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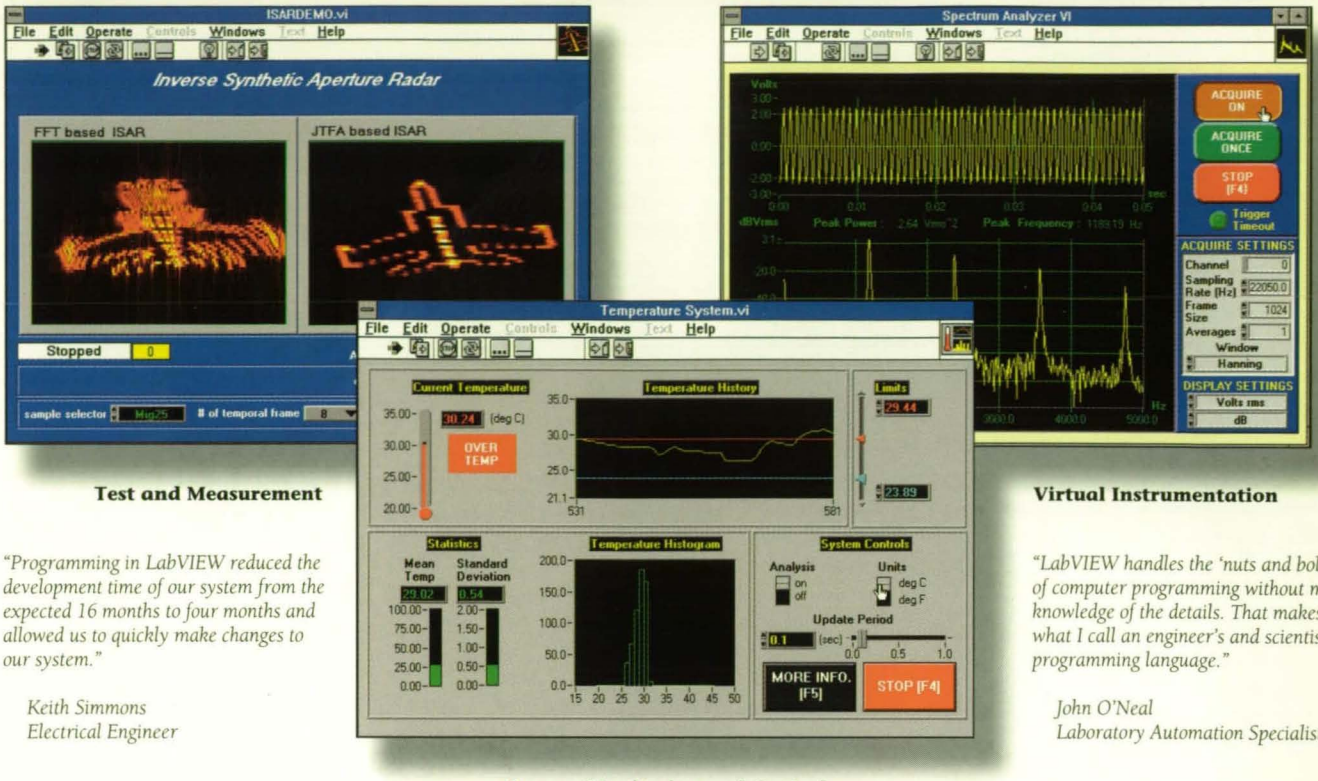

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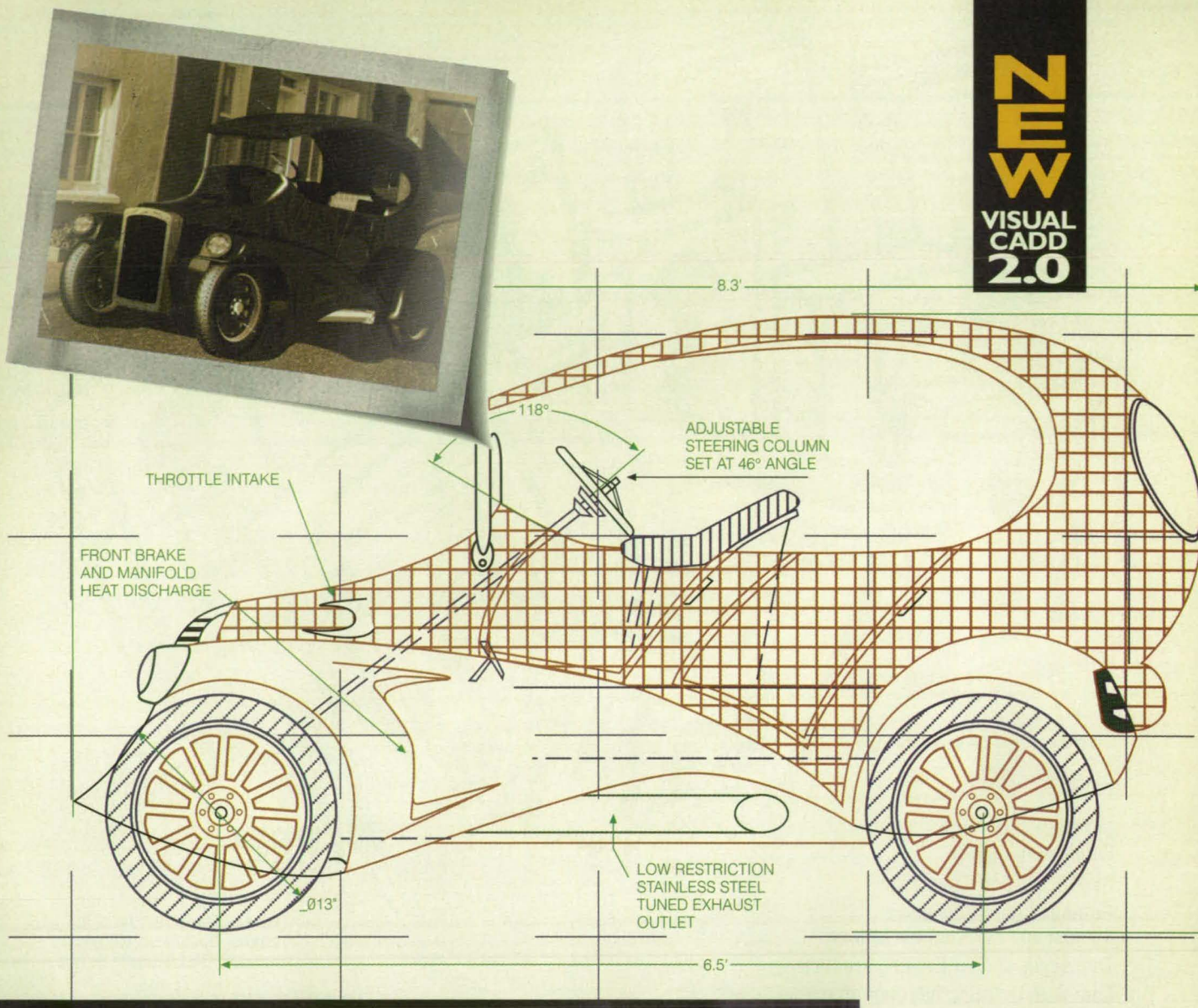

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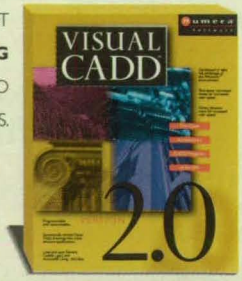

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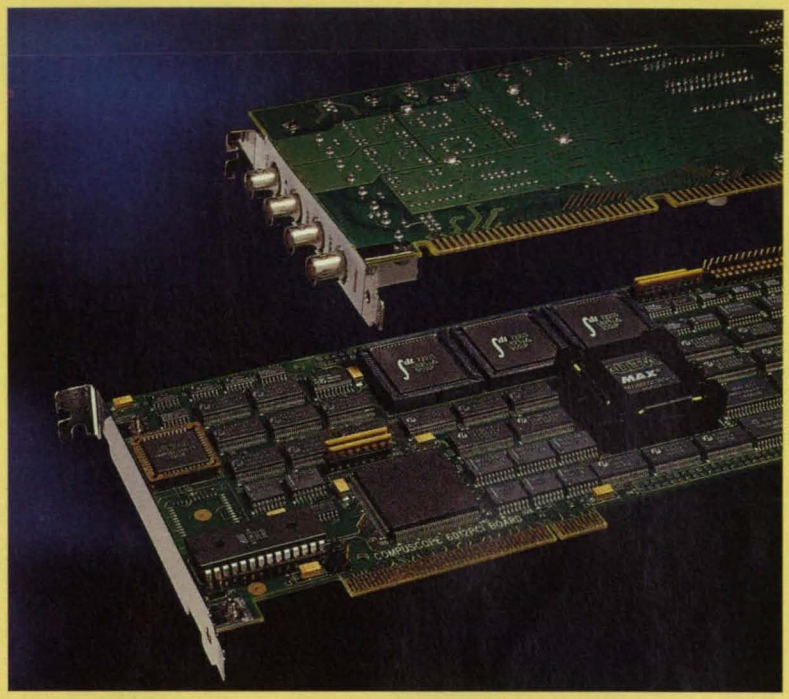

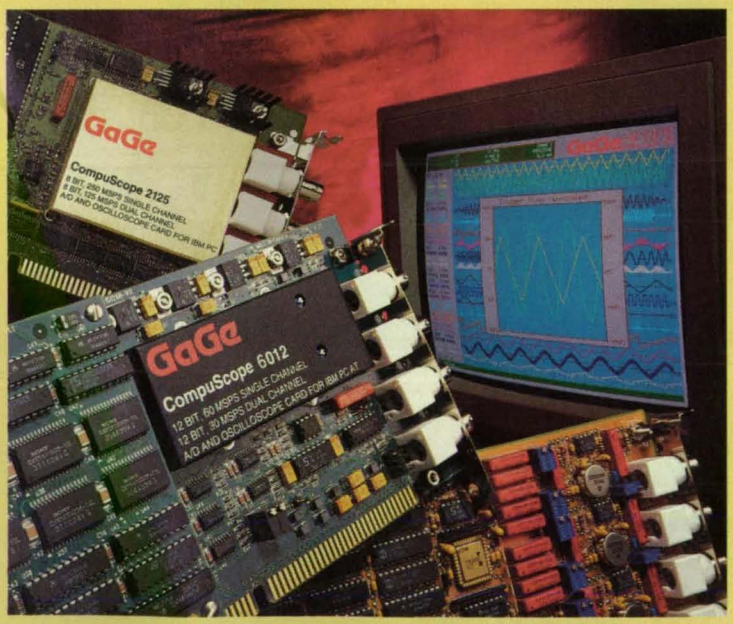

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Coryphaeus Software of Los Gatos, CA, produces high-end, real-time visual simulation products for virtual reality, CAD visualization, database modeling, and interactive instrumentation design. The six-year-old company was founded by a former NASA Ames electronics engineer, who turned his NASA experience into a multimillion-dollar software firm. See Mission Accomplished on page 18.

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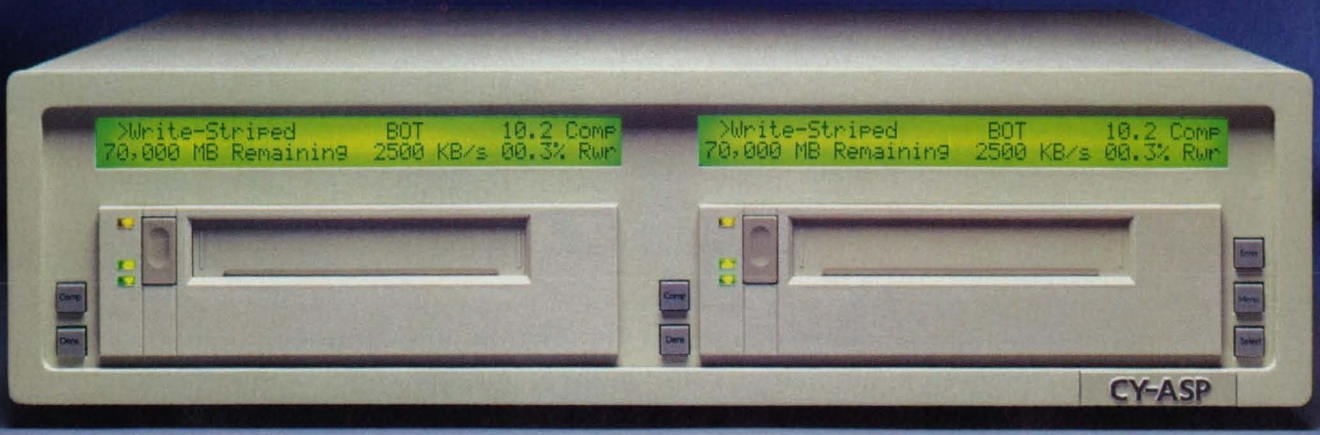

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1A-13A Laser Tech Briefs

Follows page 64 in selected editions only.

On the cover:

This magnified view shows a portion of Intel's new Pentium® Pro Processor, which features twice the operating performance of the original Pentium. The Pentium Pro is one of the new generation of chips designed for high-performance visual computing applications such as CAD and 3D simulation. For more information, see New on the Market on page 92.

Photo courtesy of Intel

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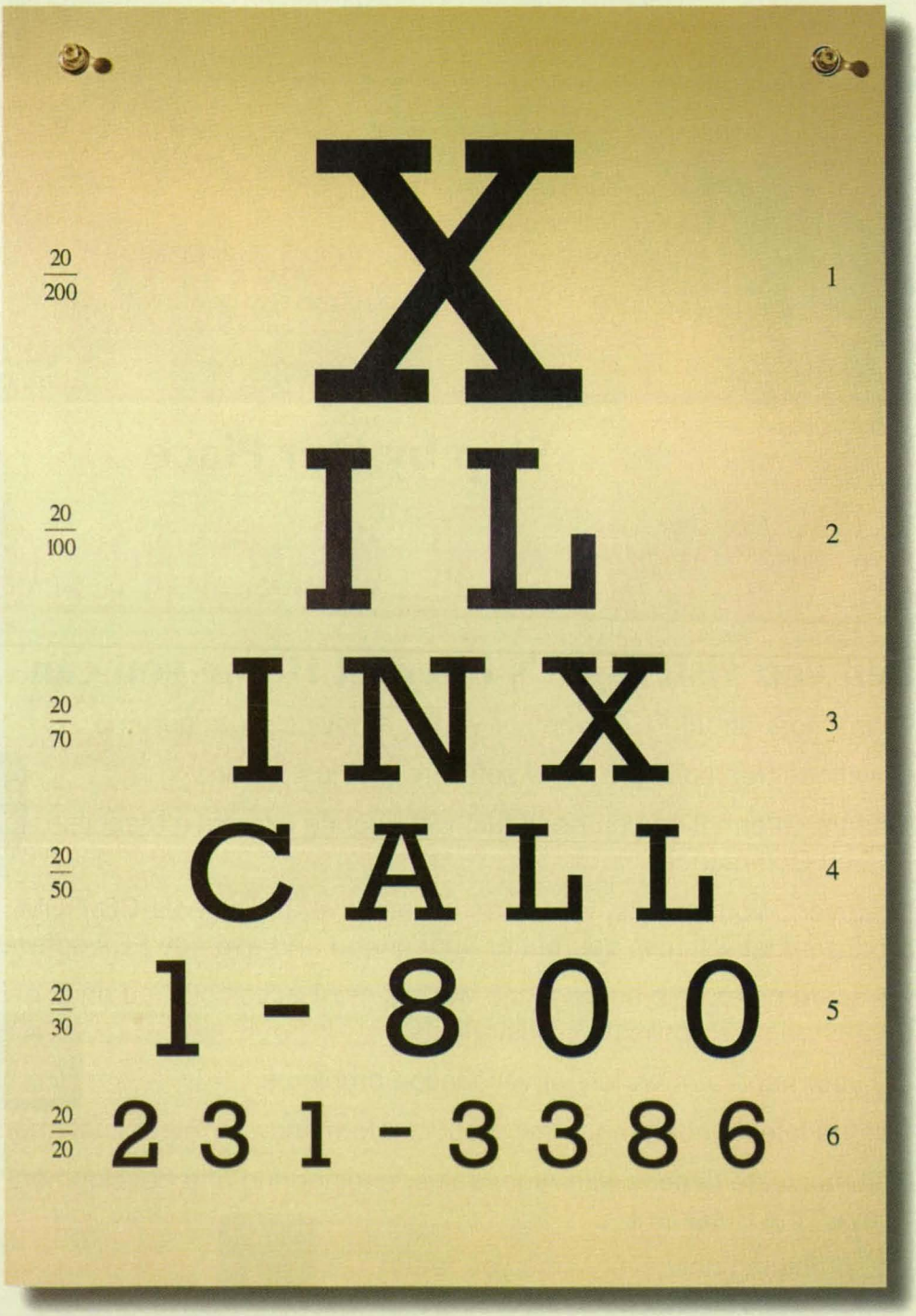

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Figure C.

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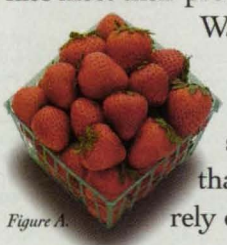

Figure A.

Here are a few of the farsighted companies that have come to rely on Xilinx.

A. *Key Technology uses Xilinx FPGAs to give vision to their machines. In this case, camera-controlled scanners that can spot a bad strawberry and eject it while moving 272 cm per second.*

Figure B.

B. *Want to make an ordinary PC perform like a supercomputer? Giga Operations Corp uses Xilinx FPGAs as Reconfigurable Computers to supercharge all sorts of applications, including real time video editing, telecommunications, and database processing.*

C. *Thanks to Xilinx FPGAs, the doctor really can see you now. MuTech developed a PCI board that works with today's Pentium and Power PC computers to deliver an affordable method of diagnosing problems in real time.*

D. *StrataCom uses Xilinx FPGAs to deliver the WAN systems their customers need today, while developing the broadband ATM solutions they'll definitely need tomorrow.*

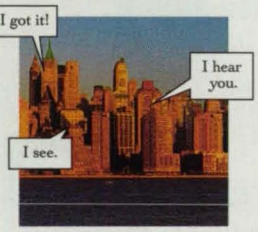

Figure D.

So if your company has any big projects on the horizon, you owe it to yourself to keep Xilinx in mind.

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NASA's Technology Sources

If you need further information about new technologies presented in *NASA Tech Briefs*, request the Technical Support Package (TSP) indicated at the end of the brief. If a TSP is not available, the Commercial Technology Office at the NASA field center that sponsored the research can provide you with additional information and, if applicable, refer you to the innovator(s). These centers are the source of all NASA-developed technology.

Ames Research Center
Selected technological strengths: Fluid Dynamics; Life Sciences; Earth and Atmospheric Sciences; Information, Communications, and Intelligent Systems; Human Factors.
Syed Shariq
(415) 604-0753
syed_shariq@qmgate.arc.nasa.gov

Dryden Flight Research Center
Selected technological strengths: Aerodynamics; Aeronautics Flight Testing; Aeropropulsion; Flight Systems; Thermal Testing; Integrated Systems Test and Validation.
Lee Duke
(805) 258-3119
duke@louie.dfrf.nasa.gov

Goddard Space Flight Center
Selected technological strengths: Earth and Planetary Science Missions; LIDAR; Cryogenic Systems; Tracking; Telemetry; Command.
George Alcorn
(301) 286-5810
galcorn@gsfc-mail.nasa.gov

Jet Propulsion Laboratory
Selected technological strengths: Near/Deep-Space Mission Engineering; Microspacecraft; Space Communications; Information Systems; Remote Sensing; Robotics.
Wayne Schober
(818) 354-2240
wayne.r.schober@jpl.nasa.gov

Johnson Space Center
Selected technological strengths: Artificial Intelligence and Human Computer Interface; Life Sciences; Human Space Flight Operations; Avionics; Sensors; Communications.
Hank Davis
(713) 483-0474
hdavis@gp101.jsc.nasa.gov

Kennedy Space Center
Selected technological strengths: Emissions and Contamination Monitoring; Sensors; Corrosion Protection; Bio-Sciences.
Bill Sheehan
(407) 867-2544
billsheehan@ksc.nasa.gov

Langley Research Center
Selected technological strengths: Aerodynamics; Flight Systems; Materials; Structures; Sensors; Measurements; Information Sciences.
Charlie Blankenship
(804) 864-6005
c.p.blankenship@larc.nasa.gov

Lewis Research Center
Selected technological strengths: Aeropropulsion; Communications; Energy Technology; High Temperature Materials Research.
Walter Kim
(216) 433-3742
wskim@lims01.lerc.nasa.gov

Marshall Space Flight Center
Selected technological strengths: Materials; Manufacturing; Nondestructive Evaluation; Biotechnology; Space Propulsion; Controls and Dynamics; Structures; Microgravity Processing.
Harry Craft
(800) USA-NASA
susan.van.ark@msfc.nasa.gov

Stennis Space Center
Selected technological strengths: Propulsion Systems; Test/Monitoring; Remote Sensing; Nonintrusive Instrumentation.
Anne Johnson
(601) 688-3757
ajohnson@ssc.nasa.gov

NASA-Sponsored Commercial Technology Organizations

These organizations were established to provide rapid access to NASA and other federal R&D and foster collaboration between public and private sector organizations. They also can direct you to the appropriate point of contact within the Federal Laboratory Consortium.

Lee Rivers
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Robert Stark
Far-West Technology Transfer Center
University of Southern California
(800) 642-2872 or
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Dr. William Gasko
Center for Technology Commercialization
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(508) 870-0042

J. Ronald Thornton
Southern Technology Applications Center
University of Florida
(800) 472-6785 or
(904) 462-3913

Gary Sera
Mid-Continent Technology Transfer Center
Texas A&M University
(800) 472-6785 or
(409) 845-8762

Lani S. Hummel
Mid-Atlantic Technology Applications Center
University of Pittsburgh
(800) 472-6785 or
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Chris Coburn
Great Lakes Industrial Technology Center
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(800) 472-6785 or
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Easy Access To The FLC: Call (206) 683-1005 for the name of the Federal Laboratory Consortium Regional Coordinator in your area. The Regional Coordinator, working with the FLC Locator, can help you locate a specific laboratory to respond to your needs.

NASA Program Offices

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

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

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

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

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

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

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

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

NASA's Business Facilitators

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

Dr. Stephen Gomes
American Technology Initiative
Menlo Park, CA
(415) 325-5353

Jill Fabricant
Johnson Technology Commercialization Center
Houston, TX
(713) 335-1200

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

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

If you are interested in information, applications, and services relating to satellite and aerial data for Earth resources, contact: Dr. Stan Morain, **Earth Analysis Center,** (505) 277-3622. For software developed with NASA funding, contact **NASA's Computer Software Management and Information Center (COSMIC)** at (706) 542-3265, fax (706) 542-4807. If you have a questions...**NASA's Center for AeroSpace Information** can answer questions about NASA's Commercial Technology Network and its services and documents. Use the Feedback Card in this issue or call (410) 859-5300, ext. 245.

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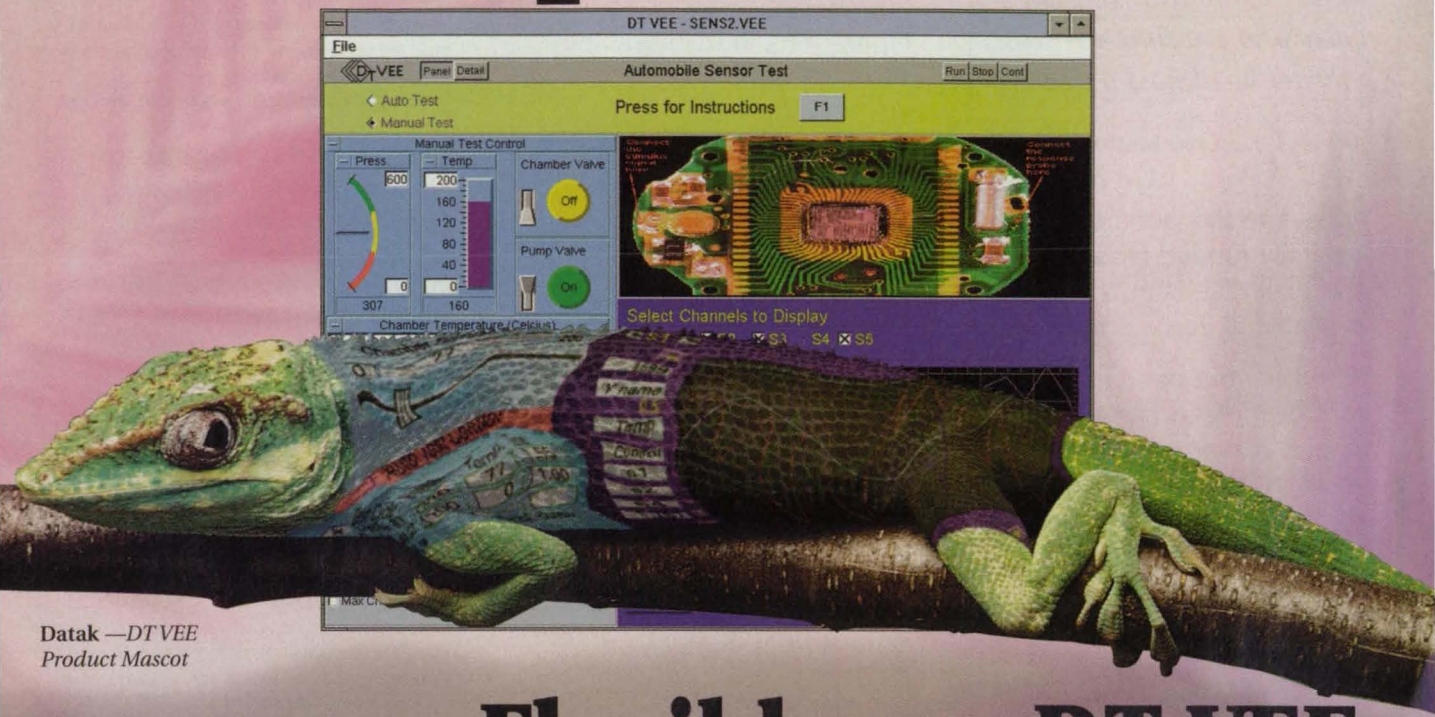

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NASA PATENTS

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

Emergency Response Mobile Robot for Operations in Combustible Atmospheres

(U.S. Patent No. 5,440,916)

Inventors: Henry W. Stone and Timothy R. Ohm, Jet Propulsion Laboratory

The inventors designed a mobile, self-powered, self-contained, and remote-controlled robot capable of operating safely in a combustible atmosphere, and also of providing the operator information about the surrounding atmosphere. The robot's non-sparking and non-arcing electromechanical and electronic components preclude igniting the atmosphere, and the enclosures that house them are positively pressurized to prevent combustibles from invading them. It also can sense the types of combustible substances and the concentration of each type. The sensing device can also determine the percentage of oxygen present in the surrounding atmosphere.

For More Information Write In No. 741

Accelerometer Having Integral Fault Null

(U.S. Patent No. 5,442,961)

Inventor: Richard J. Bozeman, Johnson Space Center

This "smart" accelerometer comprises a transducer responsive to vibration in machinery, which produces an electrical signal related to vibration magnitude and frequency; a decoding circuit responsive to the transducer signal, which produces a first fault signal; and isolating circuitry responsive to the first fault signal that produces a second, in which ground shift effects are nullified. The invention packages the transducer and the decoder circuitry together, and powers them from a single source, so noise and ground loop problems typically found between the transducer and related circuitry are greatly reduced.

For More Information Write In No. 742

Polymer/Riblet Combination for Hydrodynamic Skin Friction Reduction

(U.S. Patent No. 5,445,095)

Inventors: Jason C. Reed and Dennis M. Bushnell, Langley Research Center

The invention reduces skin friction and inhibits the effects of liquid turbulence in systems, such as marine vehicles, involving liquid flow along a surface of a body. A drag-reducing polymer is injected into longitudinal grooves on a hydrodynamic body's surface, and diffuses into the flow around the body at a rate controlled by the grooves' dimensions. As the polymer reaches the near-wall region of the boundary layer of the flow around the body just above the grooved surface, the polymer begins to reduce the turbulent skin friction.

For More Information Write In No. 745

Method and Apparatus for Noninvasive Evaluation of Diaphragmatic Function

(U.S. Patent No. 5,448,995)

Inventors: William T. Yost, Juliette L. Wait, Patricia A. Nahormek, John H. Cantrell, and Pamela D. Hanna-Hawver, Langley Research Center

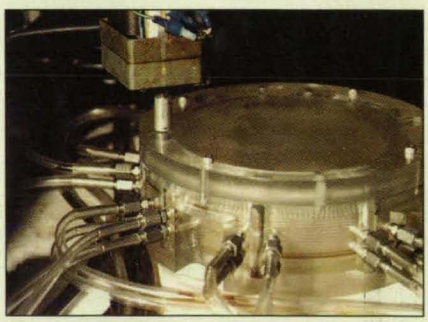
Methods for evaluating diaphragm function in human patients require measurement of the pressure differential across the diaphragm by means of two pressure sensors swallowed by the patient. These are not practical for patients requiring a respirator or those with severe breathing dysfunctions. This apparatus uses the principle of the linear relationship between diaphragm thickness and the volume of air inspired into the lung. It comprises means for real-time ultrasonic measurement of diaphragm thickness and a means for displaying such thickness as a function of time.

For More Information Write In No. 746

Magnetic Heat Pump Flow Director

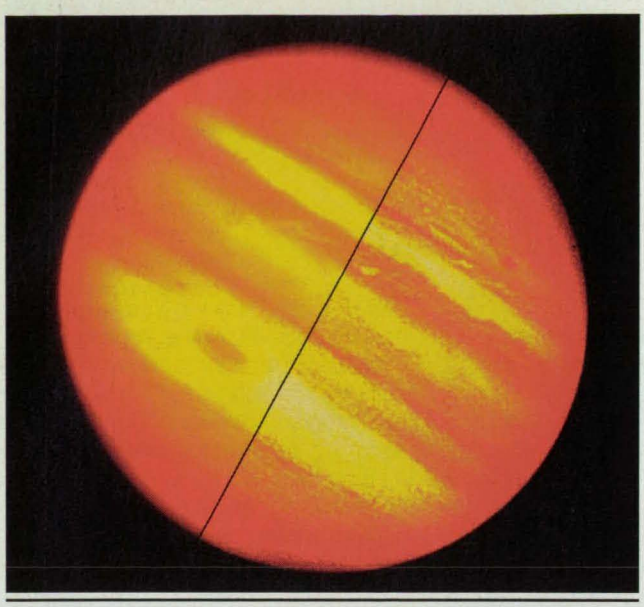
(U.S. Patent No. 5,444,983)

Inventor: Frank S. Howard, Kennedy Space Center



A magnetic heat pump consists of a rotor of magnetic material such as gadolinium that slowly rotates through a magnetic field formed from magnets. But heat-exchange fluid flowing in and out of the housing containing the rotors must follow two separated loops without mixing for maximum efficiency. By installing a flow director, a comb-shaped piece fitted between the thin rotor plates at the loop separation point, enough restriction is developed to separate the fluid into different loops within the same housing with very little mixing.

For More Information Write In No. 743



A blurred image of Jupiter (left side), produced by the Hubble Space Telescope before its repair, was corrected with the MATLAB Image Processing Toolbox using an iterative restoration technique (right side). Data: Dr. S. J. Reeves, Auburn University.

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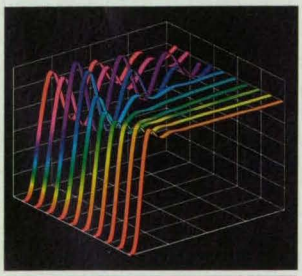

The Nonlinear Control Design Toolbox uses a series of nonlinear simulations (rear to front) to tune block diagram parameters automatically.

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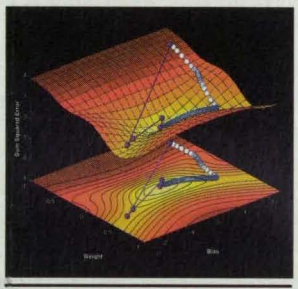

This neural network plot compares training rates for standard backpropagation (white, 108 steps) and the fast Levenberg-Marquardt algorithm (blue, 5 steps).

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192v0

Mission Accomplished

In the recent past, three-dimensional simulation software required that its users also be programmers. As a result, engineers and non-programming users were not afforded a wide selection of off-the-shelf, three-dimensional simulation programs. To fill this void, Coryphaeus Software of Los Gatos, CA is focusing its efforts on designing real-time 3D simulations for interactive instrumentation, out-the-window scenes, and virtual reality. An emerging leader in the field, Coryphaeus was founded in 1989 by Steve Lakowske, a ten-year NASA veteran who attributes much of his and his company's success to the invaluable experience he gained working with NASA and its contractors.

Lakowske's experience in simulation technology began with NASA in May of 1979 when he joined Ames Research Center as an electronics engineer in the Electro-Systems Engineering Branch. His initial responsibilities involved testing and documenting the Remote Input/Output Unit (RIOU) cards used on Ames' Vertical Motion Simulator (VMS), the world's most advanced simulator for creating high vertical accelerations. He worked on several other projects while waiting for the new Man-Vehicle Systems Research Facility (MVSRF) project to begin.

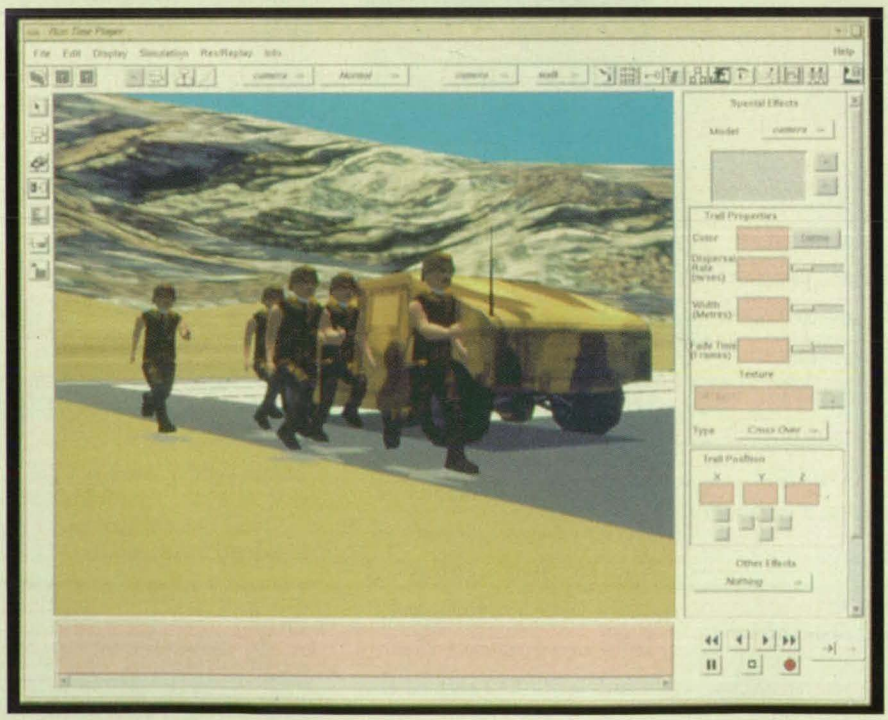
Lakowske's responsibilities with the MVSRF project were to design, fabricate, document, integrate, and test all facility audio, communications, and aural cue systems in the multimillion-dollar aviation human factors research facility. After completion of work on the project's audio systems, Lakowske directed management and integration of the Advanced Concept Flight Station, which included loading, power distribution, audio, video, flight deck I/O, and HVAC.

After completing the MVSRF work in 1984, Lakowske went to work for Sterling Software, an Ames contractor, to support Ames' Aeronautical Systems Human Factors Research Division. He developed a proposal for the Advanced Rotary Wing Simulator facility to be used for both NASA and Army research. The Army elected to buy the simulator off the shelf instead of producing it in-house, which emphasized to Lakowske the importance of making available to engineers the high-performance, off-the-shelf simulation equipment and software they required.

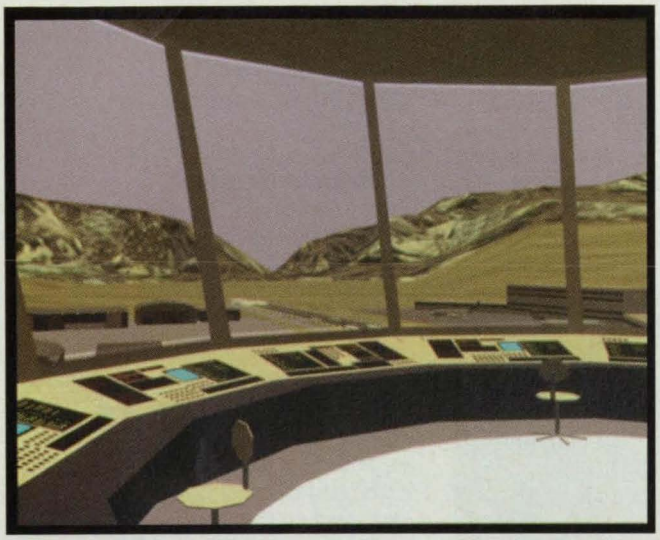
As task manager, Lakowske directed software development for a NASA/Army R&D program to develop a new computational human-performance modeling method that would allow designers of sophisticated human-machine systems such as aircraft cockpits to analyze system designs and predict certain human performance characteristics. These included new tools, techniques, and integration architectures using rapid prototyping, expert systems, object-oriented methodologies, and simulation techniques. The project, known as A^{3}I, sparked a key tool developed early in the project called the Cockpit Display Editor (CDE). Principles of the CDE would later be used to develop the first generation of Coryphaeus' EasyT™ database modeling tools, as well as Designer's Workbench™, a graphical 3D modeling environment that creates and edits models, scenes, and interactive instrumentation.

Lakowske's NASA tenure provided him with experience in real-time simulation hardware and software development methodologies and tools, all of which would be used to develop the Coryphaeus suite of products. "NASA quality assurance practices and military standards for human/machine interface design were instrumental throughout the product development and testing of Coryphaeus' commercial, off-the-shelf technology," said Lakowske.

His mission with Coryphaeus is to provide a new class of designers and developers with easy-to-use tools for simulation-based training, design and engineering, presentations, and other interactive, virtual-world applications. The company's visual simulation tools include modeling (Designer's Workbench), terrain generation (EasyT), interactive instrumentation (Realtime Module™), virtual reality (EasyScene™), and the company's newest program, Expression™, which features an integrated environment that was "very similar to the A^{3}I project," explained Lakowske. "We were trying to integrate simulation technology with cognitive science, human factors, and 3D graphics all in an integrated workstation." Expression allows non-programmers to create, prototype, test, and deliver 3D



EasyScene™ is a real-time visual system for interactive design, configuration, and control of visual systems for simulation, walk-through, virtual reality, CAD visualization, and other 3D applications.



This air traffic control tower was created with Designer's Workbench, a full-featured 3D modeler that allows non-programmers to create real-time visual simulations.

computer-based virtual experiences.

Coryphaeus, which now numbers 38 employees and enjoys annual sales of about $6 million, lists NASA Ames, Johnson Space Center, Dryden Flight Center, and Langley Research Center as current users, as well as a growing number of commercial companies, universities, and government contractors. As part of the Air Force's transport plane development program, McDonnell Douglas enlisted Coryphaeus to produce a geo-specific representation of takeoff, flight patterns, and landing at the Long Beach Airport in California. To provide a highly realistic simulation of the new aircraft in flight, Coryphaeus developed a virtual world representation of the ground patterns, the surrounding Los Angeles basin skyline, and flight conditions based on aerial photographs.

Although Coryphaeus products currently are available only for use on Silicon Graphics workstations, the company is working to develop its software for other platforms. The programs use non-proprietary database formats and industry standards such as X/Motif and ANSI C/C++, and are designed to be easy to use with minimal or no programming necessary, and reduced optimization and integration.

"My ten years at NASA allowed me to learn much of what I'm still applying today in this business," said Lakowske. "Even though it was in a government setting, the kinds of methodologies we were taught that were standard practices at NASA were extremely valuable. The technology we were developing in the various projects is something that was rarely done in the commercial sector, so there was a considerable amount of technology transfer, at least in terms of the ideas and principles. And I hope that sort of tech transfer continues."

For more information on Coryphaeus Software, contact John Murphy, Vice President of Marketing, Coryphaeus Software Inc., 985 University Ave., Ste. 31, Los Gatos, CA 95030; Tel: 408-395-4537; Fax: 408-395-6351.

Stennis Space Center

A former logging and shipping center near the banks of the East Pearl River, which separates Mississippi from Louisiana, might at first seem an unlikely location for a technological center involved in space, oceanic research, and Earth sciences. But a closer look at the activities of NASA's John C. Stennis Space Center (SSC) in Hancock County, MS–a few miles from the Gulf of Mexico and just 45 miles east of New Orleans–reveals that the site is a strategic one.

In October 1961, the federal government announced its choice of location for a static test facility for launch vehicles to be used in the Apollo manned lunar landing program. The Mississippi site was selected because of its water access, essential for moving large rocket stages, components, and loads of propellants in and out. The sparsely populated area also made possible a sound buffer of close to 126,000 acres for the 13,500-acre test facility.

The initial mission of SSC—originally named Mississippi Test Operations—was to flight-certify all first and second stages of the Apollo program's Saturn V rocket. Throughout the duration of the program, all the space vehicle boosters functioned without a failure, including those for the Apollo 11 mission, the first landing of men on the moon, in 1969.

The center's mission expanded in June 1975 when the space shuttle's main engine was tested there for the first time. Development and flight-certification of these engines is expected to continue at Stennis into the next century.

Before every space shuttle launch, the engines are tested by securing each of them individually in one of Stennis's concrete and steel test stands and "hot firing" them in a series of simulated operating conditions. Only after they have proven their flightworthiness are they shipped to Kennedy Space Center for installation on an orbiter.

Mississippi Test Operations was rechristened National Space Technology Laboratories, reporting to NASA headquarters in Washington, DC, in 1974, reflecting its growing importance in space vehicle testing. In May 1988, it was renamed the John C. Stennis Space Center to honor the Mississippi senator well known for his advocacy of space programs. SSC is NASA's Center of Excellence for large propulsion system testing.

Today, Stennis's activities go well beyond the original vision. For example, a High Heat Flux Facility can support the development of hypersonic aircraft. With this facility the center can test large-scale portions of materials exposed to high temperatures during flight.

Also reaching out to the American aerospace industry is the E-1 Facility. It is a flexible three-celled ground test setup capable of testing engines using liquid hydrogen or liquid hydrocarbon fuels, solid or hybrid rocket motor testing, or other testing involving ultrahigh-pressure gases and high-pressure cryogenic fluids. Work there has furthered knowledge in test instrumentation, the study of exhaust plumes, facility design, and test data acquisition. The center is currently conducting cooperative testing programs with aerospace companies, and the Advanced Program Development Office is seeking other opportunities for use of the propulsion testing facilities.

Dr. Greg Carter (left) and Dr. Bill Cibula use a reflectance measuring system on pine trees at the Harrison County Experimental Forest in Gulfport, MS. The system can indicate plant stress before it is visible.

Recently SSC established a Reusable Launch Vehicle (RLV)/Evolved Expendable Launch Vehicle (EELV) project office, which is responsible for all planning of testing activities associated with both programs. All future RLV engine testing will be conducted at SSC.

A partnership among NASA, the US Air Force, and industry to take world leadership in low-cost space transportation, the RLV program is intended to develop and demonstrate new technologies for the next generation of reusable space transportation. EELV, its companion program, is a $2-billion Department of Defense initiative that will focus on using existing technology, foreign or domestic, to build a family of expendable launch vehicles capable of replacing the current medium- and heavy-rocket fleet. SSC will perform all EELV engine and system testing beginning next year and continuing at least through 1999.

A Broad Reach

Stennis is not just one of NASA's four space flight centers. Today, the site is home to a cluster of 22 resident agencies involved in a far-reaching variety of research and technology projects. The center has become a multidisciplinary facility engaged in space and environmental programs and the national defense. Currently, about 3500 people are employed at SSC.

The largest among the non-NASA resident agencies is the US Navy's world-class oceanographic research community. The Commander, Naval Meteorology and Oceanography Command has as its mission to collect, interpret, and apply global data for safety at sea, strategic and tactical warfare, and weapons system design. Its principal subsidiary is the Naval Oceanographic Office, which collects hydrographic, magnetic, geodetic, chemical, navigation, and acoustic data using ships, spacecraft, and other platforms. Hydrographic information is used in nautical charts to assist the Navy as well as maritime commerce and others engaged in ocean-related activities. The office also promotes and implements cooperative survey agreements between US government agencies and other nations.

Understanding the Earth

As NASA's lead center for the commercialization of its remote sensing technology, SSC works with companies in co-funded partnerships for environmental consulting, land-use planning, and natural resource management. The center also provides the bridge between NASA's Small Spacecraft Technology Program and the private sector for developing commercial remote-sensing applications. Stennis personnel work on a wide range of science projects to foster understanding of the planet, including preserving the tropical rain forest in Central America, studying sea-surface temperatures to determine conditions for red-tide outbreak, analyzing plant stress, and monitoring cultural and historical archeological sites.

In a typical activity aimed at commercializing remote sensing, Gulf Weather Corp., a small business in the technology transfer incubator, created a computer program that uses satellite data of sea-surface temperatures and water clarity to predict prime areas for fishing in the Gulf of Mexico. The work was done as part of NASA's Earth Observations Commercial Applications Program (EOCAP), managed by Stennis for the entire space agency. The company was one of 12 in the US to be chosen by a competitive process to participate in EOCAP last year. Frank Schatzle, president and owner of Gulf Weather, noted that since fledgling businesses can be reluctant to front money for research, "EOCAP has been a shot in the arm for Gulf Weather and for the fisheries prediction system."

Another effort using SSC-developed imagery aims to help farmers distinguish healthy from unhealthy crops. Drawing on eight years of research, Drs. Greg Carter and Bill Cibula of NASA's Earth Observation Research Office at SSC determined that when subjected to stress—insects, lack of water or nutrients, or diseases—vegetation can show invisible changes in reflectance, the amount of light that a plant leaf reflects. By the time the stress is visible as discoloration or loss of leaves, it is often too late to save crops. But the scientists photograph or digitally image plants using narrow-band filters to detect reflectance at specific wavelengths. Stressed plants, they found, appear much brighter than healthy ones. "Using this remote sensing method in an aircraft," Carter observes, "you could tell in an instant where the crops may be stressed," showing farmers where to concentrate restorative measures.

A different kind of technology transfer is embodied in the Low Vision Enhancement System (LVES). Scientists from SSC and the Johns Hopkins Wilmer Eye Institute in Baltimore used NASA technology developed for computer processing of satellite images to devise a portable head-mounted sight-enhancement system. A 21-year-old Mississippian, born so severely nearsighted as to be legally blind, was the recipient of a system adapted to his needs last summer, and for the first time this fall could sit in classes and take notes like his classmates at the University of Mississippi.

SSC also offers a Visiting Investigator Program, providing US companies with low-cost opportunities to match their needs to Earth observation technology. In one instance, Louisiana-based Community Coffee, a coffee producer, used SSC technology to do crop forecasting of Guatemalan and Brazilian fields to better estimate harvests so as to determine when to buy.

The results of a survey released in September showed that more than 10,000 jobs have been created through technology transfer by the three NASA field centers and the associated regional technology transfer center in NASA's Southeast alliance—in addition to Stennis, the Marshall Space Flight Center in Huntsville, AL, the Kennedy Space Center in Florida, and the Southern Technology Applications Center in Gainesville, FL. The survey identified more than 450 new products that were being manufactured as a result of space-derived technology. Ninety-five percent of the respondents to the survey said they would seek similar assistance again in the future.

For more information, contact the NASA Technology Transfer Office, SSC, Bldg. 1100, Stennis Space Center, MS 39529-6000; (601) 688-3757; FAX (601) 688-7882; E-mail: ajohnson@wpogate.ssc.nasa.gov.

The Resource Report on Lewis Research Center in the October issue (page 24) included an incorrect phone number for Ann Heyward at the center's Office of Commercial Development. The correct number is 216-433-3484.

New Product Ideas

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

Prosthetic Hand for Holding Rods, Tools, and Handles

A new prosthetic hand for the lower arm has a significantly improved grip and an assortment of attachments. Amputees can more readily golf, fish, hunt, sweep, and work with handled tools. (See page 32.)

Graphite-Fiber Heat Radiators

Lightweight and relatively inexpensive, such fibers could serve as heat dissipators in vacuum or still air. Because these radiators do not rely on internally-contained liquids or gases, they do not leak and are more reliable than radiators that use heat pipes. (See page 57.)

Person-Locator System Based on Wristband Radio Transponders

A computerized system using wristband transponders can track and identify people in prisons, mental hospitals, and other high-security or busy places. The transponders would be very inexpensive and would not require battery power. (See page 40.)

Composite of Bisfuran/Bismaleimide With Graphite Fibers

These composites have mechanical and thermal properties that make them good candidates for high-temperature aircraft applications. (See page 63.)

Storing Fluorine in Graphitelike Carbon Fibers

This type of storage eliminates the difficulty and risk of high-pressure tanks and makes accessibility easier than storing fluorine as a constituent of metal halide. (See page 63.)

Balanced-Rotating-Spray Tank-and-Pipe-Cleaning System

With three laterally balanced jets, this system relies more on mechanical than chemical action to clean the insides of tanks and pipes. As a result, less powerful chemicals and lesser quantities of cleaning liquid are needed. (See page 78.)

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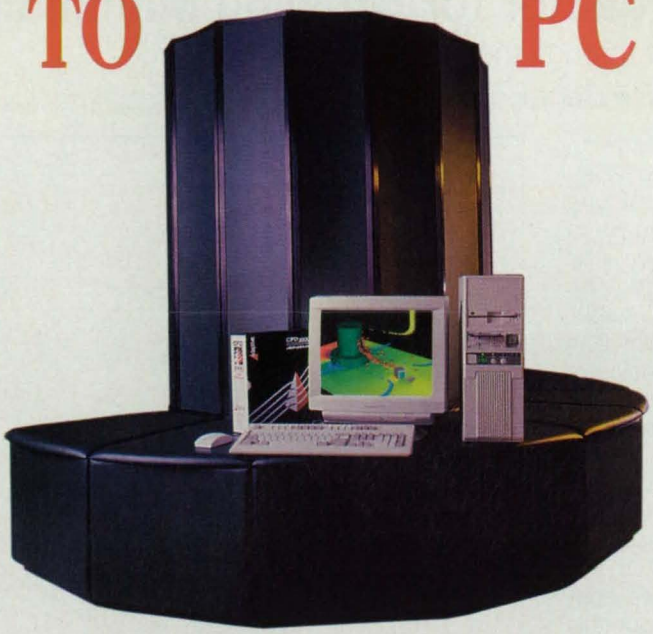

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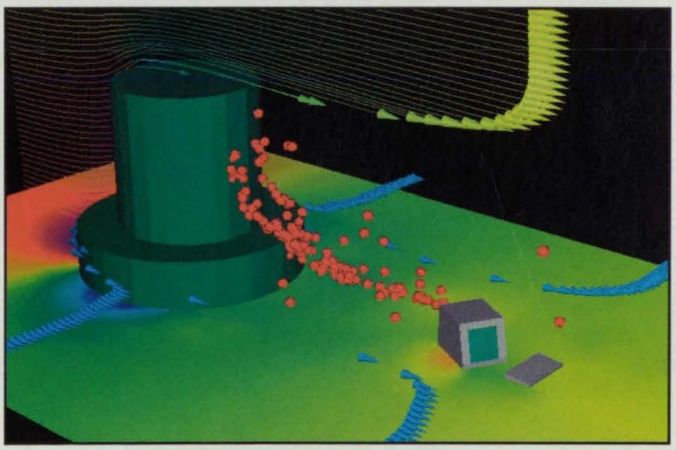

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Simplified Bioreactor for Growing Mammalian Cells

Gases diffuse in and out through the walls.

Lyndon B. Johnson Space Center, Houston, Texas

An improved bioreactor for growing mammalian cell cultures is being developed. Bioreactors of this general type are designed to support the growth of dense volumes of mammalian cells by providing ample, well-distributed flows of nutrient solution with minimal turbulence. Such gentle, nonturbulent flow environments in the growth media are necessary because mammalian cells are relatively delicate and, unlike bacteria, cannot withstand the shear forces that are present in turbulent flows.

Like other bioreactors developed previously for the same purpose, this one is cylindrical and, in operation, it is oriented with its cylindrical axis horizontal and rotated slowly about this axis. This bioreactor differs from its predecessors in the manner in which it supplies oxygen to, and removes waste gases from, the nutrient medium and the cells: In older units, this is accomplished with the help of pumps and the associated plumbing and rotating couplings, which supply pressurized air to cylindrical core perfusion membranes. However, the present bioreactor functions without connecting it to plumbing, and it can be rotated on a standard bottle roller found in many laboratories (see Figure 1).

The bioreactor vessel consists of integrally molded concentric cylinders with a connecting wall at one end and a tightly fitting cap at the other end (see Figure 2). The space enclosed by the end wall, end cap, and cylinders constitutes the growth chamber. Syringe ports in the cap are used to introduce nutrient medium and cells into the vessel and to remove excess air bubbles and spent medium. Small pores in the inner and outer cylindrical walls allow oxygen to diffuse in and waste gases to diffuse out, but are small enough to prevent the nutrient medium and cells from leaking out. Because of a significant increase, over older units, in the effective surface area for the diffusion of gases, the flow of oxygen to the culture is 2 to 10 times as large.

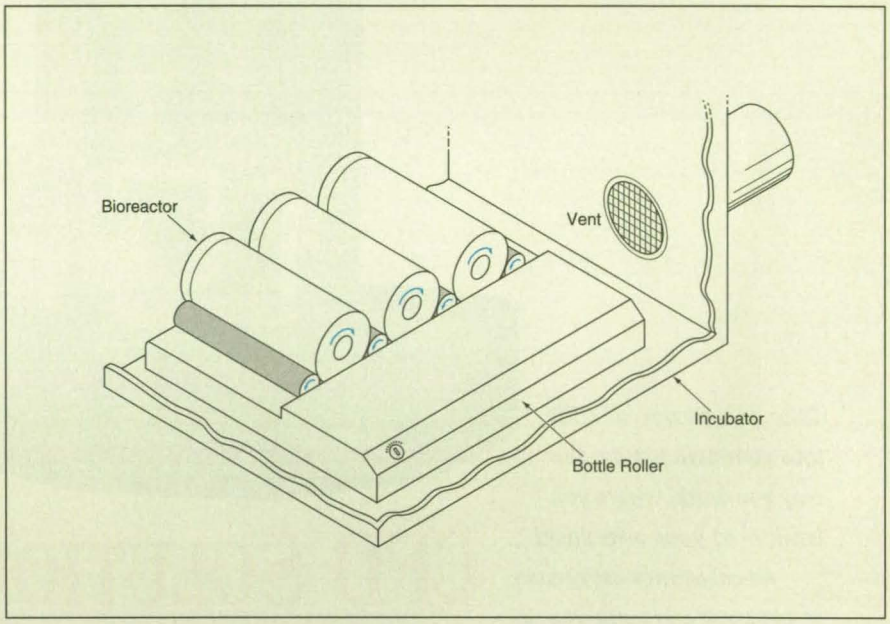


Figure 1. **Hollow-Core Cylinders Hold Culture** as they are rotated on an ordinary laboratory bottle roller in an incubator. Bioreactor cylinders are 5 centimeters long and 2.5 centimeters in diameter. The hollow-core diameter is 1 centimeter.

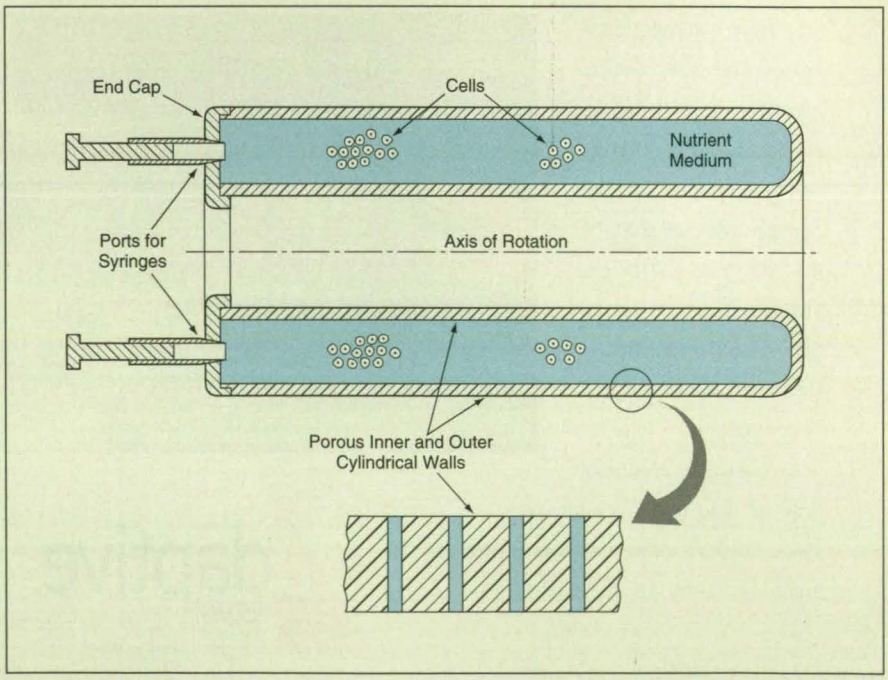
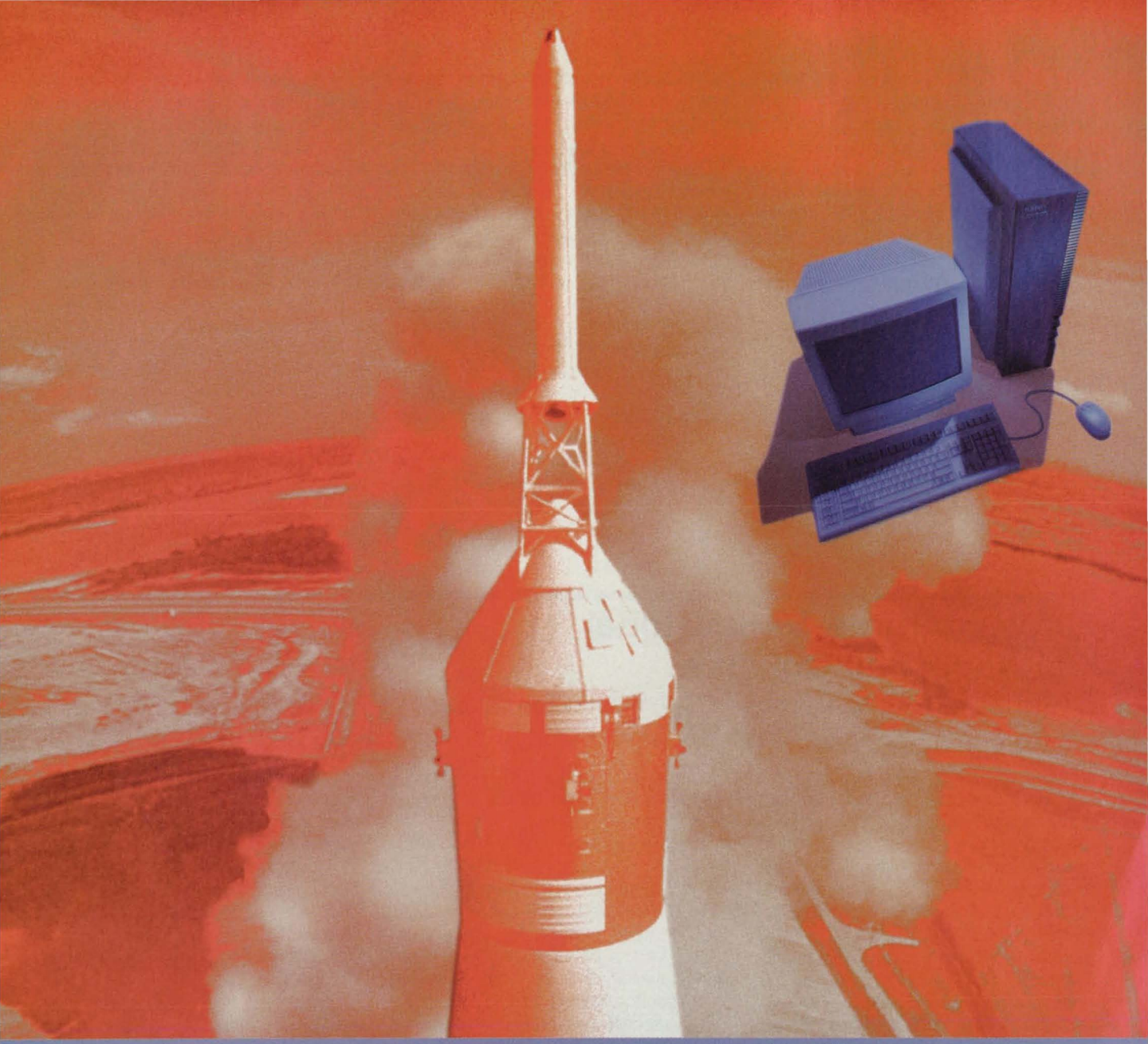


Figure 2. **Growing Cells**, medium, and beads are contained in the chamber formed by the concentric cylinders. Removable syringes in the cap inject and remove materials, and pores in the chamber walls form a permeable membrane that admits a continuous flow of oxygen.



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The present bioreactor can be made of polystyrene, polypropylene, or other suitable polymer, by inexpensive injection molding and/or vacuum forming. In contrast, older units had to be machined and assembled from such costlier materials as zirconium, stainless steel, acetal, and polycarbonate. Typically, the inner and outer cylindrical walls are 1 mm thick and pores are formed in them by rotating the vessel about its cylindrical axis while exposing it to a beam of neutrons, protons, electrons, or other particles: the impinging particles drill straight holes through both the outer and inner cylindrical walls. In the case of a neutron beam, the diameters of the holes range from 5 to 20 μm, and the exposure is adjusted so that the holes are spaced about 50 μm apart.

In a typical growth procedure, mammalian cells and beads (which serve as a substrate on which the cells grow) are introduced into the vessel by a syringe. A second syringe injects a fresh culture medium; the same syringe is used to remove air bubbles so that there is no head space. The vessel is placed on a bottle roller, and the speed of rotation is adjusted until the cells and beads are uniformly distributed. Periodically during growth, half the medium is removed and replaced with fresh medium. The proportion of glucose in the fresh solution is gradually increased to meet the demand of the growing culture. The culture is removed when the cellular aggregates have grown large enough to be useful for research — usually between 100 and 1,000 μm.

The vessel can readily be made in larger sizes to accommodate greater cell production quantities. The molding equipment presently used can make cylinders up to 30 centimeters long, for example. Alternative sintered plastic techniques can be used to vary the pore size and quantity, as necessary.

This work was done by Glenn F. Spaulding of **Johnson Space Center**. *For further information,* ***write in 148*** *on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center; (713) 483-4871. Refer to MSC-22060.

Growing Three-Dimensional Cartilage-Cell Cultures

Artificially grown tissue resembles that in mammalian cartilage.

Lyndon B. Johnson Space Center, Houston, Texas

A process for growing three-dimensional cultures of mammalian cartilage from normal mammalian cells has been devised. The process is effected using a horizontal rotating bioreactor like that described in the companion article, "Simplified Bioreactor for Growing Mammalian Cells" (MSC-22060). Such a bioreactor provides a quiescent environment with generous supplies of nutrient and oxygen. Receptors on the surfaces of the cells remain undamaged in this environment and thus can participate in cellular growth and differentiation, and in formation of an extracellular matrix. The resulting tissue has a three-dimensional structure similar to that of *in vivo* cartilage. Until now, such structures have been difficult or impossible to produce *in vitro*.

The process is initiated with noncartilage cells. After these cells have begun to grow and form aggregates, the culture is reseeded with cartilage cells (chondrocytes) to generate cartilaginous tissue and substructures. Tissue-like aggregates of cells are removed when they reach sufficient size.

The process has potential for use in developing therapies for damage to cartilage by joint and back injuries and by such inflammatory diseases as arthritis and temporal-mandibular joint disease. The process can also be used to test nonsteroid anti-inflammation medicines to ensure that they will not damage healthy chondrocytes by decomposing into harmful metabolic products.

This work was done by Glenn F. Spaulding of **Johnson Space Center** *and Tacey L. Prewett and Thomas J. Goodwin of Krug Life Sciences. For further information,* ***write in 149*** *on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center; (713) 483-4871. Refer to MSC-22118.

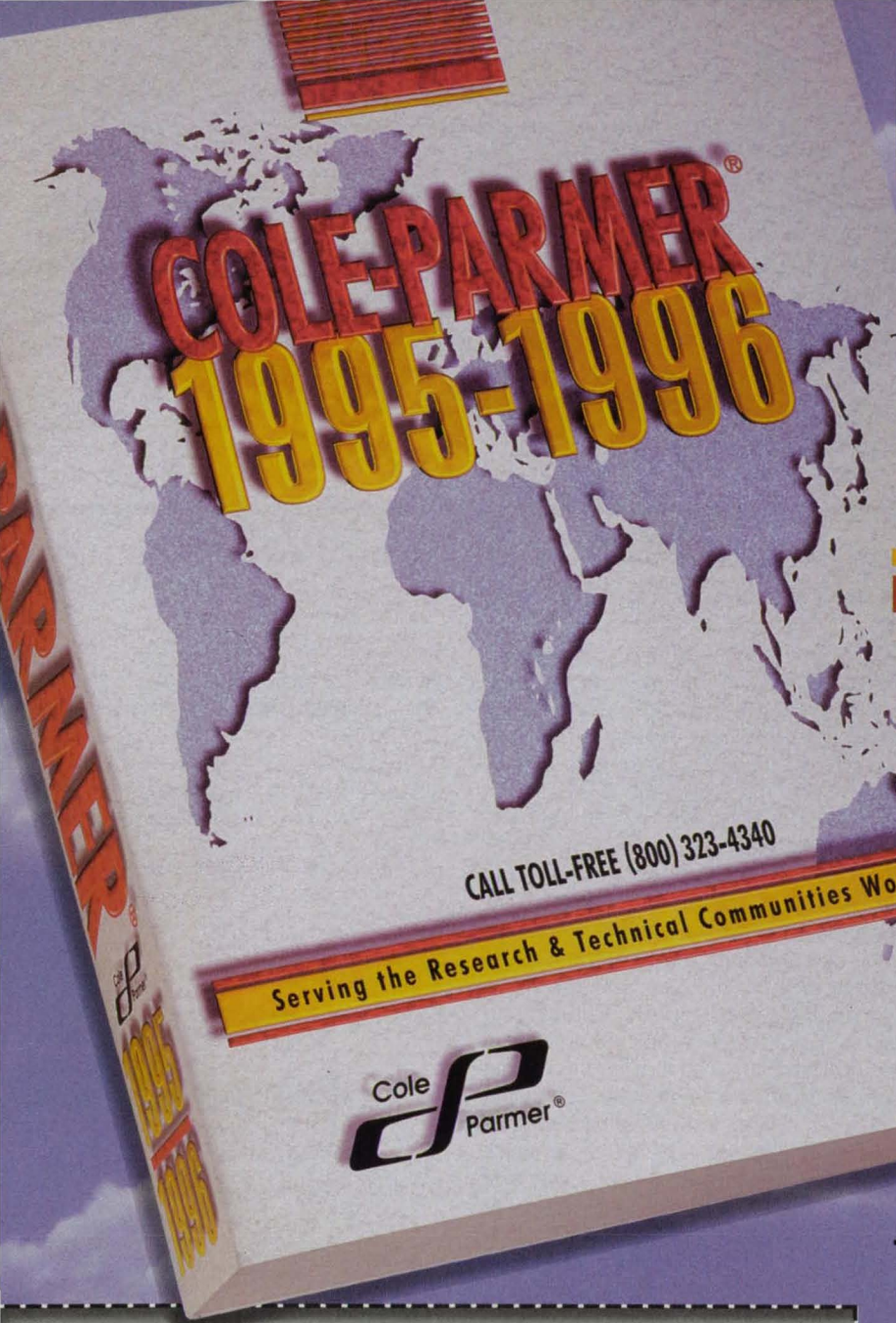
Growing Bladder-Cancer Cells in Three-Dimensional Clusters

An artificial growth process will help fill gaps in cancer research.

Lyndon B. Johnson Space Center, Houston, Texas

A process produces relatively large three-dimensional clusters of human bladder-cancer cells for research. These cell cultures are more accurate as models for *in vivo* studies and as sources of seed cells for *in vivo* studies than can be obtained in older cell-culturing processes. This process is effected in a horizontal rotating bioreactor like that described in the companion article, "Simplified Bioreactor for Growing Mammalian Cells" (MSC-22060).

Although bladder cancer has been well researched and is one of the better understood carcinomas, there are substantial gaps in knowledge because of the lack of faithful three-dimensional *in vitro* models of *in vivo* cells. This process may provide the aggregates of cells needed to fill many of the gaps.



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In a demonstration of one version of the process, normal human fibroblast cells were injected into a culture medium in a 110-milliliter bioreactor vessel at a concentration of 400,000 cells per milliliter. Microcarrier beads were added at a concentration of 5 milligrams per liter. The reactor was rotated at 25 revolutions per minute. Within 2 days, cells had grown into visible aggregates. Once the aggregates had become confluent, covering entire beads, human bladder-cancer cells were added at a concentration of 200,000 cells per milliliter. When the resulting aggregates of normal and malignant cells reached a diameter of 4 mm, they were removed from the reactor for use. The demonstration of the other version was similar except that a standard mixture of bladder-cancer cells was injected at the beginning, and there were no additional injections.

This work was done by Glenn F. Spaulding of **Johnson Space Center** *and Tacey L. Prewett and Thomas J. Goodwin of Krug Life Sciences. For further information,* ***write in 151*** *on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center; (713) 483-4871. Refer to MSC-22120.

Knee Brace Would Lock and Unlock Automatically

The braced knee could still swing freely and bear weight.

Marshall Space Flight Center, Alabama

A proposed knee brace is designed to aid the rehabilitation of a person who has suffered some muscle damage in the leg. Unlike some older knee braces, this one would not be limited to locking in the straight-leg position and, instead, could lock at any bend angle. Also unlike some older knee braces, this one would not prevent the knee from bearing weight. Instead, this knee brace would allow the knee to bear weight and would lock only when the foot and lower leg were bearing weight. Thus, the brace would prevent flexion that the wearer desired to prevent but could not prevent because of weakened muscles. At other times, the knee could be bent freely to exercise the knee-related muscles.

The proposed knee brace (see Figure 1) would include right and left assemblies that would contain identical joint mechanisms but would be oriented slightly differently to accommodate the configuration of the knee. The brace would be secured above the knee by a form-fitting restraint with hook-and-pile (Velcro or equivalent) straps. Below the knee, bars extending from the joint mechanisms would be attached to a stirrup that would be fastened in the wearer's shoe. A small pull cable would be routed from each joint mechanism to a heel-strike mechanism in the shoe.

Each joint mechanism (see Figure 2) would include an upper and a lower housing that would mate with each other at conical surfaces, which would be coated with a fluoroelastomer (Viton or equivalent) and would serve as cone clutches. To provide for free bending of the knee joint when the locking function was not activated, each upper housing would be connected to the mating lower housing via a needle bearing.

A cam would be located in the enclosed space between each upper housing and the mating lower housing. The cam would rotate about a pin affixed to the lower housing. The cam would include an elongated lever portion that would pass through a slot in an actuation rod and rest against the back plate attached to the upper housing. The actuation rod would be mounted in a passage in the lower housing. A pin would pass through a slot in the actuation rod and through a plug inside the actuation rod. The slot would limit the travel of the actuation rod. The pin and plug would retain an actuation-rod return spring. The movement of the actuation rod would be controlled by the pull cable from the heel-strike mechanism. The pull cable would be connected to the actuation rod via a screw that would enable adjustment of the cable tension. A detent submechanism including a detent ball and a preload spring would provide a slight retaining torque in the straight-leg position.

When weight was placed on the heel, the heel-strike mechanism would pull on the cables. This action would pull the activation rods down within the lower housings, compressing the return springs and causing the cams to rotate counterclockwise about their pins. In so doing, the cams would press outward against the back plates, and the resulting force coupled from the back plates to the upper housings would force the mating conical clutch surfaces together. This would lock the knee joint. When weight was removed from the heel, the heel-strike mechanism would release tension in the cables, allowing the actuation rods to retract under the forces of the return springs and causing the cams to retract from the back plates. In addition, a nose on each cam would then press against the inside of the corresponding upper housing, forcing the mating conical clutch surfaces away from each other and thereby unlocking the joint.

This work was done by Neill Myers, John Forbes, Mike Shadoan, and Kevin Baker of **Marshall Space Flight**

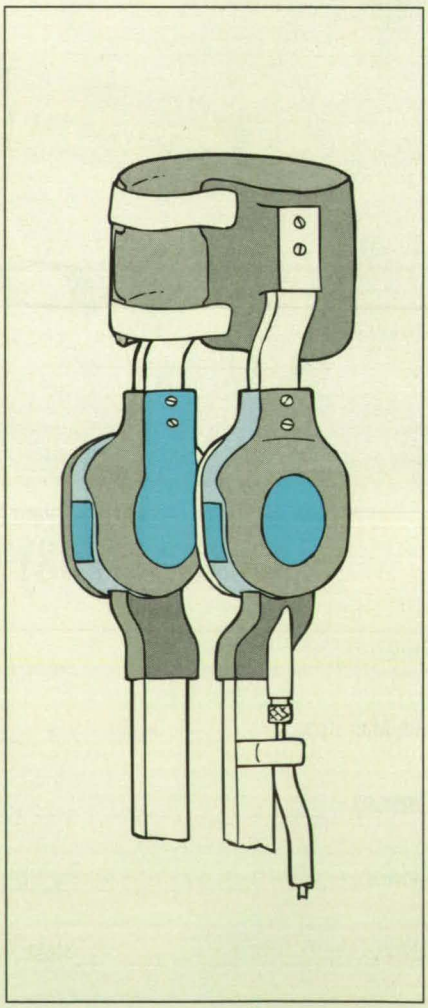

Figure 1. This **Knee Brace** would be strapped at its upper end to the leg above the knee, and anchored at the lower end (not shown) by a stirrup under the foot.

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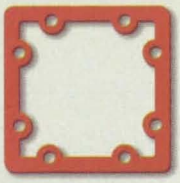

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Color Marking on Anodized Aluminum

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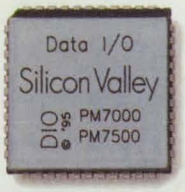

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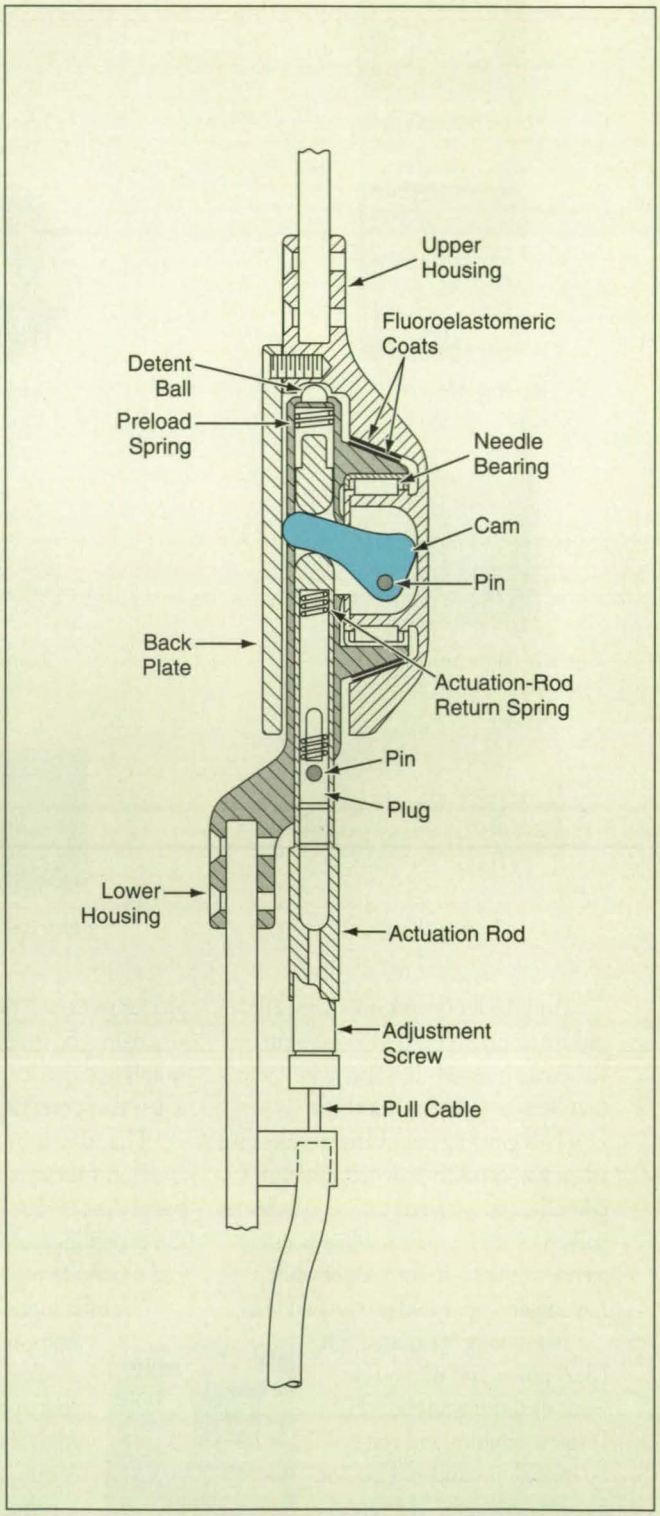
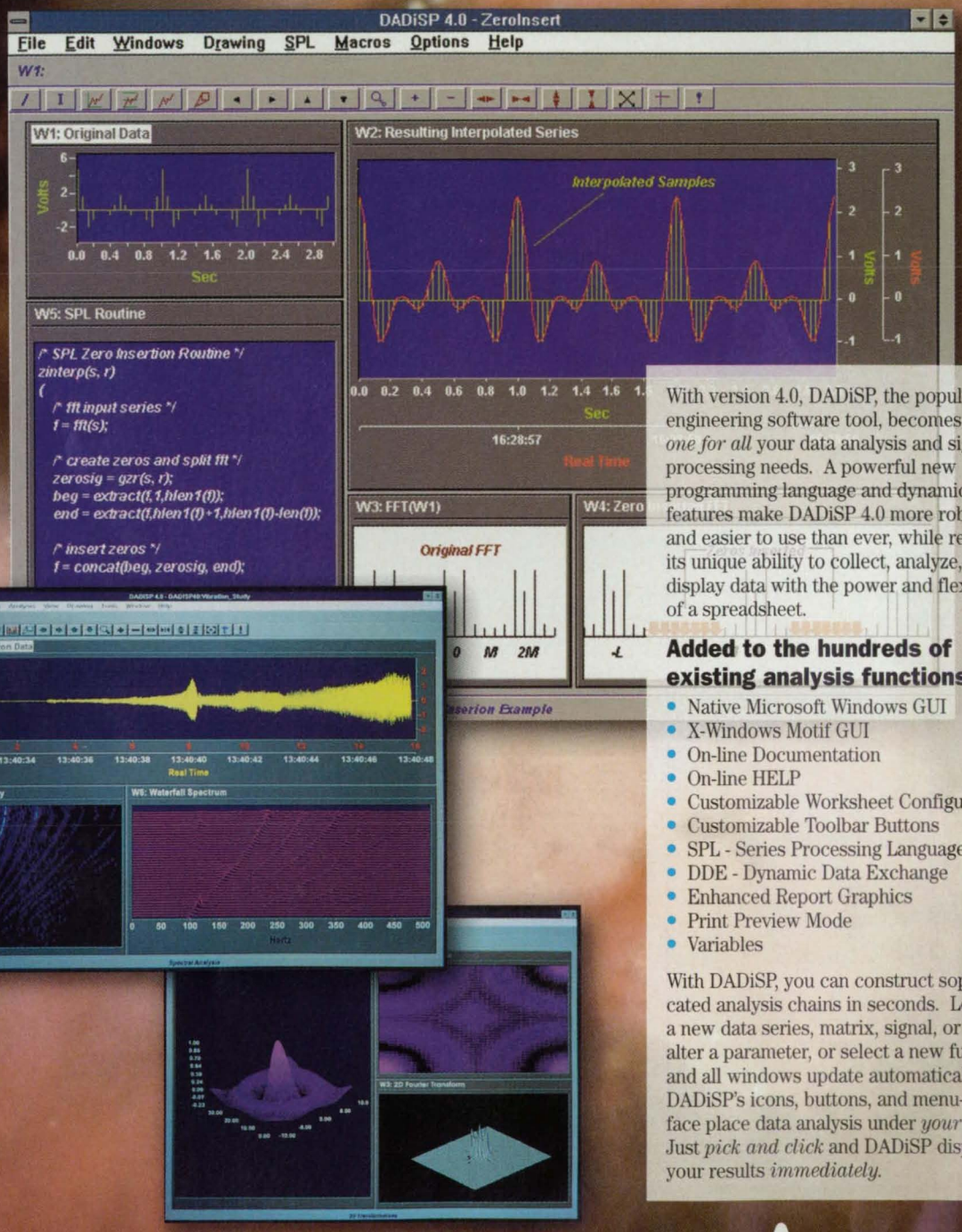


Figure 2. This **Joint Mechanism** (identical mechanisms would be used in the left and right assemblies) would allow the knee joint to flex freely except when weight was applied to the heel.

ONE 4 ALL

DADiSP 4.0



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Prosthetic Hand for Holding Rods, Tools, and Handles

A quick-change end effector offers gripping capabilities.

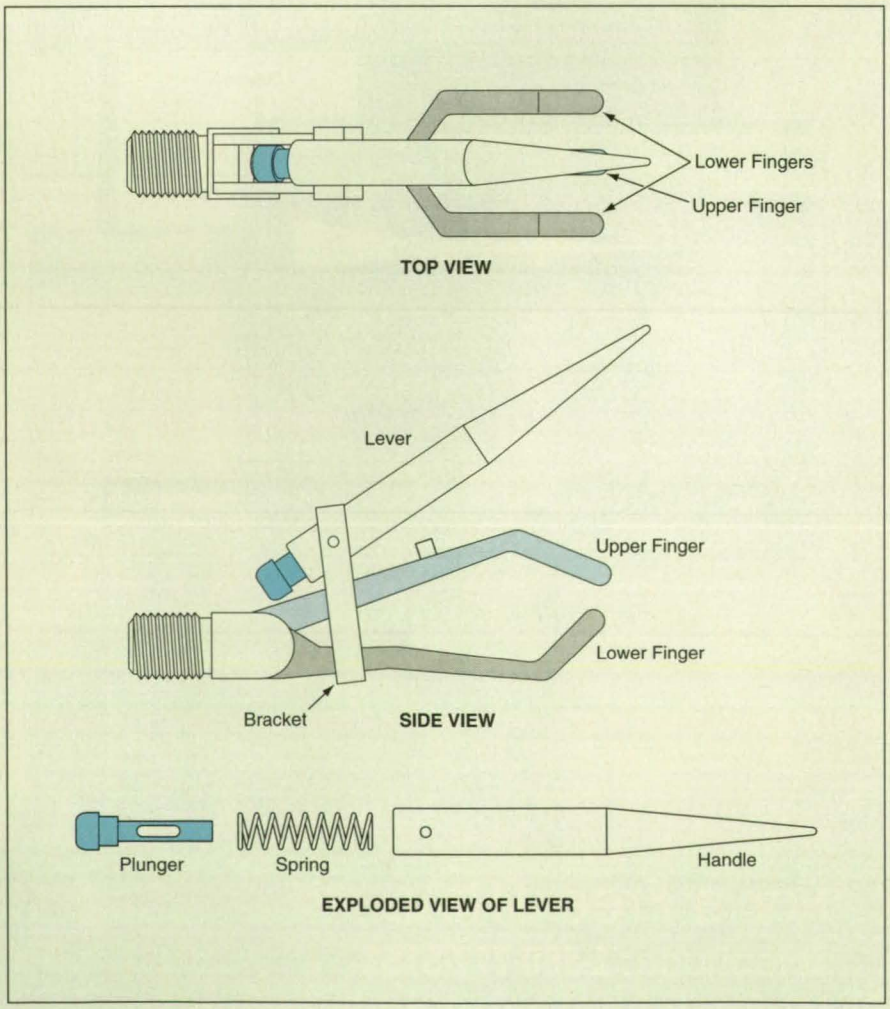
Marshall Space Flight Center, Alabama

A prosthetic hand with a quick-grip/quick-release lever broadens the range of specialized functions available to a lower-arm amputee by providing improved capabilities for gripping rods, tools, handles, and the like. The prosthetic hands available heretofore have been bulky and heavy, and have provided limited capabilities for special functions (e.g., in golf, fishing, hunting, sweeping, and work with handled tools) that involve substantial force.

This prosthetic hand (see figure) is a quick-change end effector that can be installed in or removed from an amputee's hand socket with the push of a button. The hand includes two stationary lower fingers opposed by one pivoting upper finger. The lever mentioned above operates in conjunction with a bracket to which it is attached; it can be actuated by the user's remaining hand or by contact with an external object to make the opposing fingers grip or release the object of interest.

In the "closed" or gripping position, a spring-loaded plunger in the lever pushes the opposing fingers toward each other, thereby providing the gripping force. When the lever is turned to the "open" or release position, the fingers are pushed apart by a different and relatively weak spring arrangement.

This work was done by Jewell G. Belcher, Jr., and Thomas W. Vest of **Marshall Space Flight Center**. *For further information,* ***write in 93*** *on the TSP Request Card. MFS-31070*



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SCOPE HINT 1

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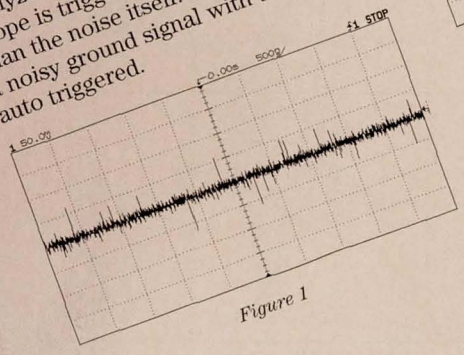

Figure 1

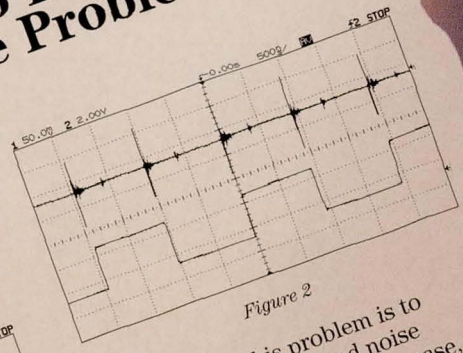

Figure 2

A solution to this problem is to trigger on the suspected noise source. See Figure 2. In this case, triggering on the 516 kHz clock signal on channel 2 results in a trigger synchronous to the noise. Now you can use averaging to average out the asynchronous noise. Using this technique, it's easy to see that this noise is indeed due to the 516 kHz clock.

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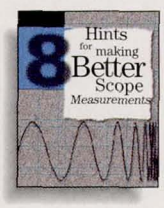

- **Hint 2: Poor Man's TDR.**
- **Hint 3: Probing Sanity Check.**
- **Hint 4: Troubleshooting Infrequent Events.**
- **Hint 5: How to Prevent Your Scope from Aliasing.**
- **Hint 6: Analyze Harmonic Distortion Using FFT.**
- **Hint 7: Use Holdoff to Stabilize Complex Digital Waveforms.**
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For More Information Write In No. 533

Measuring Q and f_r of a Microwave Cavity: Part I

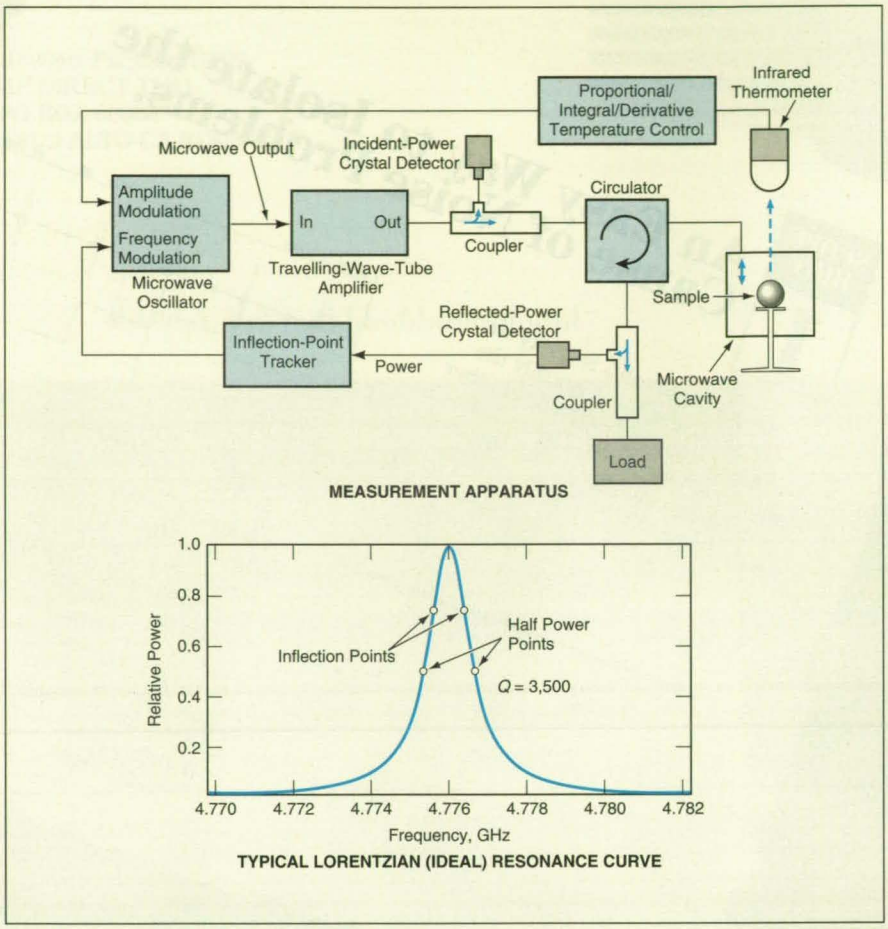
The measurement principle exploits the inflection points of a resonance curve.

NASA's Jet Propulsion Laboratory, Pasadena, California

A method of measuring the quality factor (Q) and frequency of resonance (f_r) of a microwave cavity exploits the two inflection points of the power-vs.-frequency resonance curve of the cavity. (Q is defined as $2\pi \times$ the maximum energy stored in the electromagnetic field in the cavity ÷ the energy dissipated per cycle of oscillation of the field.) The present method for measuring Q and f_r is intended particularly for use with a microwave cavity in which a sample of lossy dielectric material is being heated to a specified high temperature by microwave power at the resonant frequency. Accurate measurement of Q and f_r can contribute to enhanced monitoring and control in contactless high-temperature processing of materials. This technique can also be used with a small spherical sample to determine the temperature dependence of the complex dielectric constant.

In such an application, it is desirable to determine Q and f_r while maintaining the sample at the specified temperature. Traditionally, these quantities have been determined by exploiting the fact that the resonance curve of a single, isolated resonant mode of the electromagnetic field in the cavity is closely approximated by a Lorentzian curve, which is symmetrical about f_r. In the traditional method of determining Q and f_r, one measures the power and sweeps the frequency of a microwave oscillator from well below the lower-frequency half-power point (f_1), through the full-power point (f_r) to well above the upper half-power point (f_2). The half-power points can be determined by fitting the data to a Lorentzian curve. Then Q and f_r can be calculated from $Q = f_r/(f_2 - f_1)$ and $f_r = (f_1 + f_2)/2$.

The traditional method is not suitable for the present constant-temperature application because the temperature of the sample varies with the power. The present method is better for this purpose because most of the time it involves feedback control to maintain the cavity at one of the two inflection points of the resonance curve (see figure), so that most of the time, the power remains nearly constant and the sample thus remains at nearly constant temperature.



The **Frequency of a Microwave Oscillator** is varied by the output of a circuit that takes derivatives of the frequency-vs.-power resonance curve. This feedback control arrangement maintains the frequency at or near one of the inflection points (points of zero second derivative) of the curve.

It is necessary to measure both inflection-point frequencies to determine Q and f_r. To do this, the user electronically selects the upper or lower inflection-point frequency by use of a switch. Thus, the oscillator frequency is not so much swept as it is made to jump quickly (in less than 4 milliseconds in practice) between the two inflection points.

Now, letting f_1 and f_2 denote the inflection points instead of the half-power frequencies, one can calculate f_r from $(f_1 + f_2)/2$ as in the traditional method. Q can also be calculated from f_1 and f_2, but the applicable equation is derived from the functional form of the resonance curve and is more complex than that of the traditional method. In practice, the output of the crystal detector used to measure the microwave power is not a linear function of the power, so that the curve derived from the measurements is not a Lorentzian curve but, rather, another symmetrical curve related to a Lorentzian. This effect is taken into account in the functional form used to calculate Q.

This work was done by Martin B. Barmatz and Ofer Iny of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 13*** *on the TSP Request Card.* *NPO-19101*

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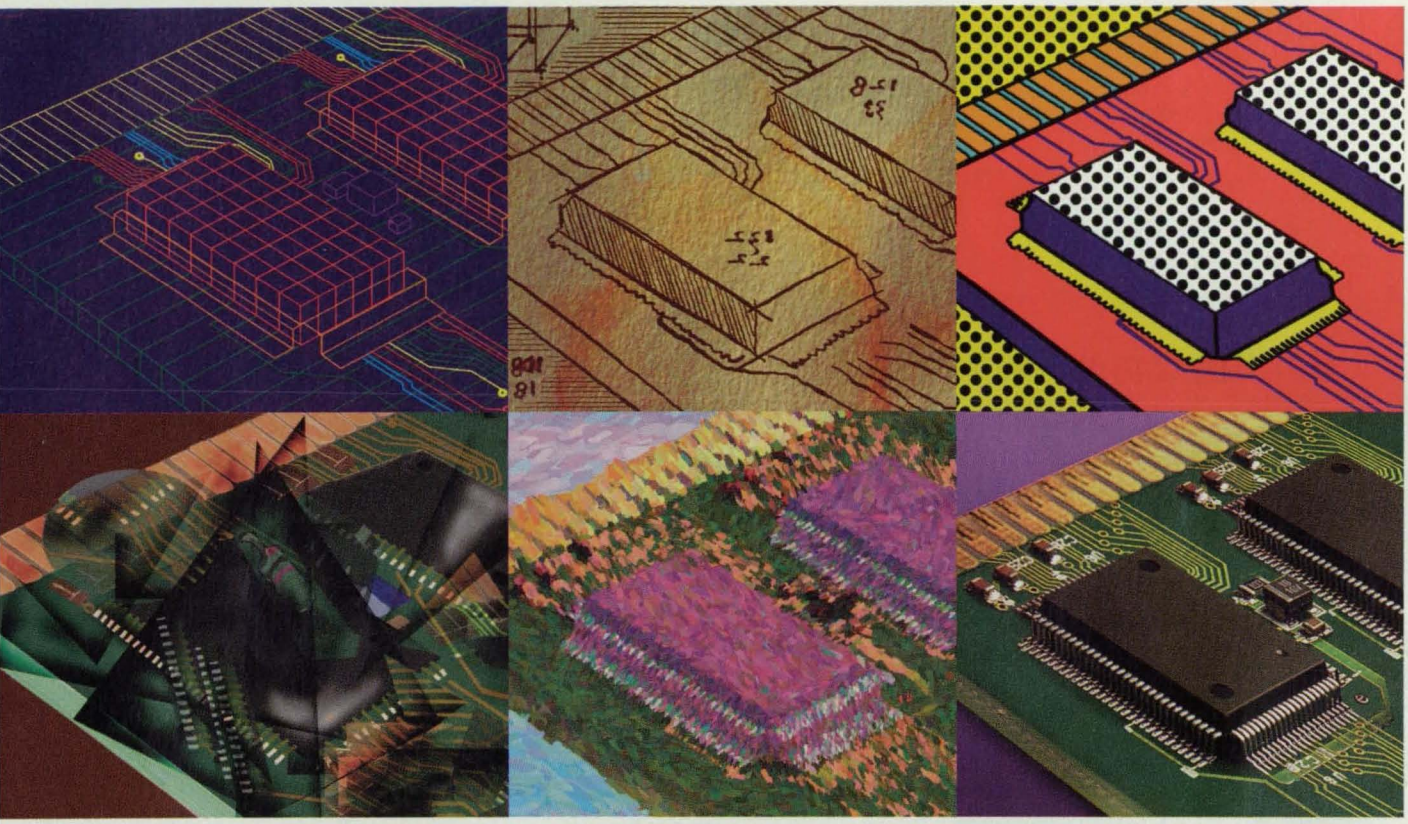

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For More Information Write In No. 505

Measuring Q and f_r of a Microwave Cavity: Part II

Frequency is maintained at f_r, and Q is determined from a decay-rate measurement.

NASA's Jet Propulsion Laboratory, Pasadena, California

An alternative method of measuring the quality factor (Q) and frequency of resonance (f_r) of a microwave cavity involves a combination of (1) feedback control to maintain the frequency of the electromagnetic field at f_r and (2) periodically determining Q from the rate of decay of the field when the source of microwave power is suddenly turned off.

Like the method in the preceding article, "Measuring Q and f_r of a Microwave Cavity: Part I" (NPO-19101), this method is intended particularly for use with a microwave cavity in which a sample of lossy dielectric material is being heated to a specified high temperature by microwave power at the resonant frequency. The methods of both this and the preceding article can contribute to accurate measurement of Q and f_r for enhanced monitoring and control in contactless high-temperature processing of materials.

As in the case of the preceding article, it is desirable to determine Q and f_r while keeping the sample at the specified temperature. It is especially important to maintain the specified temperature when the measured values of Q and f_r are to be used to compute the temperature-dependent real and imaginary parts of the dielectric constant of the sample material. In comparison with other methods (including that of the preceding article) of measuring Q and f_r, the present method is more effective in maintaining constant temperature. The present method can also be implemented more simply and at lower cost.

The apparatus of the present method (see Figure 1) includes a microwave oscillator that can be amplitude- and frequency-modulated. The output of the oscillator is fed to a traveling-wave-tube amplifier through a microwave switch that exhibits a turn-off time <10 ns. Crystal detectors are used to monitor the reflected and transmitted power and an infrared thermometer is used to measure the temperature of the sample.

The frequency of the oscillator is maintained at or near f_r by a resonance-peak-tracking circuit. This circuit modulates the oscillator frequency slightly and compares the phase of the resulting reflected power signal with the modulating source signal. The result of this comparison is an error signal that is used to shift frequency of the oscillator toward the zero-error value, which is f_r.

This method of controlling the frequency confers two benefits. First, the frequency is always at or close to f_r and thus the power is delivered efficiently to heat the sample even as the dielectric parameters of the sample change during continued heating. Second, f_r can be continuously monitored by use of a frequency counter connected directly to the output of the oscillator.

For the measurement of Q, the microwave switch is periodically turned off by pulses from a pulse generator. The pulse-repetition frequency can be selected somewhat arbitrarily, depending on the desired frequency of repetition of measurements. During each turn-off period, the decay of the microwave signal in the cavity is recorded by a digitizing

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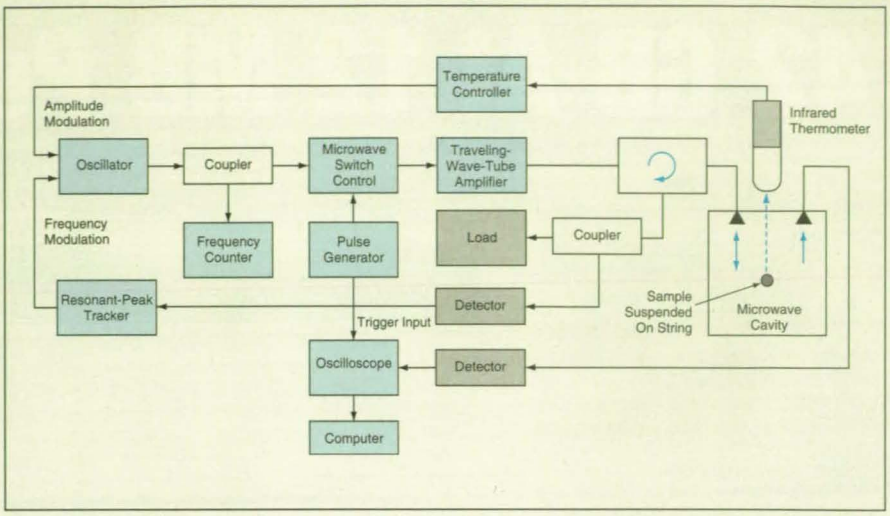


Figure 1. The **Microwave Frequency Is Maintained at f_r**, the frequency of resonance of the cavity. Periodically, the source of the microwave signal is interrupted and the rate of decay of the signal is measured and used to calculate Q.

oscilloscope. By fitting an exponential decay curve to the recorded data (see Figure 2) and using the known relationship among Q, f_r, and the rate of decay, one can immediately obtain Q with good accuracy.

The decaying microwave power is sampled by use of a weakly coupled antenna inside the cavity. This antenna is connected to a detector (a crystal diode) outside the cavity. Typical decay times are of the order of 100 ns; care must be exercised, when measuring such a rapid decay, to prevent distortion of the detected signal by the capacitances of the detector and associated circuitry. In this case, the distorting effects of these capacitances are suppressed by use of a load resistor across the output of the detector.

The decay-rate approach to determination of Q is superior to frequency-sweeping approaches because it involves minimal variation of the temperature of the sample. Because typical decay times are ≈ 100 ns, the microwave power can be turned off for a very short time (<1 μs). During this short time, temperature of the sample changes very little.

This work was done by Ofer Iny and Martin B. Barmatz of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 16*** *on the TSP Request Card. NPO-19356*

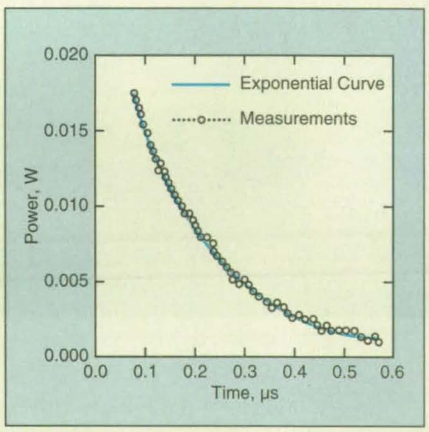


Figure 2. An **Exponential Decay Curve** was fitted to decay measurements in a microwave cavity. The fit in this case corresponds to Q = 5,104, which is within 1 percent of the Q determined by other methods.

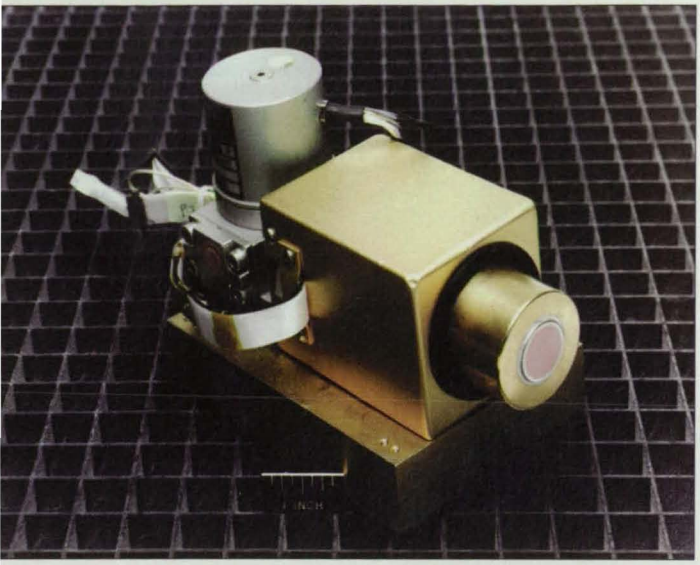
Remote Acquisition Amplifier for 50-Ohm Cable

John F. Kennedy Space Center, Florida

A buffer-amplifier unit is designed to drive 50-Ω cables up to 100 ft. (30 m) long, compensating for attenuation in the cables and enabling the remote operation of oscilloscopes. The unit contains an ultrafast field-effect-transistor (FET) operational amplifier. A variable resistor provides for adjustment of the gain of the amplifier, such that the overall gain from the input terminals of the amplifier to the output end of the cable can be set to unity.

This work was done by Jose J. Amador of **Kennedy Space Center.** *For further information,* ***write in 59*** *on the TSP Request Card. KSC-11625*

Infrared Engine



System Description:

The **Infrared Engine** uses our full television resolution 640 X 480 pixel Platinum Silicide (PtSi) MOS IRFPA mounted in a Stirling cycle cooled Dewar, with a f/1.5 baffled cold shield, and a cooled optical filter. The engine has complete drive and analog video electronics.

The **Infrared Engine** is extremely compact for use on gimbal systems an provides analog video at RS170 scan rates. A key capability is the eight IRFP operating integration modes that can be selected for electronic shuttering (o an option can be added that will allow higher frame rate operation).

Technical Characteristics

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- No blooming, no lag, no transfer smear
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- NEDT = 0.15 (typical)

Cool Down Time: 12 minutes to first image

Outputs:

- Non-composite RS170 video
- Composite sync
- Linesync
- Vertical blanking
- Pixel clock
- FPA temperature voltage output

Controls:

- Commandable integration time (63µs to 33ms)

Dimensions (mm)

- Camera head 77.72 (H) X 64.0 (W) X 156.72 (L)
- Electronics Box 23.88 (H) X 87.12 (W) X 116.08 (L)

Total weight: 1.2 kg

Applications

- Air to air/ground target tracking
- Personnel perimeter control
- Ground vehicle observation platform
- Industrial temperature measurement

Environmental Operating Conditions (Design Objectives)

- Temperature: -30°C to 60°C
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Options

- Frame-rate to 1KHz
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Person-Locator System Based on Wristband Radio Transponders

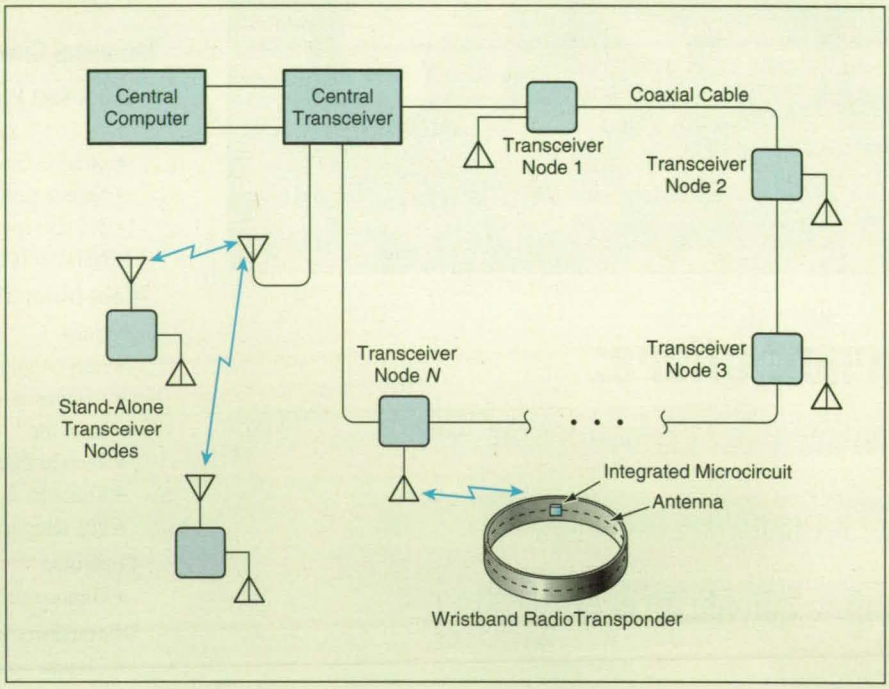
Individuals could be located in a timely fashion at relatively low cost.

NASA's Jet Propulsion Laboratory, Pasadena, California

A computerized system based on wristband radio-frequency (RF), passive transponders is being developed for use in real-time tracking of individuals in custodial institutions like prisons and mental hospitals. In comparison with other, similar systems now on the market or undergoing development, this system would offer the advantages of equal or better tracking capabilities and relatively low cost: the wristband transponders are estimated to cost less than $1.50 apiece (1993 prices) and would not require battery power.

The system (see figure) would include a monitoring system that would contain a central computer connected to a low-power, high-frequency central transceiver. The transceiver would be connected to miniature transceiver nodes mounted unobtrusively at known locations throughout the institution. Some or all of the transceiver nodes could be connected to the central transceiver by incorporating them into a coaxial cable connected to the central transceiver. Alternatively, some or all of the transceiver nodes could be set up as stand-alone units with antennas for radio communication with the central transceiver. The wristband transponders would be embedded in common hospital wristbands.

A unique digital code would be assigned to each wristband to identify the wearer and to each transceiver node to identify its location. The computer would cause the central transceiver to broadcast the digital code or codes of one or many wristbands to the transceiver nodes, which would rebroadcast the wristband codes in their local areas. Each wristband circuit would be powered by the signal radiated by the transceiver node(s) in its immediate vicinity. Upon reception of a signal modulated with its unique digital code, a wristband would become excited to rebroadcast that code for reception by the nearest transceiver node. In turn, the transceiver node would transmit both the wristband code and its location code back to the central transceiver.



This **Person-Locator System** would provide timely information on the locations and identities of individuals throughout a building or institution. Each wristband transponder unit would resemble a hospital wristband and would cost only a few dollars.

The central computer would process these codes to produce a video display showing the location of the wristband as deduced from the location of the transceiver node that received the response from the wristband. Produced by a graphical-display software module, this display would be in the form of a two-dimensional floor or terrain map or a three-dimensional layout of the entire institution or the affected building or outside area.

The computer-display module would also provide ancillary still images from file photographs, plus real-time video images and sound. The data for these ancillary displays would be provided by a data base software module, which would contain a record on each prisoner and, optionally, on each guard and/or other supervisory person. This record could include multiple photographs, voiceprints, fingerprints, and archival video displays to show distinctive gaits and other distinctive characteristics. Each such record would be labeled with the same distinct digital code assigned to that individual's wristband.

The wristbands would be tamper-proof in the following sense: Each would contain an embedded wire loop which, when broken or torn off and discarded, would cause the wristband to disappear from the system, thus causing an alarm. If a wristband were to be shielded with aluminum foil or otherwise rendered inoperable and its unique digital code were transmitted in the system, the software would similarly alert the central computer operator that the wristband was missing in the system. Similarly, every wristband in the system would contain circuitry responsive to a uniform code that would be transmitted repeatedly by transceiver nodes at the perimeter of the institution. Thus, if a prisoner approached the perimeter, a warning would be sounded

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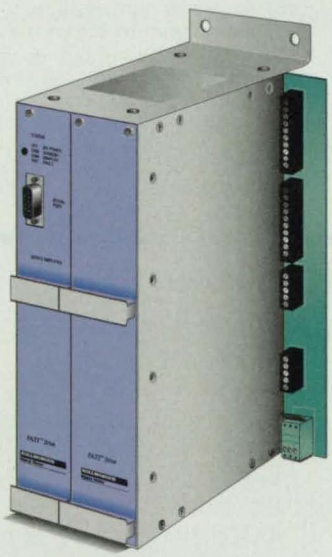

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at the monitoring station.

This work was done by Frederick W. Mintz, Brent R. Blaes, and Charles W. Chandler of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 23*** *on the TSP Request Card.*

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

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Refer to NPO-19280, volume and number of this NASA Tech Briefs *issue, and the page number.*

Computer-Controlled Movable Spotlight

This spotlight simulates reduced solar illumination at changing angles of incidence.

NASA's Jet Propulsion Laboratory, Pasadena, California

The robotic solar illumination simulator is a five degree-of-freedom (DOF) computer-controlled system which provides constant intensity of illumination at a surface, while varying the incident angle of the illumination at rates equivalent to those experienced in Earth orbit. In the system, four of the DOF are feedback controlled: pan, tilt, linear travel, and spotlight-beam focus. The fifth DOF, lighting intensity at the surface, is open-loop-controlled using calibration data measurements of the spotlight. This system is different from typical solar simulators in that the light source is mobile, controlled, and calibrated, while the illuminated environment is stationary.

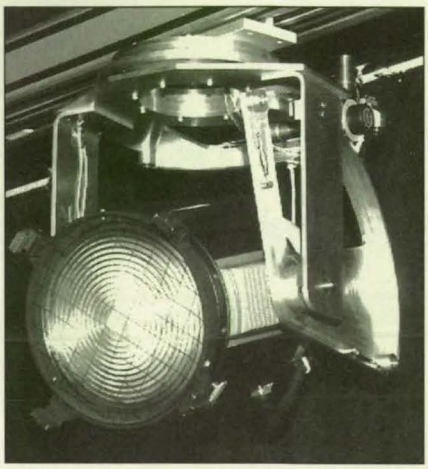
Traditional solar simulators are designed for thermal tests of actual spacecraft. To accomplish this, they utilize large vacuum chambers to house the spacecraft, and collimated lighting from arrays of xenon arc lamps. Brightness up to an order of magnitude greater than solar intensity is possible. To test the effects of changing lighting direction, the entire spacecraft is rotated while the illumination remains constant. While this approach is necessary for preflight spacecraft testing, it is simply not practical for robotic system prototype development.

Alternatively, the robotic spotlight system is a small-scale simulator that effectively mimics the relative motion of the Sun in the sky, while still providing realistically scaled illumination levels. The system is composed of a spotlight mounted on a pan/tilt/translate platform. Its ability to move spatially, as well as to modify its beam shape, enable it to provide constantly intense illumination that changes the angle of incidence at rates equal to those experienced in low Earth orbit.

The illumination system has been used as an ambient-light source to test the operation of an on-orbit robotic inspection system prototype. While the simulated solar illumination is only 1.5 percent that of true orbital sunlight, the inspection system provides compensation by adjustment of controlled lighting position, strobe lighting pulses, and camera exposure times. Therefore, the lighting conditions are a realistic test for human and machine inspection algorithms.

Trajectories for the spotlight system are specified in terms of (1) the Cartesian position of the environmental surface to be illuminated and (2) the initial and final angle of illumination. For inspection experiments, the surface is typically a one-third scale mockup of a Space Station Orbital Replacement Unit (ORU). During the trajectory execution, the lamp moves under computer control and changes the angle of illumination at low Earth orbital rates, while maintaining the center of the light beam on the specified surface coordinate. At the same time, the width of the light beam is changed to maintain constant intensity in the center of the beam at the surface position.

This work was done by Richard Volpe and Douglas McAffee of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 26*** *on the TSP Request Card. NPO-19370*



The **Computer-Controlled Movable Spotlight** resembles an ordinary spotlight, but it is translated, tilted, and focused (and its brightness is controlled) by a computerized control system to obtain the effect of sunlight with reduced but constant intensity, with slowly varying angles of incidence.

Built-In Diagnostics (BID) of Equipment/Systems

Diagnostician™-on-a-Chip technology identifies faults and commands systems reconfiguration.

Marshall Space Flight Center, Alabama

Microcontroller-based intelligent software that automatically diagnoses faults is undergoing development for incorporation into power-distribution and other electronic systems. Smart microcontrollers operating in conjunction with other system-control circuits, can command self-correcting system/equipment actions in real time. For example, a power-distribution network can be reconfigured automatically to isolate a fault soon after it occurs, thereby preventing the cascading of multiple dependent faults that, if allowed to occur, could cause shutdown of the entire network.

The underlying concept employed by these smart systems is characterized by the term "Diagnostician™-on-a-Chip" (DOC). The primary goal of DOC technology is to implement a totally embedded Built-In-Diagnostics (BID) capability

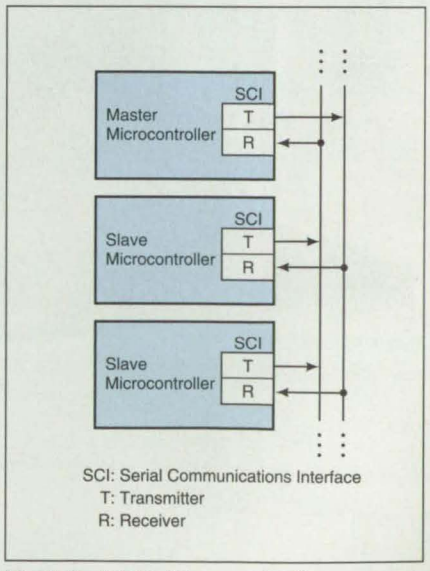
within the context of highly integrated, commercially available microcontrollers employing analog-to-digital (A/D) conversion, timer processing units, embedded random-access memory (RAM)/flash memory, and serial synchronous/asynchronous communication capabilities. Depending on the specific application, the diagnostic capability can be centralized in a single microcontroller or distributed among multiple microcontrollers (see figure): for example, a diagnostic microcontroller installed in each node of a network or in each module in an equipment assembly. When the memory within a microcontroller is not large enough to hold the data and software needed in a given application, an additional memory chip(s) can be provided.

The DOC concept is an integrated combination of concepts from the disciplines of built-in self-test of electronic systems, artificial-intelligence software, data-base management, and microcontroller technology. A DOC microcontroller is required to (1) generate commands for associated built-in test equipment to stimulate the unit of equipment to be diagnosed (hereafter denoted the "unit under test," or "UUT"), (2) collect and process the response data obtained by the built-in test equipment, and (3) perform diagnostic reasoning on the response data, using a diagnostic knowledge base derived from design data specific to the UUT, along with the Diagnostician™, which is an advanced artificial-intelligence based diagnostic reasoning inference engine.

The Diagnostician™ can generate diagnoses of, and/or hypotheses about, faults in real time. In a given case, the diagnosis or hypothesis is based on a diagnostic model of the UUT. The model consists of a fault/symptom matrix data structure that captures those aspects of the design of the UUT that pertain to connectivity (topology) and behavior (expected and known good responses). Upon the detection of a fault, the Diagnostician™ reads in all available test and diagnostic data and makes a fault hypothesis consistent with those data. Then, in cooperation with other system-control software, the Diagnostician™ commands the appropriate reconfiguration of the system, for isolation of, or recovery from the fault.

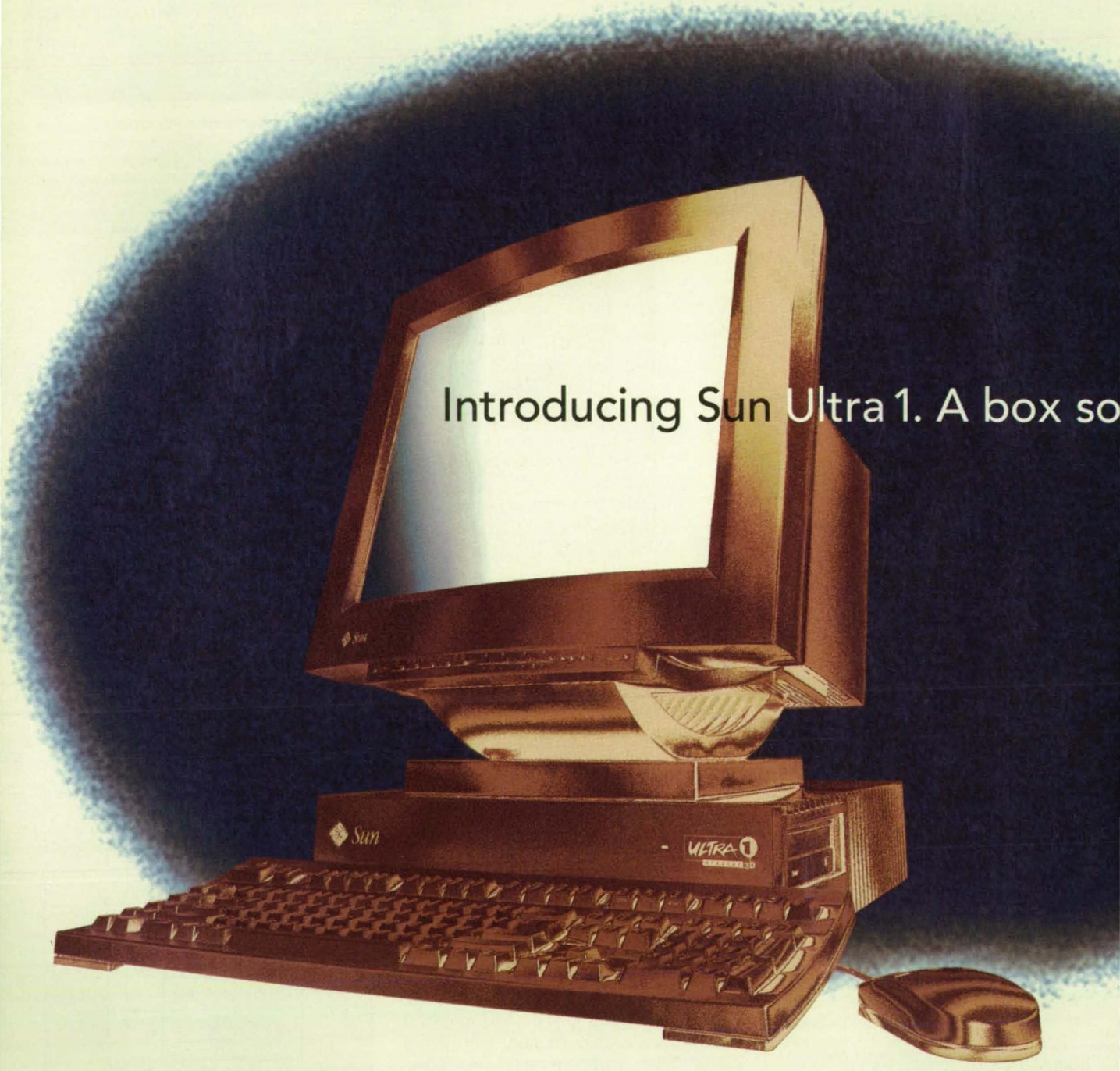
This work was done by Michael N. Granieri, John P. Giordano, and Mary E. Nolan of Giordano Automation Corp. in conjunction with McDonnell Douglas Aerospace for **Marshall Space Flight Center**. *For further information,* ***write in 70*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center; (205) 544-0021. Refer to MFS-26315.



Multiple DOC Microcontrollers are arranged in a typical master/slave configuration. The master microcontroller can reside in a card slot in a system console, and the slave microcontrollers can report statuses from equipment subsystems. The master addresses the desired slave and communicates with it to acquire the needed diagnostic information.

(continued on page 46)



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Neural Networks for Demodulation of Phase-Modulated Signals

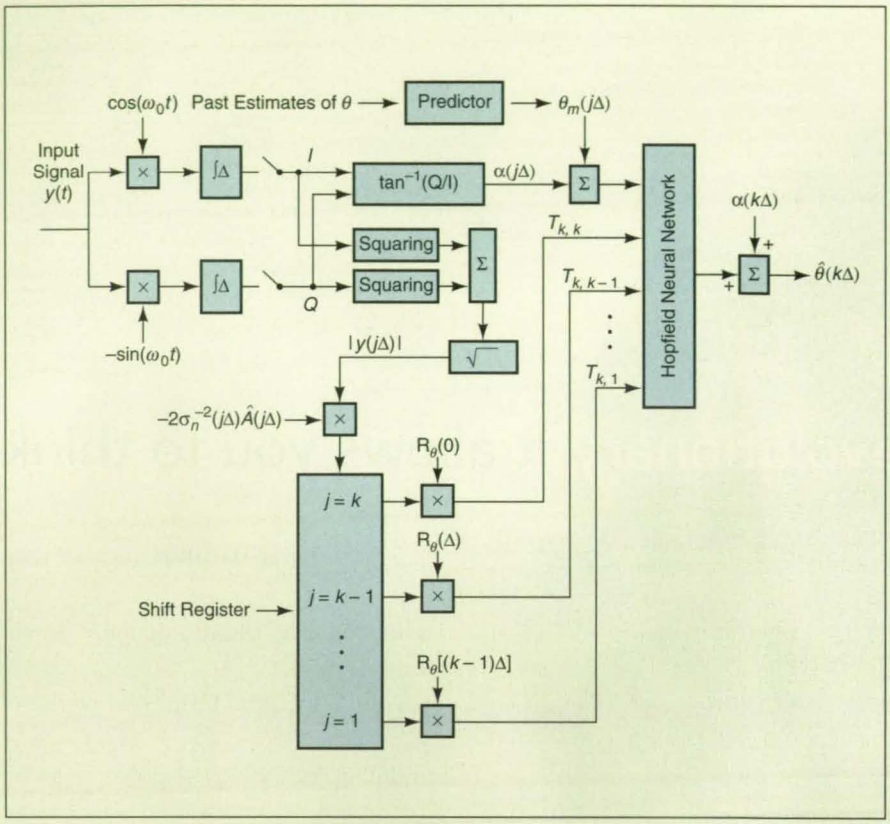
These networks would solve nonlinear integral equations that prior demodulation circuits cannot solve.

Lewis Research Center, Cleveland, Ohio

Hopfield neural networks have been proposed for demodulating quadrature phase-shift-keyed (QPSK) signals that carry digital information. They would be used to solve nonlinear integral equations associated with optimum [maximum-*a-posteriori* (MAP)] demodulation and block decoding of phase-coded signals and to solve linear matrix equations associated with adaptive filtering for equalization of noisy communication channels in which signal levels vary with time. In contrast, conventional demodulation devices are incapable of solving the nonlinear integral equations associated with exact MAP demodulation.

A Hopfield (crossbar) neural network consists of a set of N operational amplifiers connected in parallel, with weighted feedback from the output terminal of each amplifier to the input terminals of the other amplifiers. These networks can be used to solve signal processing problems in a variety of ways. A Hopfield neural network operating in a quasi-linear (low-gain) mode can be used for steepest-descent solution of quadratic optimization problems relevant to estimation, filtering, prediction, and autoregressive spectral analysis. Equalization of channels involves a low-gain (quasi-linear) Hopfield implementation for inversion of matrices. In a saturated (high-gain) mode, a network of this type can be used to find extrema of quadratic forms with a constraint that each element of the solution vectors is either 1 or 0. Such a constraint is relevant to maximum-likelihood-sequence estimation for demodulation.

For maximum-likelihood demodulation and decoding, hypothesized phase shifts are known, deterministic parameters that correspond to distinct transmitted code words. Phases of received signals can be randomized (even in the absence of noise) by such effects as one or two large uncompensated multipath components, synchronization errors, Doppler shifts, and instability of frequency and/or phase. If such randomization occurs, the corresponding optimum receiver is an estimator/correlator that uses the original hypothesized phase values together with observed data to estimate better correlator reference phase parameters for testing each code-word hypothesis. The new reference parameters for each hypothesis could be estimated by a MAP demodulator with a nonlinear Hopfield neural network (see figure). The Hopfield network shown in the figure solves the nonlinear integral equation for MAP phase estimates $\{\theta(k\Delta)\}$ based on hypothesized transmitted phase shifts $\{\theta_m(k\Delta)\}$ and arctan phase estimate $\{\alpha(k\Delta)\}$, where θ is a maximum posterior phase estimate value, α is a preliminary measured phase value, k denotes the sampling number of a signal, and Δ is a sampling interval.



A **MAP Phase Demodulator** would contain a Hopfield neural network. Only a few of the required feedback weights T_{ij} (where $1 \le i \ge N$ and $1 \le j \ge N$) are shown; others are calculated similarly and simultaneously from the outputs of the shift register.

MAP demodulation and decoding involves (1) block processing of preliminary estimates of phase from arctan(Q/I) (where Q and I denote quadrature and in-phase instantaneous signal amplitudes, respectively) extracted from data together with (2) hypothesized phase values that correspond to various code words. These parameters are used for MAP estimation of phase by a nonlinear Hopfield network that operates between low-gain (quasi-linear) and high-gain (saturated) modes. MAP estimates of phase are applied to estimator/correlator testing of different hypothesized transmitted code words by using the estimated phase values as reference parameters in a correlation receiver. For equally likely word hypotheses, the receiver decides that the hypothesized code word with the largest estimator/ correlator output corresponds to the transmitted code word.

The Hopfield neural network would be implemented as an analog very-large-scale integrated circuit that would achieve rapid convergence. Alternatively, it could be implemented as a digital simulation of such a circuit. The network can also be used to improve phase estimation performance over that of a phase-locked loop.

This work was done by Richard A. Altes of Chirp Corp. for **Lewis Research Center**. *For further information,* ***write in 73*** *on the TSP Request Card.*
LEW-15623

Analyzing Gases From Decomposing Electrical Insulation

A test fixture holds an insulated wire and traps gases emitted by heating of the wire.

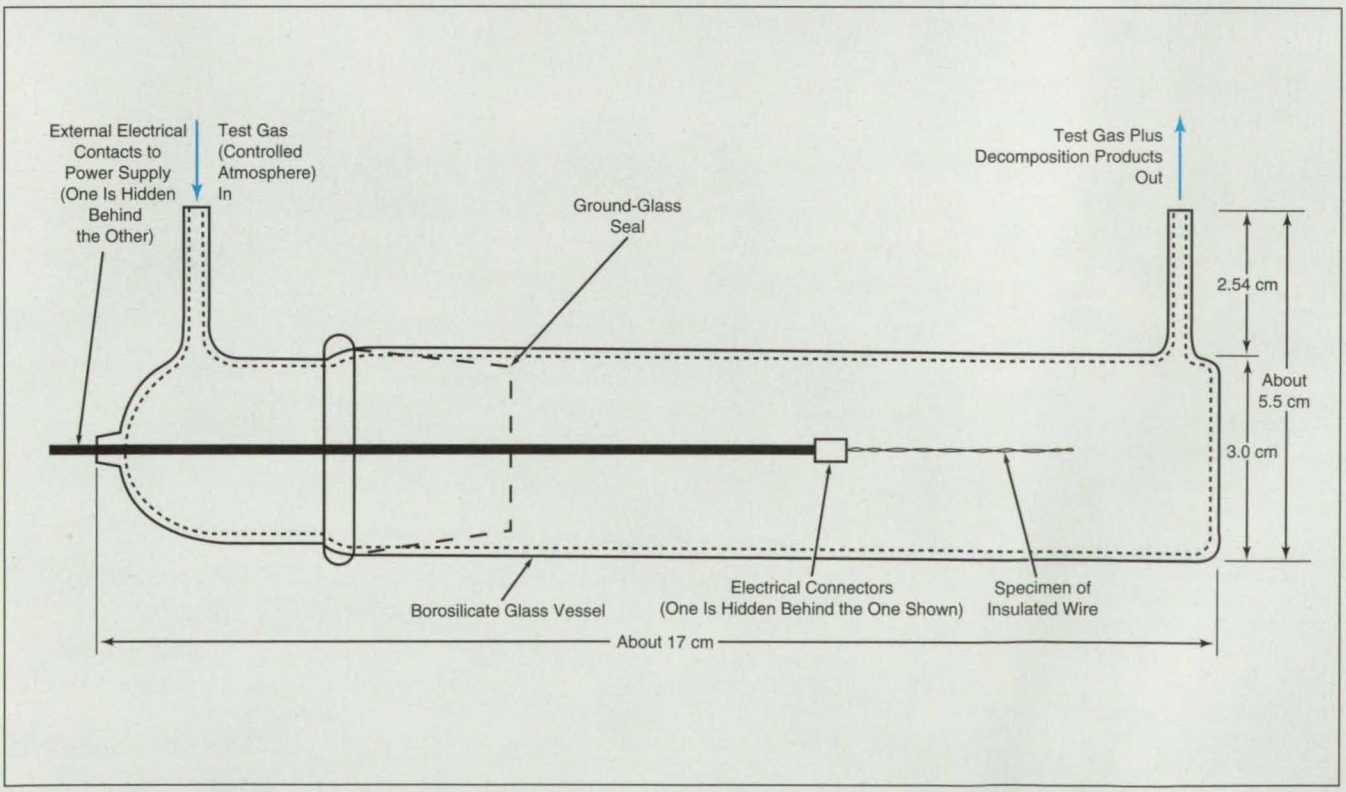
Lyndon B. Johnson Space Center, Houston, Texas

The figure illustrates a test fixture in the form of a reactor vessel equipped with electrical contacts that hold a small specimen of insulated wire by its ends. The test fixture is used, in conjunction with a gas chromatograph and/or a mass spectrometer, to analyze the gases emitted by the insulation on the wire when the wire is heated with a controlled current in a controlled atmosphere to simulate pyrolysis, combustion, and arc tracking. The test fixture and the associated equipment have been used to examine the breakdown of polyimide insulation in chemically inert atmospheres and in atmospheres that contained as much as 21 percent oxygen, the balance in each case being nitrogen, argon, or helium.

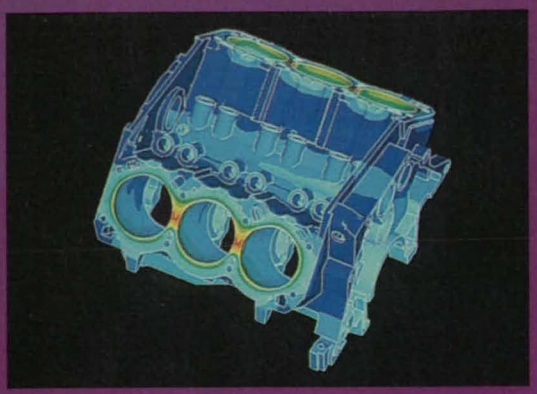
The test fixture is small, inexpensive, easily maintained, and relatively nonreactive to the organic compounds produced during breakdown of the insulation. The fixture can be used for all insulations that decompose into organic compounds that do not react chemically with the borosilicate glass of the reactor-vessel components. In cases in which the insulation under test emits compounds that react with borosilicate glass, the reactor-vessel components of the fixture can be made from fluoropolymers, fused silica, or any other suitable material that is chemically compatible with the breakdown products.

In preparation for a test, a new specimen is mounted in the fixture, which is then placed in the oven of the associated gas chromatograph. The oven is left at ambient temperature, the test atmosphere is established, and a specified current is applied to heat the specimen wire. Gas-chromatographic and/or mass-spectrometric samples of the test atmosphere are then taken to identify and quantify the breakdown products emitted into the test atmosphere during heating.

This work was done by Gary Moffett, Timothy J. Shelley, and John J. Morelli of Lockheed Engineering & Sciences Co. for **Johnson Space Center**. *For further information,* ***write in 10*** *on the TSP Request Card. MSC-22137*



This **Test Fixture** collects the gas(es) produced by heating of the insulation on the specimen. The gases are then analyzed by gas chromatography and/or mass spectrometry.



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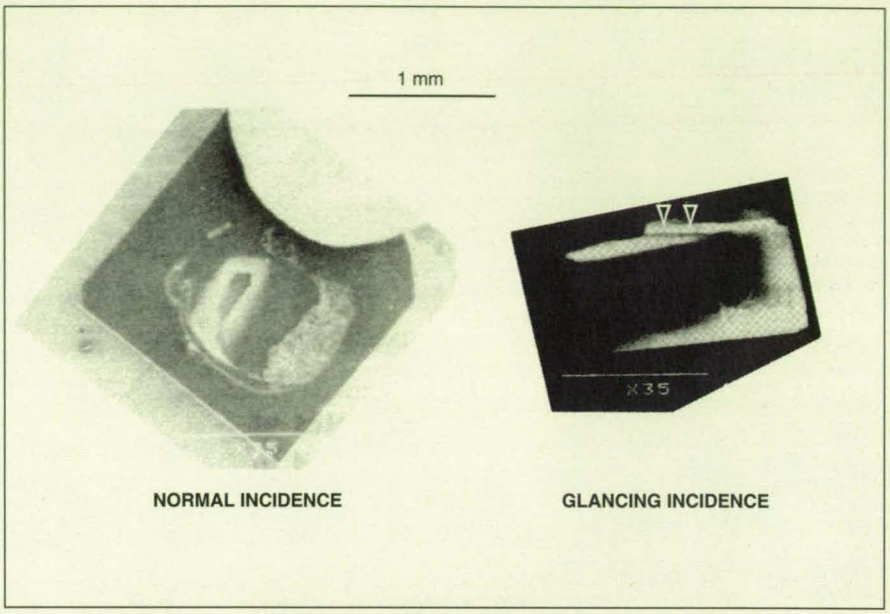
Below-Band-Gap Laser Ablation of Diamond for TEM

The use of below-band-gap radiation prevents damage in the bulk of the diamond.

NASA's Jet Propulsion Laboratory, Pasadena, California

Thin, electron-transparent layers of diamond for examination in the transmission electron microscope (TEM) can be fabricated from thicker diamond substrates by using a laser beam to ablate the surface of the substrate. Whereas an older method of ablation by laser beam involved the use of photon energy above the gap between the valence and conduction electron-energy bands ("band gap" for short) of the diamond substrate, this method involves the use of photon energy below the band gap. The growing interest in the use of diamond as a bulk substrate and as a coating material in a variety of applications has given rise to an increasing need for TEM for characterization of diamond-based materials. The below-band-gap laser ablation method may help to satisfy this need. It could also be applied in general to cutting and etching of diamonds.



These **Low-Magnification Scanning Electron Micrographs** show diamond substrates thinned by a laser beam. The glancing-incidence substrate has been cleaved in half; arrows point to the groove ablated by the laser beam.

The basic idea is that unlike above-band-gap radiation, below-band-gap radiation should not be absorbed in the bulk of the substrate. Thus, damage to the bulk of the substrate should be minimized and the major part of absorption of radiant energy should take place on the surface on which the laser beam impinges. In experiments to test the feasibility of the method, a pulsed, focused beam from a KrF excimer laser was used to thin substrates of type 1a natural diamond at normal and glancing (22°) incidence. The laser wavelength was 248 nm, whereas the band-gap wavelength of pure natural diamond is about 226 nm.

The surfaces of the laser-thinned substrates were examined by use of scanning electron microscopy (SEM). The diamond substrate thinned at glancing incidence could be examined in this way without further treatment. However, to render the substrate thinned at normal incidence transparent to electrons, it was necessary to perform argon-ion milling to remove a layer of graphitic and amorphous carbon that had formed on the ablated surface. (This layer apparently forms early in the laser ablation process and enhances the absorption of radiation at the surface.)

The figure shows low-magnification SEM micrographs of the laser-thinned diamond substrates. The front surfaces exposed to the laser beams are rough, whereas the unexposed back surfaces retain their original surface polish, confirming that damage due to laser ablation occurred only at the surfaces of incidence.

This work was done by Thomas George, Marc C. Foote, Richard P. Vasquez, and Edward P. Fortier of Caltech and John B. Posthill of Research Triangle Institute for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 17*** *on the TSP Request Card. NPO-19144*

Fast Light-Sheet Scanner

A sheet of light would be translated repeatedly along a line perpendicular to itself.

Langley Research Center, Hampton, Virginia

An optomechanical apparatus maintains a sheet of pulsed laser light perpendicular to a reference axis while causing the sheet of light to translate in oscillatory fashion along the reference axis. The apparatus produces the illumination for a laser velocimeter in which submicrometer particles entrained in a flow are illuminated and imaged in parallel planes displaced from each other in rapid succession. The selected frequency of oscillation could range upward from tens of hertz.

The apparatus includes a flat, round window mounted on a motor-driven shaft and tilted with respect to the shaft (see figure). The sheet of laser light is aimed through the window along an optical axis parallel to the shaft. Refraction of the sheet of light at the tilted surfaces of the window displaces the sheet laterally (that is, perpendicularly to the optical axis). The amount of the lateral displacement can be calculated by Snell's law as a function of the orientation, thickness, and index of refraction of the window.

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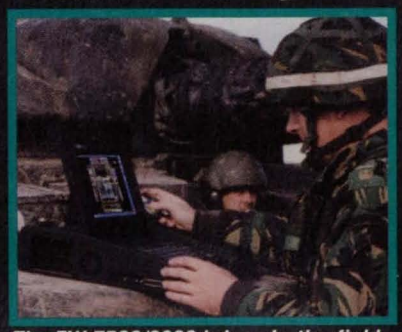

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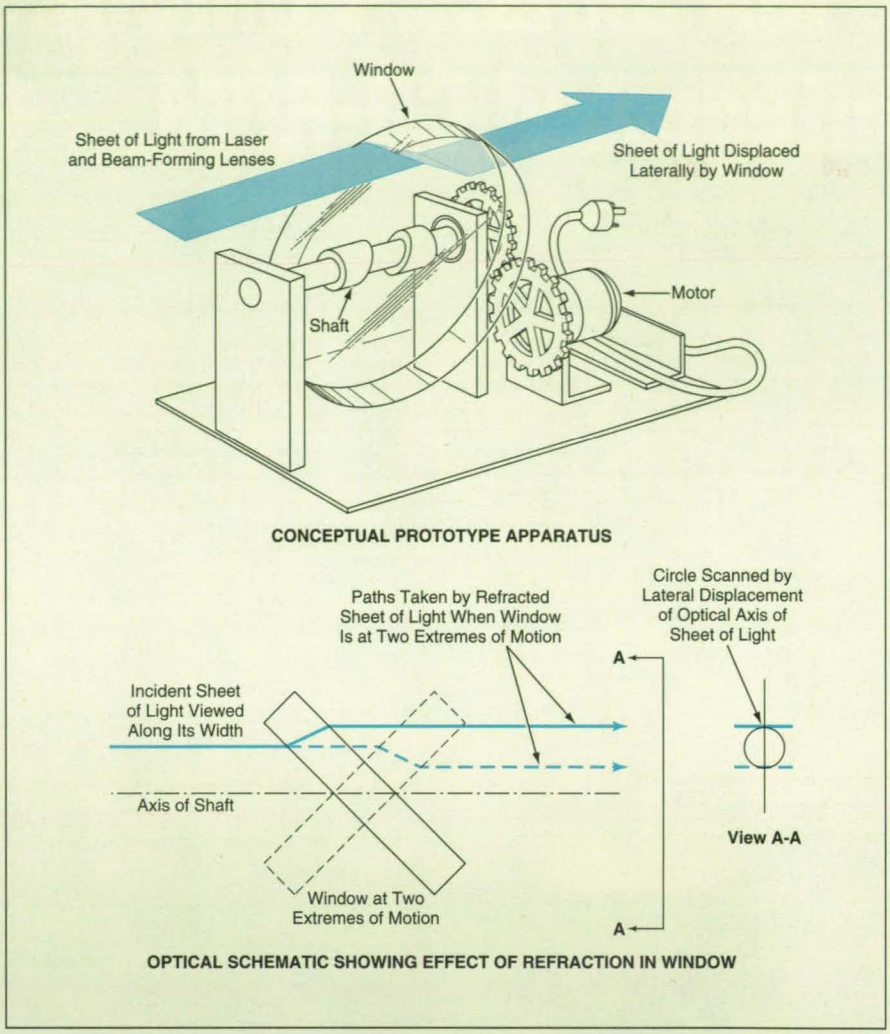
The rotation of the shaft varies the orientation of the window, causing the direction of lateral displacement to vary correspondingly. The net effect is to move the sheet continuously in a circle in a plane perpendicular to the optical axis. The component of this circular motion perpendicular to the plane of the sheet constitutes the desired oscillatory translation along the reference axis. The component of this circular motion parallel to the plane of the sheet is superfluous, but it is of little consequence because the sheet can be made wide enough to illuminate the entire desired area, even at the extremes of the oscillatory motion.

In a typical example, the sheet of laser light would be 200 mm wide; the window would have a thickness of 1 in. (25.4 mm) and an index of refraction of 1.72, and would be tilted at 45° to the shaft. The rotation of the window scans the sheet of light in a circle with a radius of about 7 mm about the original optical axis. Thus, the sheet of light moves along the reference axis between extremes 14 mm apart. The sheet also moves along the direction of its own width, but at no time would its distance from the central position be more than 3.5 percent of the width.

This work was done by William W. Hunter, Jr., William M. Humphreys, Jr., and Scott M. Bartram of **Langley Research Center**. *No further documentation is available. LAR-14644*



The **Rotating Window** would continuously shift the sheet of light laterally while maintaining the sheet parallel to the same plane.

Dual Wall Angles Would Enhance Performance of a Solar Pond

A proposed design would compromise between maximizing heating and minimizing convection.

Marshall Space Flight Center, Alabama

A proposed dual-angle design for the Sun-facing wall of a solar pond (see figure) would enhance the solar-energy-storage performance of the pond; the increase in performance over that of a similar pond with a conventional (single-angle) wall is estimated to be 25 percent. This is a potentially important improvement because solar energy stored in ponds is likely to become a significant component of the energy supply in the next century.

The proposed dual-angle design would compromise between (1) the need to maximize the amount of solar radiation arriving on the wall and (2) the need to suppress convection (because convection transports stored heat from the depths to the surface, where the heat is then dissipated into the ambient air). Heretofore, salt and/or barriers have been used to suppress convection in solar ponds, but these measures increase costs and, in the case of salt, can be harmful to the environment. The figure of merit for suppression of the instability that gives rise to convection would be 5 to 6 times that of a pond with a conventional single-angle wall. This marginal improvement would help in making solar ponds economically competitive with fossil-fueled (e.g., oil-fired) heating systems.

In the proposed design, the top part of the Sun-facing wall would be optimized for the top, colder layer of water, where there is less of a tendency toward convective mixing. The bottom part of the wall would be optimized for the bottom, warmer layer of water, where there is a greater tendency toward convection. The optimization involves consideration of both the anticipated temperature-vs.-depth profile (which affects the tendency toward convection) and the latitude (which affects the angle of incidence of solar radiation and thus the rate of heating). More solar radiation arrives on a somewhat tilted wall than on a vertical wall, and the greater amount of heat thus stored increases the driving force for convection. A great-

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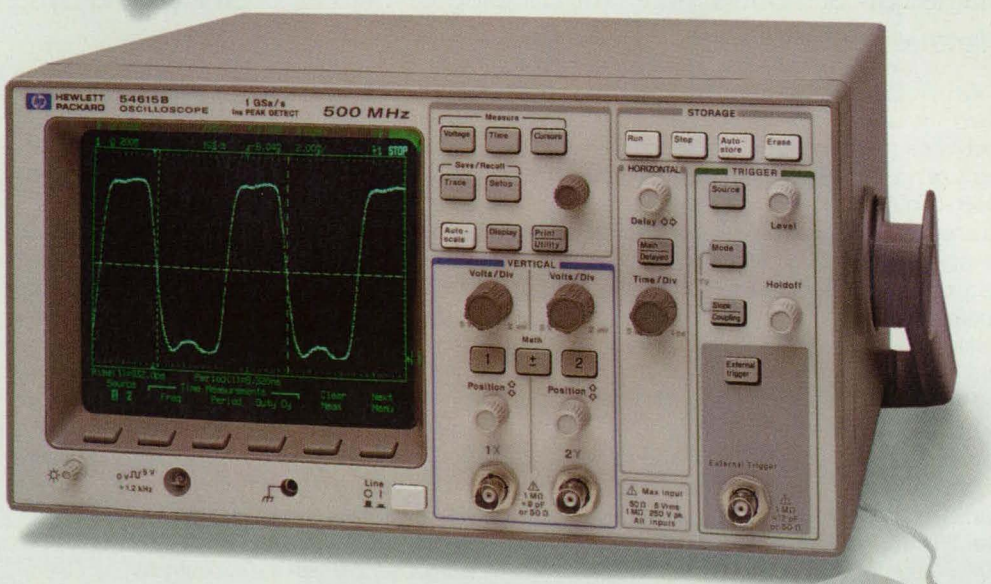

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ly tilted wall suppresses convection by making a pond shallower, on the average, than it is with a vertical wall.

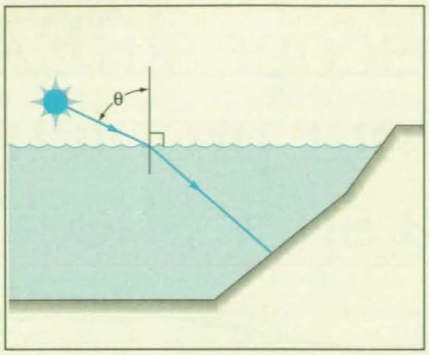
A numerical criterion called the "normalized instability potential" (NIP) has been introduced for use in evaluating the effects of wall angles and temperature layers on the stability or instability of a solar pond. The NIP for a layer is given by

$$NIP = \sin \Phi \{\sin \Phi + [(n/\sin \theta)^2] \cos \Phi\}\Delta^4,$$

where Φ is the angle of the wall in the layer, n is the index of refraction of water, θ is the angle of incidence of sunlight, and Δ is the ratio between the absolute temperature of the layer and the absolute temperature of the ambient air. The composite NIP for the two layers is given by

$$NIP_{total} = \varepsilon NIP_1 + (1-\varepsilon)NIP_2,$$

where ε is the fraction of total depth occupied by one of the layers and the subscripts 1 and 2 refer to the two layers. To optimize the wall angles, one can solve these two equations simultaneously with the help of a genetic algorithm, which, as its name suggests, works on a principle of evolution by random selection and survival of the fittest.



The **Dual-Angle** slope of the north wall (in the Northern Hemisphere) or the south wall (in the Southern Hemisphere) would enhance the performance of a solar pond.

This work was done by David A. Noever of **Marshall Space Flight Center.** *For further information,* ***write in 47*** *on the TSP Request Card. MFS-28917*

Algorithm for Computation of Chemically Reacting Flow

Mathematical models represent coupling of thermal, chemical, and dynamical effects.

Marshall Space Flight Center, Alabama

An efficient algorithm is being developed for use in solving the differential equations of transient, chemically reacting flows at all speeds from zero to high mach numbers. The original intended application is numerical simulation of flows in rocket engines; the algorithm should also be applicable, in general, to other complex flows affected by finite-rate chemistry — for example, flows in turbines and in internal-combustion engines.

The development of the algorithm has involved much analysis of the computational problems posed by the coupling of chemistry with the dynamics of fluids; particular attention has been directed to the difficulties created by the wide disparity among the various time scales characteristic of flow phenomena, chemical reactions, and transport of heat.

The algorithm is of the predictor/corrector noniterative type. It is based on a time-accurate general pressure-based flow-solving algorithm called "FDNS," into which an operator-splitting procedure and an efficient ordinary-differential-equation-solving algorithm called "DEBDF" have been incorporated. In the predictor step of the computational procedure, the chemical-kinetics terms are integrated implicitly, by use of DEBDF, over a time scale characteristic of the fluid in question. In the corrector step, the resulting effective chemical source terms are substituted into the fluid-dynamics equations together with convection and diffusion terms, and the integration takes place in a noniterative time-marching solution method.

Different chemical kinetics with different degrees of nonlinearity have also been incorporated to test the robustness and generality of the algorithm. A mathematical model of spray combustion breakup of droplets, turbulent dispersion, evaporation of droplets, and collision between droplets was also incorporated.

The algorithm has been validated in a variety of benchmark test cases of one- and two-dimensional reacting flows. Comparisons of data on transient flows computed by this algorithm with data from experiments and from other numerical simulations indicate that this algorithm correctly predicts the propagation of combustion waves, although there is still a need to investigate some unknown aspects of such phenomena. The algorithm is very efficient in computing each time step in the case of a transient, chemically reacting flow. The algorithm has also been validated with respect to steady-state premixed or diffusion flames.

This work was done by Yen-Sen Chen, Chein-Pin Chen, and Huan-Min Shang of Engineering Sciences, Inc., for **Marshall Space Flight Center**. *For further information,* ***write in 90*** *on the TSP Request Card. MFS-26267*

Computing Instability in Combustion of Liquid Propellants

A user-friendly CFD code is undergoing development.

Marshall Space Flight Center, Alabama

A computational fluid dynamics (CFD) code is being developed for use in design analyses of flow instabilities associated with combustion of sprayed liquid propellants in rocket engines. The code may also contribute to the design of improved commercial sprayed-fuel combustors in furnaces and jet engines. The code, when fully developed, should prove to be a robust, user-friendly software tool with a comprehensive analysis capability.

The code does not involve any phenomenological combustion-response models. It enables characterization of stability or instability of an engine in terms of such physically meaningful parameters as the initial conditions of the spray, the spatial distribution of the ratio between concentrations of fuel and oxidizer at injector faces, the geometry of the combustor, and configurations of baffles. The salient features of the code are the following:

- The transient combustion response is based on a comprehensive mathematical model of spray combustion.

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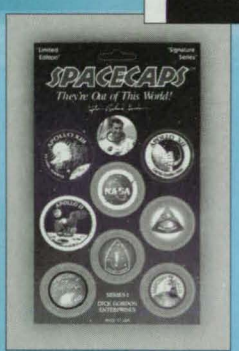

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This implies that the time lag associated with the driven mechanism of combustion instability is contributed by the droplet heat-up period, the time scale for turbulent mixing, the ignition delay time, and the time scale for breakup of droplets.

- The coupling between pressure and velocity is modeled by a pressure-based method. This method is noniterative for fast calculation of transient flows and is applicable to flows at all speeds from zero to hypersonic.
- All physical submodels are incorporated into the three-dimensional, multizone Finite-Difference Navier-Stokes (FDNS) CFD code.
- The parcel-probability-density-function stochastic tracking method is used to represent accurately the turbulent dispersion of droplets and to eliminate the computationally induced high-frequency noise associated with the injection of droplets. The major advantage of this feature is reduction of the number of computational particles needed to represent the dynamics of the spray and to obtain solutions independent of computational grids in cases of multiphase flows.
- The primary and secondary breakups of droplets are mathematically modeled by Reitz's wave-instability method on the basis of the reasonable assumption that atomization and breakup of drops are indistinguishable processes within a dense spray near the outlet of the injector. Atomization is prescribed by injecting drops that have a characteristic size equal to the diameter of the injector outlet. This feature is especially efficient in cases that involve multiple injectors.
- The modulation of turbulence by droplets is modeled semiempirically by inclusion of additional source terms in turbulence-transport equations.
- Rates of evaporation and heating of droplets are determined by a general mathematical model of evaporation that is continuously valid from subcritical to supercritical conditions.

The code as developed thus far has been validated by use of data from benchmark studies. Inasmuch as the code features a predictor/corrector noniterative algorithm for solution of the equations of flow, it is very efficient in the sense that it requires relatively little computational time for each physical time step in a transient flow.

This work was done by Yen-Sen Chen and Huan-Min Shang of Engineering Sciences, Inc., for **Marshall Space Flight Center.** *For further information,* ***write in 91*** *on the TSP Request Card.*
MFS-26268

Chelation and Extraction of Metals for GC-MS Analysis

Chelation followed by supercritical-fluid extraction may enable mass-spectrometric analysis.

NASA's Jet Propulsion Laboratory, Pasadena, California

In the proposed method of quantitative analysis of metal-ion contaminants in solid and aqueous environmental samples, the metal ions would first be chelated, then extracted from the samples and carried through a suitable restrictor to a gas-chromatograph/mass-spectrometer (GC-MS) by using a suitable supercritical fluid. When fully developed, the method might be implemented in a field-portable apparatus for the detection and quantification of metals in various matrices without the need for elaborate preparation of samples. The apparatus could be used, for example, to analyze soil samples for toxic metals.

Heretofore, a GC-MS apparatus could be used to analyze samples of soil for organic materials but not for metals, because there was no way to extract the metals from the samples and present the metals to the mass spectrometer in the required gaseous form. It would be highly cost effective if both metals and organic compounds could be analyzed by the same technique of mass spectrometry. Accordingly, the key step in the proposed technique would be the chelation, which would convert the metal from an ionic form that is essentially insoluble in a typical super-critical fluid to a chelated form that is soluble in a supercritical fluid. Because metal chelates extracted via a supercritical fluid are effectively in the gaseous state, they can be introduced directly into a mass spectrometer for analysis.

On the basis of their demonstrated ability to form metal chelates, 8-hydroxyquinoline, acetyl acetone, dialkyldithio-

carbamates, and ethylenediamine tetraacetic acid (EDTA) have been selected for investigation of their suitability as chelating agents in the proposed technique (see table). The investigation will also address the use of tetralkyl ammonium ions to increase the solubilities of metal complexes. In experiments, the supercritical-fluid extract will be led directly into the ion source through a restrictor. A rhenium filament will be installed in the ion source to increase the fragmentation of the chelates, leading to the formation of metal ions for mass-spectral analysis. The samples (for example, soil) will be leached with an acid and/or hydrogen peroxide to bring the metals and/or metal oxides into solution prior to chelation.

Metal Ion	Acetyl Acetone	EDTA	8-hydroxy-quinoline
Cd^{2+}	3.8	16.5	7.8
Co^{2+}	5.4	16.3	9.1
Cu^{2+}	8.2	18.8	12.2
Ni^{2+}	5.9	18.6	9.9
Zn^{2+}	5.0	-	8.5
Hg^{2+}	-	21.8	-
Pb^{2+}	-	18.0	9.0
Cr^{3+}	-	Very Favorable	-

Log K_f Values for three of the candidate chelating agents are given for eight metal ions. (K_f is called the "formation constant" and is used as a measure of chelation performance.)

This work was done by Mahadeva P. Sinha of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 38*** *on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Resident Office–JPL; (818) 354-5179. Refer to NPO-19002.

Graphite-Fiber Heat Radiators

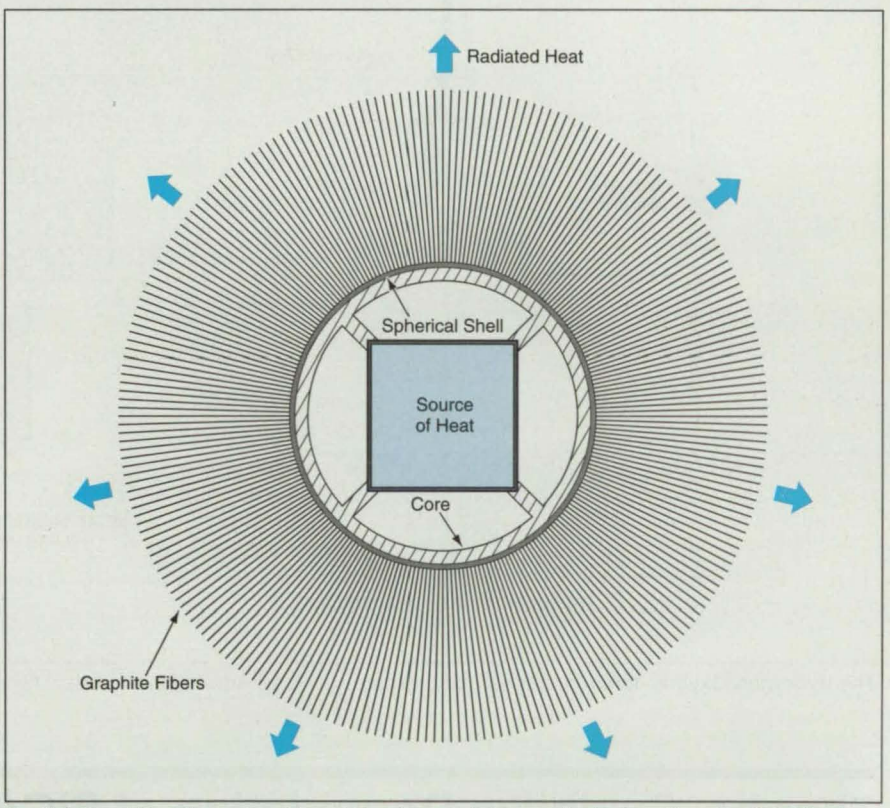
Conceptual units could supplant heat-pipe radiators at low to moderate heat-dissipation rates.

NASA's Jet Propulsion Laboratory, Pasadena, California

Heat radiators of a proposed type would feature thermally conductive fibers protruding from metallic surfaces to provide increased heat-dissipation surface areas. Originally intended for use in the vacuum of outer space, these radiators may prove useful on Earth in special industrial and scientific applications that involve dissipation of heat in vacuum or in relatively still air. Because these radiators would not rely on internally contained liquid or gaseous heat-exchange media, they would be free of leaks and more reliable than are radiators that incorporate heat pipes. They would also be lightweight and relatively inexpensive.

The fibers would be commercial graphite fibers that have become available in recent years and that exhibit a desirable combination of both toughness (unlike commercial graphite fibers available previously, they can be tied in knots without breaking) and high thermal conductivity (1,000 $Wm^{-1}K^{-1}$). Fibers with these attributes would not have to be embedded in a matrix material for support. Without a matrix material to interfere, these fibers should be able to conduct heat efficiently and radiate it into space.

The figure illustrates a radiator of the proposed type, consisting of a spherical metal shell covered with a sparse, brushlike array of graphite fibers extending perpendicularly from the surface. The shell would surround the source of heat. The inner ends of the fibers would be attached to the shell by solder joints. The fibers would increase the effective radiative surface area to about 100 times that of a flat-plate radiator of comparable size. Each fiber would be spaced about 10 fiber diameters from its nearest neighbors, so that shadowing of fibers by other fibers should be small and there would be ample solid angle for each fiber to radiate directly to space.



Radial Graphite Fibers would carry heat away from a spherical shell and radiate the heat into space.

Each fiber would be metallized at one end so that it could be soldered or brazed to the shell. The first layer to be deposited in the metallization process would be one of silicon, which would bond to the graphite fiber by forming silicon carbide on its surface. Next a layer of copper containing a small amount of titanium or zirconium would be deposited to provide a solderable or brazeable surface.

This work was done by Wayne M. Phillips of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 100*** *on the TSP Request Card. NPO-19298*

Hydrogen/Oxygen Torch Ignitor

This reliable device can be used to ignite a variety of fuels.

Lewis Research Center, Cleveland, Ohio

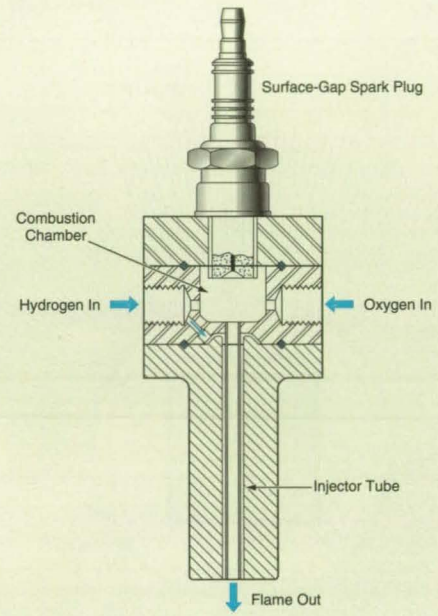
The figure illustrates a hydrogen/oxygen torch ignitor that is reliable and simple to operate. This device is the latest in a series of such devices that have been used for more than 20 years to ignite a variety of fuel/oxidizer mixtures in research rocket engines. The device can also be used as a general-purpose ignitor in other applications, or as a hydrogen/oxygen torch.

The operation of this device is straightforward. Hydrogen and oxygen flow through separate ports into a combustion chamber in the device, where they are ignited by use of a surface-gap spark plug. The hot gases flow from this combustion chamber, through an injector tube, into the larger combustion chamber that contains the fuel-oxidizer mixture to be ignited.

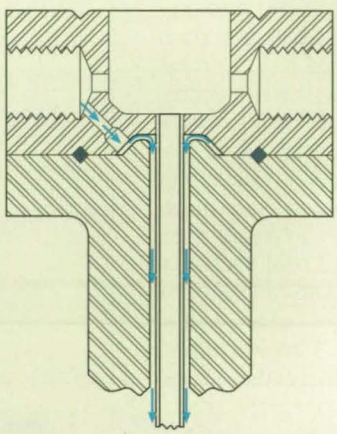
The pressures and flows of hydrogen and oxygen are adjusted to obtain a pressure of about 135 psig (gauge pressure of 0.93 MPa) in the combustion chamber during operation. The pressures and flows are also adjusted for an oxidizer/fuel ratio of 40 to obtain a combustion temperature of 2,050 K, which is low enough that there is no need to cool the combustion chamber if the operating time is short enough.

Some of the flow of hydrogen is diverted to the annular space surrounding the injector tube to cool the injector tube. The rate of this cooling flow is chosen so that when it mixes with the hot gases at the outlet of the injector tube, the resulting oxidizer/fuel ratio is 5. The resulting flame at the outlet is about 12 in. (about 30 cm) long and its temperature is about 3,100 K.

This work was done by George A. Repas of **Lewis Research Center.** *For further information,* ***write in 99*** *on the TSP Request Card. LEW-16080*



HYDROGEN/OXYGEN TORCH IGNITOR



DETAIL SHOWING COOLING FLOW OF HYDROGEN ALONG OUTSIDE OF INJECTOR TUBE

The **Hydrogen/Oxygen Torch Ignitor** can be used as a general-purpose ignitor or as a hydrogen/oxygen torch.

Thermo-Oxidative Degradation of SiC/Si_3N_4 Composites

Nondestructive tests reveal critical exposure times.

Lewis Research Center, Cleveland, Ohio

An experimental study was conducted on the thermo-oxidative degradation of composite-material specimens made of silicon carbide fibers in matrices of reaction-bonded silicon nitride. It was known from previous research that the properties of this and other ceramic-matrix composites are dominated by interphases — the materials and material phases in the interfacial regions between fiber and matrix materials. In the SiC/Si_3N_4 composites of this study, the interphase is a 3-μm-thick carbon-rich coat on the surface of each SiC fiber. Thermo-oxidative degradation of these composites involves the diffusion of oxygen through the pores of the composites to the interphases, which are then damaged by oxidation. In this study, the specimens were exposed to flowing oxygen for times ranging from 0.1 to 100 h, at temperatures ranging from 600 to 1,400 °C. The moduli of elasticity of the specimens after exposure were computed from measured velocities of propagation of ultrasonic waves in the specimens. Decreases in

these moduli are sensitive indicators of damage by oxidation in the interphases. The investigators analyzed changes in the experimentally determined moduli as functions of time and temperature in the effort to identify the critical exposure times for transitions from nonoxidized to the oxidized states, thus determining ranges of time during which the composites can resist oxidation at various temperatures. Depending on temperatures, critical exposure times are quite short: for example, at 900 °C, the critical exposure time was found to be only 6 min.

This work was done by George Y. Baaklini and Ramakrishna T. Batt of **Lewis Research Center** *and Stanislav I. Rokhlin of Ohio State University. No further documentation is available.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Lewis Research Center; (216) 433-2320. Refer to LEW-15997.

Study of Nondestructive Techniques for Testing Composites

Efficacies in characterizing microstructures and properties are evaluated.

Lewis Research Center, Cleveland, Ohio

A study was conducted to evaluate some nondestructive methods for characterizing ceramic-, metal-, and polymer-matrix composite materials. The methods were (1) a method of precise ultrasonic measurements and mapping (which yields data on velocities of sound, coefficients of attenuation, and peak frequencies of echoes), (2) acousto-ultrasonic methods (which yield data on velocities and rates of decay of waves in plates), and (3) time-resolved thermography. The results of the experiments demonstrated the utility of the two ultrasonic methods for obtaining quantitative data on microstructural anomalies in composite materials. In particular, they showed that speeds of sound vary with fractions of volume occupied by pores and by fibers, and that coefficients of attenuation increase with degrees of inhomogeneity of volume fractions of pores and fibers. The results also confirmed the efficacy of time-resolved thermography as a noncontact, nonionizing method for detecting microstructural anomalies like delaminations: time-resolved thermography is all the more valuable for this purpose in that it involves access to only one side of a specimen and can thus be used at more stages of fabrication and processing than could a testing method that depended on access to both sides.

This work was done by D. Roth, H. Kautz, S. Draper, N. Bansal, and K. Bowles of **Lewis Research Center,** *M. Bashyam of General Electric Co., and C. Bishop of Bales Scientific, Inc. No further documentation is available.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Lewis Research Center; (216) 433-2320. Refer to LEW-15996.

Fitting Prony Series to Data on Viscoelastic Materials

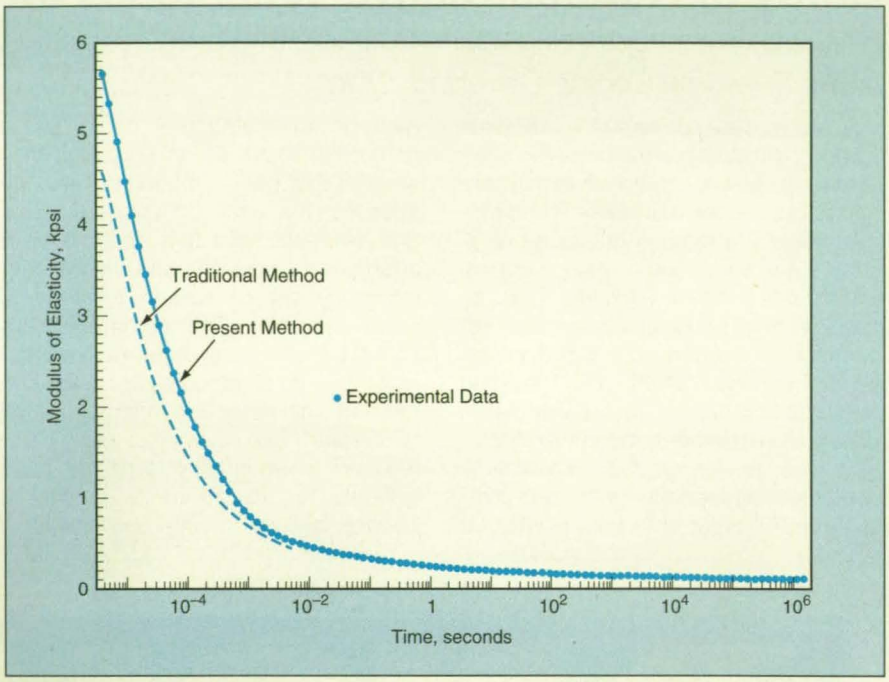
Design-optimization techniques are used.

Marshall Space Flight Center, Alabama

An improved method of fitting Prony series to data on viscoelastic materials involves the use of least-squares optimization techniques. A Prony series is of the form $f(t) = A + \Sigma B_i \exp(\gamma_i t)$; where f is the dependent variable (in this case, a modulus of elasticity); t is the independent variable (in this case, time); and A, the B_i's, and the γ_i's are constants to be determined by fitting $f(t)$ to experimental data (in this case, stress-relaxation data on the modulus of elasticity vs. time).

Heretofore, Prony series have typically been fit to such data by either (1) least-squares regression using assumed values of the γ_i's or (2) exact analytical solution using only the first two terms of the series. The first of these techniques obviously involves the risk of erroneous assumed values, while the small number of Prony terms in the second technique may not suffice to characterize all the subtleties of experimental data.

The present improved method involves no assumptions regarding the γ_i's and higher-order terms, and provides for as many Prony terms as are needed to represent the higher-order subtleties in the data. The essence of the present method is to adjust A, the B_i's, and the γ_i's iteratively to obtain a "best" fit of $f(t)$ to the experimental data, the fit being best in the sense that it minimizes a nonlinear error function known as the sum of residuals squared. The curve-fitting problem is treated as a design-optimization problem and is solved by use of partially-constrained-optimization techniques. The method is implemented by the PRONY computer program, which is a FORTRAN 77 code that incorporates optimization subroutines from a general optimization program called "Design Optimization Tool."



The **Present Method** based on optimization techniques yields a closer correlation with the data than the traditional method does.

In one of several tests of the present improved method, two Prony series were fit to data from stress-relaxation measurements on a specimen of a commercial viscoelastic fluoroelastomer. The first series, containing 14 terms, was fit by the traditional method of assuming the γ_i's, linearizing the resulting function, then solving for A and the B_i's by least-squares techniques. The second series, also containing 14 terms, was fit by the present method. The figure illustrates the superiority of the fit obtained by the present method.

This work was done by S. A. Hill of **Marshall Space Flight Center**. *For further information,* ***write in 112*** *on the TSP Request Card. MFS-28937*

Comparing Alternatives for Replacing Harmful Chemicals

Chemicals and processes are ranked numerically.

Marshall Space Flight Center, Alabama

A methodology has been developed to provide guidance for the replacement of industrial chemicals that must be phased out by law because they are toxic and/or affect the environment adversely. The methodology has been applied mostly to chemicals that contribute to depletion of ozone in the upper atmosphere; some other harmful chemicals have also been included. The chemicals in question are used in many pro-cesses that fall into such general categories as application of adhesives, blowing foams, applying insulation, brazing, cleaning, laboratory analysis, and surface conditioning (e.g., plating and anodizing).

This methodology is basically an adaptation of quality function deployment (QFD), which is a methodology that is used in the automotive industry. QFD was developed in Japan in the early

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For More Information Write In No. 511

1970s to help in planning products by transforming customers' wants and needs into quantitative engineering terms. In the present adaptation, QFD is used to address is-sues that pertain to chemicals and pro-cesses in which the chemicals are used; the issues include chemical and processing concerns and criteria, costs, scheduling, safety, and pertinent laws and regulations. The methodology provides conceptual tools for comparing alternative replacement chemicals and for assigning priorities for replacement.

The methodology involves checklists and matrices, which are used to develop quantitative figures of merit for alternative materials. For example, checklist A is a list of chemicals to be evaluated for replacement; it includes some toxic metals and metal compounds, chlorinated solvents, benzene and related compounds, and chlorofluorocarbons, ammonia, hydrogen fluoride, sulfur trioxide, and other compounds. Checklist B is a list of potential concerns involved in changing chemicals; for example, laws and regulations, costs, toxicity, effects on the environment, and interactions among chemicals.

Ten matrices are constructed to analyze the broad spectrum of concerns. Matrix A, for example, defines the target chemicals in terms of the parts and processes in which they are used. Matrix B assists in the evaluation of the technical maturity of the chemicals and processes. Matrix C provides for evaluation of the risk of hardware failure if a proposed substitution were made.

Optionally, to obtain a comprehensive rating, the data from the matrices are gathered into one large QFD matrix (see figure). The user lists the various concerns vertically and each chemical/process, old and new, horizontally. The relationship of each concern to each chemical/process is then rated on a scale of 1 (weak) to 9 (strong). Next, a weighting factor from 1 to 20 is assigned to each concern to indicate its relative importance. To obtain the overall rating for each chemical-and-process combination, the user multiplies the weighting factor by the relationship parameter and totals the products thus obtained at the bottom of each column. The chemical-and-process combination with the highest overall rating would be deemed to be the best alternative, or if prioritizing, the highest priority for replacement efforts.

The QFD methodology can be applied by use of a computer program called "QFD/CAPTURE." "MAPTIS," a Marshall information system, also contains a working data base for use in prioritization. MAPTIS provides for the user to enter a process-and-chemical combina-

tion to be evaluated, then to select the concerns associated with that combination. Then MAPTIS asks the user to enter weighting factors for each concern. MAPTIS uses these factors to compute the overall ratings of the various chemical-and-process combinations.

This work was done by W. Cruit, S. Schutzenhofer, B. Goldberg, and K. Everhart of **Marshall Space Flight Center**. *For further information,* ***write in 7*** *on the TSP Request Card.*
MFS-27319

	Weighting Factor	Chemical/ Process 1	Chemical/ Process 2	Chemical/ Process 3
Concern 1	10	3	9	1
Concern 2	15	1	9	3
Concern 3	12	9	1	9
Overall Rating		153	237	163

Relationship Parameters

The **QFD Matrix Format** provides a convenient way to compare alternative processes and chemicals. The overall rating at the bottom of each process-and-chemical column indicates its relative advantage.

Composite of Bisfuran/Bismaleimide With Graphite Fibers

Mechanical properties equal or exceed those of a composite made with a commercial formulation.

Lewis Research Center, Cleveland, Ohio

Composite-material specimens have been made of graphite fibers and a matrix composed of an experimental copolymer of a bismaleimide and a bisfuran. These composite specimens have been found to have mechanical and thermal properties comparable or superior to those of similar composite-material specimens in which the matrix is a copolymer made from a commercial mixture of the same bismaleimide plus a bisallene.

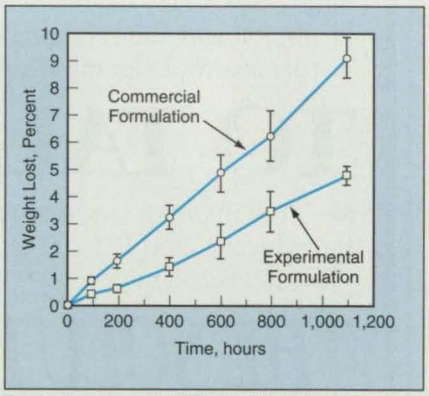
These composites are candidates for use as lightweight structural components to replace metal components in high-temperature aircraft applications. Bismaleimides have been used widely for other purposes because of low cost and ease in fabrication. However, the thermal stability of the bismaleimides used previously has been too low for high-temperature aircraft applications, and they exhibit a strong tendency to develop microcracks.

The bismaleimide that is common to both composites is 4,4′-bismaleimidodiphenylmethane (DPM-BMI). The bisfuran monomer used to make the experimental copolymer is 4,4′-bis(2-furfuryl) phenylether (BFPE), and it is used in a 1:1 stoichiometric ratio with DPM-BMI. The commercial bismaleimide resin mixture is a 1:1 stoichiometric mixture of DPM-BMI with 3,3′-diallylbisphenol A (DABPA).

To begin the fabrication of the composite materials, the mixtures of monomers were dissolved in methylene chloride and painted onto graphite fibers. Twelve-ply unidirectional laminates were fabricated from the coated fibers. Each laminate was cured in a vacuum bag by rapid heating to a temperature of 170 °C under vacuum, holding at that temperature for 10 min, then applying an external pressure of 50 psi (340 kPa) and continuing to hold at that temperature and pressure for 1 h. Each laminate was then postcured in air at 260 °C for 4 h.

In thermomechanical tests, the composite specimens made from the experimental copolymer exhibited excellent initial mechanical properties when compared with the specimens made from the commercial mixture. Some interlaminar failure was observed in flexural tests of both composites, probably because of the brittle nature of the copolymers, which are highly cross-linked. With respect to loss of weight at high temperature, the experimental composite proved to be clearly superior (see figure). During aging of the composites at a high temperature [500 °F (260 °C)], the mechanical properties of both composites deteriorated similarly.

This work was done by Mary Ann B. Meador of **Lewis Research Center** *and John F. Waters and William M. Ritchey of Case Western Reserve University. No further documentation is available. LEW-15992*



During Aging at 500 °F (260 °C), the composite specimens made with the experimental copolymeric matrix lost about half as much weight as did those made with a commercial bismaleimide matrix material.

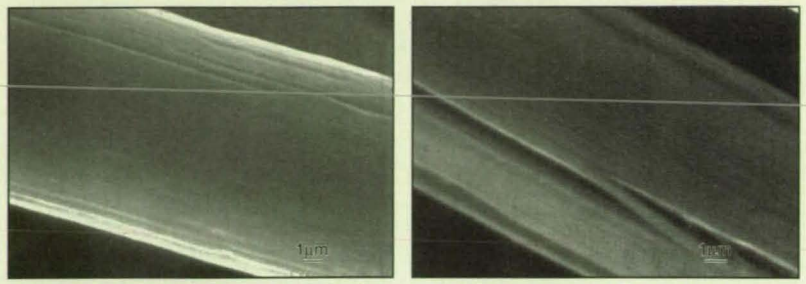
Storing Fluorine in Graphitelike Carbon Fibers

Fluorine can be stored in carbon fibers more conveniently and safely than it can be held in tanks.

Lewis Research Center, Cleveland, Ohio

Fluorine can be stored in graphite or graphitelike carbon fibers for later release and/or use in chemical reactions. Storage in carbon fibers eliminates the difficulty and risk of using high-pressure tanks and pipes to hold the corrosive gas, either as an element or in an interhalide compound. Furthermore, storage in carbon fibers makes fluorine more readily accessible than does storage as constituent of a metal fluoride.

The carbon fibers can be heated to release the stored fluorine, which can be drawn away to a vessel where it reacts with the material to be fluorinat-



(a) IODINE-INTERCALATED GRAPHITE FIBER AFTER FLUORINATION

(b) BROMINE-INTERCALATED GRAPHITE FIBER AFTER FLUORINATION

Fluorination Damages Graphite Fibers that are untreated, and inflicts somewhat less damage on fibers that have been intercalated with bromine. Intercalation with iodine reduces the damage further.

ed, possibly at a temperature other than the release temperature. Alternatively, the material to be fluorinated can be mixed or otherwise placed in contact with the fibers and the entire mass heated to or beyond the release temperature.

Pitch-based fibers are prepared for fluorination by an intercalation process in which atoms of another halogen (ordinarily, bromine) are introduced into the spaces between the planes of the graphite molecules. The intercalated fibers are then fluorinated by exposing them to fluorine gas at 250 to 450 °C. The fibers covalently bond approximately their own weight in fluorine. After treatment, the fibers retain the fluorine indefinitely at room temperature. However, when heated to a temperature range of 250 to 400 °C, the fibers release fluorine.

Direct exposure of unintercalated pitch-based fibers to fluorine does not cause any reaction at a temperature below 300 °C, but causes the fibers to split at 300 °C or higher. Intercalation with another halogen reduces the damage that the fibers incur when exposed to fluorine. Intercalation with bromine reduces the damage somewhat. Iodine is more effective in this regard (see figure), but carbon fibers cannot be intercalated with iodine directly. However, if a small amount of bromine is mixed with the iodine vapor, then iodine can be intercalated into the fibers. For this purpose, the fibers are placed in a reactor that also contains air, isoprene rubber, and an excess of solid iodine. The reactor is heated to 50 to 150 °C, and the iodine vaporizes.

Liquid bromine is added to the reactor. The temperature is adjusted as necessary so that it is above the boiling temperature of bromine (58 °C) but below that of iodine (183 °C). Most of the bromine boils away and is captured by the isoprene rubber, which selectively absorbs bromine vapor but not iodine. The iodine vapor and the small amount of bromine remaining initiate the intercalation reaction, which takes only a few hours to go to completion.

This work was done by Ching-cheh Hung of **Lewis Research Center**. *For further information,* ***write in 88*** *on the TSP Request Card.*

This invention has been patented by NASA (U.S. Patent No. 5,286,471). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Lewis Research Center; (216) 433-2320. Refer to LEW-15359.

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Physical Sciences

Program for Finite-Element Analyses of Phase-Change Fluids

Heat-transfer and flow phenomena are modeled via equations of state and conservation laws.

PHASTRAN is a program that analyzes the heat-transfer and flow behaviors of materials undergoing phase changes. Many phase changes, such as those that occur in aerospace thermal systems, operate over a range of accelerations or effective gravitational fields. To analyze such thermal systems, it is necessary to obtain simultaneous solutions for the equations of conservation of energy, momentum, and mass, and for an equation of state. A numerical procedure for solving such equations is presented in PHASTRAN.

The Galerkin form of the finite-element method is used to solve for the spatial variation of field variables, along with an implicit Crank-Nicolson time-marching algorithm. The variable-property forms of the governing equations are developed in two-dimensional Cartesian coordinates for a Newtonian Fluid. Quadratic Lagrangian elements are used for internal energy and the two components of velocity. Linear Lagrangian elements are used for pressure. The location of the solid/liquid interface as well as the temperatures are determined from the calculated internal energy and pressure. This provides for a description of heat transfer without phase change, phase change with a sharp interface, and phase change without an interface.

PHASTRAN is written in APL2 for IBM PC-series and compatible computers running either MS-DOS or OS/2. A DOS or OS/2 APL2 interpreter is required. The memory requirement varies with the size of the problem; however, 32MB or more of random-access memory is recommended. PHASTRAN can also be executed on IBM mainframe computers running MVS (using the MVS APL2 interpreter). The standard distribution medium for PHASTRAN is a 3.5-in. (8.89-cm), 1.44MB, MS-DOS-format diskette. PHASTRAN was developed in 1991 and released to COSMIC in 1994.

This program was written by L. A. Viterna of **Lewis Research Center.** *For further information,* ***write in 30*** *on the TSP Request Card. LEW-16131*

Software Helps Extract Information From Astronomical Images

This interactive program provides many functions for display and analysis of images.

IPAC Skyview 2.0 is an interactive program for display and analysis of astronomical images. This program includes a large set of functions for the display, analysis and manipulation of images. "Man" pages with descriptions of functions and examples of usage are included. Skyview can be used interactively or in the "server" mode, in which another program calls Skyview and executes the commands itself. Skyview is capable of reading image data files of four types, including those in FITS, S, IRAF, and Z formats.

The "paint" command is the most important Skyview command because it displays the images on the screen. When used with no parameters, "paint" displays the current image file. If the file parameter is specified, then that file is painted. The "stretch" command changes the color table values of all displayed images interactively. The "slice" command returns the minimum and maximum values, and the standard deviation on a cut across an image. In addition, individual pixels can be "picked" for manipulation. A histogram of the image can also be displayed. These are just a few of the many functions within Skyview.

Skyview 2.0 is written in C for Sun4-series computers running SunOS 4.1.1. It requires 24MB of disk space for the source and executable codes, 5MB of swap space, and 1MB of random-access memory for execution. This package of software requires the X Window System, Version 11 Revisions 3 or 4, with OSF/Motif 1.1. An electronic copy of the documentation is provided in PostScript format on the distribution medium. The standard distribution medium for this program is a 0.25-in. (6.35-mm) streaming-magnetic tape cartridge in UNIX tar format. Skyview was developed in 1992 and is a copyrighted work with all copyright vested in NASA.

This program was written by Booth Hartley, Rick Ebert, and Gaylin Laughlin of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 22*** *on the TSP Request Card. NPO-19059*

Computing Properties of Chemical Mixtures at Equilibrium

This program calculates chemical equilibrium compositions and thermal-transport properties.

Scientists and engineers need data on chemical equilibrium compositions to calculate the theoretical thermodynamic properties of chemical systems. This information is essential in the design and analysis of such equipment as compressors, turbines, nozzles, engines, shock tubes, heat exchangers, and chemical-

(continued on page 68)

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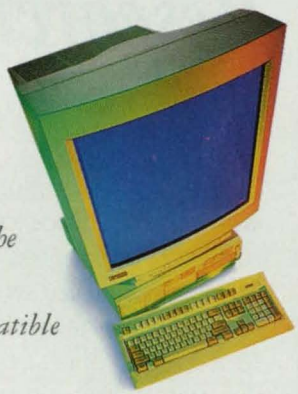

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processing equipment. The substantial amount of numerical computation required to obtain equilibrium compositions and thermal-transport properties for complex chemical systems led scientists at NASA's Lewis Research Center to develop CET93, a program designed to calculate the thermodynamic and thermal-transport properties of these systems.

CET93 is a general program that calculates chemical equilibrium compositions and properties of mixtures for any chemical system for which thermodynamic data are available. Generally, mixtures can include condensed and gaseous products. CET93 performs the following operations: it (1) obtains chemical equilibrium compositions for assigned thermodynamic states, (2) calculates dilute-gas thermal-transport properties of complex chemical mixtures, (3) obtains Chapman-Jouguet detonation properties for gaseous species, (4) calculates properties of incident and reflected shocks in terms of assigned velocities or mach numbers, and (5) calculates theoretical rocket performance for both equilibrium and frozen compositions during expansion. The rocket-performance function allows the option of assuming either a finite- or an infinite-area combustor.

CET93 accommodates problems that involve as many as 24 reactants, 20 elements, and 600 products (400 of which can be condensed). An added ONLY option provides for calculations of equilibrium compositions, considering only those species that are specified in the input. Users can now provide comments in the input and output.

The program includes a library of thermodynamic and thermal-transport properties in the form of least-squares coefficients for possible reaction products. It includes thermodynamic data for more than 1,300 gaseous and condensed species and thermal-transport data for 151 gases. The thermodynamic data for many species have been updated from those in CET89. The subroutines UTHERM and UTRAN convert thermodynamic and thermal-transport data to unformatted form for faster processing.

CET93 is written in FORTRAN 77 to be machine-independent. A FORTRAN 77 compiler that supports NAMELIST is required. CET93 has been successfully implemented on a Sun4-series computer running SunOS 4.1.3, a Sun4-series computer running Solaris 2.3, a DECstation 3100 computer running DEC RISC ULTRIX 4.3, an SGI IRIS Indigo II computer running IRIX 5.2, and a DEC micro VAX 3600 computer running VMS 5.5. Due to its memory requirements, this program does not readily lend itself to implementation on MS-DOS-based computers; however, CET93/PC (LEW-16017), a version of CET93 that includes a few limitations on sizes of arrays, is specifically designed to run within the 640K memory limit of the MS-DOS operating system. The standard distribution medium for CET93 is a 0.25-in. (6.35-mm) streaming-magnetic-tape cartridge (Sun QIC-24) in UNIX tar format. Alternate distribution media and formats are available on request. CET93 was released to COSMIC in 1995.

This program was written by B. J. McBride of **Lewis Research Center** *and S. Gordon, consultant. For further information,* ***write in 31*** *on the TSP Request Card. LEW-16153*

Software for Numerical Simulation of Geophysical Flows

This program has been verified by comparisons with both experimental and numerical studies.

Many studies of geophysical fluid dynamics have addressed flows of fluids under combined influences of buoyancy and rotation. Such experiments are

aimed at enhancing our understanding of atmospheric and oceanic dynamics by studying controlled, simple systems in which the flow dynamics can be isolated. However, any experiments are subject to instrumentation and data-acquisition errors, and the high costs of experiments discourage systematic and wider-range parametric studies.

The GEOSIM computer program, created at NASA's Marshall Space Flight Center, implements a numerical model that simulates geophysical fluid flow for a wide range of problems. The model allows for more accurate control over experimental conditions and provides a complete data source for performing diagnostic studies. The GEOSIM model is based upon the Boussinesq Navier-Stokes equations in spherical coordinates; these equations can be reduced to a system of equations in cylindrical coordinates when latitudinal walls are used near the pole and the ratio between the latitudinal length and the radius of the sphere is small. The equations are ap-proximated by finite differences in the meridional plane and spectral decomposition in the azimuthal direction. The user can specify a variety of boundary and initial conditions, and there are five different spectral-truncation options. GEOSIM has been validated by comparisons with both experimental and numerical studies.

GEOSIM is meant for use by experienced and/or professional fluid dynamicists. It can solve five classes of problems, which are handled consistently with the same numerical algorithms. The following problems are handled by GEOSIM: (1) axisymmetric flow, (2) the linear instability problem with respect to a previously computed, fixed axisymmetric state, (3) the linear instability problem with respect to an evolving axisymmetric state as in problem 1, (4) the nonlinear problem for single and multiple waves, in which problem the only quadratic terms retained are those due to the interaction between the waves and axisymmetric parts of the flow, (5) the fully nonlinear problem for multiple waves with complete wave/mean-flow and wave/wave interactions.

GEOSIM is written in FORTRAN 77 for Cray-series computers running UNICOS. With minor modifications, it has also been successfully executed on a Sun4-series computer running SunOS, a DEC VAX-series computer running VMS, and an HP9000-series computer running HP-UX. Using typical spatial resolution (array sizes), the code requires 4MB of random-access memory (RAM) under UNICOS 6.1.6, 3.6MB of RAM under SunOS 4.1.1, 3.5MB of RAM under HP-UX, and 3.3MB of RAM under VMS 5-4.3. The standard distribution medium for this program is a 0.25-in. (6.35-mm) streaming-magnetic-tape cartridge in UNIX tar format. Alternate distribution media and formats are available upon request. GEOSIM was developed in 1991.

This program was written by Timothy L. Miller of **Marshall Space Flight Center,** *Karen A. Butler of New Technology, Inc., and H. I. Lu of Universities Space Research Association. For further information,* ***write in 36*** *on the TSP Request Card. MFS-28751*

Mathematics and Information Sciences

Software for Tie-Point Registration of SAR Data

This program interpolates an image to a reference image between manually placed tie points.

The SAR-REG software package registers synthetic-aperture-radar (SAR) image data to a common reference frame based on manual tie-pointing. The image data can be in binary, integer, floating-point, or AIRSAR compressed format. SAR-REG accepts image data acquired by the NASA/JPL AIRSAR aircraft SAR, ESAs ERS-1 SAR, and NASDAs J-ERS-1 SAR. However, the SAR-REG software is flexible enough to be used with other remotely sensed image data as well. For example, SAR-REG can be used with a map of soil characteristics, a vegetation map, a digital elevation map, or a SPOT multispectral image, as long as the user can generate a binary image to be used by the tie-pointing routine and the data are available in one of the previously mentioned formats.

The registration process is organized into three steps, which are describable in terms of two sets of image data that one seeks to register with each other. One of these two sets is considered to represent a reference image. The first step is the creation of a byte image (binary file) for each of the two sets of data. The second step is the manual selection of tie points between these two binary files. For this step SAR-REG provides a zoom capability to enable precise tie-pointing and a dynamic visualization of the results to check on the quality of the tie points. Finally, the non-reference image is interpolated to the reference image on the basis of the selected tie points.

SAR-REG is written in FORTRAN 77 for execution on Sun-series computers. It has been successfully implemented on a Sun4-series computer running SunOS 4.1 as well as on SunSparc, Sun IPX, and SunServer 470-series computers running SunOS. It has also been successfully implemented on Sun-series computers running the Solaris operating system. SAR-REG requires 16MB of random-access memory for execution. It also requires (a) Revision 4 or Revision 5 of Version 11 of MITs X Window System, and (b) either PV-Wave (Visual Numerics, Inc., Boulder, CO; 800-982-3947) or IDL (Research Systems, Inc., Boulder, CO; 303-786-9900), which are interactive analysis and visualization software packages. The standard distribution medium for SAR-REG is a 0.25-in. (6.35-mm) streaming-magnetic-tape cartridge (Sun QIC-24) in UNIX tar format. An electronic copy of the documentation is included on the distribution medium in ASCII format. SAR-REG was developed in 1993 and is a copyrighted work with all copyright vested in NASA.

This program was written by Eric Rignot, Pascale Dubois, Sharon Okonek, Jacob van Zyl, Fred Burnette, and Maurice Borgeaud of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 68*** *on the TSP Request Card. NPO-19380*

Program Classifies Multiple-Frequency Polarimetric SAR Data

This software implements a maximum-*a-posteriori* classification scheme.

The POLMAP computer program classifies multifrequency, polarimetric synthetic-aperture-radar (SAR) data into homogeneous classes of radar backscatter. It accepts SAR data acquired by the NASA/JPL AIRSAR aircraft SAR polarimetric instrument, in compressed format. POLMAP is a Bayesian classifier; this means that the optimal classification is the one that maximizes the *a posteriori* probability of the image classes, given the radar observations.

Since obtaining an exact solution to this optimization problem can be difficult and time-consuming, POLMAP offers three computational alternatives. The maximum-likelihood (ML) classification, which involves the assumption that all classes have the same *a priori* probability, is quick but can produce noisy results unless the image classes are very distinctly separated. The iterated conditional mode (ICM) classification, which uses a Markov random field to model the *a priori* distribution of the image classes based on local statistics, computes an approximate, rapid solution to the classification that only locally maximizes the *a posteriori* distribution of the classes. The maximum-*a-posteriori* (MAP) classification, which POLMAP performs by use of a simulated-annealing procedure, can take much longer to compute than does the ICM solution, but it maximizes the *a posteriori* distribution of the classes for the whole scene. A POLMAP user can use the ML classifier first, improve the results for classes that are poorly separated by using the ICM classifier, and finalize the results by use of the MAP classifier.

The classifier is based partly on the assumption that the radar data are circular-Gaussian distributed (e.g., that textural variations in radar reflectivity of the surface are assumed to be negligible), so texture is not used for classification of the image pixels into classes of homogeneous radar backscatter.

POLMAP also offers users the option of reducing the dimensionality of the classification: the user can choose to use only a limited number of frequencies and/or polarizations for the classification. In this manner, one can study the value added, by incorporation of various polarizations and frequencies, to the classification results obtained. For instance, one can study the value of using the single-frequency, single-polarization SAR data such as those provided by ERS-1 SAR and J-ERS-1 SAR.

The input statistics of the image classes must be created by some independent means, and then supplied as input to POLMAP. The POLMAP output files are binary maps of the classification and a map of the probability of error of classification. This output is in byte format and can be used as input to an image-processing application program.

POLMAP is written in FORTRAN 77 for Sun4-series computers running SunOS 4.1.3 and requires 16MB of random-access memory for execution. A sample executable code is provided on the distribution medium. An electronic copy of the documentation is provided on the distribution medium in LaTex and PostScript formats. The standard distribution medium for POLMAP is a 0.25-in. (6.35-mm) streaming-magnetic-tape cartridge (Sun QIC-24) in UNIX tar format. POLMAP was developed in 1994 and is a copyrighted work with all copyright vested in NASA.

This program was written by Eric Rignot of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 71*** *on the TSP Request Card. NPO-19502*

Software for Analysis of Reliability, Redundancy, and Cost

This program assists the user in choosing a minimum-cost subsystem from among a number of alternatives.

CARRAC is a software tool for the combined analysis of reliability, redundancy, and cost of alternative choices of a subsystem that is part of a larger system. CARRAC uses various parameters entered from the computer keyboard to determine the subsystem and redundancy method (if any) that minimizes cost. Also, the method of calculation can be selected from five different mathematical models that enable the application of CARRAC to a wide variety of cases.

An arbitrary system is composed of a number of subsystems. Each subsystem is characterized by reliability and cost parameters. CARRAC uses these parameters to calculate and compare a total expected cost for alternatives of a chosen subsystem. The total expected cost includes the cost of the subsystem itself plus the expected cost due to failure of the subsystem. The expected cost of failure is a probabilistic cost defined as the cost that would be incurred if the subsystem failed multiplied by the probability of failure of the subsystem.

The five models supplied with CARRAC provide the ability to simulate many different cases. There are very simple models covering straightforward reliability and redundancy situations. A more advanced model represents the effects of partial failure. Finally, there are models that bring in the time domain by considering failure rate and that investigate cases with and without salvage value. A number of the models analyze the cost effects of catastrophic failure.

It should be noted that CARRAC is not directly a reliability or cost-analysis program although it does use reliability and cost numbers as input. CARRAC assists the user in choosing an optimal subsystem, from a number of alternatives, that minimizes cost.

CARRAC is written in Microsoft Quick-Basic v4.5 for use on IBM PC-series and compatible computers running MS-DOS v5.0 or later. CARRAC requires an 80386 or higher processor, a VGA board, and 512K of disk space. An executable code is provided. The standard distribution medium for CARRAC is a 3.5-in. (8.89-cm), 1.44MB, MS-DOS-format diskette. CARRAC was developed in 1992.

This program was written by R. L. Patterson of **Lewis Research Center** *and R. C. Suich of California State University at Fullerton. For further information,* ***write in 21*** *on the TSP Request Card. LEW-15952*

Mechanics

COLD-SAT Dynamic Model Computer Code

This program models the dynamics of a spacecraft carrying a cryogenic fluid in tanks.

The COLD-SAT Dynamic Model (CSDM) computer code implements a six-degree-of-freedom, rigid-body mathematical model for simulation of a spacecraft in orbit around the Earth. The model was developed as part of a conceptual design review at the NASA Lewis Research Center to study the fea-

sibility of a proposed spacecraft known as COLD-SAT (Cryogenic On-orbit Liquid Depot — Storage, Acquisition, and Transfer). The purpose of the COLD-SAT spacecraft is to investigate the flow dynamics and thermodynamics of subcritical cryogenic fluids in microgravity.

The design of CSDM was shaped largely by the requirements of the COLD-SAT design study. This mathematical model in CSDM was a major tool used throughout the study, primarily to evaluate and compare the performances of several design options for an attitude-control system. The model was also used extensively in an analysis of the microgravity environment within three tanks containing liquid hydrogen; evaluation of the effects of prolonged constant, low-level thrust on the orbit of the spacecraft during the 60-day life of the spacecraft mission; and an assessment of the effects, on the dynamic behavior of the spacecraft, of the sloshing of liquid hydrogen in each tank. Although the development and design of CSDM was guided by the requirements of the design study, the mathematical model was written to be as general as possible so that its usefulness would extend to future projects as well as to COLD-SAT. To achieve this goal, approximations and simplifications were avoided to the maximum extent feasible.

The COLD-SAT mathematical model consists of three parts: a translation model, a rotation model, and a slosh model. The translation model simulates the motion of the center of gravity of the spacecraft about the Earth under the influence of gravitational force, atmospheric drag, and the thrust produced by the axial thrusters and by the uncoupled control thrusters. The rotational model simulates the attitudinal motion of the spacecraft about its center of gravity under the influence of various disturbance torques and control torques acting on the spacecraft. The slosh model computes the torque on the spacecraft produced by the motion of the liquid hydrogen in any or all of the three tanks.

In addition to implementing the primary function of each part of the model, CSDM performs other computations as required. Thus, the part of CSDM that implements the translation model also computes the desired attitude of the spacecraft for a large number of attitude options, and it computes the torque resulting from the misalignment of the axial thrust acting on the spacecraft. The part that implements the rotational model simulates the attitude-control system and computes the microgravity environment within the body of the spacecraft.

CSDM is written in FORTRAN 77 and EASY5 script language, and is designed to be run on any computer running Boeing's EASY5 Dynamic Analysis software package v3.4, or the equivalent Easy5/W workstation version [Boeing Computer Services; Seattle, Washington; Easy5 Hotline (800) 426-1443]. Sample output files are included on the distribution medium. The standard medium for distribution of this program is a 3.5-in. (8.89-cm), 1.44MB MS-DOS-format diskette. Alternate distribution media and formats are available upon request. CSDM was developed in 1992.

This program was written by G. Bollenbacher of **Lewis Research Center** *and N. S. Adams of Analex Corp. For further information,* ***write in 61*** *on the TSP Request Card. LEW-15919*

Software for Design and Analysis of Tanks and Cylindrical Shells

This program enables rapid buckling analyses of tanks that include skin-stringers.

The Skin-stringer Tank Analysis Spreadsheet System (STASS) computer program was developed for use as a preliminary design software tool that enables quick-turnaround design and analysis of structural domes and cylindrical barrel sections in propellant tanks or other cylindrical shells. STASS is an integrated system of Microsoft Excel worksheets and macros that calculate critical-buckling-stress values and margins of safety in cylindrical shells with internal, integral T-stiffeners and intermediate Z-frames. STASS determines minimum required skin thicknesses for domes and cylindrical shells to withstand material failure due to applied pressures (ullage and/or hydrostatic) and runs buckling analyses on the cylindrical shells and skin-stringers.

STASS includes a user-friendly, three-page input and summary worksheet for the propellant-tank-analysis system. The user also has the option to run only the individual worksheets and macros for either the forward-dome, barrel-section, or aft-dome components. The user can choose either the max principal or von Mises failure criteria for the design. The user can also enter a minimum allowable skin thickness (as a manufacturing or fracture-mechanics constraint).

The primary data products of STASS are internal volumes, skin thicknesses, and a summary of masses. Using the minimum skin thickness calculated for

each barrel section, STASS then performs a buckling analysis. Buckling analyses include bending moments, axial forces, shear forces, and ullage pressures. Using one of two stress methods — either that of the Space Shuttle External Tank Stress Report (1982) or that of the Modified Beam Theory (Bruhn, 1973), STASS checks general instability, stringer crippling, local elastic buckling of the stringers, wide-column buckling, and sheet buckling. The primary product of the buckling analysis is a margin-of-safety summary for each cylindrical barrel section. Microsoft Excel's add-in software tool, Solver, can be used to optimize designs subject to multiple constraints.

STASS has been implemented as a workbook program, using Microsoft Excel v4.0 on Macintosh II-series computers running System 7.x. It is available only as executable code. STASS has also been implemented using Microsoft Excel v4.0 for Microsoft Windows v3.1. IBM PC users may have to change their column widths and font sizes to obtain clean displays. The standard distribution medium for STASS is a 3.5-in. (8.89-cm), 1.44MB diskette in Macintosh format. STASS is also available on a 3.5-in. (8.89-cm), 1.44MB, MS-DOS-format diskette. STASS was developed in 1993, and the current version was released to COSMIC in 1995. This program is a copyrighted work with all copyright vested in NASA.

This program was written by Paul L. Luz and Jerry B. Graham of **Marshall Space Flight Center.** *For further information,* ***write in 25*** *on the TSP Request Card. MFS-28981*

Computing Stresses in Spur Gears

Equations of motion are solved for various gear-tooth profiles and operating conditions.

Dynamic Analysis of Spur Gear Transmissions (DANST) was developed as an easy-to-use program for static and dynamic analysis of spur-gear systems. The program can be used for parametric studies to predict the effects of operating speed, torque, stiffness, damping, inertia, and tooth profile on dynamic loads and tooth-bending stresses in spur gears. DANST performs geometric modeling and dynamic analysis for low- or high-contact-ratio spur gears. The program can simulate gear systems with contact ratios ranging from one to three.

DANST calculates the properties of system components and substitutes them into the governing equations to solve for dynamic tooth loads and tooth-bending stresses. The program is based on a four-degree-of-freedom, lumped-mass model of a gear transmission. The model includes driving and driven gears, connecting shafts, motor, and load. The equations of motion were derived from basic gear geometry and elementary vibration principles. The dynamic solution is found by integrating the equations of motion.

DANST enables users to choose from a variety of gear materials, basic gear geometries, and operating conditions. Users can also choose from a number of combinations of tooth-profile variations and user-digitized profile modifications. Three standard forms of tip relief are included among the tooth-profile options. In addition, users can specify which type of printed or plotted output they want DANST to produce and whether DANST should perform a static or a dynamic analysis.

The software package that contains DANST also includes DAN-MOD, a small auxiliary program to help generate the modification data required for the digitized profile option in DANST. DANST

requires 121 values of involute-profile deviations at equal intervals of roll angle between the highest and lowest points of tooth contact. DAN-MOD can interpolate (and extrapolate if necessary) to provide these data. DAN-MOD is not needed for the standard forms of tip relief because DANST automatically generates the profile deviation data.

DANST is written in FORTRAN 77 for DEC VAX-series computers running VMS, HP9000/700-series computers running HP-UX, and DECstations running DEC RISC ULTRIX. The optional DANST preprocessor, DAN-MOD, is written in HTBasic for IBM PC-series and compatible computers running MS-DOS. A demonstration version of HTBasic is included with DANST for use with DAN-MOD. DANST requires 2MB of random-access memory (RAM) for execution. Optional graphical output requires commercially available DI-3000 graphics-library routines. Users without access to DI-3000 who wish to use the analysis routines can delete the graphics portions of the program. The standard distribution media for DANST include both a 0.25-in. (6.35-mm) streaming-magnetic-tape cartridge (Sun QIC-24) in UNIX tar format and a 3.5-in. (8.89-cm) 1.44MB MS-DOS-format diskette. Alternate distribution media and formats are available upon request. DANST was developed in 1993.

This program was written by F. B. Oswald of **Lewis Research Center** *and H. H. Lin of the University of Memphis. Further information may be found in NASA TM-106211 (AIAA-93-2295) "Dynamic Analysis of Spur Gears Using Computer Program DANST."*

Copies may be purchased [prepayment required] from AEROPLUS, Burlingame, California 94010, Telephone No. (800) 662-2376, Fax No. (415) 259-5047. LEW-15420

Software for Uniaxial Mechanical Testing of Materials

These programs help to automate tension and compression tests at constant or changing temperatures.

The Materials Testing Software system is a suite of four programs designed to simplify and automate both the routine and not-so-routine materials-testing tasks encountered in the laboratory. This software supports the plan/test/analyze cycle through a collection of programs, each optimized to a specific task. The system is capable of supporting materials tests of a uniaxial nature (both isothermal and thermomechanical).

The Materials Testing Software gives precise control over the nature of command waveforms and acquisition of data, including dynamically variable waveform types, sets of data-acquisition channels, and data rates. Differing command and data-acquisition rates required for exploring creep and fatigue material behavior are easily accommodated. Sustained acquisition of data and storage of data on disks at a rate of 100 points per channel per second is supported, enabling capture of the dynamic behavior of a material.

Control is given over the command waveforms, including not only the test-system waveforms (namely, load, strain, and stroke), but also temperature. When one uses this software system in conjunction with a Data Translation DT-2829 (or equivalent) analog-to-digital, digital-to-analog, digital input/output circuit board, one obtains high resolution (16 bits) in the generation of command waveforms and the acquisition of data. However, the software also supports the Data Translation model DT-2809 (or equivalent) circuit board. Control waveforms can be dynamically altered on the basis of events that occur in other response variables (for example, as in load-controlled, strain-limited testing). Waveforms can be nested so that material history dependences can be explored. Waveforms of different types can be concatenated and nested indefinitely to provide extensive control over materials-test-control histories. The software also supports static and dynamic switching of control modes (load, strain, and stroke), enabling multimode test control (when this capability is present in the servocontroller of the testing apparatus) and sensing of power failures when an appropriate uninterruptible power supply is used. This enables the software to properly shut down operation and close files in the event of a power outage.

The Materials Testing Software is written in Modula-2 for IBM PC-series and compatible computers running MS-DOS 5.0 or later. The software requires a 25-MHz 80386 or higher central processing unit with math coprocessor, approximately 3.5MB of disk space, and 640K of random-access memory. The Logitech Modula-2 v4.0 compiler is also needed for recompiling the source code. To run materials tests, additional hardware is required, including an appropriate analog-to-digital, digital-to-analog, digital input/output interface circuit card, a clock/timer circuit card, and suitable cables and termination panels. The user's testing-system hardware is required to have a supporting computer interface. It is strongly suggested that the prospective purchaser of this software first purchase the program documentation to ascertain whether the appropriate hardware for use with the Materials Testing Software is on hand. Sample executable codes are included on the distribution medium. The standard distribution medium for this program is a 3.5-in. (8.89-cm), 1.44MB, MS-DOS-format diskette. The Materials Testing Software was developed in 1994 and is a copyrighted work with all copyright vested in NASA.

This program was written by M. A. McGaw of **Lewis Research Center**, *and D. K. Pech, consultant. For further information,* ***write in 32*** *on the TSP Request Card. LEW-16160*

Materials

Updated Fatigue-Crack-Growth and Fracture-Mechanics Software

This software implements an improved crack-growth model and other enhancements.

The software NASA/FLAGRO 2.0 was developed as an analytical aid in predicting the growth and stability of preexisting flaws and cracks in structural components of aerospace systems. It is used for fracture-control analysis of space hardware and is currently the standard computer code used for this purpose in NASA, the U.S. Air Force, and the European Space Agency. An earlier version of the program was released by COSMIC in February, 1990. Since then, it has undergone extensive enhancements, which are incorporated in version 2.0.

Many user-friendly features, such as interactive input and execution from session (pseudobatch) files were implemented. A large data base of material properties (for about 350 materials and environments) is supplied with the software in both U. S. and metric units. The software is organized into three modules to maximize efficiency in operation. The three modules are useful in: (1) crack-instability/crack-growth analysis, (2) processing raw crack-growth data from laboratory tests, and (3) boundary-element analysis to determine stresses and stress-intensity factors.

NASA/FLAGRO predicts crack growth by use of a model from a library of about

30 crack geometries, including part-through cracks in plates, cylinders, and spheres. In this release, four crack cases allow nonlinear stress input across the thickness of a component, thus providing the ability to deal with realistic stress states. Weight-function methods that were developed on the basis of finite-element data for the full range of geometric parameters were implemented. The fatigue load spectrum can now be specified in a more flexible manner. Predefined blocks of variable-amplitude load steps can be combined to form a load schedule by repeating the blocks any number of times in any sequence. Each block can represent a mission of a spacecraft.

The crack-growth-rate equation has been further improved in this version, providing a better curve fit for most materials and including the effects of crack closure. The new equation was used to curve-fit and derive a new set of material constants, which are supplied with the software. The equation can also be reduced to the simple Paris form if desired. In addition to the major option of computing safe lives of structures during fatigue-crack growth, the first module provides options to compute stress-intensity factors, to determine critical crack sizes in the context of proof testing and to analyze glasslike materials subjected to sustained loading for time-dependent crack growth. Extensive plotting features are available for checking data and interpreting results.

The second module, which processes raw fatigue-crack-growth data, allows for the entry and editing of da/dN-vs.-ΔK data along with the specimen and material/environment information and provides options to process the data by curve fitting to the NASGRO or Paris equations. The material data base can be retrieved conveniently and updated as needed by use of this module.

The third module uses the boundary-element method to determine the stresses and/or stress-intensity factors for arbitrary two-dimensional bodies. High accuracy of the stress-intensity-factor computation is achieved by use of the dislocation-density method for modeling cracks. The stress computation is very accurate even close to the boundaries because modified kernels were used to avoid the singularities at the boundary.

Since NASA/FLAGRO is designed to be modular, advanced users will be able to add their own stress-intensity solutions or other features easily. The users' manual provides all the necessary information such as the flow chart and descriptions of special routines.

NASA/FLAGRO 2.0 is written in FORTRAN 77 and ANSI C (C is used for the top-level menu that drives the three modules) for execution on an IBM-compatible 386 personal computer with 4 MB of random-access memory and a math coprocessor. A ready-to-use Macintosh version is also available. For other workstations or mainframe systems, the source code must be transferred and compiled by use of a C compiler for the menu program NASGRO and a FORTRAN compiler for the three modules NASFLA, NASMAT, and NASBEM. The source for graphics routines DIGLIB must be compiled and linked with each module. A few minor system-dependent changes may be needed. The standard medium for distribution of NASA/FLAGRO 2.0 is two 1.44-MB, 3.5-in. (8.89-cm) diskettes in compressed format.

This program was written by Royce G. Forman of Johnson Space Center, Venkataraman Shivakumar of Lockheed Engineering and Sciences Co., and James C. Newman, Jr., of **Langley Research Center**. *For further information,* ***write in 72*** *on the TSP Request Card. MSC-22550*

Optimized Coolant-Flow Diverter for Increased Bearing Life

The diverter is designed according to hydrodynamic considerations.

Marshall Space Flight Center, Alabama

A coolant-flow diverter for rolling-element bearings in a cryogenic turbopump has been designed to enhance the cooling power of the flow in contact with the bearings and thereby reduce bearing wear. In the original application, the bearings are parts of the high-pressure-oxidizer turbopump of the main engine of the space shuttle. However, the basic principle of the design could be applied to reduce wear and thereby increase operating lives of other highly stressed rolling-element bearings cooled by flowing liquids.

For purposes of designing the coolant-flow diverter, the bearing cavity, bearings, and other components in the bearing cavity were regarded collectively as components of a flow device. This made it possible to optimize the design of the diverter by optimizing the flow paths, according to hydrodynamic principles, to enhance cooling in the critical hot-spot region of contact between each bearing ball and the inner bearing race.

The hydrodynamic optimization involved the use of an empirical data base and computational-fluid-dynamic analysis to obtain flow paths that maximize the through-flow effectiveness and increase the vapor margin of the coolant liquid in the ball/race contact region. (The vapor margin is the pressure and temperature margin between the actual condition of the liquid and the condition in which the liquid would vaporize.) The design thus minimizes the formation of vapor pockets; it also minimizes adverse effects of vapor pockets in that any vapor that might form would be efficiently flushed out of the bearing cavity.

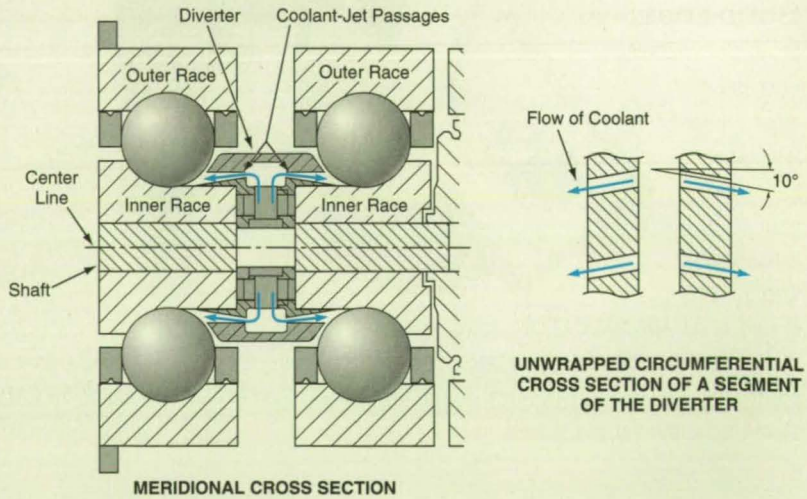
The diverter brings the coolant from the center line of the shaft supported by the bearing and delivers the coolant into the vicinity of the balls in the form of discrete jets (see figure). The diverter is positioned at the smallest radius of the inner races, opposite the shoulder ramps of the inner races. The diverter extends axially (left and right in the figure) into the ball space to bring the coolant jets as close to the ball/race-contact point as permitted by the geometry and operating conditions. This reduces the losses due to churning of the coolant by the balls and increases the vapor margin.

Losses are further reduced by increasing the cross-sectional area presented to the jets to keep the speeds of the jets about an order of magnitude lower than the tangential speed of the race. An enhanced pumping effect and increase in the convective transfer of heat is achieved by increasing the tangential component of the velocity of the coolant through pre-rotation; this is accomplished by slanting the jet passages 10° to 40° in the direction of rotation — contrary to the usual practice of designing for counterswirl. This feature takes maximum advantage of the inherent pumping tendency of the shoulder ramps of the inner races. The resulting lower operating temperature enhances the effects of elasto-hydrodynamic separation of rolling surfaces, pre-applied coatings, and/or film-transfer lubrication (for example, from Salox™ cages), thereby helping to realize the full benefits of these measures.

The concept of an optimized coolant-flow diverter in a bearing was experimentally verified and perfected by use of a water model in the Super Scale Bearing Flow Tester at Marshall Space Flight Center. An optimized bearing coolant-flow diverter according to this concept has been used with success in an end ball bearing of a high-pressure-oxidizer turbopump.

This work was done by Maria R. Subbaraman and Myles F. Butner of Rockwell International Corp. for **Marshall Space Flight Center**. *No further documentation is available.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center; (205) 544-0021. Refer to MFS-30008.



The **Coolant-Flow Diverter** delivers jets of coolant as close as possible to the hot spots at the points of contact between the balls and the race. It also imparts a swirl that enhances a beneficial pumping effect.

Valve for Extracting Samples From a Process Stream

Marshall Space Flight Center, Alabama

A valve for extracting samples from a process stream includes a cylindrical body that is bolted to the pipe that contains the stream. An opening in the valve body is matched and sealed against an opening in the pipe. The valve body houses a rotating valve gate and a piston activated by an air cylinder. The cylinder moves the piston back to expose the opening in the pipe, and the vacuum left by the piston is filled by a sample of material that flows from the pipe. The piston is retracted until the desired amount of sample has been taken, then the valve gate is rotated until the opening in the pipe is sealed and a bottom opening in the valve body is exposed. The cylinder then extends, and the propellant is ejected into a sample container. The valve can be used to sample process streams in a variety of facilities, including cement plants, plants that manufacture and reprocess plastics, oil refineries, and pipelines.

This work was done by Dave Callahan of Aerojet General Corp. for **Marshall Space Flight Center.** *For further information,* ***write in 37*** *on the TSP Request Card. MFS-28955*

Reverse-Acting Temperature-Control Louvers

The louvers are configured to accept rather than reject heat.

NASA's Jet Propulsion Laboratory, Pasadena, California

A louver for automatic temperature control has been designed to operate in the reverse of the usual manner for mechanical temperature-control devices of its type: instead of operating with increasing temperature to reject heat to a cold environment, it opens with decreasing temperature to receive heat from a warm environment. The louver is visually identical to those that open with increasing temperature, the only difference being that a bimetallic spring that actuates the open and closing would be mounted backwards to obtain the reverse function.

This work was done by James W. Stultz of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 39*** *on the TSP Request Card. NPO-19180*

Balanced-Rotating-Spray Tank-and-Pipe-Cleaning System

Large volumes of solvent are not needed as in other systems.

John F. Kennedy Space Center, Florida

The upper part of the figure schematically illustrates a system for cleaning and/or verifying the cleanliness of the inside of a tank or pipe. The cleansing is effected by three laterally balanced gas/liquid jets from a spray head that rotates about a longitudinal axis. In comparison with older cleaning systems based on spraying liquids at high pressures or flushing with solvents, this system uses much less liquid, and even when a solvent is used in this system, it need not be a powerful solvent as in a typical older solvent-flushing system. This is because the cleaning process in this system relies on the mechanical action of the jets instead of contaminant dissolution.

The gas/liquid mixture that constitutes the cleaning fluid is generated in an orifice mixing chamber fed from a tank of liquid and a supply of pressurized gas. One of the orifices reduces the pressure of the gas and creates turbulence to mix the gas and liquid. The pressure of the upstream gas pushes the liquid through another orifice into the mixing chamber. From the mixing chamber, the mixture flows through a hose, a rotating fluid coupling, and a tube to the spray head. The rotating fluid coupling allows the spray head to spin and thereby to clean along the entire circumference of the tank or pipe. A gear motor and drive belt move the spray head, at a controlled rate, in and out of the item to be cleaned. By thus scanning the entire circumference and length, one cleans the entire inner surface.

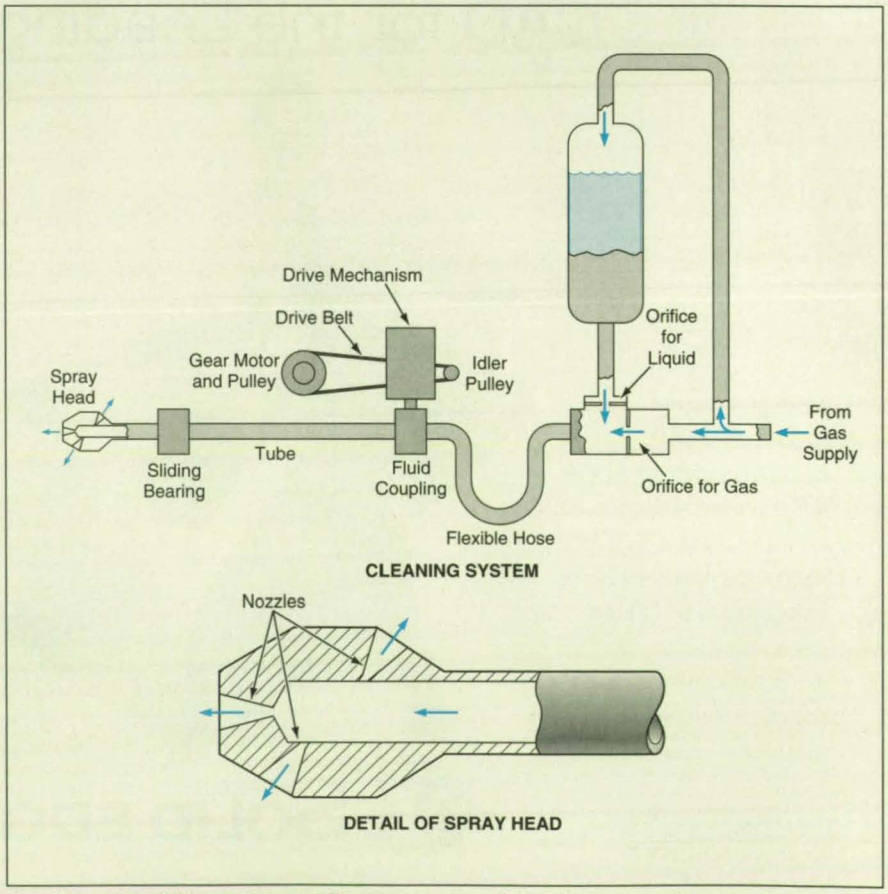
As shown in more detail in the lower part of the figure, the spray head contains three nozzles; one pointed forward along the longitudinal axis, and the other two pointed 45° and 135° from forward, respectively. This arrangement of the nozzles enables the system to clean a dead end in a tank or pipe. The forward nozzle and the 45° nozzle combine to clean the dead end. The 135° nozzle can clean a narrow entrance to a tank or pipe. The two angled nozzles are on opposite sides of the spray head and are in line with each other so as to exert no net force on the spray head. Thus, there is only the longitudinal force from the forward-facing nozzle and the net side force is zero: in this sense, the spray head is said to be balanced.

The nozzles are of the supersonic, two-phase, diverging-only type. Unlike a typical converging/diverging design, this nozzle design takes advantage of the stagnation regions around the nozzle entrance to cause streamlines to converge. For this purpose, it is necessary to design the nozzle carefully to control the flow path; otherwise, the fluid to be sprayed will remain sonic or subsonic, as occurs in a typical diverging-only nozzle. One of the advantages of the diverging-only design is that it eliminates the very difficult machining needed to make multiple converging/diverging nozzles within the one spray head. Another advantage is that it makes the nozzle much smaller, so that the spray head can be smaller and can therefore be inserted into pipes and tanks through smaller openings.

In an alternative version of the spray head, the side nozzles could be at different angles. The basic two-phase-flow, supersonic-nozzle design could also be applied to other spray systems for interior or exterior cleaning.

This work was done by Eric A. Thaxton and Raoul E. B. Caimi of **Kennedy Space Center.** *No further documentation is available.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Kennedy Space Center; (407) 867-2544. Refer to KSC-11694.



The **Spray Head Translates and Rotates** to clean the entire inner surface of a tank or pipe.

Special-Purpose High-Torque Permanent-Magnet Motors

These motors must satisfy unusual heat-dissipation requirements.

Marshall Space Flight Center, Alabama

Permanent-magnet brushless motors that must provide high commanded torques and must satisfy an unusual heat-removal requirement are being de-veloped. The motors are intended for use as thrust-vector-control actuators in large rocket engines. The techniques and concepts used to design them could also be used to design improved motors for special terrestrial applications.

The conceptual motor design calls for the use of a rotor containing the latest high-energy-product rare-earth permanent magnets so that a motor could produce the required torque while drawing the smallest possible currents from its power supply. The stator would contain three-phase windings excited in the brushless-dc-motor mode. The torque would be generated by the electromagnetic interaction between the stator and the permanent magnets in the rotor when associated electronic circuits applied appropriately temporally and spatially phased currents to the stator windings. The phase relationships needed to produce the commanded torque would be computed in response to the torque command and to the electronically sensed angular position of the rotor relative to the stator. In these respects, the basic concepts of the design and operation are encompassed by standard brushless-motor technology.

The magnetic aspect of the motor has been designed and analyzed by use of finite-element mathematical models of magnetostatics. These models incorporate the nonlinearities of the various magnetic materials. When the final magnetic and electronic aspects of the design are integrated, the motor should produce a torque proportional to a torque-command voltage or current.

The design concept calls for heat-transmission paths that would conduct much more heat out of the motor than is possible with more conventional designs. The unique heat-removal requirement arises from the need for the motor to hold against constant loads and to accommodate cyclic loads for long times. The thermal environment within the motor has been analyzed by use of a thermal-analyzer computer code that implements a lumped-parameter-network mathematical model.

The inertia of the rotor is a design consideration because it affects the behavior of the motor during acceleration. Other concerns include minimization of cogging and of non-current-induced torque, obtaining linear torque-vs.-current characteristics, and acquisition of data on thermal conductivities of dielectric motor materials to refine the thermal aspect of the design.

This work was done by George B. Doane III of the University of Alabama for **Marshall Space Flight Center.** *For further information,* ***write in 5*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center; (205) 544-0021. Refer to MFS-26285.

Polarization Rotator for LCTV Spatial Light Modulator

Polarization would be varied electronically to select the complex-amplitude operating curve.

Lyndon B. Johnson Space Center, Houston, Texas

An electronically variable polarization-rotation device (or perhaps two such devices) would be incorporated into the filter-plane modulator of an optical correlator, according to a proposal. The resulting assembly of devices would provide for programmable electronic adjustment of the complex-amplitude operating curve of the modulator (the curve of magnitude and phase of a spatially modulated output laser beam vs. modulating voltage). Thus, the curve best suited to a specific optical-correlator task could be selected rapidly and repeatably by use of a simple electronic command.

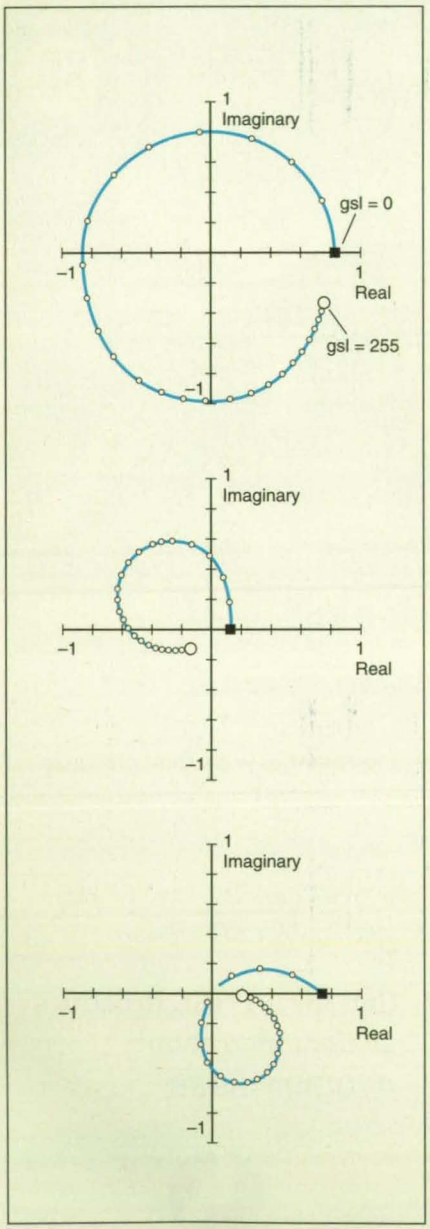


Figure 1. These **Examples of Complex-Amplitude Operating Curves** are representative of those that can be obtained by adjustment of the polarizer in a filter-plane modulator. The data points on each curve represent increments of a digitized modulation gray scale.

A typical optical correlator includes a filter-plane modulator that consists of a liquid-crystal television (LCTV) spatial light modulator sandwiched between two sheets of polarizing material — a polarizer and an analyzer. The LCTV is a spatially and temporally variable polarization-rotating device. The operating curve of the LCTV/sheets sandwich depends on the orientations of the sheets — most critically on that of the polarizer (see Figure 1). Heretofore, operating curves could be adjusted only with difficulty, by mechanical rotation of the polarizer.

Figure 2 illustrates schematically an optical correlator that contains one or two electronically adjustable polarization-rotating device(s) according to the proposal. The polarization-rotating device could be, for example, a commercial liquid-crystal polarization rotator. By application of the appropriate electronic polarization-control signals, the filter-plane modulator could be switched among substantially different operating curves or else fine-tuned to return the correlator to a standard configuration for which the filters were computed.

Typically, the input modulator would be operated in a high-contrast configuration. The filter-plane modulator would be set at the desired operating curve by application of the appropriate analog voltage(s) to the polarization-rotating device(s). Each such voltage could be programmed along with the filter setup in that it could be specified along with the two-dimensional array of filter control values for the pixels of the spatial light modulator. The advantage of using two electronically variable polarization-rotating devices instead of one is that at the cost of only a slight increase in complexity (the need to specify an additional analog voltage for each filter setting), all operating curves possible with the particular LCTV can be achieved.

This work was done by Richard Juday of **Johnson Space Center** *and Colin Soutar of the National Research Council. For further information,* ***write in 8*** *on the TSP Request Card.*

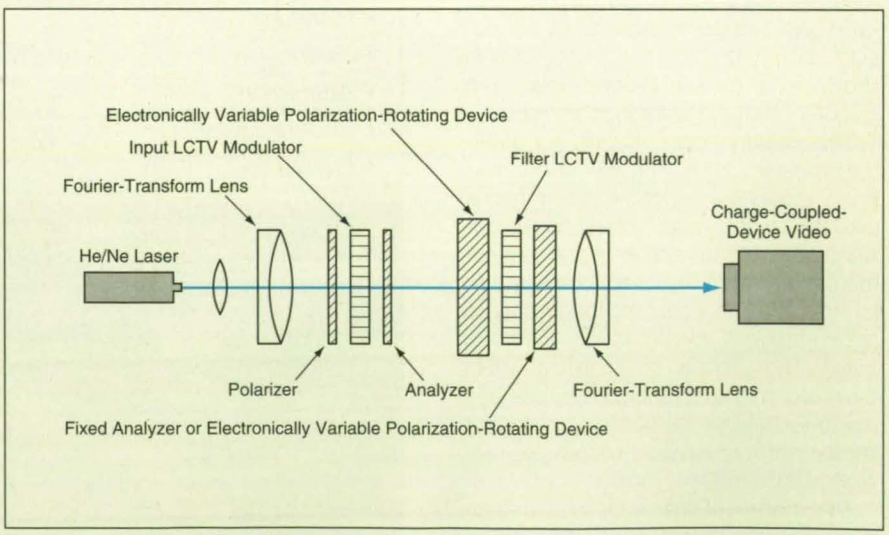


Figure 2. An **Optical Correlator** according to the proposal would contain an electronically-variable polarization-rotating device in place of a fixed polarizer, and possibly an additional such device in place of a fixed analyzer.

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center; (713) 483-4871. Refer to MSC-22378.

Braiding and Wrapping Tape To Make a Composite Vessel

Braiding and forming are combined in a one-step process.

Marshall Space Flight Center, Alabama

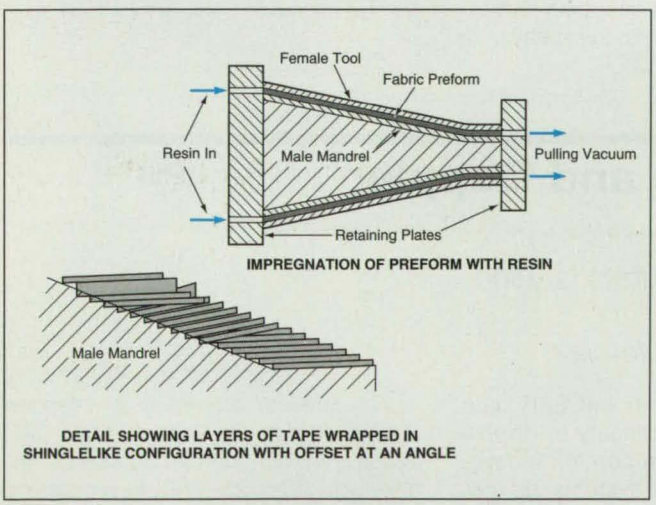
A braiding process has been developed for making an axisymmetric vessel out of matrix/fiber composite material. In the original application, a carbon-fiber fabric preform is impregnated with a phenolic matrix resin to make the conical nozzle body of a solid-fuel rocket motor. Other axisymmetrically shaped vessels (for example, cylindrical pressure vessels) could also be made of the same or different materials in modified versions of this process.

In this process, a continuous ±45° bias braided tape is fabricated. This braiding is done on site, and the braided tape is immediately wound on a male mandrel in a shinglelike configuration to make the fabric preform. Subsequently, the preform is impregnated with the matrix resin.

In the previous process, the tape was made by a relatively expensive, labor-intensive procedure: Short strips of dry 0°/90° fabric were slit along the bias direction, then sewn together to form the tape. The quality of the tape made in this way was variable, and the tape contained stitches (which are undesired), and scrap rates were high. The improved process does not produce stitches. It is expected to yield consistent quality, to involve less handling of fabric, to produce less scrap, and thus to cost less.

This work was done by Glenn Freitas, Joe Richard, and Connie Magee of Foster-Miller, Inc., for **Marshall Space Flight Center**. *No further documentation is available.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center; (205) 544-0021. Refer to MFS-26276.



Tape Is Braided and Wrapped continuously on a mandrel to make a fabric preform for an axisymmetric composite-material vessel.

Mathematics and Information Sciences

Distributed Computerized Catalog System

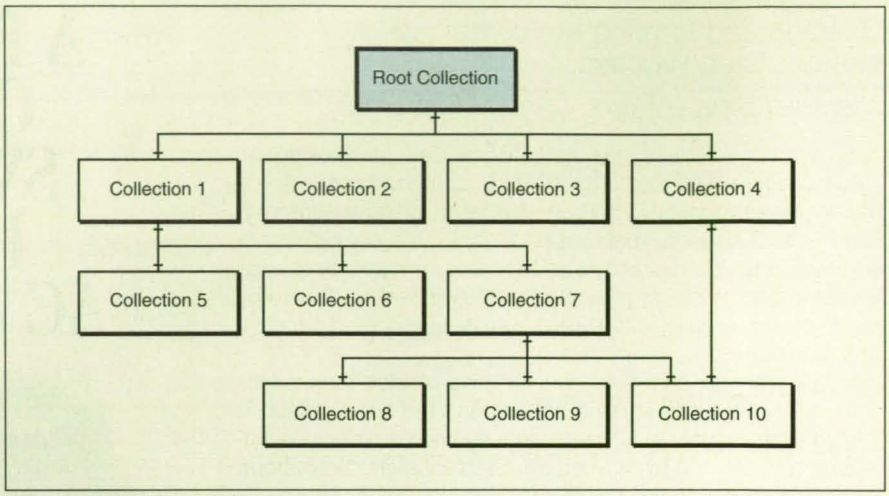
This system provides built-in generic and dynamic graphical user interfaces.

NASA's Jet Propulsion Laboratory, Pasadena, California

The DarkStar Distributed Catalog System is a general-purpose computerized catalog system that describes arbitrary data objects in a unified manner, providing end users with a versatile, yet simple search mechanism for locating and identifying objects. The system is distributed in the sense that various parts of it reside in various computers in a network. The system runs on conventional UNIX workstations with tcp/ip-based protocols.

The DarkStar system applies some of the principles of a distributed generic data base-management system (DBMS) to the comparatively restricted task of cataloging arbitrary data objects. This system can describe such static objects as files and compact disk read-only memories (CD ROMs), perform focused searches (with focus provided by expressions of criteria), browse, identify discovered objects, and report the locations of objects. The design of the system avoids some of the problems of a standard DBMS, and the system provides more flexibility than do conventional relational data bases, or object-oriented data bases.

The built-in dynamic GUIs (graphical user interfaces) are made possible by a combination of two established concepts from older DBMSs. First, automated searches are made possible by use of a multiple-parent directory, called a "smart directory tree" or "data-collection lattice," in which attributes that enable automated searches are attached to each node of the tree. Items on the lattice can be objects, files, complex data collection, or interlacing hierarchies. Items can exist across the boundaries between computers, so that multiple servers can be used in the single catalog system. The second established concept is that of a "schema" data base, which enables adaptation to a specific design. The system even has its own query language.



A **Data-Collection Lattice** is a partly hierarchical representation of the relationships among collections, subcollections, and data objects.

The most important element of the schema is the data-collection lattice. Every object defined in the catalog is made a member of at least one collection, and a collection can include other collections. In addition, all collections are grouped together in one root collection (see figure), with each collection organized as either a simple hierarchy or a complex lattice (collections appear under multiple parents). Collections can inherit attributes and access privileges of parent collections.

This work was done by Richard L. Borgen and David A. Wagner of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 97*** *on the TSP Request Card. NPO-19564*

Optimal Estimation of Range and Doppler Centroid in ScanSAR

Information from overlapping adjacent image bursts is used to compensate for pointing errors.

NASA's Jet Propulsion Laboratory, Pasadena, California

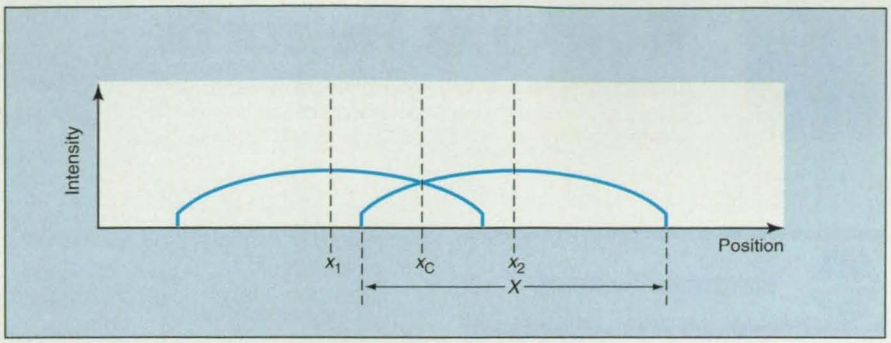
An algorithm processes synthetic-aperture-radar (SAR) returns into optimal estimates of ranges, pointing angles, and Doppler centroids. Like some other SAR-data-processing algorithms, this one derives radar-beam-pointing angles partly from the SAR data themselves; it is necessary to do this because the attitude-control subsystems of most SAR systems do not provide pointing-angle data of sufficient accuracy.

The present algorithm is intended especially for use in scan-mode SAR (ScanSAR), although it can also be applied to strip-mode SAR. In processing SAR data, errors in pointing angles lead to variations in image intensities as

functions of azimuth. The radiometric errors caused by errors in pointing angles are more severe in scan-mode SAR than in strip-mode SAR. Older algorithms that improve pointing accuracy were derived for strip-mode SAR and are, variously, inapplicable or ill-suited to scan-mode SAR.

The present algorithm exploits the information available in overlapping regions between adjacent image bursts or, equivalently, between adjacent radar beams that correspond to adjacent image bursts. The range or Doppler centroid is obtained from the estimate of the range or Doppler value at which the intensity in one image burst equals that in the adjacent burst. The steps of the algorithm are summarized as follows:

1. Process two adjacent SAR bursts into range-Doppler images.
2. Correct these images by taking out the variation of gain with slant range.
3. Convert these images into projection-domain images.
4. Compute ratios between samples in the overlapping region of the two burst images.
5. Compute the logarithms of these ratios; this changes the nature of speckle noise from multiplicative to additive.
6. For each dimension (azimuth or range) for which the logarithm of the ratio was computed in step 5 as a function of position along that dimension, take the average of the function along the other dimension (range or azimuth, respectively).
7. Convolve each resulting averaged logarithm-of-ratio function with the first-order derivative of $\{A(x - x_c) \equiv \log[W(x - x_1)/W(x - x_2)]\}$, where x denotes the coordinate in question, $W(x - x_i)$ denotes the similarly averaged antenna gain pattern centered at x_i, x_1 and x_2 denote the target locations at the center of radar illumination in the two bursts, and x_c denotes the coordinate of the equal-intensity point in the overlap between the two image bursts (see figure).
8. Detect the zero-crossing point over the interval from $x_2 - X/2$ to $x_1 - X/2$, where X denotes the width of an image burst. Since the distance of $|x_2 - x_1|$ is known, this zero-crossing point minus $|x_2 - x_1|/2$ is the desired estimate of the centroid.



These **One-Dimensional Intensity Functions** represent the azimuth or range dependence of the intensities in two adjacent SAR image bursts with homogeneous targets located at x_1 and x_2.

This work was done by Michael Y. Jin of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 62*** *on the TSP Request Card.*
NPO-19519

Books & Reports

These reports, studies, and handbooks are available from NASA as Technical Support Packages (TSPs) when a Request Card number is cited; otherwise they are available from the NASA Center for AeroSpace Information.

Electronic Systems

Zero-Annihilation Periodic Control for Damping Vibrations

A report presents a study on the use of a recently developed zero-annihilation periodic (ZAP) controller for active suppression of vibrations in flexible structures characterized by non-minimum-phase transfer functions. A non-minimum-phase situation can occur if certain kinds of vibration-sensor/vibration-actuator pairs (e.g., piezoelectric) are used, and/or if the vibration sensor(s) is (are) not colocated with the vibration actuator(s).

This work was done by David S. Bayard and Dhemetrios Boussalis of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Noncolocated Structural Vibration Suppression Using Zero Annihilation Periodic Control,"* ***write in 3*** *on the TSP Request Card. NPO-19287*

Architecture of a Sciencecraft To Fly Past Pluto

Two reports discuss the architecture of a proposed small sciencecraft that would carry scientific instruments on a trajectory that would pass near Pluto and continue into interstellar space. The discussion emphasizes those aspects of the design that pertain to compactness, efficiency, and small mass (dry mass < 100 kg). For purposes of description, the system block diagram of the sciencecraft is divided into blocks for sensors, integrated microelectronics, and motive effectors. Most electronic circuitry in the sciencecraft, including a block-redundant flight computer, would be combined into a single three-dimensional stack of multichip modules. Other, similar stacks would house telecommunication and thruster-valve-control electronics. A flat antenna would contain thousands of printed-circuit elements arranged to simulate a parabolic array. Waste heat from a radioisotope electric power source would be directed and controlled by blankets and louvers to create several thermal zones and maintain temperatures within desired ranges.

This work was done by Humphrey W. Price, Robert L. Staehle, Leon Alkalaj, Richard J. Terrile, and Robert N. Miyake of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain copies of the reports, "Pluto Express Sciencecraft Architecture" and "Pluto Flyby Sciencecraft,"* ***write in 34*** *on the TSP Request Card. NPO-19676*

Electronic Components and Circuits

Conductor-Backed Superconductive Coplanar-Waveguide Resonators

A report describes comparative tests of conductor-backed coplanar-waveguide resonators with a design resonant frequency of 10.8 GHz. The dielectric layers in the resonators were made of $LaAlO_3$ and the conductive ground planes on the back surfaces of the dielectric layers were made of gold. The coplanar-waveguide conductive strips on the front surfaces of the resonators were thin films of Tl/Ba/Ca/Cu/O, in some units and Y/Ba/Cu/O in other units. (Tl/Ba/Ca/Cu/O and Y/Ba/Cu/O are high-transition-temperature superconductors.) As one might expect, the Tl/Ba/Ca/Cu/O and Y/Ba/Cu/O units performed better than the all-gold-conductor unit did, at all but the highest temperatures. These results suggest that, among other things, Tl/Ba/Ca/Cu/O may be the material of choice for cryogenic microwave applications.

This work was done by F. A. Miranda and K. B. Bhasin of **Lewis Research Center**; *M. A. Stan of Kent State University; K. S. Kong of TRW, Inc.; and T. Itoh of the University of California at Los Angeles. To obtain a copy of the report "Conductor-Backed Coplanar Waveguide Resonators of Y-Ba-Ca–Cu–O and Tl–Ba–Cu–O on $LaAlO_3$,"* ***write in 27*** *on the TSP Request Card. LEW-15909*

Machinery

Spacecraft for Transport Between the Earth and the Moon

A report proposes the development of a family of spacecraft for transport between the Earth and the Moon. The development program would be oriented toward evolutionary improvements of equipment with minimal redesign of hardware. The intention is to develop a lineage of spacecraft, the designs of which would evolve to adapt to changing requirements and that could be fabricated on long-lived production lines. Conceptual future enhancements include different propulsion systems, transfer habitats, crew cabs, and aerobrakes for reentry to the atmosphere of the Earth.

This work was done by Stephen Capps, Brent Sherwood, and Gordon R. Woodcock of the Boeing Co. for **Marshall Space Flight Center.** *To obtain a copy of the report, "Evolutionary Lunar Transportation Family (LTF),"* ***write in 11*** *on the TSP Request Card. MFS-28950*

Active Suppression of Vibrations in Stirling-Cycle Coolers

A report presents the results of early research directed toward the development of active control systems for the suppression of vibrations in spacecraft Stirling-cycle cryocoolers. The dominant source of vibrations in such a cryocooler is its compressor, which contains a piston driven by a linear motor, typically at a frequency between 40 and 60 Hz. The researchers developed dynamical models of a cryocooler compressor, designed narrow-band control algorithms for two control schemes based on these models, coded these control algorithms for implementation with a digital signal processor, and demonstrated the performances of these control schemes in a cryocooler-vibration-test facility.

This work was done by Bruce G. Johnson, Frederick J. Flynn, and Monique S. Gaffney of SatCon Technology Corp. for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Demonstration of Active Vibration Control on the JPL Cryocooler Vibration Testbed,"* ***write in 98*** *on the TSP Request Card. NPO-19544*

Bearing Remover and Presser

A document describes a simple bearing-servicing tool consisting of only three parts capable of removing and replacing a rotary bearing within its race. A threaded drive operates between a guide and a pressure plate for dislodging the bearing from its race. For reinstallation, the guide holds the bearing in alignment with the race while pressure is applied to the bearing.

This work was done by Rex A. Boyce for **Johnson Space Center.** *To obtain a copy of the report, "Bearing Servicing Tool,"* ***write in 76*** *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 de-velopment should be addressed to the Patent Counsel, Johnson Space Center; (713) 483-4871. Refer to MSC-21881.

Tests of a Stirling-Engine Power Converter

A report describes acceptance tests of a power converter that consists of a pair of opposed free-piston Stirling engines that drive linear alternators. The reason for choosing free-piston Stirling engines is that they offer the potential for extremely long life, high reliability, high efficiency at low hot-to-cold temperature ratios, and relatively low heater-head temperatures. The Stirling engines operated at a power-conversion efficiency of 22 percent, producing 25 kW of mechanical power to drive the alternators. The output power of the alternators was initially 17 kW, corresponding to an efficiency of about 70 percent; the efficiency of the alternators was increased to about 90 percent by removing magnetic structures that surrounded the alternators. Vibration amplitudes were low, as exemplified by a casing motion of 0.03 mm.

This work was done by George Dochat of Mechanical Technology, Inc., for **Lewis Research Center.** *To obtain a copy of the report, "SPDE/SPRE Final Summary Report,"* ***write in 43*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Lewis Research Center; (216) 433-2320. Refer to LEW-16090.

Materials

Bondable Stainless Surface Coats Protect Against Rust

A one-page report describes tests that were conducted to assess the use of bondable stainless surface (BOSS) coating materials to protect the steel cases of solid-fuel rocket motors against corrosion and to provide surface microstructure and chemistry suitable for bonding to insulating material. The BOSS coatings that have received the most attention are plasma-sprayed Ni/Cr coatings, but others are also suitable. BOSS coating eliminates the need to cover the cases with grease to prevent corrosion and thereby also eliminates the need for degreasing immediately prior to use.

This work was done by G. D. Davis, D. K. Shaffer, H. M. Clearfield, D. Nagle, and G. Groff of Martin Marietta Laboratories for **Marshall Space Flight Center**. *To obtain a copy of the report, "Bondable Stainless Surface (BOSS) Coatings,"* ***write in 44*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center; (205) 544-0021. Refer to MFS-28870.

Preparation of Thermoelectric Materials From Melts

A report discusses the preparation of thermoelectric materials from melts. The materials used most commonly in thermoelectric devices (Bi_2Te_3, Sb_2Te_3, Sb_2Se_3 PbTe, PbSe, GeTe, SnTe, and $Si_{0.8}Ge_{0.2}$) are made by cold or hot pressing of powders of the desired composition obtained from single-crystal or large-grain polycrystalline ingots which, in turn, have been prepared by the techniques described in the report. The first stage in the preparation of a thermoelectric material is one of alloying or synthesis, in which high-purity elemental constituents are melted together in a stoichiometric or nonstoichiometric mixture. The report describes the techniques used in synthesis, with special attention to the techniques necessary to prevent and/or remove contamination during handling, synthesis, and subsequent processing.

This work was done by Alexander Borshchevsky of Caltech for **NASA's Jet Propulsion Laboratory.** *To obtain a copy of the report, "Preparation of Thermoelectric Materials from Melts,"* ***write in 56*** *on the TSP Request Card. NPO-19696*

Physical Sciences

Strain-Sensing Technology for High-Temperature Applications

A paper reviews the status of strain-sensing technology for high-temperature applications. The strain-sensing techniques discussed in the paper are those supported by NASA, such as those needed for applications in hypersonic vehicles and engines, advanced subsonic engines, and the development of materials and structures for high temperatures. These applications involve temperatures from 540 °C (1,000 °F) to more than 1,400 °C (2,600 °F). [Commercial resistance strain gauges do not give repeatable readings at temperatures above 400 °C (750 °F).] The most promising developments at present are those of (1) advanced resistance strain gauges made of high-temperature alloys with temperature-compensating designs and (2) remote sensing instruments based, variously, on measurements using laser speckle, phase-shifting interferometry, and x-ray extensometry techniques. The capabilities and limitations of these developmental techniques are discussed.

This work was done by W. Dan Williams of **Lewis Research Center**. *To obtain a copy of the report, "Strain Sensing Technology For High Temperature Applications,"* ***write in 50*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should

(continued on page 91)

Cast Your Vote For Product of the Year

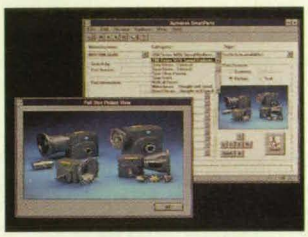
Throughout the year, *NASA Tech Briefs* has highlighted the Product of the Month—the product in each issue with exceptional technical merit and practical value to our readers.

This month, *NASA Tech Briefs* readers are invited to vote for the one product you feel is the most significant new product introduced for the engineering community in 1995. The product with the most votes will be awarded *NASA Tech Briefs'* **1995 Product of the Year.**

Below are descriptions of each of the Products of the Month and the months in which they appeared. Choose the **one** product you feel should receive Product of the Year honors, and write in the corresponding number on the reader service card. Return the card by **January 2, 1996** in order for your vote to be counted.

The winner will be announced in the February 1996 issue.

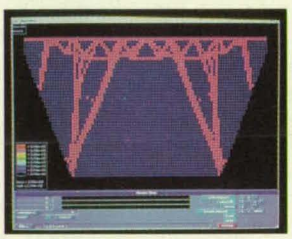
Product of the Month: May



Autodesk Inc., San Rafael, CA, has introduced the first two titles in its **CD-ROM mechanical library**: PartSpec™, an interactive database of more than 200,000 ready-made parts from 17 leading manufacturers, and Material-Spec™, continuing information on more than 25,000 material types. Autodesk estimates that the new tools will reduce average design time by 20 percent.

Write In No. 750

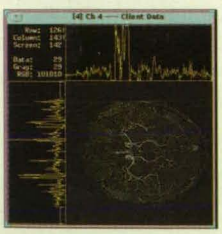
Product of the Month: June



OptiStruct **optimization software** from Altair Computing Inc., Troy, MI, uses topology optimization to synthesize optimum design concepts or layouts based on a finite element model of package space, load cases, boundary conditions, and an estimate of available material. The design can be further analyzed and refined using standard CAE tools. The software runs on most UNIX workstations and supercomputers.

Write In No. 751

Product of the Month: July



General Imaging Corp., Billerica, MA, has introduced what it calls the world's fastest **signal/image processor**. Capable of 30 billion operations/second, the MegaPIPE integrates object-oriented design/control software with CPU-I/O balance hardware within a single, scalable environment. Included are a mother card and up to 15 daughter cards. Applications include machine vision and remote sensing.

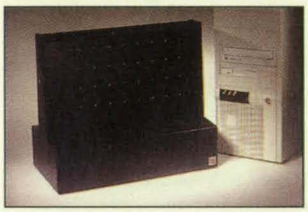
Write In No. 752

Product of the Month: August

The SmartMotor™ line of **drives** from Baldor Electric Co., Fort Smith, AR, combines adjustable speed control electronics with an industrial motor in one package. Advantages include guaranteed motor-control compatibility, easy installation, and elimination of the panel space previously needed for a stand-alone inverter. The drive design reduces line voltage reflections that contribute to premature motor failure in adjustable speed drive applications.

Write In No. 753

Product of the Month: September



Integrated Computing Engines Inc., Cambridge, MA, has introduced the Desktop RealTime Engine™ **computing system** combining the speed of a supercomputer with the economy of a desktop workstation. The "superstations" work with existing PC and workstation hosts, and are the size of a small briefcase. Designed for simulation, graphics, signal processing, imaging, and neural network applications, the systems incorporate Analog Devices' ADSP-21060 Sharc chips, and run on OS/2, Windows NT, or Digital UNIX.

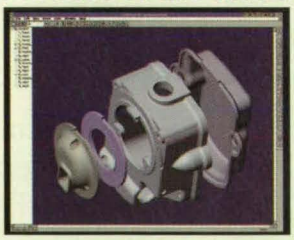
Write In No. 754

Product of the Month: October

Parker Hannifin Corp., Compumotor Division, Rohnert Park, CA, has introduced the ZETA Drive **microstepping motor/drive system** incorporating three patent-pending features: electronic damping, built-in stall verification, and electronic viscosity for greater usable torque and reduced settling time. According to the company, it is the fastest and smallest microstepping drive of its type, and is an alternative to open loop motion control systems. The drive measures 8.8" x 2" x 6.1", handles torques from 65 to 400 oz.-in., and operates at continuous speeds to 3000 RPM.

Write In No. 755

Product of the Month: November



SolidWorks Corp., Concord, MA, has introduced what it calls the first **solid modeling mechanical design software** developed specifically for Microsoft Windows. SolidWorks 95 includes all Windows features, in addition to a DesignBrowser™ dual-mode interface; real-time shaping of parts with visual feedback previewing; right mouse button control; and feature construction wizards. The program's 3D-centric design process incorporates a solid model used as a master for rapidly producing drawings and performing other functions such as finite-element analysis and numerical control programming.

Write In No. 756

December's Product of the Month, the Intel Pentium Pro Processor, is described on page 92. Write in No. 757 to vote for this product.

LITERATURE SPOTLIGHT

Free catalogs and literature for *NASA Tech Briefs'* readers. To order, write in the corresponding number on the Readers Information Request Form (preceding page 65).

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Priced 30-40% under comparable models, the Titan Stereo Zoom comes with 10X and 20X eyepieces and 2X objective, making it the only stereo zoom microscope to offer a zoom range of 7X to 160X without the need for costly extra optics. Binocular body is 360° rotatable and inclined 45° for comfortable viewing. TITAN TOOL SUPPLY CO., INC., 68 Comet Avenue, Buffalo, NY 14216; Tel: 716-873-9907; Fax: 716-873-9998.

Titan Tool Supply Co., Inc.

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This 500-page catalog contains an assortment of components including toggle clamps, modular fixturing, clamping devices, power workholding, chuck jaws, pins, knobs, drill bushings, leveling feet, power workholding, and much more.

Carr Lane Mfg.

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FREE 1996 INSTRUMENTATION CATALOGUE

The National Instruments 1996 catalogue features new versions of LabVIEW® LabWindows®/CVI, and HiQ® application software, as well as Measure™, a new spreadsheet add-in for direct data acquisition and control and VirtualBench™ Windows-based turnkey virtual instruments. New hardware includes GPIB, DAQ, and VXI interfaces for PCI-based computers; PCMCIA interfaces; MXI-2 interfaces; and serial interfaces. National Instruments, 6504 Bridge Point Pkwy., Austin, TX 78730; Tel: 800-433-3488 or 512-794-0100; Fax: 512-794-8411; E-mail: info@natinst.com; WWW: http://www.natinst.com.

National Instruments

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PRESSURE TRANSDUCERS/TRANSMITTERS

Taber pressure transducers/transmitters are outlined in a new brochure. They are available in low and high models in a variety of pressure ranges. Differential transducers provide high differential overload pressure and high line pressure capability. Oceanographic transducers are completely submersible, highly accurate pressure sensors. For more information contact: John Pinder. Tel: 800-333-5300.

Taber Industries

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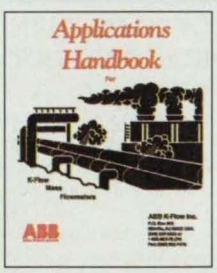

MASS FLOW METER APPLICATIONS HANDBOOK

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

ABB K-Flow

For More Information Write In No. 304

PRECISION MOTION CONTROL

API's 1995/96 172 page step motor systems catalog, featuring the new Intelligent Drive series, contains motion control technical, application and product data. Definitions, market applications, comparison charts, specifications and diagrams simplify the selection process. API products range from full/half-step driver modules to high performance microstep systems. American Precision Industries, Motion Technologies Group, Controls Div., 45 Hazelwood Drive, Amherst, NY 14228; Tel: 716-691-9100; Fax: 716-691-9181.

American Precision Industries

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TIME AND FREQUENCY PRODUCTS

TrueTime's Precision Time and Frequency Products catalog features GPS-Synchronized Clocks in rackmount, portable, and board-level configurations. Included are illustrations and product specs for Synchronized Clocks, Time Code Products, Board Level Products and Remote Displays. TrueTime products fit a variety of time and frequency applications. TrueTime, Inc., 2835 Duke Court, Santa Rosa, CA 95407; Tel: 707-528-1230; Fax: 707-527-6640; E-mail: truetime@nbn.com.

TrueTime, Inc.

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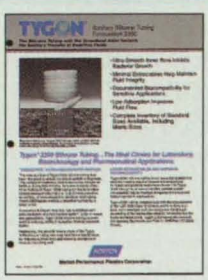

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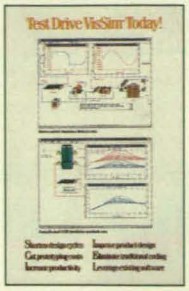

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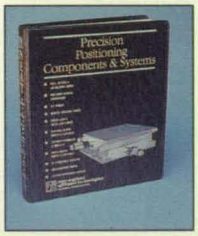

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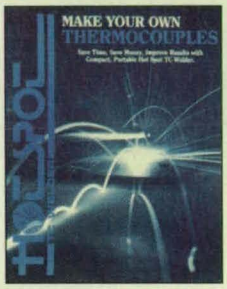

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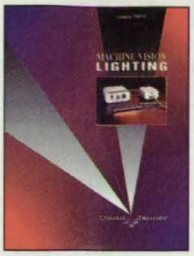

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PRECISION TEST & MEASUREMENT INSTRUMENTS

A new, full-color test and measurement catalog from Gould Instrument Systems, Inc. provides descriptions of Digital Storage Oscilloscopes, Recorders, Data Acquisition Systems, Signal Conditioners, and Analysis Software. Also included are traditional recorders and recorder products for field service and lab applications and products. For a free catalog, call 216-328-7000; Fax: 216-328-7400. Gould Instrument Systems Inc., 8333 Rockside Rd., Valley View, OH 44125.

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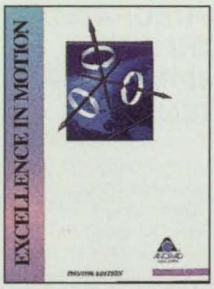

EXCELLENCE IN MOTION - 1995/1996 EDITION

The 1995/1996 edition, full-color positioning equipment technology guide from Anorad provides an overview of engineered motion control solutions for many industries. The brochure presents Anorad's broad array of positioning technologies including linear, rotary and air bearing stages; linear servo motors; gantry systems and controls. An easy-to-use selection guide is included to help users select the most appropriate equipment for their application.

Anorad Corporation

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FRICTION DATA GUIDE

Friction Data Guide is an engineering study of the coefficient of friction of a wide variety of materials and of Magnaplate-applied, super-hard, non-stick surface enhancement coatings. Compiled in an easy-to-use slide chart format, it aids engineers in selecting combinations of materials that can improve the service life of mating components. General Magnaplate Corp., 1331 Route 1, Linden, NJ 07036; Tel: 800-852-3301 or 908-862-6200; Fax: 908-862-6110.

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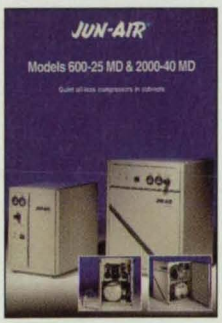


JUN-AIR consistently works on reducing noise levels, thus improving the work environment. Therefore, we offer our oil-less compressors in compact metal cabinets. This solution reduces the noise considerably (45 dB(A)) so the compressors may be placed directly at the work place. JUN-AIR USA Inc., 1303 Barclay Blvd., Buffalo Grove, IL 60089; Tel: 708-215-9444; Fax: 708-215-9449.

JUN-AIR USA Inc.

For More Information Write In No. 327

LINEAR MOTION COMPONENTS

US manufacturer offers a 24-page brochure containing helpful information and specifications on patented roller-bearing pillow blocks for hostile environments, precision case-hardened and ground shafting that is stocked in over 50 diameters, pre-drilled and tapped shafts, support rails, support blocks, and slide assemblies. They have many aerospace industry applications. Lee Controls, Inc., 727 South Ave., Piscataway, NJ 08854; Tel: 800-221-0811 or 908-752-5200; Fax: 908-968-7080.

Lee Controls, Inc.

For More Information Write In No. 328

The company's specification guide, CM-2, offers complete information on CRT MONITOR ENCLOSURES for protection of all models of CRTs from magnetic fields. Image distortion, jitter, and smeared colors can be eliminated by properly shielding CRTs and monitors from magnetic fields. Enclosures are manufactured to customer requirements from high-permeability CO-NETIC AA alloy. Magnetic Shield Corp., 740 North Thomas Drive, Bensenville, IL 60106; Tel: 708-766-7800; Fax: 708-766-2813.

Magnetic Shield Corp.

For More Information Write In No. 329

TOOLING AND MANUFACTURING PRODUCTS

This FREE catalog provides information on more than 2000 tooling/manufacturing components. Dimensions, photos, prices and applications are included. The full line covers standardized tooling components for jigs and fixtures, and a complete line of set-up and work clamping tools, including spring, ball and hand retractable plungers, nuts, bolts, washers, knobs, and thread repair inserts. Many components are available in stainless steel and metric sizes. Northwestern Tools, Inc., 3130 Valleywood Dr., Dayton, OH 45429; Tel: 513-298-9994; Fax: 513-298-3715.

Northwestern Tools, Inc.

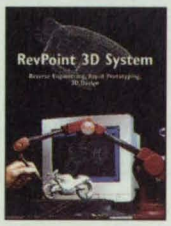
For More Information Write In No. 330

LOCATE HIGH-TECH RESEARCHERS & RESEARCH CENTERS

Synergistic Technologies, Inc. (STI) publishes valuable information on researchers and research centers in the high-tech areas of semiconductors, advanced materials, electronics, optoelectronics, environmental management and biotechnology. Comprehensive information on each researcher or research center such as research focus, lab equipment used, and funding allows you to quickly locate new technologies, identify early-stage research and reach laboratory decision-makers. Synergistic Technologies, Inc., 800-972-8501; Fax: 919-544-5084.

Synergistic Technologies, Inc.

For More Information Write In No. 331



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The RevPoint 3D System is a complete package that provides real-time 3D input with all the software you'll need for Reverse Engineering, Rapid Prototyping, 3D Modeling, or Design. As simply as you would use a tablet stylus, place the 3D probe on the surface of an existing part, and you are now working in 3D. Fully interactive, the RevPro digitizer always updates your position on the screen in real time. The RevPoint 3D system also exports your work as DXF, DWG, IGES, IBL, STL, CADL, or ASCII formats. SoftWorld International, 133 Admiral St., Bridgeport, CT 06601; Tel: 203-367-7789; Fax: 203-367-8331.

SoftWorld International

For More Information Write In No. 332

AIR FILTERS

Universal Air Filter Company (ISO 9002 certified) manufactures custom-designed air filters for original equipment manufacturers in the electronics, HVAC, digital switch, medical, defense, data processing, and other industries. Brochure describes applications, and engineering and production capabilities. Universal Air Filter Co., 1624 Sauget Industrial Parkway, PO Box 5006, Sauget, IL 62206; Tel: 800-541-3478; Fax: 618-271-8808.

Universal Air Filter Company

For More Information Write In No. 333

OPERATOR INTERFACE

The ProPanel® is a completely sealed, PC-based operator interface that meets NEMA 4/12 requirements and is approved for Class I, Div. 1 and 2 hazardous locations. It incorporates a full-color LCD flat-panel display and runs DOS, Windows, Windows NT, OS/2, SCO UNIX or any other PC-based software. The ProPanel offers two touchscreen options that provide superior performance in any industrial environment. Typical applications include food and chemical processing, pharmaceutical manufacturing, off-shore drilling, natural gas pipeline monitoring and aluminum smelting. Azonix Corporation, Billerica, MA; Tel: 800-365-1663; Fax: 508-670-8855.

Azonix Corporation

For More Information Write In No. 334

GLOBAL MOTION CONTROL–ISO 9001 REGISTERED

CAMCO, your first step to designing automation equipment, is the world's largest manufacturer of cam driven index drives, custom cams, parts handlers, precision conveyors, and servo mechanical drives. Application, analytical, and product engineering services offer the best value and quality. Commercial Cam Co. CAMCO, subsidiary of Emerson Electric Co., 1444 S. Wolf Rd., Wheeling, IL 60090; Tel: 708-459-5200 or outside the US, 800-645-5207.

CAMCO

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GENESYS INSTRUMENTS OFFERS SCOPES-DIRECT CATALOG

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Genesys Instruments

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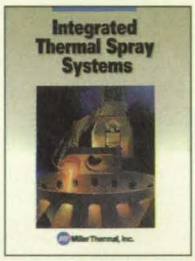

INTEGRATED THERMAL SPRAY SYSTEMS

New brochure details Miller Thermal's ability to provide complete coating solutions. From the design and installation of Integrated Arc, Flame, Plasma or HVOF Thermal Spray Systems, to the development of specialized metal or ceramic coatings, Miller Thermal can be your single-source supplier for thermal spray coating solutions. Miller Thermal, Inc., N670 Communication Dr., PO Box 1081, Appleton, WI 54912; Tel: 414-734-9292 or 800-637-8307; Fax: 414-734-2160.

Miller Thermal, Inc.

For More Information Write In No. 337

Workmanship Standards were developed by Lockheed Martin to use as guidelines in manufacturing electromechanical and electronics systems. The manuals available are: Electrical/Mechanical, Surface Mount (Revised 1995), Microelectronics, and Electrostatic Discharge–all with color photographs and clear instructions in a variety of formats for use on the production line and in training programs. The publications are augmented by slides, an ESD video, Electrical/Mechanical CD ROM and posters. All stress production excellence by recognizing unacceptable levels of quality. Lockheed Martin Corporation, 12506 Lake Underhill Rd., MP 1510, Orlando, FL 32825; Tel: 407-356-4769; Fax: 407-356-6288.

Lockheed Martin Corporation

For More Information Write In No. 338

REFRACTORY METALS DELIVER PERFORMANCE BY DESIGN

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CSM Industries, Inc.
(formerly Climax Specialty Metals)

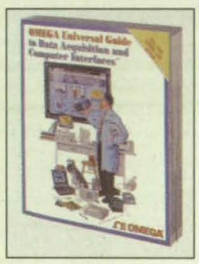
For More Information Write In No. 339

NEW BROCHURE DESCRIBES DUAL PERFORMANCE CAPABILITIES OF GV3000

Reliance Electric's new GV3000 brochure provides detailed information on the most advanced digital PWM inverter available today. The dual purpose GV3000 can be software-switched from open-loop general purpose regulation to closed-loop vector regulation for optimum positioning performance at a cost-effective price. Reliance Electric Company, Marketing Information Center, 24701 Euclid Ave., Cleveland, OH 44117; Tel: 800-245-4501.

Reliance Electric Company

For More Information Write In No. 340



OMEGA UNIVERSAL GUIDE TO DATA ACQUISITION & COMPUTER INTERFACES™

OMEGA Engineering Inc. announces the release of its latest publication. This 500-plus page handbook is packed with technical information and the latest product developments in automated data monitoring and control. For more information on this new literature, contact OMEGA Engineering, Inc., or use our OMEGAfax℠ service to request Document #9988 by calling 800-848-4271.

OMEGA Engineering, Inc.

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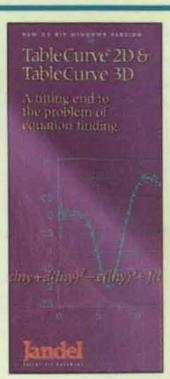

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Jandel Scientific Software

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FREE DRIVE COMPONENT LIBRARY

Features over 52,400 off-the-shelf inch and metric, commercial and precision small drive components. These 5 new catalogs include technical specifications for over 13,000 gears (D190); 7,900 shafts, bearings and couplings (D200); 18,300 timing belt drives (D210); 9,400 design components (D220); and Fairloc® hub fastening components (D240). Stock Drive Products/Sterling Instrument, 2101 Jericho Tpke., Box 5416, New Hyde Park, NY 11042-5416; Tel: 516-328-3300; Fax: 516-326-8827; Internet: http://www.sdpsi.com.

Stock Drive Products/Sterling

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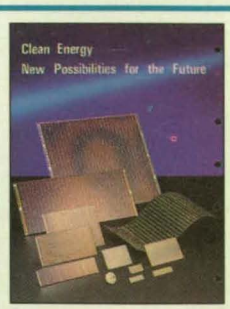


SANYO SOLAR CELLS

Sanyo is the largest manufacturer of amorphous solar cells in the world. Product line includes: 13 indoor models (1.5 to 3.0V @ 8 to 42uA), 31 outdoor models (1 to 15V @ 37 to 350mA), thin-film bendable, flexible, see-through power modules, and photosensors. Custom designs for power increase or shape available. Sanyo Electric Co., Ltd., 2001 Sanyo Ave., San Diego, CA 92173-2297; Tel: 619-661-6620; Fax: 619-661-4900.

Sanyo Electric Co., Ltd.

For More Information Write In No. 344

(continued from page 85)

be addressed to the Patent Counsel, Lewis Research Center; (216) 433-2320. Refer to LEW-16225.

Bubble-Free Containers for Liquids in Microgravity

A pair of reports discusses the entrainment of gas bubbles during handling of liquids in microgravity, and one of the reports proposes containers that could be filled with liquids in microgravity without entraining bubbles. Bubbles are troublesome in low-gravity experiments — particularly in biological experiments. Typically, bubbles form from turbulence and/or from pockets of gas that are trapped as liquid fronts advance during filling of vessels. Unlike in normal Earth gravity, there is no significant buoyant force available to remove bubbles from liquids. A vessel of the proposed type would be a wire-mesh cage. It would retain its liquid contents without a solid wall, because in microgravity, the surface tension of the liquid would exert sufficient confining force.

This work was done by Dale M. Kornfeld of **Marshall Space Flight Center** *and Basil L. Antar of the University of Tennessee Space Institute. To obtain copies of the reports, "Low Gravity Liquid Receiving Vessel" and "Bubble Generation During Low-Gravity Fluid Handling Procedures,"* ***write in 51*** *on the TSP Request Card. MFS-26366*

Mechanics

New Lubricants Increase Surface-Fatigue Lives of Gears

A report describes an experimental study of the effectiveness of seven oils with various additives and viscosities in prolonging the surface-fatigue lives of spur gears. Two of the oils were polyol-ester base stocks and one of them served as a reference lubricant, four of the oils consisted of polyol-ester base stocks with additives, and one was a polyalkylene-glycol with additive. The experiments were conducted on pairs of meshing spur gears of 3.5-in. (8.89-cm) pitch diameter, all fabricated to the same specifications from the same lot of steel. The surface-pitting fatigue life of each pair of gears in each oil was determined in a test at a speed of 10,000 r/min, at a temperature of 170 °F (350 K), and with a pitch-line maximum Hertz stress of 1.71 GPa (248 kpsi).

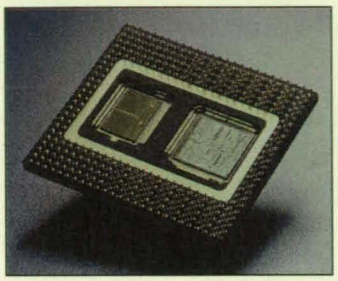
One of the parameters used to characterize the ability of a lubricant to protect against surface fatigue is the specific film thickness (Λ), defined by $\Lambda = h/\sigma$, where h is the elastohydrodynamic film thickness of the lubricant and σ is the composite roughness of the lubricated surfaces. In these experiments, it was found that oils with viscosities that provided $\Lambda > 1$ and that contained additives yielded surface-fatigue lives 4 to 8.6 times those of oils with viscosities that provided $\Lambda < 1$. In the cases of oils with viscosities sufficient to provide Λ well above 1, surface-fatigue lives were found to increase with viscosity.

This work was done by Dennis P. Townsend of **Lewis Research Center** *and John Shimski of the Naval Air Warfare Center. To obtain a copy of the report, "Evaluation of the EHL Film Thickness and Extreme Pressure Additives on Gear Surface Fatigue Life,"* ***write in 45*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Lewis Research Center; (216) 433-2320. Refer to LEW-16099.

New on the Market

Product of the Month



Intel, Santa Clara, CA, has introduced the Pentium® Pro, a 150 MHz **processor** that achieves twice the performance of the original Pentium in 32-bit, high-end visual computing applications, including CAD and 3D animation applications. The dual-cavity construction allows additional CPUs or high-speed I/O channels to be connected to the processor's bus with no loss in system performance. The processor core continues to process instructions following a cache miss and can make up to four concurrent requests of the bus.

For More Information Write In No. 700

The Drivelink 2000 **motor control system** from Futaba Corporation of America, Irvine, CA, is a radio-control system that interfaces with variable-speed electric motor controls. Any drive capable of following a 0-10 VDC analog signal speed command can be controlled with the system. Radio-controlled contact closures for on, off, run, stop, forward, reverse, and other functions are included.

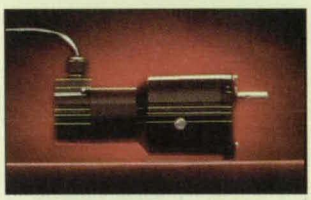
For More Information Write In No. 701

Sharp Digital Information Products, Irvine, CA, has introduced the GPB-2 high-speed **machine vision image processing board** that is adaptable for real-time product inspection. It features plug-in I/O modules for customization to any input and display and allows optimization of camera inputs. Camera image data is saved and processed simultaneously.

For More Information Write In No. 705

The uDCS Plus® **process control system** from Azonix Corp., Billerica, MA, controls hundreds of analog and digital I/O points in research labs and small manufacturing applications. The system operates independently from the host computer, and interfaces to pumps, balances, single-loop controllers, and other analog, digital, and serial devices. The metal enclosure resists dirt and moisture and provides EM/RFI immunity.

For More Information Write In No. 702



Bodine Electric Co., Chicago, IL, has introduced the 22B-Z **brushless gearmotor**, combining a brushless motor for quiet operation with a gearhead that features helical and spur gearing for higher output torque. Totally enclosed and non-ventilated, it is used in applications requiring quiet, maintenance-free operation. It is available in 24-, 90-, and 130-volt models with a rated torque to 100 lb.-in.

For More Information Write In No. 703

The Series 477 handheld **digital manometers** from Dwyer Instruments, Michigan City, IN, enable instant selection from up to nine English/metric pressure units, including psid, inches w.c., mm w.c., inches HG, Pascals, bar, and millibar. A nonvolatile memory feature stores up to 20 readings. Positive, negative, or differential pressures from 0-20 inches w.c. to 0-30 psid can be measured. Accuracy is +0.5% of full scale from 15 to 25°C.

For More Information Write In No. 706

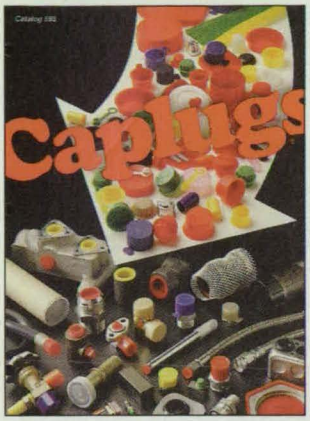
The Polychrome I from Applied Scientific Instrumentation Inc., Eugene, OR, is a high-speed, polychromatic **illumination system** for fluorescent microscopy that delivers a field of monochromatic light and can jump to any wavelength between 260 and 680 nm in less than 3 ms. Ultraviolet achromatic epifluorescence attachments couple the light to most microscopes.

For More Information Write In No. 704

Velmex Inc., East Bloomfield, NY, has introduced the Model B5990TS **rotary positioning table** for assembly, testing, and production applications. It accepts NEMA 17 stepper motors, employs a worm-gear drive, and has a 360° scale on the top surface. Maximum load capacity is 50 lbs. when horizontal and 5 lbs. when vertical. The table and base are made of anodized aluminum, and table size with the motor is 1.7" x 3.42" x 5.07".

For More Information Write In No. 707

New Literature



Available from the Caplugs Division of Protective Closures Inc., Buffalo, NY, is a 62-page catalog describing **protective closures**. Caps, plugs, edge liners, and grommets are available in plastic, metal, paper, and silicone rubber.

For More Information Write In No. 730

Bentley Systems, Exton, PA, offers a four-page brochure describing MicroStation® **CAD software** for drafting, modeling, database management, and visualization. Reference files, cell libraries, concurrent licensing, and a common file format among all MicroStation products are included.

For More Information Write In No. 731

Spiralock® Corp., a Detroit Tool Industries Company, Madison Heights, MI, offers interactive product-catalog software for its **internal locking thread form tools and fasteners**. The software includes information on troubleshooting, tapping RPM calculation, and drill charts.

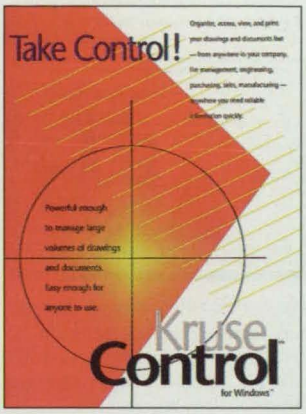
For More Information Write In No. 734

Electroid Co., Springfield, NJ, has released literature on **rare-earth permanent magnet power-off clutches and brakes**. The four-page catalog describes devices that can supply five times the torque-to-weight ratio of spring-set devices for robotics, aerospace, and medical applications.

For More Information Write In No. 737

A four-page brochure offered by Aerodyne Controls Corp., Ronkonkoma, NY, outlines development of custom precision **pneumatic valves and assemblies**. It also describes CAD systems, manufacturing facilities, and concurrent engineering practices.

For More Information Write In No. 736

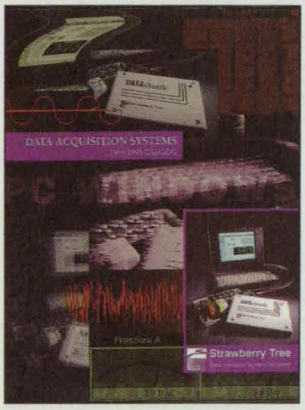


A four-page brochure from Kruse Inc., Downingtown, PA, contains information on Kruse Control™, a Windows-based **document control program** for organizing, accessing, and viewing large volumes of electronic drawings and documents. The program allows engineers to view more than 70 different file formats instantly.

For More Information Write In No. 732

The *1996 Master Source-Book* for **data acquisition and control** from Industrial Computer Source, San Diego, CA, includes embedded controllers, computer accessories, analog and digital I/O, motion controllers, and software.

For More Information Write In No. 733



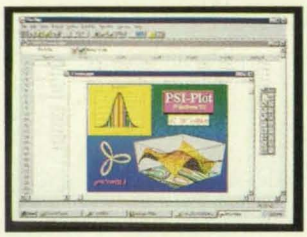
Strawberry Tree, Sunnyvale, CA, has released a catalog of **data acquisition and control products**, including how to choose a system, hardware and software selection guides, an applications reference, and ordering information. Also featured is the new DATAshuttle family of parallel port devices.

For More Information Write In No. 735

New on Disk

Enterprise Software Products Inc., Exton, PA, has announced FEMAP 4.4 **finite element analysis software** that includes 3D automatic meshing and support for new analysis disciplines. CAD solid models can be imported directly from AutoCAD, MicroStation Modeler, or any ACIS-based CAD package. Structural analyses can be performed in 20 different FEA programs.

For More Information Write In No. 720



PSI-Plot 32-bit **technical plotting and data processing software** for Windows from Poly Software International, Salt Lake City, UT, performs statistical analysis, data transformation/interpolation, digital signal processing, linear and nonlinear curve-fitting, model development, and differential equation-solving. Data can be exchanged with Lotus 1-2-3, dBase, Quattro Pro, Microsoft Excel, and ASCII formats. The cost is $299; upgrades are $79.99.

For More Information Write In No. 721

Design/Analysis Consultants Inc., Tampa, FL, has introduced Design Master™ **design analysis software** that provides worst-case solutions to design equations, and probability estimates of out-of-spec conditions and sensitivities. Probability models can be stored and edited. The program operates on Windows or Warp through a DOS window, and costs $295.

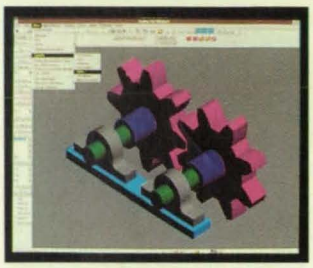
For More Information Write In No. 722

Altair Computing Inc., Troy, MI, offers HyperMesh version 2.0 **FEA pre- and post-processor program** for large-scale finite element models. The program allows engineers to develop, compare, and contrast design conditions, and provides interface with most FEA packages. It is available for $4500 per year on UNIX workstations; purchase price for PCs is $1500.

For More Information Write In No. 724

JB Data, New York, NY, announces *The NASA Technology CD-ROM*, containing 800 previously unpublished **NASA software programs**, abstracts of more than 90,000 NASA technical reports, front pages and claims to more than 2800 NASA patents, and more. Source code listings are included for the programs, which comprise expert systems, CAD/CAM, aerospace analysis, robotics, materials analysis, and more. Prepublication price is $195.

For More Information Write In No. 728



Cadkey Inc., Windsor, CT, has announced Release 2 of CADKEY 7 for Windows **CAD software** that includes surface modeling capabilities, an advanced drafting module, networking enhancements, and bi-directional data translation capabilities. Enhanced third-party development support enables users to write or adopt customized applications. The program costs $795.

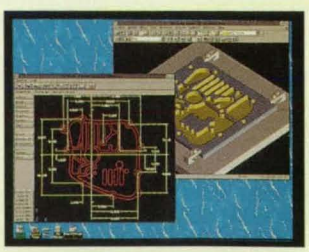
For More Information Write In No. 725

Visual Thought 1.2 **diagramming and flowcharting software** from Confluent Inc., San Francisco, CA, is a UNIX-based program for drawing flowcharts; organizational charts; software, process and block, network, and circuit and logic diagrams; and for designing World Wide Web graphics. It features a library of more than 100 shapes, and can add sound to any object to verbally annotate diagrams. A floating license costs $1295; a node-locked license is $695.

For More Information Write In No. 726

Generator **genetic algorithm software** from New Light Industries, Spokane, WA, is a Windows-based program that operates with an Excel spreadsheet, but is external to Excel, allowing future versions to be adapted for other spreadsheet and CAD software. It uses processes of natural evolution to solve optimization problems in electronic circuit design, curve-fitting, dynamic systems, and differential equations. The price is $375.

For More Information Write In No. 727



SURFCAM version 6.0 **CAD/CAM software** for Windows from Surfware Inc., San Fernando, CA, enables 3D design, surface modeling, and two- to five-axis NC programming, verification and machining. Enhanced features include gouge-free machining of single and multiple surfaces, a planar-cutting option, and toolpath verification.

For More Information Write In No. 723

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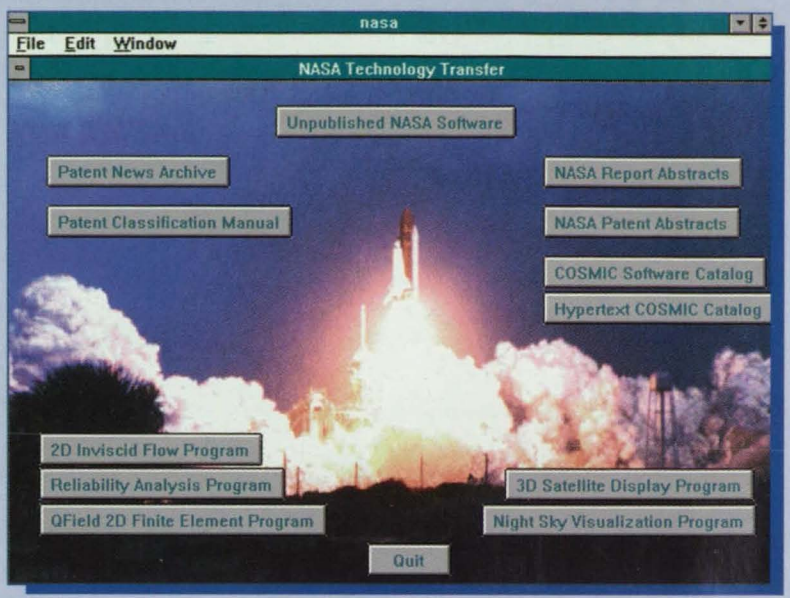

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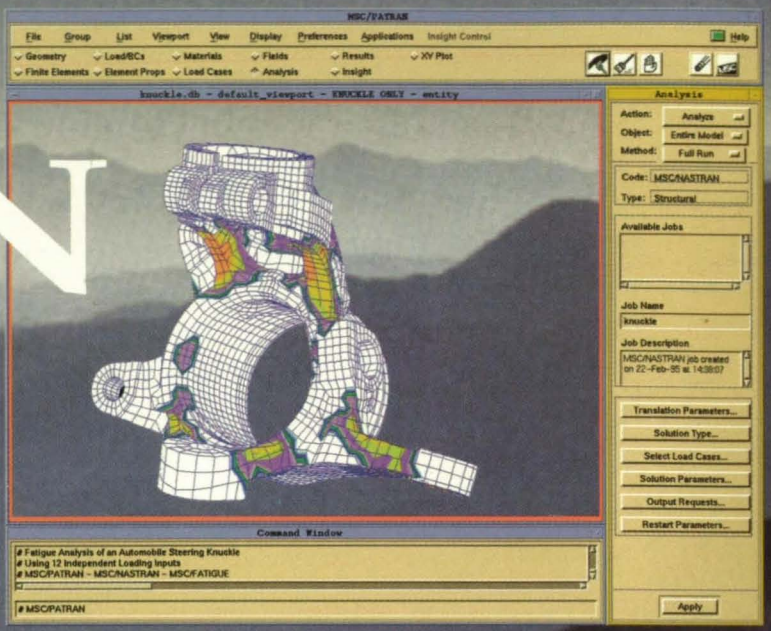

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