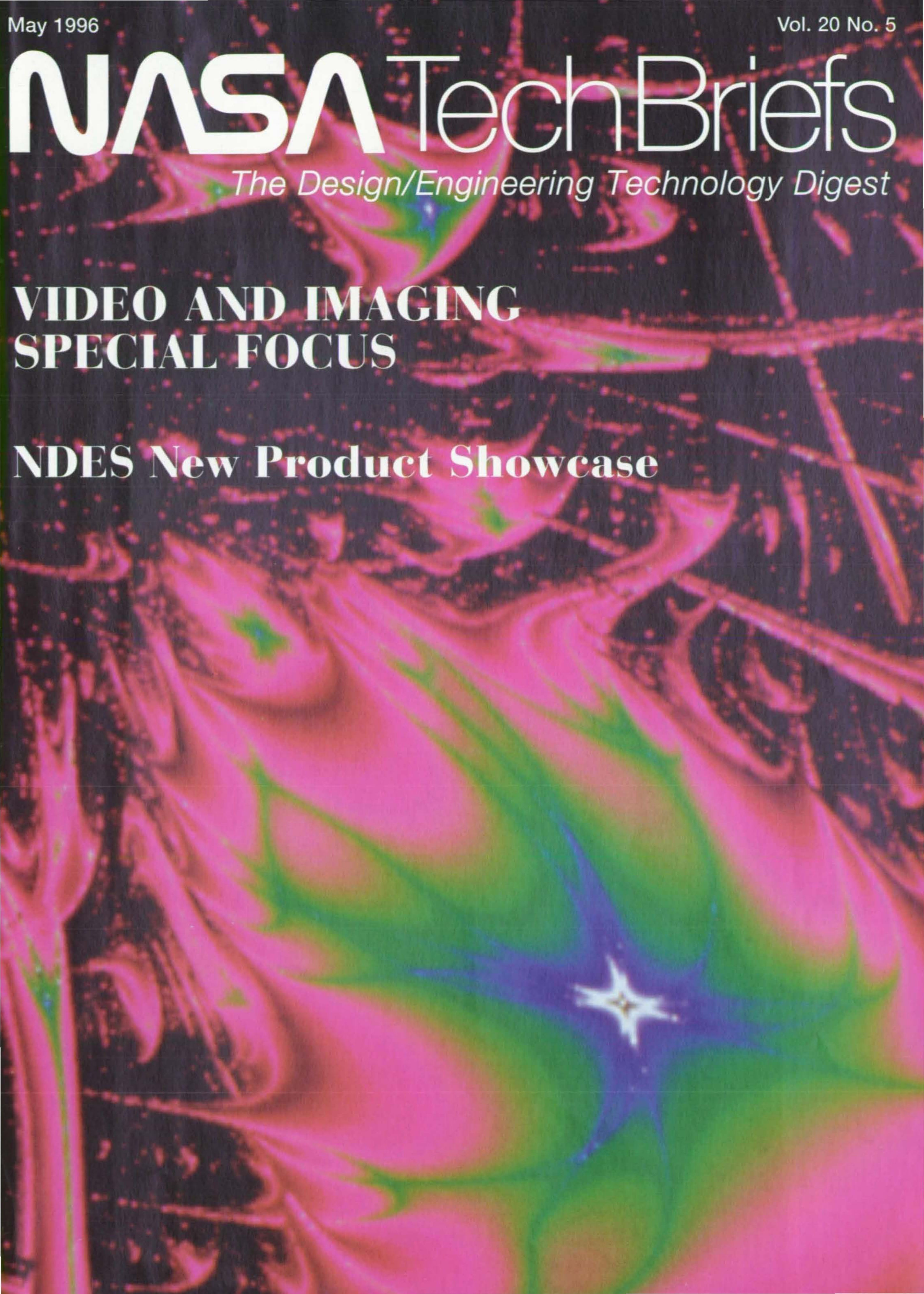
May 1996 Vol. 20 No. 5

NASA Tech Briefs

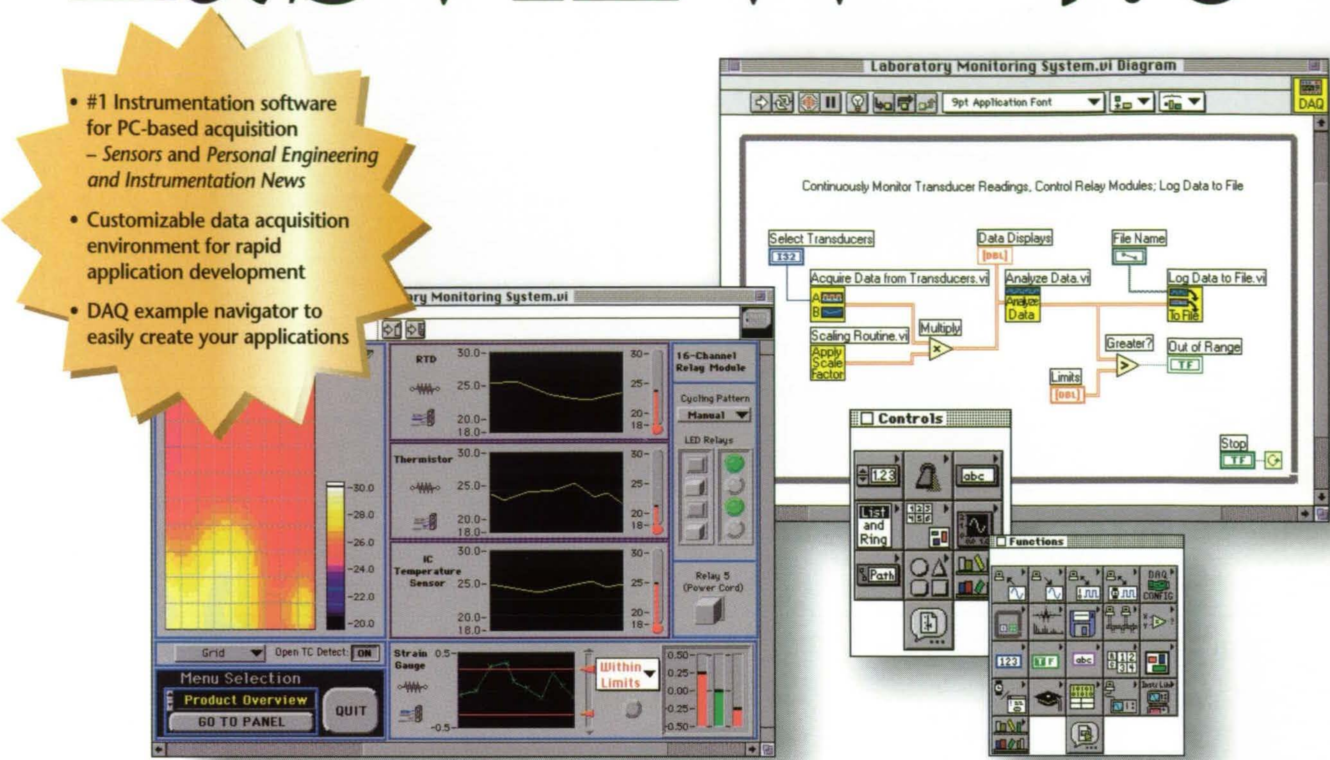
The Design/Engineering Technology Digest

VIDEO AND IMAGING SPECIAL FOCUS

NDES New Product Showcase



LabVIEW® 4.0



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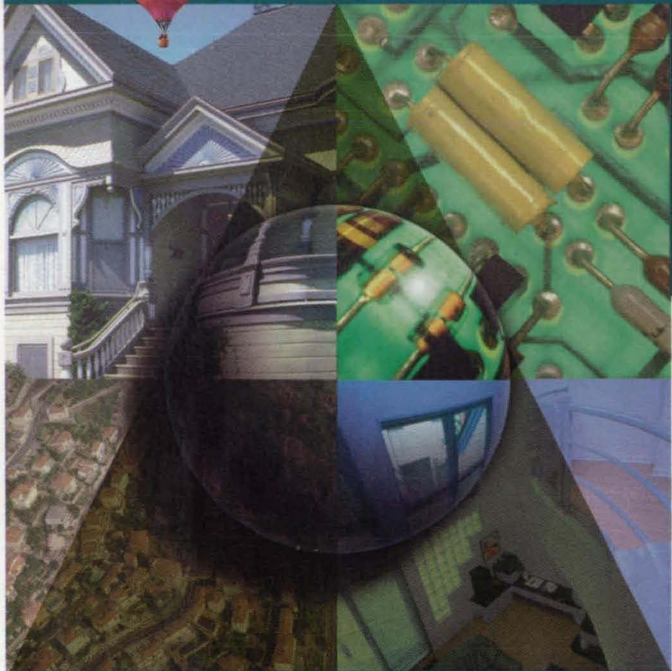

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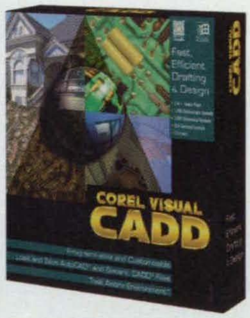

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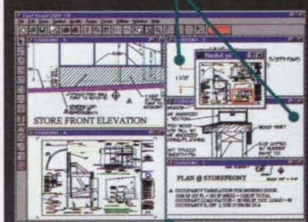
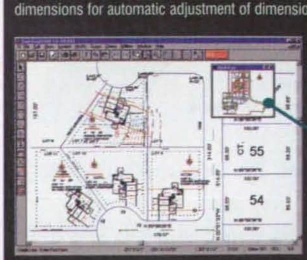
Multiple Viewports enable you to work on several views within the same drawing file or at different magnifications in several sections of a large complex drawing. Plus, when you exit the file, the multiple viewports you've established will be saved automatically.



Multiple Dimension Types - Select from ordinate, datum, linear, angular and radial options. Plus, associative dimensions for automatic adjustment of dimension lines.



All tool palettes and menu bars are fully customizable.

Quick Commands are logically located on the left-hand palette, so you can access the tool you need with a click of the mouse. Plus, each command has a quick 2-keystroke shortcut to speed the process even further. Spend your time drawing, not searching through tool menus.

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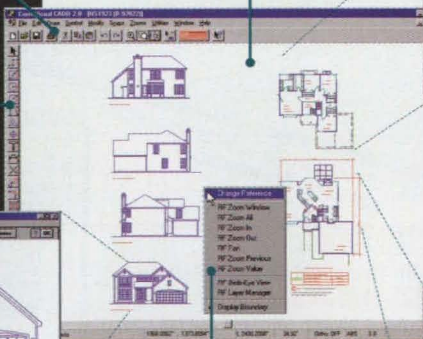
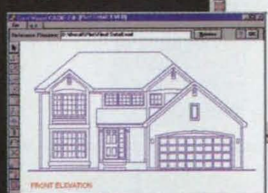
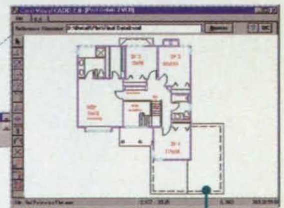
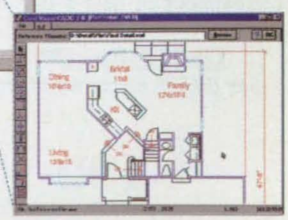






Dynamic Reference Frames give you absolute control over your printing layout by allowing you to reference multiple drawings and/or multiple views of the same drawing on your output sheet. You can also seamlessly integrate AutoCAD® xrefs and paper space.



Bird's-Eye View™ allows you to easily reference specific locations within a drawing with a thumbnail sketch.

Task Aware Environment™ is able to keep track of where you are in the design process. Since it incorporates enhanced features such as nested commands, matching tools, speed bar dialogs and a context-sensitive right mouse button, you can count on finishing your work in record time.

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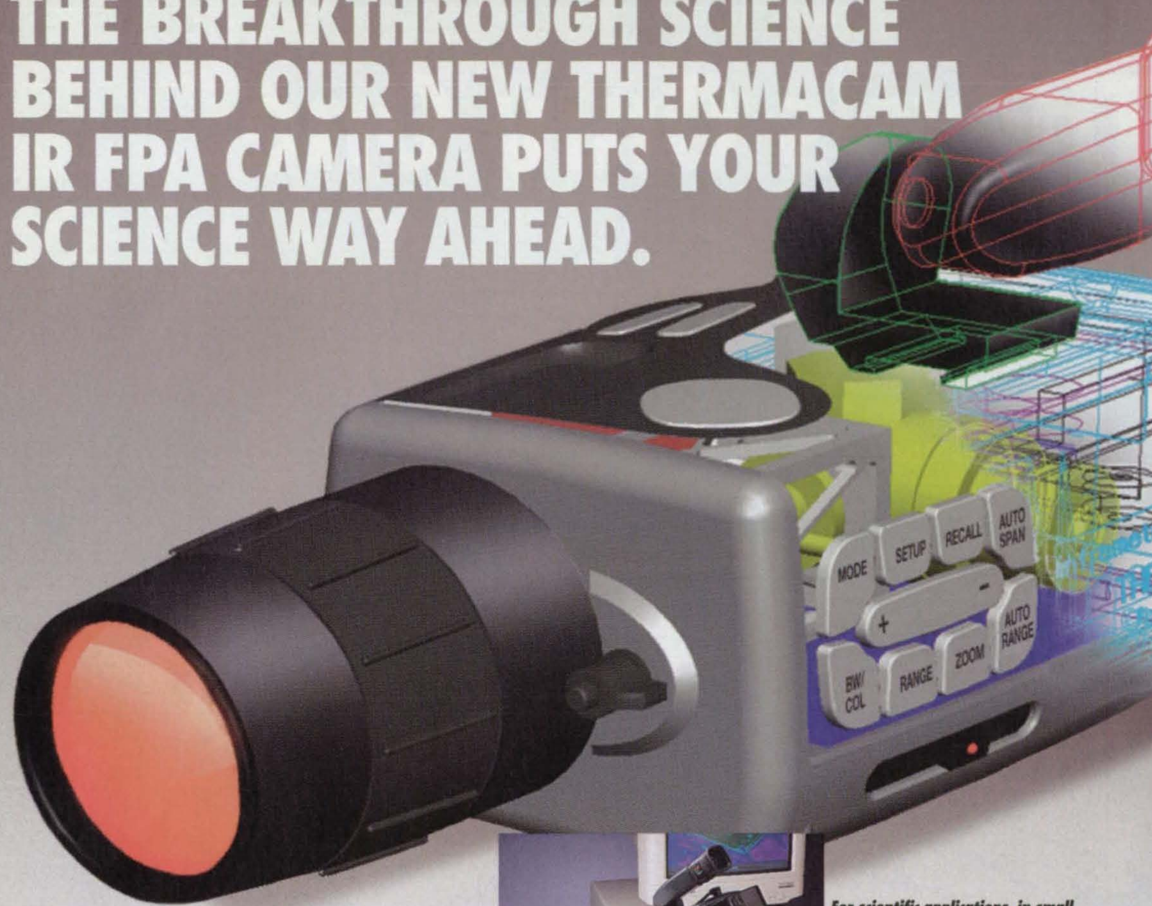
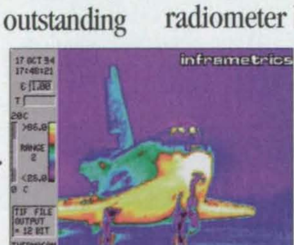


Digital storage of 12-bit images on a PCMCIA memory card eliminates floppy disks. Just plug the card into your PC for image processing and report generation.

For scientific applications, in small test chambers and constricted settings, ThermaCAM's compactness simplifies experiment set-up.

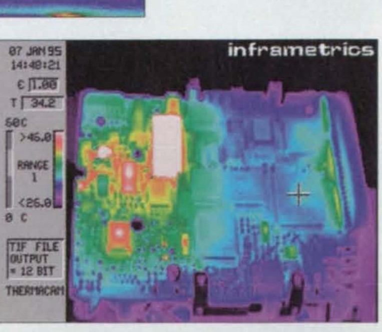
What if you were designing breakthrough capability and convenience into R&D thermal analysis instrumentation? You'd probably create a totally portable, self-contained infrared imaging system. One with 256 x 256 pixel, full-screen temperature measurement, a 12-bit dynamic range, and outstanding spatial resolution.

Well, consider it done. Inframetrics' ThermaCAM™ focal plane array radiometer is a true performance and portability breakthrough. Weighing just six pounds complete with integral power source, ThermaCAM is the ideal solution for scientific applications.



And with just this rugged, palm-sized sensor, you can take full IR measurement and data storage capability into the field.

Engineering the world's smallest radiometer began with the smallest cryo-cooler, Inframetrics' patented Microcooler. Optimized electronics, custom ASICs, efficient diffractive optics, and a PCMCIA digital memory card achieved breakthrough size and weight reduction. There's a full-color LCD display/viewfinder, plus remote and video links. And just 12 watts powers it all. Better still, Windows®-based ThermaGRAM image processing creates reports faster than you thought possible, right on your PC. Put ThermaCAM's science to work on your next breakthrough. Call Inframetrics today: (508) 670-5555.



ThermaCAM offers full screen temperature measurement and outstanding spatial resolution.

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TECHNICAL SECTION

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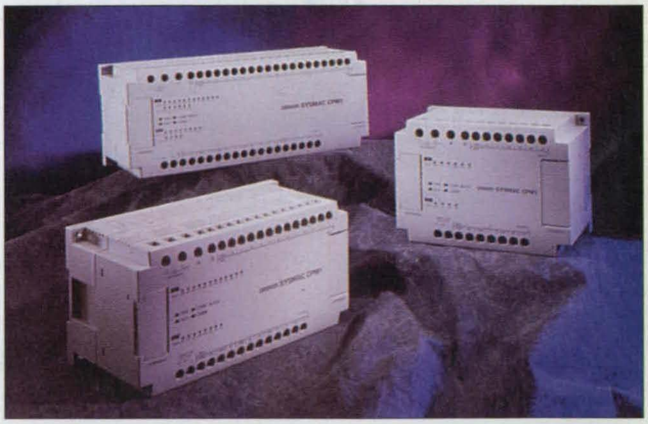
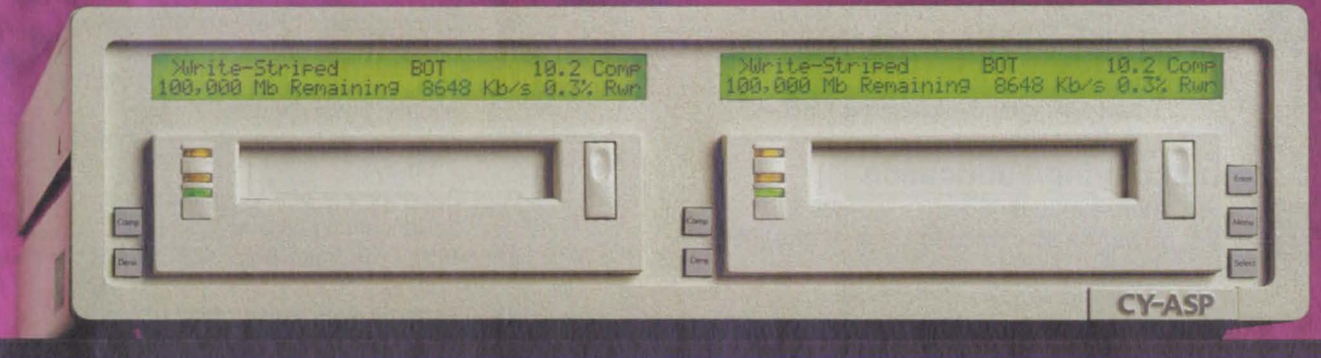


National Manufacturing Week, held in March, showcased more than 2,000 exhibitors in four major shows: the 44th National Design Engineering Show (NDES); the Industrial Automation, Integration and Control Show; the Plant Engineering & Management Show; and the Logistics '96 Show. New products introduced during the week included programmable logic controllers from Omron Electronics, Schaumburg, IL. For more information on this and other new product introductions, see the NDES New Product Showcase beginning on page 94.

Photo courtesy of Omron Electronics

Write 200 GB At *18 MBS*



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

Now, you can store 20 GB per tape at 3 MBS, uncompressed.

Up to ***100 GB*** per tape at ***9 MBS*** with optional data compression.

With the technology that has set the standard in reliability and data integrity since 1987.

But performance and flexibility hit the ceiling when two or more drives work together with the Advanced SCSI Processor.

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

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

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

Independent Write data to one drive while you restore with another

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

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

No other tape drive can match it.

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

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

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

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On the cover:
Multi-dimensional chaos theory can be visualized by modeling physical phenomenon. Interactive Data Language (IDL), a scientific computing environment from Research Systems, Boulder, CO, uses systems of nonlinear, partial differential equations of movement to demonstrate nonpredictability (chaos). Signal processing, statistical data fitting, random and pseudorandom number generation, and plotting are integrated to process the image. For more video and imaging advances, see the Special Focus beginning on page 24.

Photo courtesy of Research Systems Inc.

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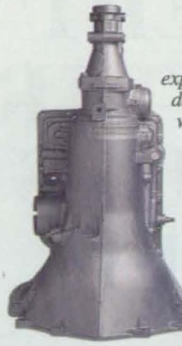
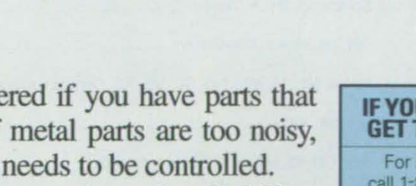
Insulators. *In plasma-arc cutting torches, Vespel insulators provide superior strength and durability at high temperatures up to 550°F, lasting up to six times longer than fragile ceramic insulators.*



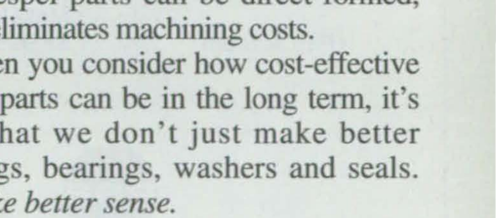
Seal Rings. *In the assembly of automobile transmissions, Vespel seal rings reduce costs by replacing expensive metal rings, which can fracture or deform during assembly. They also reduce warranty costs by producing a better seal.*

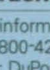
Thrust Washers. *In farm tractor transmissions, Vespel thrust washers reduce costs and manufacturing time by eliminating the need for secondary machining. Vespel washers also exhibit high performance and low wear with limited or no lubrication.*

Bearings. *In photocopiers, Vespel composite idler gear hub bushings are a cost-effective alternative to metal. The Vespel parts provide ultra-high temperature resistance and dimensional stability while offering a low coefficient of friction, as well as long life without lubrication.*



Bushings. *In aircraft engine vanes, Vespel bushings withstand high-frequency vibration dithering and offer excellent stability and lubricity at high temperatures. They also reduce assembly time.*





Wear Strips. *In textile equipment, Vespel tenter frame clip wear strips reduce costs by eliminating the need for lubrication. They also improve textile manufacturing quality by eliminating oil contamination, and provide good wear and temperature resistance.*

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(804) 864-6005
j.s.heyman@larc.nasa.gov

Lewis Research Center
Selected technological strengths: Aeropropulsion; Communications; Energy Technology; High Temperature Materials Research.
Ann Heyward
(216) 433-3484
ann.o.heyward@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
National Technology Transfer Center
(800) 678-6882

Robert Stark
Far-West Technology Transfer Center
University of Southern California
(800) 642-2872 or
(213) 743-2353

Dr. William Gasko
Center for Technology Commercialization
(800) 472-6785 or
(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
(412) 648-7000

Chris Coburn
Great Lakes Industrial Technology Center
Battelle Memorial Institute
(800) 472-6785 or
(216) 734-0094

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 phone: (706) 542-3265; Fax: (706) 542-4807; E-mail: http://www.cosmic.uga.edu or service@cosmic.uga.edu. If you have 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.

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).

Patterned Video Sensors for Low Vision

Miniature video cameras containing photoreceptors can be arranged in prescribed patterns to compensate partly for some visual defects. This approach promises to restore some visual function to people suffering from losses of peripheral or central vision.
(See page 31.)

Advanced Video Data-Acquisition System for Flight Research

A new system offers a broad range of features to meet the requirements for a comprehensive in-flight video documentation and provides capabilities previously unavailable from an in-flight video system.
(See page 40.)

Multimode Data-Compression System

A system is being developed to satisfy the need for high-speed, high-performance compression of data from sources as diverse as medical images, audio signals, high-definition television images, readouts from scientific instruments, and binary data files.
(See page 44.)

Adaptive Machining of Large, Somewhat Flexible Parts

A system can precisely machine a large variety of workpieces that may be temporarily deformed by thermal, gravitational, and/or machining forces. The system compensates for the deformation and guides the cutting tool to the precise spot on the workpiece.
(See page 78.)

Making Ceramic/Polymer Parts by Extrusion Stereolithography

A computer-controlled manufacturing process is being developed to manufacture parts out of ceramic/polymer composite materials. Computer software translates the design into a series of commands to move a resin dispenser so that the extruded material takes the size and shape of the desired part.
(See page 80.)

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b. Root canal

c. Opera

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NASA NEWS BRIEFS

In separate ceremonies, *NASA Tech Briefs* presented its 1995 Product of the Year Award to co-winners Autodesk Data Publishing of San Rafael, CA, for its Autodesk Mechanical Library CD-ROM, and SolidWorks of Concord, MA, for its SolidWorks 95 solid mechanical design software.

For more information on the Autodesk Mechanical Library, contact Autodesk at 415-507-5000; for information on SolidWorks 95, contact SolidWorks at 508-371-2910.

In Boston, SolidWorks President and CEO Jon Hirschtick (second from right) and Marketing Communications Manager Sabine Gossart (right) received the Product of the Year Award from NASA Tech Briefs *Publisher Joseph Pramberger (left) and Chief Editor Linda Bell.*

In conjunction with National Manufacturing Week in Chicago, Autodesk Data Publishing General Manager Blair LeCorte (second from left) and Product Manager Chris Hock (second from right) were presented with the Product of the Year Award by Joseph Pramberger and Linda Bell of NASA Tech Briefs.

The Louisiana Business and Technology Center, in conjunction with NASA's Stennis Space Center in Mississippi, is helping Cryopolymers of St. Francisville, LA, to improve its process for recycling vehicle tires and turning them into material for building new roads and other useful items. Engineers with Lockheed Martin Stennis Operations and Johnson Controls World Services at NASA Stennis have been working to freeze shredded tires and separate the rubber from reinforcing steel belts and polyester fibers.

A material called "crumb" is then produced using liquid nitrogen to freeze the rubber to -225°F. It can be broken down into various grades according to particle size. Large particle crumb is of less value and typically is used to improve wearability of road surfaces. Fine crumb is of more value and can contribute to making new tires and agricultural hoses, as well as producing bed liners for trucks when mixed with plastics.

The NASA/business collaboration has helped reduce the disposal problem of a worldwide annual production of more than 300 million tires.

For more information, contact Ron Keller of the Louisiana Business and Technology Center at 504-334-5555.

The November, 1995 issue of *NASA Tech Briefs* featured an article detailing the testing and subsequent use at Denver International Airport of the NASA Ames-developed Terminal Radar Control (TRACON) Automation System (CTAS). NASA is due to complete testing this month of the last part of the three-part air traffic control system—the Final Approach Spacing Tool (FAST)—at the Dallas/Fort Worth International Airport.

Depending on the size of an aircraft, the FAA requires aircraft to stay three to six miles apart for safety reasons. Air traffic controllers typically give themselves an extra buffer of about one-half mile. FAST can safely reduce the buffer by two-tenths to three-tenths of a mile by providing advisories that help controllers manage arriving aircraft and space the flow of traffic on final approach. NASA and the FAA plan to have FAST installed in five to ten major airports by the year 2000.

For more information, contact Mike Mewhinney of NASA Ames Research Center at 415-604-3937.

NASA has flight-tested a synthetic vision concept that may help make supersonic flight practical and affordable for the average air traveler by the turn of the century.

The "windowless landing" tests used a digital video camera, three infrared cameras, and two microwave radar systems. The video and infrared images were combined with computer-generated graphics that gave the pilot cues during approach and landing. Researchers hope that designers of future aircraft will be able to eliminate the expensive, mechanically drooping nose of early supersonic aircraft. Forward-looking windows would be eliminated, allowing for large-format displays filled with high-resolution images and computer graphics.

The flight tests are part of NASA's High-Speed Research (HSR) Program's Flight Deck Systems research effort, which develops technologies allowing airframe companies to design, build, and certify an aircraft cockpit without forward-facing windows. The HSR team includes NASA Langley, NASA Ames Research Center, the Boeing Co., McDonnell Douglas, and Honeywell.

For more information, contact NASA Langley's High-Speed Research Project Office at 804-864-2267.

The largest, most comprehensive demonstration of a prototype, interactive satellite communications network was held recently in Washington, DC. The demonstration linked a seismic data-gathering ship in the Gulf of Mexico with remote, interactive network sites in Minnesota, Houston, and California, including Jet Propulsion Laboratory and Sandia National Laboratories. NASA's Advanced Communications Technology Satellite (ACTS) was used to relay digital data, video, and audio simultaneously from the ship 120 miles south of High

Island, TX. Participants were able to see in real time the contours of the Gulf floor through incoming seismic data.

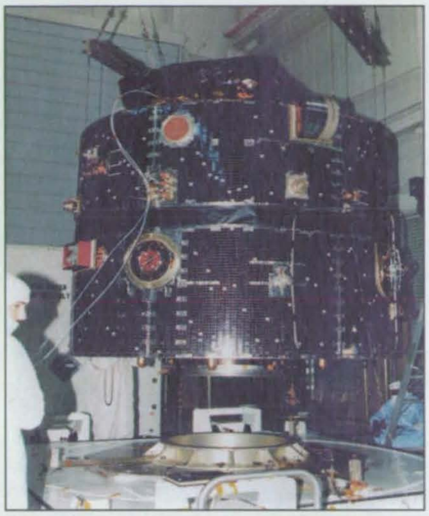
The potential applications for the network include national defense, weather forecasting, and medical data acquisition.

For more information, contact Chris Kelley of the American Petroleum Institute at 202-682-8181.

NASA has awarded a $70,000 Phase I Small Business Innovation Research (SBIR) grant to Advanced Refractory Technologies Inc. of Buffalo, NY, for evaluation of its DYLYN™ coatings as electrically conductive, flexible coatings for space applications. NASA seeks to use the thin films to provide electrical conductivity while simultaneously protecting sensitive underlying materials such as polymers from harsh space environments, which include large temperature fluctuations, ultraviolet radiation, and particle bombardment. The coatings are expected to be of use in commercial applications that require electrical conductivity, hardness, low friction, and infrared transparency.

For more information, contact Advanced Refractory Technologies at 716-875-4091; Fax: 716-875-0106.

Recent advances in charge-coupled device (CCD) imaging technology for space observation have dual-use potential in the medical field—specifically in digital mammography (see *NASA Tech Briefs*, February 1996, page 18). A new CCD technology developed by researchers at NASA's Langley Research Center has been tested successfully in a preliminary version of a mammography instrument being evaluated by the University of Virginia Hospital.



DYLYN™ thin film coatings may be used by NASA to coat satellite components exposed to harsh space environments.

The prototype instrument employs 48 CCD arrays capable of covering an entire breast, and provides high resolution without losing spatial resolution. The arrays are mounted to a positioning platform in a checkerboard pattern. To eliminate gaps in the image, the instrument uses multiple x-ray exposures that are accomplished by rapid and accurate repositioning of the CCD array platform. The repositioning is performed along two orthogonal axes with reference to the patient, at very high speed to negate patient movement between exposures. A stock commercial positioning system manufactured by Parker Hannifin's Daedal Division of Harrison City, PA, was used to ensure precise movement in both direction and distance.

The project was approved for a development and evaluation grant of $450,000 for three years from the National Cancer Institute of the National Institutes of Health, with NASA support continuing through research. The instrument and its testing for use in large-field imaging are expected to impact other medical needs.

For more information, contact James McAdoo of NASA Langley at 804-864-1640 or Chris Durkin at Parker Hannifin, Daedal Div. at 800-245-6903.

Automation Sciences Research Facility

The Automation Sciences Research Facility is co-located with the Human Performance Research Laboratory at Ames Research Center. The facilities share the high bay and mechanical spaces between the buildings.

The need for a productive bond between humans and the high-tech tools they create was the basis for establishing the Automation Sciences Research Facility (ASRF) at Ames Research Center at Moffett Field, CA. Completed in 1992, the facility is part of Ames' Information Sciences Division, which was created in 1982 to develop and demonstrate high-performance computing and artificial intelligence (AI) technologies to support four major aerospace project goals: the Space Station, the National Aero-Space Plane, a Lunar outpost, and the Mission to Mars.

The Information Sciences Division collaborates with other NASA centers in fundamental research and technology applications. An important function of the division is to provide artificial intelligence education and training for NASA, including an inter-center NASA exchange program designed to strengthen and broaden management skills. The division also maintains connections with U.S. universities to support research projects and provides opportunities for new technology introductions. Technology transfer activities include consulting on specific technical problems related to intelligent systems, and support of commercial uses of spaceborne automation and robotic payloads.

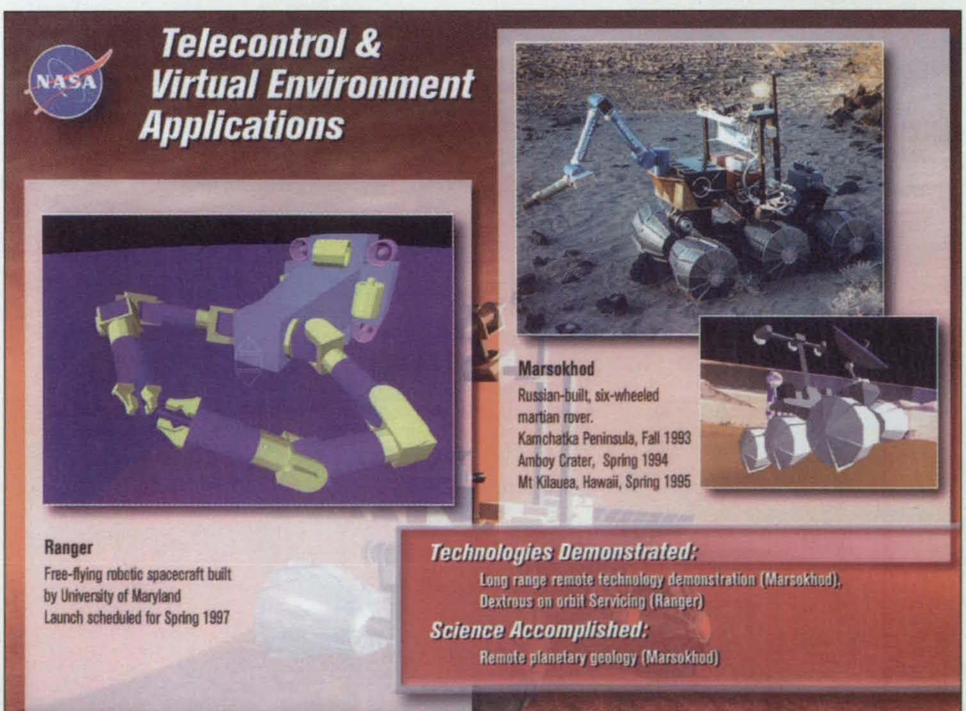
A key factor in establishing the ASRF was to provide, in one location, the equipment, facilities, and advanced computer systems necessary to attract the country's top automation systems scientists, mathematicians, engineers, physicists, chemists, human factors experts, psychologists, and social scientists to work together on diverse but related artificial intelligence applications. Prior to forming the ASRF, automation sciences research took place throughout NASA's laboratories nationwide.

ASRF scientists focus on synchronizing humans and machines through machine intelligence—making computers more useful by making them more intelligent. Using this technology, computers can be fused into autonomous systems that can adapt to new situations. Human senses such as vision and touch can be implanted in automated systems to work for, or in place of, humans—especially in space development applications such as constructing the Space Station and planetary exploration.

Since human factors research and artificial intelligence complement each other, Ames located the ASRF adjacent to the Human Performance Research Laboratory (HPRL), which was designed to develop systems that complement highly trained humans who supervise and control complex physical devices, such as robots. A shared 12,000-square-foot high bay in the HPRL houses full-scale mockups of space modules and simulators to test advanced decision-making computers.

A Cooperative Facility

The ASRF is a 60,000-square-foot building housing laboratories, training facilities, and offices. Laboratories include a photonics/optical information processing lab, which consists of five separate lab areas, four research bays with light-isolated optical tables, and a human-friendly computer area. Projects under development include robotic vision, planetary lander guidance, autonomous aircraft inspection, and optical matrix processing. Pattern recognition applications



The Intelligent Mechanisms Laboratory at the ASRF supports applications using remote operations, such as robotic spacecraft and Mars exploration rovers.

to help the blind, construct underwater robots, and detect metal cracks in aircraft also are being studied.

The neuro-engineering laboratory focuses on neuro-network research—software that imitates how the human brain works and learns in order to duplicate some of its functions. Neural algorithm development, and parallel and advanced architectural implementations are emphasized. In the neural control area, projects include hyperstability and hypervelocity control, and extracting human skills in nonlinear flight control.

Dryden Flight Research Center worked in cooperation with the ASRF in applying neural networks to support engines-only aircraft control, emphasizing the use of human landing skills in a hybrid traditional/neural network paradigm. The Engines-Only Flight Control System, developed by a Dryden team, was selected as NASA's nominee to the 1995 National Inventor of the Year competition (see *NASA Tech Briefs*, April 1996, page 20).

The intelligent mechanisms laboratory encompasses all systems having embedded machine intelligence. Projects involve the development of software tools to test and validate artificial intelligence concepts in robotics. In addition, the lab offers a platform for implementing and testing optical processing techniques developed in the photonics laboratory—such as enabling an intelligent mechanism to identify, track, and grasp moving and rotating objects within its field of view.

Telecontrol and virtual environment applications using remote operations have been developed through the intelligent mechanisms laboratory. Virtual reality terrain views and volcanic gas composition analysis performed by the Dante robotic vehicle (developed by Carnegie-Mellon University) in the Mt. Spurr volcano in Alaska in 1994 were supported by the lab, as were underwater surveys of McMurdo Station, Antarctica, performed by the Telepresence Remotely Operated Vehicle (TROV) in 1993.

Commercial Benefits

Many of the applications for artificial intelligence studied at the ASRF are important not only to NASA, but to the commercial marketplace. These applications include expert systems, computer vision, natural language processing, speech recognition and understanding, speech synthesis, problem-solving and planning, and human factors.

In the area of speech recognition, for example, ASRF scientists are studying ways to remove the psychological hurdles people must overcome when talking to a machine, since many speech recognizers have limited vocabularies. To solve the problem, scientists are developing interfaces that can recognize continuous natural language, taking into account variables in punctuation, inflection, and background noise.

Medical areas that will benefit from ASRF artificial intelligence advances include microsurgery, prosthetic innovations, and sensory augmentation and replacement. Other benefits are expected in the low-cost production of industrial items, improved air traffic control, better environmental hazard detection and response, and low-risk nuclear monitoring and control systems.

Through ASRF research, computers equipped with artificial intelligence will be able to perform a wide range of intricate operations at high speeds and at high cognitive levels, requiring fewer human operators. Labor-intensive tasks such as materials handling and assembly are particularly well-suited to benefit from the automation advances developed at the ASRF.

For more information on the Automation Sciences Research Facility, contact Gregg Swietek, Computational Sciences Division Chief, Ames Research Center, at 415-604-4162.

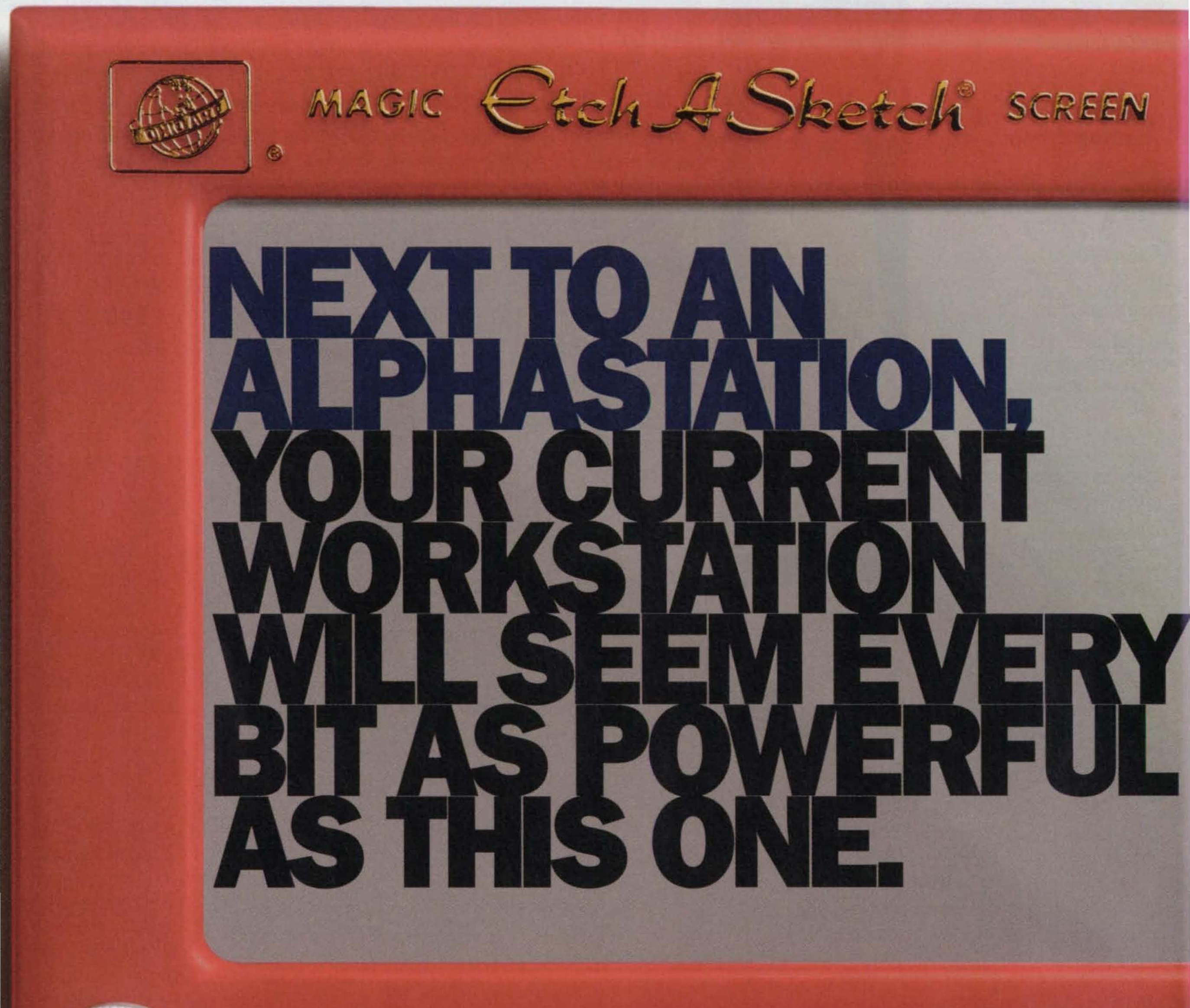

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Image Processing in Laser-Beam-Steering Subsystem

Image data would be processed rapidly and efficiently to achieve high frequency response.

NASA's Jet Propulsion Laboratory, Pasadena, California

A conceptual design of image-processing circuitry has been developed for the proposed tracking apparatus described in "Beam-Steering Subsystem for Laser Communication" (NPO-19069), *NASA Tech Briefs*, Vol. 19, No. 6, (June, 1995), page 32. As explained in more detail in that article, the image in question would be two spots of light on a charge-coupled-device (CCD) imaging array on the focal plane of a telescope, one spot being the projection of a beam of light received from a distant beacon, the other spot being the projection of a transmitted laser beam to be aimed at a commanded small point-ahead angle with respect to the received beam.

The task of the image-processing circuitry would be to produce data on the centroids of the two spots as measures of the angular positions of the two beams with respect to each other and to the optical axis of the telescope. The image data must be processed rapidly enough to provide the high frequency response that would enable associated beam-steering circuitry and electromechanical components to compensate effectively for jitter in the optical components and supporting structures. In the original intended application, this requirement would amount to processing at a frame rate of at least 2 kHz.

The maximum vertical and horizontal transfer clock speed of a typical CCD lies between 5 and 10 MHz. In conventional image processing, one reads out every pixel in the CCD array. Consequently, the frame rate in conventional image processing is a small fraction of this clock speed — unacceptably small in this case. In the proposed system, the desired frame rate would be achieved by a "windowed" readout scheme (see Figure 1) in which only pixels containing and surrounding the two spots would be read out and the others would be skipped without being read.

Unlike conventional camera circuits that must incorporate clock timing control to match the associated video displays, this camera circuitry could be under direct control of an image-data-processing computer, thus simplifying the design. Two major design features would help to maximize the pixel- and frame-processing rates: First, the pixel data would be processed on the fly; that is, without being stored in memory after readout, thus eliminating the memory-storage/retrieval cycle typically associated with image processing. Second, the

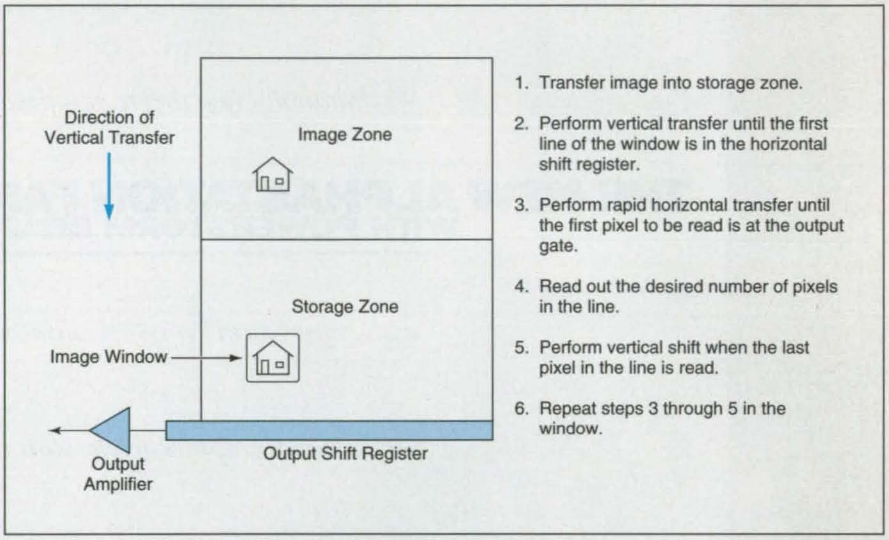


Figure 1. In a **"Windowed" Readout Operation**, only the lines containing the areas of interest would be read on a pixel-by-pixel basis, whereas other lines would be skipped without being read.

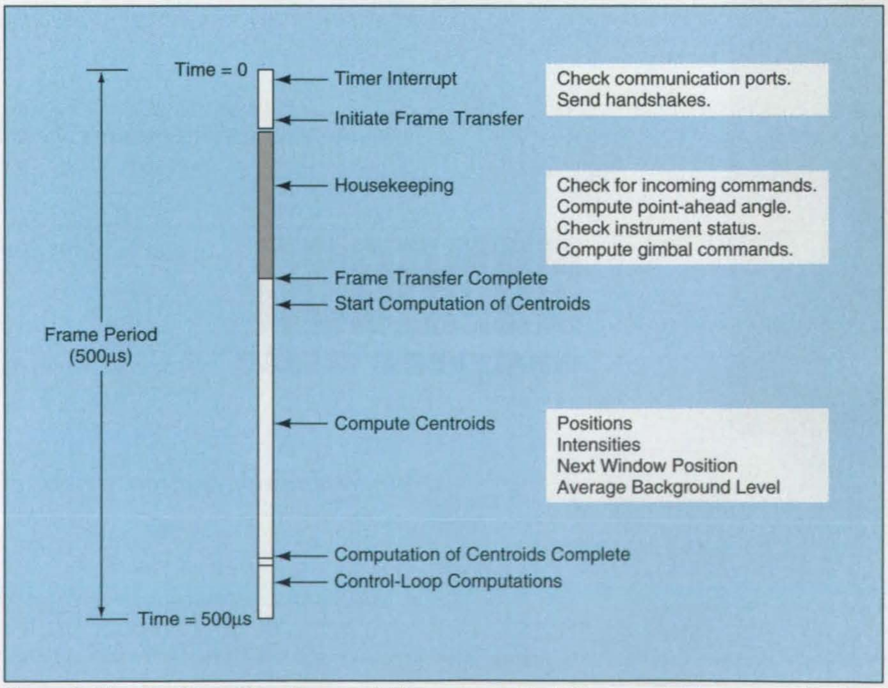


Figure 2. The **Tracking Algorithm** would be executed in 500-µs cycles (corresponding to a frame rate of 2 kHz) on a fast data processor.

INFRARED ENGINE

Commandable Integration Time

Full TV Resolution Imager

No Blooming, No Lag, No Transfer Smear

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 an 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 and provides analog video at RS170 scan rates. A key capability is the eight IRFPA operating integration modes that can be selected for electronic shuttering (or an option can be added that will allow higher frame rate operation).

TECHNICAL CHARACTERISTICS

640 X 480 Pixel PtSi FPA

- 24 (H) X 24 (V) micron pixels
- 50% fill factor
- No blooming, no lag, no transfer smear
- 3-5 µm spectral band
- NEDT = 0.15

Cool Down Time: 6 minutes to first image at 25°C

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 82.0 (H) X 60.0 (W) X 146.0 (L)
- Electronics Box 23.88 (H) X 89.0 (W) X 114.3 (L)

Total weight: 2.6 lbs

APPLICATIONS

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

ENVIRONMENTAL OPERATING CONDITIONS

- Temperature: -30°C to 60°C operational
  -40°C to 70°C storage
- Performs within specification under typical random vibration environment of 6G (rms) from 5 to 500 Hz
- Performs as specified at 50°C and 55,000 ft

OPTIONS

- Frame-rate to 1KHz
- 12-bit video processor
- CCIR

Sarnoff

For more information, contact:

Business Development
David Sarnoff Research Center
Subsidiary of SRI International
CN 5300
Princeton, NJ 08543
Telephone: 609/734-2553

readout of the CCD would be synchronized with the processing by use of an asynchronous first-in/first-out (FIFO) buffer memory. A programmable gate array would be used to initiate the horizontal line transfer after each vertical-transfer pulse. The pixel output would then be stored in the FIFO buffer at a constant speed of 10 MHz. The processor would then take the pixel data from the FIFO buffer when it was ready to handle the data.

To avoid the complexity of interprocessor communication and synchronization, the laser-beam-aiming control functions would be performed by the same computer that processed the image data. This would impose stringent demands for processing power. Fortunately, these demands could be satisfied by commercially available digital-signal-processing circuit boards that operate at throughput rates of up to 50 million floating-point operations per second. Furthermore, these boards include built-in timers for control of frame rates, and direct-memory-access channels that can be used for controlling the camera.

Figure 2 shows a typical control flow of the tracking algorithm. At the beginning of every frame period, the CCD would be set to transfer the image from the image plane to the storage plane. Note that for a frame-transfer CCD, the processor need not be processing the image centroids when the detector is transferring the image between the image plane and the storage plane. The processor would then be available to perform such housekeeping tasks as computing the point-ahead angle and monitoring the status of the system. At the end of the frame-transfer operation, the computation of centroids would be started. After the computation, the control signal would be computed on the basis of the actual and desired point-ahead angles.

This work was done by James R. Lesh, Homayoon Ansari, Chien-Chung Chen, and Donald W. Russell of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 91*** *on the TSP Request Card.*
NPO-19396

Active-Pixel Image Sensors With Programmable Resolution

Outputs of contiguous pixels could be combined.

NASA's Jet Propulsion Laboratory, Pasadena, California

Active-pixel image sensors with programmable resolution have been proposed for use in applications in which the speed and efficiency of processing of image data could be enhanced by providing those data at varying resolutions. Such applications might include modeling of biological vision, stereoscopic range-finding, recognition of patterns, tracking targets, and progressive transmission of compressed images. For example, in a target-tracking application, a sensor could initially form a low-resolution image from which an area of interest could be identified, then the sensor could be set at higher resolution for examination of the identified area (see Figure 1).

These image sensors would be complementary oxide/semiconductor (CMOS) integrated circuits that would include two-dimensional arrays of photodiodes or photogates with active pixel and peripheral readout circuits that could be programmed to combine the outputs of designated groups of contiguous pixels. Thus, a sensor of this type could be made to act as though it comprised fewer and larger pixels.

In one scheme, programmable for implementing variable resolution, switches would connect photodiodes in a square subarray to the transfer gate of one of the photodiodes; this would effectively form a larger pixel with correspondingly greater sensitivity and with block averaging of response over the component pixels. In another scheme for implementing variable resolution (see Figure 2), the outputs of individual pixels would be read out individually by row and column readout circuits as in full-resolution sensors, then the outputs of the row and column circuits would be fed to two banks of programmable summing (or averaging) circuits. One bank would combine the outputs from groups of adjacent columns; the other bank would combine the outputs from groups of adjacent rows.

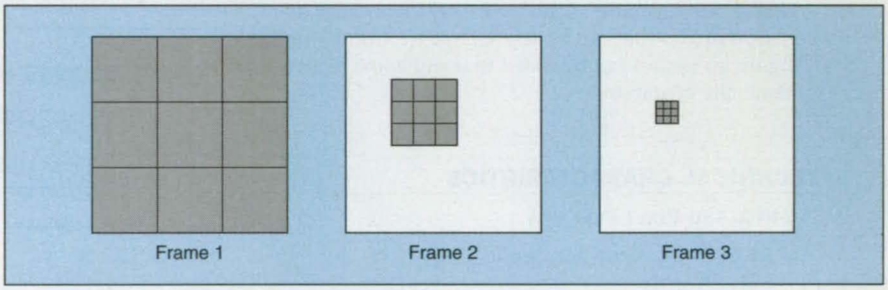


Figure 1. **Successively Smaller Areas With Finer Resolution** could be viewed in a process of "zeroing in" on a small area of interest without having to waste time processing fine-resolution data from the rest of the image.

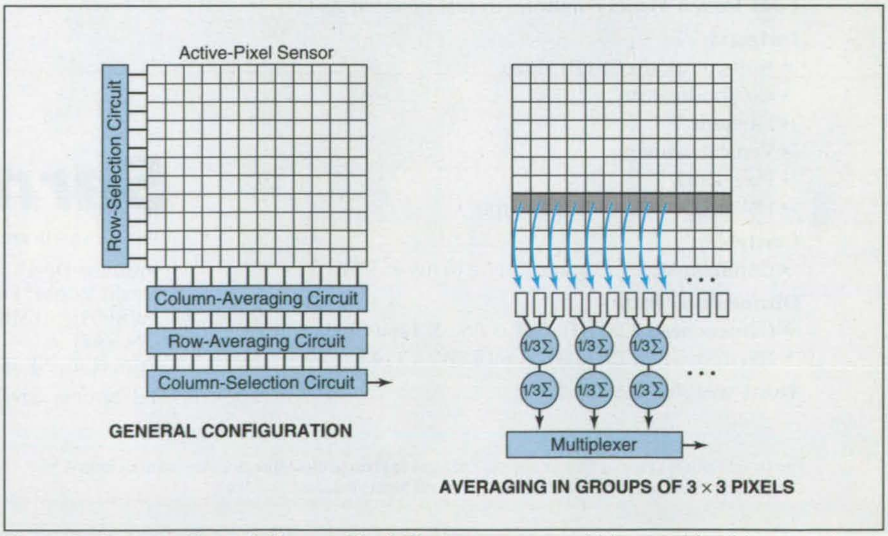


Figure 2. **Outputs From Adjacent Pixel Photosensors** could be combined by use of multiresolution circuitry at the bottoms of the columns.

This work was done by Sabrina E. Kemeny, Eric R. Fossum, Bedabrata Pain, Junichi Nakamura, and Larry H. Matthies of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 81*** *on the TSP Request Card.*

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

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

Refer to NPO-19510, volume and number of this NASA Tech Briefs *issue, and the page number.*

CMOS Active-Pixel Image Sensor With Simple Floating Gates

Complete reset eliminates *kTC* noise.

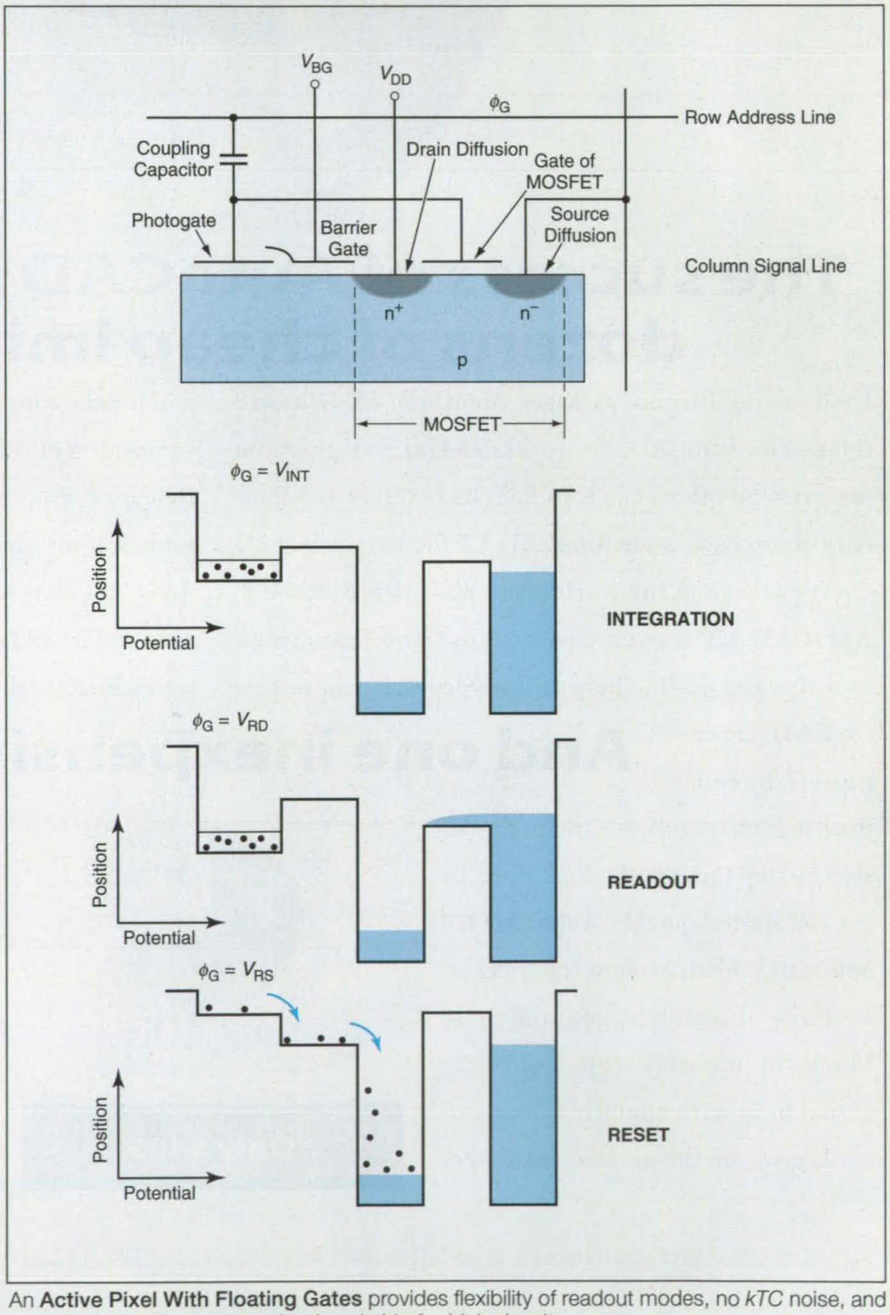
NASA's Jet Propulsion Laboratory, Pasadena, California

An experimental complementary metal-oxide/semiconductor (CMOS) active-pixel image sensor integrated circuit features a simple floating-gate structure, with a metal-oxide/semiconductor field-effect transistor (MOSFET) as the active circuit element in each pixel. Each pixel (see figure) also contains a photogate (which is part of a photosensor), a barrier gate, and a capacitor for ac coupling between the floating gates and a row address line. The photogate and the gate of the MOSFET are both electrically floating and are electrically connected to each other. The active-pixel design provides amplification and buffering capabilities that are expected to result in high signal-to-noise ratio. The design features a row- and column-addressing scheme that provides flexibility for a variety of readout modes, including random access, windowing, and electronic shuttering. These features are desirable for "smart sensor" applications.

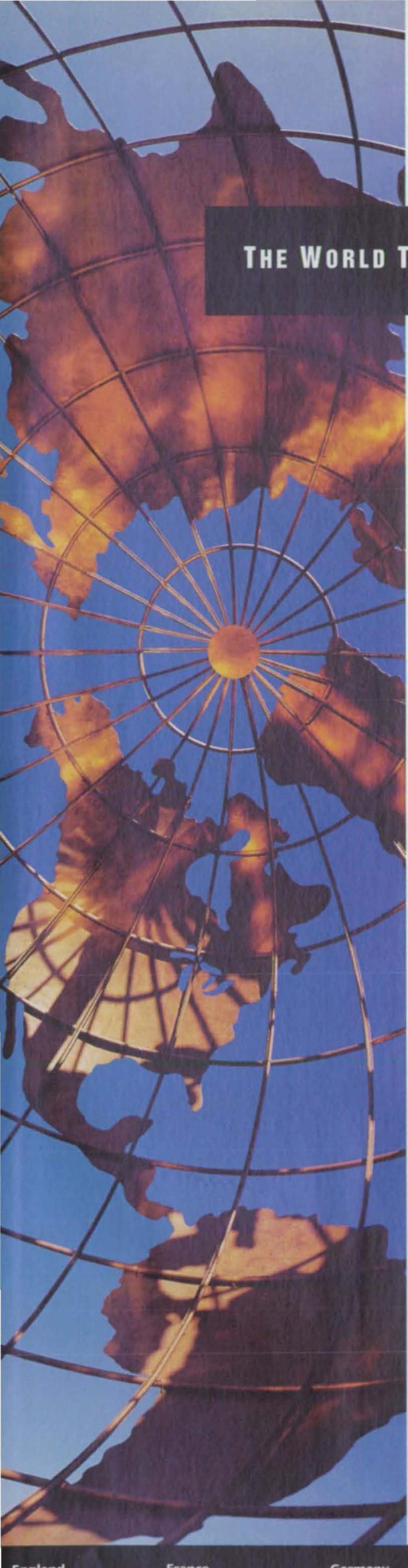
During operation, the barrier gate and the drain diffusion are dc-biased at potentials of V_{BG} and V_{DD}, respectively. The drain diffusion is the drain of the MOSFET; it also acts as the lateral-overflow drain for signal electrons during the integration (photosensing) period and as the reset drain during the reset period.

During the integration period, the row address line is biased at the integration potential V_{INT}, and the photon-induced signal electrons accumulate in the potential well under the photogate. When the row address line is pulsed to the readout potential V_{RD}, the floating-gate potential, which depends on the amount of accumulated signal charge, is sensed by a source follower that comprises (a) the MOSFET in the pixel and (b) an active load in the form of an n-channel MOSFET at one end of the column signal line. When the row address line is biased at V_{RS} (which is usually ground potential), the signal charge accumulated under the photogate is drained to the drain diffusion.

The array of active pixels is served by peripheral readout circuitry that is conventional except that a level-mixing circuit is placed between the row decoder and the row address lines to generate row address pulses with the



An **Active Pixel With Floating Gates** provides flexibility of readout modes, no *kTC* noise, and a relatively simple structure that is suitable for high-density arrays.



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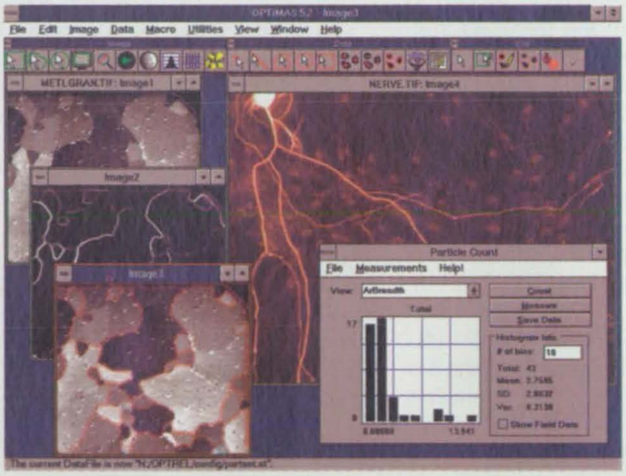

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potentials V_{INT}, V_{RD}, and V_{RS}. The pixels are arranged in 27 rows and 32 columns, with a pixel size of 40 by 40 µm. The sensor was fabricated in a 2-µm double-polycrystalline-silicon n-well CMOS process.

Readout from each row of pixels is performed during the horizontal blanking period. In addition to the operations described above, readout includes the following operations: The readout potential V_{RD} is applied to the selected row, and the signal level from each pixel in the row is sampled and held on one of two holding capacitors at one end of the column that contains the pixel. After this signal-level sampling, the row address line is biased at the reset potential V_{RS}, thereby resetting the photogate. Then the row address line is again biased at the readout potential V_{RD}, and the reset level is sampled and held on the other holding capacitor. During the succeeding horizontal-scanning period, the signal and reset levels from the holding capacitors of each column are read out. The fixed pattern noise is suppressed by subtracting the reset level from the signal level.

Because of completeness of the reset operation, there is no *kTC* noise [a component of noise with mean-squared charge approximately equal to *kTC*, where *k* is Boltzmann's constant, *T* is absolute temperature, and *C* is a capacitance] and there is no image lag. The lateral-overflow drain structure suppresses blooming. The floating-gate structure enables nondestructive signal readout, which is useful for image processing and for multiple readout to extend the dynamic range of the sensor.

There are drawbacks inherent to the floating-gate structure. One is poor response in the short-wavelength region of the spectrum due to the poor transmission rate through the polycrystalline silicon layer(s). The other is poor charge-handling capacity. Future development of denser arrays of pixels is expected to address these issues.

This work was done by Eric R. Fossum, Junichi Nakamura, and Sabrina E. Kemeny of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 90*** *on the TSP Request Card.*

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

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Refer to NPO-19621, volume and number of this NASA Tech Briefs *issue, and the page number.*

Estimating Distances to Objects From Motion in Images

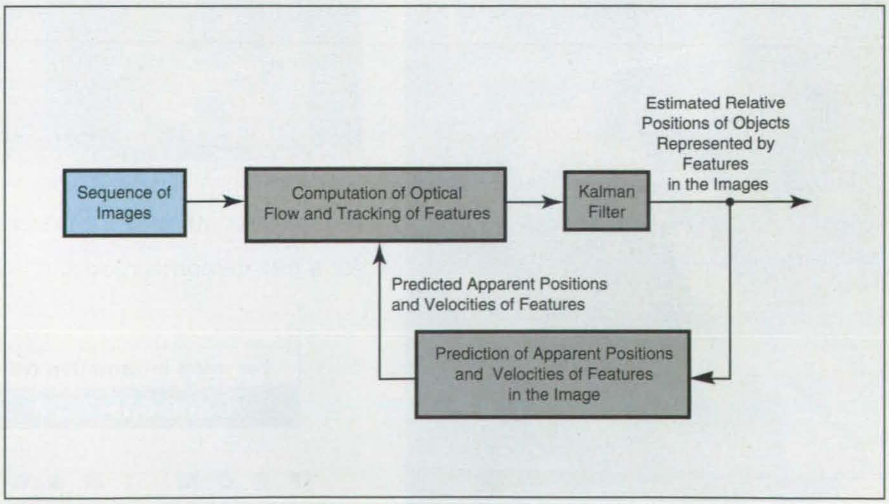
Estimates are enhanced by use of an extended Kalman filter.

Ames Research Center, Moffett Field, California

In a developmental method of estimating distances between a moving platform and nearby stationary objects, the positions of the objects relative to the moving platform are deduced from the apparent motions of those objects in images generated by a video camera affixed to the platform. The method can be regarded as a quantitative version of the qualitative intuitive method by which humans gauge distances to relatively moving objects in the foreground; it is also related to conventional methods of estimating distances from ships to visible shore features and to similar methods used in older military reconnaissance sensors. Although the method is being developed for use in controlling military helicopters in low-altitude evasive maneuvers, it is also potentially applicable in robotics and in autonomous navigation of vehicles in general.

This method is based partly on the assumption that the translational and rotational motions of the platform are known (in the case of the helicopter, motion data can be obtained from onboard inertial navigation equipment). As in the older methods mentioned above, the basic idea in this method is to find the relative positions of the observed objects by triangulation in sequential views. The changes in position and orientation of the camera between views can be computed from the motion data and from the elapsed time between the views; these changes can be processed via coordinate transformations, then applied as corrections to the changes in positions of features in the image. Then the distances to the features can be computed by triangulation from the corrected apparent positions of the features and from the known change in position of the camera.

This method differs from the older method in that the image and motion data are processed by recursive algorithms, including an extended Kalman filter, to track features in the image and to account for the curvilinear motion of the platform (see figure). Features are tracked incrementally by an area-based matching algorithm, which uses the most recent estimate of distance and the apparent motions of features as predicted by the Kalman filter to limit the areas to be searched for matches. Features that do not behave as predicted are regarded as inconsistent and are discarded to prevent false matches.



The **Estimate of Relative Positions** of objects is generated by recursive algorithms that track features in sequential video images.

The method was evaluated in laboratory tests, using a video camera aimed toward stationary objects while moving toward them along a partly straight, partly curved trajectory. The results showed that with the equipment used, distances could be estimated to within about 10 percent. Presumably accuracy could be increased by calibration of the camera.

The problems of real-time implementation of the method are yet to be solved. Subsequent development of the method is likely to include several improvements. One of them could be the incorporation of a Kalman filter with variable time intervals between updates to accommodate the wide dynamic range of apparent motions of features in the image. Like most distance-estimating methods that depend on motion, this one performs poorly close to a focus of expansion (a point toward which the platform moves and the camera is aimed, and about the image of which the rest of the image appears to expand). A Kalman-filter-based version of the method that integrates a stereoscopic estimation technique with the motion-dependent estimation techniques is being developed to overcome this deficiency.

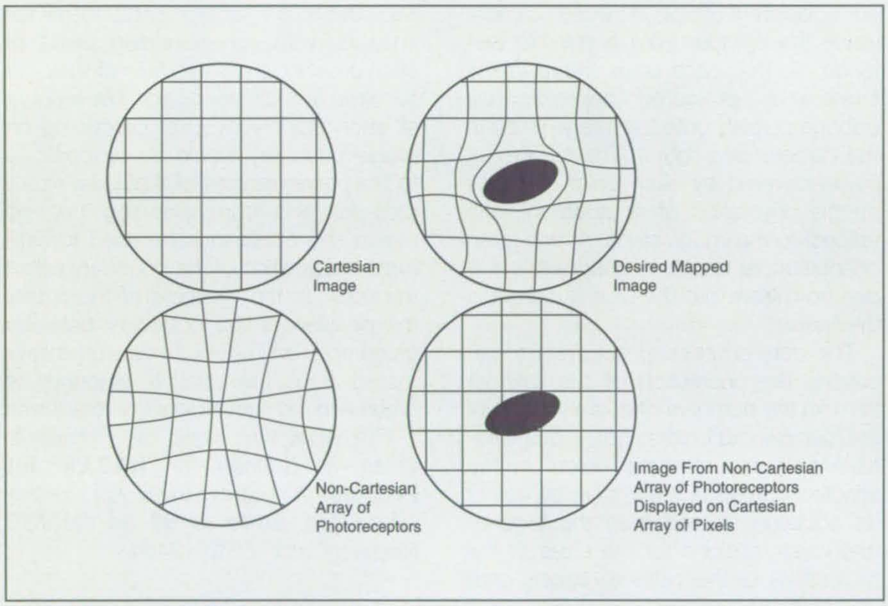
This work was done by B. Sridhar and R. Suorsa of **Ames Research Center** *and B. Hussien of Sterling Software. For further information,* ***write in 21*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Ames Research Center; (415) 604-5104. Refer to ARC-13247.

Patterned Video Sensors for Low Vision

Sensed images would be mapped onto remaining visual fields.

Lyndon B. Johnson Space Center, Houston, Texas



The **Entire Image Is To Be Mapped** onto the non-Cartesian coordinates of the field outside the dark ellipse, but displayed on pixels arranged in Cartesian coordinates. The required mapping can be effected by use of the non-Cartesian pattern of photoreceptors.

Miniature video cameras containing photoreceptors arranged in prescribed non-Cartesian patterns to compensate partly for some visual defects have been proposed. These cameras, accompanied by (and possibly integrated with) miniature head-mounted video display units would restore some visual function in humans whose visual fields are reduced by defects like retinitis pigmentosa (in which peripheral vision is lost and the world is seen as though through a narrow tube) or age-related maculopathy (in which the central portion of the visual field is lost).

Heretofore, the concept of patterned photoreceptors has been better known in conjunction with machine vision. The application of patterned photoreceptors to human vision is being investigated, along with various digital image-processing techniques (e.g., contrast enhancement), in a continuing effort to find optimal combinations of techniques that can utilize the remaining visual function most effectively. Patterning of photoreceptors would address the part of the problem that involves warping the image, from a video camera that has a field of view like that of a normal eye, onto the remaining visual field of a defective eye.

This warping must satisfy conflicting requirements to maintain (a) local shape, (b) usable resolution somewhere in the remaining visual field, and (c) normal whole peripheral awareness. In principle, a conformal mapping that wholly or partly satisfies these requirements could be implemented digitally, but the digital processing would introduce a delay that could be unacceptable in viewing a moving scene, as in walking around obstacles. The patterned-photoreceptor concept would be more suitable for a lightweight, head-mounted visual prosthesis because the mapping would be effected without digital processing, eliminating the processing delay as well as the cost and weight of the digital processing circuitry.

The figure illustrates the patterned-photoreceptor concept. The pixels in the video display presented to each eye would be arranged in a Cartesian (x, y) pattern. Let (u, v) denote the Cartesian coordinates of a point in the image plane. Suppose that the desired mapping from the image plane to the display plane has been found and that it is of the form

$$\begin{bmatrix} x \\ y \end{bmatrix} = f\left(\begin{bmatrix} u \\ v \end{bmatrix}\right)$$

The inverse of the mapping can be computed and used to find the required location (u, v) of each photoreceptor in the image plane corresponding to the pixel at x, y in the image plane:

$$\begin{bmatrix} u \\ v \end{bmatrix} = f^{-1}\left(\begin{bmatrix} x \\ y \end{bmatrix}\right)$$

This work was done by Richard D. Juday of **Johnson Space Center**. *For further information,* ***write in 63*** *on the TSP Request Card. MSC-22276*

Monocular Video Measurement of Position and Orientation

The visible pattern of colors on a four-colored cylinder would reveal orientation.

NASA's Jet Propulsion Laboratory, Pasadena, California

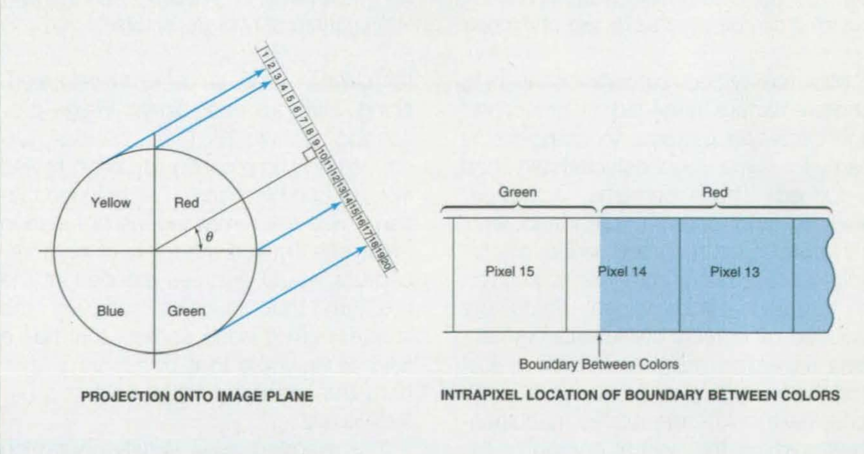
A monocular video imaging and image-data-processing system views a robotic vehicle and measures the position and orientation of the vehicle in terms of the position and orientation of a colored cylinder mounted on the vehicle. The data-processing subsystem determines the position of the cylinder from the viewing angle and the size of the colored cylinder in the image. The system also follows an innovative approach in determining the orientation of the cylinder, as explained below.

Each quadrant of the cylinder is painted a different color. A video camera views the cylinder from a suitable distance, so that each color visible to the camera is projected approximately orthographically onto the image plane in the camera (see figure). The number of pixels covered by each color depends on the orientation of its quadrant with respect to the image plane. At any given orientation, at least one quadrant is hidden from view, like the blue quadrant in the figure.

The data-processing subsystem calculates the orientation of the cylinder from (a) the numbers of pixels in each of the four cylinder colors and/or (b) the relative amounts of these colors in the affected portion of the image, by use of an equation derived from the trigonometric expressions for the sizes of the projections of the colored regions onto the image plane. The selection of terms in the equation depends on which quadrant(s) of the cylinder is (are) hidden from view, as determined by which color(s) is (are) not visible.

Usually, the images of the boundaries between colors and the images of the boundaries between the cylinder and the background will fall inside pixels. With the proper choice of camera, the intrapixel positions of these boundaries could be determined, yielding subpixel resolution. For this purpose, the video camera should comprise either (a) three separate color charge-coupled-device imagers, with corresponding pixels of each covering the same field of view but sensitive to a different color. The amount of each color in a pixel containing an image boundary would be proportional to the fractional area of that pixel occupied by the corresponding colored region and could thus be used to estimate the position of the boundary within the pixel. In the example of the figure, the position of the boundary between green and red in pixel 14 would be estimated from the relative amounts of green and red light incident on that pixel.

This work was done by Richard A. Volpe of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 53*** *on the TSP Request Card. NPO-19404*



The **Pattern of Colors** projected from a four-colored cylinder onto the image plane of a video camera would be used to estimate the angle of rotation, θ, of the cylinder. Furthermore, the proportion of each of two colors that fall on the same pixel could be used to estimate the position of the intrapixel boundary between the colors, thereby achieving subpixel resolution.

Electronic Components and Circuits

Instrument for Simulation of Piezoelectric Transducers

This instrument generates realistic dynamic signals and displays their magnitudes.

Marshall Space Flight Center, Alabama

An electronic instrument has been designed to simulate the dynamic output of an integrated-circuit piezoelectric acceleration or pressure transducer. The instrument operates in conjunction with an external signal-conditioning circuit, generating a square-wave signal of known amplitude for use in calibrating the signal-conditioning circuit. The instrument may also be useful as a special-purpose square-wave generator in other applications.

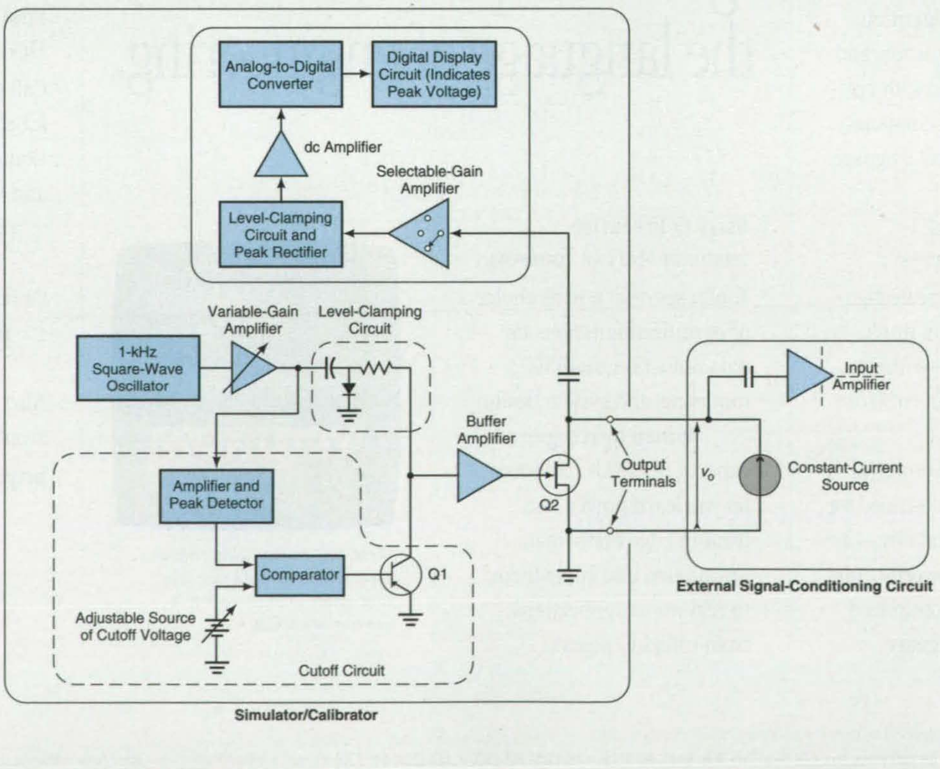
The instrument (see figure) includes a square-wave oscillator that operates at a frequency of 1 kHz. The output of this oscillator is fed to an amplifier, the gain of which can be adjusted continuously to obtain the desired output amplitude. The output of the variable-gain amplifier is fed through a level-clamping circuit to a buffer amplifier, then to *n*-channel junction field-effect transistor Q2, which is configured to provide a voltage-controlled resistance. A constant current from a source in the signal-conditioning circuit is applied to this voltage-controlled resistance to obtain the output voltage v_o, that is desired for calibrating the signal-conditioning circuit.

A cutoff circuit is included to prevent overdriving of an input amplifier in the signal-conditioning circuit. An amplifier and peak detector produce a dc voltage proportional to the amplitude of the output of the variable-gain amplifier. This voltage is compared with dc cutoff voltage that can be set to a level that corresponds to the maximum allowable signal amplitude. When the peak-detected signal voltage exceeds the cutoff voltage, the comparator turns on transistor Q1, short-circuiting the buffer-amplifier input to ground and thereby turning off the output signal.

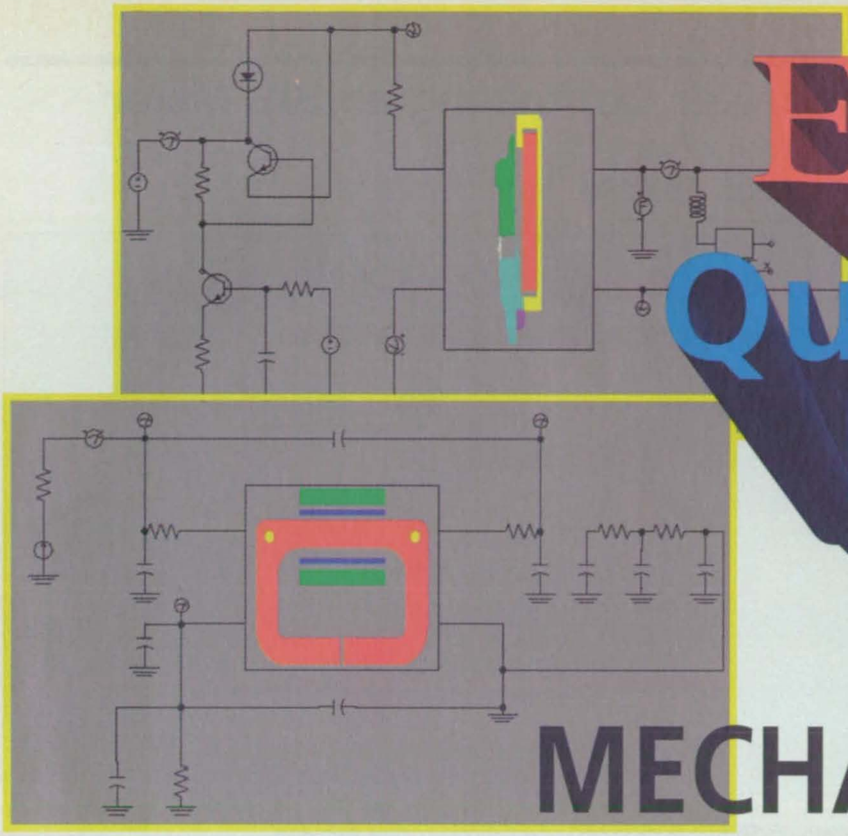
The output voltage v_o is coupled to a circuit that amounts, in effect, to a selectable-range, digital, peak-alternating-voltage meter. First, v_o is fed to a selectable-gain amplifier. The output of this amplifier is fed to a level-clamping circuit and peak rectifier, then through a dc amplifier to an analog-to-digital converter. The output of the analog-to-digital converter drives a digital display circuit containing a liquid-crystal display device.

This work was done by Randal S. McNichol of **Marshall Space Flight Center**. *For further information,* ***write in 92*** *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-31031.



The **Simulator/Calibrator** operates in conjunction with a signal-conditioning circuit as a special-purpose adjustable-amplitude square-wave generator equipped with a digital amplitude indicator.



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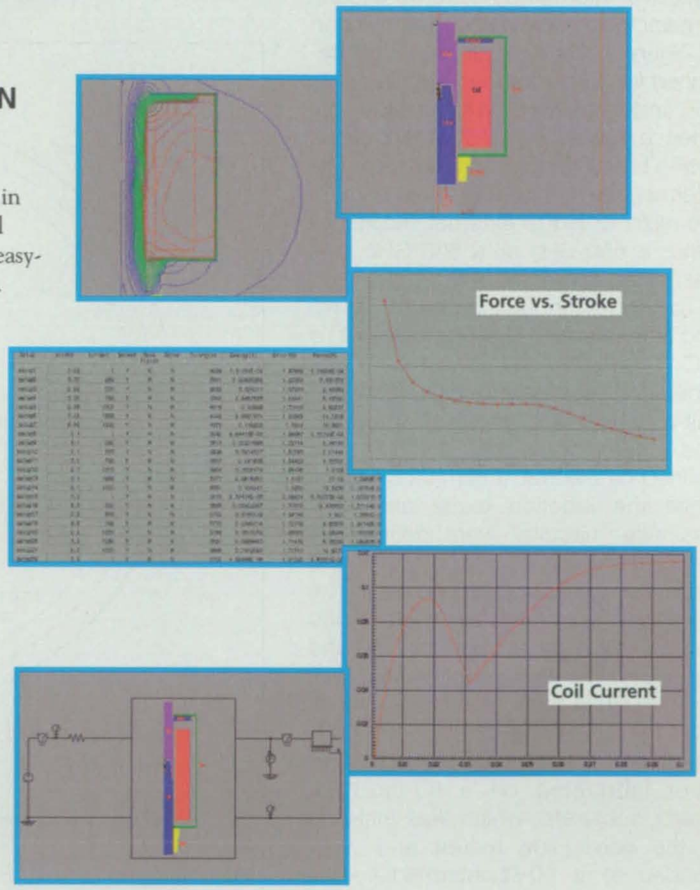

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Submillimeter-Wave Receiver Containing an SIS Mixer

This receiver is designed for use in radio astronomy.

NASA's Jet Propulsion Laboratory, Pasadena, California

A submillimeter-wave heterodyne receiver is designed to operate at input frequencies in the range of 480 to 650 GHz. It is intended especially for use in radio astronomy at a frequency of 547 or 626 GHz (the frequencies of ground-state transitions of $H_2^{18}O$ and HCl, respectively). The heart of the receiver is a waveguide mixer that includes an adjustable backshort and electric-field-plane tuner. The mixing element is a high-current-density superconductor/insulator/superconductor (SIS) tunnel junction integrated with a superconductive microstrip radio-frequency circuit that tunes out the capacitance of the junction; that is, matches the complex impedance of the junction to the available tuning range of the waveguide mount.

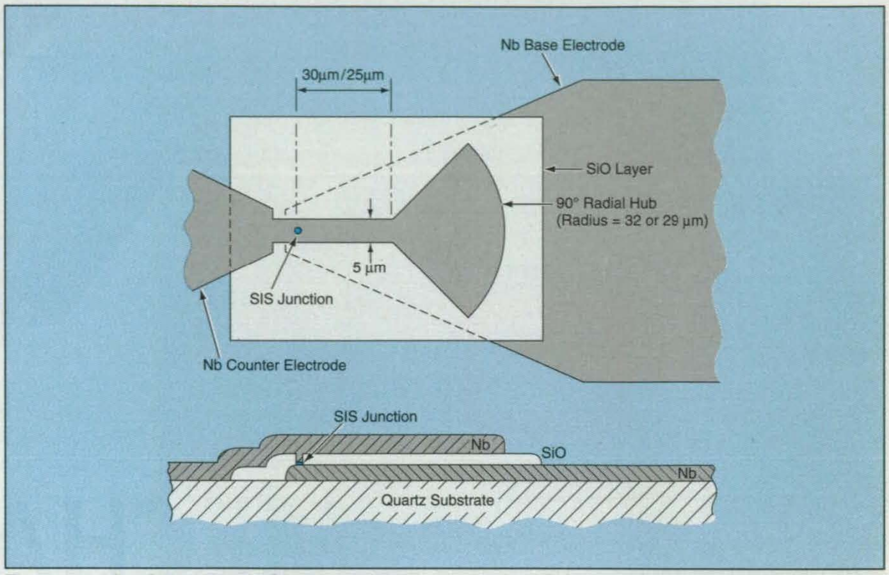


Figure 1. An **Integrated Circuit** contains both the SIS junction and superconducting microstrip radio-frequency impedance-matching circuit elements.

The integrated tuning circuit includes a parallel microstrip line terminated in a radial stub, as shown in the top part of Figure 1. This circuit has been designed for center frequencies near both 550 and 630 GHz. The radial stub provides a radio-frequency short circuit over a broad range of frequencies. The intermediate frequency (IF) output of the mixer is fed to external circuits via either a 550-GHz or a 630-GHz low-pass filter.

The superconducting material is Nb and the junction barrier material is AlO_x. The Nb/AlO_x/Nb junction was fabricated in a trilayer-deposition and self-aligned-insulator lift-off process. The junction area of 0.25 μm^2 was defined by electron-beam lithography, while the junction leads and low-pass-filter circuitry were defined by conventional photolithography and deposited by dc sputtering of Nb. The lower and upper Nb layers are 1,600 and 2,300 Å thick, respectively, and are separated (except at the junction) by a 2,000-Å-thick insulating layer of SiO. The SIS tunnel junction, integrated tuning circuit, and low-pass filter were fabricated on a 50-μm-thick quartz substrate, which was installed in the waveguide mount and wire-bonded to a 50-Ω intermediate-frequency output connector.

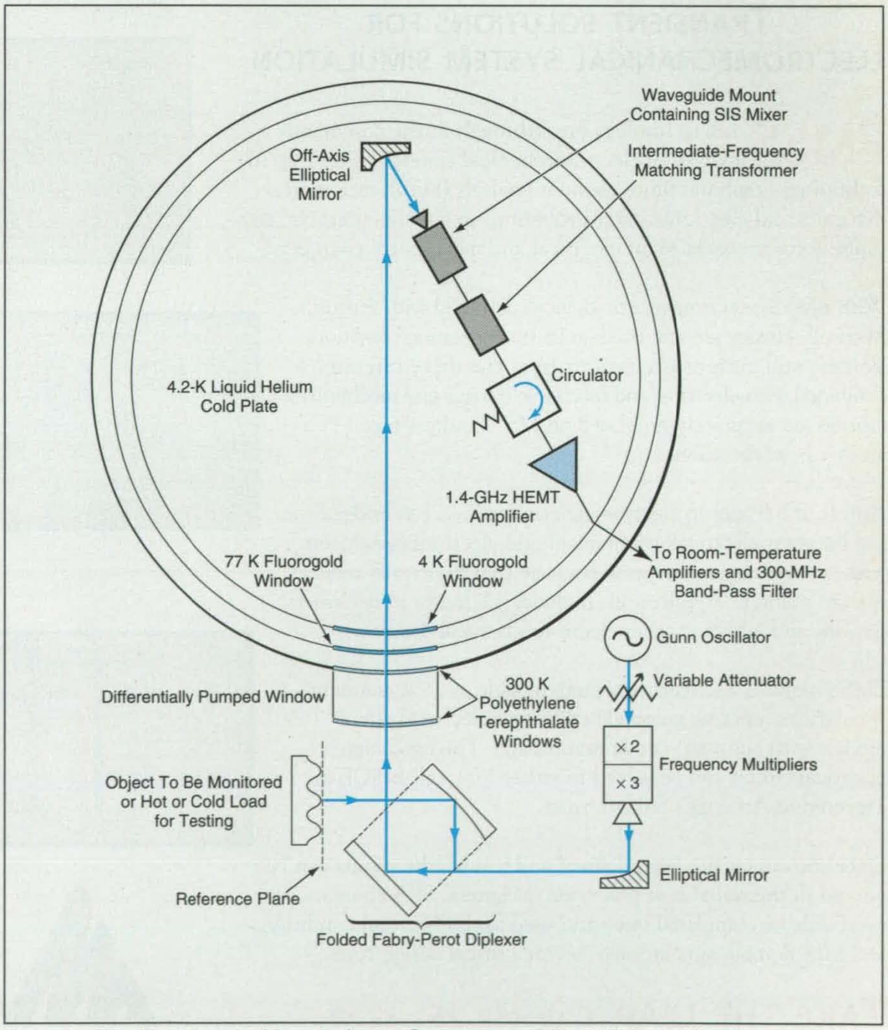


Figure 2. The **Receiver Is Mounted in a Cryostat**, and the initial amplification of the intermediate-frequency output of the mixer is performed in the cryostat to minimize noise.

Figure 2 is a block diagram of the receiver. Radiation from both a local oscillator and from the distant object to be monitored is coupled optically into the cryostat and then coupled into the waveguide mount via a dual-mode conical horn. A superconducting magnet

(not shown) is used to create a magnetic field in the vicinity of the junction to suppress unwanted Josephson interference and thus improve the performance of the receiver. The local oscillator consists of two whisker-contact Schottky varactor frequency multipliers (× 2, × 3) driven by a Gunn oscillator. The frequency of the oscillator is chosen to obtain mixer output at an intermediate frequency of 1.4 GHz; this output is transformed to an impedance of 50 Ω and fed to a low-noise high-electron-mobility transistor (HEMT) amplifier. The amplified intermediate-frequency signal is coupled out of the cryostat to high-gain room-temperature amplifiers.

The performance of the receiver has been measured at frequencies from 480 to 650 GHz. DSB receiver noise-temperature-vs.-frequency figures as low as 200±17 K at 540 GHz and 362±33 K at 626 GHz have been obtained, and are among the best such figures yet reported at the time of submission of information for this article. In addition, negative differential resistance has been observed in the dc current-vs.-voltage curve of the mixer at frequencies from 490 to 570 GHz, depending on the SIS junction. This result indicates that the superconductive Nb microstrip transmission lines in the tuning circuits exhibit low loss and perform well at frequencies up to at least 90 percent of the superconductor-energy-gap frequency.

This work was done by Pascal Febvre, William R. McGrath, Paul D. Batelaan, Henry G. LeDuc, Bruce Bumble, and Margaret A. Frerking of Caltech and Juergen Hernichel of Universität Köln for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 100*** *on the TSP Request Card. NPO-19127*

Microwave Resonators Containing Diamond Disks

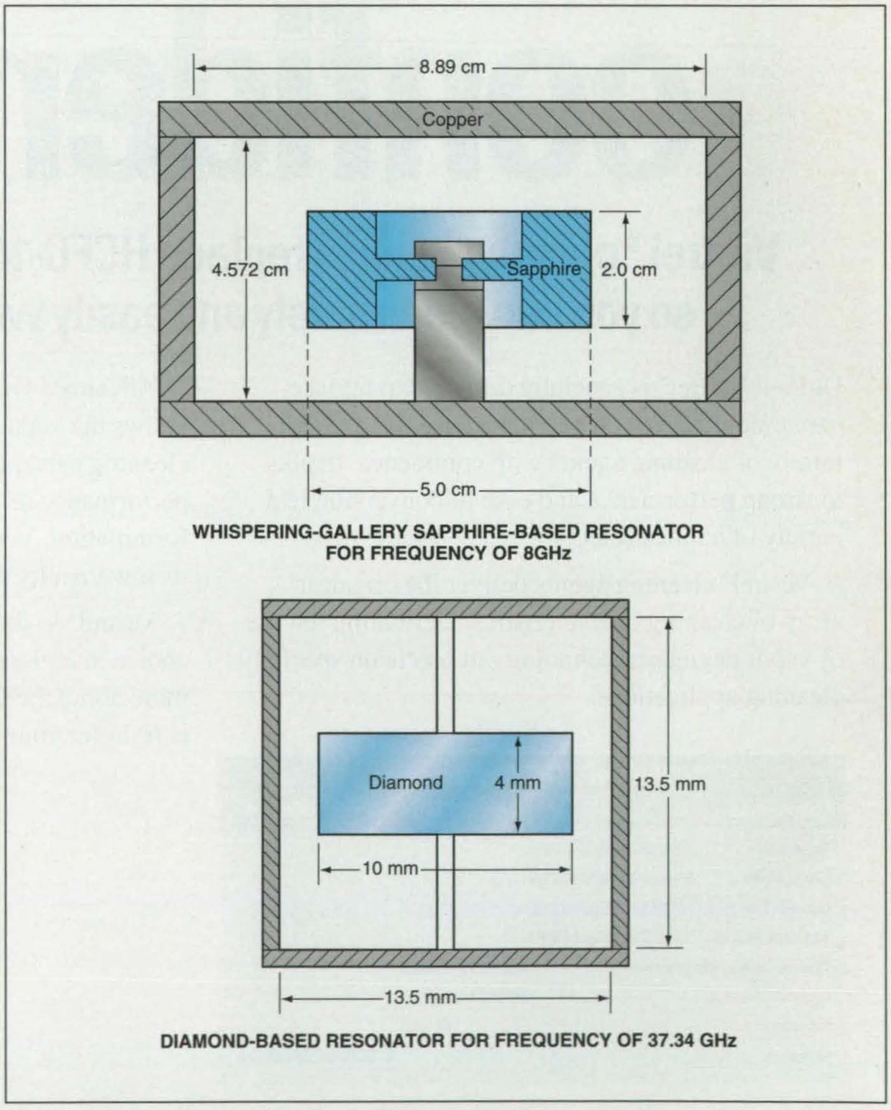
Performances at room temperature might exceed those of liquid-nitrogen-cooled sapphire-based resonators.

NASA's Jet Propulsion Laboratory, Pasadena, California

Synthetic diamond dielectric bodies have been proposed for use in cylindrical resonators that help to stabilize the frequencies of some microwave oscillators. Acting in conjunction with the metal resonator cavities in which they are mounted, such dielectric bodies support "whispering-gallery" waveguide modes that are characterized by the desired frequencies of resonance and by electromagnetic-field configurations that limit dissipation of power on the metal surfaces outside the dielectric bodies. The diamond bodies would supplant the sapphire rings that are now used for this purpose (see figure).

Sapphire was originally chosen because its thermal and dielectric properties are favorable for the development of resonators that provide relatively high frequency stability at operating temperatures that range from ambient down to cryogenic. The principal figure of merit of a resonator, denoted as the quality factor, (Q) is a measure of the sharpness of resonance and is defined as $2\pi \times$ the energy stored in the electromagnetic field in the resonator ÷ the energy dissipated per cycle of oscillation. Resonators that contain sapphire rings exhibit $Q \approx 3 \times 10^5$ at room temperature, increasing to about 3×10^7 at a temperature of 77 K (the temperature of liquid nitrogen).

The state of the art of whispering-gallery-mode microwave resonators is now such that the inherent bulk properties of sapphire limit further increases in frequency stability, so that a superior dielectric material is needed to enable further improvements. Because



Dielectric Bodies Made of Synthetic Diamond would make possible resonators with room-temperature Q values greater than the cryogenic Q values of sapphire-based resonators.

the Q values of sapphire-ring resonators decrease with increasing frequency, it is not possible to make very small millimeter-wave resonators with high performance. Furthermore, thermal expansion, and, more importantly, thermal variation of the permittivity of sapphire give rise to frequency instability. The thermal conductivity of sapphire is not large enough to enable further compensation for this source of instability.

For several reasons, diamond is the leading candidate to replace sapphire. Synthetic diamond samples with electrical properties superior to those of natural diamond are now available, and further improvements in the nonelectrical properties of synthetic diamond are expected. The thermomechanical and electrical properties of diamond are superior to those of sapphire: The coefficient of thermal expansion of diamond at room temperature is 0.8×10^{-6}/K, as compared with 8.4×10^{-6}/K for sapphire; the coefficient of thermal variation of relative permittivity of diamond is about 10^{-5}/K, as compared with 1.2×10^{-4} for sapphire; and the thermal conductivity of diamond is 20W/(cm·K), as compared with 0.3 W/(cm·K) for sapphire.

By itself, the foregoing combination of properties should make it possible to construct diamond-based resonators with 10 to 100 times the stability of sapphire-based resonators. Furthermore, according to theoretical predictions, the dielectric losses in diamond should be much less than those in sapphire. The net result would be that Q values of diamond resonators would be more than 10^3 times those of sapphire-based resonators; at room temperature, a diamond-based resonator could exhibit a $Q \approx 3 \times 10^8$ — 10 times that of a sapphire-based resonator under liquid nitrogen.

The low losses of diamond-based resonators would also enable operation at higher frequencies without the performance penalty characteristic of sapphire. Thus, an exceedingly small millimeter-wave diamond-based resonator operating at room temperature would perform better than does a much larger sapphire-based resonator in the cryogenic temperature range.

This work was done by G. John Dick, Lutfollah Maleki, and Rabi T. Wang of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 1*** *on the TSP Request Card. NPO-19486*

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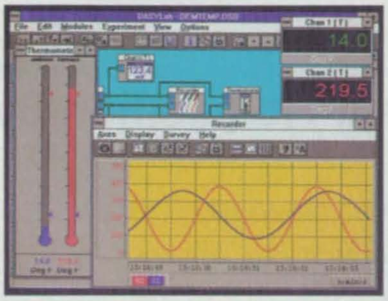

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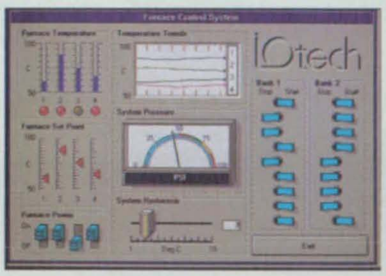

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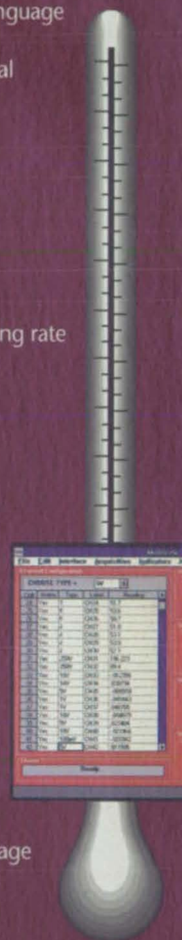

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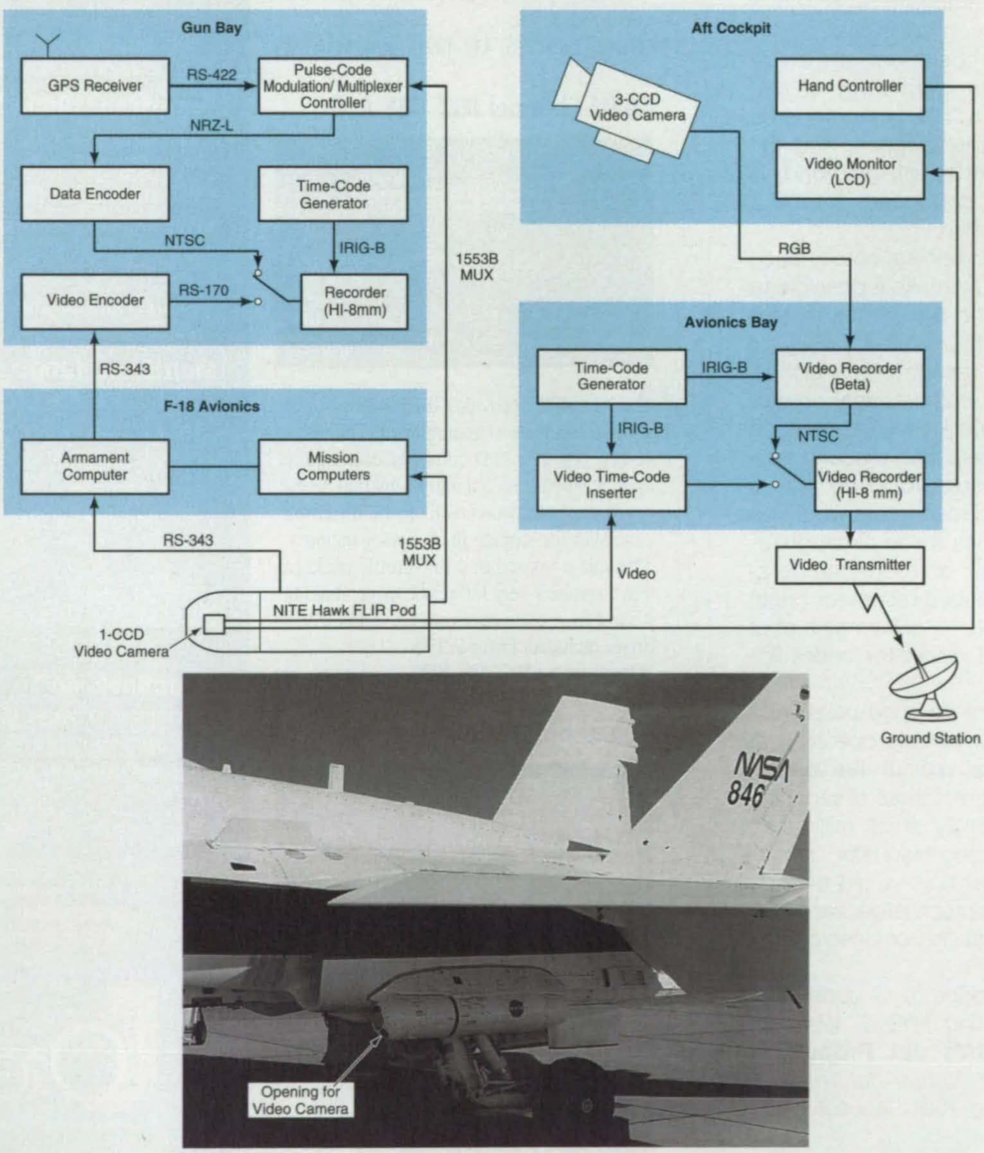
Advanced Video Data-Acquisition System for Flight Research

This system has unique capabilities previously unavailable.

Dryden Flight Research Center, Edwards, California

Engineers at the NASA Dryden Flight Research Center and Loral Aeronutronic have developed an advanced video data-acquisition system (AVDAS) to satisfy a variety of requirements for in-flight video documentation. These requirements range from providing images for visualization of airflows around fighter airplanes at high angles of attack to obtaining safety-of-flight documentation like that for the Pegasus® launch dynamics. The F/A-18 AVDAS takes advantage of very capable systems like the NITE Hawk forward-looking infrared (FLIR) pod and recent video develop-



This **Advanced Video Data-Acquisition System** can satisfy most requirements for in-flight video documentation and provides many unique capabilities previously unavailable from an in-flight video system.

ments like that of miniature charge-coupled-device (CCD) color video cameras and other flight-qualified video hardware.

A two-place F/A-18 chase aircraft at Dryden is the host vehicle for the AVDAS, which takes advantage of the F/A-18 flight envelope. The AVDAS operator sits in the aft seat with the additional system controls. The centerpiece of AVDAS is the F/A-18 NITE Hawk FLIR pod (see figure) modified to accept a small color video camera and zoom lens. Basic pod capabilities have been retained to take advantage of existing pod performance and aircraft systems.

The primary advantages of the NITE Hawk FLIR pod include an actively stabilized camera platform, large field of regard, concurrent video and FLIR operation, multiple modes of autotracking, multiplexing data according to a military standard called "1553B," existing cockpit controls, and a proven system verified to be capable of operating throughout the entire F/A-18 flight envelope. The color camera located in the video pod contains a one-chip, 1/2-in. CCD imager that provides 400 vertical lines of television resolution and output in the form of luminance, chrominance, and National Television Systems Committee (NTSC)-standard video signals. The camera includes a 2×-extender-and-motorized-zoom-lens combination, the focal length of which ranges from 16 to 96 mm.

A broadcast-quality hand-held camera in the aft seat of the F/A-18 complements the video pod by providing higher resolution and zoom capability coupled with a larger field of regard above and to the right of the aircraft. The hand-held camera is a remote-head three-chip CCD color video camera that provides up to 700 vertical lines of television resolution with red/green/blue video output. Several zoom lenses with stabilization and focal lengths as high as 238 mm are available for the hand-held camera.

The video signals from the hand-held camera can be recorded with time code in a 30-minute Beta SP (or equivalent) video-tape format. Video signals from both the pod and hand-held cameras can be recorded with IRIG-B time code on an HI-8-mm-format video-tape recorder for 120 minutes with 400 vertical lines of television resolution. NTSC video output from the HI-8-mm-format video-tape recorder can be viewed by the operator on a video monitor (with a liquid-crystal display device) in the aft cockpit or telemetered to the ground if desired for real-time viewing in a control room. Isolated power from a regulated dc-to-dc power source is supplied to all video equipment to minimize system noise and achieve optimum video quality.

The output of the NITE Hawk FLIR pod provides other unique capabilities to the AVDAS system. The 1553B-multiplexed data from the pod and aircraft are extracted for documentation of pod viewing angles and aircraft positioning. Global Positioning System (GPS) and 1553B-multiplexed data are merged with IRIG-B time code, and the combination is recorded as flight data on an HI-8-mm-format tape. Electrical output (according to standard RS-343) from infrared sensors in the pod, which output would normally be displayed in the cockpit, is converted to monochrome video (according to standard RS-170) that can be sent to the HI-8-mm-format video-tape recorder. All standard cockpit controls for the NITE Hawk FLIR pod, including manual control and autotrack functions, have been retained. Aft-seat pod controls located on the control stick and throttle can be shifted to a separate hand controller to enhance operator control.

This work was done by Geoffrey Miller of Loral Aeronutronic and David M. Richwine and Neal E. Hass of Analytical Services and Materials for **Dryden Flight Research Center**. *No further documentation is available. DRC-96-01*

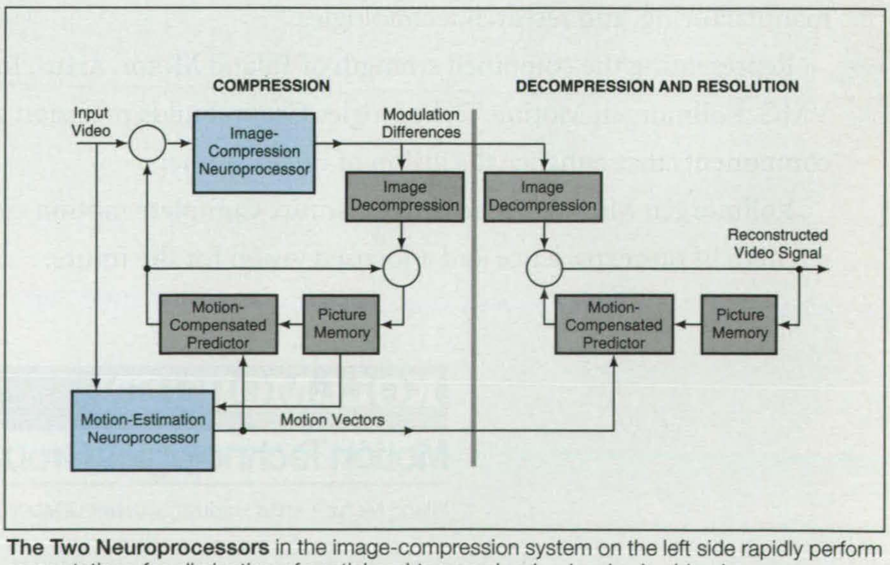
VLSI Neural Networks Help To Compress Video Signals

Neural networks perform motion-estimation and image-data-compression processing.

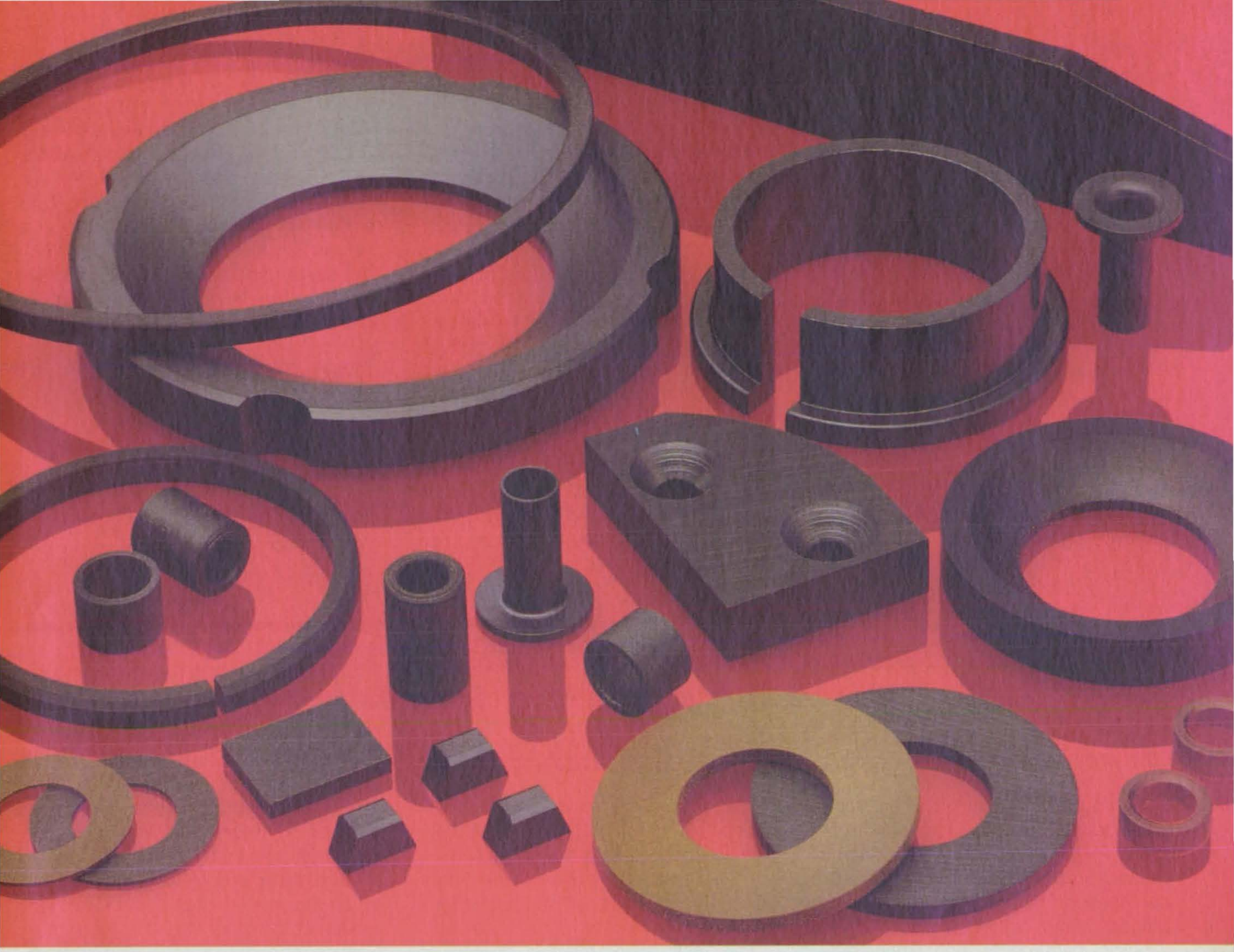
NASA's Jet Propulsion Laboratory, Pasadena, California

An advanced analog/digital electronic system for compression of video signals incorporates artificial neural networks. Like other systems designed for the same purpose, this system effectively eliminates temporal and spatial redundancies of sequences of video images; it processes video image data, retaining only the nonredundant parts to be transmitted, then transmits the resulting data stream in the form of an efficient code. The system thus reduces the bandwidth and storage requirements for transmission and recording of the video signal.

The system (see figure) includes a motion-estimation processor and an image-compression processor implemented in very-large-scale integrated (VLSI) circuitry. The motion-estimation neuroprocessor implements a neural-network-based motion-estimation algorithm to achieve high-speed, wide-range estimation of motions in images. The design of the motion-estimation neuroprocessor is based on that of a locally connected, multilayer, competitive neural network developed for high-performance optical flow-computing systems. The motion-estimation neuroprocessor contributes to overall compression efficiency in that it helps to eliminate redundant motion-related data by enabling the more accurate choice of image



The Two Neuroprocessors in the image-compression system on the left side rapidly perform computations for elimination of spatial and temporal redundancies in video images.



points between which modulation differences are derived.

The design of the image-compression neuroprocessor is based on that of a single-layer, frequency-sensitive competitive (self-organization) neural network developed for adaptive vector-quantization systems. This neuroprocessor can achieve high-speed, high-ratio compression of image data by taking advantage of massively parallel neural computing architectures and VLSI technology. Efficient compression is achieved because code vectors in the vector-quantization code book are adaptively trained from the scene so that image-data vectors can be more accurately represented by the indices of the corresponding most nearly matched code vectors.

The image-compression neuroprocessor includes a pipeline code-book generator and a parallel vector quantizer that completes the full-search vector-quantization process for each input vector in a minimal computation time that is independent of the dimensionality of the vector. This neuroprocessor features a mixed-signal (analog/digital) design, with analog circuitry to perform neural computation and digital circuitry to process multiple-bit pixel information. A prototype complementary metal oxide/semiconductor integrated-circuit neural 25-dimensional vector quantizer of 64 code vectors has been built and tested. This circuit occupies a silicon chip of 4.6 × 6.8 mm. Its throughput rate is about 2×10^6 vectors per second. An adaptive vector quantizer of 1,024 code vectors could be implemented by cascading 16 such prototype chips or by use of a larger chip.

This work was done by Wai-Chi Fang and Bing J. Sheu of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 12*** *on the TSP Request Card.*

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

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

Refer to NPO-19354, volume and number of this NASA Tech Briefs *issue, and the page number.*

Multimode Data-Compression System

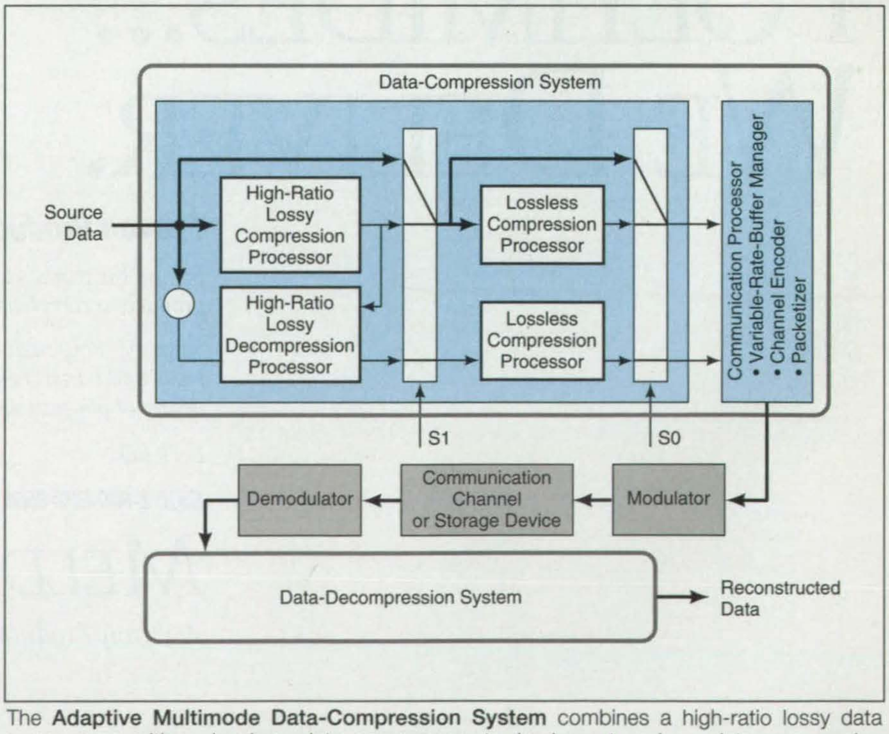
Various combinations of lossless and lossy compression can be chosen to suit various data streams.

NASA's Jet Propulsion Laboratory, Pasadena, California

A data-compression system is being developed to satisfy a need for high-speed, high-performance compression of data from sources as diverse as medical images, high-definition television images, audio signals, readouts from scientific instruments, and binary data files. The maximum data-transmission capability of a communication channel or storage capacity of a storage device can be multiplied by approximately the compression ratio. The system (see figure) includes a communication processor plus both a high-ratio lossy compression processor and a lossless compression processor. The system is made of very-large-scale integrated (VLSI) circuit modules to satisfy requirements for real-time processing, low mass, small volume, and low power consumption.

The system is designed to be reconfigurable so that operating modes that involve various combinations of lossless and lossy compression can be selected. These five modes are (1) bypass (no compression), (2) lossy compression, (3) lossless compression, (4) lossy compression enhanced with lossless compression, and (5) lossless compression enhanced with lossy compression. The reconfiguration signals S0 and S1 are to be generated by the communication processor, according to the characteristics of both the source data stream and the data-communication channel or data-storage device for which the data are to be compressed. The communication processor would also perform channel coding and variable-length packetization of data for correction of errors (introduced by noise in the channel) and buffering of variable-length data streams.

The lossy compression processor would be an assembly of high-speed VLSI analog/digital neural networks especially suitable for adaptive compression of image data. This processor is designed so that the losses are small enough that the data as reconstructed by an associated data-decompression system at the other end of the communication channel or in playback from storage will constitute an acceptably faithful reproduction of the source data.



The **Adaptive Multimode Data-Compression System** combines a high-ratio lossy data compressor with a lossless data compressor to implement various data-compression schemes.


OR1400
The Multiple Personality Recorder.

This processor would implement a frequency-sensitive self-organization (FSO) neural algorithm, which involves a relatively light computational burden and a massively parallel computing structure.

The prototype modular unit of the lossy compression processor is a VLSI integrated-circuit chip that performs adaptive quantization of 25-dimensional vectors with a 64-vector code book. This chip can operate at 2 million vectors per second, and its equivalent computational power is 3.2 billion connections per second. It provides an intrinsic compression ratio as high as 33. This chip can be extended to implement a larger code book.

The lossless compression processor provides for those situations in which there is a need to compress data without introducing any distortion in the subsequently decompressed and reconstructed version of the data. This processor is based on the Rice algorithm, which effects a subset of Huffman codes. A prototype of this processor has been implemented on a pipeline-architecture VLSI universal-noiseless-coder chip at relatively low cost. This chip can operate at a speed as high as 20 million pixels per second.

This work was done by Wai-Chi Fang of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 95*** *on the TSP Request Card.*

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

William T. Callaghan, Manager
Technology Commercialization
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Refer to NPO-19292, volume and number of this NASA Tech Briefs *issue, and the page number.*

Parallel-Processing Test Bed for Simulation Software

An upgradeable computation system is used for research on parallel algorithms.

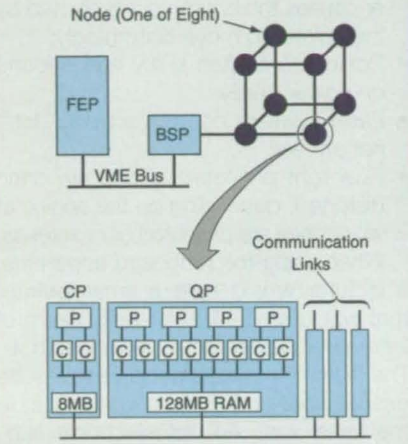
Lewis Research Center, Cleveland, Ohio

The second-generation Hypercluster computing system is a multiprocessor test bed for research on parallel algorithms for simulation in fluid dynamics, electromagnetics, chemistry, and other fields with large computational requirements but relatively low input/output requirements. The first-generation Hypercluster system was described in "Hypercluster Parallel Processor" (LEW-15283), *NASA Tech Briefs*, Vol. 16, No. 11 (November 1992), page 55.

The second-generation system is built from standard, off-the-shelf hardware that can readily be upgraded as improved technology becomes available. The system is used for experiments with such parallel-processing concepts as those of message-passing algorithms, debugging software tools, and computational steering. The latter involves interactive graphical and alphanumerical displays, through which the user can observe the progress of the computation and alter the algorithm. Such experiments would be difficult, if not impossible, on a shared commercial system.

The system (see figure) includes a front-end processor (FEP) connected via a VersaModule Eurocard (VME) bus and a back-plane service processor (BSP) to a network of nodes arranged in a hypercube distributed-memory topology. Each node contains a communication processor (CP) with an 8-MB memory that is connected to an intranode VME bus; a quad processor (QP) in which the four processors are connected to each other through a 128-MB shared random-access memory (RAM) that is, in turn, connected to the intranode VME bus; and three communication links between the intranode VME bus and the nearest-neighbor nodes along the edges of the hypercube (except that node 0 contains an additional communication link with the BSP). The front-end processor is a computer workstation that runs a version of UNIX. There are a total of 40 processors in the network, of which 32 are used for application processing. The processors are reduced-instruction-set computer (RISC) integrated circuits.

The software in this system is divided between front-end software (which runs on the FEP) and a message-passing kernel that runs on the processors in the nodes. The front-end software provides access by clients, configures the system, loads application and kernel software, and performs health checks. The message-passing kernel supports single task and shared memory operations within a node. The message-passing kernel does not control the flow of messages, but this lack of flow control does not seem to give rise to any problems. Typical simulations that are iterative and involve exchange of data prior to each subsequent iteration have been found to pace themselves.



P: 88100 Processor
C: 88200 Cache/Memory Management Unit

DETAIL OF ONE NODE

The **Front-End Processor Handles Communications** between the nodes and the outside world. Dual-port-memory communication links join nodes to each other and to the BSP.

However, the addition of flow control is under consideration.

The system has been used to develop and debug a large parallel program for simulation of three-dimensional fluid dynamics in turbomachinery. The program was successfully ported to commercial multiple-instruction, multiple-data computers without modification. The performance of the system was tested by using it to run the nCUBE version of the benchmark SLALOM program; in this test, the system performed at a rate corresponding to 14.7 million floating-point operations per second.

This work was done by Richard Blech and Gary Cole of **Lewis Research Center** *and Scott Townsend of Sverdrup Technology, Inc. For further information,* ***write in 77*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Lewis Research Center; (216) 433-2320. Refer to LEW-16204.

Apparatus Would Position Bright Spot on Projection Screen

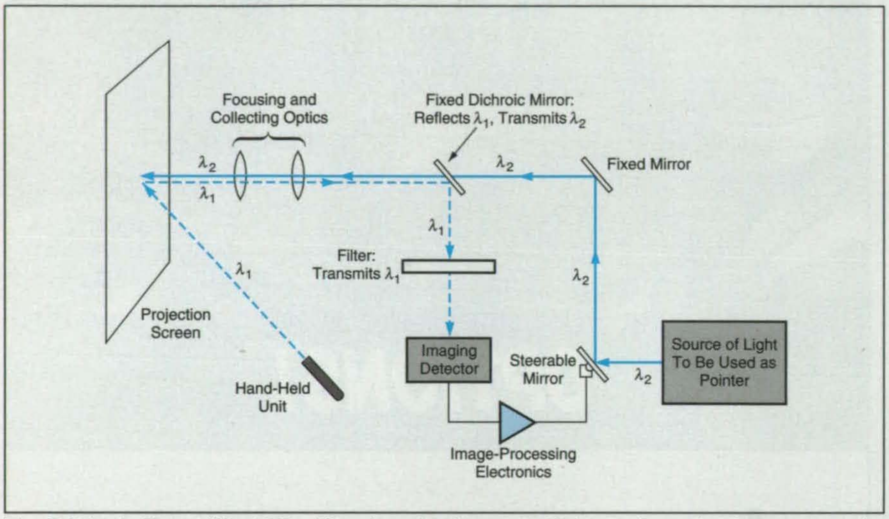
The beam of light could not be inadvertently aimed toward the audience.

NASA's Jet Propulsion Laboratory, Pasadena, California

The figure illustrates schematically a proposed apparatus that would aim a beam of visible light at wavelength λ_2 to create a bright spot at a desired position in an image on a projection screen. The apparatus is intended to replace hand-held laser and flashlight pointers that lecturers sometimes use to indicate features in projected images.

The hand-held pointers are problematic in several ways:

- Lecturers sometimes inadvertently aim the bright pointer beams at their audiences;
- Any shaking of a hand holding a pointer causes the bright spot projected by the pointer to move disturbingly;
- Pointers are often bulky and depend on power cords;
- Laser pointers can project only dots, not arrows;
- Flashlight-projected arrows are often distorted, depending on the angles at which they are projected onto screens.



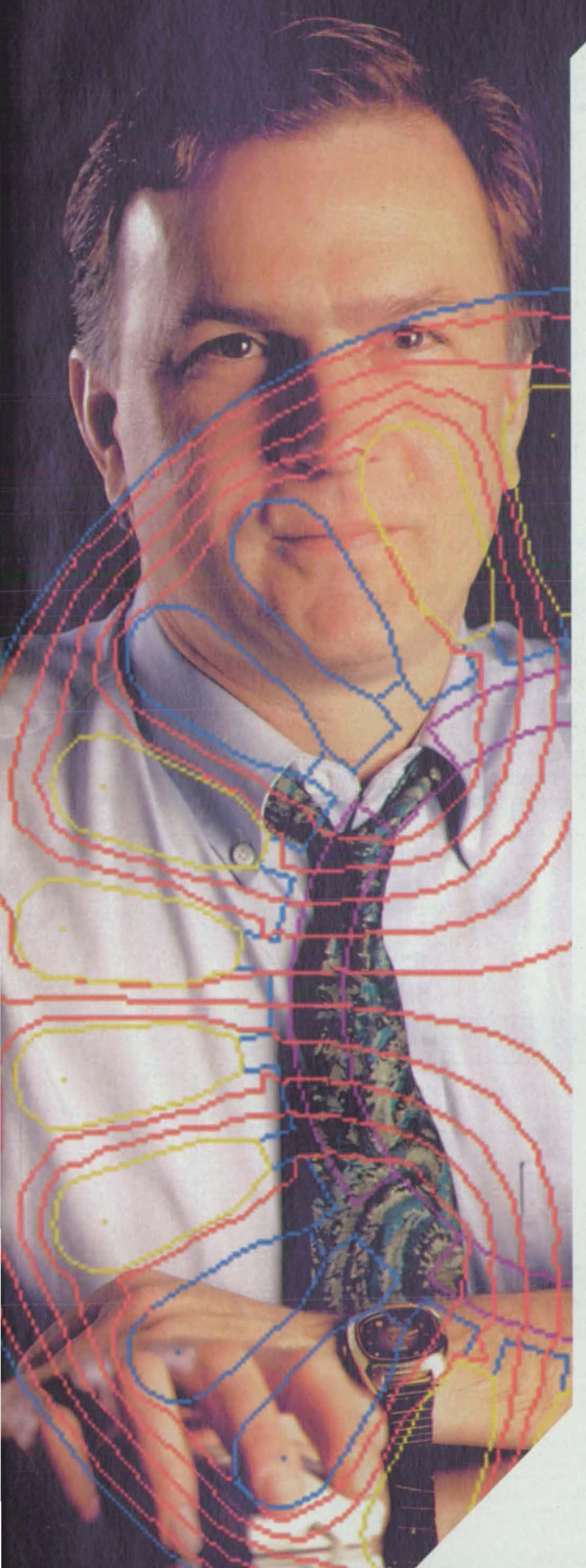
The **Bright λ_2 Beam Would Be Aimed** so that its spot of light on the projection screen coincided with that of the fainter λ_1 beam.

When using the proposed apparatus, a lecturer would hold a small pointer that would emit a low-intensity beam of infrared or visible light of wavelength λ_1. The lecturer would aim this beam at the desired spot on the projection screen in the usual way. An optoelectronic subsystem in the main part of the apparatus would view the projection screen and would measure the position of the λ_1 bright spot. This measurement would be used to generate a control signal for aiming the strong λ_2 beam to position the λ_2 bright spot in coincidence with the faint or invisible λ_1 spot.

By limiting the frequency response of the aiming control circuitry, one could remove most of the jitter. The control circuitry could also be designed to limit the aiming field to the projection screen, preventing aiming of the bright λ_2 beam toward the audience. The main part of the apparatus would ordinarily be located where it could project an arrow on the screen without significant distortion. The arrow (or other desired shape) would be created by steering the λ_2 beam in a preprogrammed repetitive pattern at a high rate.

There would be no need for a complex autoalignment system. Initially, the overlap between the λ_1 and λ_2 spots would be set manually. Thereafter, the lecturer's own pointing motion would provide some inherent correction of optical misalignment, because there would be an inherent tendency to move the pointer until the bright λ_2 appeared where it was wanted.

This work was done by Marc D. Rayman of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 18*** *on the TSP Request Card. NPO-19429*



Efficient, Narrow-Pass-Band Optical Filters

It is no longer necessary to trade narrowness of pass band against efficiency.

Langley Research Center, Hampton, Virginia

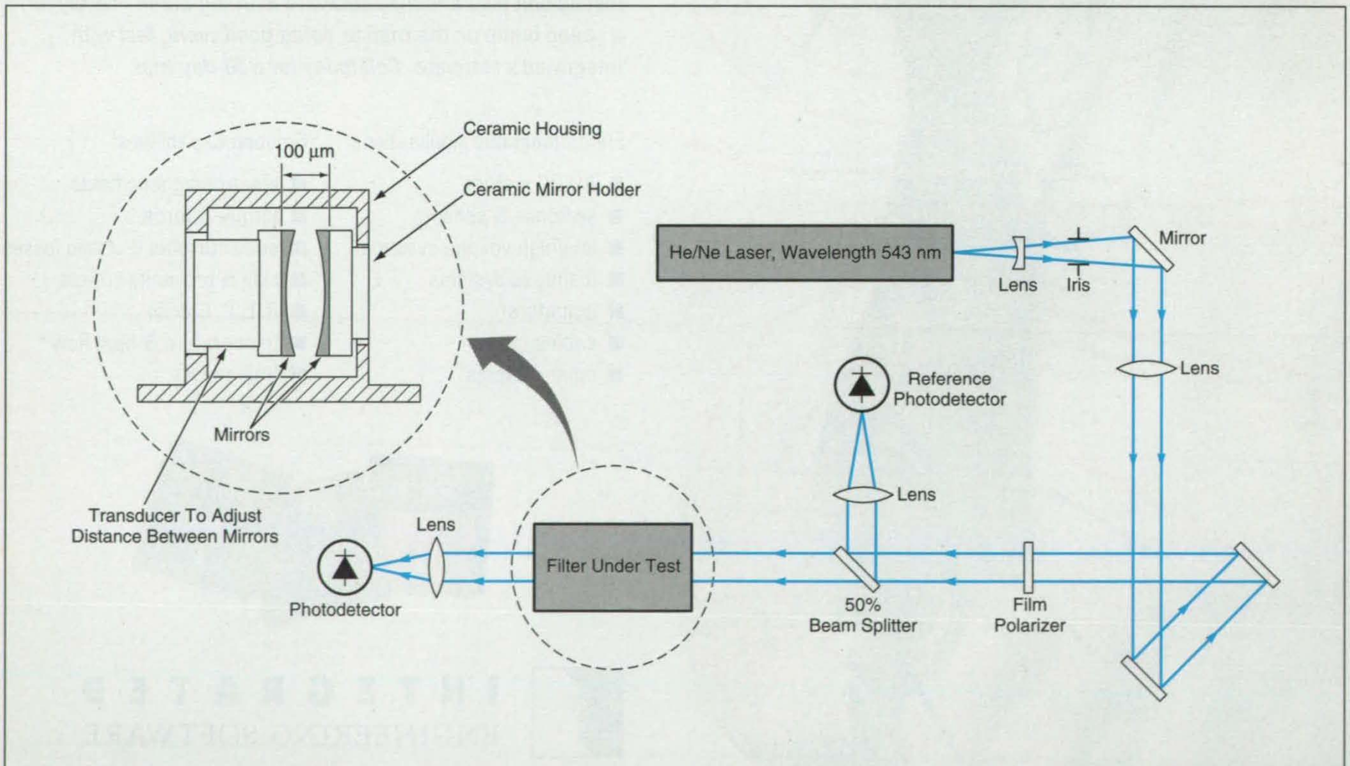
Optical filters with both narrow pass bands and high efficiencies can now be precisely fabricated to design specifications. These filters offer tremendous improvements in performance for a number of optical (including infrared) systems. For example, in fiber-optic and free-space communication systems, the precise frequency discrimination afforded by the narrow pass bands of these filters can provide higher channel capacities. For another example, in active and passive remote sensors like lidar and gas-filter-correlation radiometers, the increased efficiencies afforded by these filters can enhance the detection of small signals against large background noise. In addition, the sizes, weights, and power requirements of many optical and infrared systems can be reduced by taking advantage of the gains in signal-to-noise ratios delivered by these filters.

Previously, in designing and fabricating a band-pass optical filter, it was necessary to choose between (a) narrow pass band and low efficiency, (b) wide pass band and high efficiency, or (c) a compromise between the two. However, as a result of recent developments in polishing and thin-film-deposition techniques, it is no longer necessary to make such choices or compromises. It is now possible to fabricate, to specifications, surfaces that exhibit well-known transmission coefficients and extremely low losses to absorption and scattering of light; a typical loss figure is 10^{-6} per pass.

In particular, improved polishing techniques reduce surface roughnesses to less than 1 Å root mean square, thereby greatly reducing losses to stray reflections at surfaces and providing excellent interfaces for the first layers of multilayer mirror coats. Further, improved materials and deposition techniques provide mirror coats that are stoichiometrically homogeneous and contain low-stress interfaces between layers. By constructing a filter with high-quality mirror coats in a Fabry-Perot configuration, it is possible to achieve both narrow pass band and high efficiency in the same filter.

Another factor believed to increase the efficiency of these advanced filters is the disposition of the mirror surfaces in a symmetric spherical geometry rather than in the traditional plane/plane geometry. The spherical geometry reduces the width of the electromagnetic mode that can be sustained in a filter but offers the advantage of reduction of those losses that are caused by misalignment of the mirrors with each other and by misalignment of the overall filter with the beam of light to be filtered.

These advanced filter concepts have been demonstrated by the design and fabrication of two narrow-pass-band, high-efficiency filters for a mid-pass-band wavelength of 532 nm; one for a pass band 1 Å wide, the other for a pass



This **Experimental Setup** was used to measure the efficiencies and widths of pass bands of the two high-performance band-pass optical filters.

band 0.1 Å wide. As a practical matter, it was necessary to test them at a different wavelength, by use of the laboratory setup shown in the figure. The efficiency of the filter under test was measured by splitting the laser beam and sending exactly half the power to the filter under test and half to a reference photodetector identical to the photodetector behind the filter. The efficiency could thus be computed as the ratio power incident on the photodetector behind the filter and the power incident on the reference detector. The free spectral range (the speed of light ÷ twice the distance between the mirrors) and thus the precise frequency of each pass was adjusted and measured by adjusting and measuring the distances between the mirrors in the filter. The width of each pass band was measured by sweeping the middle frequency of the pass band over at least one free spectral range while measuring the efficiency.

The measurements showed that the two filters exhibited pass bands 0.7 Å and 0.07 Å wide, with efficiencies >90 percent and >80 percent, respectively. The difference between the design and actual widths of the pass bands is attributed to two factors; the difference between the design wavelength and the wavelength used to make the measurements, and uncertainty in the measurement of the free spectral range.

This work was done by Stephen P. Sandford of **Langley Research Center.** *For further information,* ***write in 39*** *on the TSP Request Card. LAR-14743*

In Situ Fiber-Optic Reflectance Monitor

Marshall Space Flight Center, Alabama

An in situ fiber-optic reflectance monitor serves as a simple means of monitoring changes in the reflectance of a specimen exposed to simulated outer-space or other environments in a vacuum chamber. The use of an in situ fiber-optic monitor eliminates the need to remove the specimen from the vacuum chamber, thereby eliminating the optical changes and bleaching that such removal might usually cause in coatings. Two vacuum-compatible fiber-optic cables — one for illuminating the specimen and the other for sensing the light reflected from the specimen — are routed into the vacuum chamber. Reflectance is usually monitored over a wavelength range of 370 to 1,000 nm. The reflectance monitor is calibrated by use of a specimen of known reflectance and by normalization to ex situ spectral reflectance measurements.

This work was done by Roger C. Linton of **Marshall Space Flight Center** *and Perry A. Gray of Micro Craft, Inc. For further information,* ***write in 3*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center; (205) 544-0021. Refer to MFS-26319.

Transmission Electron Microscope Measures Lattice Parameters

Specimens as small as nanometers can be characterized by this technique.

NASA's Jet Propulsion Laboratory, Pasadena, California

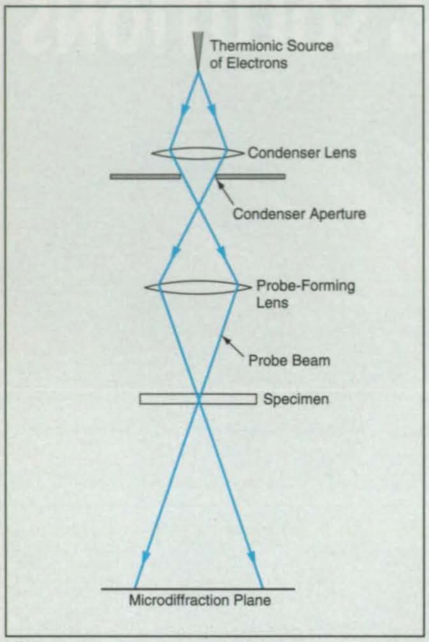


Figure 1. **Condenser-Objective Electron Optics** have been adopted by all major TEM manufacturers as the standard electron optics for high-resolution electron microscopy.

Convergent-beam microdiffraction (CBM) in a thermionic-emission transmission electron microscope (TEM) is a technique for measuring the lattice parameters of nanometer-sized specimens of crystalline materials. Lattice parameters determined by use of CBM are accurate to within a few parts in a thousand. The technique was developed especially for use in quantifying lattice parameters, and thus strains, in epitaxial mismatched-crystal-lattice multilayer structures in multiple-quantum-well and other advanced semiconductor electronic devices. The ability to determine strains in individual layers can contribute to understanding of the novel electronic behaviors of these devices.

In the prototype CBM apparatus, the TEM is built around condenser-objective electron optics (see Figure 1). The condenser lens demagnifies the electron image of the thermionic source, generating a probing electron beam that converges to a spot of about 0.5 nm in diameter on or in the specimen.

The electrons in the probe beam travel through the specimen at various angles throughout a range of angles defined by the condenser aperture. As the electrons travel through the specimen, the crystal planes that are tilted with respect to the direction of travel diffract the electrons, deflecting them by angles that depend on Bragg's law, to a first approximation.

At the plane at which the electron diffraction pattern is imaged (the microdiffraction plane, which is in the far diffraction field) each of these reflections corresponds to a dark line that crosses the otherwise bright disk image cast by the transmitted electron beam (see Figure 2). These lines are known as higher-order Laue-zone (HOLZ) lines; they are very sensitive to the angles and spacing of the crystal planes, and so can be used to determine accurately the lattice parameters of the crystalline structure of the specimen. The widths and visibilities of the HOLZ lines depend on the thickness of the specimen, optimum results

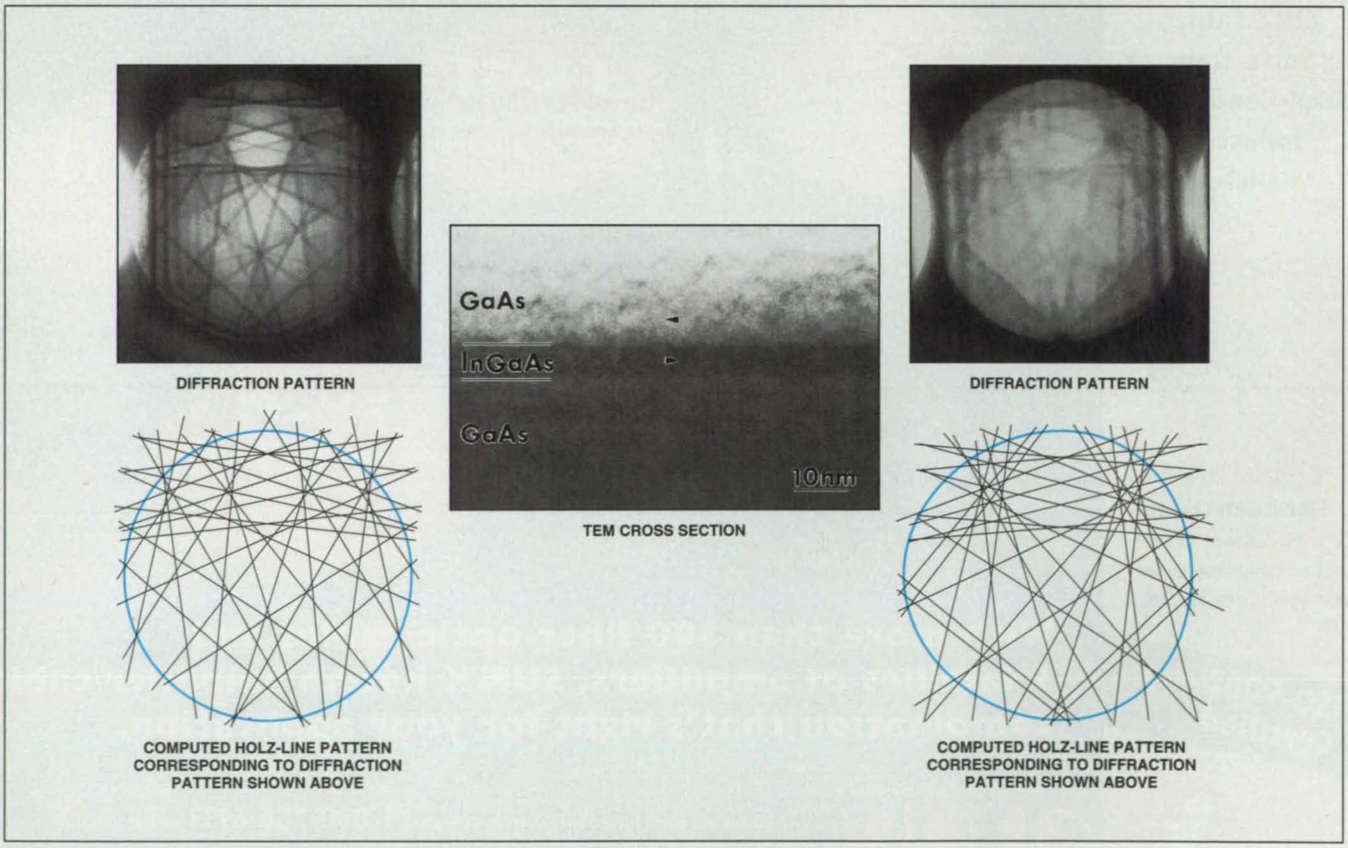


Figure 2. These **Electron Diffraction Patterns** and matching HOLZ-line patterns were obtained from the gallium arsenide substrate and the indium gallium arsenide quantum-well layer of the three-layer quantum-well device shown in the cross section.

Let Microway build your next Graphics Workstation, Web Server or Personal Supercomputer using

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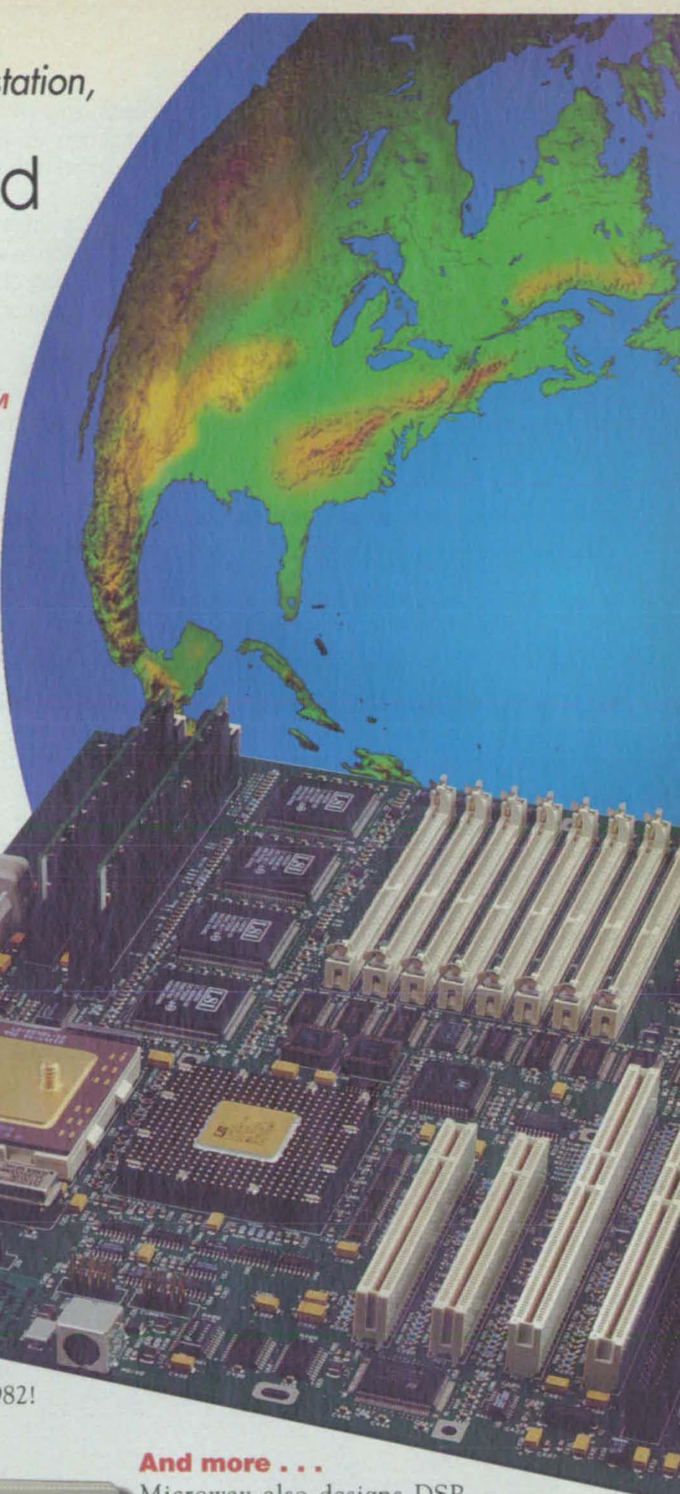

The Microway family of "Screamer" motherboards utilizes the fastest processor to hit the workstation market in the last ten years! The DEC Alpha 21164 not only blows away all other CPUs, but has the VLSI support needed to build memory systems that take full advantage of its numeric speed. Microway Alpha based products set a new standard in price/performance for workstations. The 266/300 MHz Alpha is a clear winner in both the numerics and integer processing arenas. With its ability to issue four pipelined instructions per cycle, the 21164 hits peak speeds of 1200 MOPS. Common numeric operations, such as dot products, peak at mind-boggling, on-chip throughputs of 600 megaflops! This results in Linpack ratings that go from 100 to 400+ mflops (as vector lengths increase) and scalar rates of 80 to 150 mflops. Motherboards priced from $4995 for 266NT, systems from $8995.

Memory, Cache, PCI . . .

The biggest challenge to running numeric intensive code on CPU's clocked over 200 MHz is building a cache/memory subsystem capable of keeping up with the CPU's numeric units. The 21164's Harvard architecture starts with two 32 deep 64-bit register files, followed by two 8K primary caches and an internal 96K cache. The 21164's external 128-bit data bus gets fed by 2 to 8 MB of Bcache built with 10ns SRAMS. The 256-bit wide interleaved memory subsystem that backs up the Bcache can hold up to 512 MB of DRAM. The coup de grace is the Screamer's PCI bus interface, which can accommodate both 32- and 64-bit PCI add-in cards. The Screamer is the biggest numeric winner Microway has introduced since we made it possible to run an 8087 in the IBM-PC in 1982!

A motherboard by itself does not a system make.

Microway adds the operating systems and compilers you need to put the 21164 to work. These include NT, Linux, DEC UNIX and OpenVMS, which now run thousands of applications including AutoCad, Excel and Word. The Screamer and Microway's NDP Fortran, C|C++ and Pascal compilers are available to both OEMs and end users.

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being obtainable at thicknesses of 100 to 300 nm for most semiconducting materials.

A cross-sectional specimen is prepared by mechanical thinning followed by ion-beam milling down to electron transparency. The specimen can then be imaged and orientated conventionally in the TEM before realigning the electron optics to produce the previously described convergent probe beam with the subnanometer focal spot. Precise positioning of the probe beam on the specimen is achieved by viewing the specimen with a defocused probe beam, producing a shadow image in the microdiffraction plane. This requires observation at very low electron-counting rates, which observation is greatly facilitated by use of an image intensifier.

Next, the CBM image is recorded, either by use of a conventional photographic emulsion or else by capturing the image from the display screen of the image intensifier. Finally, to determine the lattice parameters of the specimen, the HOLZ-line pattern in the image is compared to HOLZ-line patterns computed for assumed crystal lattices until a match is found.

This work was done by William T. Pike of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 27*** *on the TSP Request Card.* *NPO-19070*

Pendant-Drop Surface-Tension Measurement on Molten Metal

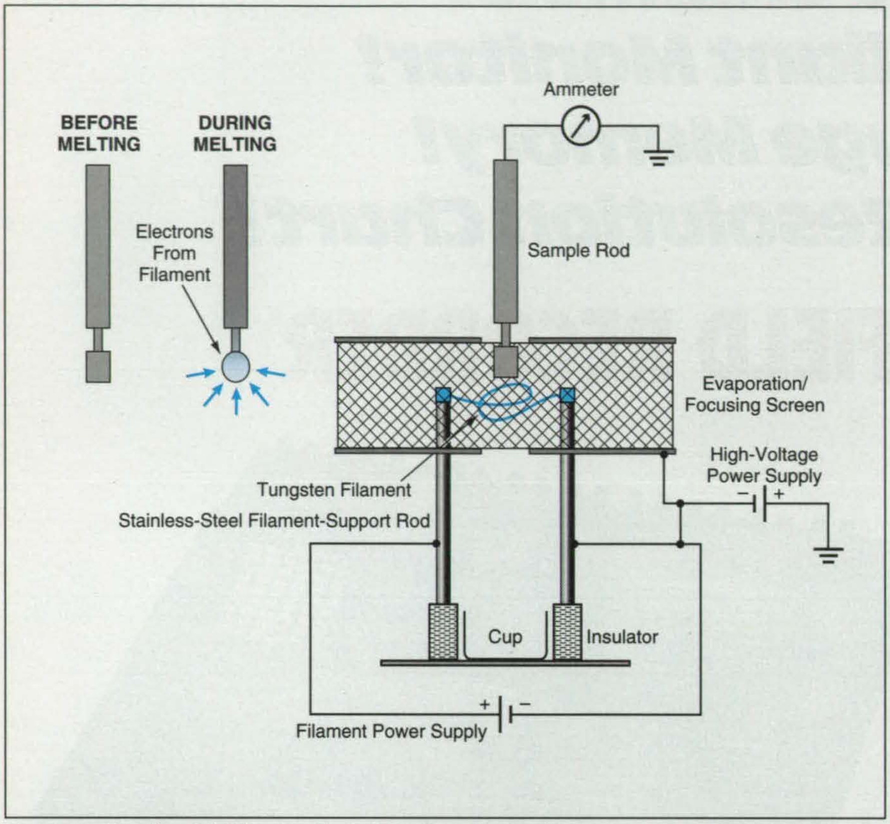
A quasi-containerless technique minimizes effects of contamination.

NASA's Jet Propulsion Laboratory, Pasadena, California

A method of measuring the surface tension of a molten metal is based on the pendant-drop method implemented in a quasi-containerless manner and augmented with digital processing of image data. The pendant-drop method is one of the oldest ways of determining the surface tensions of liquids and is based on the fundamental relationships among the surface tension, the shape of the drop, the density of the material in the drop, and the gravitational acceleration.

In the present method (see figure), a rod of the metal in question is held vertically in an ultrahigh vacuum (for the sake of purity) while its lower end is melted by bombarding it with electrons, causing a drop of molten metal to hang down. A side-view image of the drop is recorded and digitized. A computer program reads the pixel intensities of the digitized image, searches for an edge that coincides with the outline of the drop, and stores the coordinates of the edge in an array.

The program then computes theoretical drop shapes from the solution of the Young-Laplace equation, which is a differential equation that expresses the fundamental relationships mentioned above. The solution of this equation gives the shape of a drop as a function of three geometric boundary parameters, the gravitational acceleration, the density of the drop material, and a material parameter that is inversely proportional to the surface tension. Trial theoretical drop shapes are computed for various sets of values of these parameters, and the parameters are optimized by finding the theoretical shape that gives the least-squares best fit to the shape of the drop as determined in the digital image analysis. The surface tension of the drop is then taken to be the surface tension that belongs to the best-fit set of parameters.



Electrons Bombard the Lower End of the Sample Rod in a vacuum, generating a hanging drop of molten metal. The surface tension of the drop is computed from its shape.

One of the advantages of this image-analysis approach is that one utilizes the full information on the shape of the drop. A standard older approach is based on a technique known as selected-plane analysis, in which the only shape information that is used consists of two diameters measured at different heights from the bottom of the drop. The present full-shape approach generally gives a lower standard deviation than does the selected-plane approach. Furthermore, in the present method, failure of the theoretical and experimental shapes to match closely after optimization of the parameters can be taken as an indication of nonuniformities in the surface tension arising from gradients of temperature or from nonuniform distribution of impurities along the surface.

Another important advantage of the present method is that the pendant drop of molten metal is in contact with only the solid from which it was melted. Any initial surface contamination can be evaporated away by prolonged heating of the drop near its melting point. This is expected to produce a surface purity comparable to what can be achieved by low-gravity containerless processing in outer space.

This work was done by Kin Fung Man and David Thiessen of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 17*** *on the TSP Request Card. NPO-19344*

Comprehensive Mathematical Model of Real Fluids

Marshall Space Flight Center, Alabama

A mathematical model of the thermodynamic properties of water, steam, and liquid and gaseous hydrogen and oxygen has been developed for use in computational simulations of the flows of mass and heat in the main engine of the space shuttle. Similar models could also be developed for other fluids and applications. The model is based on the HBMS equation of state, which expresses the pressure and enthalpy of a liquid or gas as functions of its density and temperature. The model and the computer program that implements it incorporate several improvements over the HBMS equation:

- Capabilities for determining density and temperature from other independent values are added to enable modeling in situations in which current values of density and temperature are not available.
- Assumed values of parameters in the HBMS equation are refined to reflect the differences between the assumed and real properties of the fluids in question.
- A submodel is added to represent the two-phase (liquid/vapor) regime, which the HBMS equation cannot represent.
- Saturation values of vapor pressures, densities of liquids and vapors, and heats of vaporization are obtained by polynomial interpolation among data supplied by the National Institute of Standards and Technology.
- Specific heats of hydrogen, oxygen, and water are incorporated in tables.
- Ideal or reference enthalpies for use in the HBMS equation are provided by incorporating a set of equations for enthalpy as a function of temperature.

This work was done by Peter G. Anderson of SECA, Inc., for **Marshall Space Flight Center**. *For further information,* ***write in 10*** *on the TSP Request Card. MFS-26305*

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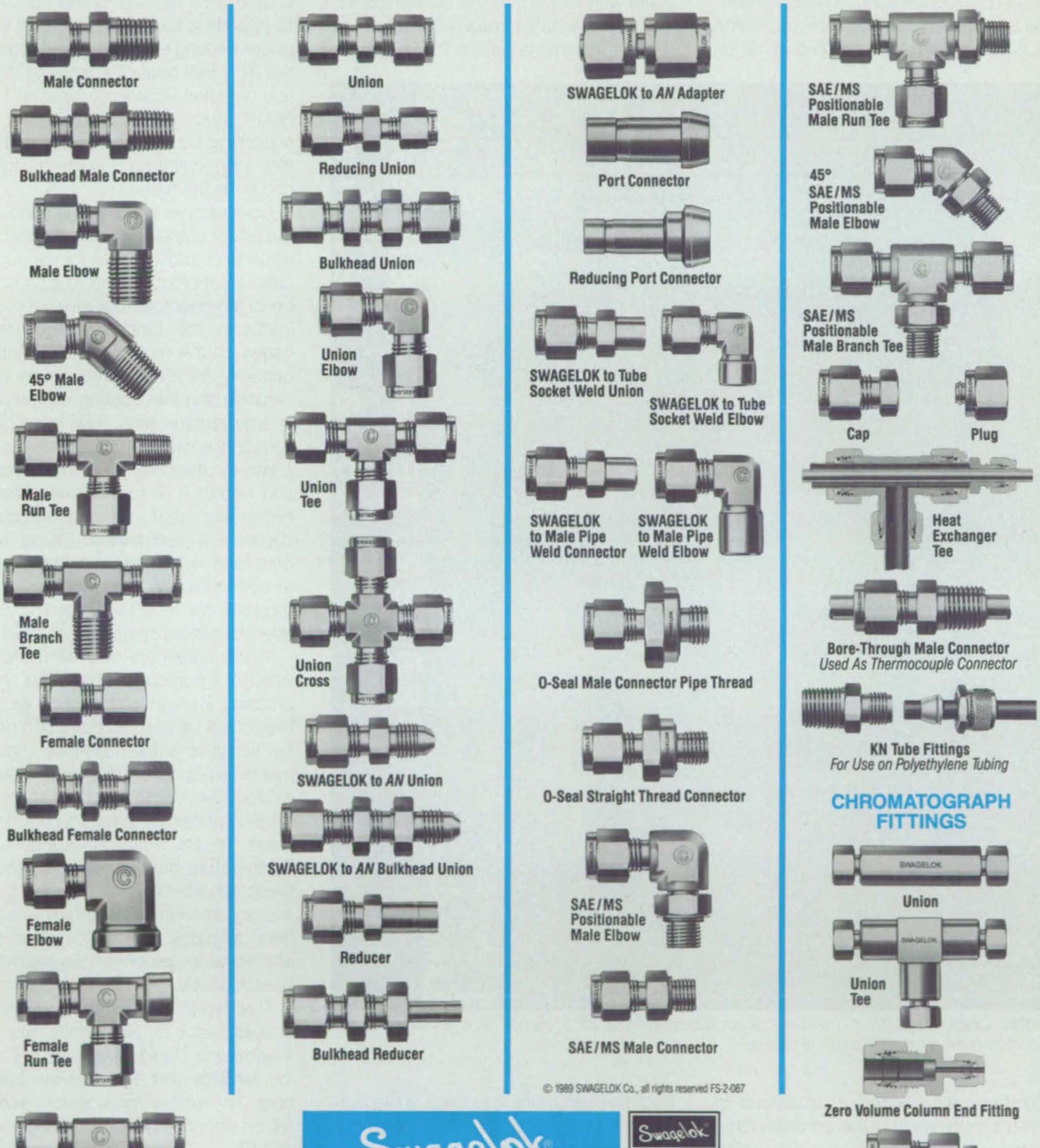

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Highly Efficient Molecular Adsorbers

Contaminants stick to the surfaces of these simple devices.

NASA's Jet Propulsion Laboratory, Pasadena, California

Molecular adsorbers have been developed to reduce contamination of sensitive optoelectronic components inside housings of scientific instruments. Such adsorbers are needed in situations in which simply venting the contaminants to the environment is not an option because the environment is even more contaminating. The molecular adsorbers act as though they were one-way (out) vents with respect to the contaminants, which are volatile materials. Some of the contaminants enter the housings through instrument apertures, while others are produced by outgassing from equipment within the housings.

Zeolite Crystallites on the surface of an adsorber coat at a corner of a honeycomb are shown here at a magnification of 500 ×.

A molecular adsorber of this type is fabricated on a cordierite ceramic honeycomb substrate. An alumina wash coat is then applied to the honeycomb to provide a suitable surface for subsequent coating with the adsorbing material. The final coat of adsorbing material is a modified version of a zeolite formulation that contains faujasite. The adsorbing coat must be thin and have a fine polycrystalline structure like that shown in the figure.

Operation as an adsorber is based on the ability of the particular zeolite formulation to provide access for various contaminant molecules and to strongly bind up to a monomolecular layer of contaminants in the functional equivalent of cages on the molecular level. Sufficient capacity for this limited mode of adsorption and thin coating is provided by a large surface area. This is an unconventional application of zeolite — appropriate in situations in which adsorption and retention at room temperature are necessary and modest adsorption capacity is acceptable. These adsorbers take in and retain contaminants at temperatures up to 50 °C and may be modified for selectively binding certain specific contaminants.

These adsorbers may be useful for a variety of purposes in addition to suppressing contamination. For example, they could be used as collection devices for sensitive total-mass-loss measurements on specimens of materials that exhibit low outgassing or as passive witness plates for collection of contaminants to be analyzed subsequently. Temperature-differential desorption from these adsorbers could be used for preliminary separation of chemical species prior to mass spectroscopy or as an alternative to gas chromatography/mass spectroscopy.

This work was done by Gerald E. Voecks, Jack B. Barengoltz, Sonya H. Moore, and David M. Soules of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 84*** *on the TSP Request Card. NPO-19345*

Boron/Carbon/Silicon/Nitrogen Ceramics and Precursors

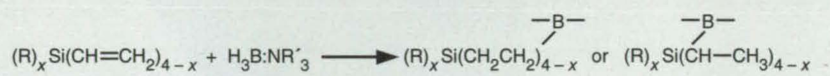
Polymers are pyrolyzed in inert atmospheres to produce the ceramics.

Ames Research Center, Moffett Field, California

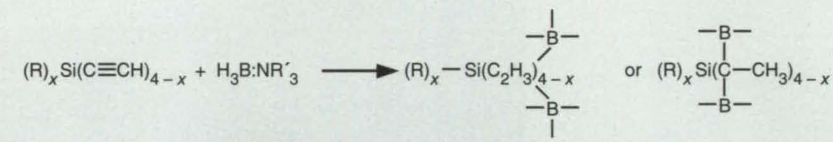
Ceramics that contain various amounts of boron, carbon, silicon, and nitrogen can be made from a variety of polymeric precursors. The precursors can be synthesized in high yield from readily available and relatively inexpensive starting materials. The precursors are stable at room temperature; when polymerized, they are converted to the ceramics in high yield. These ceramics resist oxidation and other forms of degradation at high temperatures: they can be used in bulk to form objects or to infiltrate other ceramics to obtain composites that have greater resistance to oxidation and high temperatures.

A polymeric precursor is synthesized by reaction of a vinylsilane, vinylmethylsilane, acetylene silane, or acetylene alkyl silane with a borane or a borane:amine derivative, as shown in the figure. The reactants are mixed in an inert atmosphere, either neat or in an aprotic solvent like acetonitrile, tetrahydrofuran or a hydrocarbon, or in a mixture of such solvents. The reaction mixture is heated for an interval that can range from 0.1 to 120 h at a temperature that can range from 90 to 170 °C. The solvent (if any) is then removed. The resulting polymer is usually sensitive to water; therefore, it and the starting ingredients used to synthesize it must be protected against moisture.

The polymer is pyrolyzed in an atmosphere of nitrogen or argon to convert it into the ceramic. Suitable pyrolysis temperatures range from 500 to 1,500 °C. A typical pyrolysis time is 1 h. The optimum temperature schedule depends upon the specific polymer.



SYNTHESIS FROM A VINYLSILANE OR VINYLMETHYLSILANE



SYNTHESIS FROM AN ACETYLENE SILANE OR ACETYLENE ALKYL SILANE

Notes:
1. R denotes methyl, ethyl, hexyl, propyl, decyl.
2. x = 0, 1, or 2.
3. R′ = hydrogen, methyl, ethyl, propyl, butyl, phenyl, tertiary-butyl, or another functional group.
4. Alternatively, $:NR'_3$ can be an aryl amine like pyridine, alkyl-substituted pyridine or alkyl-substituted quinoline.

Polymeric Precursors to the B/C/Si/N ceramics are synthesized in chemical reactions like these. Ceramics of this type can be single compounds or mixtures of compounds like B_4C, SiB, SiC, CB, BN, Si_3N_4, or $Si_pB_qC_rN_s$ (where p, q, r, and s can have various numerical values).

This work was done by Salvatore Riccitiello, Ming Ta Hsu, and Timothy S. Chen of **Ames Research Center.** *For further information,* ***write in 24*** *on the TSP Request Card.*

This invention has been patented by NASA (U.S. Patent No. 5,130,278). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Ames Research Center; (415) 604-5104. Refer to ARC-11891.

Designing Ni- and Co-Base Superalloys To Resist Oxidation

Analysis of experimental cyclic-oxidation data yields a quantitative design criterion.

Lewis Research Center, Cleveland, Ohio

An equation that characterizes the abilities of superalloys to resist oxidation at high temperatures may prove useful for designing new alloy compositions to resist oxidation. The equation rates the tendency to become oxidized in terms of a single attack parameter, K_a, as a function of composition and temperature: a decrease in K_a signifies an increase in resistance to oxidation.

The use of K_a as a measure of thermo-oxidative instability and the equation for K_a as a function of temperature

Significant Terms	Coefficient ($\log_{10} K_a$)
Al · Ta	−.03008490
$1/T_K$	−28,733.83015
Al^2	−.05162169
Al · V	+.16395511
Cr	−.71873828
Nb · Ta	+.05346153
Cr · $(1/T_K)$	+924.75130
Ti · Ta	+.01932161
Cr · W	+.003726623
Al · Mo	+.01273215
Ti · Nb	+.08140372
Nb · Hf	+.24155034
Ti	+.08344541
Re	+.21293029
a_o(Intercept)	22.75638644

R^2 + 84.43%, S.E.E. = .352155

These **Coefficients of Significant Terms** in composition and absolute temperature (T) in the equation for $\log(K_a)$ were derived by multiple regression.

and composition were derived in an experimental and statistical study of the cyclic oxidation of 36 Ni- and Co-base superalloys. A typical alloy specimen was tested in cycles, during each of which the specimen was exposed for 1 h in a furnace in static air at a temperature of 1,000, 1,100, or 1,150 °C, then automatically lifted out of the furnace for a minimum of 20 min. This cycle was repeated 100, 200, or 500 times for 1,150 1,100, or 1,000 °C, respectively. At selected intervals between cycles, each specimen was weighed to determine its specific weight loss ($\Delta W/A$) as a function of cycle time (t).

By use of multiple linear regression, the $\Delta W/A$-vs.-t data for each specimen were fitted to $\Delta W/A = k_1^{1/2} t^{1/2} \pm k_2 t \pm \sigma$, where $k_1^{1/2}$ and k_2 are analogous to oxide-scale-growth and oxide-scale-spalling constants, and σ is a standard error. The data for each specimen were reduced to a single attack parameter via $K_a = k_1^{1/2} + 10|k_2|$. The attack parameter K_a can be used to rank the ability of an alloy to resist oxidation at a given temperature: the higher the value of K_a, the poorer the resistance. Analysis of a large body of data showed that resistance to oxidation ranges from excellent at $K_a \leq 0.20$ through poor at $1.0 \leq K_a \leq 5.0$ to catastrophically poor at $K_a > 5.0$.

The equation for $\log_{10}K_a$ as a function of temperature and composition was obtained by multiple regression analysis on 315 experimental values of these parameters. The equation consists of 14 terms, which include terms up to second order in the proportions of constituent elements, plus a term proportional to the reciprocal of absolute temperature. The validity of the estimating equation was tested by predicting K_a values for a related alloy run under similar conditions.

Of the coefficients of the compositional terms in the equation, only three were found to be negative (see table), signifying that increases in the proportions of the particular constituents (Cr, Al, and Ta) would reduce K_a, thus increasing resistance to oxidation; in the cases of some other constituents, decreases in their proportions could result in decreases in K_a. More specifically, the coefficients show that (a) increases in proportions of Cr and Al are beneficial; (b) an increase in the proportion of Ta is beneficial when Al is present; (c) an increase in the proportion of Nb is deleterious when Ta, Ti, and Hf are present; and (d) the proportions of Mo and W should be minimized because they increase K_a when Al and Cr, respectively, are present.

One could attempt to use the equation and its coefficients to choose an optimal composition of a new alloy, subject to constraints imposed on compositions by other criteria based on chemical, microstructural, and/or mechanical considerations. One such proposed composition for a strong, oxidation-resistant superalloy would be (in approximate weight percentages) Ni–10Co–6Al–5Cr–8.6Ta–0.9Ti–1Hf–0.15C–0.015B–0.05Zr.

This work was done by Charles A. Barrett of **Lewis Research Center.** *For further information,* ***write in 76*** *on the TSP Request Card.*
LEW-15910

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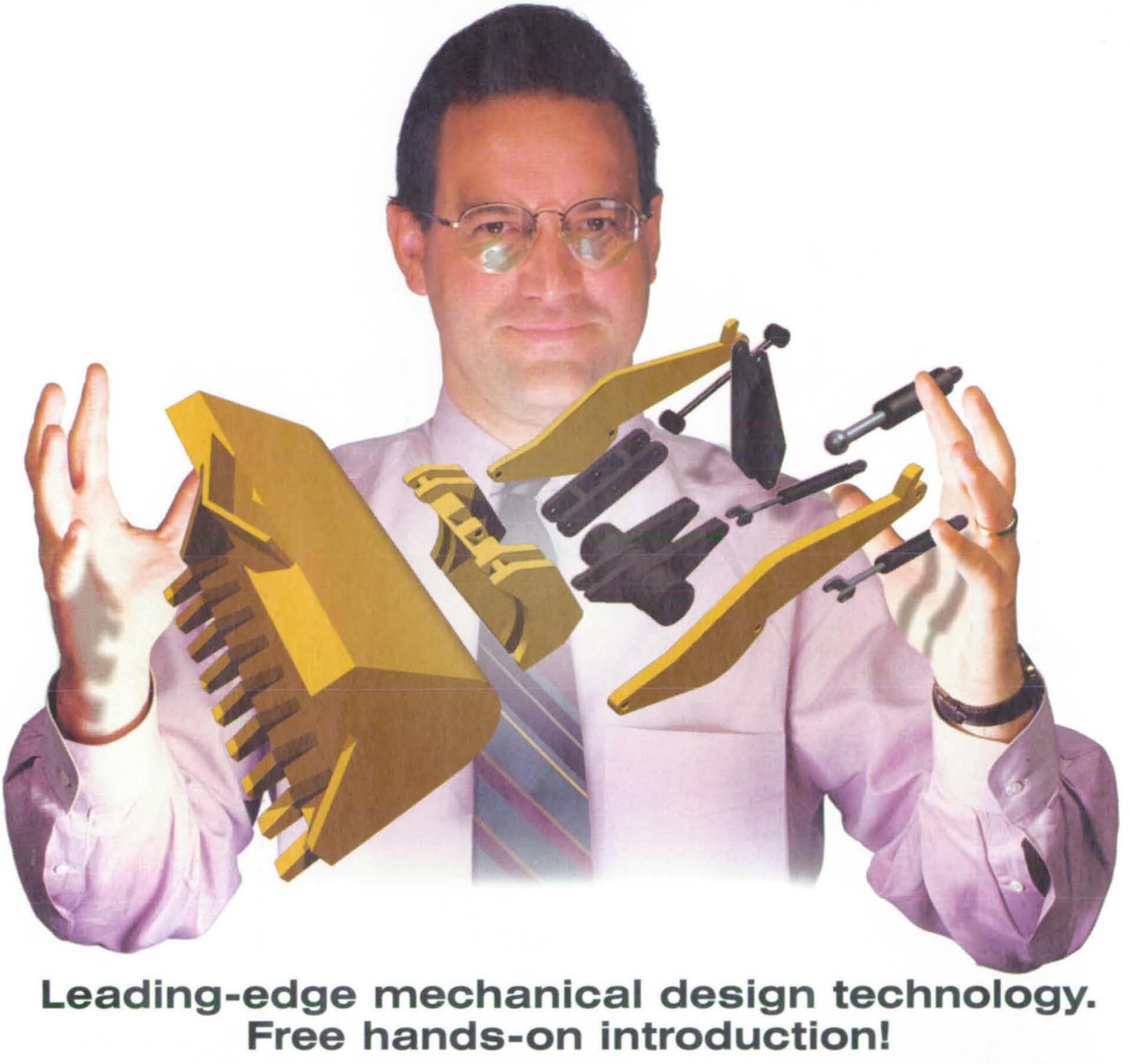

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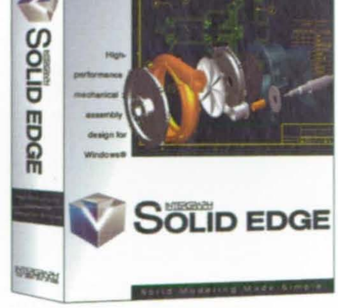

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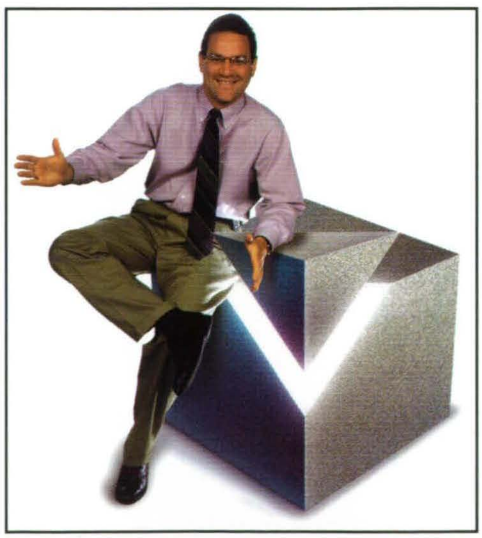

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Physical Sciences

Software for Converting SAR Data Formats

This program converts between SIR-C and AIRSAR formats.

The CVERT computer program converts AIRSAR data to SIR-C format, or converts SIR-C data to AIRSAR format. The Spaceborne Image Radar - C (SIR-C) has successfully imaged areas at many sites around the world. Many investigators have experience using data from the airborne prototype of SIR-C, called AIRSAR, which is a NASA/JPL quad-polarization, multifrequency radar system flown aboard a DC-8 aircraft.

AIRSAR has imaged many of the SIR-C supersites. Some investigators have written software for analyzing AIRSAR data or use programs that were written for AIRSAR data. CVERT is not a substitute for such image-display, analysis, or calibration software as RAVEN or POLCAL (NPO-18954).

There are many differences between the formats of AIRSAR and SIR-C data, even though the data themselves are very similar. CVERT is based partly on the assumption that the first 12 bytes of each line of the input image file, which contain Committee on Earth Observing Systems (CEOS) prefix information, have been stripped off. The SIRC CEOSREADER software package (NPO-19463, NPO-19543) is required for reading CEOS headers and decompressing SIR-C data.

CVERT is written in FORTRAN 77 to be machine-independent. It has been compiled on Sun4-series computers running SunOS 4.1.3, SGI IRIS-series computers running IRIX 5.2, HP9000-series 700/800 computers running HP-UX 8.07, and DEC VAX-series computers running VMS 5.1. The SIRC CEOSREADER software package (NPO-19463, NPO-19543) is necessary for running the program. The standard distribution medium for CVERT 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 upon request. CVERT is a copyrighted work with all copyright vested in NASA.

This program was written by Bruce Chapman of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 8*** *on the TSP Request Card. NPO-19465*

Rotating Microphone Rake Measures Spinning Acoustic Modes

Acoustic modes can be measured on a wide range of test-engine configurations.

Lewis Research Center, Cleveland, Ohio

A rotating rake of pressure transducers has been developed for use in experimental studies of the sources and propagation of noise generated by subsonic fan engines. The pressure transducers are used as microphones to measure acoustic modes that are generated by, and spin with, the fans. By use of a closed-loop, computerized sensing-and-control subsystem and a motor drive (see figure), the rake is made to rotate at an integer submultiple of the speed of the fan and in synchronism with the fan, as though the fan and rake were mechanically geared together.

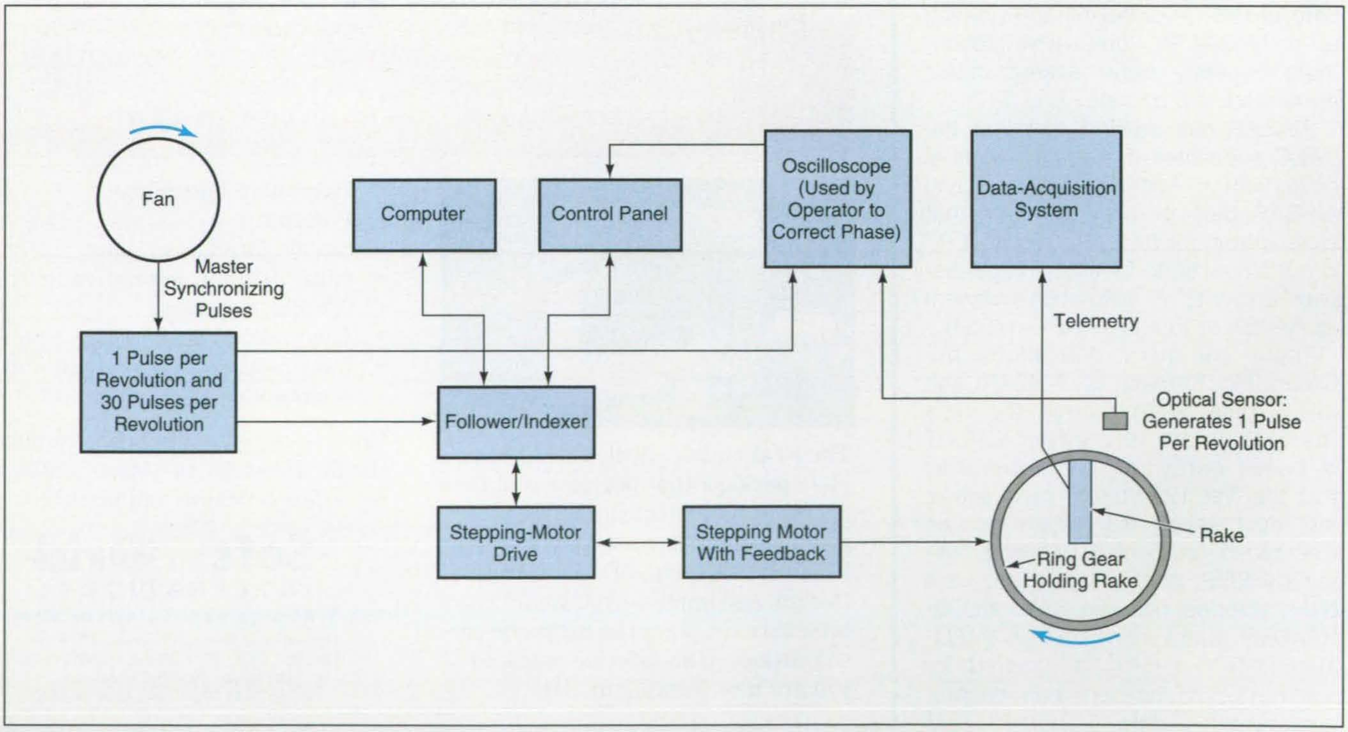
The integer submultiple can have any value within a range defined by the requirements of a given research project. In the original application, a value of 1/250 was used in measurements on a fan rotating at a maximum speed of 12,500 r/min. Thus, the maximum speed of the rake was 12,500/250 = 50 r/min. The angular position of the rake is required to track the precisely synchronized submultiple of the angular position of the fan within 1°: this is necessary for accurate measurement of sounds at both the fundamental and harmonics of the blade-passing frequency.

Two unique features of the spinning-rake method are the following:

- The circumferential mode order is directly determined in terms of frequency. A Doppler shift separates the various circumferential orders into different frequencies.
- The fan blades slice the wake of the rake itself, thereby creating additional noise. The rotating microphones detect this noise at one frequency only. This frequency is such that the wake-slicing noise does not interfere with any mode measurements at subsonic fan-tip speeds.

The rake-drive system must provide synchronization despite fluctuations in the speed of the fan: it must maintain phase lock between fan and rake during an entire test period (typically, about 10 min) without any buildup of phase error. Thus the rake-drive subsystem must be slaved directly to the fan. The master synchronizing signals are two sequences of pulses (30 per revolution and 1 per revolution) generated by a shaft-angle encoder in the engine that turns the fan. These signals direct the position and velocity of a stepping motor via the closed-loop control subsystem, with feedback on the angular position of the rake supplied by an optical sensor. The motor turns the rake through a 5:1 gear reduction. Thus, the rake becomes, in effect, electronically geared to the fan.

A phase/position tolerance of 0.085° between the rake and fan was achieved



The **Angular Position of the Rake Is Slaved** to an integer submultiple of the angular position of the fan as the fan rotates.

in the initial application. The versatility of the control software used in the rake-drive system enables measurements of acoustic modes on a wide range of test-engine configurations. The rake-drive hardware can be easily adapted to different engines because it is not mechanically coupled to the engine under test.

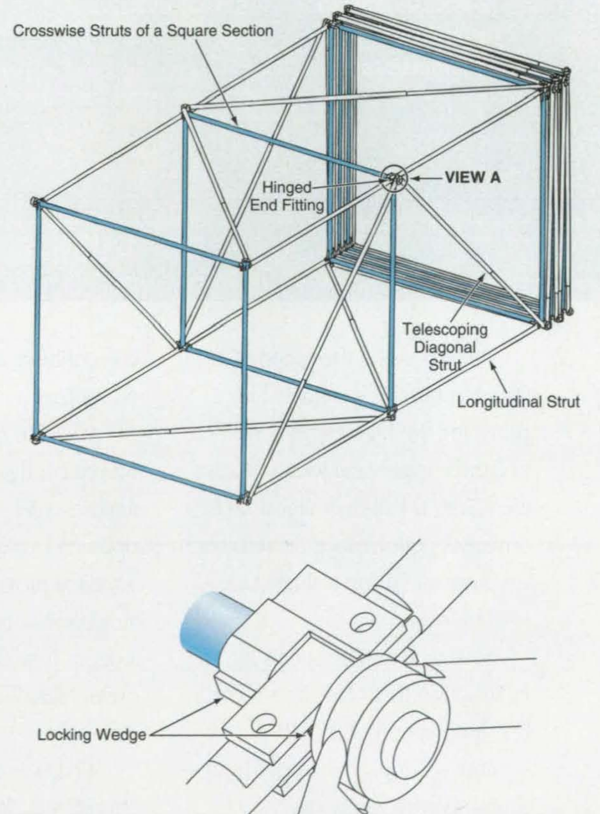
This work was done by Kevin E. Konno and Clifford R. Hausmann of **Lewis Research Center.** *For further information,* ***write in 57*** *on the TSP Request Card. LEW-15892*

Truss Structure Could Be Folded for Transport

When folded, the truss would be 1/25.6 as long as when fully extended.

Lewis Research Center, Cleveland, Ohio

A proposed truss structure would comprise cubical bays and could be folded for compactness during transport (see figure). Conceived for transport and deployment in outer space, the truss may be suitable for terrestrial structures that must be transported compactly and erected quickly.



VIEW A: DETAIL OF HINGED END FITTING LOCKED IN POSITION

The **Truss Structure** would be folded for transport. During unfolding, the hinged end fittings would snap into place at the completion of extension of each succeeding cubical bay.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The ends of each cubical bay would be defined by two square sections, each of which would consist of four fixed-length crosswise struts. The square sections would be connected by fixed-length longitudinal struts and telescoping diagonal struts.

During unfolding, hinged end fittings connected to the longitudinal and diagonal struts would slide along the crosswise struts of the square sections, toward the corners. The crosswise struts would be made smooth to facilitate this sliding. As each successive bay would become fully extended and cubical, spring-detent locking-wedge mechanisms would lock the end fittings at the corners, while spring-detent shear pins would slide into aligned holes to lock the diagonal struts at full extension.

When completely folded, the truss would be 1/25.6 as long as when completely extended. Once the truss had been extended, individual diagonal and longitudinal struts could be replaced. However, each square section would constitute a unit; that is, all four struts of a square section would have to be replaced together; this would necessitate disassembly of the truss. The truss could be refolded and transported to another location.

This work was done by Douglas S. Theer of Rockwell International Corp. for **Lewis Research Center.** *For further information,* ***write in 88*** *on the TSP Request Card. LEW-15532*

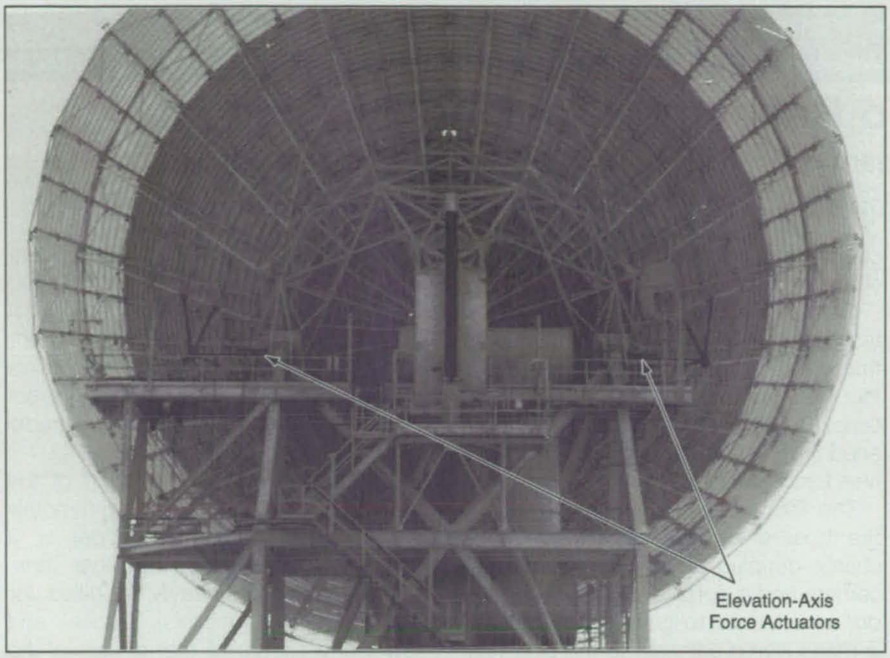
Actuators Help Correct for Gravitational Bending of Antenna

About 1 dB of gain can be recovered.

NASA's Jet Propulsion Laboratory, Pasadena, California

A force-actuator scheme has been devised to help correct for the decrease, caused by gravitational bending, in the gain of a 34-m-diameter paraboloidal microwave antenna reflector that is used for tracking distant spacecraft and observing celestial radio sources. The scheme should also be applicable to other antennas that bend significantly under their own weight, with consequent degradation of performance.

The concept of using force actuators to correct for distortions (including gravitational bending) of an antenna is not new. The novel aspect and advantage of this particular scheme lies in its simplicity and thus relatively low cost: Whereas a typical other scheme based on the same concept calls for tens to hundreds of actuators distributed throughout an antenna structure, the present scheme involves only two force actuators located where they can produce a large corrective effect — on opposite ends of the elevation axis in the original application (see figure).



Force Actuators (hydraulic jacks) exert forces on the antenna structure along the elevation axis. These forces can be chosen to compensate partly for distortion of the antenna under its own weight.

This scheme does not rely on the accuracy of a finite-element mathematical model of gravitational bending of the structure, even though such a model can be used initially to guide the choice of actuator structural positions and actuator forces. Instead, the actuator forces as functions of elevation angle are chosen on the basis of measurements of the antenna gain. In the original application, this involved observations of the radio star 3C84 as its elevation changed during the hours of 4 p.m. to 12 p.m. local time. Antenna gains were measured with actuator forces of various levels, including zero. The resulting data were then interpolated and otherwise processed to obtain a curve of actuator force vs. elevation angle. Typical increases in gain achieved by application of suitably chosen actuator forces were found to be about 1 dB at an elevation angle of 10° and about 0.6 dB at 75°.

This work was done by Roy Levy and Douglas M. Strain of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 23*** *on the TSP Request Card.*
NPO-19170

Machinery/Automation

Robot Drills Holes To Relieve Excess Tire Pressures

This small unit helps to protect nearby people and equipment against tire explosions.

Dryden Flight Research Center, Edwards, California

A small, relatively inexpensive, remotely controlled robot called a "tire assault vehicle" (TAV) has been developed to relieve excess tire pressures to protect ground crew, aircraft equipment, and nearby vehicles engaged in landing tests of the CV-990 Landing System Research Aircraft. These tests are performed to gather data for analysis of landing loads, speeds, and tire slip angles of the space shuttle orbiter.

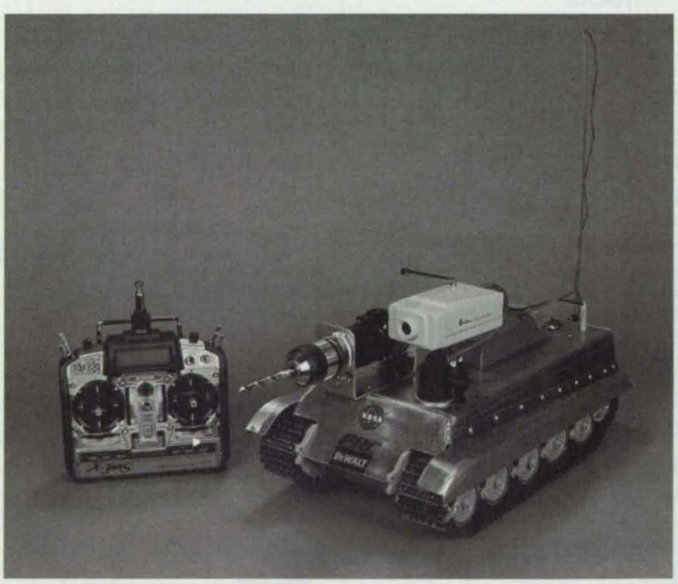
An orbiter test tire is deemed to be in one of three conditions, as determined by use of a graph of temperature, pressure, and cord wear. The conditions are "green" (no chance of explosion), "yellow" (possible risk of explosion), and "red" (imminent danger of explosion). The possibility of a tire explosion can last up to one hour after completion of testing under the "yellow" condition. However, tires in the "red" condition will always pose a danger of exploding, even after one hour of cooling. A standard tire is pressurized to 340 psig (gauge pressure of 2.34 MPa), which is above the pressure limit for "red" cord wear. Therefore, the tire could explode at any time and no personnel are allowed to approach it.

Concerns about tire explosions after testing brought about a project policy that the TAV be used to drill test tires found to be in "red" and "yellow" conditions. By preventing explosions of weakened tires, this policy also preserves the tires for postflight analysis.

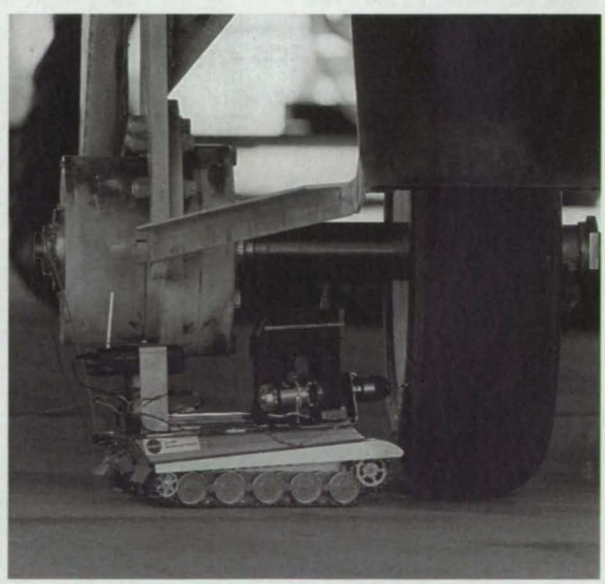
The TAV (see figure) moves on tracks like those of a tank. A black-and-white charge-coupled-device wireless video camera and a portable 3/8-in. (9.5-mm) drill are attached to its top side. The TAV is maneuvered adjacent to the side wall of a tire and drills a hole to release energy buildup.

The TAV is 10 in. (25.4 cm) tall, 19 in. (48.3 cm) long, [plus 2.5 in. (6.4 cm) for the drill], and 10 in. (25.4 cm) wide. A 12-volt rechargeable gel-cell battery supplies power to the video camera and to three high-torque drill motors. One of these motors drives the drill, while the other two drive the tracks. The motors are controlled by use of custom-built, solid-state speed controllers (one for each motor). The transmitter/receiver used for remote control is a JR Model X-388S airplane system modified for (1) government frequency and (2) independent, spring center, track control. This system can also accommodate direct servo control via cable instead of radio transmission.

The design and construction of the TAV started from a kit for a remotely controlled, 1/16th-scale model of a World War II German King Tiger Tank. The transmission (heavily modified for the high-torque motors), tracks, and lower chassis are all that remain of the kit. The motors for the tracks are geared through the modified transmission adapter to drive the left and right tank tracks independently. The drill motor and its gearing are from a battery-powered, reversible, variable-speed 3/8-in. (9.5-mm) drill. The video camera transmits at a frequency of 900 MHz with a signal strength of 50 mV/m at a range of 120 ft (37 m). The received signal is down-converted to channel 3 for viewing on a portable black-and-white television.



TAV and Controller



TAV Operating in Temperature-Probe Configuration

A **Remotely Controlled Tank Was Modified** to carry a drill and video camera and, optionally, a temperature probe.

Equivalent units (remotely controlled robots) are operated by the United States Air Force Explosive Ordnance Disposal (EOD) group at Edwards Air Force Base and by security personnel at Kennedy Space Center. These units weigh 450 lb (200 kg) and cost between $75,000 and $125,000 (1995). The TAV weighs 20 lb (9 kg), and the cost of its materials is less than $3,000 (1995). If damaged by a tire explosion, it can be repaired with inexpensive replacement parts. Also, the setup time for the TAV is about 3 minutes, compared with 15 to 20 minutes for the EOD robots. Moreover, the small size of the TAV facilitates maneuvering around the underside of the CV-990 airplane.

The TAV can be adapted to perform other duties; for example, it can be used to investigate the postlanding status of an orbiter nose-wheel tire, for which no pressure- or temperature-sensor data are available. Without such data, the status of the tire is unknown after a test and, therefore, no one may approach for 1 hour after the landing while the tire cools. The TAV can be adapted to carry a portable noncontact temperature probe, and the video camera can be remounted at the rear center of the TAV, where the camera can acquire a clear view of both the scene ahead and the digital display of the temperature probe. Thus equipped, the TAV can be moved into position next to this tire and used to monitor temperatures of the metal hub.

The TAV reduces the costs and saves time in training, maintenance, and setup related to "yellow" and "red" tire conditions. It could be adapted to any heavy-aircraft environment in which ground-crew safety is at risk because of the potential for tire explosions. Also, the EOD has observed that the TAV would be ideal as a scout vehicle for performing inspections in hazardous locations. It could be used prior to setting up and deployment of the main EOD robot.

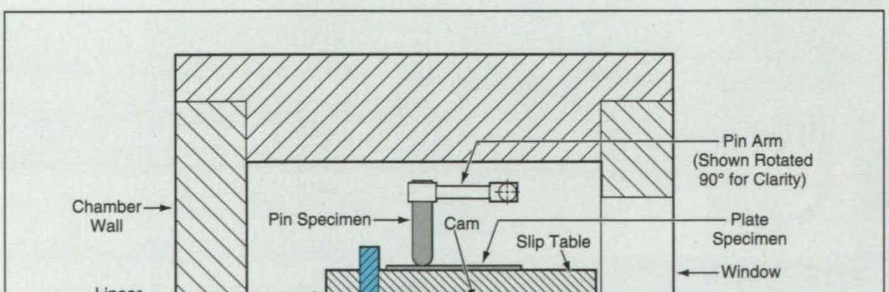
This work was done by David T. Carrott of PRC Inc. for **Dryden Flight Research Center.** *No further documentation is available. DRC-95-20*

Apparatus Measures Friction in Vacuum or Pressurized Gas

Reciprocating linear motion of the rubbing specimens is generated within a test chamber.

Lyndon B. Johnson Space Center, Houston, Texas

The figure illustrates a friction-testing apparatus in a small test chamber that contains a special atmosphere, which could include a vacuum or a pressurized gas. This apparatus provides readings indicative of the friction between a pin specimen and a plate specimen that slides under the pin in reciprocating lin-



The **Cam and the Cam Follower on the Slip Table** convert rotary motion to reciprocating linear motion of the plate specimen under the pin specimen. The chamber can contain a vacuum or any of a variety of gases.

ear motion. The pin and plate specimens can be made of the same or different material.

This apparatus is based on an older friction-testing apparatus in which friction is measured in circular sliding contact between a pin specimen and disk specimen. The older pin-on-disk apparatus is designed to operate in a high-pressure test chamber but does not provide the reciprocating linear motion needed for some friction measurements. Current, commercially available reciprocating apparatuses are limited to use under natural and nearly natural terrestrial atmospheric conditions.

The pin in the present apparatus is mounted on a stationary arm (the pin arm), which is instrumented with strain gauges to measure the frictional force. The plate specimen is attached to a slip table, which is mounted on linear bearings. The force of contact between the pin and plate specimens is set by use of a rotary pneumatic actuator or by applying weights to the pin arm.

The reciprocating linear motion is generated by use of a cam and cam follower. The cam is rotated by a motor drive via a drive shaft that extends through the floor of the chamber. The cam follower, which is attached to the slip table, provides rolling contact between the slip table and the cam. The slip table is spring-biased (toward the right in the figure) to ensure constant contact between the cam follower and the cam, thereby ensuring repeatable motion. The cam is selected to provide the desired stroke length. The preload on the spring is adjusted to suit the size of the cam. The progress of the test can be monitored visually through a window in one wall of the chamber.

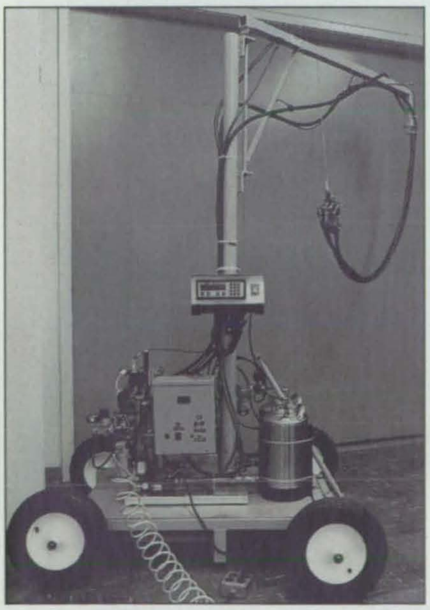
This work was done by Joseph R. Trevathan of **Johnson Space Center.** *For further information,* ***write in 48*** *on the TSP Request Card. MSC-22625*

Foam-Mixing-and-Dispensing Machine

A time-and-money-saving machine produces consistent, homogeneously mixed foam, enhancing production efficiency.

Lyndon B. Johnson Space Center, Houston, Texas

A machine automatically mixes and dispenses polyurethane foam in quantities specified by weight. The machine (see figure) includes a commercial cart-mounted, air-driven proportioning unit for mixing the two chemical ingredients used to make polyurethane foam, an air-actuated mechanical mixing gun, a programmable timer/counter (which is programmed with the weights of foam to be dispensed), and a controller.



The **Foam-Mixing-and-Dispensing Machine** consists of a cart-mounted, air-driven proportioning unit; an air-activated mechanical mixing gun; a programmable timer/counter, and a controller.

The use of the machine offers advantages over the older practice of manually mixing the ingredients of foam from prepackaged kits: In the original production situation for which the machine was acquired, the machine can be operated and foam applied by only one or two technician(s), whereas manual mixing and application of foam requires 5 or 6 technicians. Unlike the manual foaming process, the automated foaming process based on this machine produces consistent, homogeneously mixed foam. The machine reduces cost further by making it unnecessary to repackage the foam kits into semikits, as must be done in the manual process.

This work was done by Keith Y. Chong, Gordon R. Toombs, and Richard J. Jackson of Rockwell International Corp. for **Johnson Space Center.** *No further documentation is available. MSC-22666*

Portable Spray Booth

Advantages include controllable application for high quality, reduced processing time, and containment of fumes.

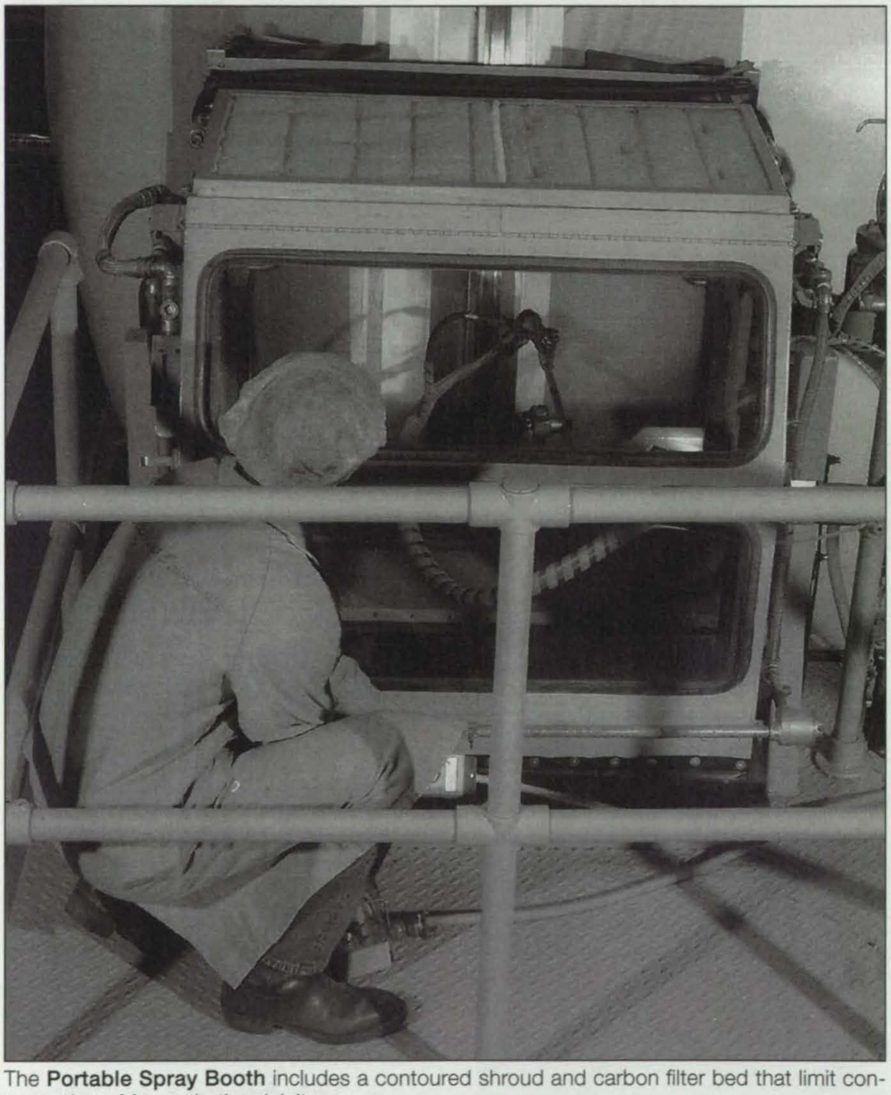
Marshall Space Flight Center, Alabama

A portable spray booth provides for controlled application of coating materials with high solvent contents. It was originally designed to substitute spraying for brush application of a solvent-based adhesive prior to installing rubber waterproof seals over the joints between segments of a solid-fuel rocket motor. In this original use, the portable spray booth produces coatings superior to those produced by brushing, does not disturb other adjacent material (grease that must not be spread onto the adhesive-coated area), reduces processing time, and reduces the exposure of technicians to solvent fumes. With minor adjustments and modifications, it could be used to apply other solvent-based adhesives, paints, and the like.

The spray booth is mounted on a wheeled platform. That allows the spray booth to be positioned at the workpiece to be sprayed. The spray booth could be described, more accurately, as a large spray gun surrounded by a fume hood. It provides for control of the standoff (the distance from the spray head to the workpiece), the width of the spray, and the rate of flow of the spray.

As shown in the figure, one side faces the technician and includes windows that enable the technician to see through to the workpiece. The opposite side is open and is contoured to match the surface contour of the workpiece. The open side is placed close to the workpiece, leaving only a small air gap for dimensional tolerance for turning the workpiece relative to the spray booth. A minimal amount of overspray escapes through the air gap. The booth contains a carbon filter bed [540 lbs. (245 kg)] that absorbs solvent fumes from the spray.

In the original rocket-motor application, the adhesive spray emits methyl ethyl ketone, methyl isobutyl ketone, trichloroethylene, and xylene fumes. Measurements showed that the maximum concentration of any of these fumes near the spray booth was about 149 parts per million (xylene). The concentration of each of these fumes averaged over time was found to be less than 1 part per million. These levels are about 1/10 those encountered in brushing and were below the maximum levels allowed by the laws and regulations applicable at the time of the measurements.



The **Portable Spray Booth** includes a contoured shroud and carbon filter bed that limit concentration of fumes in the vicinity.

This work was done by Timothy D. Hansen and Micheal J. Bardwell of Thiokol Corp. for **Marshall Space Flight Center**. *For further information,* ***write in 51*** *on the TSP Request Card.* MFS-28941

Adaptive Machining of Large, Somewhat Flexible Parts

Despite elastic deformations, workpieces can be machined to close tolerances.

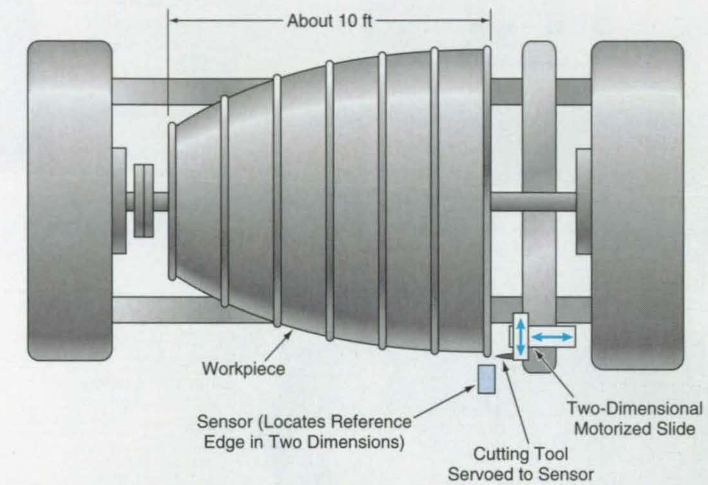
Marshall Space Flight Center, Alabama

Adaptive machining is a method of machining large, somewhat flexible workpieces to close tolerances. The method was devised for machining precise weld lands on the aft skirts of rocket nozzles, but the underlying adaptive-machining concept is generally applicable to precise machining of any of a large variety of workpieces that are deformed by thermal, gravitational, and/or machining forces. For example, in principle, the method could be used to bore a precise hole on the unanchored end of a long cantilever beam.

An adaptive-machining system consists of four main subsystems: (1) a sensor subsystem that locates or measures a reference surface, edge, contour, or other feature on the workpiece; (2) a motorized slide that holds the cutting tool and moves the tool in two dimensions (in the case of a lathe, radially and axially); (3) a control subsystem that commands the motorized slide to apply corrective motions in response to the output of the sensor subsystem; and (4) a fail-safe subsystem that quickly backs the cutting tool away from the workpiece in the event of power failure or other fault.

The figure is a schematic illustration of adaptive machining in the rocket-engine application. The cutting tool is made to follow a trajectory, the reference coordinates of which are servoed to (that is, made to follow) the reference feature located or measured by the sensor. Thus, when the workpiece is deformed, the trajectory of the cutting tool is automatically adjusted to maintain the required relationship between the coordinates of the reference feature and the feature being machined.

The selection of a reference feature depends on the specific nature of the machining operation. For example, if the objective is to cut a cylindrical wall to precise thickness on a lathe, the reference feature should be the point on the inside or outside of the cylinder closest to, and on the opposite side of the wall from, the cutting tool. For another example, if the objective is to machine a second edge at a precise distance from a first edge, then the first edge itself should be used as the reference feature.



The **Sensor Subsystem** locates the reference edge of a workpiece on a lathe. The edge moves radially and axially as the workpiece becomes deformed by machining forces and its own weight. The cutting tool follows this motion and machines a surface accurately relative to the reference edge.

This work was done by David Gutow, Garrett Wagner, Jeffrey L. Gilbert, and David Deily of Rockwell International Corp. for **Marshall Space Flight Center**. *For further information,* ***write in 7*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center; (205) 544-0021. Refer to MFS-30028.

Spot-Welding Gun With Pivoting Twin-Collet Assembly

Two electrodes produce two spot welds of improved quality.

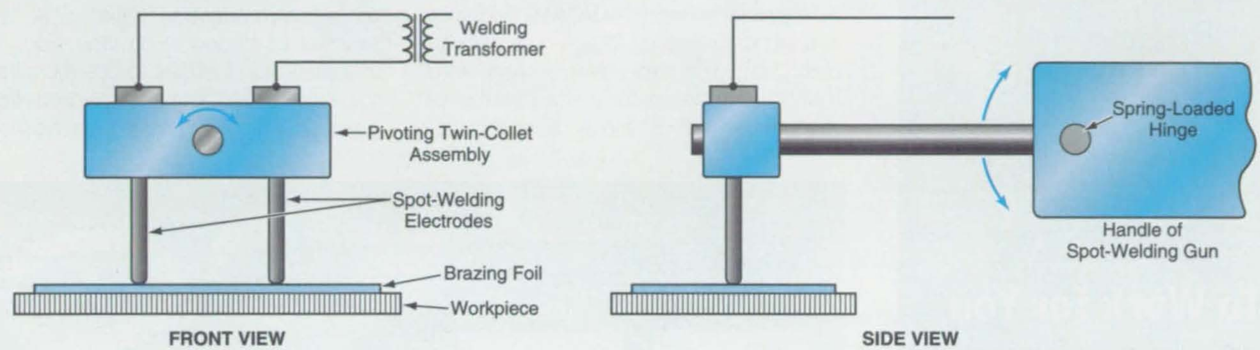
Marshall Space Flight Center, Alabama

A modified spot-welding gun includes a pivoting twin-collet assembly that holds two spot-welding electrodes. The modified spot-welding gun is designed to weld highly conductive (30 percent gold) brazing-alloy foils to thin nickel alloy workpieces; it is also suitable for other spot-welding applications compatible with the two-electrode configuration.

Pivoting of the twin-collet assembly accommodates the curvature of the workpiece and helps to ensure firm contact at the electrodes. The electrodes are connected to opposite terminals of the welding transformer, so that the full welding current flows through both electrodes in series and no additional ground electrode is needed. The quality of spot welds produced by this gun is better than that of welds produced by spot-welding guns of older design that include single welding electrodes surrounded by grounding rings. The improvement in quality has been attributed to consistency of the voltage drops at the two electrodes.

The distance between the collets (and thus the electrodes) can be chosen according to the desired distance between spot welds on the workpiece and to minimize the number of weld impulses needed to complete the spot-welding job. Electrodes with hemispherical tips can be used to increase freedom in positioning the welding gun while maintaining consistent spot-weld quality.

This work was done by Francis Nguyen, Gareth Simpson, and William S. Hoult of Rockwell International Corp. for **Marshall Space Flight Center.** *For further information,* ***write in 82*** *on the TSP Request Card. MFS-30064*



Pivoting of the Twin-Collet Assembly provides for contact between the workpiece and the electrodes, regardless of curvature of the workpiece.

Making Ceramic/Polymer Parts by Extrusion Stereolithography

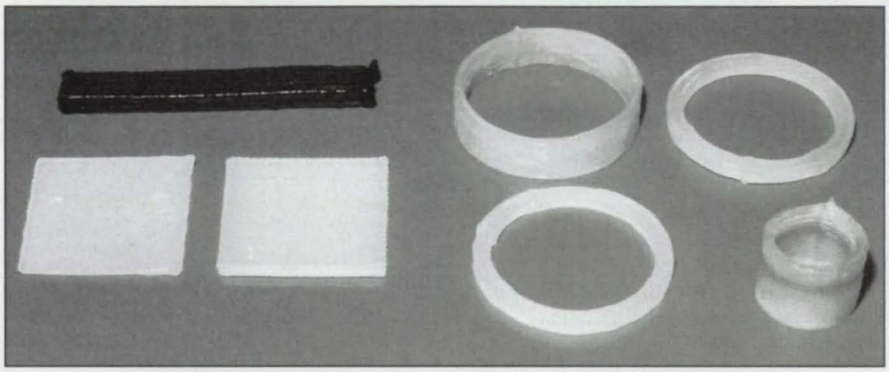
Parts are built up by extrusion of resins reinforced with carbon fiber and silica particles.

Marshall Space Flight Center, Alabama

Extrusion stereolithography is a developmental method of computer-controlled manufacturing of objects out of ceramic/polymer composite materials. Computer-aided design/computer-aided manufacturing (CAD/CAM) software is used to create an image of a desired part and translate the image into motion commands for a combination of mechanisms that move a resin dispenser. The uncured composite material (matrix resin plus reinforcing particles and/or chopped fibers) is extruded from the dispenser through a needle onto a heated platen or onto material that was extruded previously onto the platen. The extrusion is performed in coordination with the motion of the dispenser so that the buildup of extruded material takes on the size and shape of the desired part. The part is thermally cured after deposition.

A prototype extrusion-stereolithographic system includes a resin dispenser in the form of a screw-actuated glass syringe. For accurate volumetric control of extrusion, the plunger of the syringe is actuated by a linear translation stage driven by a stepping motor. The temperature of the heated platen is monitored by a thermocouple attached to the platen. At present, the CAD/CAM software provides for only two-dimensional (horizontal) motion of the dispenser, so that parts can be made with two-dimensional shapes in the horizontal plane, with upward indexing to build up thickness. Eventually, CAD/CAM software for three-dimensional shapes and motions will be used.

One of the resins used in tests of the prototype system was a mixture of urethane acrylate, 1,6-hexanedioldiacrylate, and N-vinylpyrrolidone, with a small amount of azobis-isobutyronitrile as a polymerization initiator. A small amount of fumed silica was added to increase the viscosity to a level suitable for extrusion. Chopped carbon fibers were added to some specimens; chopped glass fibers were added to others. Some specimens included water and tetraethoxysilane (TEOS), which reacts with water (slowly at room temperature, faster when heated with steam) to form silica particles. The figure shows plates and rings made in some of the tests.



These **Plates and Rings** were made by extrusion stereolithography.

This work was performed by Kevin Stuffle, A. Mulligan, P. Creegan, and J. M. Boulton of Advanced Ceramics Research, Inc., and J. L. Lombardi and P. D. Calvert of the University of Arizona for **Marshall Space Flight Center**. *For further information,* ***write in 9*** *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:

Advanced Ceramics Research, Inc.
841 E. 47th Street
Tucson, AZ 85713

Refer to MFS-26270, volume and number of this NASA Tech Briefs *issue, and the page number.*

Chill-Bar Assembly for Cooling Areas Adjacent to Welds

Complexly shaped contact surfaces are made by numerically controlled machining.

Marshall Space Flight Center, Alabama

An assembly of custom-shaped water-cooled chill bars has been developed for use during a repair process in which cracks and pinholes in a rocket-engine combustion chamber are welded closed. Held in the required relative geometric relationships by a rigid framework, the chill bars are pressed against the surface of the chamber to conduct heat away from areas surrounding the welds, preventing damage that would be caused by overheating of areas not meant to be welded. Despite its special purpose, this assembly of chill bars has design features that would be beneficial in other welding applications; for example, the manufacture and repair of pressure vessels, chemical-processing vessels, and complexly shaped laboratory vacuum vessels.

Channels for cooling water are machined into the chill blocks. In the original rocket-engine application, the contact surface of each chill bar must be machined to the complex shape of the chamber surface at the designated location next to a weld. Previously, two chill blocks were used at a time — one on each side of the weld path. Each chill bar was fitted manually and, because of the manual fitting and the complexity of the shape, was limited to a length of 1.5 in. (≈38 mm). Thus, the length of the weld that could be performed with one setup was limited to 1.5 in. (≈38 mm).

The present assembly of chill bars includes a total of 18 chill bars — nine on each side of the weld path, positioned to allow access to the majority of the defects to be welded, with no limit on the length of a weld. Unlike in the previous approach, the chill bars are not fitted by hand. Instead, the contact surface of each chill bar is shaped by numerically controlled machining, using numerical control data from a computer-aided-design mathematical model of the complex chamber surface at the designated location of the chill bar. Then the machined chill bars are installed at their designated locations in the rigid framework, along with small pipe fittings and tubes for the cooling water. Set screws in the rigid framework are used for fine adjustment of the position and orientation of each chill bar to ensure intimate contact with the chamber wall.

This work was done by David S. Hoffman of **Marshall Space Flight Center** *and David C. McFerrin, J. Ben Coby, Jr., Kenneth J. Gangl, and Sidney G. Dawson of Rockwell International Corp. For further information,* ***write in 16*** *on the TSP Request Card. MFS-30022*

Mathematics and Information Sciences

Automated Telerobotic Inspection of Surfaces

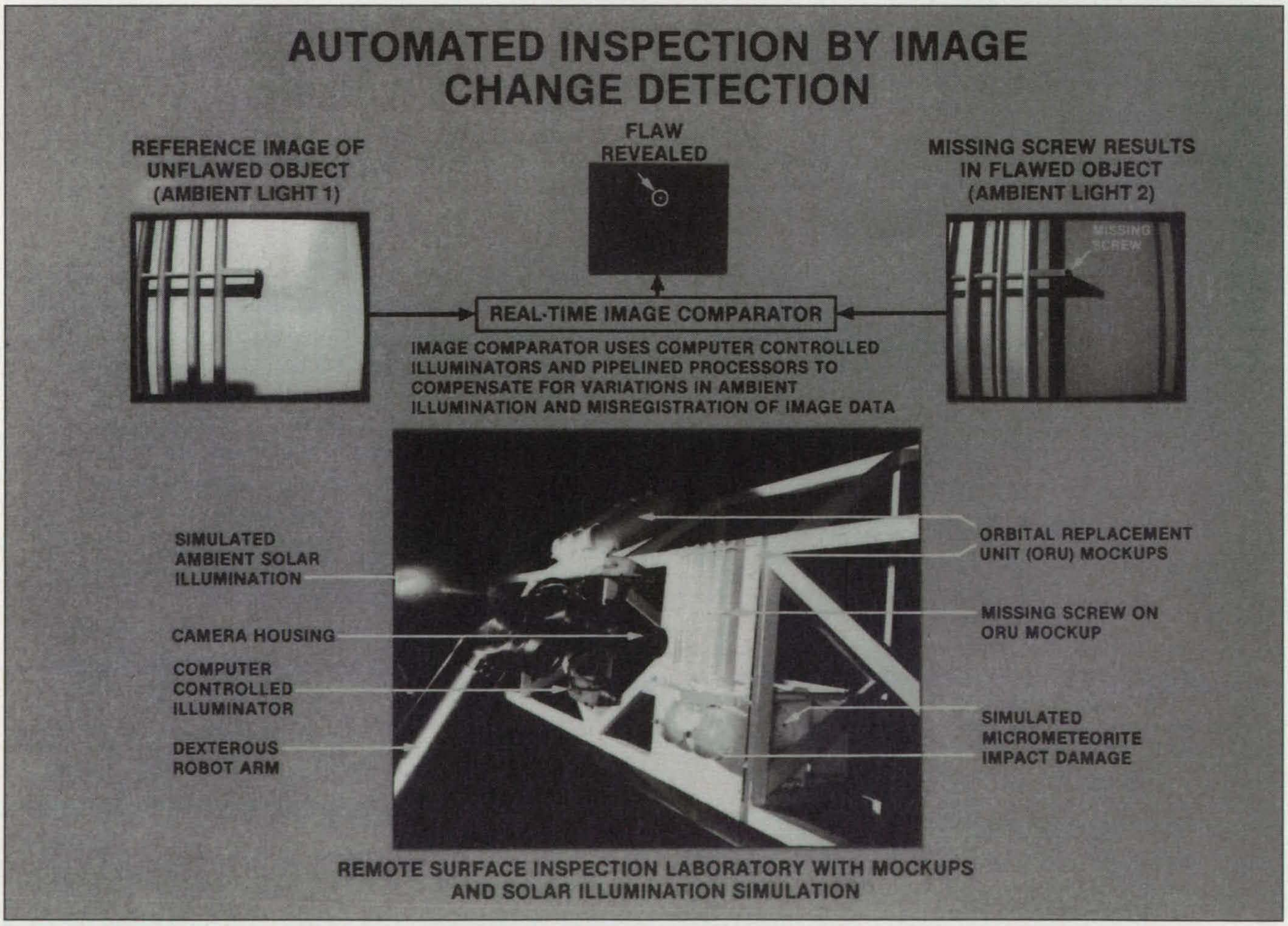
Images of surfaces are compared with reference images to detect flaws.

NASA's Jet Propulsion Laboratory, Pasadena, California

A method of automated telerobotic inspection of surfaces is undergoing development. An apparatus that implemented the method would include a video camera that would be scanned over surfaces to be inspected, in the manner of a mine detector. Image-data-processing circuits in the apparatus would compare selected features of the inspection video images with the corresponding features of reference images taken when the surfaces were new and known to be in good condition; the automated comparison would yield indications of damage and/or deterioration (see figure), which a technician could then inspect visually in more detail.

The method is related to methods of industrial automated visual inspection, but is intended for use under more demanding and less controllable field conditions. It is being developed specifically for inspecting external structures of the Space Station Freedom for damage from micrometeorites and debris from prior artificial satellites; degradation from exposure to monatomic oxygen, solar wind, ultraviolet radiation, and thermal cycling; fluid leaks; and thermal anomalies. On Earth, it might be applied to inspection for damage, missing parts, contamination, and/or corrosion on interior surfaces of pipes or exterior surfaces of bridges, towers, aircraft, and ships, for example.

To be more precise, each of the inspection and reference images mentioned above is a compensated image that consists of the difference between (1) an image made under artificial illumination in the presence of ambient illumination and (2) an image made under ambient illumination only. Subtraction of the ambient-illumination component from the ambient-plus-artificial-illumination image removes effects like variations in shadows and in highlights with the angle of the Sun. What remains after subtraction is the artificial-illumination component image, which is independent of the ambient illumination and thus suitable for comparison with an



Comparison of Inspection and Reference Images reveals a flaw — in this case, a screw missing from a radiator assembly.

image made at a different time under the same ambient illumination.

The optimum scale (sizes of pixels) for analysis of images is selected on the basis of prior knowledge of textures and features of objects to be inspected. The use of an optimum scale minimizes distracting background information and thus maximizes information on flaws. For example, if the task is to inspect a surface for defects about 1 cm in diameter, then presenting an image with a field of view that is too large (of the order of meters) or too small (of the order of micrometers) will not provide information that will help a technician locate flaws.

This work was done by J. Balaram and K. Venkatesh Prasad of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 22*** *on the TSP Request Card. NPO-19067*

Failure-Modes-and-Effects Analysis of Software Logic

A method of rigorous analysis can be applied early in the design effort.

Marshall Space Flight Center, Alabama

A method of identifying potential inadequacies and the modes and effects of failures that would be caused by those inadequacies (failure-modes-and-effects analysis or "FMEA" for short) has been devised for application to software logic. "Software logic" is defined, somewhat loosely, as a conceptual ensemble of logical functions and/or operations that are to be effected by software that is about to be written for use in a computer in a complex automated hardware system like a control or monitoring system for a power plant or large industrial

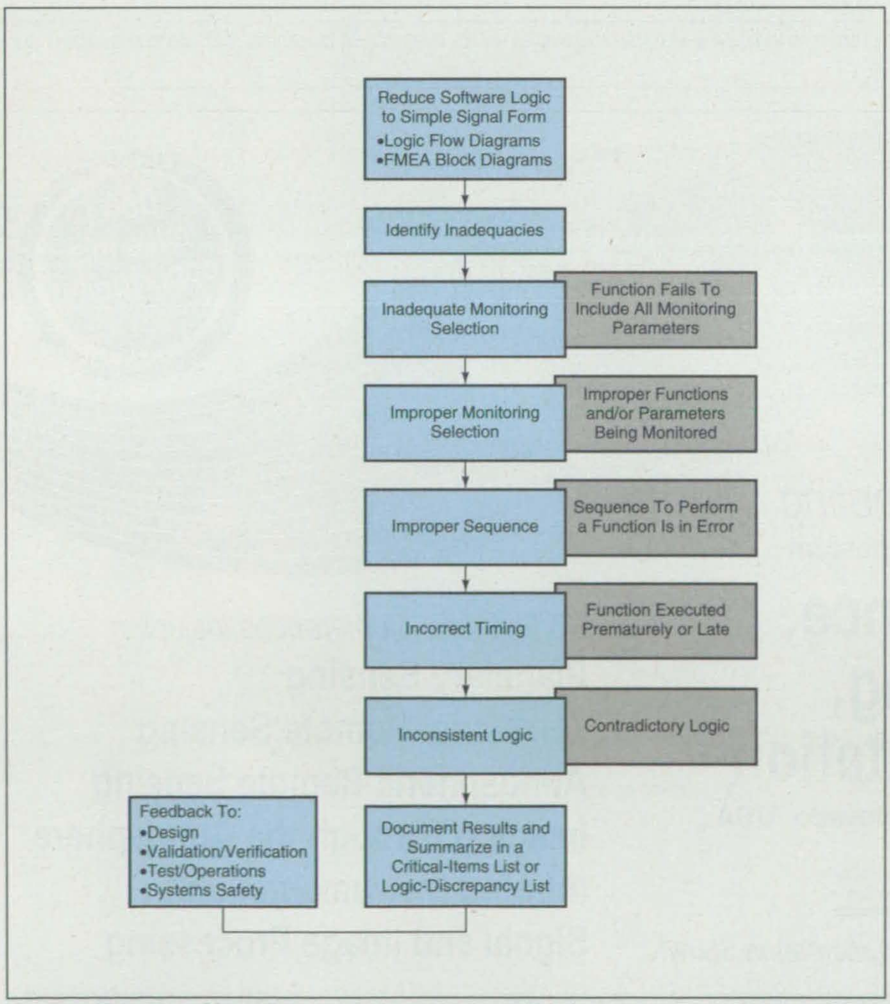


Figure 1. This **Flow Chart** illustrates schematically an FMEA process as applied to software logic by the method described in the text.

facility. Software logic can be represented in a narrative, tabular, and/or graphical form and is used to draw up a specification of requirements upon the software to be written.

Traditionally, reliability engineers perform FMEA on hardware, and software engineers validate and verify the accompanying software through rigorous test procedures. Usually, however, the specification of requirements from which the software is developed is not analyzed as rigorously as is the specification of requirements upon the hardware. In a traditional approach to FMEA, the analyst determines failure modes and then determines the effects.

In the present method, the software is reduced to its lowest level and checked for adequacy (that is, to determine whether the logic was designed correctly). An FMEA of software logic, according to this method, is independent of the analysis of associated hardware and is separate from the process of validation of the software that is ultimately written.

Analysis (see Figure 1) begins with determination of the software-logic functions. The next step is to establish the basic ground rules to be used in conducting the analysis. The analyst then prepares FMEA block diagrams that describe the interrelationships and interdependencies among parts of the software logic. Once the FMEA block diagrams have been completed, a reference system should be developed to enable tracing of the logic throughout the software logic system.

Software-logic flow diagrams (see Figure 2) that depict the structures of the software-logic routines represented in the FMEA block diagrams are then prepared separately from the specification of requirements. The software logic flows are then analyzed for such inadequacies as sequencing, timing, or monitoring er-

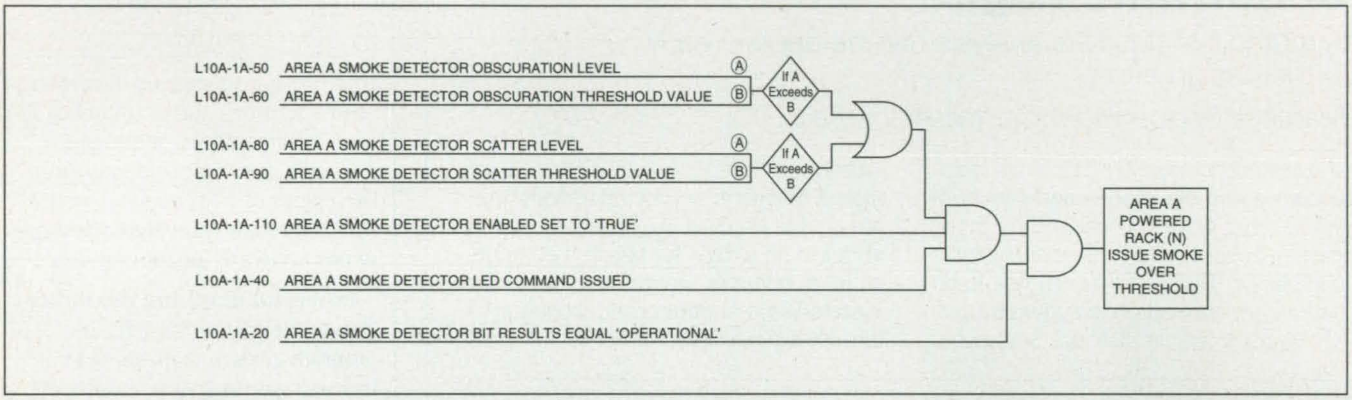


Figure 2. This **Logic Flow Diagram** of part of the software logic of a fire-warning system is an example of diagrams that are constructed during FMEA by this method.

rors, and the results are documented on FMEA worksheets. From the FMEA worksheets, those software logic failures which have the most adverse effect on mission/personnel safety or performance are compiled into a critical-items list (CIL) to highlight their importance.

This work was done by Danny Garcia, Thomas Hartline, Terry Minor, David Statum, and David Vice of **Marshall Space Flight Center**. *For further information,* ***write in 41*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center; (205) 544-0021. Refer to MFS-28856.

Detecting Faults in Helicopter Gearboxes by the MVIM Method

This method shows promise for reliable automated detection of faults, without false alarms.

Lewis Research Center, Cleveland, Ohio

Preliminary experiments have shown that the multivalued influence-matrix (MVIM) method has potential utility as the theoretical basis of proposed automated monitoring systems that would detect faults in helicopter gearboxes. The MVIM is a pattern-classification method that, in this case, would be applied to recognize patterns in vibration measurements. A fault-recognition system of the type in question would be required to operate continuously while a helicopter was airborne, analyzing measurements of vibrations for signs of trouble so as to provide real-time warning of any dangerous or potentially dangerous fault like a cracked case or a fractured gear tooth. The system would also be required not to give false alarms, so as to prevent unnecessary emergency landings.

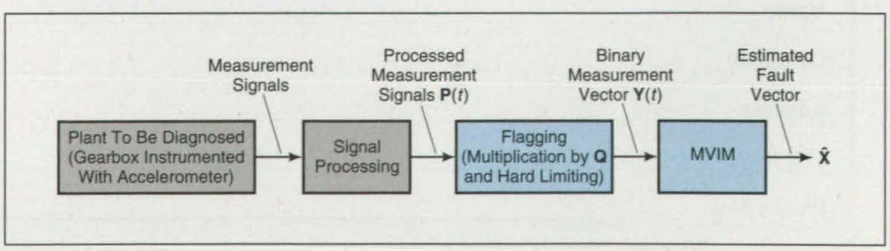
The MVIM method (see figure) involves two matrices that effect various operations on an m-dimensional column vector, $\mathbf{P}(t)$, that represents a set of m processed measurements at time t. The first matrix is the $m \times m$ quantization matrix, $\mathbf{Q} = [\mathbf{W}_1, \mathbf{W}_2, ...\mathbf{W}_i, ...\mathbf{W}_m]$, where $\mathbf{W}_i$ is an m-dimensional weighting column vector. $\mathbf{Q}$ is used to "flag" the processed measurements, converting them to a binary column vector, $\mathbf{Y}(t) = \{y_1(t), y_2(t), ...y_i(t), ...y_m(t)\}^T$, by weighted summing followed by hard limiting; namely, $y_i(t) = 1$ when $\mathbf{P}^T(t)\mathbf{W}_i \geq 1/2$ and $y_i(t) = 0$ when $\mathbf{P}^T(t)\mathbf{W} < 1/2$.

The second matrix is the multivalued influence matrix, $\mathbf{A}$, which is an $m \times 2$ matrix that expresses the relationship between $\mathbf{Y}$ and a two-dimensional fault vector, $\mathbf{X}(t) = \{x_1(t), x_2(t)\}^T$. Here, $x_1(t)$ and $x_2(t)$ are the no-fault variable and the fault variable, respectively. When the fault-detection system is operating correctly, each of these variables must be either 0 or 1 (and the other one must be 1 or 0, respectively), depending on the status of the measurement and the presence or absence of a fault at time t.

In a manner somewhat reminiscent of a neural network, the system must be trained to produce these results, using measurements taken under known representative fault and no-fault conditions. Initially, $\mathbf{Q}$ and $\mathbf{A}$ are guessed; thereafter, $\mathbf{Q}$ and $\mathbf{A}$ are adjusted by use of fault-detection-error feedback after exposure to each training example in which a fault occurs or a flag is posted in the absence of a fault. The adjustment is effected by use of a recursive estimation algorithm that strives to minimize the sum of the squared detection error.

In a demonstration and test of this method, processed vibration measurements from a helicopter main-rotor gearbox were collected during normal operation and in the presence of various known faults. The results of the test indicate that a system based on the MVIM method can detect faults perfectly when trained with the full range of fault effects and the measurement signals are appropriately processed. The results also indicate that an MVIM-based system detects faults better than does a back-propagation-learning artificial neural network trained and tested on the same data. The MVIM method can also be used to rank measurement signals from different sensors with respect to significance for detection of faults, making it possible to select an optimal subset of sensors; this could be particularly valuable in reducing processing time to enable real-time detection of faults.

This work was done by Hsinyung Chin and Kourosh Danai of the University of Massachusetts at Amherst and David G. Lewicki of the Propulsion Directorate of the U. S. Army Research Laboratory for **Lewis Research Center**. *For further information,* ***write in 65*** *on the TSP Request Card. LEW-16089*



A **Fault-Detection System Based on the MVIM Method** would be installed in a helicopter to process measurements of vibrations in the main-rotor gearbox into indications of faults.

Devices Would Detect Drugs in Sweat

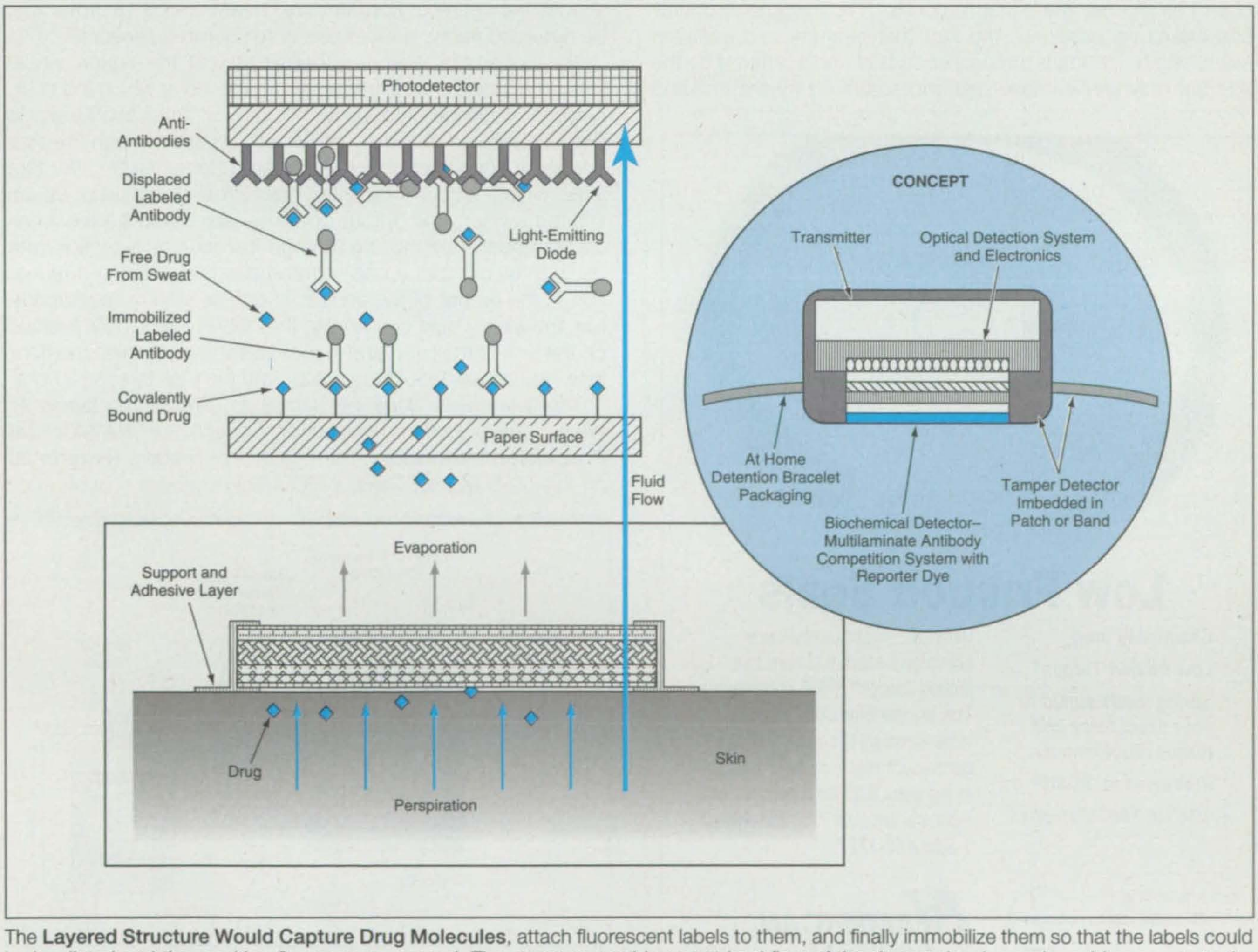
The device would telemeter its assay to a monitoring station in real time.

NASA's Jet Propulsion Laboratory, Pasadena, California

Proposed devices that would be worn on the skin would detect such substances as methamphetamine, morphine, tetrahydrocannabinol (THC), and cocaine in wearers' sweat and transmit radio signals in response to computer queries. Such a device, called a Remote Biochemical Assay Telemetering System (R-BATS), commonly referred to as a "drug badge," could be attached to the wearer by use of an adhesive wristband, for example. Drug badges were conceived for use in monitoring convicted drug users on probation; a drug badge would alert enforcement officers when the wearer injected, ingested, or inhaled a forbidden substance. On a broader scale, drug badges could be used for noninvasive monitoring of levels of prescribed medications in hospital and home-care settings and to detect overdoses quickly.

The principle of operation exploits the fact that most of the popular illegal drugs are eliminated from the body in significant amounts via the sweat glands. In a drug badge, sweat would be absorbed through a semipermeable membrane (see figure). Only small molecules like those of drugs, water, and salt could pass through the membrane; large molecules and bacteria would be excluded.

The drug badge would function by means of antigen/antibody interactions: On the inner side of the membrane, there would be a layer of paper in which a solid-state version of the drug would be loosely immobilized by covalent bonding. The antibodies would be labeled by fluorescent dye and would initially be held loosely immobilized in this layer by an antigen/antibody interaction. The free drug molecules that enter through the semipermeable membrane would competitively bond to the labeled



The **Layered Structure Would Capture Drug Molecules**, attach fluorescent labels to them, and finally immobilize them so that the labels could be irradiated and the resulting fluorescence sensed. The structure would prevent backflow of the drug molecules and would concentrate the labeled drug in a small volume, where the fluorescence could be detected readily.

antibodies, which would thereby be freed and would migrate through a layer of superabsorbent polymer, driven by transpiration. The migrating labeled antibodies would eventually reach another layer of polymer, wherein they would be trapped by an anti-antibodies layer.

A light-emitting diode (LED) illuminates the polymer layer containing the antibodies at a wavelength of 595 nm, causing any labeled antibodies trapped there to fluoresce at a wavelength of 615 nm. A photodetector shielded by a 615-nm band-pass interference filter would sense the fluorescence and produce an electrical signal that could be integrated over time, indicating the presence of the drug. The signal would be transmitted by a small radio transmitter in the badge, alerting a remote monitoring station.

The LED could be pulsed to reduce the influence of ambient light and thereby reduce the incidence of false alarms. An array of photodetectors could be used instead of only one to detect multiple drugs, and several could be required to put out signals before the transmitter could be triggered. A unique transmission code would be assigned to each badge so that the badge and its wearer could be identified as the source of its alarm signal.

This work was done by Fredrick W. Mintz, Gil Richards, David A. Kidwell, Conrad Foster, Roger G. Kern, and Gregory A. Nelson of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 71*** *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-19130, volume and number of this NASA Tech Briefs *issue, and the page number.*

Cherry-Slush-Candling Apparatus

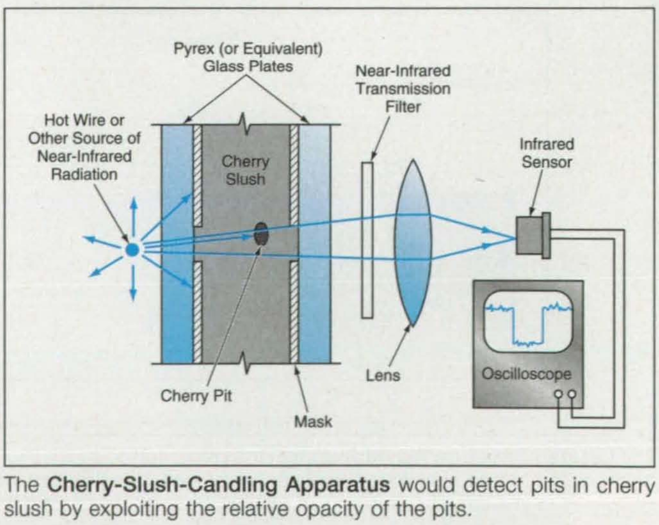
Cherry pits would be detected via their relative opacity to infrared radiation.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed infrared-scanning apparatus for use in bakeries that make cherry pies would detect cherry pits that remain in cherry slush after the pitting process. The principle of operation would be based on the fact that near-infrared radiation (wavelength ≈ 1 μm) is strongly absorbed and scattered by the pits but only weakly absorbed and scattered by the crushed cherry flesh and juice that constitute the slush; that is to say, in the near infrared, the pits are opaque while the slush is almost transparent. Furthermore, near-infrared photons can be detected easily, without use of refrigerated sensors.

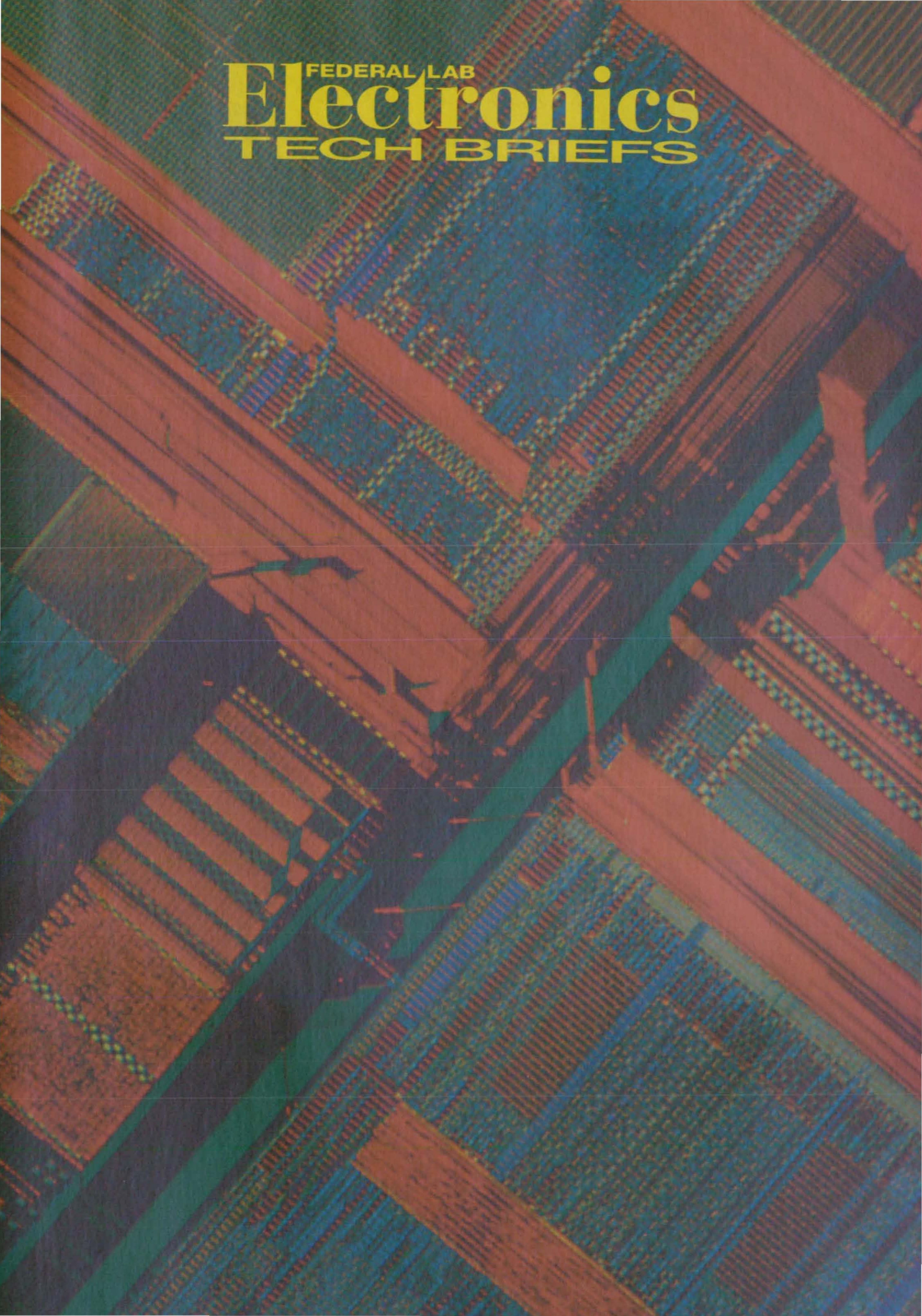
The apparatus, shown schematically in the figure, would include a near-infrared-transparent pipe along which the cherry slush would be pumped. A hot wire or other source would produce infrared radiation, which would pass through the pipe and slush, then through a near-infrared transmission filter to a lens, which would focus the near-infrared radiation on an infrared sensor. The output of the sensor would be fed to an oscilloscope. A pit moving through the source-to-sensor optical path would cast a near-infrared shadow, causing a reduction in the output of the sensor. In one version of the apparatus, the pipe would be annular, the hot wire would be located on the axis of the pipe, and a subassembly containing the filter, lens, and sensor would revolve around the pipe to scan for pits.

This work was done by James B. Stephens, James R. Weiss, and Gordon Hoover of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 20*** *on the TSP Request Card. NPO-18721*



The **Cherry-Slush-Candling Apparatus** would detect pits in cherry slush by exploiting the relative opacity of the pits.

FEDERAL LAB Electronics TECH BRIEFS



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Federal Lab Electronic Tech Briefs Supplement to *NASA Tech Briefs* May 1996 Issue Published by Associated Business Publications

ELECTRONIC TECH BRIEFS

DEPARTMENTS

On the cover:

Photomicrograph illustrating surface features of the new MIPS Technologies R10000 microprocessor taken with a prototype Nikon 2.5X DIC objective, courtesy of Michael W. Davidson, National High Magnetic Field Laboratory, the Florida State University. Silicon Graphics is using the new microprocessor in a variety of its products (see "News Briefs"). © 1995 M.W. Davidson.

NEWS BRIEFS

News of the Industry and Federal Laboratories

Silicon Graphics Inc. (Mountain View, CA) and Cray Research Inc. (Eagan, MN) announced that they had agreed to merge. Silicon Graphics (SGI) made a cash tender offer of $30 a share for approximately 75 percent of Cray's outstanding shares of common stock, and following completion of the offer will convert the remaining shares to SGI stock one-to-one. The offer is subject to the tender of at least 51 percent of Cray shares and to customary conditions, including government approvals. The firms have a combined revenue run rate of almost $4 billion.

The companies say the merger will bring together SGI's commitment to scalable, deployable supercomputing and 3D visualization and Cray's global leadership in large-scale supercomputing for the scientific and engineering community. SGI Chairman and Chief Executive Officer Edward R. McCracken commented, "The acquisition of Cray will be instrumental in expanding our scalable architecture from high-volume, low- cost desktops to teraflops, while retaining the unequaled brand equity established by Cray as the worldwide gold standard for supercomputing solutions." In November, Cray announced its T3E™, which it calls the world's first truly scalable supercomputer, scheduled to begin shipping in the third quarter of this year. As of year-end 1995, the company had logged more than $160 million in advance orders for the system.

In January, SGI announced new products ranging from visualization supercomputers to desktop workstation and server families powered by the new MIPS® R10000™ and MIPS R5000™ microprocessors from MIPS Technologies Inc. It also said that IRIX™6.2, its third-generation 64-bit operating system, will be available across the entire product line.

James M. Winget, SGI chief scientist for research and development, who will head a team to harmonize the companies' product lines, said that a "software compatibility layer" for all products was the "first priority." He also remarked on the "synergy" of the combination of the two firms, pointing to the similarity in their "fundamental architectures and strategies for the high-performance high-bandwidth computers of the future."

National Instruments (Austin, TX) announced that it would acquire Georgetown Systems Inc. (Georgetown, TX), the privately held manufacturer of Lookout™, an industrial automation software package for Windows PC. Dr. James Truchard, president and chief executive officer of National Instruments, said, "Joining our family of software for data acquisition, measurement, and instrumentation, Lookout gives us a man-machine interface software product designed specifically for the industrial automation market." Scientists and engineers worldwide use National Instruments PC and workstation software and hardware to build virtual instrumentation systems for automated testing, factory automation, physiological monitoring, and data visualization.

A new consortium formed in March by leading U.S. electronics firms and several government agencies, including the National Institute of Standards and Technology (Boulder, CO) and the Advanced Research Projects Agency (Washington, DC), aims to advance the sustained growth and competitiveness of American electronics manufacturers and suppliers in the global marketplace. The National Electronics Manufacturers Initiative, the membership of which includes Motorola, Texas Instruments, Dow Chemical, DuPont Electronics, and more than a dozen other firms, will focus on five manufacturing areas: interconnection substrates, board assembly, final assembly, flip-chip packaging, and energy storage systems. NIST will host a NEMI Technology Roadmap Workshop for the 16 Technology Working Groups at its Boulder laboratory next month. Representatives of industry wanting more information about NEMI should contact Robert J. Klaiber at (703) 351-8532.

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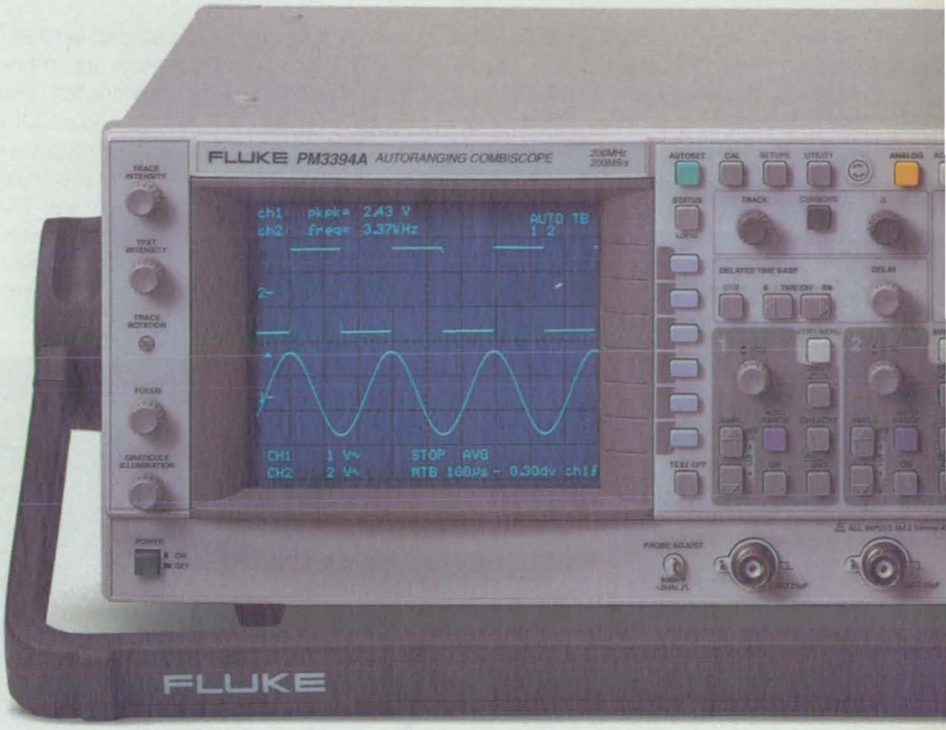

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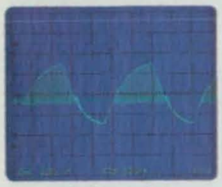
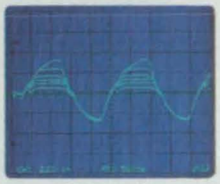


Analog mode



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Resonant Snubber Inverter (RSI) Improves Efficiency

Electric cars, adjustable-speed motors, heat pumps, fans, and compressors may benefit from a new electric power inverter.

Oak Ridge National Laboratory, Oak Ridge, Tennessee

A new electric power inverter, the Resonant Snubber Inverter (RSI), offers improved efficiency and reliability, and greatly reduced electromagnetic interference, compared with conventional power inverters. In addition, the RSI is smaller and lighter, and potentially lowers the cost of electric power inverters. Inverters, used with many electric devices and motors, convert available power to the type needed, such as direct current to alternating current.

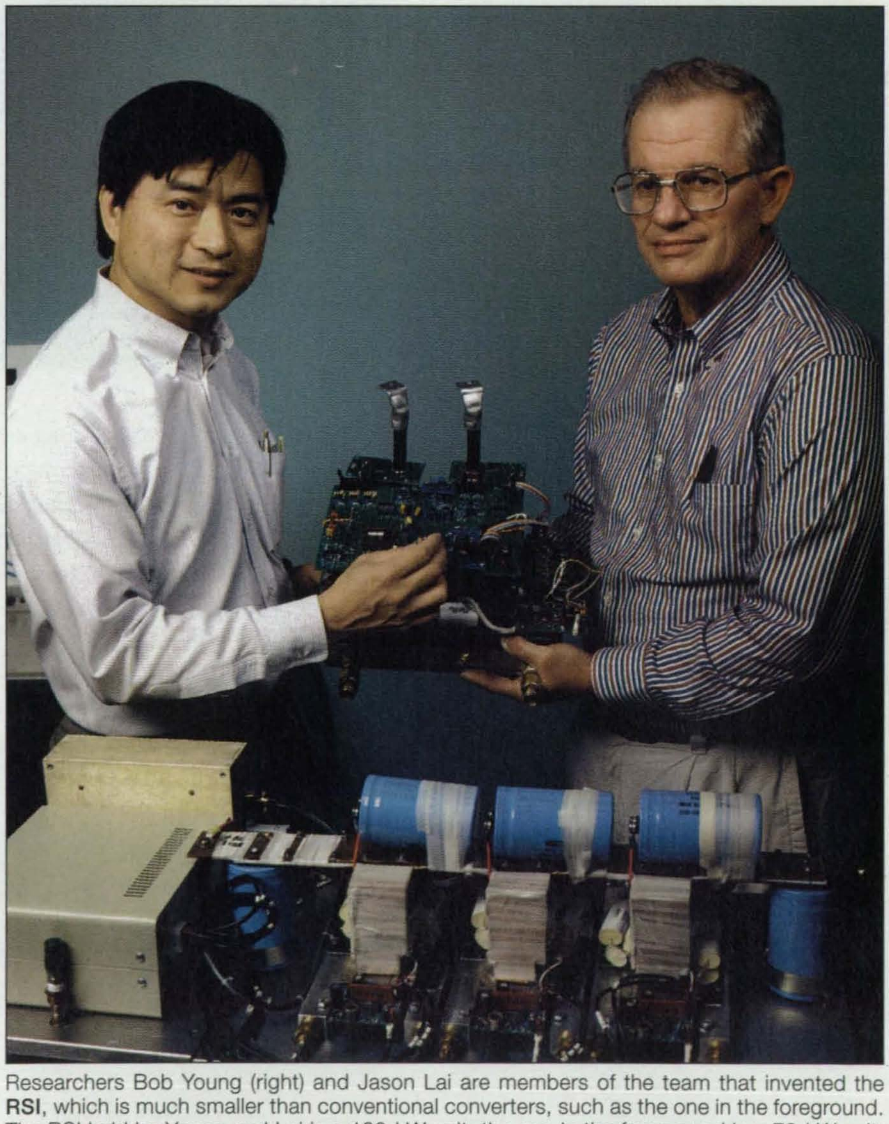
The RSI is about 80 percent efficient at low speeds and 98 percent at high speeds. Conventional inverters are about 60-70 percent efficient at low speeds and 94 percent at high speeds. Efficiency gains of that magnitude—especially at the lower speeds typical of its use in a car—could help electric vehicles become a viable option.

To perform their function, inverters employ a series of switches and electronic components. A conventional electric power inverter consists of six power semiconductor switches that turn on or off about 20,000 times per second in different combinations to provide the desired output. The inverter switch turns on and off at full voltage and current, generating a huge, wasteful power spike. This type of "hard switching" is an effective way of obtaining a specific current; however, this circuit design causes many problems.

While the conventional inverter uses six switches to achieve a desired output, the RSI adds three small auxiliary switches that temporarily—and very briefly—divert current, then route it back to one of the six main switches. This diversion, which lasts only a couple of microseconds, produces a zero voltage across the switch and helps reduce damaging power spikes. It also enables the RSI's soft switching to increase efficiency from 4 to 15 percentage points compared to a conventional inverter. The efficiency gain is dependent on the speed of the motor connected to the inverter. Greatest efficiency gains occur when the motor is run at less than full speed, typical of an inverter's function in an electric vehicle.

While gains in efficiency are important, the RSI virtually eliminates EMI. Tests using an oscilloscope show EMI is greatly reduced compared to conventional hard-switching inverters and previously developed soft-switching inverters. EMI can interfere with functions of appliances, telephones, electronic instruments, television reception, and other electronic equipment, such as computer-controlled ignition in automobiles. In addition to EMI caused by hard switching, conventional inverters put considerable stress on silicon devices and other parts within the inverter, causing reliability problems.

Another benefit of the RSI is that it reduces voltage and current stress to inverter components. This improves the reliability and allows lower-cost power devices to be used. Because the RSI smoothly (or softly) changes the voltage



Researchers Bob Young (right) and Jason Lai are members of the team that invented the **RSI**, which is much smaller than conventional converters, such as the one in the foreground. The RSI held by Young and Lai is a 100-kW unit; the one in the foreground is a 70-kW unit.

and current during device switching, it can also help reduce the possibility of motor failure caused by insulation breakdown and bearing overheating. Soft switching also reduces operating temperature, reducing the need for large, heavy heat sinks. Instead, the RSI can use smaller, lighter, less expensive heat sinks. Excessive heat degrades electronic equipment and causes failures.

The latest 100-kW three-phase RSI is compact, measuring 9 × 12 × 26 inches and weighing 20 pounds. Hard-switching inverters from several years ago were bulky and weighed several hundred pounds. Even newer state-of-the-art inverters weigh two to three times as much as the RSI.

The advanced RSI is being incorporated into an advanced air conditioner to be installed on electric buses, including one in Chattanooga in 1997. The unit is the product of advanced electric motor technology and a cooperative research and development agreement partner's new air-conditioner technology. Installation of the unit is expected to eliminate the need for an auxiliary power unit required for the bus's air conditioner. These auxiliary units are currently powered by propane, which results in emissions, noise, and added weight and cost.

In addition to the use in electric vehicles, another likely application for the RSI is in heat pumps. Using the RSI and fans that run continuously, comfort levels and efficiency levels could be increased.

This work was done by Jason Lai, Robert Young Sr., Matt Scudiere, John McKeever, George Ott, Cliff White, and University of Tennessee coinventors Daoshen Chen and Fang Z. Peng. All are members of the Engineering Technology Division's Digital and Power Electronics Group of the **Oak Ridge National Laboratory**, *which is led by Don Adams. ORNL is managed by Lockheed Martin Energy Research Corp. for the U.S. Dept. of Energy.*

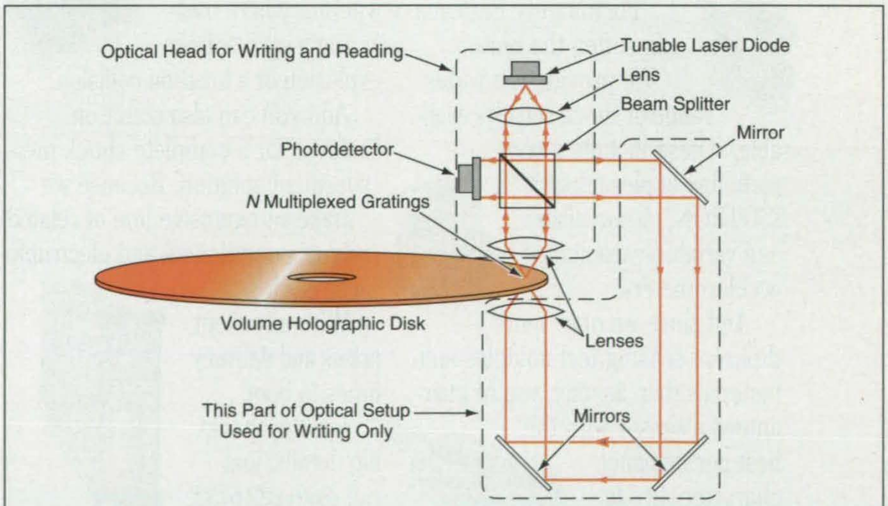
Inquiries concerning rights for the commercial use of this invention should be addressed to Don Adams, Manager, Digital and Power Electronics Group, ORNL, PO Box 2009, Bldg. 9401-2, MS 8058, Oak Ridge, TN 37831; (423) 576-0260; FAX: (423) 241-6124.

Holographic Compact Disk Read-Only Memories

Wavelength multiplexing would increase the data-storage density.

NASA's Jet Propulsion Laboratory, Pasadena, California

Compact disk read-only memories (CD-ROMs) of a proposed type would store digital data in volume holograms instead of in the surface differentially reflective elements (pits and lands) of currently available CD-ROMs. The data-storage density of the proposed memories could be made an order of magni-



A **Holographic CD-ROM**, shown here in writing configuration, would consist largely of parts similar to those used in conventional CD-ROMs. However, a holographic CD-ROM would achieve 10 or more times the data-storage capacity and throughput by use of a wavelength-multiplexing/volume-hologram scheme.

tude greater than the bit density of currently available CD-ROMs. The designs of the proposed memories would take advantage of the mature state of CD-ROM technology; in many respects, conventional CD-ROM designs could be adapted to the holographic-CD-ROM concept with minor modifications.

Conventional compact disks would be replaced by volume-hologram disks of the same diameter but with thicknesses of about 2 mm. Each reflection element (pit or land) on the surface of a conventional compact disk would be replaced by a reflection-grating element (a volume hologram) — one such element for each bit. The projection of each such element on the surface of the disk would be of the same size (about 1 μm wide) as that of a reflection element on a conventional compact disk; this size is also about equal to the diameter of the spot to which light from a laser diode is focused onto the disk to read out the data by measurement of variations in reflectance.

As described thus far, a holographic CD-ROM would store the same number of data as does a conventional CD-ROM. To increase the storage density beyond that of the conventional CD-ROM, wavelength multiplexing would be used. Because of the wavelength selectivity of Bragg diffraction, each grating would reflect primarily at one wavelength, and so the bit stored in the grating would be read out by measuring light reflected from it at that wavelength. Additional bits would be stored in other volume holograms formed at the same location at different wavelengths and read out accordingly at those wavelengths.

The readout light would be supplied by an injection-current-tunable laser diode of about the same size as that of the fixed-wavelength laser diodes used in conventional CD-ROMs. The injection current would be varied repeatedly to scan the range of wavelengths at which bits were stored; because the rate of this scan could easily be made greater than the throughput rate of conventional CD-ROM drives, all the wavelengths could be scanned before the drive mechanism moved the optical head and/or disk to the next readout position on the disk.

As a result, a memory of the proposed type would contain N times as many data as does a conventional CD-ROM (where N is the number of wavelengths used) and would be N times as fast. A preliminary estimate suggests that N could exceed 10 for a disk thickness of 2 mm, wavelength range of 2 nm, and crosstalk ratio of 1/10. Because the proposed improvements would be achieved with an optical head and drive mechanism similar to those of a conventional CD-ROM drive, mass production should not present any major problems.

The figure schematically illustrates the optical layout for recording. For this purpose, the disk would have to be made of a photopolymer or other suitable material in which volume holograms can be formed. Light emitted from a tunable laser diode would first be collimated by a lens or lenses. The collimated beam of light would be directed into a beam splitter, which would divide it into two beams; (1) a transmitted beam that would be focused into the designated storage spot from the top side of the disk, and (2) a reflected beam that would be focused into the same designated storage spot from the bottom side of the disk.

Within the overlapping focal spots, the two beams would interfere with each other, forming an interference pattern that could subsequently be fixed within the material to make the desired hologram. In this manner, a datum would be recorded at each of the N wavelengths at each position.

Most of the same optical setup could be used for readout, except that one would measure the reflectance of each wavelength grating from the top side

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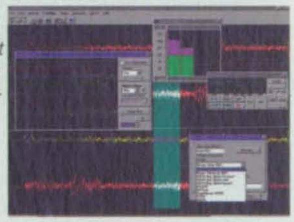

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only; the beam incident from underneath the disk would not be needed. Thus, in a CD-ROM optical head devoted to read-out only, the three mirrors and the lens underneath the disk could be eliminated.

This work was done by Tsuen-Hsi Liu of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 49*** *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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JPL-301-350
4800 Oak Grove Drive
Pasadena, CA 91109

Refer to NPO-19295, volume and number of this NASA Tech Briefs *issue,* Electronic Tech Briefs *supplement, and the page number.*

Microfabricated Field-Emission Electron Source

A new vertically oriented thin-film-edge field emitter promises unprecedented scalability, stability, area uniformity, and inexpensive manufacturing.

Naval Research Laboratory, Washington, D.C.

Field-emitter arrays (FEAs) are microfabricated cold electron sources. They consist of an array of cells each of which contains one or more field emitters with its own integrated extraction electrode. FEA field emitters are extremely sharp, usually having a radius of curvature less than 100 angstroms.

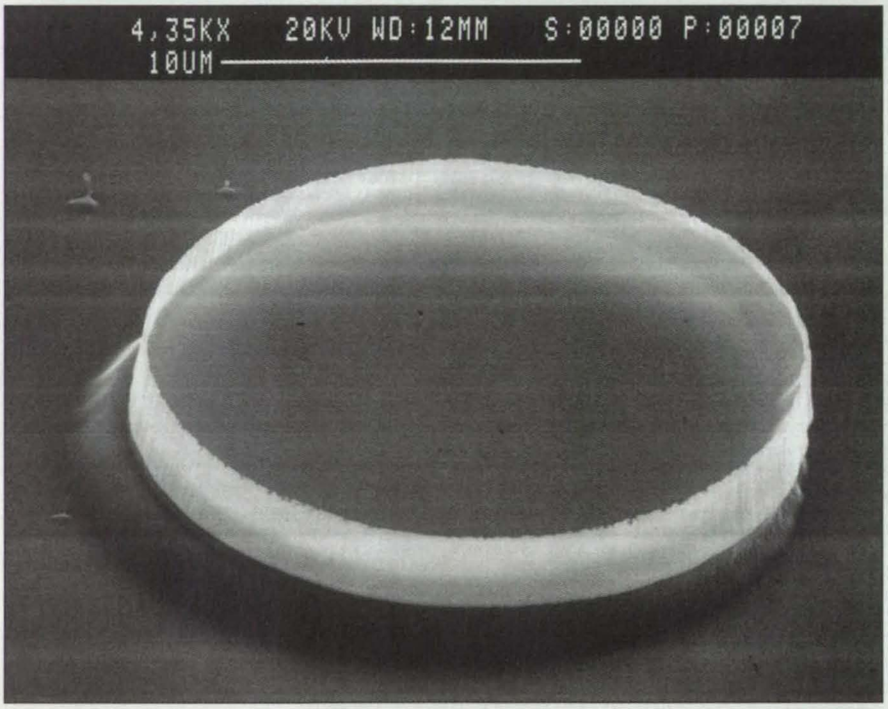
The usual fabrication processes for these sharp nanostructures are very complex and hard to control, and require expensive fabrication equipment. Furthermore, the field-emitter material is either expensive or forms large grains that do not permit uniformly small radii of curvature, resulting in gross nonuniform electron emission. These structures also blunt with age, due to ion bombardment.

The Naval Research Laboratory's Electronics Science and Technology Division has developed a new process that eliminates these problems. In addition, the fabrication process is easy to implement and very inexpensive. This new structure should be useful for field-emitter displays, high-voltage switches and rectifiers, millimeter-wave amplifiers, ionization sources, electrostatic protection devices, electronic document and photographic printing, new light sources including blue lasers and backlights for LCDs, multielectron E-beam lithography, and radiation-hard and temperature-insensitive electronics.

Most FEAs have field emitters that look like sharpened pencil points, *i.e.*, a conical or pyramidal shape. They are made with expensive E-beam deposition and other state-of-the-art microelectronics fabrication equipment.

Furthermore, because the structures are so small, below the optical limit of the human eye, it is very difficult to get area uniformity in the electron emission. And ion bombardment blunts the field-emitter tips, resulting in ever-decreasing electron current.

By using a vertically oriented edge of a very thin film of metal, the NRL team created a field emitter with the same radius of curvature as the classical point-like emitter, but with a much larger emitting area. The structures are made by chemical beam deposition (CBD), a very low-pressure variant of chemical vapor deposition. CBD results in extremely small grains, smaller than the required 100-angstrom radius of curvature. It also has an excellent conformal deposition character, so that the team was able to use almost any template to make the film, *e.g.*, inexpensive stamping processes used to make molds for audio CDs.



Shown is a scanning electron micrograph of an ungated cylindrical vertical **Thin-Film-Edge Platinum Field Emitter**, having a height of 2 micrometers, a diameter of 10 micrometers, and a wall approximately 100 nanometers thick, situated on top of a silicon substrate. Its jagged top edge has many sharp points with radii of less than 10 nm that can act as electron field-emission sources.

Cathodoluminescence produced by field-emitted electrons on a ZnO-Zn phosphor plate from an array of platinum vertical thin-film-edge emitters, one of which is shown in the other figure. Each bright spot is produced by electrons from a single emitter.

The same CBD process can be used to deposit both metals and insulators sequentially, resulting in the possibility of closely spaced, self-aligned low-voltage FEAs. Emitting films consisting of a low-work-function metal sandwiched between two thin films of a high-work and oxidation-resistant metal have also been made and characterized. These films exhibited a significant improvement in emission performance and stability. Because of the thin-film-edge nature of the emitter, when the emitting surface is ion-bombarded as it ages, the new surface will have the same radius of curvature and work function as the original. This should result in long-term stability and lifetime. The vertical orientation of the emitting edge with its associated self-aligned symmetric extraction electrode allows tight focusing of the electron beam. The CBD process has no fundamental limit on scalability and can be adapted for a very wide assortment of conductor and insulating films.

This work was done by Dr. David S.Y. Hsu, Chemistry Division (202-767-2742) and Dr. Henry F. Gray, Electronics Science and Technology Division (202-767-2812; FAX 202-767-0546) at the **Naval Research Laboratory.** *Inquiries concerning rights for the commercial use of this invention should be addressed to Dr. Richard H. Rein, Head, Technology Transfer Office of the Naval Research Laboratory, 4555 Overlook Ave. SW, Washington, D.C. 20375-5320; (202) 767-3744.*

Spectrum-Sharing Scheme for Two BPSK Systems

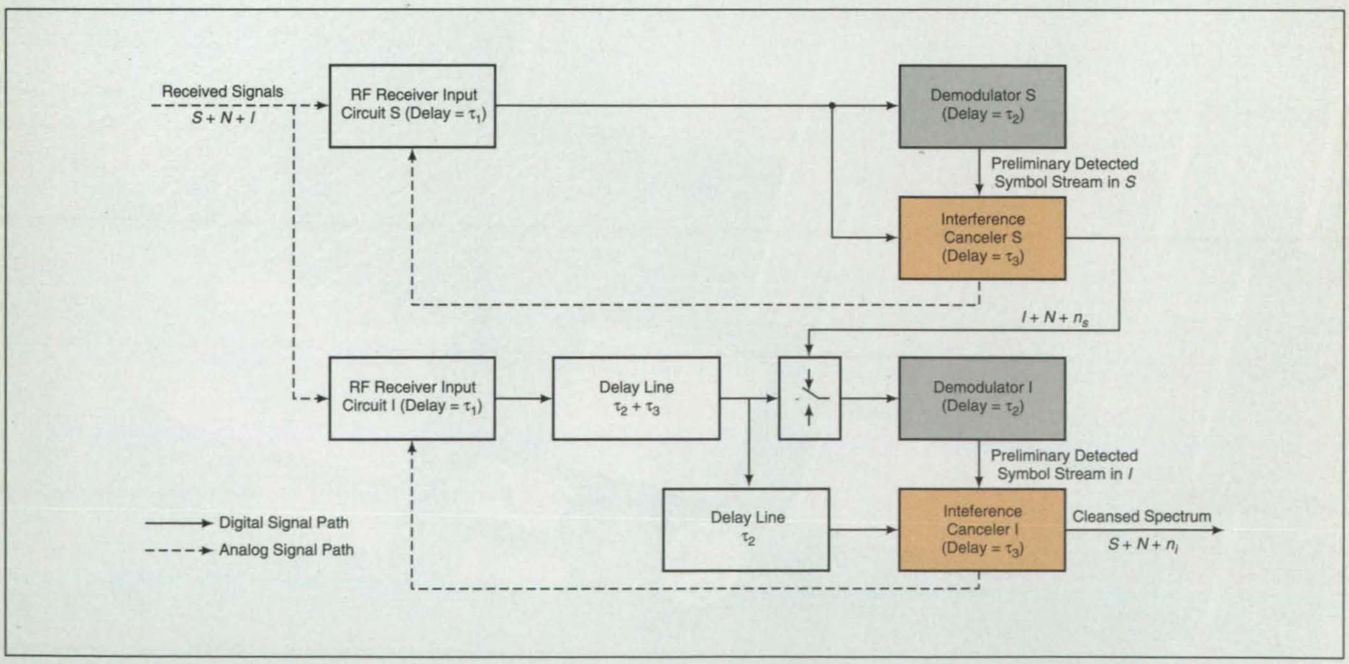
The spectrum of the undesired signal would be estimated and subtracted from the total received spectrum.

NASA's Jet Propulsion Laboratory, Pasadena, California

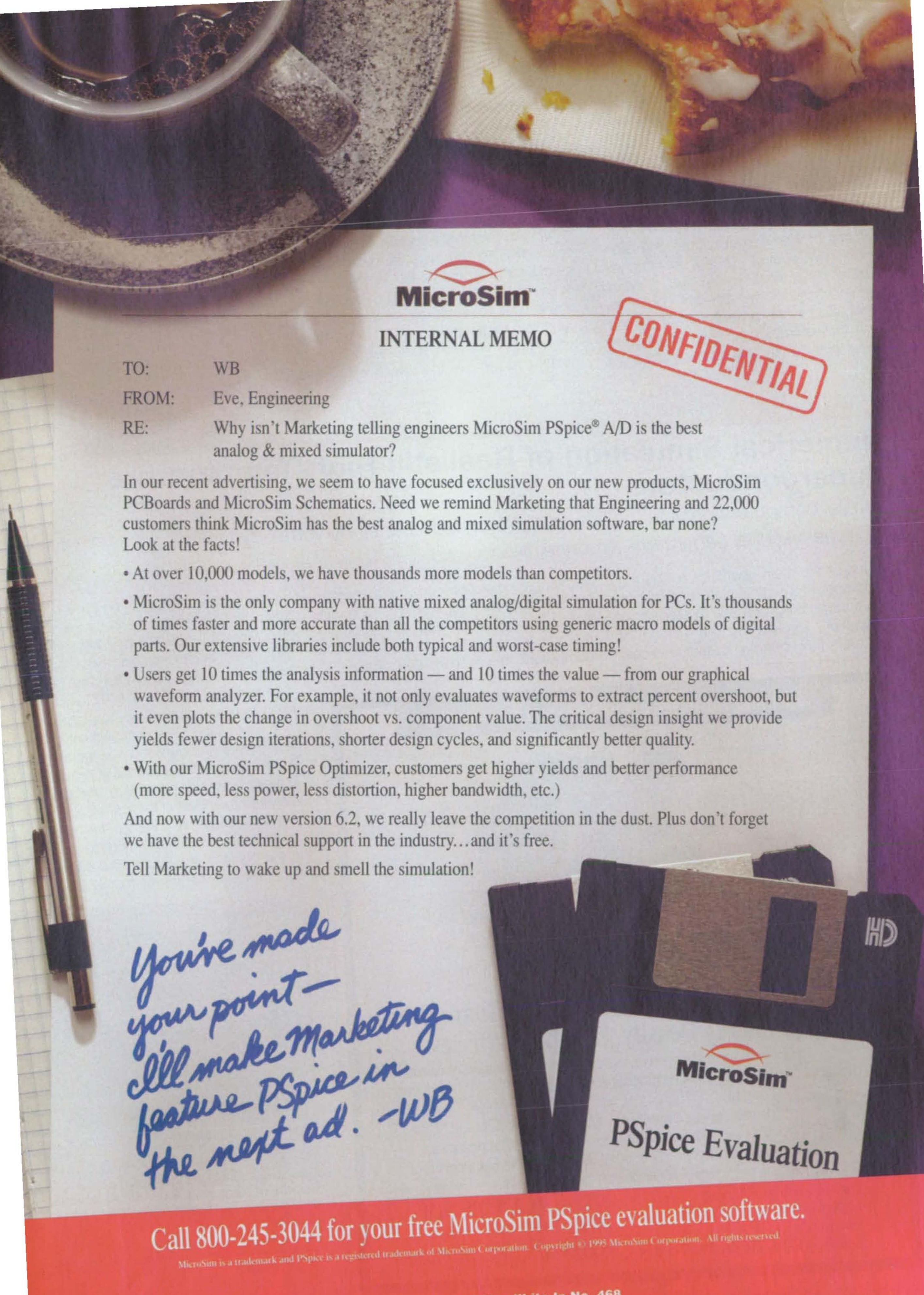
A scheme has been proposed to enable two binary-phase-shift-keyed (BPSK) radio-communication systems to operate simultaneously in the same frequency band. More specifically, the scheme applies to two received BPSK signals that convey different messages but otherwise are nominally identical. However, it is assumed that the carrier frequencies of the two signals differ slightly — enough to enable the receiver to distinguish between the two signals and detect their symbol streams separately. It is also assumed that although the two symbol streams have the same nominal symbol rate and each is synchronized with its carrier signal, they are not synchronized with each other.

A receiver according to this scheme would (a) initially process both the undesired (interfering) received BPSK signal along with the desired one, (b) using the stream of symbols detected by processing of the undesired signal, numerically simulate the modulation process at the transmitter and the filtering process of the receiver input circuitry to construct an estimate of the received interference spectrum, (c) subtract the estimated received interference spectrum from the total received signal spectrum to obtain a "cleansed" spectrum that nominally contains only the desired signal plus noise, then (d) process the cleansed spectrum to obtain the desired received data stream. If the desired signal were encoded at the transmitter with an error-correcting code, then final processing in the receiver would include decoding and correction of errors, with consequent reduction in the error rate and thus a further reduction in the effect of interference. Of course, each of these processing steps would add a small delay, but these processing delays would be compensated by digital delay lines, and the overall delay from input to output would be tolerable in a typical data-communication system.

The scheme appears to have recently become feasible because of the advent of highly miniaturized digital demodulators, real-time digital combiners, and circuitry for digital generation of



An **Estimate of the Interference Spectrum** would be generated in one of the interference cancelers and subtracted from the total spectrum of the received signal + noise to obtain an interference-free spectrum.



For More Information Write In No. 468

precise filtered BPSK signals. Thus, provided that the stream of data conveyed by a BPSK signal has been efficiently detected, it should be possible to reconstruct the BPSK spectrum by use of such digital signal-processing circuits.

The figure shows the main functional blocks of a receiver according to the proposed scheme. Each interference canceler would include digital circuitry for generation and filtering of the estimate of the interference spectrum and automatic-gain-control (AGC) commands. Digital delay lines ($\tau_2+\tau_3$) and τ_2 would compensate for the different delays encountered in the propagation of the signals through radio-frequency (RF) receiver input circuits (τ_1), the demodulators (τ_2), and the interference cancelers (τ_3).

Even when the undesired input spectrum included antenna noise (N) in addition to the interfering BPSK signal (I), the receiver would effectively eliminate the interfering BPSK spectrum, leaving only the desired BPSK signal (S) plus N, with a small amount of noise (n) added by the interference-cancellation process. When I was weaker than S, the digital switch would connect the output of interference canceler S to the input terminal of demodulator I. In that case, demodulator I would detect the interfering data stream and its output would cause interference canceler I to generate an AGC signal that would adjust the gain of RF receiver input circuit I to remove the unwanted spectrum from the input. When $S \approx I$, the digital switch would connect the output of digital delay line ($\tau_2+\tau_3$) to the input terminal of demodulator I. When $I > S$, the removal of the I spectrum would again be performed by demodulator I and interference canceler I. The main output of interference canceler I would be the cleansed spectrum composed of S, N, and a small additional noise n_i contributed by the interference-cancellation process.

This work was done by Benito O. Gutiérrez-Luaces of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 4*** *on the TSP Request Card. NPO-19360*

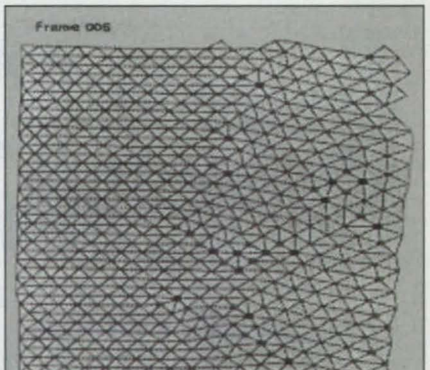
Numerical Simulation of Realistic High-Temperature Superconductors

Parallel computers provide the fine resolution needed to study vortex dynamics.

Argonne National Laboratory, Argonne, Illinois

One of the main obstacles to the development of practical high-temperature superconducting (HTSC) materials is dissipation, caused by the motion of magnetic-flux quanta called vortices. Numerical simulations provide a promising new approach for studying such vortices. By exploiting the extraordinary memory and speed of massively parallel computers, researchers can obtain the extremely fine temporal and spatial resolution needed to model complex vortex behavior. The results may help identify new mechanisms to increase current capabilities and to predict the performance characteristics of HTSC materials intended for industrial applications.

In a simulation, a superconducting perfect crystal is modelled as a rectangular prism. The crystal is placed in a magnetic field, which is parallel to the prism's axis (into the plane of the figure), and subject to a transport current. The resulting Lorentz force pulls the vortices to the right in the plane of the figure. The computational model has approximately 600,000



Results of Numerical Simulations of vortex dynamics in a superconducting sample. Here the vortex lattice is at steady state. The fault lines, which separate the regions of approximately constant vortex density, are clearly visible.

degrees of freedom. The average number of vortices in the system, which measures 32 X 48 penetration depths, is 657.

The simulations are based on the time-dependent Ginzburg-Landau equations of superconductivity. The programs use a distributed-programming model, the BlockComm library for the domain decomposition developed at Argonne, and interprocessor communication. The Chameleon library, also developed at Argonne, is used for message passing and I/O.

The results of numerical simulation of vortex dynamics in a superconducting sample show that, in the presence of a strong magnetic field, the vortex lattice maintains a *superstructure*, where regions of slowly varying vortex density are separated by a stationary fault line. These fault lines provide a mechanism to accommodate the density gradient across the sample. While the vortices diffuse across the crystal, the fault lines remain roughly stationary.

The simulations also reveal other features of the vortex lattice. For example, it was found that the vortex lattice may have misoriented grains that gradually "heal" when the sample is subject to a weak current. Also, the orientation of the vortex lattice, predominantly horizontal in the figure, depends on the strength of the transport current.

These observations help in the interpretation of experimentally observed phenomena and point the way to possibly new mechanisms to increase the current-carrying capabilities of HTSC materials.

This work was done by Hans G. Kaper and Gary K. Leaf of the Mathematics and Computer Science Division at **Argonne National Laboratory.** *The research is coordinated closely with scientists in Argonne's Materials Science Division (George W. Crabtree, Alexei E. Koshelev, Valerii M. Vinokur) to ensure that the results are relevant and useful.*

For more technical information, contact Gail W. Pieper, Mathematics and Computer Science Division, Argonne National Laboratory, 9700 S. Cass Ave., Argonne, IL 60439; (708) 252-7222; FAX (708) 252-5986. For information on licensing, contact James Gleeson, Industrial Technology Development Center, Bldg. 900, 9700 S. Cass Ave., Argonne, IL 60439; (708) 252-6055; FAX (708) 252-5230.

Electronic-to-Optical-to-Electronic Packet-Data Conversion

Long packets are segmented and transmitted optically by wavelength-division multiplexing.

NASA's Jet Propulsion Laboratory, Pasadena, California

The space-time multiplexer (STM) in Figure 1 is a cell-based communication system designed to take advantage of both the high throughput attainable in optical transmission links and the flexibility and functionality of electronic processing, storage, and switching. The STM allows for *M* source hosts at the transmitter to send packets to *M* destination hosts at the receiver over a single fiber. At the transmitter, large incoming packets are electronically segmented into smaller cells. These cells are used to modulate laser elements at different wavelengths, which are optically cou-

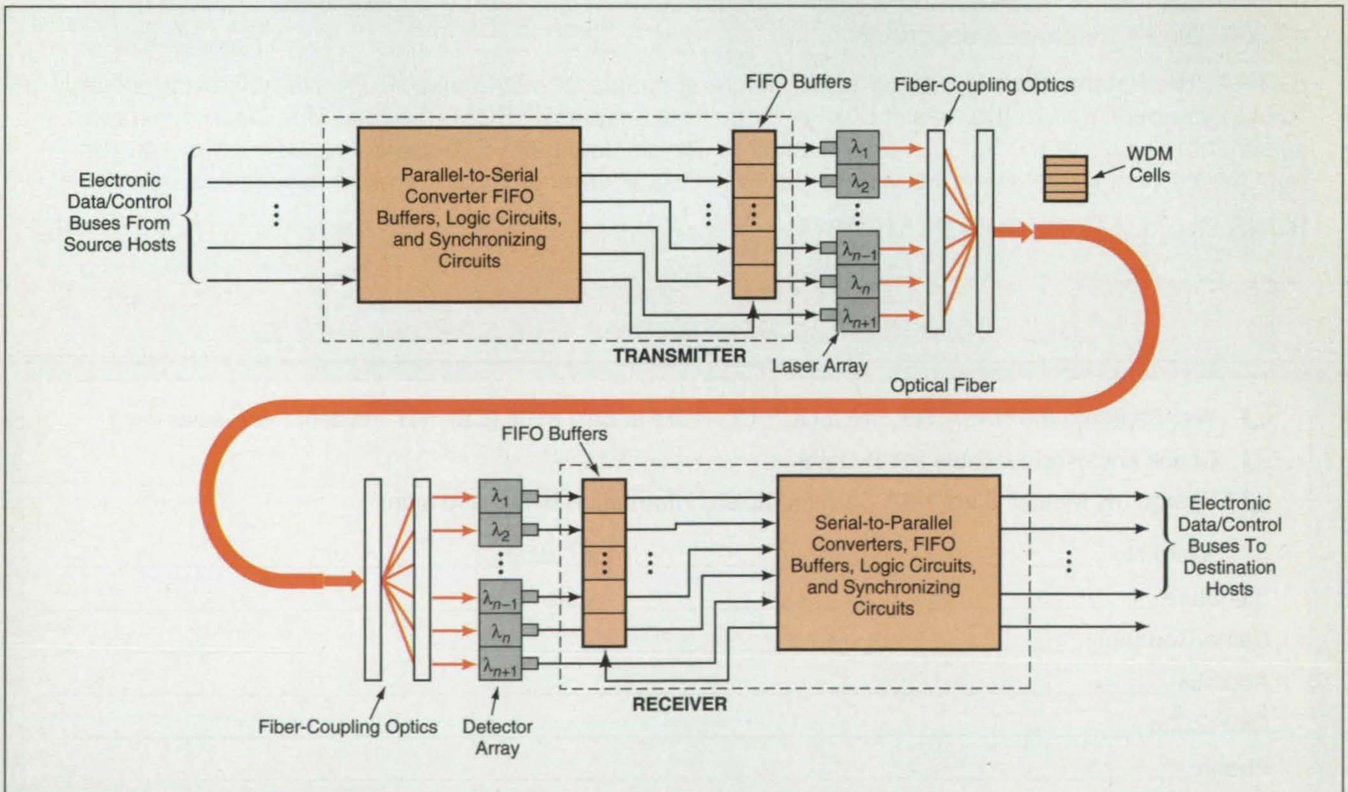


Figure 1. The **Space-Time Multiplexer** performs optoelectronic and protocol conversion between electronic "store-and-forward" protocols and optical "hot-potato" protocols.

pled into a single fiber to realize a wavelength-division-multiplexed (WDM) format. At the receiver, the optical cells are converted back to electronic form and routed to their required destinations.

The functionality of the STM electronics includes conversion between the "store-and-forward" protocols well-suited to electronic networks and deflection protocols (such as "hot potato") well-suited to optical networks. In electronic networks, packets can be stored for arbitrary time periods while waiting for a particular data path to become available. A "hot-potato" protocol accommodates the inability to statically store optical packets by deflecting a blocked packet to an alternative path when the desired path is not available. The blocking of such networks can be reduced by using small-sized packets called cells.

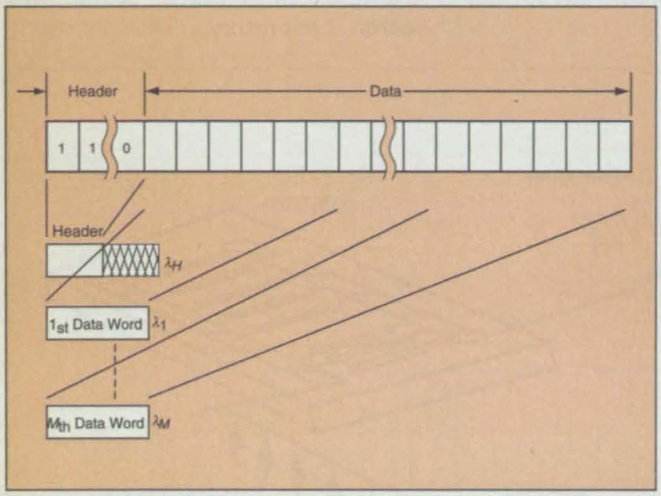


Figure 2. This **WDM Cell** generates packets in serial and wavelength parallel signal formats.

Large electronic packets in bit-parallel format are converted to cells through the use of parallel-to-serial converters, segmentation and synchronization logic, multiplexing logic, and first-in-first-out (FIFO) buffers. The basic scheme is to segment a packet into smaller cells, add a header for routing and identification of each cell as part of a larger packet, convert the cell to bit serial format, and time-multiplex the cell into each of the FIFOs. The outputs of the FIFOs are used to modulate laser elements to generate the WDM cell shown in Figure 2. This scheme maps the packets from each source host to all optical wavelengths as a time sequence of discrete cells. Flow control for the STM is governed by the "store-and-forward" protocol used by the hosts connected to the transmitter.

The light emerging from the fiber at the receiver is decomposed into the separate laser wavelengths. A separate photodetector and FIFO are used at each wavelength for optoelectronic conversion and storage of cells as bit-serial pulses. Each cell is sequentially read out from the FIFOs, routed to the logic for the desired destination host, converted back to bit-parallel format, and stripped of the additional header. The receiver logic also includes additional FIFOs and crossbar switches to store and redirect deflected cells (due to potential contention from the "hot-potato" protocol) to the correct destination host.

This work was done by Steve Monacos of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 38*** *on the TSP Request Card. NPO-19316*

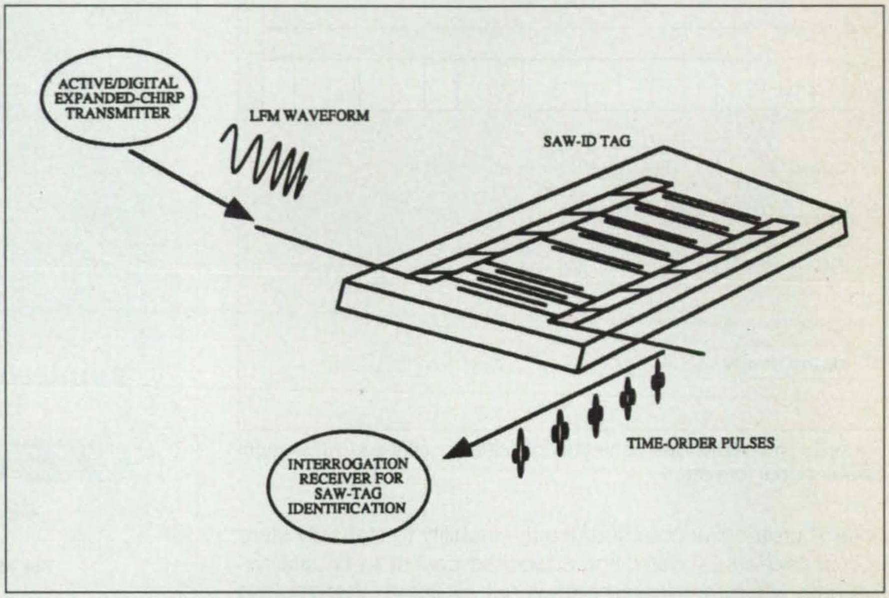
Passive SAW ID Tag with Processing Gain for Extended Range

The remote ID system can track materiel, personnel, vehicles, livestock, and wildlife.

Physical Sciences Directorate, Army Research Laboratory, Fort Monmouth, New Jersey

The surface acoustic wave (SAW) identification tag provides a concept for a low-cost, miniature configuration that uses pulse compression techniques to achieve significant processing gain (*i.e.*, about 20 dB) for extending the tag system's range. The processing gain would effectively enhance the received signal power by one hundredfold and increase the range about tenfold. The use of SAW technology permits a rugged, temperature-stable, planar device, slightly over one inch long, to achieve 10^5 to 10^6 possible coded pulses.

As illustrated in the figure, an actively generated linear FM (chirp) waveform is emitted by a nearby system transmitter. This chirp signal is received via a built-in dipole antenna that feeds the SAW input transducer that is designed to provide a "complementary" response to the input chirp and thereby compresses the signal into a narrow pulse on the order of 20 ns. The compressed pulse then propagates toward a number of appropriately spaced taps, which are connected to the device bus bars. Each tap in the array samples the compressed pulse at a particular position in time. Thus the tap spacings establish the coding pattern for each tag; these spacings could be discretely varied to establish unique sets of time-ordered pulses to define a specific tag identity. The number of possible codes increases with an increasing number of taps, where five or six taps provide codes on the order of 10^6.



Schematic showing operation of the passive **SAW Identification Tag**.

These time-ordered pulses are retransmitted to a nearby interrogation receiver to identify each uniquely coded SAW tag. Important features of the tag are its small size (about 1.5 × 0.5 × 0.125 in.), low cost in quantity production, passive nature, and planar and rugged construction.

This work was done at the **Physical Sciences Directorate, Army Research Laboratory**, *Fort Monmouth, NJ. For further information contact Mr. Duc Huynh, ARL, AMSRL-EP-MD, Fort Monmouth, NJ 07703-5601; (908) 427-3849; FAX (908) 427-4323; E-mail: dhuynh@monmouth-etdl1.army.mil.*

Fiber-Optic Distribution of Pulsed Power to Multiple Sensors

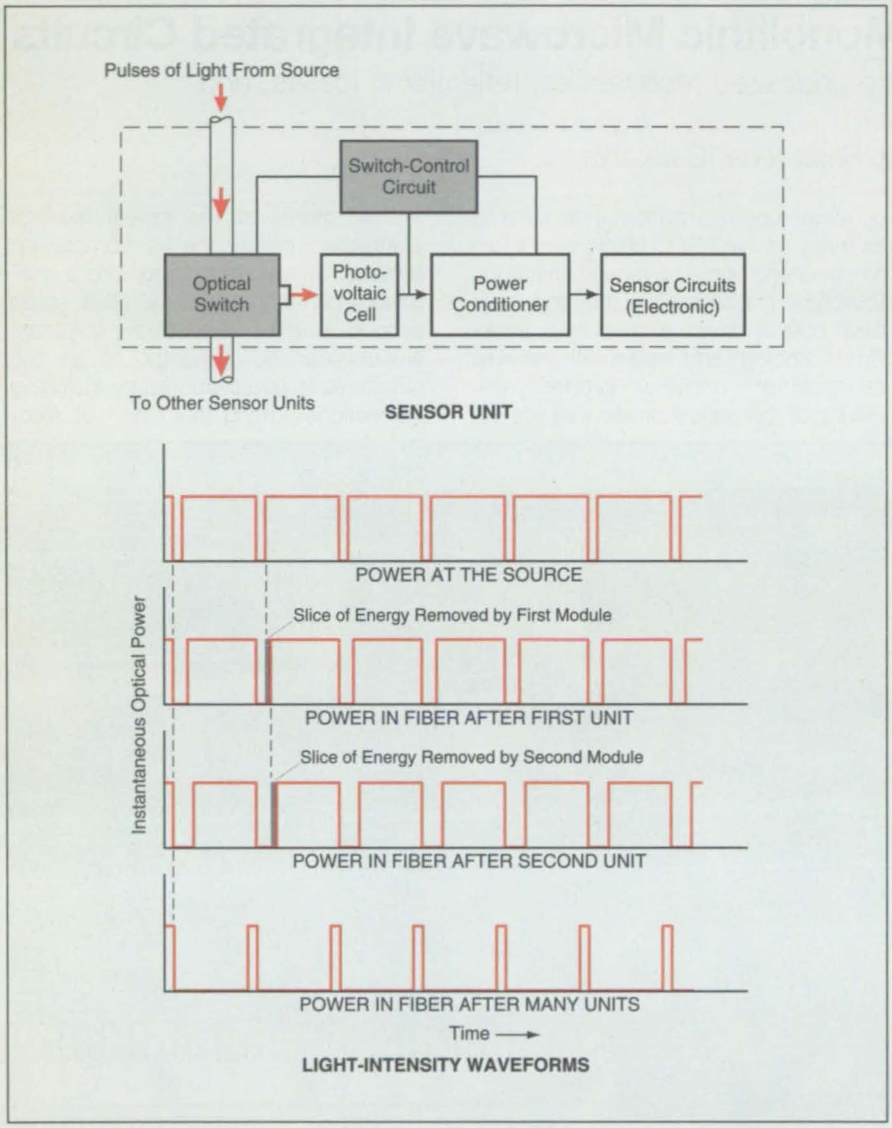
Parts of optical pulses would be apportioned to sensor circuits in a time-sharing scheme.

NASA's Jet Propulsion Laboratory, Pasadena, California

Optoelectronic systems designed according to a time-sharing scheme would distribute optical power to multiple integrated-circuit-based sensors in fiber-optic networks. These networks would combine the flexibility of electronic sensing circuits with the advantage of electrical isolation afforded by the use of optical fibers instead of electrical conductors to transmit both signals and power. Moreover, unlike electrical conductors, fiber optics resist corrosion and are immune to electromagnetic interference. Sensor networks of this type could be useful in a variety of applications; for example, in monitoring strains in aircraft, buildings, and bridges, and in monitoring and controlling the shapes of flexible structures.

A typical system according to this concept would include an optical fiber and a number of sensor units located at various positions along the fiber. Heretofore, the division of optical power to multiple sensor units located along an optical fiber would have been based on continuous sharing of total power, rather than on time-sharing. However, this older continuous-sharing scheme involves expensive optical components and is inflexible. For example, if five sensor units were to continuously use equal parts of the power in a fiber, the first would take one-fifth the power, the next would take one-fourth of the remaining power, and so forth. Unfortunately, fiber-optic taps with power-division ratios other than 1/2 are difficult and costly to fabricate. Moreover, the addition of new sensor units to the fiber would not be simple because it would upset the power ratios for sensors already in the chain. In contrast, as explained below, a system according to the present concept would be flexible.

In the proposed system, a laser would supply optical power to the fiber, but not steadily; the laser beam would be one nearest the laser source, would take all the optical power in the fiber for a fraction of each pulse period, and then would once again allow light to pass through to the next sensor. Thus, each sensor in turn would consume all the power for some fraction of the time of the pulse that remained after partial consumption by the preceding sensors.



The **Control Circuit and Optical Switch** in each sensor unit would cause all light propagating along the optical fiber to be diverted to a photovoltaic cell for brief intervals at the onset of each light pulse. Once an energy-storage device in the power-conditioning circuit had been charged by the output of the photovoltaic cell, the control circuit would command the optical switch to relinquish light to other sensor units during the remainder of the pulse. Successive slices of the pulse would thus be removed by successive units along the optical fiber.

chopped at a conveniently low frequency to produce a train of light pulses. Each sensor unit would include an electronically controllable optical switch that could be made either to allow light to continue traveling along the fiber or to divert the light momentarily to a photovoltaic cell to generate electric power for consumption in that unit (see figure). Each sensor unit, beginning with the

To provide for those times when a sensor unit needed power but an optical power pulse was not available, the unit would contain a power-conditioning circuit that would include a battery, capacitor, or other energy-storage device. As soon as a light pulse became available to that unit, the control circuit in that unit would activate the optical switch to divert all the optical power to the photovoltaic cell. The switch would remain activated for an interval long enough to satisfy the energy demand in that unit, as determined by its control circuit. In this scheme, it would be a simple matter to add sensors to the chain. By virtue of the normal operation of the control circuits in the sensor units, the system would automatically adjust itself to accommodate additional sensor units, as long as sufficient optical power for all of the units was supplied at the input end of the fiber.

This work was done by Harold Kirkham of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 5*** *on the TSP Request Card. NPO-19420*

Package Holds Five Monolithic Microwave Integrated Circuits

Packaging is designed to minimize undesired resonances, reflections, losses, and impedance mismatches.

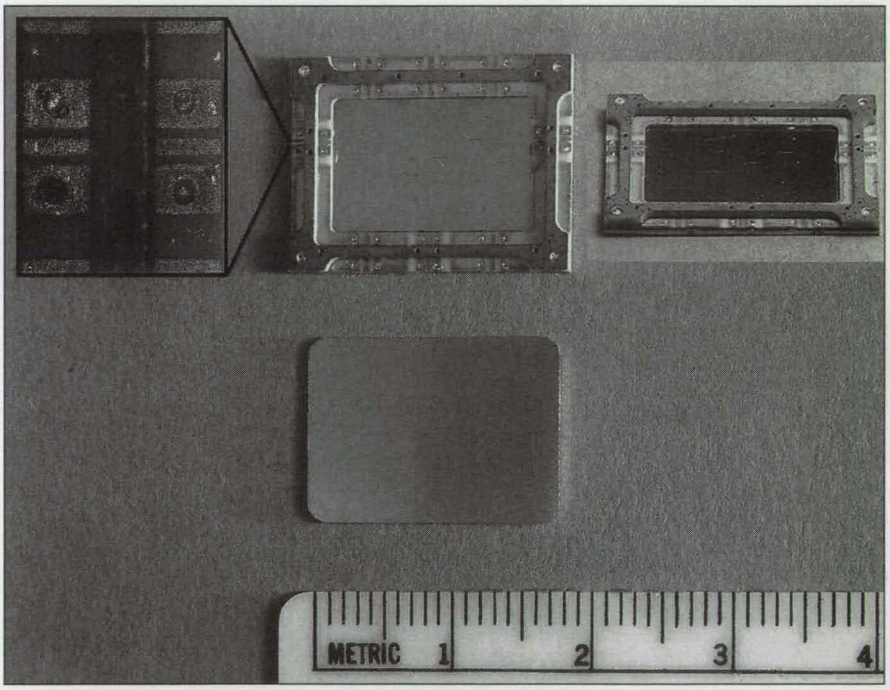
NASA's Jet Propulsion Laboratory, Pasadena, California

Packages that protect and hold monolithic microwave integrated circuit (MMIC) chips while providing dc and radio-frequency (RF) electrical connections for the chips are undergoing development. The packages are required to be compact, lightweight, and rugged. The packages must also satisfy stringent electrical requirements, as described below.

The MMICs in question operate at frequencies up to tens of gigahertz, at which dimensions of circuit and packaging components are often significant fractions of wavelengths. Consequently, this frequency range presents packaging-design problems different from those of lower frequencies. Greater care must be taken to avoid undesired resonances and impedance mismatches. The accurate and reproducible placement of chips, bonds, capacitors, and other components is much more critical. Also, losses can be much greater because of the combined effects of smaller skin depths and roughness of the surfaces of metal layers.

In the face of these and other complications, the packages are required not only to provide the basic RF and dc connections but also to feature low RF insertion and return losses in the intended range of operating frequencies, to be usable in a wide temperature range, and to provide adequate mechanical integrity. Accordingly, the electrical, thermal, and mechanical properties of the dielectric and conductor materials as well as surface finishes, dimensions, and other aspects must all be taken into account in designing the packages.

The figure shows a prototype package that can accommodate as many as five MMIC chips. It includes three RF and five dc feedthroughs for connection to external circuits. The RF feedthroughs are of a mixed-mode, conductor-backed, coplanar-waveguide design that minimizes reflections and insertion losses over a wide frequency range. The dc feedthroughs provide connections to as many as five MMIC chips, plus internal mounting of chip-bypass capacitors. Prototype packages like this one have been built by use of glass-sealed, thick-film technology and tested with the help of miniature coplanar probes. The results of the tests indicate that the RF feedthroughs meet design goals at frequencies up to about 30 GHz and can be used at frequencies to up to about 35 GHz.



This **Package Includes dc and RF Feedthroughs** for several MMICs. The package is designed to optimize RF coupling between external circuits and the MMICs inside.

The analysis and design of these and other packages is aided by computational simulations based on a composite mathematical model, as an approximate alternative to full three-dimensional computations of the electromagnetic fields in the packages. In the composite-model approach, a package is represented as an assembly of basic structures (e.g., feedthroughs and walls), each of which is represented by a component mathematical model at the lowest level of abstraction. Initially, the electromagnetic behavior of each basic structure is analyzed separately at this level. Next, at the second level of abstraction, collective electromagnetic behavior of all the structures is approximated by including interactions among them via wall electromagnetic modes. Finally, at the third level, the effects of coupling through the electromagnetic fields in the cavity of the package are also included. Despite the approximate nature of these calculations, the numerical results have agreed quite well with measurements.

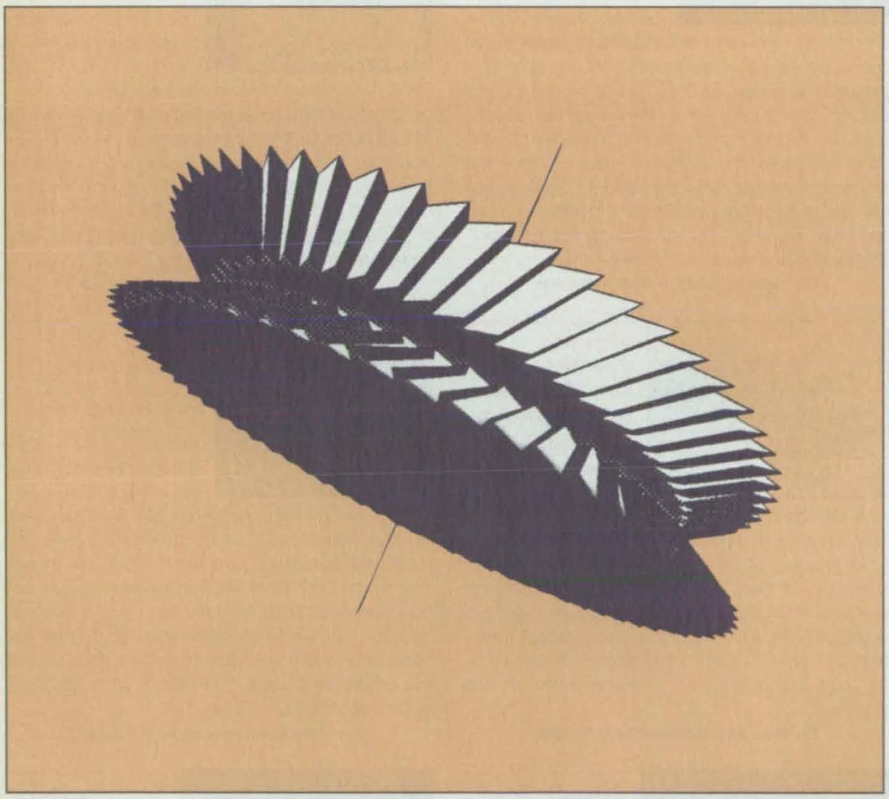
This work was done by Narayan R. Mysoor of Caltech and D. Richard Decker and Hilding M. Olson of Lehigh University for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 37*** *on the TSP Request Card. NPO-19436*

Turbines for Optomechanical Energy Conversion

Photon energies would be increased by repeated Doppler-shifting reflections from moving mirrors.

NASA's Jet Propulsion Laboratory, Pasadena, California

A class of proposed optomechanical energy-conversion machines would exploit multiple reflections from precise, high-reflectivity mirrors, some of which would be fixed to turbinelike rotors (see figure) that would spin at high speeds. The basic idea is to increase the frequencies of photons (and thus the energy of light) by repeated Doppler-shifting reflections from moving mirrors. The gain in optical energy in such a reflection would be proportional to the speed of the mirror, while the loss would be a function of imperfections of the mirror.



Mirror Facets on a Turbine Rotor would reflect light many times, each time increasing the energies of photons via the Doppler effect.

A machine of this class could be designed to operate in either a cyclic batch mode or a continuous throughput mode. In the cyclic batch mode, radiation would be trapped and compressed between reflectors: the effect would be equivalent to that on standing waves in a two-flat-mirror resonator, the mirrors of which are pushed toward each other to compress the light adiabatically. In principle, high compression ratios could be achieved, using only two high-quality mirrors. The successful exploitation of this mode would require the development of sequential processes to alternately fill the resonator with light, compress the light, and release the light after compression.

In the continuous throughput mode, the optical energy would be built up by multiple, geometrically distinguishable reflections between two or more mirrors, and the optical energy could enter and escape by virtue of the mirror geometry. Because the gain upon each reflection would be very small (typically, a fractional photon-energy gain of the order of 5×10^{-6}), many reflections would be needed.

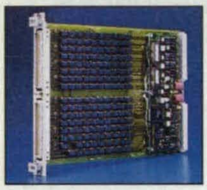
This work was done by G. John Dick of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 94*** *on the TSP Request Card.* NPO-19043

NEW PRODUCTS

Data Collection for Production/Research

The integrated VXI data collection system (DCS) from Tektronix, Inc., Beaverton, OR, provides signal conditioning, digitization, and data storage for applications ranging from production test to advanced research. Based on Tektronix's 16-channel VX4244 digitizer, it includes two new modules, the VX4780 signal conditioner and the VX4570 mass storage controller, and is tied together with a new system management control software package. Base price is $11,995.

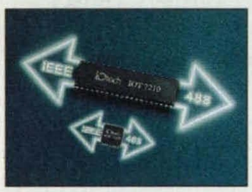
For More Information Write In No. 800



High-Density VXIbus Switch Card

Racal Instruments, Irvine, CA, announces the Model 1260-38, which it calls the highest-density C-sized single-slot VXIbus switch card currently available. Its internal configuration relays yield 16 1-X-8 two-wire multiplexers and up to a 1-X-256 one-wire scanner/multiplexer. The 30-MHz bandwidth enables switching of a wide variety of signals. It is designed for applications with large switching requirements such as relay monitoring, synchronous scanning of multiple test points, and audio or telephone line switching. Price in single-piece quantities is $2850.

For More Information Write In No. 801



CMOS Replacement for NEC IEEE 488 Controller

IOtech Inc., Cleveland, OH, introduces the IOT 7210, a replacement for NEC's µPD7210 IEEE 488 controller chip, which is to be phased out. Users of the NEC devices simply plug in IOtech's 40-pin DIP CMOS ASIC without the need to modify software or printed circuit boards. The device also comes in a low-profile TQFP package for surface-mount applications. The IOT 7210 requires 2 mA of power vs. the NEC's 180 mA, and can operate 7 times faster. Price is $10 each in quantities of 1000.

For More Information Write In No. 802

Wafer Thin-Film Characterization System

The TMS-10 from Pacific Lightwave, Carlsbad, CA, is a complete turnkey system for automatic measurement of thickness, refractive index, and absorption of dielectric films used in silicon, III-V, and LCD fabrication. Configurable for patterned or unpatterned films, and for tabletop or *in situ* measurements, it also models and characterizes complex multilayer optical coatings and optoelectronic structures. Systems start under $10,000.

For More Information Write In No. 803

Compact 20-W DC/DC Converter

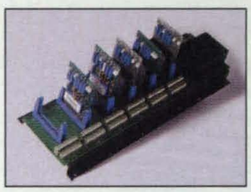
The GC Series 20-W DC/DC converter from Semiconductor Circuits, Windham, NH, measures 2.0" X 1.6" X 0.40" in its metal case. Designed for space-critical applications, according to the company, it features 4:1 input ranges of 9-36 V and 18-72 V, and a 2:1 of 36-72 V, typical efficiency of 87%, and I/O isolation of 500 V DC. Ripple and noise are rated at 50 mV peak-to-peak at 20 MHz bandwidth. Price is about $35 in OEM quantities.

For More Information Write In No. 804

Trigger to Capture Intermittent Failures

Exclusion Trigger from LeCroy, Chestnut Ridge, NY, allows users of its 9300 series of digital signal oscilloscopes to specify the normal width or period of pulses. The scope will then ignore normal-shaped signals and trigger only on abnormal events. Exclusion Trigger provides time/date stamp for each abnormal signal, the ability to display signal-shape worst-case analysis, and the ability to make screen bar charts showing which failure modes are most and least common. LeCroy now makes Exclusion Trigger standard on all 9300 series units.

For More Information Write In No. 805



Signal Conditioning for Measurement Systems

The OM2 Series modular signal conditioning system from Omega Engineering, Stamford, CT, can interface directly with sensor or analog signals such as strain gauges, mV, thermocouples, and RTDs and interconnect them to measurement and control systems. It conditions the signal to an amplified output of ±10 V DC, enabling longer signal transmission from A/D cards, dataloggers, programmable logic controllers, and chart recorders. Prices start at $165.

For More Information Write In No. 806

Planar Resistors Rated from 3-10 W

Spectrol Electronics Corp., Ontario, CA, rates its Power-Ω™ planar resistors from 3-10 W with a resistance range of 1-200 K. Only 1/64 of an inch thick, they can dissipate up to 50 W/in.^{2}. Constructed of a ceramic substrate with an embedded thick-film cermet resister element, the devices exhibit high resistance to shock, vibration, solder heat, and moisture, the company says. Price is $0.03/W in large quantities.

For More Information Write In No. 807

Bidirectional FIFO Memory Devices

Sharp Electronics Corp., Camas, WA, introduces LH543601, the first of three planned new bidirectional 50-MHz first-in first-out memory devices. It can buffer wide-word data and "funnel/defunnel" data between buses of different widths running at different speeds. It is configured at a 256 X 36 X 2 word depth; the LH543611 is planned at 512 X 36 X 2 and the LH543621 at 1024 X 36 X 2. They come in a low-profile TQFP package that requires 38 percent less board space than the PQFP package.

For More Information Write In No. 808

Fully Automated BGA Workcell

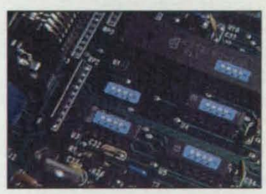
The VAi5200 from Vanguard Automation Inc., Tucson, AZ, is an automated placement workcell for the Ball Grid Array (BGA) surface-mount packaging technology. It can perform an entire cycle in 10 s, an hourly throughput of 1800 devices, assuming the use of a 5-unit strip. The workcell uses a screen-print process for fluxing and a gravity-feed technique for ball placement. The VAi5200 handles all other functions needed, including part loading, postplacement inspection, and offload to reflow. Prices begin at $425,000.

For More Information Write In No. 809

D-to-A Converter for "Smart" Transmitters

Analog Devices, Wilmington, MA, describes its AD421 loop-powered digital-to-analog converter (DAC) as designed to meet the needs of "smart" transmitter manufacturers with industrial control applications. The monolithic 16-bit DAC sends 4-20-mA signals to a microcontroller for a variety of digital processing functions. Its zero-scale 4-mA output current has ±0.1-percent offset error and the 20-mA full-scale output current has ±0.2-percent error. The AD421 costs $6.95 in quantities of 1000.

For More Information Write In No. 810



Temperature Measuring and Recording Labels

Sized only 5 X 12 mm, the Micro-Celsi temperature measuring and recording labels from SAT Inc., Springfield, MA, can go on any component surface within densely packed electronic assemblies and permanently visualize maximum-value temperature history. The self-adhesive labels come on sheets for easy peel-off and carry four different temperature-level sensing spots: *i.e.*, 60, 71, 82, and 93 °C.

For More Information Write In No. 811

Vol. 20, No. 5 May 1996 Expiration Date: Oct. 31,1996

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- Y ☐ Consumer Goods.
- U ☐ University
- L ☐ Library
- Z ☐ Other *(specify)*: ____________

3 **Your engineering responsibility is:** *(check one)*

- A ☐ Manage Engineering Department
- B ☐ Manage a Project Team
- C ☐ Manage a Project
- D ☐ Member of a Project Team
- E ☐ Other *(specify)* ____________

4 **Your job functions are:** *(please check all that apply)*

- 10 ☐ Design Engineering
- 11 ☐ Research & Development
- 12 ☐ Testing & Evaluation
- 13 ☐ Manufacturing & Production
- 14 ☐ Management
- 15 ☐ Other (specify) ____________

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- 08 ☐ Machine Design
- 09 ☐ Mechanical Engineering
- 10 ☐ Personal Engineering & Instrumentation
- 11 ☐ Product Design & Development
- 12 ☐ Research & Development
- 13 ☐ Sensors
- 14 ☐ Test & Measurement World
- 15 ☐ Laser Focus World
- 16 ☐ Photonics Spectra
- 17 ☐ None of the above

6 **How many engineers and scientists work at this address?** *(check one)*

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- C ☐ 6-19
- D ☐ 20-49
- E ☐ 50-99
- F ☐ 100-249
- G ☐ 250-499
- H ☐ 500-999
- J ☐ over 1000

7 **What is your title?** *(check one)*

- 02 ☐ President
- 03 ☐ Owner/Entrepreneur
- 06 ☐ General Manager
- 15 ☐ VP (specify) ____________
- 37 ☐ Director (specify) ____________
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- 39 ☐ Engineer (specify) ____________
- 57 ☐ Educator (specify) ____________
- 99 ☐ Other (specify) ____________

8 **Products you recommend, specify, or authorize the purchase of:** *(check all that apply)*

- 01 ☐ Electronic components
- 02 ☐ Board-level electronics
- 03 ☐ Electronic systems
- 04 ☐ Lasers/optics
- 05 ☐ Software
- 06 ☐ Computers/ Workstations/ Peripherals
- 07 ☐ CAD/CAE
- 08 ☐ CAM Tools
- 09 ☐ Mechanical components
- 10 ☐ Fastening/joining & assembly components
- 13 ☐ Ferrous & nonferrous metals
- 27 ☐ Composites
- 28 ☐ Plastics & nonmetals
- 15 ☐ Vacuum equipment
- 16 ☐ Data acquisition
- 17 ☐ Video/imaging technology
- 18 ☐ Sensors/ transducers
- 19 ☐ Test/measurement instruments
- 20 ☐ Motion control/ positioning equipment
- 21 ☐ Industrial controls/systems
- 22 ☐ Laboratory equipment
- 23 ☐ Communications equipment
- 80 ☐ None of the above

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- 10 ☐ Personal Engineering & Instrumentation
- 11 ☐ Product Design & Development
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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.

Mechanics

Computation of Flow About a Pitching Wing/Fuselage

A report presents a computational study of the unsteady transonic flow about an airplanelike body as the body pitches upward in an increasing angle of attack. The study is relevant to the prediction of aeroelastic responses via computation as a substitute for experimentation, which can be expensive. The study involves the use of an updated version of the ENSAERO computer program, which computes aeroelastic responses by simultaneous numerical integration of (1) the Navier-Stokes equations of flow and (2) the equations that describe the modes of vibration of the body, using aeroelastically adaptive dynamic grids.

This work was done by S. Obayashi, G. P. Guruswamy, and E. L. Tu of **Ames Research Center.** *For further information,* ***write in 99*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Ames Research Center; (415) 604-5104. Refer to ARC-13172.

Comparative Study of Four Models of Turbulence

A report presents a comparative study of four popular eddy-viscosity models of turbulence. Computations are reported for three different adverse pressure-gradient flowfields. A detailed comparison of the numerical results and the experimental data is given. The following models have been tested:

1. The Baldwin-Lomax model. A purely algebraic model that does not employ a transport equation (zero-equation model).
2. The Johnson-King model. An algebraic baseline model is coupled with an ordinary differential equation for the maximum shear stress (half-equation model).
3. The Baldwin-Barth model. This model involves the solution of one transport equation for the turbulent Reynolds number (one-equation model).
4. The Wilcox model (k-ω model). Two transport equations are solved for the turbulent kinetic energy, k, and for the specific dissipation rate, ω (two-equation model).

This work was done by Florian R. Menter of the Eloret Institute for **Ames Research Center**. *For further information,* ***write in 11*** *on the TSP Request Card. ARC-13175*

Computation of Flow About a Helicopter Rotor

A report describes computations of flow about a hovering helicopter rotor. The thin-layer Navier-Stokes equations in conservation-law form are solved numerically on embedded grids (also known as chimera grids), which offer the advantage of efficient discretization of the flow field via decomposition of the domain (spatial region) of interest into multiple interconnected subdomains. The grid in each subdomain can be optimized for the flow field in that subdomain.

This work was done by Earl P. Duque of **Ames Research Center** *and Ganapathi Srinivasan of JAI Associates. To obtain a copy of the report, "Numerical Simulation of a Hovering Rotor Using Embedded Grids,"* ***write in 2*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Ames Research Center; (415) 604-5104. Refer to ARC-13255.

Physical Sciences

Liquid Crystals Indicate Directions of Surface Shear Stresses

A report consisting of the main text of U. S. Patent 5,394,752 presents detailed information on one aspect of a method of using changes in the colors of liquid-crystal coatings to indicate the instantaneous directions of flow-induced shear stresses (skin friction) on aerodynamic surfaces. A suitably formulated liquid-crystal coating scatters incident white light into a spectrum of colors, each color at a different orientation relative to the surface.

This work was done by Daniel C. Reda of **Ames Research Center.** *To obtain a copy of the report, "Method for Determining Shear Direction Using Liquid Crystal Coatings,"* ***write in 59*** *on the TSP Request Card.*

This invention has been patented by NASA (U.S. Patent No. 5,394,752). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Ames Research Center; (415) 604-5104. Refer to ARC-13379.

(continued)

(continued from previous page)

Behavior of Clusters of Fuel Droplets in Sprays

A report describes the first phase of a study of the behavior of droplets of liquid fuels and oxidants in dense and dilute regions of sprays. This is one in a series of studies conducted by the author and others in an effort to understand the evaporation and combustion of sprayed liquid fuels at both atmospheric and higher pressures. The report discusses physical mechanisms that have been conjectured to exert significant effects on the performances of liquid-fuel rocket engines. The ultimate goal is to combine the spray model with a model of the chamber configuration in order to obtain a multispray model of a liquid-fuel rocket combustion chamber.

This work was done by Josette Bellan of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Droplet Cluster Behavior in Dense and Dilute Regions of a Spray,"* ***write in 56*** *on the TSP Request Card. NPO-19707*

Development of a Magnetic Directional-Solidification Furnace

A report describes the development of a directional-solidification furnace in which an axial magnetic field is imposed by surrounding ring permanent magnets and/or electromagnets and pole pieces. The furnace provides controlled axial temperature gradients in multiple zones, through which an ampoule containing a sample of material to be solidified is translated at a controlled speed by a low-vibration, lead-screw, stepping-motor-driven mechanism. The basic concepts of directional-solidification furnaces with these features have been described previously in *NASA Tech Briefs*. This furnace is intended for use in low-gravity (spaceflight) experiments on melt growth of high-purity semiconductor crystals. The next stage of development would include the further development of the furnace components, including the translation mechanism, magnets, and magnetic shielding; the development of the associated electronic control and data-acquisition circuitry; and the integration of all parts into a prototype.

This work was done by Bill R. Aldrich and Sandor L. Lehoczky of Microgravity Systems, Inc., for **Marshall Space Flight Center.** *To obtain a copy of the report, "Development of a Space Flight Magnetic Furnace Facility,"* ***write in 98*** *on the TSP Request Card. MFS-26293*

Mathematics and Information Sciences

Tutorial on Reed-Solomon Error-Correction Coding

This report discusses the mathematical principles of Reed-Solomon (RS) error-correction coding, but without rigorous proofs or extreme mathematical detail. RS encoding and decoding, with and without erasing code symbols, are explored. The prerequisite concepts of groups and fields (specifically, Galois fields) are discussed. Similar Block codes are presented as examples to introduce the RS-coding concept before a primitive (15,9) RS code example is completely illustrated. Typical coding features are also included to increase understanding. Appendices discuss design considerations regarding RS encoding and decoding hardware, matrix encoding and decoding calculations, and a derivation of the error-locator polynomial.

This work was done by William A. Geisel for **Johnson Space Center**. *To obtain a copy of the report, "Tutorial on Reed-Solomon Error Correction Coding,"* ***write in 60*** *on the TSP Request Card. MSC-21834*

Software Aids Visualization of Mars Pathfinder Mission

A report describes the Simulator for Imager for Mars Pathfinder (SIMP) computer program. SIMP generates a "virtual reality" display of the view through a video camera on the Mars lander spacecraft of the Mars Pathfinder mission, along with a display of pertinent textual and graphical data, for use by scientific investigators in planning sequences of activities for the mission. The program integrates a variety of mathematical models of the Mars environment and generates seamless mosaic images from previously acquired images by processing the previously acquired images to account for photometric relationships between (1) the previous illumination and look angles and (2) the illumination and look angles to be simulated. A scientific investigator can interact with the simulation through point-and-click navigation, selection from menus, selection from among toggle buttons, text entry, and selection of data bases. The products of the interaction are new and/or updated entries in the mission-sequence activity files, which will then be incorporated into the sequence of command signals to be transmitted to the Mars Pathfinder lander.

This work was done by Richard J. Weidner of **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 44*** *on the TSP Request Card. NPO-19547*

Electronic Systems

Mixed-Norm Design of Fixed-Order Controllers

A report describes recent advances in the theory of fixed-order multiple-input/multiple-output controllers from the perspectives of the H_2 and H_∞ control problems. The H_2 control problem is to design a control compensator or an equivalent algorithm that minimizes a quantity called the "H_2 norm" of the transfer matrix that expresses the relationship between a disturbance vector and a measurement vector; a compensator that minimizes the H_2 norm also minimizes the root-mean-square (rms) measurement response of the control system and the controlled plant to white-noise disturbance inputs. H_2 control design is appropriate for meeting performance objectives that involve minimization of rms values of such performance measures as control energies and line-of-sight errors. However, performance in H_2 control design depends strongly on knowledge of dynamics of the plant. In H_∞ design, one seeks to minimize the peak frequency response in the measurement vector to the worst-case disturbance input. Recent developments have enabled mixed-norm design, wherein the H_2 norm is minimized for one set of inputs and outputs and an upper bound on the H_∞ norm is guaranteed for another set of inputs and outputs. Mixed-norm design provides both rms-type optimization and robustness.

This work was done by Mark Whorton of **Marshall Space Flight Center** *and Harald Buschek and Anthony Calise of the Georgia Institute of Technology. To obtain a copy of the report, "Design of Fixed-Order Robust Control Laws,"* ***write in 93*** *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-26404.

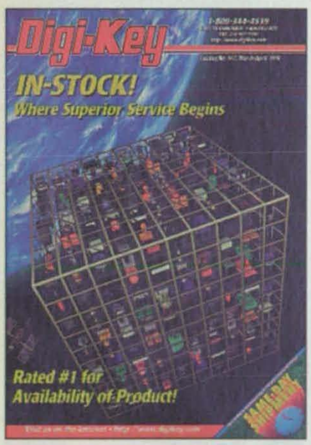
New Literature

A 408-page catalog of **positioning control systems and drives** is available from Parker Hannifin Corp., Compumotor Div., Rohnert Park, CA. Included are AC brushless servo systems, linear step motion systems, microprocessor-based controls, full step and microstepping systems, and incremental and absolute encoders.

For More Information Write In No. 700

Advanced Micro Systems, Nashua, NH, offers a 12-page brochure on **motion control products and accessories**. Indexer ICs and boards, standalone control systems, programmable drivers and power supplies, step motors, encoders, and computers are described.

For More Information Write In No. 704



Digi-Key Corp., Thief River Falls, MN, has released a 412-page catalog of **electronic components**. Products include connectors, sockets, semiconductors, oscillators, capacitors, resistors, switches, relays, tools, power supplies, test equipment, fuses, batteries, and optoelectronics.

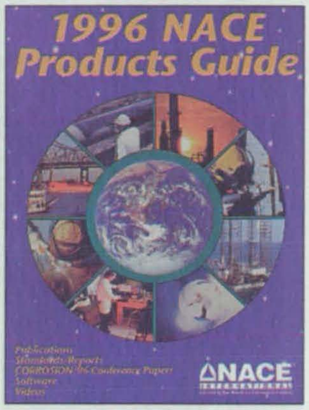
For More Information Write In No. 701

NB Corporation of America, Elk Grove Village, IL, has released an eight-page brochure on high-carbon chromium bearing steel and Martensite stainless steel **shafts**. The inch-diameter Slide Shaft Products are available as custom-machined spindles, guide rods, controls, and mandrels.

For More Information Write In No. 705

A 20-page catalog of **electronics materials** is offered by Electro-Science Laboratories, King of Prussia, PA. Included are thick film materials, solder pastes, and polymer thick film materials.

For More Information Write In No. 706



More than 1000 **corrosion reference materials** are described in a catalog from NACE International, Houston, TX. Featured are reference books, videos, technical standards and software for use in corrosion control.

For More Information Write In No. 707

A 24-page guide to **thermoplastic gears** is available from LNP Engineering Plastics, Exton, PA. Sections on gear action, design, testing, and failure mechanisms are included, as well as evaluations of thermoplastic materials.

For More Information Write In No. 708

Kurt J. Lesker Co., Clairton, PA, has released a brochure on **deposition materials and services** offered by the company's Deposition Materials Division. The brochure describes sputtering targets, target backing plates, bonding, and evaporation-grade pellets.

For More Information Write In No. 703

Parts Express, Dayton, OH, offers a 1996 catalog of **electronics parts and accessories**. The 228-page catalog describes repair parts, test equipment, semiconductors, tools, connectors, instruction books and tapes, and accessories.

For More Information Write In No. 702

National Design Engineering Show New Product Showcase

Products featured below and on the following four pages were introduced recently at the National Design Engineering Show.

Product of the Month

Interactive Process Controls Corp., South Easton, MA, has introduced a new family of SensorPulse™ **generic analog signal processors**, which replace the use of analog input and output modules in programmable logic controllers (PLCs) by converting analog signals to 12- or 16-bit data, and communicating the data to a PLC via a single digital I/O point. Any type of sensor can be used for machine and processor control with any PLC, PC or standalone application. SensorPulse's Intel-based processor works with thermocouples, strain gauges, potentiometers, frequency, current, and voltage over a wide analog range. Also included are signal conditioning and communications algorithms and pre-loaded software drivers for all major PLCs.

For More Information Write In No. 730

Bisco Products, A Dow Corning Subsidiary, Elk Grove Village, IL, introduced CS-5800 **cellular silicone material** for use in sealing, cushioning, vibration dampening, and gasketing applications. The material is designed to bridge the gap between high-end, specification-grade silicone foam and sponge products, and low-grade silicone substitutes.

For More Information Write In No. 731

SolidWorks Corp., Concord, MA, has introduced PhotoWorks **photo-realistic rendering software**, which creates photo-quality rendered images from solid models created with SolidWorks 95 solid modeling software. The program is Windows NT and Windows 95 compatible and includes a materials editor, background editor, background scenery, and lighting options. The price is $795 when purchased separately; $395 with SolidWorks 95.

For More Information Write In No. 732

Raytek Corp., Santa Cruz, CA, has announced the Thermalert 2C two-color **digital infrared thermometer**, which offers both two-color and one-color measurement modes. Other features include two-way RS485 connection, which allows remote programming and on-screen monitoring. Designed for high-temperature applications in the manufacturing and semiconductor processing industries, the unit covers temperature ranges from 600°C to 3000°C.

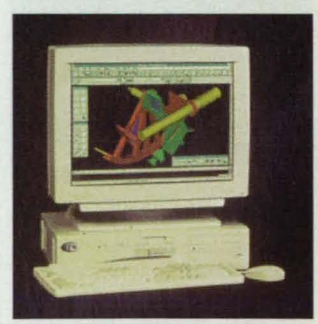
For More Information Write In No. 733

The ServoMount self-aligning **gearhead mounting system** was introduced by Bayside Controls, Port Washington, NY. The system, which is available on Planetary and Right Angle Planetary gearheads, consists of a Clamp-On pinion gear preinstalled in the gearhead's rear housing. The pinion is held in place by a floating bearing, which compensates for motor shaft misalignment.

For More Information Write In No. 735

The MAGNUM™ Series of **robotic grippers** was announced by Zaytran Inc., Elyria, OH. Made of corrosion-resistant materials, the grippers are universally applicable for use in machining, cleanrooms, and wafer and disk fabrication. They produce 29 pounds of gripping force and are available in 13 mm and 26 mm models. A dual usage purge system can be pressurized to remove debris from the gripper mechanism.

For More Information Write In No. 737



The TD-300 and TD-400 series of **personal workstations** introduced by Intergraph Computer Systems, Huntsville, AL, provide CAD, mapping, mechanical design, and animation professionals with PC-level 3D graphics capabilities. Powered by single and dual Pentium Pro processors and Intergraph's G95 graphics accelerator, the systems work with 2D/3D CAD packages such as AutoCAD, MicroStation, ProEngineer, and Solid Edge.

For More Information Write In No. 734

National Design Engineering Show
New Product Showcase

Invention Machine Corp., Cambridge, MA, introduced the latest version of Invention Machine™ Lab™ **engineering problem-solving software**, which includes three modules: IM Principles, which solves engineering problems by inventive principles selected from analysis of 2.5 million patents; IM Effects, a knowledge-based system of 1350 physical, geometrical effects, and design cases; and IM Prediction, which predicts technology evolution of a concept. The software is available for Windows 3.1 and Windows 95 and costs $1495.

For More Information Write In No. 736

3D Systems Corp., Valencia, CA, introduced the SLA-250/50 **stereolithography system**, which incorporates the new Zephyr™ Recoating System and a 40 milliwatt laser standard. The new system provides faster fabrication of solid objects using input from CAD/CAM systems. It is also available as an upgrade for current users.

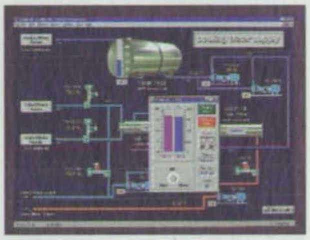
For More Information Write In No. 738

Total Control Products, Melrose Park, IL, displayed QuickPanel **touch screens**, which are available in 5" LCD monochrome, 5" STN color, 9" EL amber, 10.5" STN color LCD, and 10.5" TFT color LCD models. They are less than 3" deep, allowing installation in limited spaces. A serial cable connects the panel to an RS-232 or RS-485 communications port of most PLCs. A Windows-based software editor provides set-up, control, and downloading capabilities.

For More Information Write In No. 739

Toroid Corp., Salisbury, MD, introduced the ISO-BOX Series **isolation transformers** mounted in an aluminum enclosure with four standard power ratings of 300 VA, 600 VA, 1200 VA, and 1750 VA. The transformers feature low magnetic strayfield, weight, and mechanical noise, and operate at a line frequency of 60 Hz with 120V input and output voltages. Applications include computers, video monitors, cameras, and test and measurement instruments.

For More Information Write In No. 741



National Instruments, Austin, TX, offers Lookout™ **industrial process control animation software** for Windows. It provides a man-machine interface to control communication, alarming, monitoring, logging, security, and other process events using object-oriented graphics. Alarms are triggered with a user-specified event or combination of events and multiple communication protocols can be used over a single radio frequency. Custom applications can be created online via a menu command.

For More Information Write In No. 740

Omron Electronics, Schaumburg, IL, introduced the CPM1 **micro programmable logic controller** for high-speed control applications on small machines. The controller is available in 10, 20, and 30 density I/O, and is expandable to 50 I/O. It can execute basic instructions in 0.72 microseconds and special instructions in 16.3 microseconds. Memory capacity is 2048 words, and the unit offers 91 programming instructions.

For More Information Write In No. 742

The Universal **elastomer grommet** from TA Mfg. Co., Glendale, CA, seals tube and wire penetrations from air, dust, fluids, and fire without using sealants, adhesives, or potting. A single grommet size seals a range of panel thicknesses and accommodates variations in payload diameters.

For More Information Write In No. 750

For More Information Write In No. 435

For More Information Write In No. 436

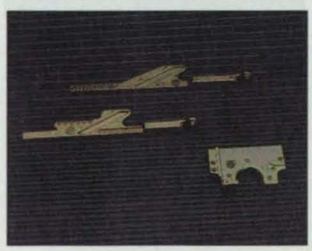
National Design Engineering Show New Product Showcase

The Nyliner™ Bushing Bearing from Thomson Industries, Port Washington, NY, is a **linear bearing** that uses two self-lubricating engineering polymer inserts. Open and closed bearings are available in 1/2" to 2" sizes and can be used in rotary or linear applications. An aluminum housing allows size-for-size replacement of rolling-element and solid nonlubricated bushings.

For More Information Write In No. 743

CONTEC Microelectronics USA, San Jose, CA, announced the PANECON™ UT ISA bus **industrial PC** with a depth of less than 2.5". The panel mounts in less than 2" and the entire unit is 1.9" deep without a bezel, 12.2" wide, and 10.6" high. It features an active matrix 10.4" LCD flat panel color display and an analog resistive touch screen. An external floppy drive and Flash hard disk interfaces are included, with RS-232/485 ports and Ethernet ports available.

For More Information Write In No. 744



Fishercast, Division of Fisher Gauge Ltd., Peterborough, ON, Canada, licensed General Motors Research's ACuZinc ternary **zinc-copper-aluminum alloy** for die casting of small components for structural applications and multi-step assemblies. The primarily zinc alloy contains 5 to 6 percent copper and 2.8 to 3.3 percent aluminum, and features low friction coefficient for bearing applications. ACuZinc components are completely recyclable.

For More Information Write In No. 746

CATIA/CADAM Solutions Version 4 Release 1.6 **CAD/CAM software** was introduced by IBM, White Plains, NY. The new version is available for Silicon Graphics workstations and features a desktop viewing suite for Windows NT PC compatibility. New features include a 4D Navigator visualization tool, which enables users to fly through and inspect digital mockups in real time; a STEP-based Assembly Navigator for exploring digital product structures; and Realistic Rendering for photo-realistic images in seconds.

For More Information Write In No. 745

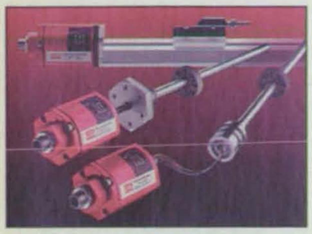
The Command Panel VIP 6000 **operator interface enclosure** from Rittal Corp., Springfield, OH, is a modular enclosure with more than 60 configuration options and a choice of a keyboard housing for control panels or a keyboard tray for standard PC keyboards. Features include access to the rear of the housing via a hinged door or screw-on rear wall, and cable ducts from the operator interface housing to the keyboard housing.

For More Information Write In No. 747

MagneTek Drives & Systems, New Berlin, WI, has introduced the InteliPac adjustable-speed **motor/drive package**, which integrates a PWM drive with an E-Plus® TEFC motor. The drive is integrally mounted to the motor in the F3 position and is designed with separate conduit openings for power and control wiring. It provides constant torque across a 10:1 speed range, is available in 1/4 through 1 hp, and features a 16-bit microprocessor.

For More Information Write In No. 749

National Design Engineering Show New Product Showcase



The Temposonics III Series of **position sensors** from MTS Sensors Division, Cary, NC, consists of three components: a wave guide, electronics, and application housing. They offer resolution of 2 microns at 10,000 measurements per second and feature nonlinearity of 0.02 percent. The sensors measure either two displacement outputs or one displacement output and one velocity output. A microprocessor-based serial bus provides position, velocity, programmable set points, and status data.

For More Information Write In No. 748

MSC/FEA **mechanical engineering software** from MacNeal-Schwendler Corp., Los Angeles, CA, combines CAD interfaces, geometric modeling, finite element pre- and post-processing, and analysis capabilities. Engineers can create parts with 2D and 3D wireframe, surface, and solid geometry, which can be imported from CAD systems. An analysis model can then be created using a suite of meshing tools. Other features include solution algorithms and procedures, simultaneous modeling and analysis, and graphical editing of analysis models.

For More Information Write In No. 751

Stabilus, Colmar, PA, has introduced the Stab-O-Shoc® reversing **motion damper**, which can be mounted in any orientation without loss of damping. The custom-designed units can be used for a variety of motion-sensitive applications and feature smooth reversing of direction.

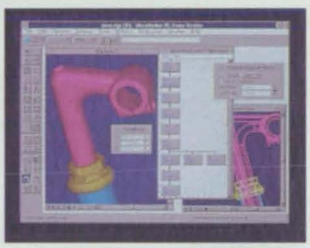
For More Information Write In No. 753

D-STAT **static-dissipative polyurethane tubing** from Freelin-Wade Co., McMinnville, OR, alloys polyurethane resins with a polymer to provide permanent electrostatic discharge (ESD) protection in semiconductor, medical equipment, electronic equipment, robotics, and powder coating machinery applications. It is available in a variety of custom colors and sizes.

For More Information Write In No. 754

CONCEPT™ **equipment consoles** were introduced by Hoffman Engineering, Anoka, MN. The enclosures are designed to house electrical and electronic controls, instruments, displays, and other components, and can be used as a desk unit or freestanding unit. A sloping control panel allows mounting of pushbuttons, meters, switches, and displays, and a hinged cover can be held open at a 90° angle.

For More Information Write In No. 755



Bentley Systems, Exton, PA, announced a new version of MicroStation Modeler™ **mechanical engineering software**, which includes a feature manager, the QuickVision™ rendering accelerator, and a constraint tutor. The feature manager allows users to graphically view, edit and manage mechanical design features. QuickVision provides high-speed 3D rendering, and the constraint tutor allows automatic conversion of existing or new sketches to constrained models. The cost is $5325; an upgrade to MicroStation 95 is $1650.

For More Information Write In No. 756

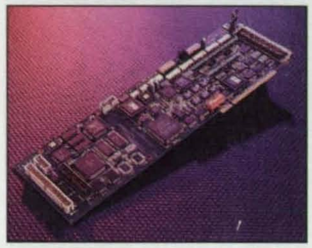
Device Technologies, Marlborough, MA, has announced SpringFast **composite grommet edging** for abrasion protection of wires and cables. The edging locks on to any two-axis contour without adhesive and eliminates sharp edges. Features include a stainless steel core material and a choice of a non-conductive polymer coating or an uncoated version. It is available in 25- or 100-foot reels, or in custom lengths.

For More Information Write In No. 757

National Design Engineering Show New Product Showcase

Schroff Development Corp., Mission, KS, offers the JP System 5 **rapid prototyping system** suitable for use in an office environment. Designs can be created using any CAD software capable of exporting files in the stereolithography (.STL) format; users also can reverse a CAD drawing and create a mold. The system uses commercial paper or foam materials and does not require special plumbing, electrical, or ventilation. Prototypes creating using foam are suitable for investment casting.

For More Information Write In No. 752



nuLogic, Needham, MA, has released FlexMotion PCI **motion controller** for the PCI bus, which controls point-to-point, vector motion, jogging, contouring, electronic gearing, master/slave, camming, and linear, circular, spherical, and helical interpolation. The dual-processor controller provides 2, 4, or 6 axes of servo control with 2 axes of stepper control. A graphical users interface and motion programming tools are included.

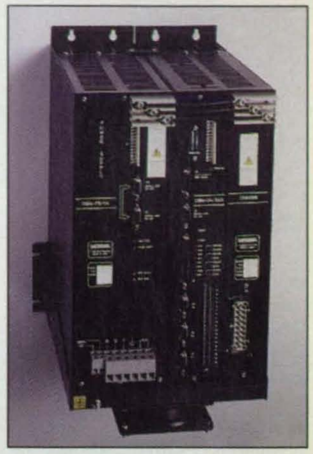
For More Information Write In No. 758

ITW Devcon, Danvers, MA, has introduced a five-minute flame-retardant **epoxy adhesive**, which bonds metals, ceramics, and plastics and encapsulates and pots electronic components. The two-component adhesive is a medium-viscosity, rapid-setting epoxy that offers one-to-one mixing and is available in a variety of tubes and cartridges.

For More Information Write In No. 761

Imagenation 4.1 **imaging software** from Spicer Corp., Kitchener, ON, Canada, incorporates scan, view, annotate, markup, edit, plot, hotspot, and text search capabilities for Windows, Macintosh, and UNIX for imaging of electronic information. The new version supports AutoCAD r13 and native Microsoft Excel spreadsheets, and can be integrated into most engineering document management, product data management, and workflow systems. Prices start at $199 for all platforms.

For More Information Write In No. 759



The DBS 04 Single-Axis and DBM 04 Multi-Axis digital brushless **servo drives** from Vickers, Maumee, OH, feature digital speed-loop and both digital and analog interfaces. The DBS is a standalone, single-axis unit; the DBM has microprocessor control to allow drive configuration by a handheld terminal or PC. Both models have built-in surge protection and can run a variety of servomotors without a transformer or encoder.

For More Information Write In No. 760

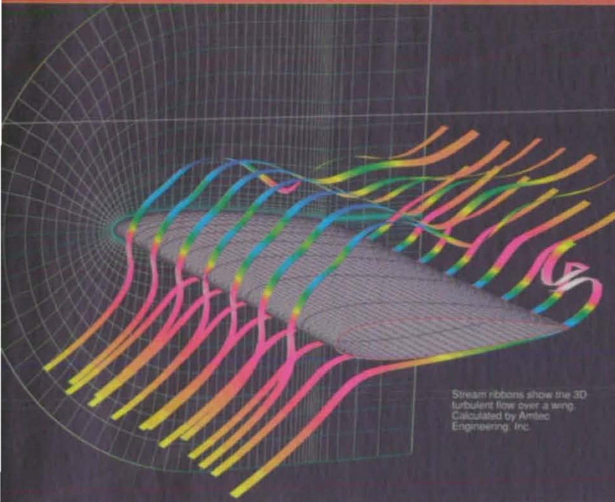
Datastream Systems, Greenville, SC, announced a **computer interface program** linking its MP2® for Windows maintenance management system with Wonderware InTouch man-machine interface software. MP2 reports machine failures detected by Wonderware to both the Wonderware operator and the maintenance worker. Parts required for maintenance or repair are automatically tagged and requisitioned through MP2 to electronic parts catalogs.

For More Information Write In No. 762

The ScanPlus III 600 **large-format document scanner** from CalComp, Anaheim, CA, provides scans of drawings, maps, and documents at 600, 500, 400, 300, 200, 150, 75, 50, or 25 dpi. Documents can be stored or manipulated on PC, Macintosh, Digital Equipment, Power PC, Hewlett-Packard, Silicon Graphics, and RS 6000 computer platforms for CAD, mapping, or GIS applications. Images up to 36" wide by unlimited length can be scanned with 256 levels of grayscale.

For More Information Write In No. 763

Tecplot® Interactive Data Visualization for Scientists & Engineers



Stream ribbons show the 3D turbulent flow over a wing. Calculated by Amtec Engineering, Inc.

The Package Chosen by Thousands

Tecplot is the versatile and powerful, interactive software package that thousands of engineers and scientists have chosen for visualizing their technical data. With Tecplot you can easily create XY plots, contour plots, vector plots, mesh plots, carpet plots, 3D stream ribbons, isosurfaces, light-source-shaded surfaces, and many other plots. You can visualize complex data defined in one, two, or even three dimensions. You can even visualize data on its original non-rectangular grid (e.g., multi-block, curvilinear, triangular, quadrilateral, 8-node bricks, and tetrahedral), preserving its original variation of grid resolution and retaining exact grid boundaries. Tecplot was elected "Best Data Visualization Software" of 1994 by the readers of Scientific Computing and Automation Magazine.

The Total Data Visualization Solution

Tecplot tightly integrates basic plotting and graphing with advanced scientific visualization techniques in one versatile package, making Tecplot the comprehensive solution to all your data visualization needs. Tecplot is easy to use, yet has the power, capacity, and flexibility to please even the most demanding research scientist. Tecplot's versatility and cross-platform support makes it ideal for a wide range of scientific and engineering applications. When considering a company-wide data visualization solution, think Tecplot.

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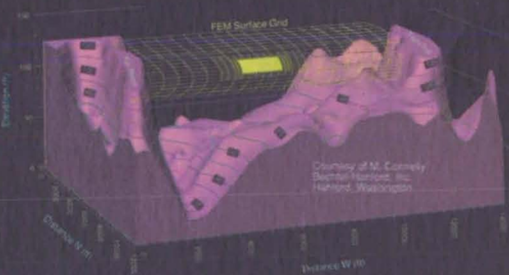
Are you spending too much time programming or getting frustrated trying to do scientific visualization with regular plotting programs? Use Tecplot to focus on your real work and begin producing results from the moment you read in your data. Tecplot enables you to interactively explore and analyze your data to gain new understanding and insights. With Tecplot, you can create beautiful, publication-quality plots in minutes.

Courtesy of M. Connelly, Bechtel-Hanford, Inc., Hanford, Washington

Available for Unix, Linux, VMS Workstations and PC's.



Courtesy of M. Connelly, Bechtel Hanford, Inc., Hanford, Washington

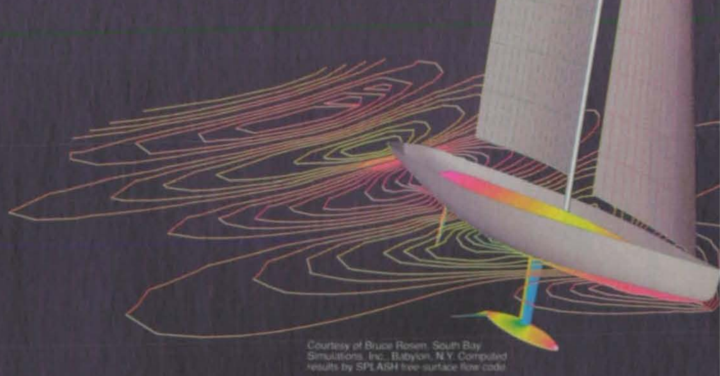
What Our Users Are Saying

"Tecplot is the best engineering and scientific plotting package. I wish I could have used it when I was doing my Ph.D."
-H. Chen, Adv. Laser and Fusion Tech., Quebec

"The best scientific plotting package around! Best technical support, too! I love it and have told everyone about it!"
-R. Ott, SWL, Inc., NM

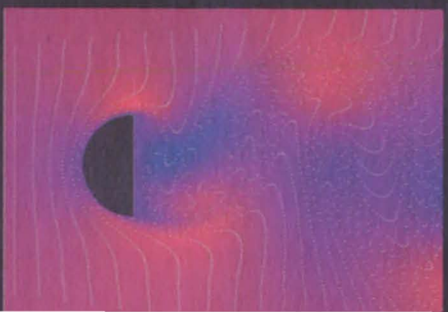
"The quality and flexibility of the plots produced by our research group has significantly improved since we started using Tecplot."
-M. Overholt, Cornell University, NY

"Very easy to learn and use, but still extremely powerful."
-G. Land, Ingersoll-Rand Co., VA



Courtesy of Bruce Rosen, South Bay Simulations, Inc., Babylon, N.Y. Computed results by SPLASH free-surface flow code

Courtesy of R. D. Henderson and G. E. Karniadakis, Dept. of Mech. & Aero. Engineering, Princeton University. Near-wake streamwise velocity field with massless particles show results of new unstructured spectral element method



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For More Information Write In No. 474

Amtec Engineering, Inc.

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New on the Market

Oriental Motor U.S.A. Corp., Torrance, CA, offers the PMU Series **hybrid stepping motor and driver**, which combines a five-phase hybrid stepping motor and 115 VAC input five-phase driver. The PMU33AH motor can be combined with gear-heads having various speed ratios. The driver incorporates an onboard power supply with drive and control electronics in a miniature 1.38" x 4.34" x 5.32" box.

For More Information Write In No. 765

DigiVision, San Diego, CA, has introduced the CDE-3000 **infrared image enhancement board**, a standalone processing unit which accepts various video inputs such as signals from most video cameras. The unit processes the digital input signals in real time; the enhanced image can be displayed or recorded on any standard video device.

For More Information Write In No. 766

The CCD-300U **color video camera** from Mitsubishi Imaging Products, Cypress, CA, uses a 1/3" charge-coupled device with 380,000 pixels for applications in industrial inspection and other high-resolution requirements. Other features are electronic shutter speeds to 1/10,000 second and a motorized 6.5 to 52 mm eight-power zoom lens.

For More Information Write In No. 767

A line of corrosion-resistant **ceramic fasteners** has been introduced by Aremco Products, Ossining, NY. Based on high-purity alumina ceramics, the nuts and bolts are available in lengths to 3" and are resistant to high-temperature oxidation. Applications include the instrument and electronics industries as replacements for plastic, nylon, and Teflon fasteners.

For More Information Write In No. 776

CUI Stack, Beaverton, OR, offers the MEL-12 **optical encoder**, which uses a magnetic drive system that eliminates coupling, alignment problems, and stress or vibration on the bearings. The encoder experiences no mechanical load or friction wear and can be used in the medical, aeronautics, and robotics fields.

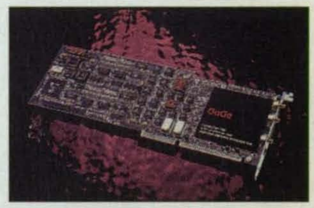
For More Information Write In No. 770

OMEGA Engineering, Stamford, CT, offers the "MIT Video Series on Measurement," a set of eight **basic measurement videotapes** presented with the Massachusetts Institute of Technology. They provide general and specific measurement theory and techniques, including temperature measurement, fluid quantity and flow; and mass, force, strain, torque, pressure, distance, velocity, and acceleration measurement.

For More Information Write In No. 771

The RGB/Videolink® HD high-resolution **video scan converter** from RGB Spectrum, Alameda, CA, records detailed computer-generated images and can be used with HDTV recorders in applications requiring small size character fonts or symbology. It converts high-resolution computer signals up to 1280 x 1024 pixels and provides playback at close to the same quality.

For More Information Write In No. 772



Gage Applied Sciences, South Burlington, VT, has introduced the CompuGen 1100 arbitrary **waveform generator card**, which offers 12-bit resolution at D/A conversion rates of up to 80 million samples per second. The IBM-compatible ISA bus card comes with 512 kilosamples of on-board memory and CompuGen for Windows software, which enables the card to be operated without writing programming code.

For More Information Write In No. 773

SUNX Sensors, West Des Moines, IA, has introduced the FX-10 series of **fiber-optic sensors**, which feature eight-turn potentiometer, 12 to 24 VDC operation, NPN or PNP output, and automatic crosstalk prevention. Various models include thru-beam and diffuse sensing ranges of 750 mm and 230 mm, respectively, and high-speed response of 0.03 ms.

For More Information Write In No. 775

Schlegel Corp., Rochester, NY, has announced Thermoformed **shielding components** for designs requiring EMI shielding, structural support, and acoustical shielding. The components conform to geometrical shapes or printed circuit boards in computers and medical devices. They are made of a laminate comprised of a conductive silver metallized fabric.

For More Information Write In No. 768

New on Disk

Wolfram Research, Champaign, IL, has introduced Mathematica 3.0 **mathematical software**, which handles numerical, symbolic, and graphical computations. It can be used as a numerical/symbolic calculator, a visualization system for functions and data, a programming language, a modeling and data analysis tool, and a tool to create interactive documents combining text and graphics with formulas. The program accepts traditionally typeset mathematical input from which the user can perform computations and generate editable typeset output.

For More Information Write In No. 711

Cimatron Technologies, Burlington, ON, Canada, has announced the New Interface Release of its Cimatron **CAD/CAM software** with a window-based environment that provides identical user interfaces on both PC and UNIX platforms. Solid modeling, surface modeling, NC machine control, rendering, drafting, and reverse engineering modules are contained in the package. A Session Monitor control window allows access to the library of CAD/CAM files; several parts files can be opened simultaneously.

For More Information Write In No. 712

Princeton Electronic Systems, Princeton, NJ, has released version 6.0 of Simion 3D **electron and ion optics simulation software** for mass spectrometers and other ion optics instruments. It also serves as a mechanism for the simulation of electron lenses and any devices based on focusing or manipulating electrons. The PC-based program costs $500.

For More Information Write In No. 716

The MATRIX$_x$® family of **visual design development tools** from Integrated Systems, Santa Clara, CA, enables engineers to design, test, and modify models through the design process. SystemBuild™ features visual block diagram modeling and simulation; Xmath™ provides object-oriented graphics and analysis, interactive 2D and 3D color graphics, and a programmable user interface; AutoCode® automatically generates C and Ada real-time source code; and DocumentIt™ incorporates information on SystemBuild models into written documents and produces formatted documents. It runs on Windows NT, Sun, and Hewlett-Packard workstations.

For More Information Write In No. 714

Design for Assembly version 8.0 **assembly design analysis software** from Boothroyd Dewhurst, Wakefield, RI, provides product development engineers with tools to analyze assembly efficiency and reduce part counts. Pictorial images of redesign suggestions and assembly operations are incorporated. It operates in Windows 3.1 and Windows 95.

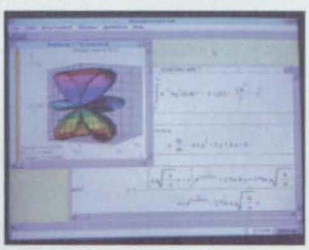
For More Information Write In No. 715

SINDA/FLUINT 3.1 **thermal/fluid analysis software** from Cullimore and Ring Technologies, Littleton, CO, is a finite-difference, lumped-parameter analysis tool for thermal/fluid systems in the electronics, automotive, and aerospace industries. Features include steady-state and transient solutions, user-definable fluid properties, and general models for pumps, valves, and ducts. It is Windows-compatible and is available for Sun and Hewlett-Packard workstations, PCs, and Macintosh.

For More Information Write In No. 717

Nematron Corp., Ann Arbor, MI, offers AutoNet **data acquisition and control software**, which presents real-time process data through configurable graphic instruments, trends, and cartesian plots that update control computations, data logging, and I/O scan rates up to 30 times per second. The software provides math, statistical, and trigonometric calculations; control, test sequencing, filtering, and batch management; and presents stored data in reports, historical graphics, or ad hoc queries.

For More Information Write In No. 713



Macsyma® 2.1 **math software** from Macsyma Inc., Arlington, MA, features on-line help, data acquisition capabilities, and compatibility with Windows 95, Windows NT, and Windows 3.1. The MathTips™ Advisor shows sample computations in all areas of mathematics, including algebra, calculus, linear algebra, and partial and ordinary differential equations. The DataViewer™ allows data viewing, editing, importing, and exporting, as well as data graphing and analysis. Macsyma 420 for UNIX also is available. Prices for the PC versions are $499 for Windows 3.1 and 95, and $599 for Windows NT; the UNIX package is $1249.

For More Information Write In No. 718

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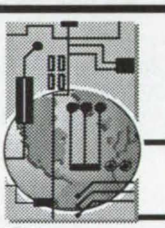

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Must be an experienced real-time embedded programmer in C and C++. Must also possess experience with routing protocols such as TCP/IP, SPX/IPX or Appletalk. Experience in RTOS (e.g. VRTX or PSOS), Frame Relay, ATM, ISDN, FDDI, T1/E1 or WAN helpful.

CELLULAR/WIRELESS SOFTWARE DEVELOPER

Must possess a minimum of 2 years experience in tele/data communications software development as well as a background in a Windows and/or Windows NT environment. Must also be skilled in GSM, CDMA, TDMA, Analog Cellular, CDPD, Mobile Data Communications, Wireless Data Networks, Call Processing or Cellular/Wireless Infrastructure.

ROUTING PROTOCOL DEVELOPMENT

Must be a hands-on engineer with a strong technical ability in IP, IPX or Appletalk protocols. Software and embedded systems development skills a plus.

NETWORK MANAGEMENT SOFTWARE ENGINEER

Will design and implement network management applications in both a Windows and UNIX environment. Must possess experience in Windows 3.1/95/NT, Visual C++, MFC, VBX, WinSock, WinSNMP, Solaris, HPUX, AIX, Motif/X-Windows, Open View or SunNet Manager. Experience in TCP/IP protocols and SNMP preferred.

DQ TEST ENGINEER

Will be responsible for developing test plans, creating test platforms and the development of automating test suites for product regression/stress testing. Must possess experience in LAN communication and routing products with knowledge of bridges, routers, protocol analyzers, UNIX systems and testing in a LAN/Novell environment.

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