Center, Houston, Texas

The captive bolt illustrated in the figure can be installed, removed, and reinstalled easily, even with heavily gloved hands that deprive the technician of the feeling of engagement of threads. Unlike some other captive bolts, this one is not equipped with a spring that forces the bolthead away from one of the mating parts in which the bolt is inserted. Therefore, the technician does not have to struggle against spring force when reinstalling the bolt. The bolt is expected to be useful in construction in environments where visibility, tactility, and/or maneuverability are poor; for example, in cold or underwater environments.

The bolt has two threads that have different diameters but the same pitch. The larger-diameter thread engages a threaded hole in a housing; the smaller-diameter thread engages a threaded hole in a part that mates with the housing. Because both threads have the same pitch, the bolt can be driven into the mating part while riding in the housing. The bolt is captured by an E-ring inside the housing. The thread engages the mating part automatically.

When the technician rotates the bolt clockwise, the bolt unthreads itself from the housing while simultaneously threading itself into the mating part. The clockwise rotation is continued until the bolt comes to a stop at the designated torque in threaded engagement with the mating part. To disengage the bolt, the technician simply turns it counterclockwise until it stops. The bolt threads itself into the housing while unthreading from the mating part.

This work was done by Richard D. Smallcombe of ILC Space Systems for **Johnson Space Center**. *For further information,* ***write in 1*** *on the TSP Request Card.*
MSC-22134



The **Captive Bolt** is turned between full threaded engagement with the housing and full threaded engagement with the mating part.

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Frequency-Domain Identification With Composite Curve Fitting

The mathematical model of a system is divided into multiple models in parallel.

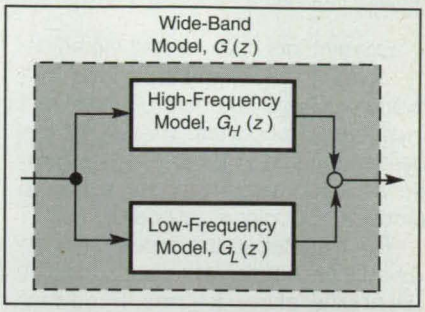
NASA's Jet Propulsion Laboratory, Pasadena, California

An improved method of parameter identification is introduced based on decomposing a single wide-band model into two or more component systems in parallel (see figure), such that each component model predominates in a specific frequency range. Each component or narrow-band model can be simpler than the wide-band model because it does not have to account for the dynamics at all frequencies. The method is applicable to diverse systems, including vibrating structures, electronic circuits, and control systems.

The various mathematical models of the system are z-transform transfer functions that are rational functions and can be approximated to acceptable accuracy by ratios of polynomials of finite order. In the standard identification procedure, one first obtains the nonparametric frequency response of the system from measurements, then uses any suitable curve-fitting technique to fit a single wide-band model.

Unfortunately, the high-order polynomials typically associated with wide-band models can be poorly numerically conditioned. The major advantage of using the parallel-model parameterization is that it involves polynomials of lower order than would be needed to fit a single wide-band model. Thus, the parallel-model parameterization increases both the orders and bandwidths of systems that can be identified using finite-precision arithmetic.

In composing a wide-band model from parallel narrow-band models, an iterative procedure is used involving a squence of curve-fitting steps. The procedure stops when each component model correctly "dovetails" with its neighbor, to sum correctly to the measured data. In practice, the orders of the component models are not known in advance, so that some trial and error is necessary to obtain meaningful values of parameters.



The **Wide-Band Mathematical Model** of a system is identified as two narrow-band models: one that contains most of the information on high-frequency components of the dynamics, and one that contains most of the information on low-frequency components.

This work was done by David S. Bayard of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 40*** *on the TSP Request Card. NPO-18785*

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Enhanced Cultivation of Stimulated Murine B Cells

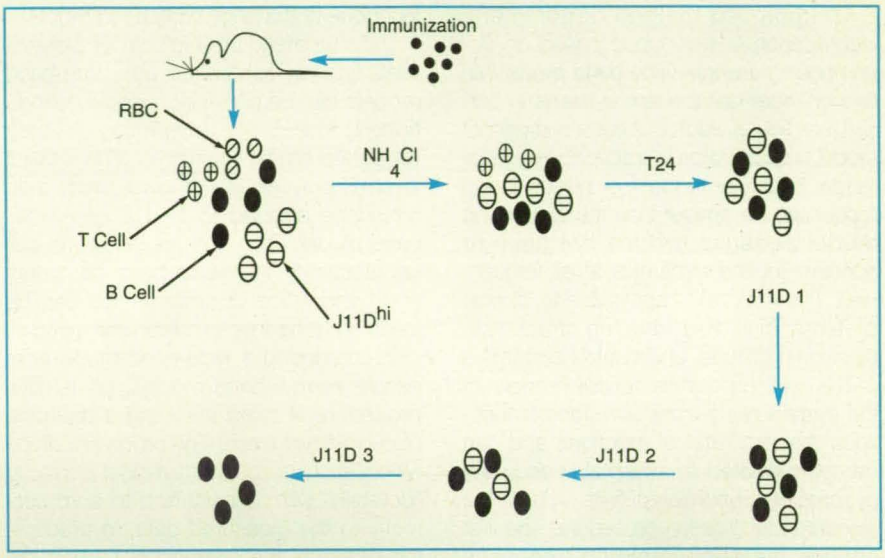
These cells can be used to produce hybridomas and monoclonal antibodies.

Marshall Space Flight Center, Alabama

Experiments have verified the efficacy of a method (see figure) of in vitro cultivation of large numbers of stimulated murine B lymphocytes. These cells can be electrofused with other cells to produce hybridomas, which can be used to produce monoclonal antibodies.

The first step in the experiments involved immunization of selected mice by use of either of two antigens. Three days after the final immunization, the spleens of the mice were crushed to obtain cells, which were then suspended in a salt solution. The suspension was then enriched in B cells by depleting it of red blood cells, T cells, and J11D^{hi} cells as follows: red blood cells were lysed with NH_4Cl, T cells were depleted with T24 (rat monoclonal anti-thymine 1.2) and rabbit complement, and J11D^{hi} cells were depleted with three cycles of the rat monoclonal anti-mouse J11D and complement (J11D 1, J11D 2, and J11D 3).

The cell preparations thus enriched in B cells were cultured and stimulated with *S. typhosa* lipopolysaccharide and dextran sulfate: these substances exerted a mitogen-synergistic effect on both the proliferation and the differentiation of the B cells. At various times up to 14 days after starting the cultures, samples of these cultures were electrofused to nonsecreting murine SP2/0 cells, yielding hybrid clones. The yield of these hybridomas increased with culture time. Of such hybridomas generated from mice immunized by one of the antigens (DNP–conjugated *Limulus polyphemus* hemocyanin), the majority secreted antibodies specific to that antigen.



Suspensions Enriched in B Lymphocytes were made from the spleens of mice that had been immunized with an antigen. The B cells were used to generate hybridomas that generated antibodies specific to the antigen.

Thus, the method offers several advantages: polyclonally stimulated B-cell blasts can be cultivated for as long as 14 days, hybridomas can be created throughout the culture period, the yield of hybridomas increases during cultivation, and it is possible to expand polyclonally in vitro the number of B cells specific for antigenic determinants first recognized in vivo. This method should prove appropriate for further investigation of polyclonal activation of B cells and for the generation of hybridomas that secrete antibodies to specific antigens like viruses and isolated proteins.

This work was done by David W. Sammons of the University of Arizona for **Marshall Space Flight Center**. *For further information,* ***write in 90*** *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 MFS-26175, volume and number of this NASA Tech Briefs *issue, and the page number.*

Three-Dimensional Coculture of Human Small-Intestine Cells

Three-dimensional tissue models may prove useful in studies of growth, differentiation, and disease.

Lyndon B. Johnson Space Center, Houston, Texas

Complex three-dimensional masses of normal human epithelial and mesenchymal small-intestine cells have been cocultured in a process that involves specially designed bioreactors. These three-dimensional masses may prove useful as tissue models for studies of growth, regulatory, and differentiation processes in normal intestinal tissues; of diseases of the small intestine; and of interactions between cells of the small intestine and viruses that cause disease both in the small intestine and elsewhere in the body. In addition, the process might be used to produce other tissue models, leading to advances in understanding of growth and differentiation in developing organisms, of renewal of tissue, and of treatment of a myriad of clinical conditions.

The bioreactors include cylindrical rotating-wall culture vessels, which are oriented with their cylindrical axes horizontal and are rotated slowly about these axes while oxygen and nutrients are supplied

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

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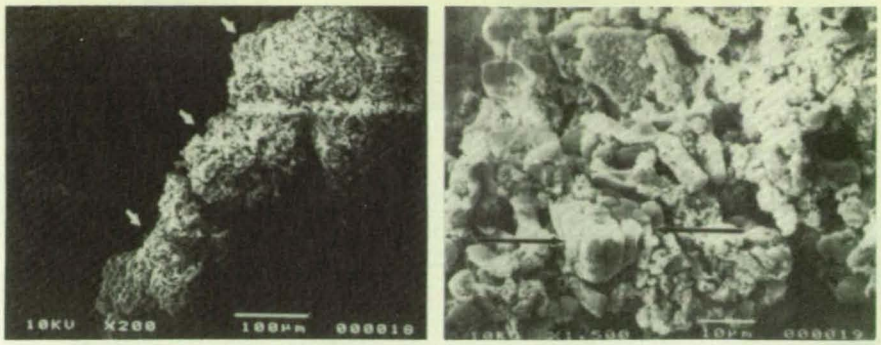
to the cells and wastes are removed from the cells via growth media contained in the vessels. The slow rotation prevents the cells from settling in the medium, suspending them with minimal turbulence and extremely low shear. Thus, the bioreactors provide growth conditions that simulate some of the effects of microgravity and that minimize damage to delicate mammalian cells and tissues. Prior articles in *NASA Tech Briefs* that describe aspects of the design and use of rotating-wall culture vessels include "Growing and Assembling Cells Into Tissues" (MSC-21559), Vol. 14, No. 12 (December 1990), page 67; "High-Aspect-Ratio Rotating Cell-Culture Vessel" (MSC-21662), Vol. 16, No. 5 (May 1992), page 150; and "In Vitro, Matrix-Free Formation of Solid Tumor Spheroids" (MSC-21843), Vol. 17, No. 3 (March 1993), page 115.

In experiments that demonstrated the process of growing the three-dimensional masses of cells, the 125 mL of culture medium in the rotating vessel was first inoculated with mesenchymal cells at a concentration of 2×10^5 cells/mL and with 5 mg/mL of microcarriers in the form of collagen-coated dextran beads 175 μm in diameter. The cells were allowed to attach and proliferate for 48 to 72 hours.



These **Scanning Electron Micrographs** show proliferation of columnar epithelium, even in the small recesses between microcarriers. The microvillous (furry) appearance of the epithelium can be seen at the higher magnification.

Then the medium was changed, epithelial cells were added, and growth was allowed to continue for another 30 to 40 days, with daily replenishment of 65 percent of the growth medium in the vessel.

The cocultures thus grown contained various concentrations of cells up to about 6×10^6/mL and became differentiated, forming tissuelike masses 0.4 to 0.5 cm wide with minimal necrosis (see figure). The masses exhibited apical brush borders, differentiated epithelial cells, cellular polarity, extracellular matrices, and basal lamina, all of which represent ordering of cells into tissue in the nurturing chemical and physical environment in the bioreactor.

This work was done by David Wolf and Glen Spaulding of **Johnson Space Center** *and Thomas J. Goodwin and Tracy Prewett of KRUG Life Sciences. For further information,* ***write in 42*** *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 [see page 20]. *Refer to MSC-21984.*

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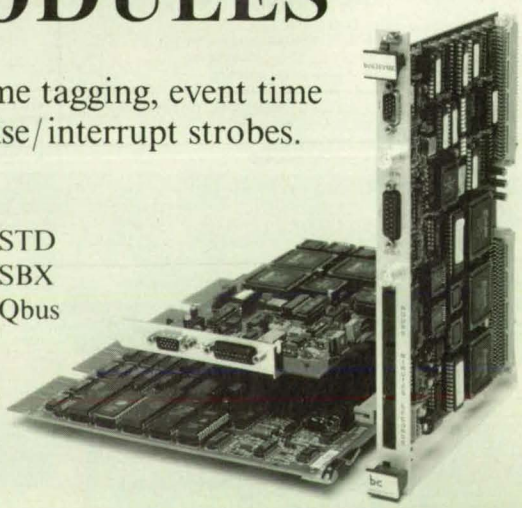

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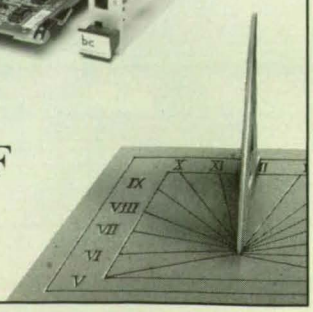

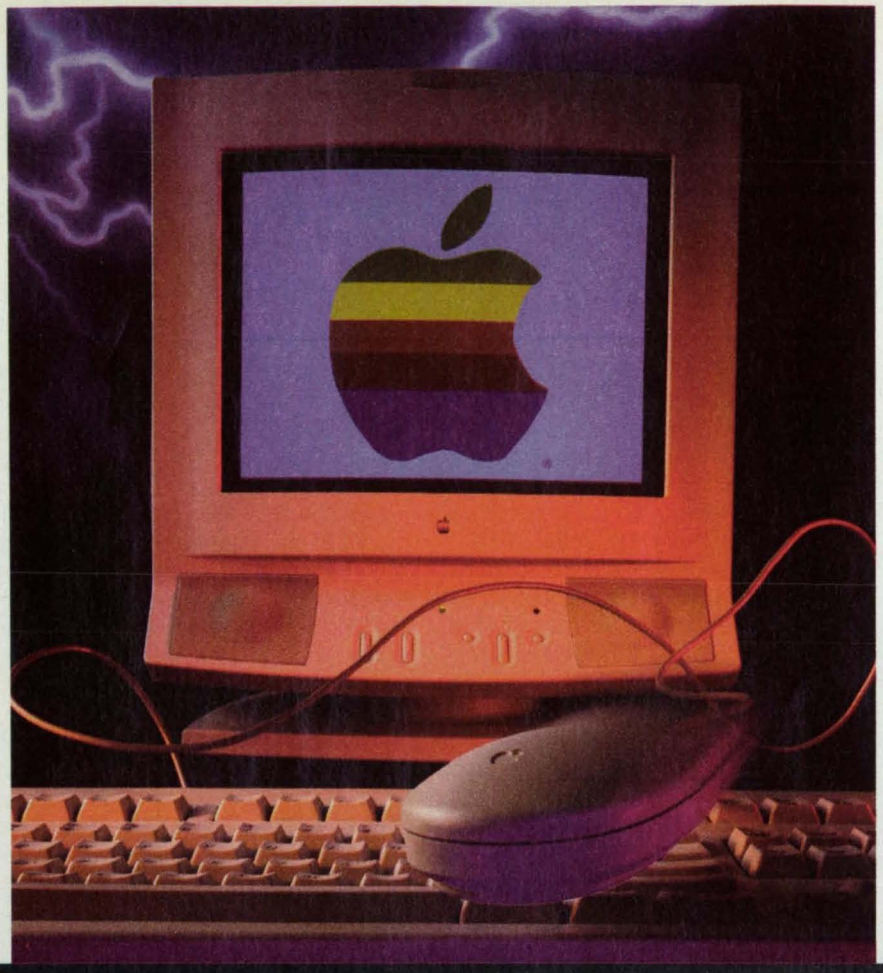

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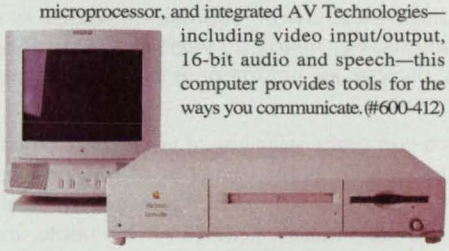

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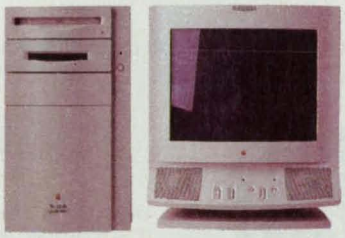

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Books & Reports

These reports, studies and handbooks are available from NASA Technical Support Packages (TSP's) when a Request Card is cited; otherwise they are available from NASA Technical Information Service.

Electronic Systems

Designing Controllers for Second-Order Dynamic Systems

Control theory for time-invariant linear systems that are described by first-order dynamical equations has been well established for decades. A few iterations of design and analysis may suffice to complete a satisfactory design of a small system. However, for a large system like the proposed Space Station, the mathematical model of its dynamics usually involves a large number of degrees of freedom and is best described by second-order dynamical equations in terms of sparse structural matrices, including mass and stiffness matrices. For second-order dynamical systems, transformation to first-order form results in loss of computational efficiency. There are basically two ways to address the controller design problems for a large system. The first way is to minimize the number of dimensions of the mathematical model by use of a procedure in which one first preserves the second-order form and then simplifies the model. The second way, which is the subject of the report specified at the end of this article, is to design a model-independent controller, which is insensitive to uncertainties in the system, by use of second-order dynamical equations according to a novel method.

This work was done by Jer-Nan Juang of **Langley Research Center** *and Minh Phan formerly of the National Research Council, presently of Lockheed Engineering and Science Company. Further information may be found in NASA TM-102666 [N90-25369], "Robust Controller Designs for Second-Order Dynamic Systems: A Virtual Passive Approach."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700. LAR-14625

Shaping Transmitted Pulses To Provide Synchronizing Signals

A report presents a theoretical analysis of the relationships among (1) the shapes and bandwidths of data pulses in pulse-amplitude modulation (PAM) and quadrature amplitude modulation (QAM), (2) the pulse-repetition rates (baud rates), and (3) the presence or absence of sinusoidal baud-frequency components in the envelopes (magnitudes) of the overall received signals, which components could be used by receivers to synchronize themselves with the signals. The analysis was directed toward finding pulse shapes that would guarantee the presence or absence of the synchronizing components.

This work was done by Edgar H. Satorius of Caltech for **NASA's Jet Propulsion Laboratory** *and James J. Mulligan of US Army IEWD. To obtain a copy of the report, "Pulse Shape Design Considerations for Self-Synchronizing Systems," **write in 86** on the TSP Request Card. NPO-18765*

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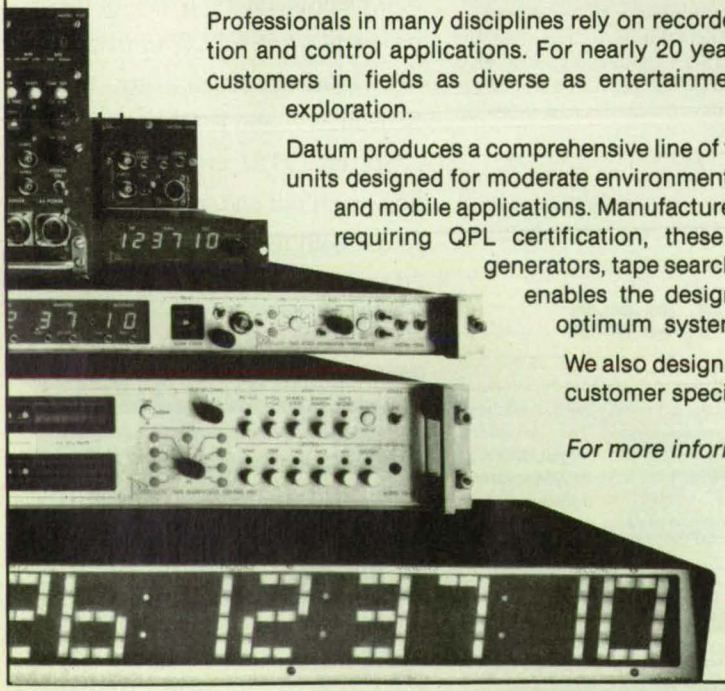

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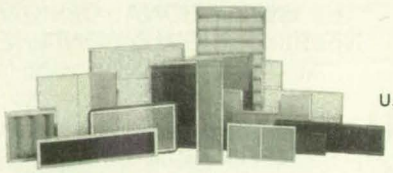

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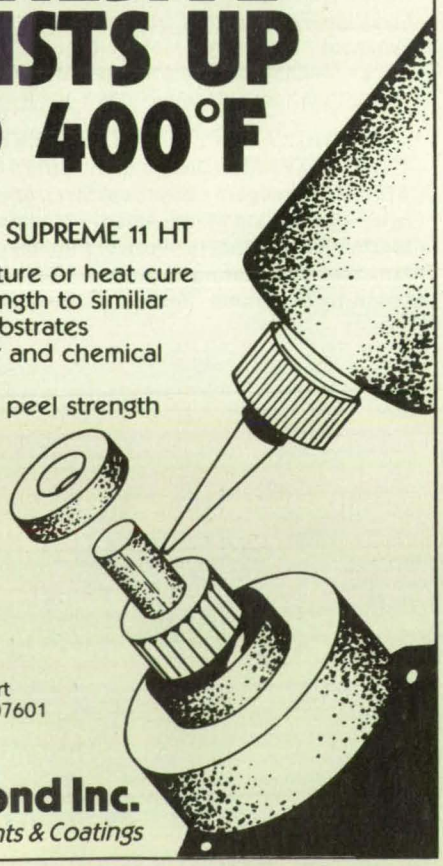

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Analysis of Digital-Matched-Filtering Schemes for Receivers

A report presents an analysis of three digital-matched-filtering schemes that involve weighted integrate-and-dump filters (WIDF's) and that are being considered for use in advanced digital radio receivers. The analysis is conducted by way of computer simulations of the performances of quadrature-phase base-band receiver channels that include input analog-to-digital filters, low-pass filters, variable delay lines, symbol-lock loops, and digital matched filters.

This work was done by John M. Gevargiz and Jack Homes of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Analysis of Digital Matched Filtering Schemes for Digital Receiver Applications Using Simulation Methods,"* ***write in 69*** *on the TSP Request Card.*
NPO-18682.

Mechanics

Study of Structural-Load Safety Factors

A NASA technical paper presents a study of structural-load safety factors—the factors by which structures and components thereof are strengthened in design to withstand loads greater than nominal design loads. Heretofore, it has been common practice to choose safety factors deterministically, with a view toward ensuring virtually zero failure rates under known normal loads and under initially unknown (but anticipated) overloads within ranges that seem reasonable under the circumstances. However, despite the "deterministic" label, the selections have ultimately been arbitrary and subjective in that they have usually been based on related corporate experiences and designers' personal judgment.

The purpose of the study was to begin to devise a more systematic and coherent method and the accompanying criteria for the design of more-uniform and more-reliable high-performance structures. This was done by approaching the deterministic method from a probabilistic perspective.

This work was done by V.Verderaime of **Marshall Space Flight Center.** *Further information may be found in NASA TP-3203 [N92-19355], "Structural Deterministic Safety Factors Selection Criteria and Verification."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700.
MFS-27285.

SImulation of Flow in A Spacecraft Cabin

A report presents a computational simulation of the flow of air in a two-dimensional enclosed space that represents, in simplified form, part of a habitable cabin in the Spacelab. Air is forced through the cabin by a temperature-control-and-ventilation system. In addition, a refrigerator/freezer unit in the cabin contains a fan that pulls air in at the top and exhausts air at the floor level. The purpose of the simulation was to estimate the flow velocity everywhere in the cabin and, in particular, to estimate the effect of the refrigerator/freezer unit on the overall flow pattern.

This work was done by Elias Y. Azzi of G. E. Government Services for **Johnson Space Center**. *To obtain a copy of the report, "Potential Flow Analysis in the Spacelab Habitable Cabin,"* ***write in 53*** *on the TSP Request Card. MSC-22068*

Machinery

Dynamic Coordination of a Two-Arm Robotic Manipulator

A report presents a study of dynamical and kinematical considerations that could guide the selection of the configuration of a self-reconfigurable, two-arm robotic manipulator. The basic idea is that two multiple-link arms would cooperate in manipulating a single object, reconfiguring their mutual, cooperative structure according to changing task requirements.

This work was done by Sukhan Lee of Caltech and Sungbok Kim of the University of Southern California for **NASA's Jet Propulsion Laboratory.** *To obtain a copy of the report, "Dynamic Coordination of A Self-Reconfigurable Manipulator System,"* ***write in 21*** *on the TSP Request Card.*
NPO-18816

Errant-Satellite Simulator

A report describes an errant-satellite simulator — a machine that simulates, in the normal gravitational environment of Earth, the inertial properties and behavior of a spinning artificial satellite floating in outer space near another spacecraft. The machine is designed for use in training astronauts to retrieve or repair satellites with the help of a remote manipulator arm, or with extravehicular activities (EVA).

This work was done by Robert L. Harvey of **Johnson Space Center.** *To obtain a copy of the report, "Errant Satellite Simulator,"* ***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 [see page 20]. Refer to MSC-21975

Physical Sciences

Thermal Convection Affects Shape of Solid/Liquid Interface

A report describes an experimental and theoretical study of the effect of thermal convection on the shape of the interface between solid and liquid succinonitrile, a clear commercially available plastic, in a Bridgman (directional-solidification) apparatus in vertical and horizontal orientations. Studies like this one are important because the Bridgman technique is commercially used to grow electronic materials and because thermal convection (among other effects) can alter and degrade the qualities of the product crystals.

This work was done by C. Mennetrier of the United States Research Agency, M. A. Chopra of Cleveland State University, M. Yao of the Ohio Aerospace Institute, H. C. de Groh, III, of **Lewis Research Center,** *and G. H. Yeoh, G. de Vahl Davis, and E. Leonardi of the University of New South Wales. To obtain a copy of the report, "Effect of Thermal Convection on the Shape of a Solid-Liquid Interface," and a related report, "A Numerical and Experimental Study of Natural Convection and Interface Shape in Crystal Growth,"* ***write in 76*** *on the TSP Request Card.*
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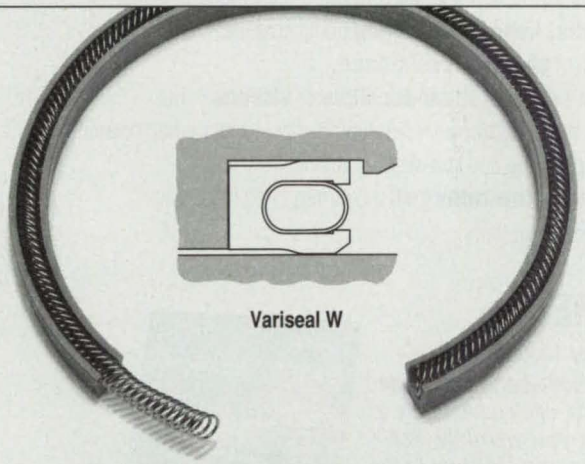

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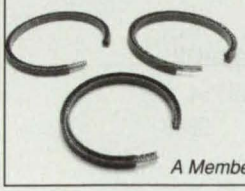

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For More Information Write In No. 700

NAI Technologies Inc., Hauppague, NY, has released the MC-40, a two-pound, ruggedized 486 PC approximately the size of a VHS tape. The unit can interface with any standard keyboard, Super VGA, or LCD color display. It is available as a 486 DX or SX, running at 25 or 33 MHz, with 8 MB RAM (expandable to 40 MB) and a hard disk capacity from 120 to 260 MB.

For More Information Write In No. 705

Southco Inc., Concordville, PA, has introduced the Quad™Latch series of **latches** featuring interchangeable operating drivers, IP65 and NEMA 12 performance, and fast, single-hole installation. The series offers a choice of ten operating drivers, each with a latched/unlatched indicator, and a pawl rotation of 90°.

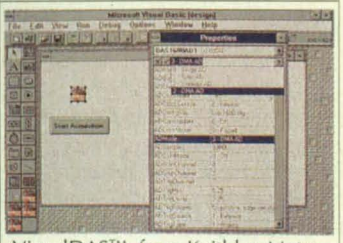
For More Information Write In No. 722

Baumer Electric Ltd., Southington, CT, has released a portable **diagnostic tool** for assessing inductive sensor malfunction. The IP2 features a simple schematic and LEDs for graphic output of failure analysis, which help to pinpoint installation, system, and operational errors. Powered by two 9 V batteries, the IP2 will operate any DC sensor and can test the coil/oscillator function of an AC sensor.

For More Information Write In No. 725

Texim Project®, an interactive project management tool, is now available for Windows™ and Windows NT™ from Welcom Software Technology, Houston, TX. The programs feature the ability to edit tabular views and reports graphically as on a spreadsheet. Under Windows NT, multiple files can be opened simultaneously, allowing interactive data editing across project files.

For More Information Write In No. 704



VisualDAS™, from Keithley MetraByte, Taunton, MA, assists **data acquisition board** programming with Visual Basic for Windows by providing a set of custom controls, virtually eliminating the need to write board control code. Priced at $99, the program features an easy-to-use interface and reduces setting up a data acquisition operation to selecting appropriate parameters from a list of options or typing a value for each property.

For More Information Write In No. 706

New Media Graphics Corp., Billerica, MA, has unveiled TapeIT! Portable, a **converter box** that changes VGA computer signals to standard NTSC television signals, allowing TV monitors or projection TVs to display PC screen images simultaneously. Priced at $539, TapeIT! also provides direct connection to any standard VCR, eliminating the need for a camera to tape programs running on a PC.

For More Information Write In No. 724

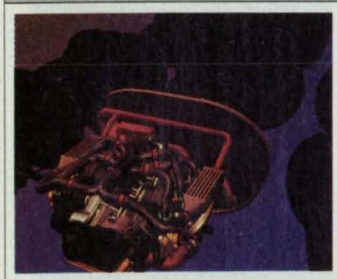
New on the Market

The F300 **machine vision system** from Omron Electronics Inc., Schaumburg, IL, accepts up to eight camera inputs simultaneously for multi-position inspection and measurement applications. Its high-speed processor calculates area, center of gravity, and angles of inclination in 33.3 ms for near-real-time control. The F300 has a 512 x 484 pixel resolution and features edge detection, shading and position displacement compensation, and binary level control.

For More Information Write In No. 721

Configurable Solutions, a series of **building blocks for automating manufacturing**, has been introduced by Vanguard Automation, Tucson, AZ. These automated work cell and assembly system designs are built to industry standards and take into consideration protection from electrostatic discharge, contamination control, and improving yields, throughput, quality, and reliability. The first release focuses on automating rigid disk drive assembly and includes a cell designed to locate and transfer stored head gimble assemblies, a system to produce head actuator assemblies, and a cell that employs a vision-guided robot to load and unload rigid disk media.

For More Information Write In No. 701



VisLab™, from Engineering Animation Inc., Ames, IA, is the first **3D animation program** to integrate laws of motion with high-speed rendering for improved realism and accuracy. It renders a complex 500,000-polygon frame of animation in a few seconds, enabling users to select a variety of environments pre-programmed to mimic real-world motion. The program features a unique A/B Roll System for built-in post-production.

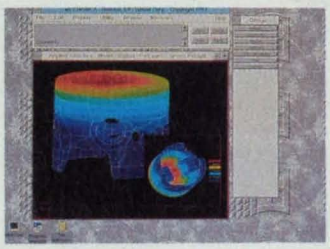
For More Information Write In No. 727

Pulse-operated **bi-stable brakes** from the Electroid Company, Springfield, NJ, latch and hold in either the on or off position without the need for a continuous current, eliminating power loss and heat dissipation. The brakes can be used with any battery-powered or low-current supply requiring a brake, such as wheelchairs, robots, aircraft actuators, satellites, and electric forklifts.

For More Information Write In No. 703

Flow Charting 4™ for Windows™ from Patton & Patton Software Corp., Morgan Hill, CA, allows shape, line, and text attributes to be changed via task-specific commands. Object attributes also can be recorded and transferred to new objects. The program features Sensible-Shapes™ for shape resizing without distortion; SensibleLines™, which lets the user determine how lines will react when shapes are moved; and Sensible-Text™, which enables easy fitting of text in and around shapes.

For More Information Write In No. 726



MECHANICA®5 **mechanical design synthesis software** from Rasna Corp., San Jose, CA, features AutoGEM™, which eliminates the need for designers to perform meshing and remeshing before beginning analysis and optimization. MECHANICA 5 provides load path optimization, new structural and dynamic measures, improved Direct Geometry Access, post processing, and editing capabilities.

For More Information Write In No. 723

ArchiveLib™, a Windows-compatible **data compression and archive library** for C and C++ programmers, has been announced by Greenleaf Software Inc., Dallas, TX. The object-oriented library allows users to compress ASCII or binary data into a storage archive, move files from one operating system to another, and store internal program data. Buffers of data can be archived within their applications without having to store them as a file.

For More Information Write In No. 702

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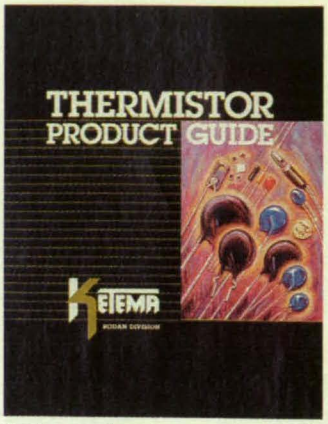
New Literature

The *Space Data Book* from TRW Space & Technology Group, Redondo Beach, CA, features chapters on orbital mechanics, mission planning, launch vehicles and space propulsion, spacecraft design, the solar system, and atmospheric entry. Design factors examined include spacecraft attitude control, communications, propulsion, electrical and thermal control, and structure.
For More Information Write In No. 735

The TV series of high-capacity, in-line **hydraulic valves** is spotlighted in a catalog from Zaytran Inc., Elyria, OH. Styles range from manual throttling to servo-controlled. Flow versus pressure drop information is provided to enable specification in circuits requiring up to 5000 psi and 1500 gpm capability.
For More Information Write In No. 734

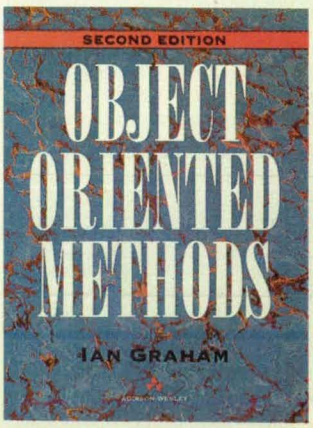
A DC parametric test system capable of **high-voltage testing** to 1500 V is described in an application note from Reedholm Instruments, Fremont, CA. The high-voltage capability has been extended from providing continuous I/V characteristics on one pin to measuring snap-back breakdown of intermetal dielectric test structures on any of four device pins. The system is suitable for process testing of thick dielectrics and monitoring of power IC manufacturing.
For More Information Write In No. 729

Berkeley Process Control Inc., Richmond, CA, has announced a quarterly technical newsletter covering **machine control and factory automation**. *In the Loop* focuses on applications related to the company's line of machine controllers, principally the Bam® Series-64. The unit features a 64-bit RISC processor and a multi-tasking, real-time operating system designed to integrate multi-axis motion control, I/O, communications, and a color touch-sensitive operator interface.
For More Information Write In No. 736



A 20-page **thermistor** product guide is available from the Rodan Division of Ketema Inc., Anaheim, CA. It includes information on negative temperature coefficient and silicon positive temperature coefficient thermistors. The guide also provides conversion tables, curves, and flow charts for easy determination of applications, and a glossary of terms.
For More Information Write In No. 739

Literature from PaR Systems Inc., St. Paul, MN, describes the company's **remote positioning and robotic production systems**. Featured products include the XR® series material removal systems that drill, mill, rout, and waterjet cut large parts to machine-tool accuracy and at production line speed. The PaR® nuclear systems enable manipulation of hazardous materials.
For More Information Write In No. 738



Addison-Wesley Publishing Co., Reading, MA, has released the second edition of *Object-Oriented Methods* by Ian Graham. Emphasizing the practical issues governing use of object-oriented techniques in industry, the book contains a language-independent introduction to object technology, a survey of available methods and applications, and an evaluation of programming languages and databases.
For More Information Write In No. 728

New Literature

The *Directory of Manufacturing Research Centers* published by the Manufacturing Technology Information Analysis Center, Chicago, IL, offers data on 200 centers that engage in **manufacturing research** and are available to the manufacturing community on a free or fee basis. Offered in hard copy, floppy disk, and on line, the directory lists sponsors, personnel, technical areas, goals, facilities, and funding.
For More Information Write In No. 740

A reference guide from Scott Specialty Gases Inc., Plumsteadville, PA, highlights **gases and gas handling equipment**. The 304-page book includes new products for continuous emissions monitoring (CEM) systems such as CEM Daily Standards™ for accurate calibration, CEM Zero/Calibration Air™ for more effective zero-leveling calibration, and a CEM Station™ Gas Delivery System. Also offered are excimer laser gas mixtures designed to improve laser performance.
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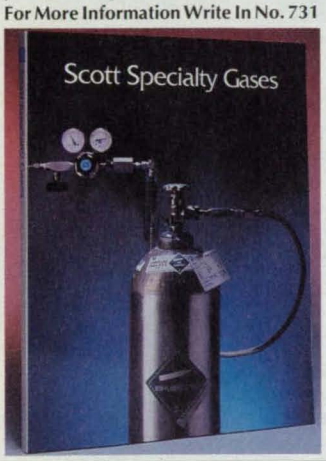

Viewpoint DataLabs, Orem, UT, has published a catalog of its real-time 3D Datasets™, **wireframe representations of 3D objects** used in computer animation and visualization applications. The company is introducing ready-to-order Datasets optimized for simulation, interactive 3D games, and virtual reality. Custom Datasets of both real and imagined objects are also available.
For More Information Write In No. 737

Halocarbon Products Corp., River Edge, NJ, is offering a 20-page brochure describing its inert, nonflammable, noncorrosive **oils, greases, and waxes**. The publication details chemical composition, physical properties, material compatibility, and quality assurance. Also included are a table for determining applicable grades and charts graphically presenting viscosity vs. temperature and typical vapor pressures.
For More Information Write In No. 733

MRC Bearing Services, Jamestown, NY, has published a 12-page brochure describing its **ball bearings**, including made-to-order and special bearings to replace bearings in aging equipment where they may be unavailable as standard products. The company's modified-standard bearings are designed for special lubricants, closures, ball retainer materials, and surface treatments.
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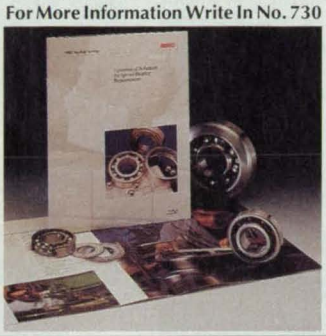

DALSA Inc., Waterloo, ONT, has released a databook on the new MEGASENSOR **area scan sensors and cameras**, and the interface of DALSA cameras to image processing and frame grabber boards. Companies providing interfaces include Alacron, Coreco, Datacube, EPIX, Imaging Technology, and Vision Modules. Other new products include the CL-G1 color and CT-C5 multiple tap line scan cameras and option board modules for 12-bit A/D and digital MUX.
For More Information Write In No. 741

Four free catalogs totaling 2190 pages and featuring 50,000 off-the-shelf components are available from the Stock Drive Products and Sterling Instrument divisions of Designatronics Inc., New Hyde Park, NY. The books focus on **gears; shafts, bearings, and couplings; timing belts, chains and friction drives; and design components**, respectively. They feature precision and commercial tolerance components and 618 pages of application data.
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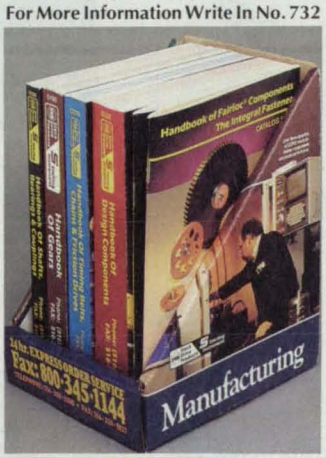

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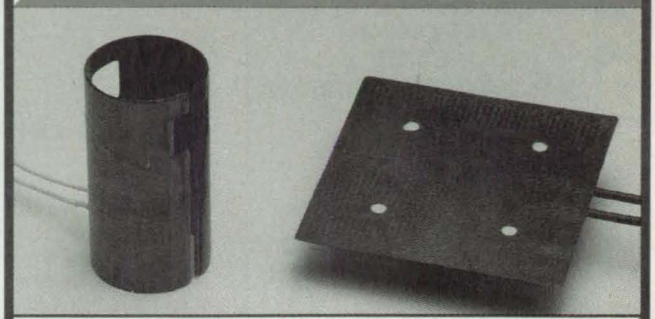

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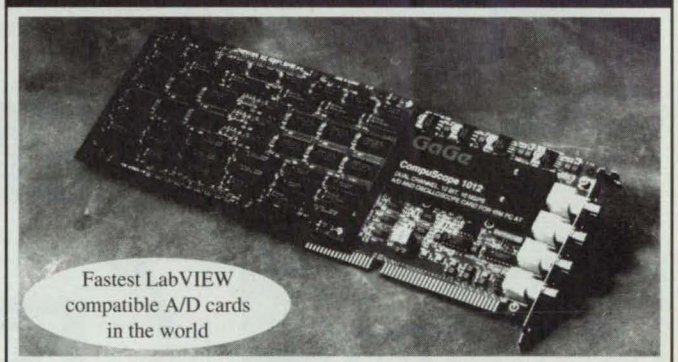

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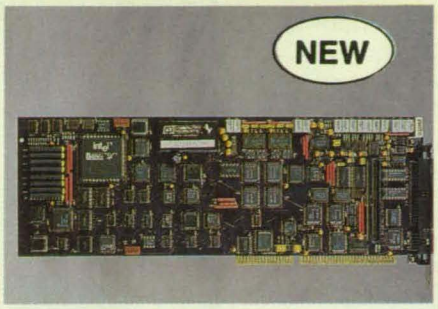

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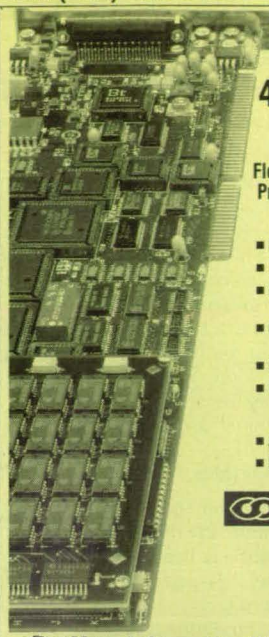

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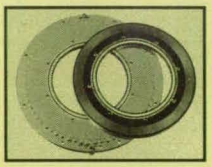

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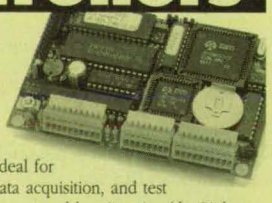

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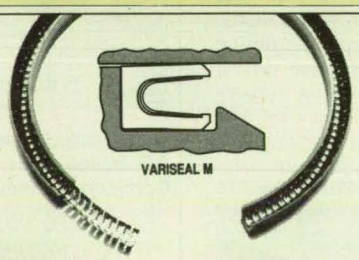

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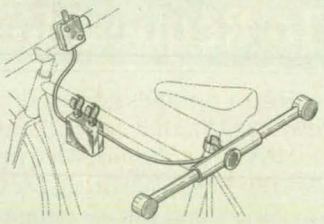

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